

IBM i 7.2 Technical Overview with Technology Refresh Updates

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**IBM i 7.2 Technical Overview with Technology
Refresh Updates**

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Note: Before using this information and the product it supports, read the information in “Notices” on page xi.

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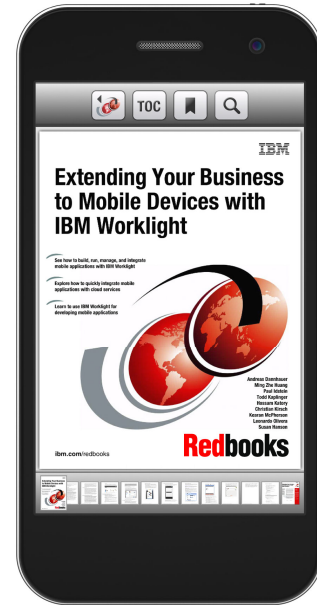
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Preface

This IBM® Redbooks® publication provides a technical overview of the features, functions, and enhancements that are available in IBM i 7.2, including all the available Technology Refresh (TR) levels, from TR1 to TR3. This publication provides a summary and brief explanation of the many capabilities and functions in the operating system. It also describes many of the licensed programs and application development tools that are associated with IBM i.

The information that is provided in this book is useful for clients, IBM Business Partners, and IBM service professionals that are involved with planning, supporting, upgrading, and implementing IBM i 7.2 solutions.

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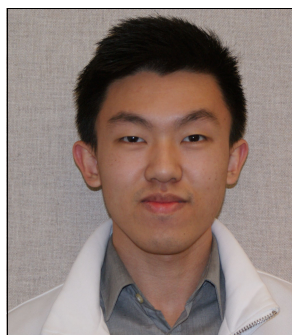
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Introduction to IBM i 7.2

This chapter introduces IBM i 7.2. Subsequent chapters in this book provide in-depth information about specific functional areas of IBM i and associated licensed programs. As a technical overview document, detailed instructions or examples are beyond the scope of this publication. The purpose of this document is to consolidate into a single reference a summary of information that is related to IBM i 7.2.

This chapter describes the following topics:

- ▶ 1.1, “IBM i 7.2” on page 2
- ▶ 1.2, “Technology Refresh” on page 2
- ▶ 1.3, “Upgrading to or installing IBM i 7.2” on page 5
- ▶ 1.4, “Documentation and support locations” on page 8
- ▶ 1.5, “Topics that are covered in this book” on page 11
- ▶ 1.6, “Functions available from previous releases” on page 12

A valuable starting point for readers of this publication, and anyone that is involved with the installation or an upgrade from a previous release of the IBM i operating system, is the IBM i Memo to Users. It is available in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgmtu.htm

More detailed information about IBM i 7.2 enhancements can be found at these websites:

- ▶ IBM i 7.2 IBM Knowledge Center:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/ic-homepage.htm
- ▶ IBM developerWorks® IBM i Technology Updates wiki:
<https://ibm.biz/BdsdpH>
- ▶ Planning to upgrade to IBM i 7.2:
<http://www.ibm.com/systems/support/i/planning/upgrade/v7r2/index.html>
- ▶ Customer notices and information for IBM i 7.2:
<http://www.ibm.com/systems/support/planning/notices72.html>

1.1 IBM i 7.2

On May 2, 2014, IBM i 7.2 was made generally available. This release is the 23rd major release of the IBM i family of operating systems. Previous releases included IBM i5/OS™ and IBM OS/400®. The following are the release dates for the subsequent IBM i 7.2 Technology Refresh dates:

- ▶ On October 6, 2014, IBM i 7.2 Technology Refresh 1 was announced.
- ▶ On April 28, 2015, IBM i 7.2 Technology Refresh 2 was announced.
- ▶ On October 5, 2015 IBM i 7.2 Technology Refresh 3 (TR3) was announced.

For more information about the dates of support for the various IBM i releases, see the following website:

<http://www.ibm.com/systems/support/i/planning/upgrade/suptschedule.html>

1.2 Technology Refresh

IBM i 7.2 continues to use the Technology Refresh concept for product updates throughout the life of the operating system.

For more information about the Technology Refresh PTF Group, and many more details regarding the Technology Refresh concept, see this website:

<http://www.ibm.com/systems/support/i/planning/techrefresh/index.html>

1.2.1 Definition of a Technology Refresh

The Technology Refresh concept was introduced in IBM i 7.1. Technology Refresh allows for updates to the operating system that affect mainly the System Licensed Internal Code (SLIC), I/O, and virtualization functions. These updates are delivered by using a PTF Group, but provide changes and enhancements that are normally reserved for SLIC updates or even full releases.

Technology Refresh: A collection of OS software for “new function enablement” that is packaged together, tested together, and delivered as a single PTF Group.

Additionally, new and updated products within the OS are bundled together and delivered at approximately the same time as a Technology Refresh. These new and updated products also use PTF Groups. This concept allows for major enhancements to occur during the same time frame as the Technology Refresh release.

By implementing Technology Refresh, IBM i became even more flexible and responsive to a changing environment without adding the burden of installing and qualifying a new release to keep systems up-to-date. The Technology Refresh makes it possible to implement new hardware and software features in a way that is relatively seamless by using a familiar PTF application process. By simply ordering and applying the current Technology Refresh PTF Group, the system is updated and the new or updated features are ready to use.

Review the cover letters and online documentation for all PTF Groups and Technology Refreshes to ensure that you are ordering all the necessary fixes to acquire the new functions.

Important: Large enhancements to parts of IBM i are released at the same time as Technology Refreshes, but they typically do not depend on each other. For example, if you ordered only the new Technology Refresh PTF Group, you do not receive the improvements to IBM DB2® for i or for BRMS. Updates to DB2 for i are included in the Database PTF Group. Updates to BRMS are handled within the Backup and Recovery Solutions PTF Group. Schedules of releases have the potential to vary in cadence among PTF Group releases and Technology Refreshes.

Similar to firmware updates, Technology Refreshes are cumulative. All the new and updated features that are introduced in earlier Technology Refreshes are included in later ones, and only the most current version is orderable. Previous versions become unavailable for ordering after a new Technology Refresh is released.

Figure 1-1 shows a representation of how Technology Refreshes relate to the IBM i operating system, and how the Technology Refresh PTF Group is ordered. The figure indicates how the contents of Technology Refresh 1 are included in Technology Refresh 2, and likewise how the contents of Technology Refresh 1 and 2 are included with Technology Refresh 3. This pattern continues through all iterations of Technology Refreshes for the current release of the IBM i version that supports Technology Refreshes.

Note: To order the newest Technology Refresh, you must order the IBM i 7.2 Technology Refresh PTF Group SF99717.

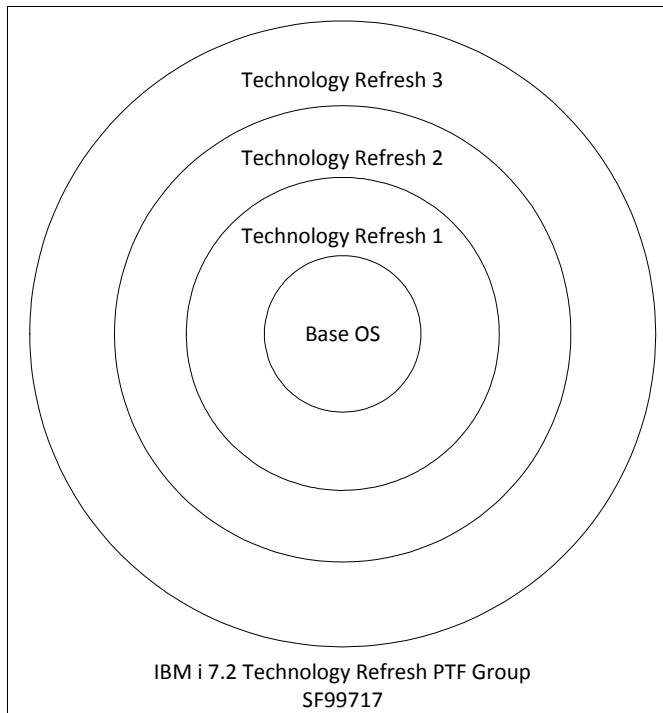


Figure 1-1 Graphical representation of the cumulative structure of Technology Refreshes

Here are some notable examples of previous Technology Refreshes:

- ▶ IBM i 7.1 TR4: Support for Live Partition Mobility (LPM)
- ▶ IBM i 7.1 TR8: Increased number of disks for VSCSI connections from 16 to 32
- ▶ IBM i 7.1 TR9: Support for IBM i 7.1 on POWER8® Enterprise Systems hardware
- ▶ IBM i 7.2 TR1: Support for IBM i 7.2 on POWER8 Enterprise Systems hardware

1.2.2 Ordering and checking the installation status of a Technology Refresh

To order the most recent Technology Refresh PTF Group for IBM i 7.2, use the group identifier SF99717. *All Technology Refreshes are ordered by using the PTF Group.* Future Technology Refresh packages are orderable by using the SF99717 identifier, but contain additional fixes to support the level of the most recent Technology Refresh.

Important: It is not possible to remove an installed Technology Refresh level without performing a reinstallation of the Licensed Internal Code. This is colloquially known as “slipping the SLIC.” For more information, see 1.3.7, “IBM i resave levels and their relationship to Technology Refresh” on page 7.

Always review cover letters for the Technology Refresh PTF Group, and any other PTFs, before applying the Technology Refresh to your system to ensure that there are no special instructions for which you should account.

To order fixes, go to the IBM Fix Central website:

<http://www.ibm.com/support/fixcentral>

You can review your installed Technology Refresh level by using the Work with PTF Groups (**WRKPTFGRP**) Command Language (CL) command and looking at the installed level of SF99717. See Figure 1-2.

```
Work with PTF Groups                                System:  RCHESPI
Type options, press Enter.
 1=Order  4=Delete  5=Display  6=Print  8=Display special handling PTFs
 9=Display related PTF groups  10=Display PTF apply information

Opt  PTF Group          Level  Status
-----
SF99776          1  Installed
SF99775          3  Installed
SF99766          2  Installed
SF99766          3  Installed
SF99747          8  Installed
SF99747          9  Installed
SF99720         14101 Installed
SF99720         14276 Installed
SF99719          20  Installed
SF99719          22  Installed
SF99718          8  Installed
SF99718          9  Installed
SF99717          1  Installed

More...

F3=Exit  F6=Print  F11=Display descriptions  F12=Cancel
F22=Display entire field
```

Figure 1-2 Work with PTF Groups display showing IBM i 7.2 Technology Refresh 1 installed

Releases of software enhancements that are produced at the same approximate time as Technology Refreshes are orderable and viewable in the same manner. Ordering is performed by using the appropriate PTF Group identifier. Examples of some IBM i 7.2 PTF Group identifiers are shown in Example 1-1.

Example 1-1 List of various IBM i 7.2 PTF Group packages

SF99480 - WebSphere App Server v8.
SF99481 - WebSphere App Server v8.5
SF99702 - DB2 for IBM i
SF99713 - IBM HTTP Server for i
SF99714 - Performance tools for IBM i
SF99715 - Backup Recovery Solutions
SF99716 - Java
SF99717 - Technology Refresh
SF99718 - Group Security
SF99719 - Group Hiper
SF99720 - IBM i 7.2 Cumulative PTF Package
SF99721 - All PTF Groups Except Cumulative PTF Package
SF99747 - DB2 Web Query for i v2.1.0
SF99759 - IBM MQ for IBM i - v7.1.0/v8.0.0
SF99766 - Print PTF Group
SF99767 - TCP/IP PTF Group
SF99775 - Hardware and Related PTFs
SF99776 - High Availability for IBM i

1.3 Upgrading to or installing IBM i 7.2

Upgrading from IBM i 7.1 and 6.1 to 7.2 are both supported paths. If a system is running at a release older than 6.1, upgrading to either IBM i 6.1 or 7.1 is required before performing the upgrade to IBM i 7.2.

1.3.1 Supported hardware

IBM i 7.2 runs on many different models of IBM Power Systems. There are various prerequisites that must be met to ensure a successful installation or upgrade.

Note: IBM i 7.2 is not supported on any POWER5 or POWER5+ system.

Here is the supported hardware for running IBM i 7.2:

- ▶ POWER8 Enterprise Systems models (Requires IBM i 7.2 with TR1)
 - E880 9119-MHE
 - E870 9119-MME
- ▶ POWER8 Scale-out Power Systems models
 - S814 8286-41A
 - S824 8286-42A
- ▶ IBM Power System S822
 - S822 8284-22A

- ▶ POWER7/7+
 - IBM POWER7+™ 750/760 (these models do not support native I/O)
 - Power 710, 720, 730, 740, 770, 780, and 795
 - IBM PureFlex® p260/p460
- ▶ POWER6/6+
 - IBM POWER6+™ JS23, JS43, 520, 550, and 560
 - IBM POWER6® JS12, JS22, 520, 550, 570, and 595

Note: IBM i 7.2 provides no support for IOPs or for HSL connectivity.

Make sure to review the *Memo to Users for IBM i 7.2* for further details about the hardware requirements and supported combinations, especially as they relate to POWER6 hardware. The *Memo to Users for IBM i 7.2* also includes many useful links showing where to begin planning for your particular upgrade strategy. The *Memo to Users for IBM i 7.2* is available in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgmtu.htm

Additional information about hardware and firmware prerequisites can be found in the *IBM i - Hardware and Firmware enhancements* topic in the IBM developerWorks, IBM i Technology Updates wiki, found at:

<https://ibm.biz/Bdsdp4>

1.3.2 IBM Pre-Upgrade Verification Tool for IBM i

Use of the Pre-Upgrade Verification Tool for IBM i is optional, but can provide excellent benefits. It can help in determining whether needed prerequisite fixes are on the system, and ensure that all pre-upgrade steps have been taken in an effort to ensure the smoothest and fastest upgrade possible.

The IBM Pre-Upgrade Verification Tool for IBM i is available at the following website:

<http://www.ibm.com/support/docview.wss?uid=nas8N1014074>

1.3.3 POWER8 reference documentation

For more information about POWER8 Enterprise Servers, see *IBM Power Systems E870 and E880 Technical Overview and Introduction*, REDP-5137.

For more information about POWER8 Scale-out systems, see *IBM Power Systems S814 and S824 Technical Overview and Introduction*, REDP-5097.

For specific IBM i information relating to hardware, see the *IBM i - Hardware and Firmware enhancements* topic in the IBM developerWorks, IBM i Technology Updates wiki, found at:

<https://ibm.biz/Bdsdpi>

1.3.4 POWER8 update access keys

POWER8 servers include an update access key that is checked when system firmware updates are applied to the system. Update access keys include an expiration date. System firmware updates are not processed if the calendar date has passed the update access key's expiration date.

As these update access keys expire, they must be replaced by using either the Hardware Management Console (HMC), the Advanced Management Interface (ASMI) on the service processor, or directly by running the `update_flash` command.

For more information about the management of POWER8 update access keys, see the following website:

<http://www.ibm.com/support/docview.wss?uid=isg3T1020902>

1.3.5 Load source usable space

Starting with IBM i 7.2 Technology Refresh 1, the minimum load source requirements have changed:

- ▶ Minimum of 35 GB for 520-byte sectors (IBM DS8000®, virtual disks with VIOS as server)
- ▶ Minimum of 41 GB (to get 35 GB useable space) for 512-byte sectors (SAN Volume Controller, IBM Storwize®, virtual disks with VIOS VSCSI, or IBM i as server)
- ▶ Minimum of 70 GB for native-attached SAS (Both 520-byte or 4-K sectors)

Review the calculation data on the IBM i and Related Software wiki to ensure that the appropriate space exists on your system:

<http://www.ibm.com/developerworks/ibmi/software>

1.3.6 HMC and central electrical complex firmware levels

Be sure to validate that your central electrical complex and HMCs are at an appropriate version to run IBM i 7.2. Central electrical complex firmware requirements and compatible HMC releases can be found at the following links:

- ▶ IBM i Server Firmware and HMC Code wizards:
http://www-912.ibm.com/s_dir/slkbases.NSF/DocNumber/408316083
- ▶ IBM Power code matrix:
<https://www-304.ibm.com/webapp/set2/sas/f/power5cm/home.html>

1.3.7 IBM i resave levels and their relationship to Technology Refresh

Resaves of IBM i are created from time to time because of new hardware releases and other issues that require addressing by IBM i development. Resaves are also produced when a new Technology Refresh is released. In the normal course of business, using a resave to install a Technology Refresh is not required. However, there might be situations where using a new resave might be necessary.

For the most current information regarding IBM i 7.2 resave levels and information about determining what is installed on a particular system, see the following IBM i Resaves Information for IBM i 7.2 website:

<http://www.ibm.com/systems/support/i/planning/resave/v7r2.html>

1.3.8 Network installation support for SLIC updates

Replacing the Licensed Internal Code from an image that is in a Network File System (NFS) is supported on IBM i 7.2.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahc/restor.htm

1.4 Documentation and support locations

Systems used to ship with large volumes of paper-based reference documentation. Over the past several years, there has been a move to online access of support information. Even more recently, tools such as wikis have made documentation much more fluid and immediate.

1.4.1 IBM Knowledge Center

Reference documentation can be found at the IBM Knowledge Center, formerly known as the IBM Information Center. The IBM Knowledge Center for IBM i is at the following website:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i/welcome

Navigation and search in the IBM Knowledge Center has been improved over the previous IBM Information Center. Figure 1-3 shows an example view of the IBM Knowledge Center for IBM i 7.2.

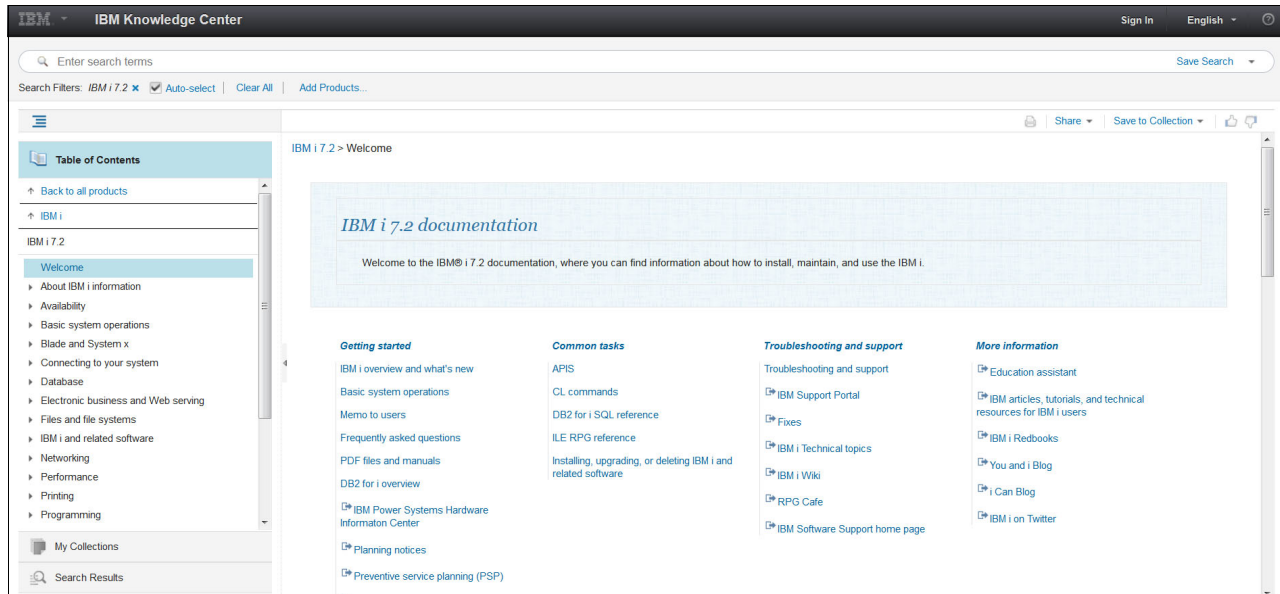


Figure 1-3 IBM Knowledge Center for IBM i 7.2

1.4.2 IBM Redbooks publications

IBM Redbooks publications are another source of technical documentation for IBM i, and many other IBM products and solutions.

The following links are specific to the IBM Power Systems and IBM i IBM Redbooks publications:

- ▶ IBM Power Systems IBM Redbooks portal:
<http://www.redbooks.ibm.com/portals/power>
- ▶ IBM i specific IBM Redbooks publications:
<https://ibm.biz/BdsdpY>

1.4.3 Announcements

Another communication method that the IBM i team uses is the Request for Announcement (RFA). The RFA is the formal document that contains information about a function that is being delivered to the market.

For more information and to search for various RFAs, see the IBM Offering Information website:

<http://www.ibm.com/common/ssi/>

1.4.4 IBM developerWorks, blogs, and wikis

The IBM i zone in IBM developerWorks and social media is part of the platform strategy for getting information to IBM Business Partners and clients quickly. The information in developerWorks is for everyone, not just developers. The IBM developerWorks IBM i website can be found at:

<http://www.ibm.com/developerworks/ibmi/>

With developerWorks, if there is new information to share with IBM customers, it can be shared immediately. Here are different ways that information is delivered through developerWorks:

- ▶ Article-based information

Much of the information about developerWorks is in the form of short articles that define a task or technology. The content provides not only information about a topic, but also tries to answer the question, “Why is this topic important to me?”. These articles are written by many developers.

- ▶ Technology Updates wiki

The IBM i Technology Updates page in developerWorks is the home for detailed information about the functions that are delivered with each new Technology Refresh, and the functions that are delivered through other means between releases. The technology updates section is organized for easy navigation, searches, and subscription. At the bottom of these pages is a button that allows you to subscribe to the page so that you are notified when updates are made to it. Because this page is updated every time a new PTF Group is updated, you can track and monitor new enhancements and fixes as they are delivered. To view the page, go to the following website:

<https://ibm.biz/BdXiJG>

► Community and Forums

– The Community section is a list of links to help you connect to various items. There are blogs from experts in the development lab, and blogs from others in the industry. These are short articles on a wide array of topics, all aimed at communicating with IBM i users throughout the world. Here are some of the blogs:

- *You and i, IBM i Trends and Strategies*: Steve Will's blog on IBM i. Steve is the Chief Architect for IBM i and is responsible for strategy and planning that is related to the operating system and its related products and solutions. You can find this blog at the following website:

<http://ibmsystemsmag.com/Blogs/You-and-i/>

Steve also uses Twitter to notify followers whenever his blog has something new, what is going on in IBM i development, and to point to a webcast, article, or blog that might be useful. Follow @Steve_Will_IBMi on Twitter.

- *i Can, Technical Tips for i*: Dawn May's blog on IBM i. She is a senior technical staff member at IBM and is the technical lead for the IBM i Systems Software Development organization. You can find this blog at the following website:

http://ibmsystemsmag.blogs.com/i_can/

- *DB2 for i*: Mike Cain's blog on insights and perspectives that are related to data management by using DB2 for i. He is a team leader of the IBM DB2 for i Center of Excellence. You can find this blog at the following website:

<http://db2fori.blogspot.com/>

- *Open Your i*: Brian May is an IBM Champion for Power Systems and writes about a wide range of topics that are focused on his experience running various applications on IBM i. Topics include open source applications, application modernization, integration with other platforms/languages, and more. You can find this blog at the following website:

<http://iprodeveloper.com/blog/open-your-i>

– The forums target different topical categories and give you an opportunity to ask IBM i developers questions. These forums are monitored by experts in the development lab.

IBM developerWorks has many links to other topic and technology areas that IBM i users need, and is organized to help you get the information that you need when you need it. It also is a great place for helping you stay informed about what is happening with IBM i.

1.4.5 IBM i technical support

IBM i technical support can be reached online or by telephone to open service requests. Use the IBM support website at the following link, or contact 800-IBM-SERV toll-free in the US:

<http://www.ibm.com/support>

1.5 Topics that are covered in this book

Here are brief descriptions of the different topics that are covered in this book:

- ▶ **Systems management**

Chapter 2, “Systems management” on page 13 covers various system management topics, including IBM Navigator for i, Advanced Job Scheduler, improved mobile access, and other work management topics.

- ▶ **Cloud and virtualization**

Chapter 3, “Cloud and virtualization” on page 195 covers items pertaining to virtualization and cloud implementations, including IBM PowerVP™, SmartCloud Entry, and iVirtualization.

- ▶ **Security**

Chapter 4, “Security” on page 209 covers enhancements to security in IBM i 7.2, and methods that can be used to implement these new features to help make your system more secure.

- ▶ **Networking**

Many new functions were added to networking in IBM i 7.2. Chapter 5, “Networking” on page 225 covers these enhancements, and describes how they can be put in place to help improve your environment.

- ▶ **High availability**

Chapter 6, “High availability” on page 251 covers IBM PowerHA® and improvements to processes relating to other high availability software products.

- ▶ **Backup and recovery**

IBM i 7.2 provides another leap forward in functionality for Backup, Recovery, and Media Services (BRMS). Improvements to base save and restore operations also have been implemented. Chapter 7, “Backup and recovery” on page 269 describes these enhancements and provide examples.

- ▶ **DB2 for i**

Significant enhancements are introduced for DB2 for i in IBM i 7.2. Chapter 8, “IBM DB2 for i” on page 321 covers security, performance, and usability improvements. Additionally, an overview of the Row and Column Access Control (RCAC) enhancement and links to more specific documentation about this significant new feature is provided.

- ▶ **Application development**

Chapter 9, “Application development” on page 415 covers free-form RPG, mobile access and data consumption improvements, PHP, WebSphere, Liberty, and other new items.

- ▶ **IBM i server enhancements**

Chapter 10, “IBM i server functions” on page 475 covers topics that did not fit specifically in any of the previous chapters of this book, and includes the following topics:

- 10.1, “IBM HTTP Server for i” on page 476
- 10.2, “IBM i Integrated Web Application and Web Services Server” on page 480
- 10.3, “IBM WebSphere Application Server” on page 484
- 10.4, “IBM Social Collaboration products” on page 487
- 10.5, “IBM Printing” on page 487

1.6 Functions available from previous releases

This publication supports improved features and functions that are available at IBM i 7.2. Certain things that are listed in this book might be possible by using previous releases of IBM i. For example, running on a Power Systems E880 server is supported at IBM i 7.1 if Technology Refresh 9 is installed. Additionally, some features of BRMS, DB2 for i, and IBM Navigator for i have been added to IBM i 7.1 and 6.1. However, many other features, such as Row and Column Access Control, are available in IBM i 7.2 only.

This document is not meant as a reference guide for cross-release compatibility, and statements of the existence of a feature or requirement in IBM i 7.2 does not necessarily confirm or deny their existence in any other release.



Systems management

This chapter covers various IBM i system management topics, including IBM Navigator for i, Advanced Job Scheduler, improved mobile access, and other work management topics.

This chapter describes the following topics:

- ▶ 2.1, “IBM Navigator for i” on page 14
- ▶ 2.2, “IBM i Access” on page 118
- ▶ 2.3, “Application Runtime Expert for i” on page 162
- ▶ 2.4, “Journal management” on page 162
- ▶ 2.5, “Work management enhancements” on page 167
- ▶ 2.6, “Operating system limitation changes” on page 182
- ▶ 2.7, “IBM Advanced Job Scheduler for i” on page 182
- ▶ 2.8, “Performance” on page 191

For more information about the IBM i 7.2 system management enhancements, see the IBM i Technology Updates developerWorks wiki, found at:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

2.1 IBM Navigator for i

The IBM Navigator for i is a web console interface. Using it, you can perform key tasks to administer your IBM i system. Most tasks that are available in the IBM System i® Navigator Windows client application are also supported within IBM Navigator for i. There are also additional functions that are available in IBM Navigator for i that are not found in the System i Navigator Windows client.

Unlike the Windows client application, nothing needs to be installed on your workstation for you to use IBM Navigator for i. The web application is part of the base IBM i operating system, and can easily be accessed by pointing your web browser to the following URL:

`http://system:2001`

The following IBM Navigator for i topics are covered in this section:

- ▶ 2.1.1, “Requirements” on page 14
- ▶ 2.1.2, “Usability and performance improvements” on page 15
- ▶ 2.1.3, “Searching for a task by keywords and CL commands” on page 16
- ▶ 2.1.4, “Bookmarking your favorite tasks” on page 16
- ▶ 2.1.5, “File systems” on page 17
- ▶ 2.1.6, “Target Systems and Groups” on page 21
- ▶ 2.1.7, “PTF management” on page 22
- ▶ 2.1.8, “Message and system monitors” on page 49
- ▶ 2.1.9, “Performance” on page 67
- ▶ 2.1.10, “Security” on page 92
- ▶ 2.1.11, “Network” on page 93
- ▶ 2.1.12, “Omnifind Text Search” on page 94
- ▶ 2.1.13, “Disk management” on page 95
- ▶ 2.1.14, “Partition management” on page 100
- ▶ 2.1.15, “Support for additional system values” on page 102
- ▶ 2.1.16, “Integrated server administration” on page 103
- ▶ 2.1.17, “Database” on page 115
- ▶ 2.1.18, “Printers and printer output” on page 115

For more information about IBM Navigator for i, see the following websites:

- ▶ IBM i 7.2 IBM Knowledge Center:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzat10/rzatgdirectoroverview.htm?lang=en
- ▶ IBM developerWorks:
<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20Navigator%20for%20i>

2.1.1 Requirements

IBM Navigator for i is installed as part of the IBM i operating system. It is part of SS1 option 3. The following list of IBM i license programs is recommended for use with IBM Navigator for i:

- ▶ 5770SS1 option 1, Extended Base Support
- ▶ 5770SS1 option 3, Extended Base Directory Support
- ▶ 5770SS1 option 12, Host Servers
- ▶ 5770SS1 option 30, Qshell

- ▶ 5770SS1 option 33, Portable App Solutions Environment
- ▶ 5770DG1 *BASE, IBM HTTP Server for i
- ▶ 5770JV1 *BASE, IBM Developer Kit for Java
- ▶ 5770JV1 option 11, Java SE 6 32-bit
- ▶ 5770JV1 option 12, Java SE 6 64-bit
- ▶ 5770PT1 option 1, Manager Feature (provides access to PDI Disk Watcher, Database and PEX packages, and Batch model)
- ▶ 5770PT1 option 3, Job Watcher (provides access to PDI Job Watcher package)

The actual PTFs are all packaged and delivered as part of the HTTP PTF Group. There are also many other PTF Groups that are required to ensure that all parts of the IBM Navigator for i interface functions correctly:

- ▶ SF99713 level 9: HTTP Server PTF Group
- ▶ SF99714 level 2: Performance Tools PTF Group
- ▶ SF99702 level 8: Database PTF Group
- ▶ SF99716 level 7: Java PTF Group

For the list of required PTFs for IBM Navigator for i, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20Navigator%20for%20i>

2.1.2 Usability and performance improvements

By using Dojo technology, there are now significant improvements in IBM i 7.2 within the workspace for the following areas:

- ▶ Navigation area

Similar to the IBM i Navigator client application, the task categories can now be opened to display any resource containers in the navigation area. It is now much easier and quicker to access tasks.

- ▶ Common list view

Common list views now use new Dojo tables that make it easier and quicker to filter lists, scroll through large lists, and select items in the list to perform related actions.

- ▶ Handling of tabs

After multiple tasks are selected, resulting in multiple tabs in the console workspace, data is no longer refreshed each time that you click back to a previous tab.

2.1.3 Searching for a task by keywords and CL commands

On the Welcome page within IBM Navigator for i, it is now possible to simply enter a keyword as a search argument and the related CL commands are automatically shown. Simply clicking the corresponding CL command redirects you to the corresponding task within the navigation pane, as shown in Figure 2-1. This is a quick way to access a particular task without having to navigate to it by using the navigation hierarchy.

Note: You can also type in a phrase that describes what you want to find (for example, create a user) or a system value (for example, qpwd1v1).

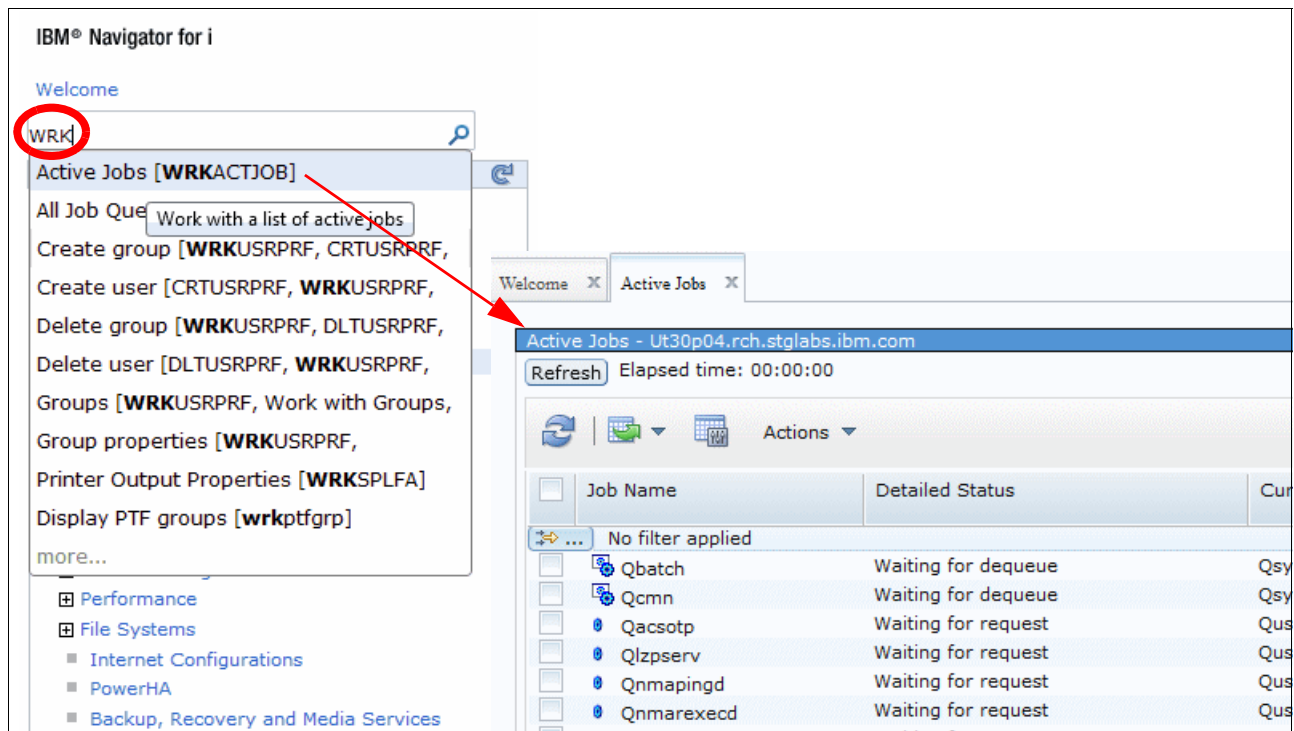


Figure 2-1 Search a task by keyword

2.1.4 Bookmarking your favorite tasks

There is now a new Favorites node in the navigation area. These favorites are saved and shown by user profile and system. It is possible to save a particular list view as a favorite. Favorites can also be organized by category.

Most likely, there are a few specific areas of the IBM i systems management that you use often during your daily job. For example, if you are interested in the jobs for a specific user, click **Users and Groups** → **Users**, find the user profile in which you are interested, right-click that user profile, and select **User Objects** → **Jobs**. From the Actions menu, select **Save as Favorite**, and specify a name for the task (TOMV_jobs in this example) and the category (SYSMGMT in this example) that you want.

The task, TOMV_jobs, is now displayed in the SYSMGMT category under Favorites in the navigation area, as shown in Figure 2-2.

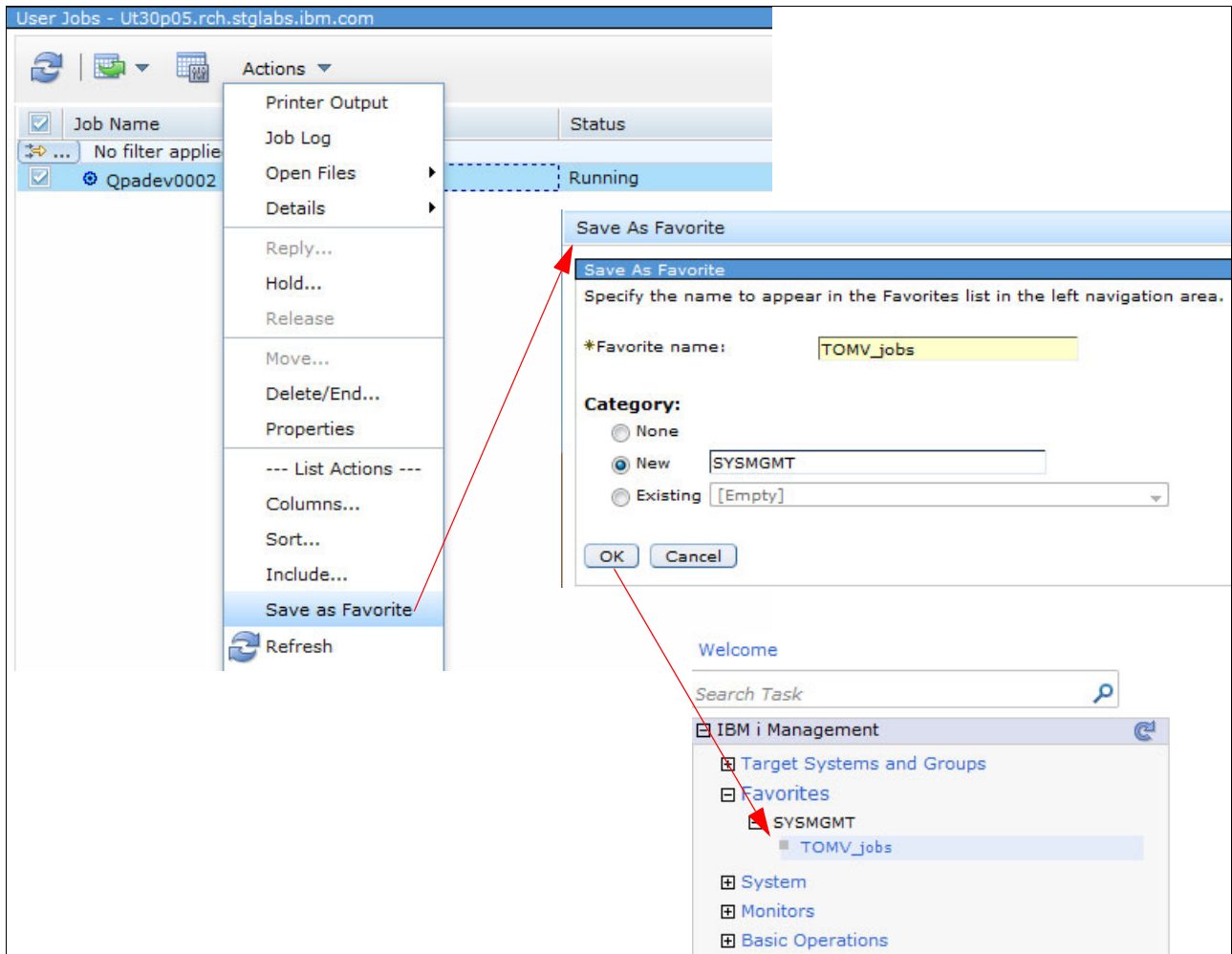


Figure 2-2 Save an action as a favorite

2.1.5 File systems

The following new file systems actions were added to IBM Navigator for i for IBM i 7.2, allowing users to do the following tasks:

- ▶ Upload files to an IBM i directory.
- ▶ Download files from an IBM i directory.
- ▶ Edit certain types of files.
- ▶ Go to an Integrated File System folder.

Uploading files to an IBM i directory

In IBM i 7.2, by using the File System task in IBM Navigator for i, users can now upload files from their PC or a mapped drive to an IBM i directory, as shown in Figure 2-3.

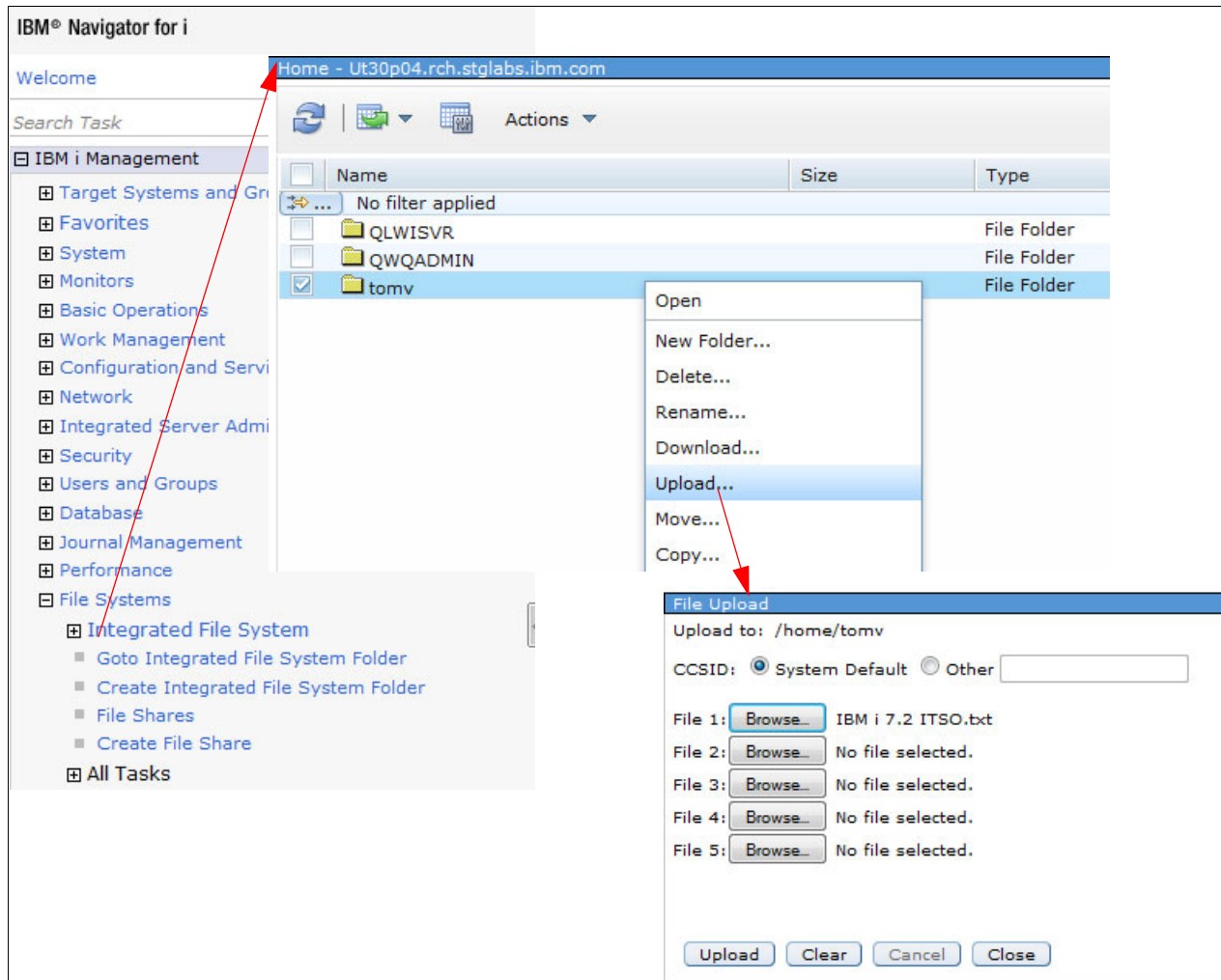


Figure 2-3 Upload files to an IBM i directory

Downloading files from an IBM i directory

A similar interface is available for downloading files from an IBM i directory to the user's wanted location, as shown in Figure 2-4.

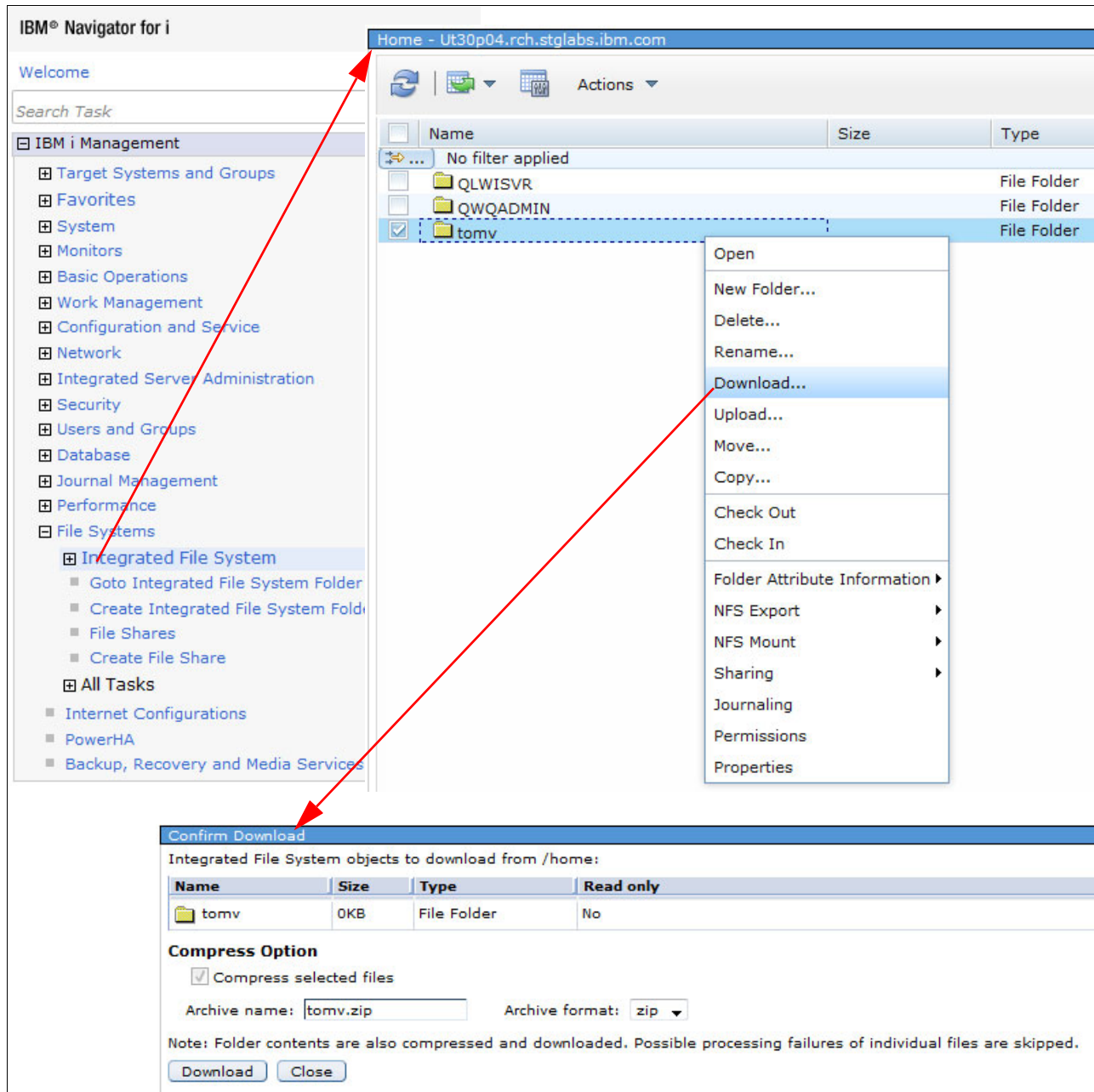


Figure 2-4 Download files from an IBM i directory

Editing certain types of files

Another feature that is now available with IBM i 7.2 is the ability to edit files by using the IBM Navigator for i interface. To do this task, you must first specify the file types that you want to be able to edit. Complete the following steps, as shown in Figure 2-5:

1. From the main IFS list, select **Properties** from the Actions drop-down menu.
2. On the Integrated File System Properties window, enter the file extensions that you want to be able to edit and click **OK**.

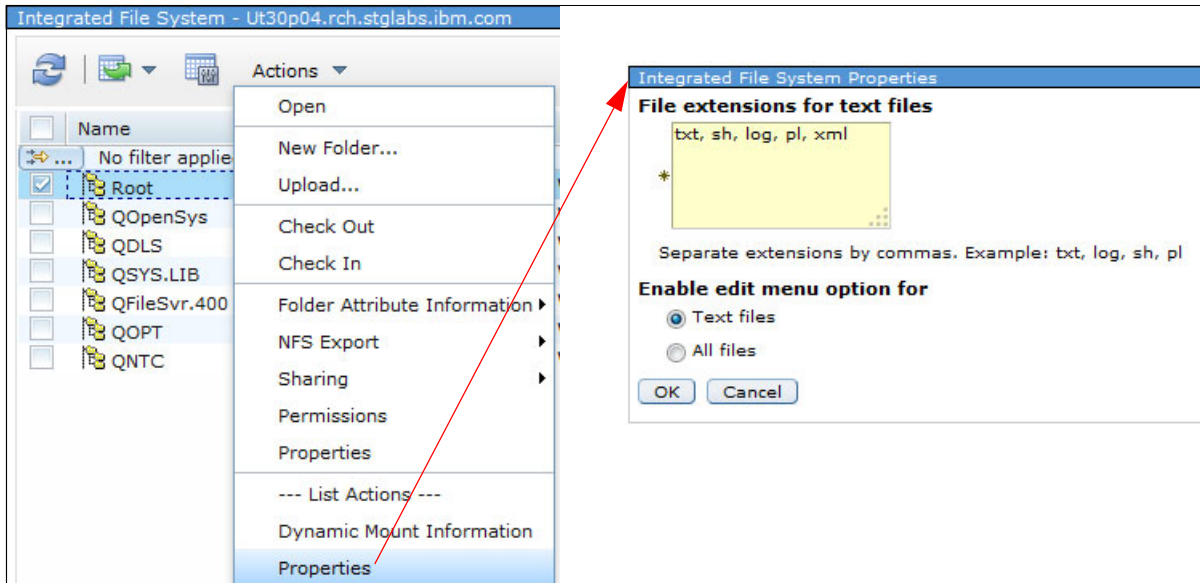


Figure 2-5 Specify the file types to be able to edit

The user now sees the Edit action appear for these types of files when right-clicking them within the IBM Navigator for i. Selecting the **Edit** action opens the Edit window, as shown in Figure 2-6. The user now has full edit functionality for that specific file.

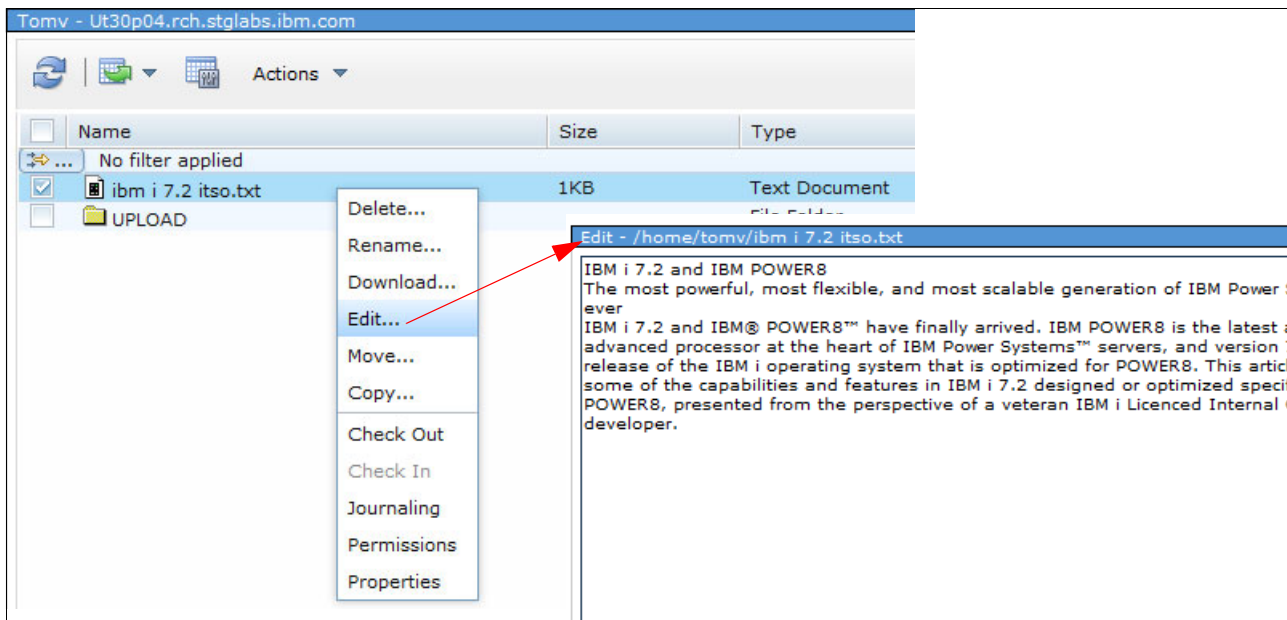


Figure 2-6 Edit a file in the IBM i Integrated File System

Goto Integrated File System Folder function

The Goto Integrated File System Folder function was added in IBM i 7.2. You can use it to go quickly to a specific folder within the Integrated File System. All the previous selections are saved by user profile and system within the IBM Navigator for i environment.

Within IBM Navigator for i in IBM i 7.2, it is now possible to enter directly a specific Integrated File System path, as shown in Figure 2-7. This task saves you time because you do not have to drill down the entire Integrated File System path.

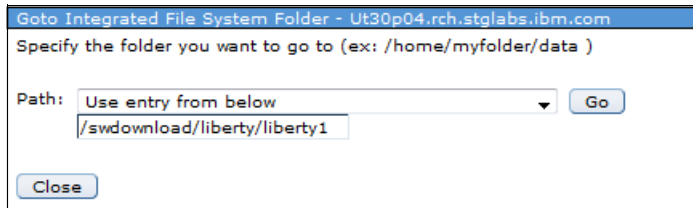


Figure 2-7 Go to a specific IBM i directory in the Integrated File System

2.1.6 Target Systems and Groups

Target Systems and Groups is a new navigation node in the IBM Navigator for i, as shown in Figure 2-8.

A new interface is available to specify the target system to manage and to be able to group similar target systems into groups. A specific target system can be part of several systems groups. You can select to manage another IBM i 7.2 system. IBM i 7.1 and IBM i 6.1 systems are also supported.

In the example that is shown in Figure 2-8, one System group is defined (ITSO residency IBM i 7.2 Technical Overview) with the following two target systems:

- ▶ One running IBM i 7.2
- ▶ One running IBM i 7.2 with TR1 installed

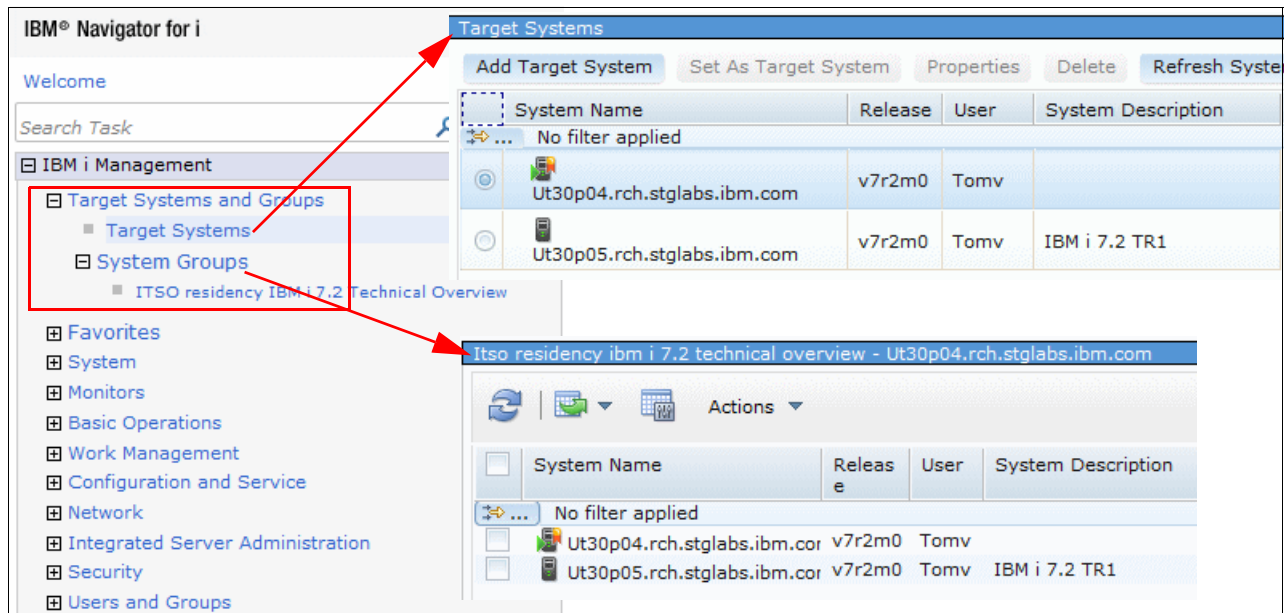


Figure 2-8 Target Systems and Groups option

2.1.7 PTF management

Within IBM Navigator for i in IBM i 7.2, it is now possible to perform program temporary fix (PTF) management-related functions. Program Temporary Fixes is a new section under the Configuration and Service task navigation area, as shown in Figure 2-9, and you can perform the following tasks:

- ▶ Display PTFs: Display PTFs for a specified product.
- ▶ Display PTF Groups: Display all group PTFs on an IBM i system.
- ▶ Load PTFs: Load selected PTFs.
- ▶ Apply PTFs: Apply selected PTFs.
- ▶ Install PTFs: Install selected PTFs.
- ▶ Remove PTFs: Remove selected PTFs.
- ▶ Cleanup PTFs: Delete PTF save files and cover letters for selected PTFs or all PTFs for selected products.

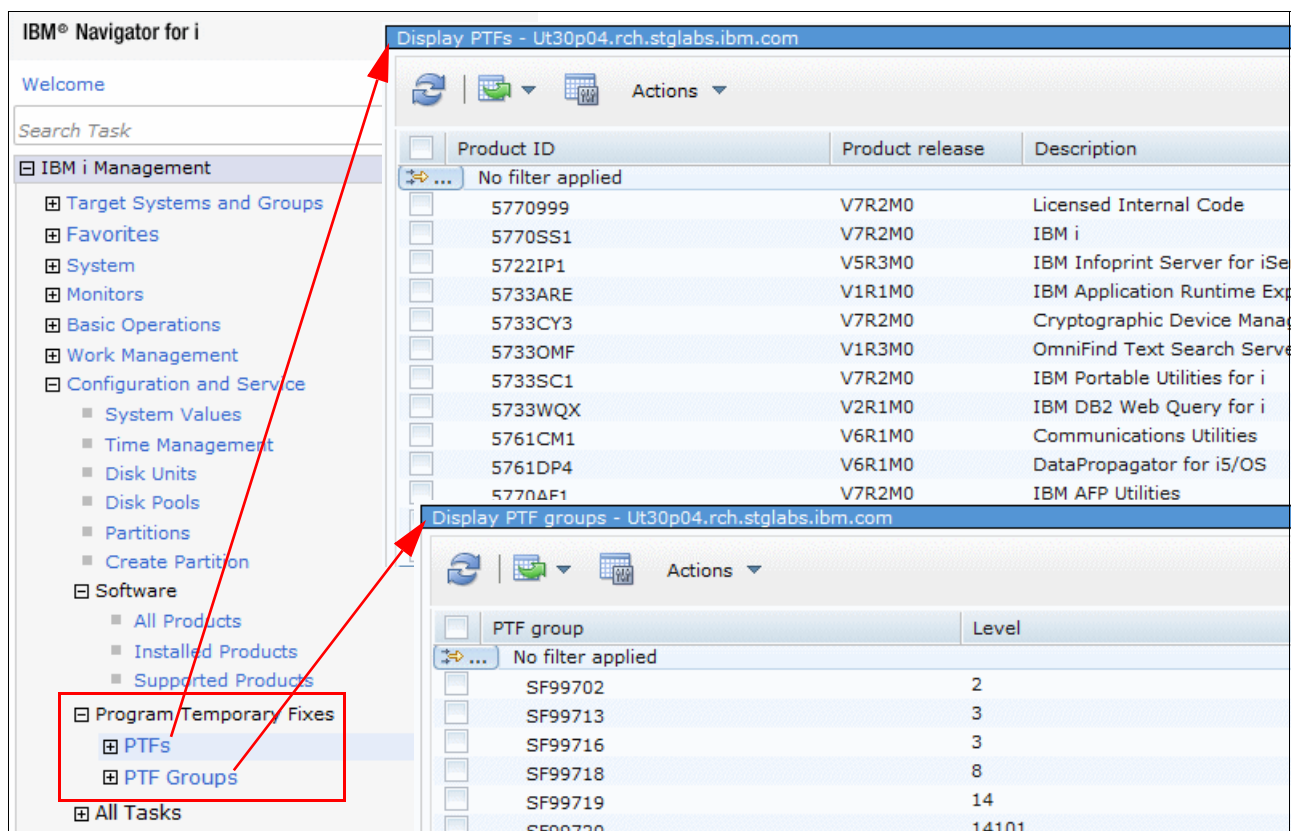


Figure 2-9 Program Temporary Fixes tasks

The following topics are covered in this section:

- ▶ “Working with PTFs for a specific licensed product” on page 23
- ▶ “Working with PTF groups” on page 31
- ▶ “Working with individual PTFs” on page 36
- ▶ “Comparing PTFs and PTF groups on different systems” on page 44

Working with PTFs for a specific licensed product

On the Display PTFs window, when you right-click one of the licensed products that are installed on the system, you have the following options available, as shown in Figure 2-10:

- ▶ Open
- ▶ Install PTFs
- ▶ Remove PTFs
- ▶ Cleanup PTFs
- ▶ Send
- ▶ Send and Install

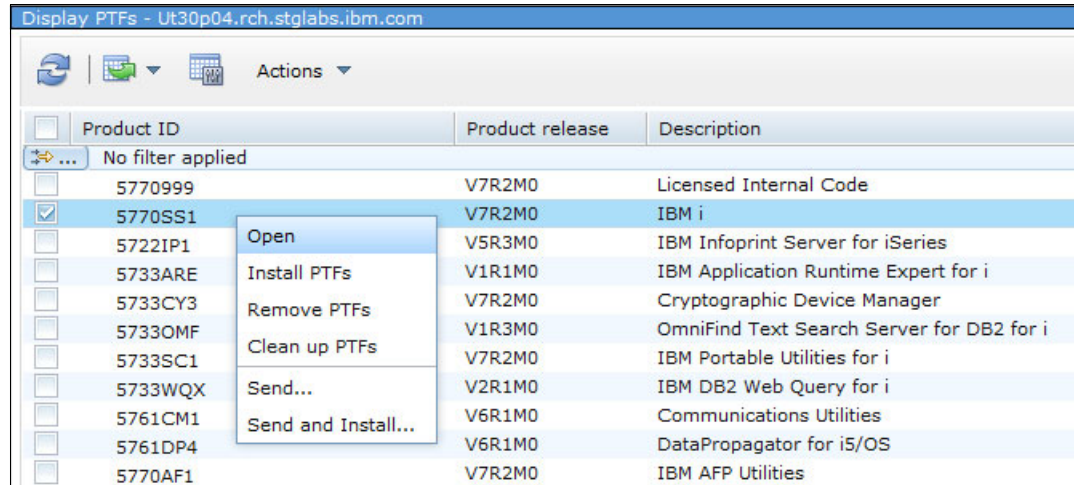


Figure 2-10 Display PTF options

Displaying PTFs

To display PTFs for a specific licensed product, click **Open** and the results, as shown in Figure 2-11, are displayed.

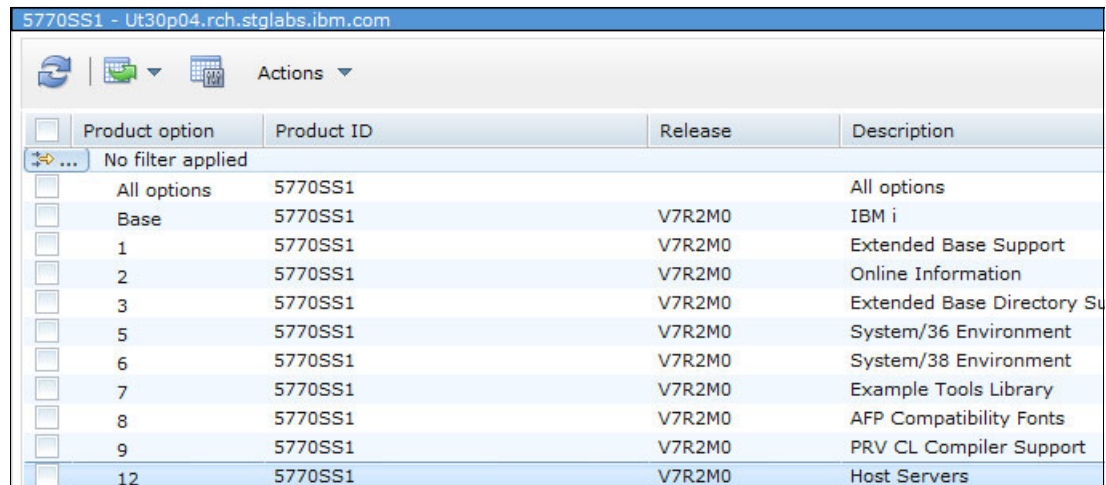


Figure 2-11 Display PTFs for a specific licensed product

Installing PTFs

To install PTFs for a specific licensed product, select **Install PTFs** and complete the following steps:

1. In the Install PTFs window (Figure 2-12), click **Next**.

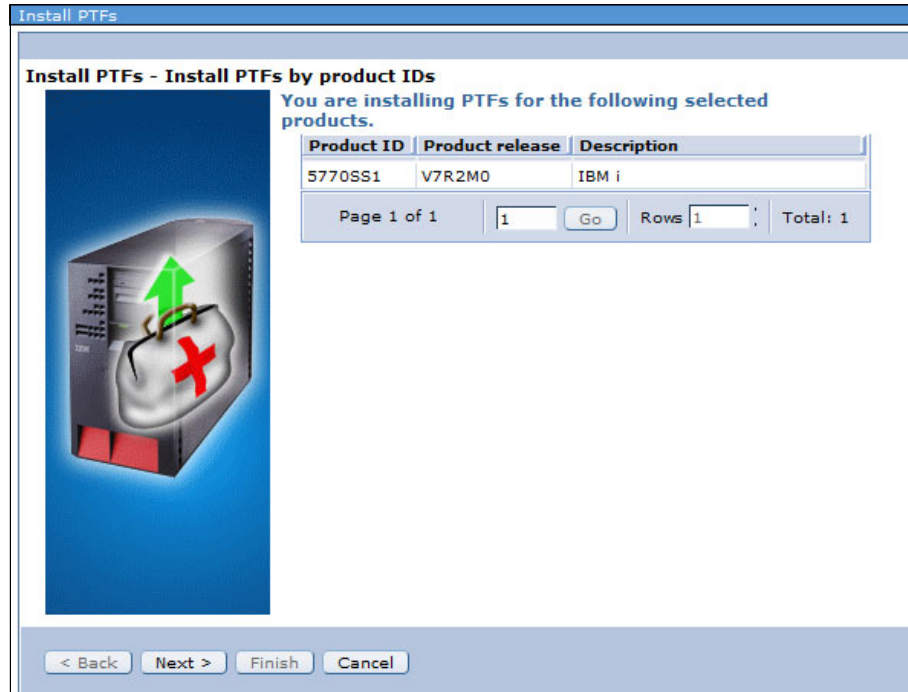


Figure 2-12 Install PTFs

2. As shown in Figure 2-13 on page 25, specify the installation source and the installation type and click **Next**.

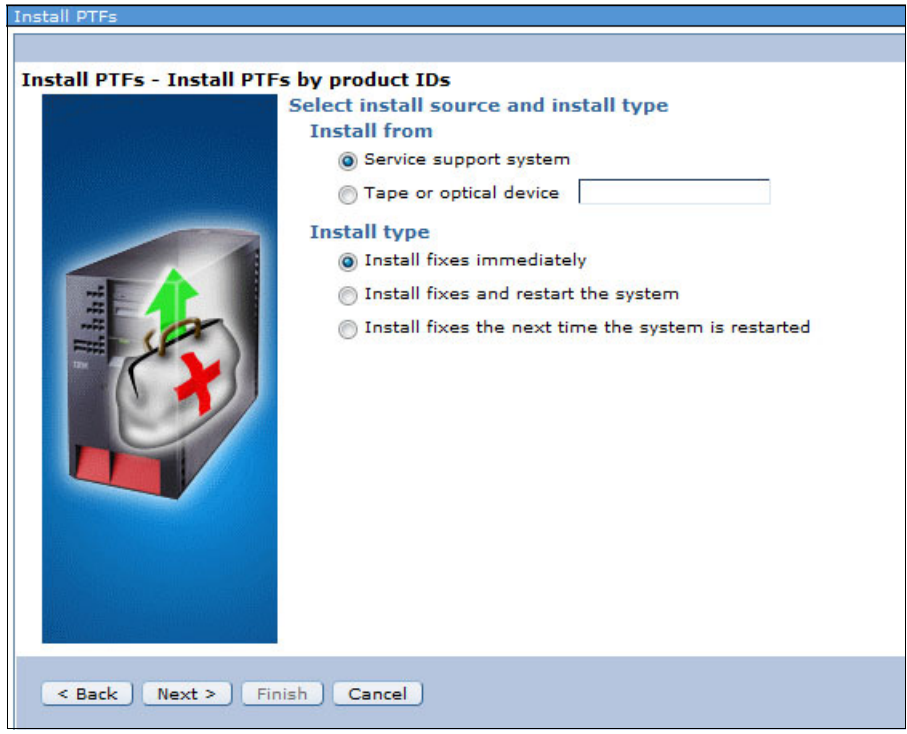


Figure 2-13 Install PTF options

Removing PTFs

To remove PTFs for a specific licensed product, click **Remove PTFs** and complete the following steps:

1. In the Remove PTFs window that opens (Figure 2-14), click **OK** to confirm the removal of the PTFs for the selected licensed product.

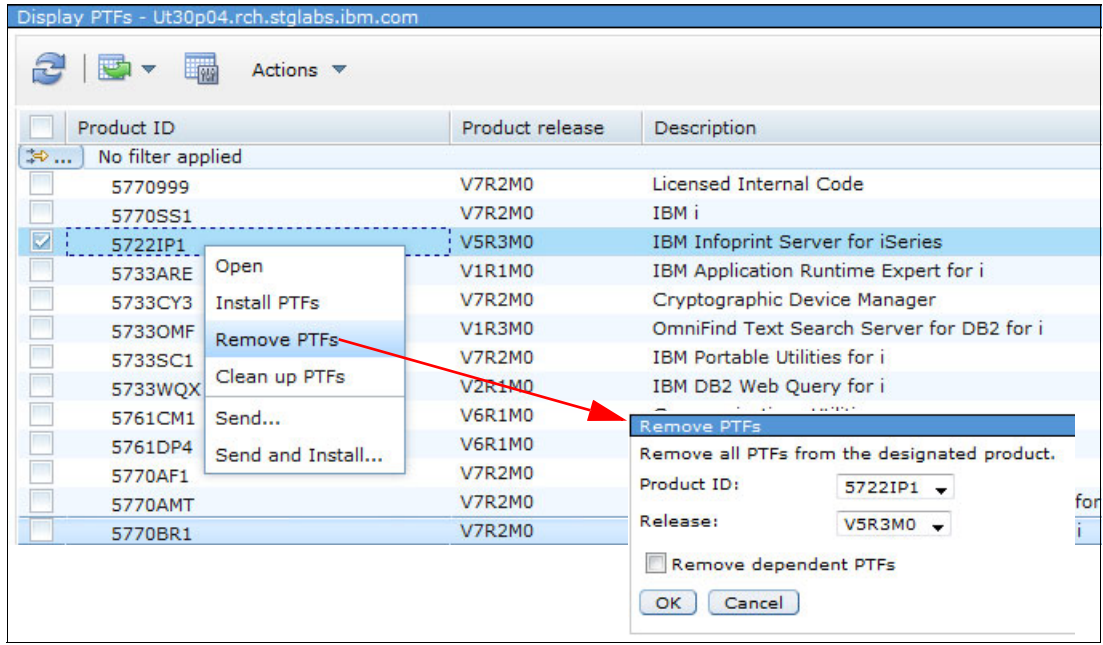


Figure 2-14 Remove PTFs for a selected licensed product

Note: Specifying to include the removal of dependent PTFs for all PTFs is *not* valid and results in an error.

2. In the Confirm Remove window that opens (Figure 2-15), click **Remove** to confirm the removal of all PTFs for the selected license product. This action starts the removal process of all PTFs for the specified licensed program.

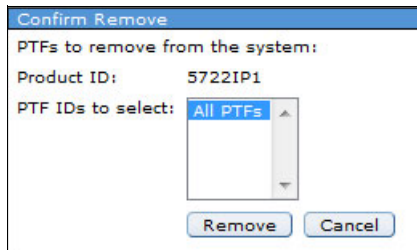


Figure 2-15 Confirm to remove PTFs for a selected licensed product

Cleaning up PTFs

To clean up PTFs for a specific licensed product, click **Clean up PTFs**, as shown in Figure 2-16, and complete the following steps:

1. Click **OK** in the Clean up PTFs window.

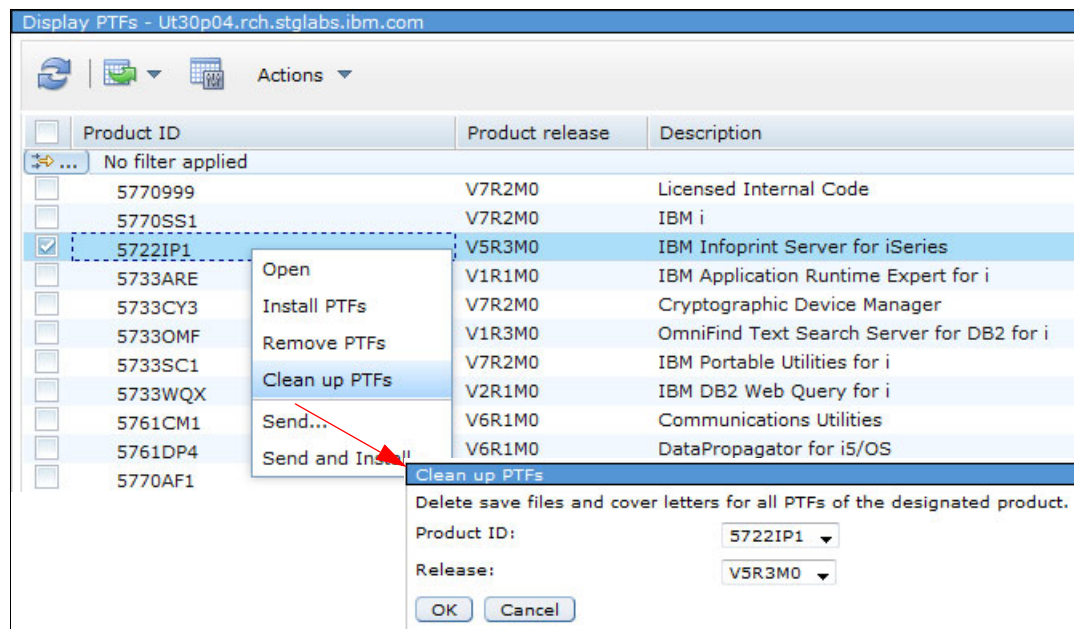


Figure 2-16 Clean up PTFs for a selected licensed product

2. In the Confirm Clean Up PTFs window that opens (Figure 2-17 on page 27), click **Clean up** to start the cleanup process of the PTFs for the selected licensed program. This action removes all save files and cover letters from the system for the selected licensed program.

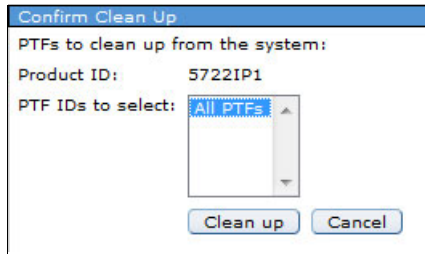


Figure 2-17 Confirm to clean up PTFs for a selected licensed product

Sending PTFs

It is now possible within IBM Navigator for i to send PTFs from one system to a target system or a system group (as described in 2.1.6, "Target Systems and Groups" on page 21).

To send PTFs for a specific licensed product, complete the following steps:

1. From the Display PTFs window, right-click the selected license product and click **Send**, as shown in Figure 2-18.

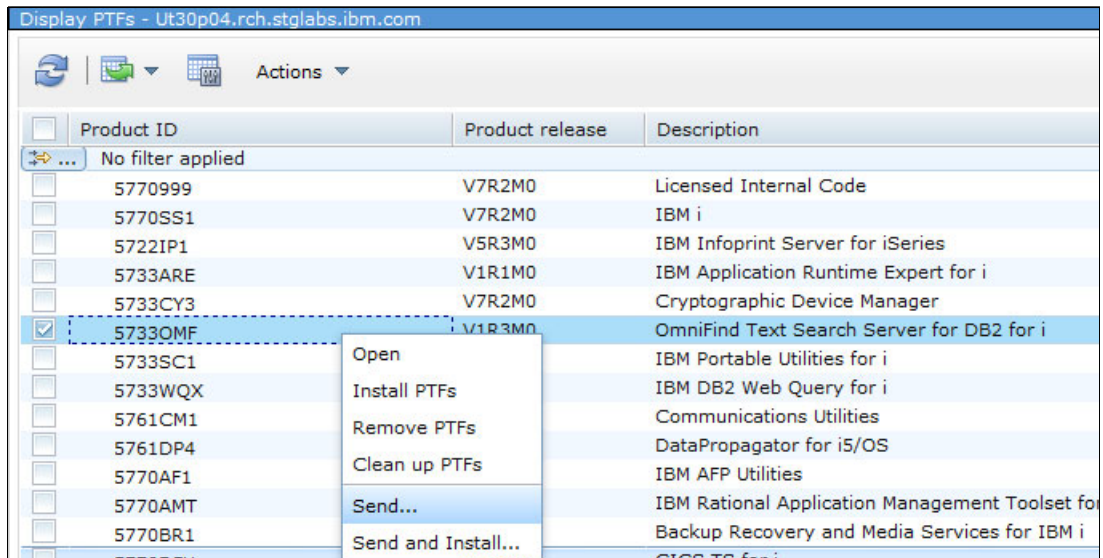


Figure 2-18 Send PTFs

2. The Send PTF wizard starts, as shown in Figure 2-19. Select the target system that you want the PTFs to be sent to on the left side of the window, click **Add**, and then click **Next**.

Note: Send PTFs can also be applied to a specific product option.

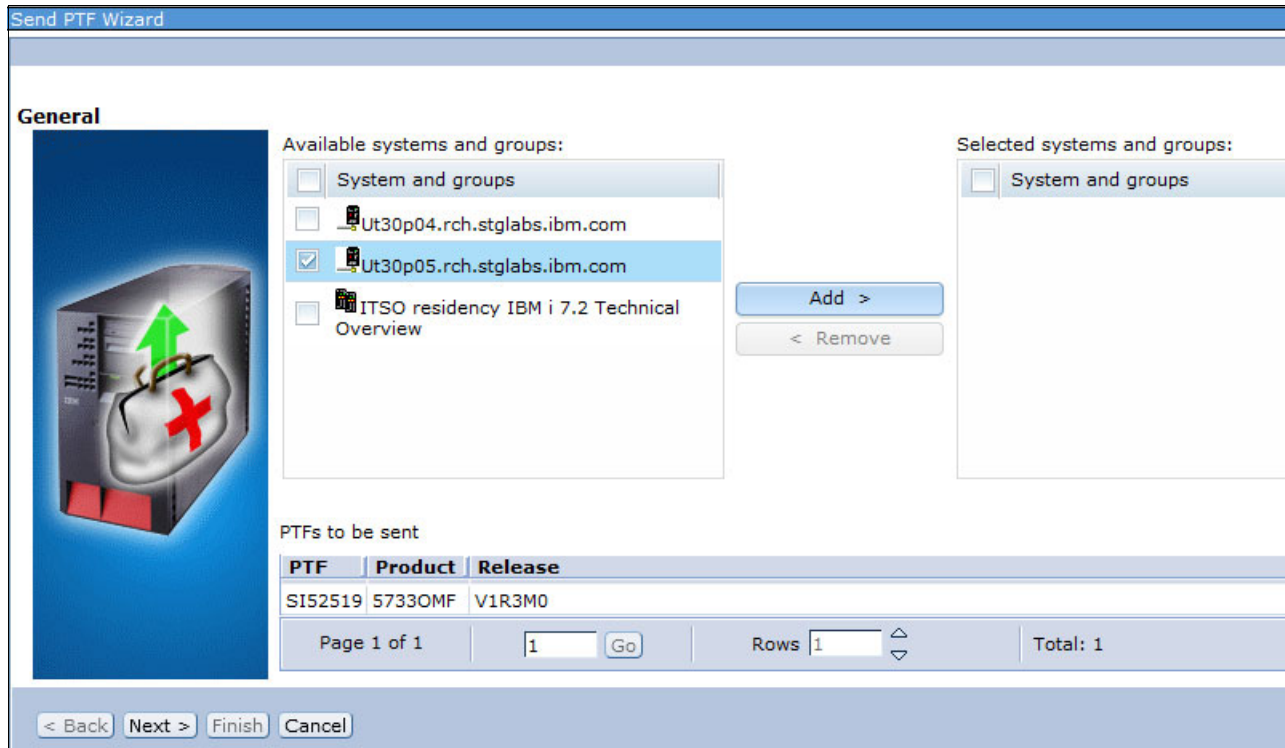


Figure 2-19 Send PTF Wizard: add the target system

3. The target system is added, as shown in Figure 2-20. Click **Next**.

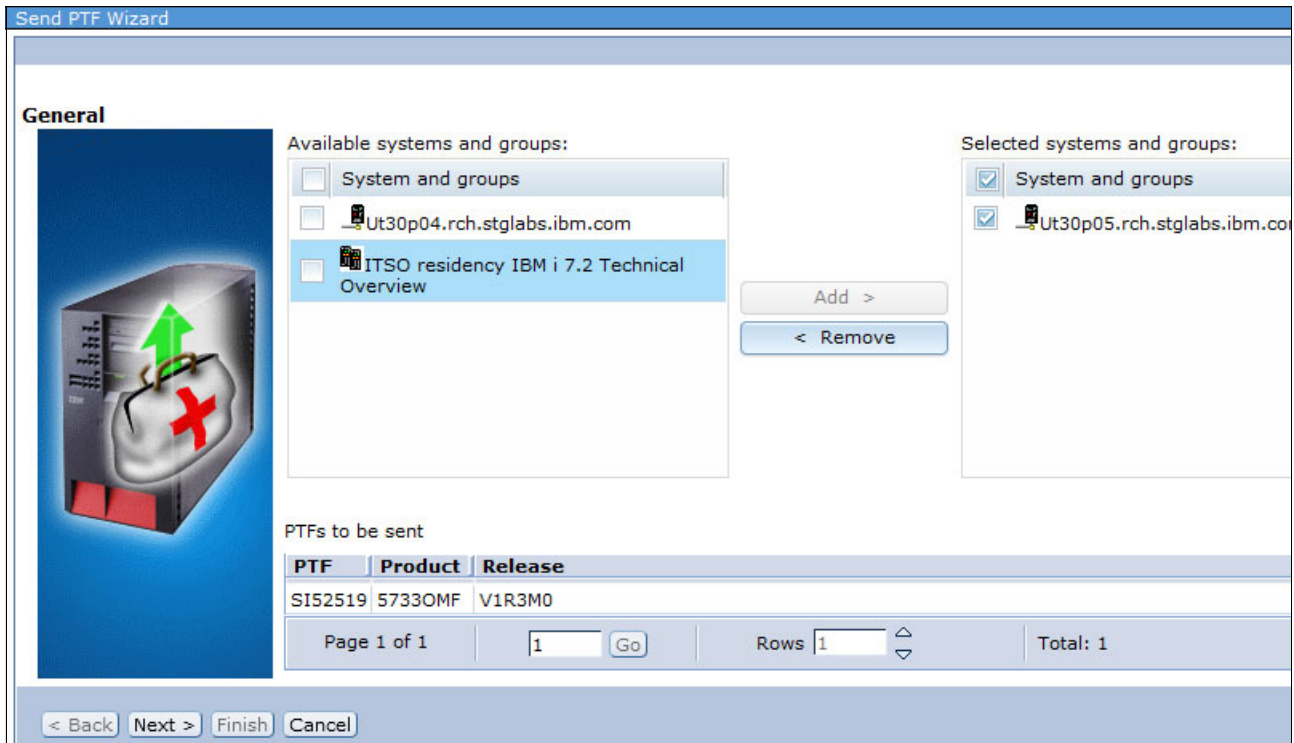


Figure 2-20 Send PTF Wizard: target system added

4. As shown in Figure 2-21, you have the following options when sending PTFs:

- Send requisite PTFs, which is the recommended way.
- Send PTFs, even though they are already installed on the target system.
- Send the cover letters.
- Override the save files if they exist on the target system.

Click **Next**.

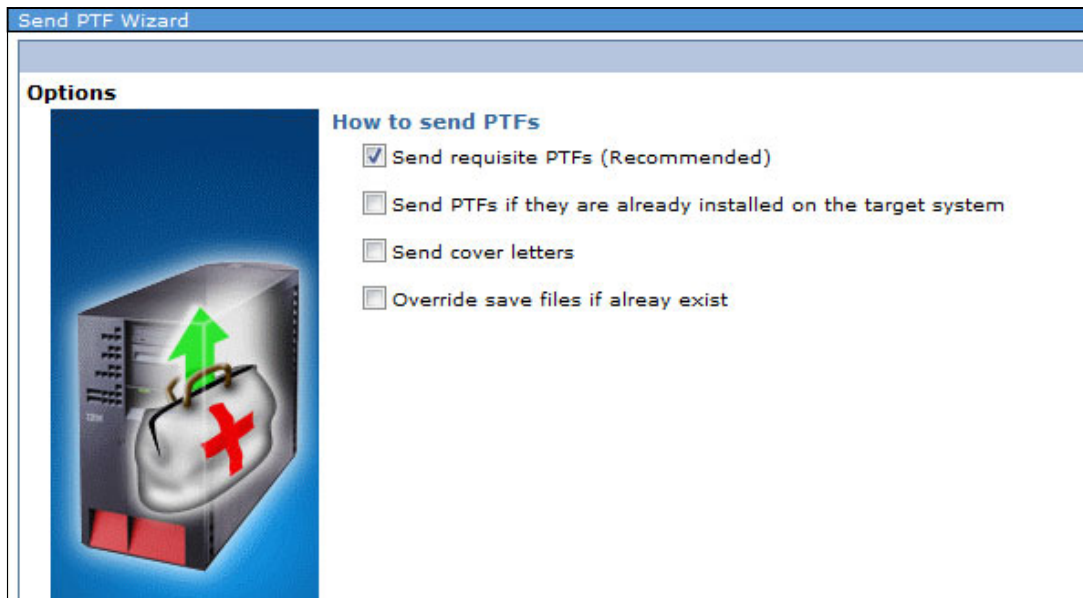


Figure 2-21 Send PTF Wizard: specify how to send PTFs options

5. A summary of the selected options is displayed (Figure 2-22). Click **Finish**.

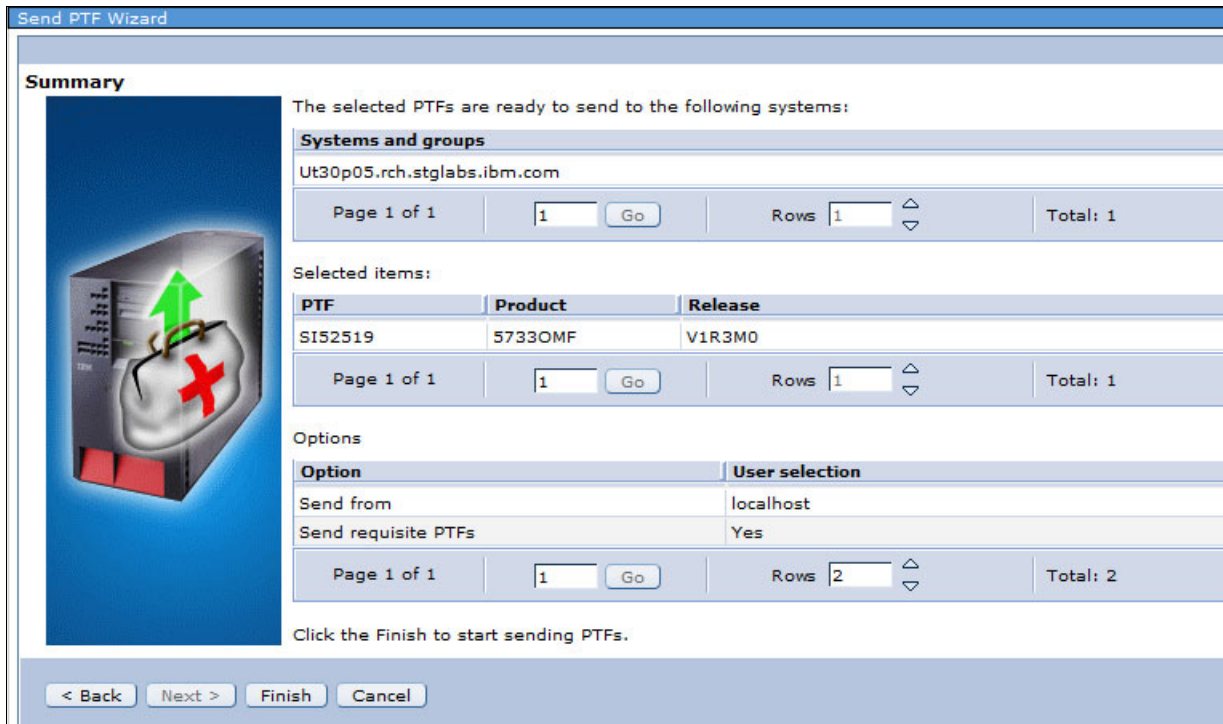


Figure 2-22 Send PTF Wizard: summary of the selected options

6. The window that is shown in Figure 2-23 shows you the progress of sending the PTFs. The following actions are being completed:

- Copying the PTFs to an image on the local IBM i system.
- Sending the PTF package.
- Cleaning up on the local IBM i system.

Note: If there is a failure, you can display the log by clicking **View Log** in the Descriptions column.

Send PTF Wizard				
You are sending PTFs to the following systems:				
Target Systems and Groups	Task	Time Elapsed	Progress	Descriptions
localhost	Copy PTFs to image	00:00:01	<div style="width: 100%; background-color: green;">100%</div>	View Log PTF SI52519 was packaged successfully.
Ut30p05.rch.stglabs.ibm.com	Send PTFs	00:00:17	<div style="width: 100%; background-color: green;">100%</div>	View Log All PTFs have been successfully put into service.
localhost	Clean up	00:00:01	<div style="width: 100%; background-color: green;">100%</div>	View Log Cleaning up on source system completed successful.

Figure 2-23 Send PTFs progress

Sending and installing PTFs

It is also possible within IBM Navigator for i to first send PTFs from one system to a target system or a system group (as described in 2.1.6, “Target Systems and Groups” on page 21) and then immediately afterward install those PTFs on the target system or system group.

To send and install PTFs for a specific licensed product, select **Send and Install**, as shown in Figure 2-24 on page 31.

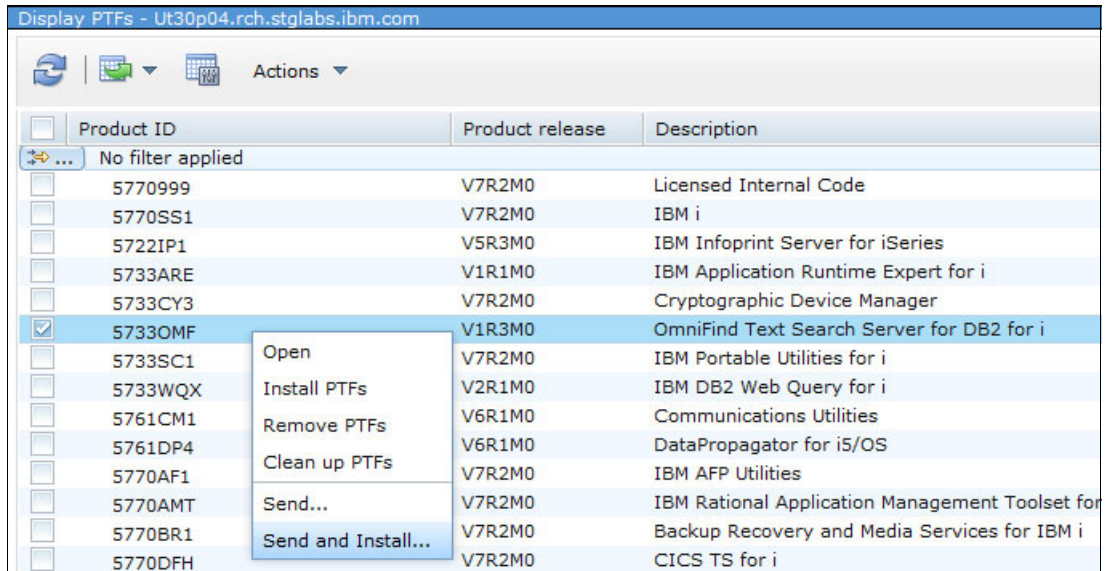


Figure 2-24 Send and Install PTFs option

The process is the same as described in “Sending PTFs” on page 27 except that afterward those PTFs are also immediately installed on the target system or system group. The result is shown in Figure 2-25.

Note: The Send and Install PTFs option can also be applied to a specific product option.

Target Systems and Groups	Task	Time Elapsed	Progress	Descriptions
localhost	Copy PTFs to image	00:00:04	100%	View Log PTF SI52519 was packaged successfully.
UT30p05.rch.stglabs.ibm.com	Send and install PTFs	00:00:20	100%	View Log Installing PTFs on target system completed successfully.
localhost	Clean up	00:00:04	100%	View Log Cleaning up on source system completed successful.

Figure 2-25 Send and Install PTFs progress

Note: If there is a failure, you can display the log by clicking **View Log** in the Descriptions column.

Working with PTF groups

In the Display PTFs groups window, when you right-click one of the PTF groups that are listed, you have the following options available, as shown in Figure 2-10 on page 23:

- ▶ Open
- ▶ Send
- ▶ Send and Install

Sending a PTF group

It is now possible within IBM Navigator for i to send a PTF group from one system to a target system or system group (as described in 2.1.6, “Target Systems and Groups” on page 21).

To send a PTF group, complete the following steps:

1. From the Display PTF groups window, right-click a PTF group and click **Send**, as shown in Figure 2-26.

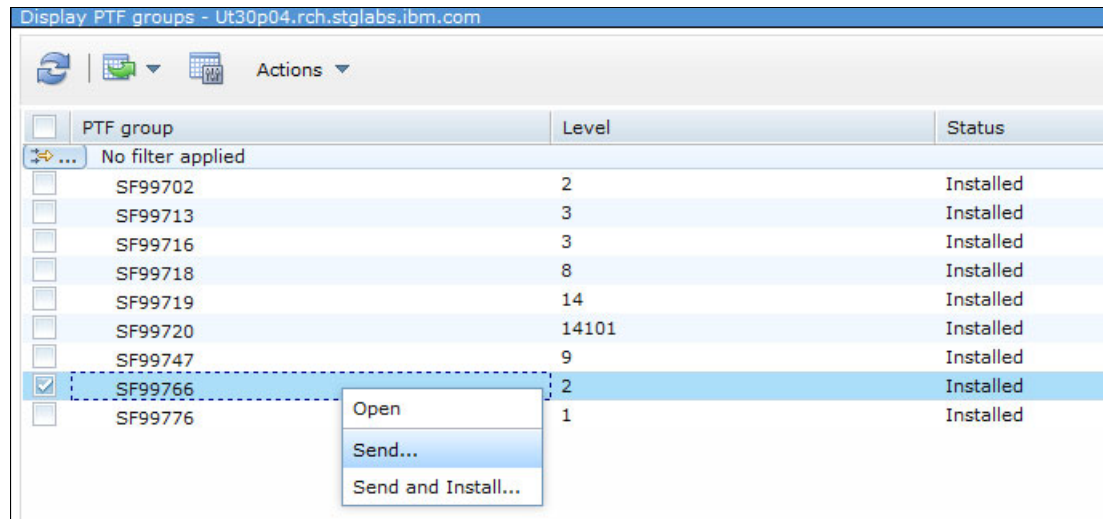


Figure 2-26 Send a PTF group

2. The Send PTF group Wizard starts, as shown in Figure 2-27. Select the target system that you want the group PTF to be sent to from the left side of the window, click **Add**, and click **Next**.

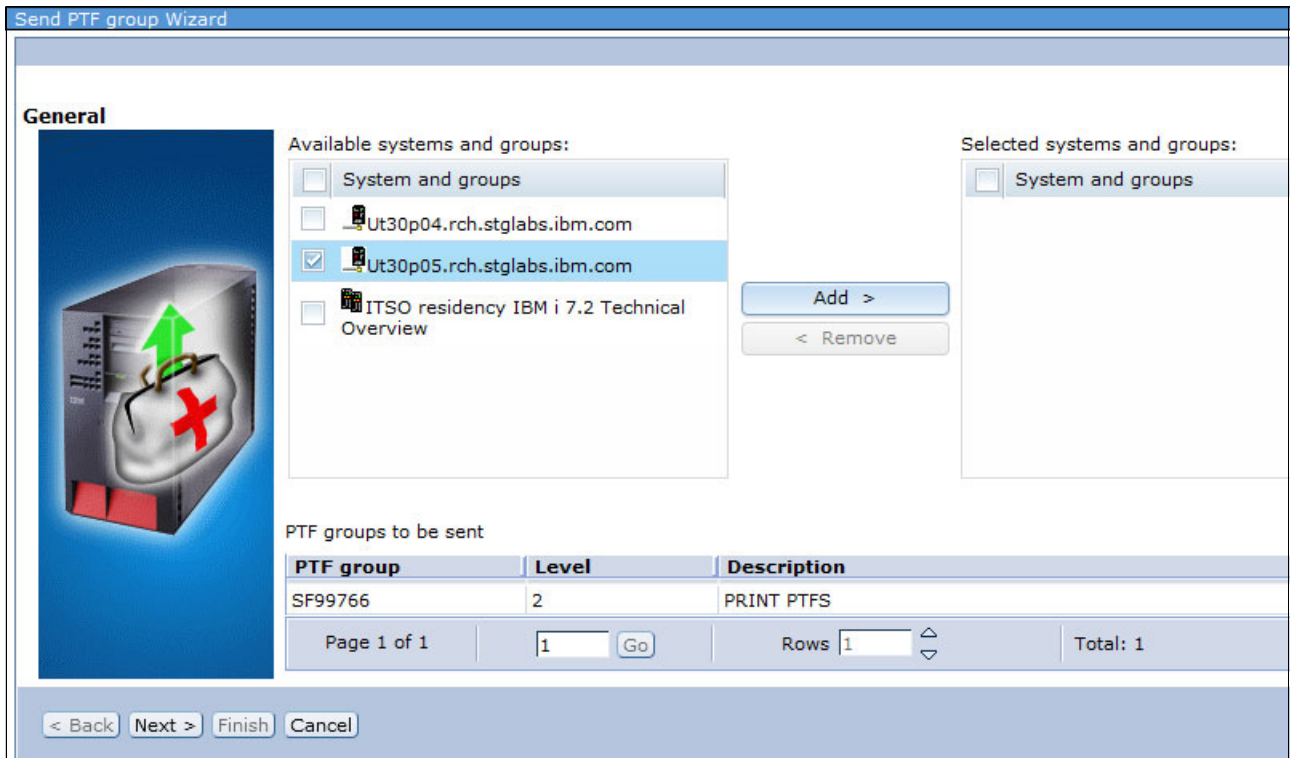


Figure 2-27 Send PTF group Wizard

3. The target system is added, as shown in Figure 2-28. Click **Next**.

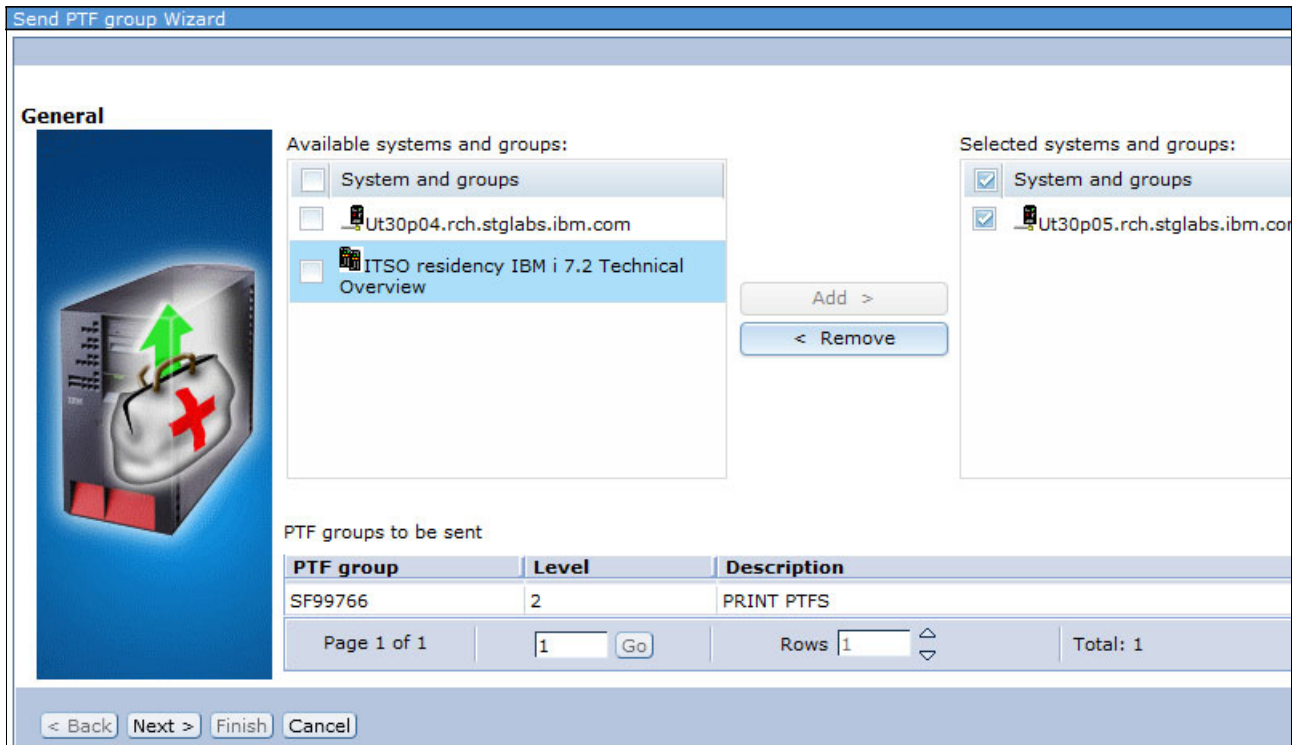


Figure 2-28 Send PTF group Wizard: add a target system

4. As shown in Figure 2-29, specify how to replace existing PTF groups with the same names on the target system and which related PTF groups to send from the source system. Click **Next**.

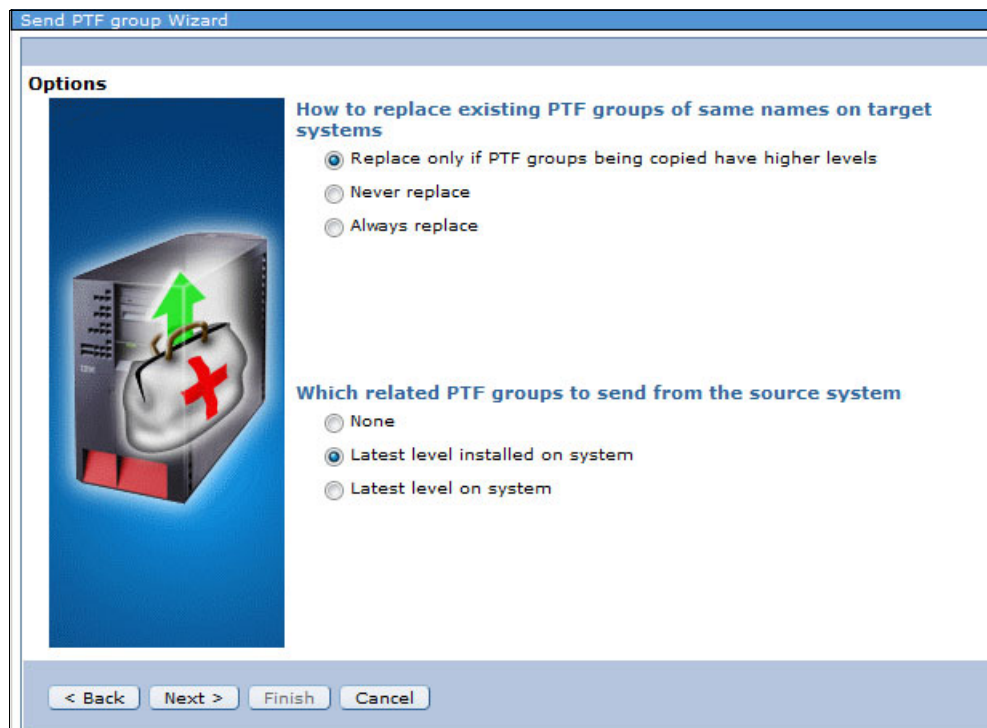


Figure 2-29 Send PTF group Wizard: available options

5. A summary of the selected options to be accounted for when sending the PTF group is shown in Figure 2-30. Click **Finish**.

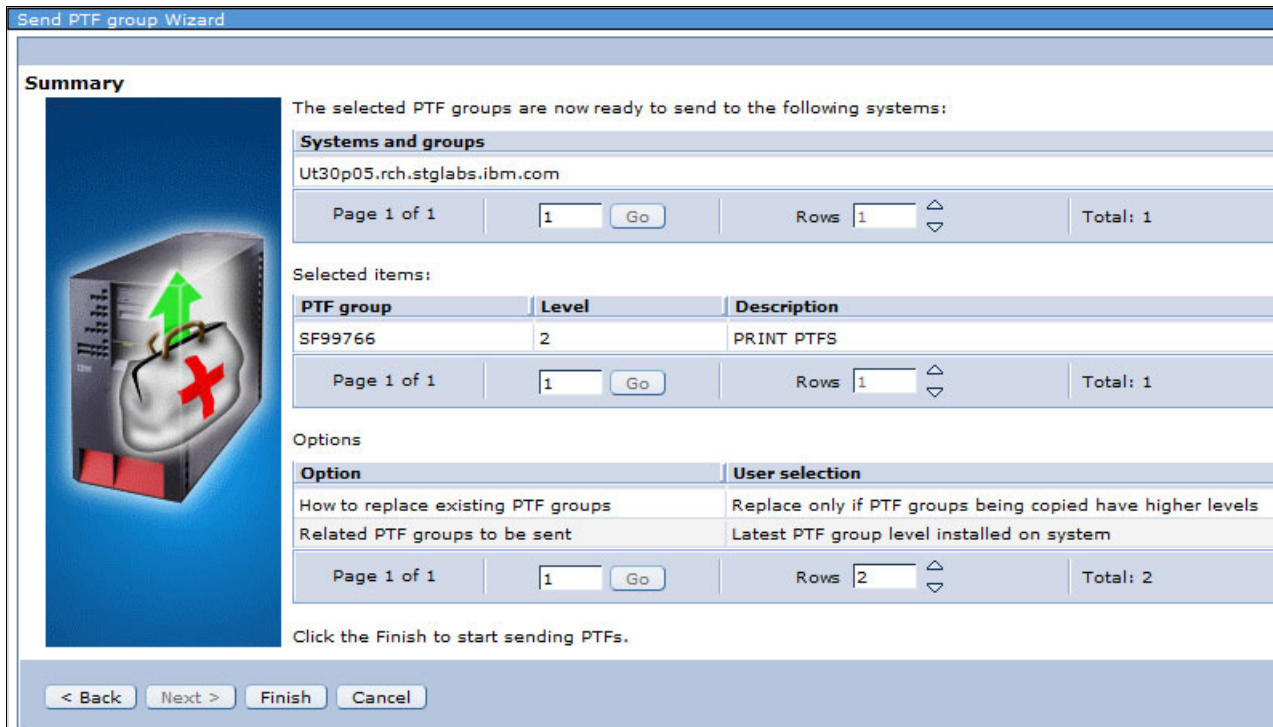


Figure 2-30 Send PTF group Wizard: summary of selected options

6. Figure 2-31 shows the progress of sending the PTF group. The following actions are completed:
 - Copying the group PTF to an image on the local IBM i system
 - Sending the PTF group
 - Cleaning up on the local IBM i system

Note: If there is a failure, you can display the log by clicking **View Log** in the Descriptions column.

Target Systems and Groups	Task	Time Elapsed	Progress	Descriptions
localhost	Copy PTF groups to image	00:00:41	100%	View Log PTF SF99766 was packaged successfully.
Ut30p05.rch.stglabs.ibm.com	Send PTF groups	00:06:50	100%	View Log Send PTFS to system is complete.
localhost	Clean up	00:00:04	100%	View Log Cleaning up on source system completed successful.

Figure 2-31 Send PTF group progress

Sending and installing PTF groups

From the Display PTF groups window, it is possible to send a PTF group to a target system or a system group and immediately install this group PTF on the target system or system group.

To send and install a PTF group, right-click a specific PTF group, as shown in Figure 2-32, and click **Send and Install**.

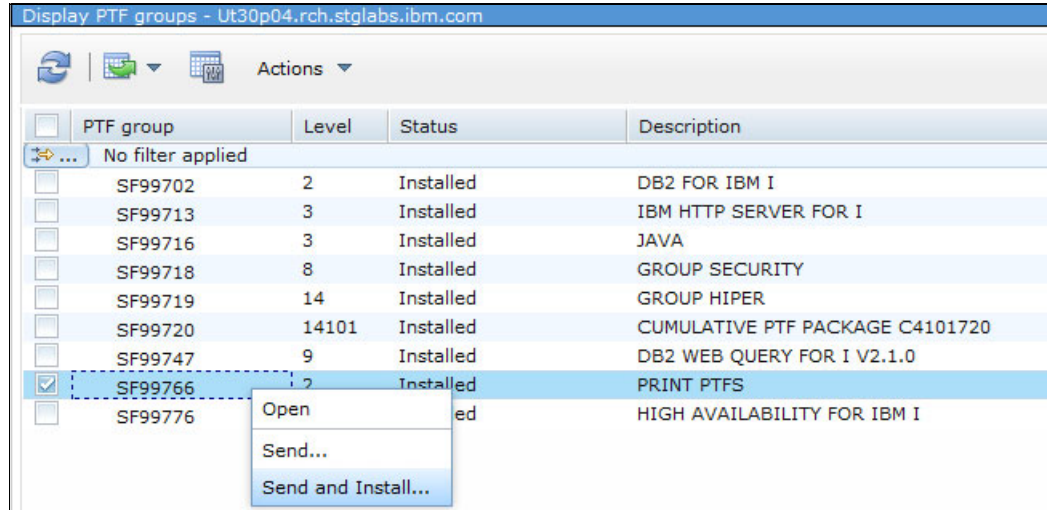


Figure 2-32 Send and Install PTF group option

The process is the same as described in “Sending a PTF group” on page 31, except that afterward the PTF group is immediately installed on the target system or system group.

Note: In the Send and Install PTF group Wizard, there is an additional option to be specified to either immediately install the group PTF or at the next IPL of the target system.

The result is shown in Figure 2-33.

Send and Install PTF group Wizard				
You are sending and installing PTF groups on the following systems and groups:				
Target Systems and Groups	Task	Time Elapsed	Progress	Descriptions
localhost	Copy PTF groups to image	00:00:32	100%	View Log PTF SF99766 was packaged successfully.
Ut30p05.rch.stglabs.ibm.com	Send and install PTF groups	00:03:28	100%	View Log Installing PTFS on target system completed successfully.
localhost	Clean up	00:00:03	100%	View Log , Cleaning up on source system completed

Figure 2-33 Send and Install PTF group Wizard: progress and results

Note: If there is a failure, you can display the log by clicking **View Log** in the Descriptions column.

Working with individual PTFs

Depending on its status, you can perform the following tasks on an individual PTF level. These tasks are similar to the actions that can be performed on all PTFs for a specific licensed program, as described in “Working with PTFs for a specific licensed product” on page 23.

- ▶ Load a PTF.
- ▶ Apply a PTF temporarily or permanently.
- ▶ Remove a PTF temporarily or permanently.
- ▶ Clean up a PTF.
- ▶ Send a PTF.
- ▶ Send and install a PTF.
- ▶ Display the properties of a PTF.

Loading a PTF

To load an individual PTF for a specific licensed program, complete the following steps:

1. From the IBM Navigator for i Display PTFs window (Figure 2-34), right-click a specific PTF and click **Load**.
2. In the Load PTF window, click **OK**, which starts loading the selected individual PTF for the licensed program.

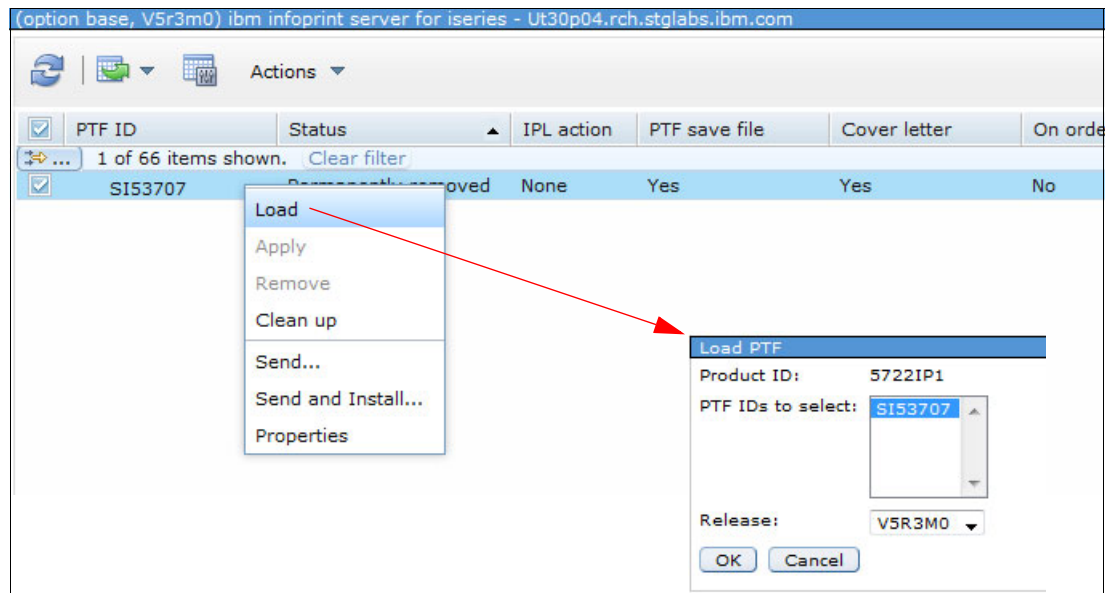


Figure 2-34 Load an individual PTF

Applying a PTF

To apply an individual PTF for a specific licensed program, run the following steps:

1. From the IBM Navigator for i Display PTFs window (Figure 2-35), right-click a specific PTF, and click **Apply**.
2. In the Apply PTF window, specify the extent of change (temporarily applied or permanently applied) and whether to apply the prerequisite PTFs. Click **OK**.

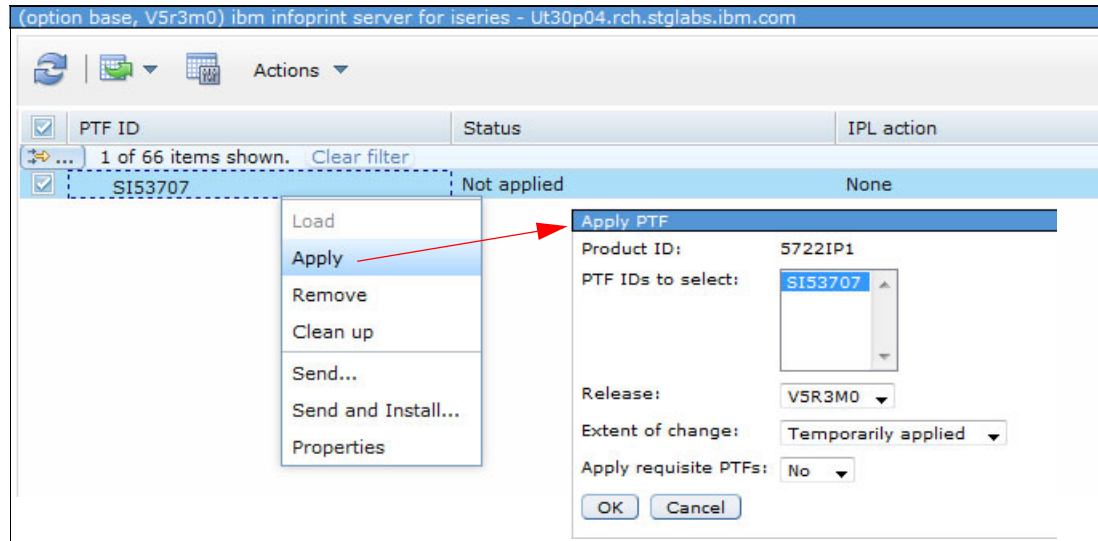


Figure 2-35 Apply an individual PTF

Removing a PTF

To remove an individual PTF for a specific licensed program, complete the following steps:

1. From the IBM Navigator for i Display PTFs window (Figure 2-35), right-click a specific PTF and click **Remove**.
2. In the Remove PTFs window, click **OK**. You also have the possibility to specify that you want to remove dependent PTFs.

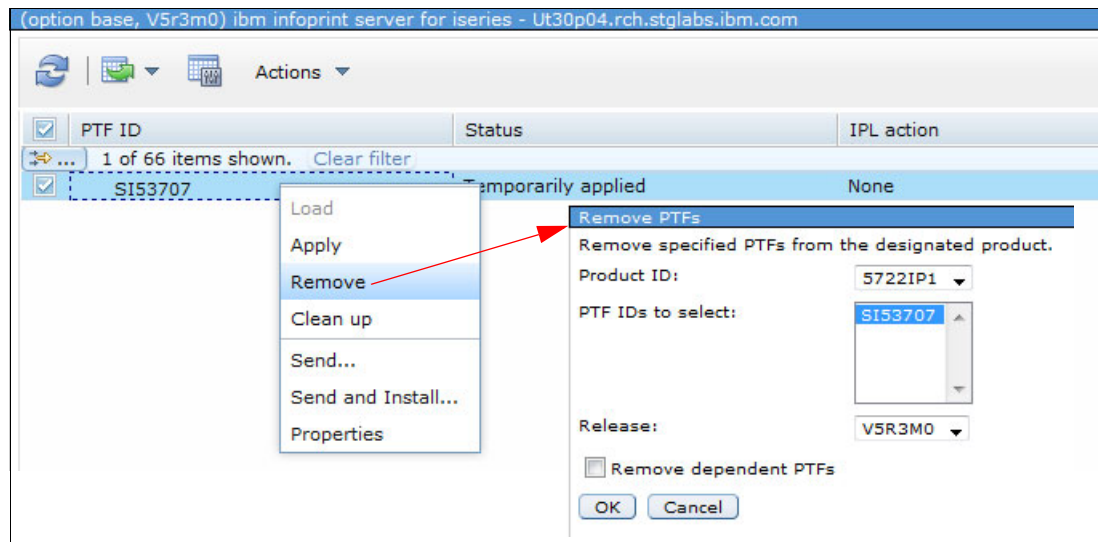


Figure 2-36 Remove an individual PTF

3. In the Confirm Remove window (Figure 2-37), click **Remove** to confirm the removal of the individual PTF from the licensed program. This temporarily removes the individual PTF from the specified licensed program.

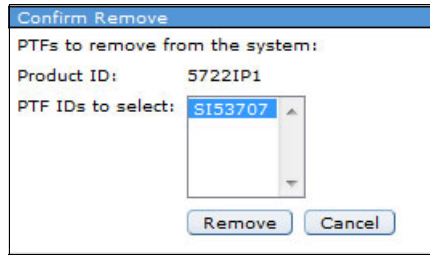


Figure 2-37 Confirm to remove an individual PTF

Cleaning up a PTF

To clean up an individual PTF for a specific licensed program, complete the following steps:

1. From the IBM Navigator for i Display PTFs window (Figure 2-38), right-click a specific PTF and click **Clean up**.

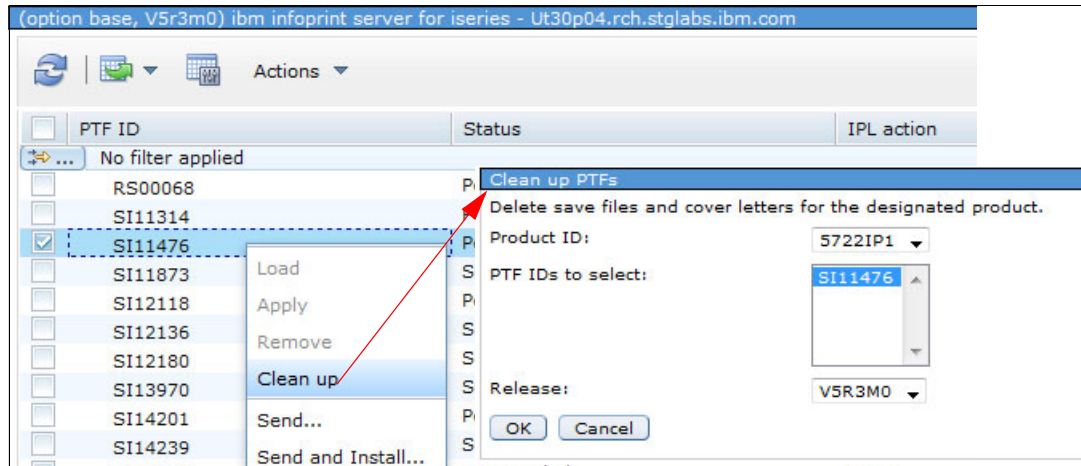


Figure 2-38 Clean up an individual PTF

2. In the Clean up PTFs window, click **OK**.
3. In the Confirm Clean up window, click **Clean up** to confirm the cleanup of the individual PTF from the licensed program, as shown in Figure 2-39, which deletes the save file and the cover letter for the individual PTF.

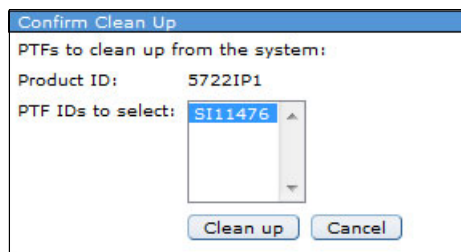


Figure 2-39 Confirm the cleanup of an individual PTF

Displaying PTF properties

To display the properties of an individual PTF, right-click the specific PTF, and click **Properties**, as shown in Figure 2-40.

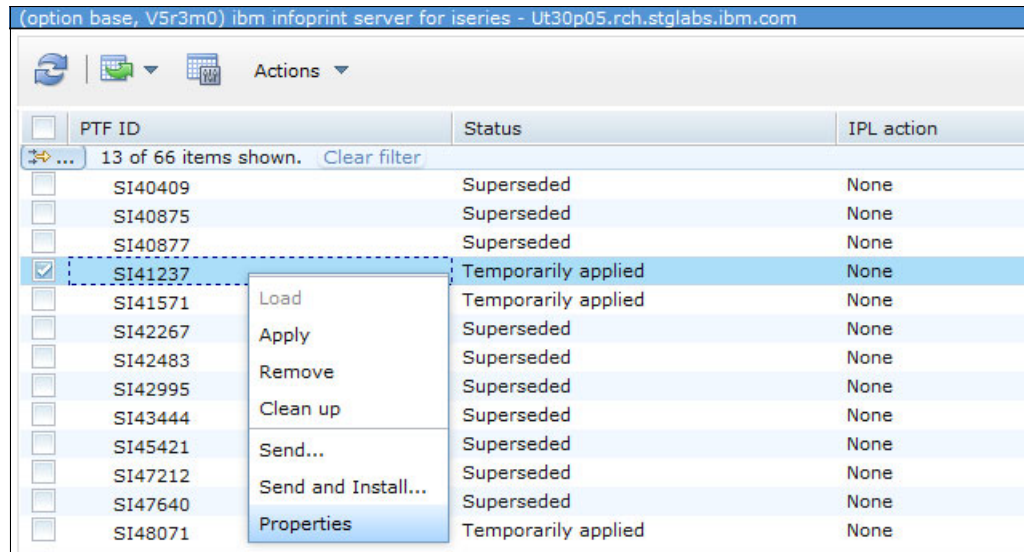


Figure 2-40 Display PTF properties

The PTF Properties window opens, as shown in Figure 2-41. Notice the following tabs that you can click to get additional information about this PTF:

- ▶ General information
- ▶ PTF objects
- ▶ Prerequisite PTFs
- ▶ Superseded PTFs
- ▶ Symptom strings
- ▶ Exit programs
- ▶ APARs fixed
- ▶ Cover letter
- ▶ Dependent PTFs
- ▶ Preconditions

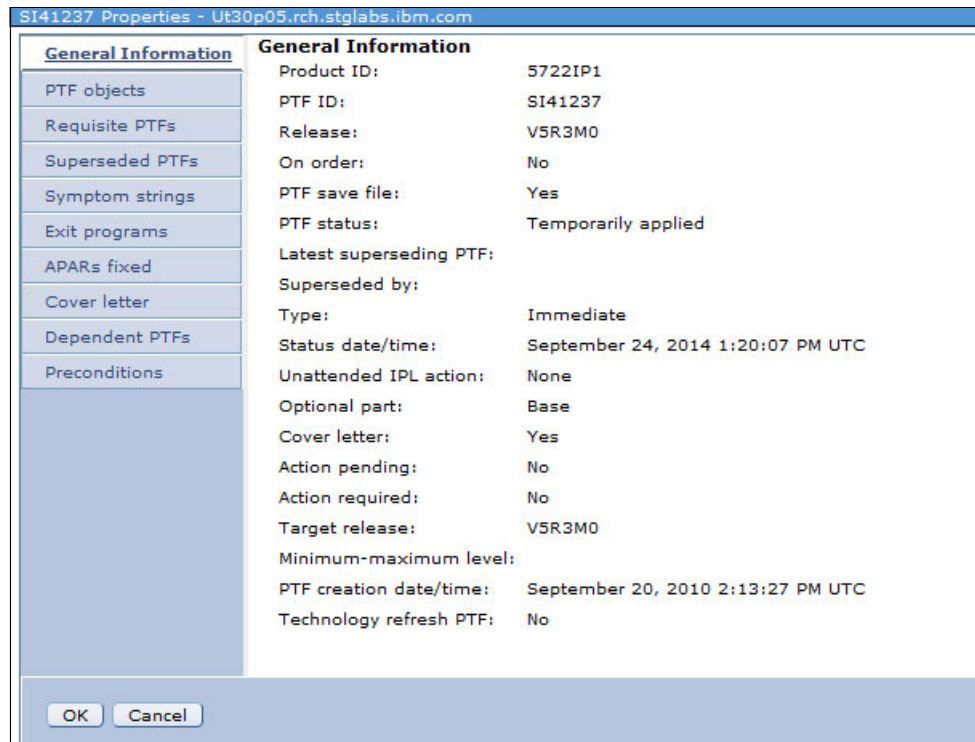


Figure 2-41 Display properties of a PTF

Sending a PTF

To send an individual PTF for a specific licensed program to a target system or system group, right-click the specific PTF and click **Send**, as shown in Figure 2-42.

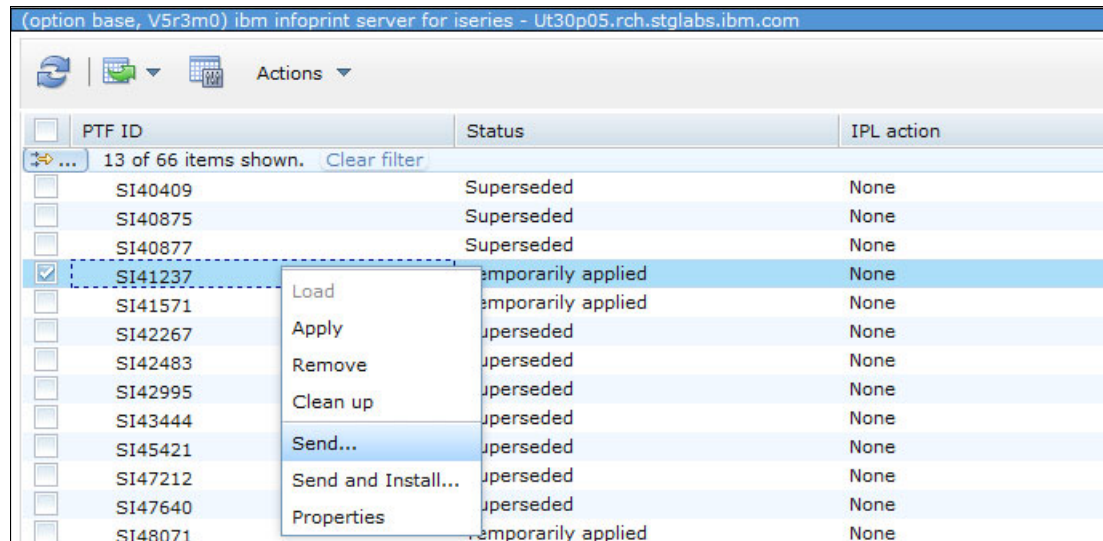


Figure 2-42 Send an individual PTF

The Send PTF Wizard opens, as shown in Figure 2-19 on page 28. To send an individual PTF, complete the steps in "Sending PTFs" on page 27.

Installing a PTF

To install an individual PTF on the system, complete the following steps:

1. From IBM Navigator for i, click **Configuration and Service** → **All Tasks** → **Program Temporary Fix** → **Install PTFs**.
2. In the Install PTFs window (Figure 2-43), select the **PTF IDs** option and click **Next**.

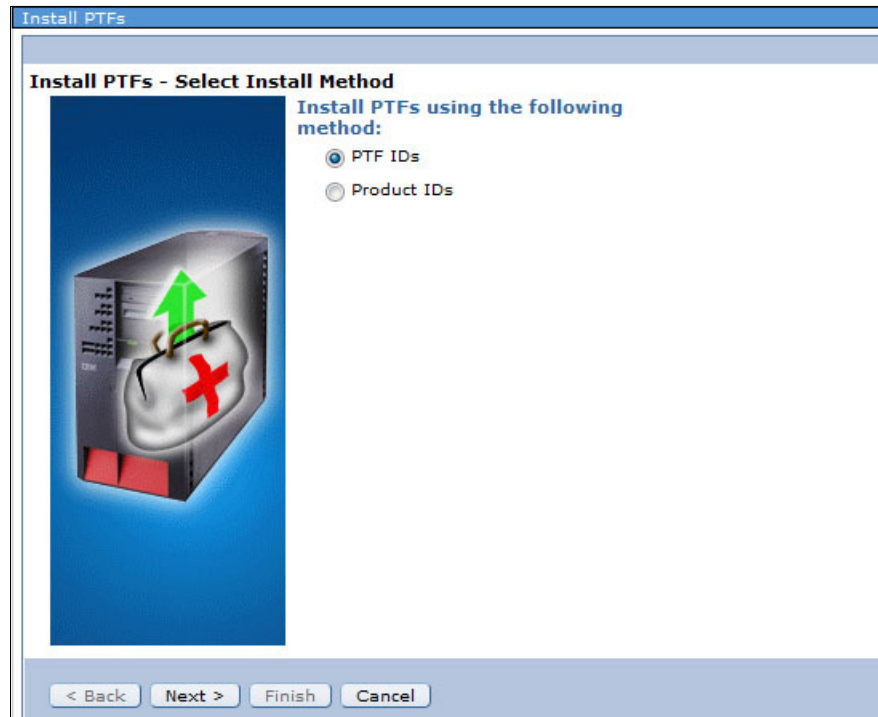


Figure 2-43 Install an individual PTF

3. In the Install PTFs by PTFs IDs window (Figure 2-44), specify a specific PTF ID to be installed and from where this PTF is to be installed. Click **Next**.

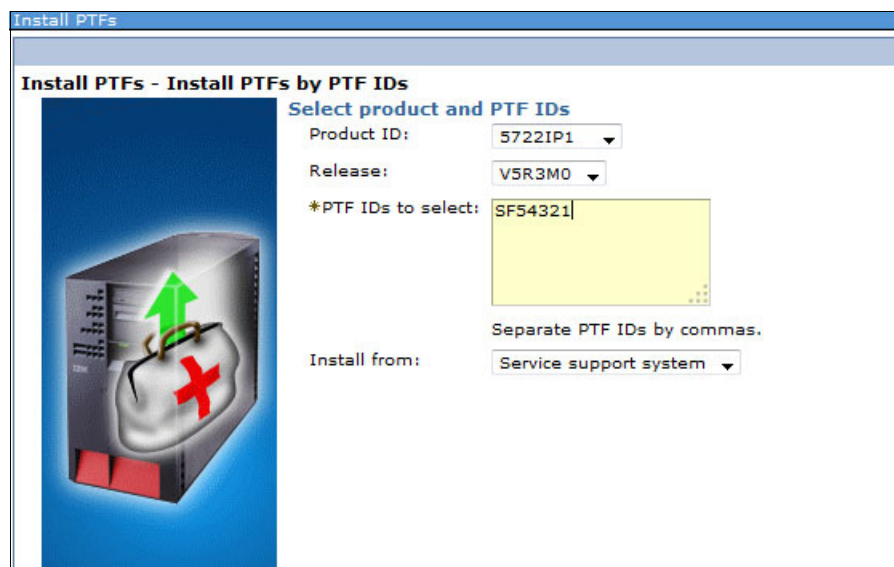


Figure 2-44 Install an individual PTF: select the PTF ID

- In the Summary window that is shown in Figure 2-45, click **Finish** to start the PTF installation process.

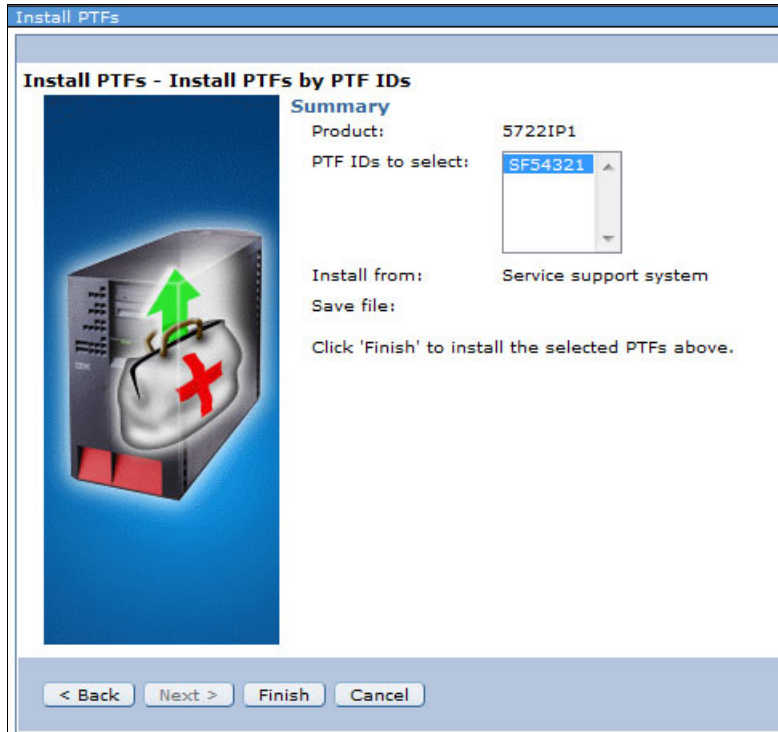


Figure 2-45 Install an individual PTF by PTF ID

Sending and installing a PTF

To send and install an individual PTF for a specific licensed program to a target system or system group, right-click the specific PTF and click **Send and Install**, as shown in Figure 2-46.

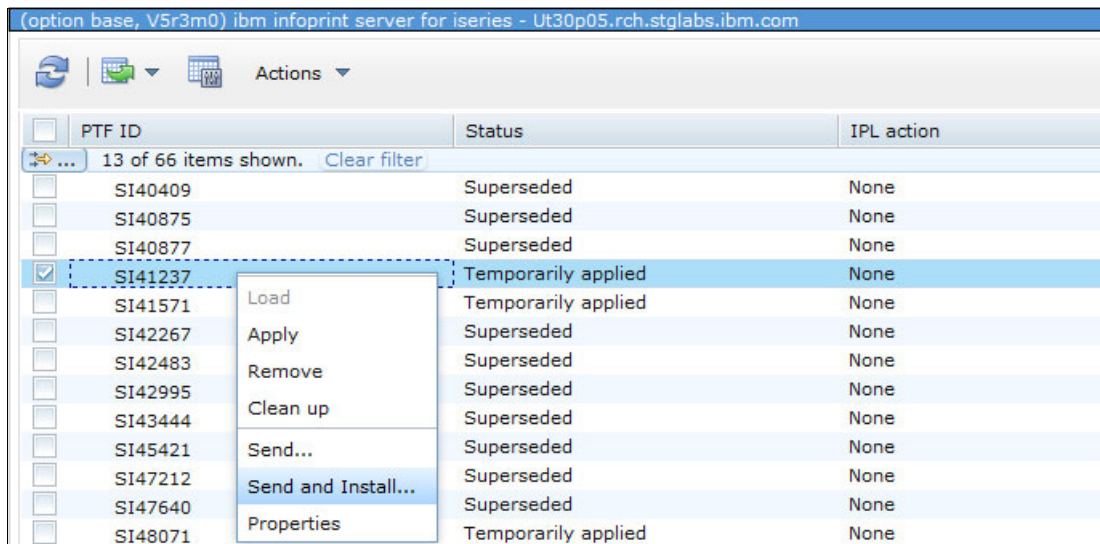


Figure 2-46 Send and install an individual PTF

This action starts the Send PTFs Wizard, as described in “Sending PTFs” on page 27. The process is the same as described in “Sending PTFs” on page 27 except that afterward the PTF is immediately installed on the target system or system group.

Sending and installing PTFs and PTF groups to multiple systems: Similar to what was described for sending and installing PTFs in “Sending and installing PTFs” on page 30, you can also send and install PTFs or PTF groups to multiple systems.

Comparing PTFs and PTF groups on different systems

Within IBM Navigator for i, it is now possible to compare PTFs and PTF groups on different systems. Complete the following steps:

1. From the Display PTFs window, on the Action menu, select **Compare and Update**, as shown in Figure 2-47.

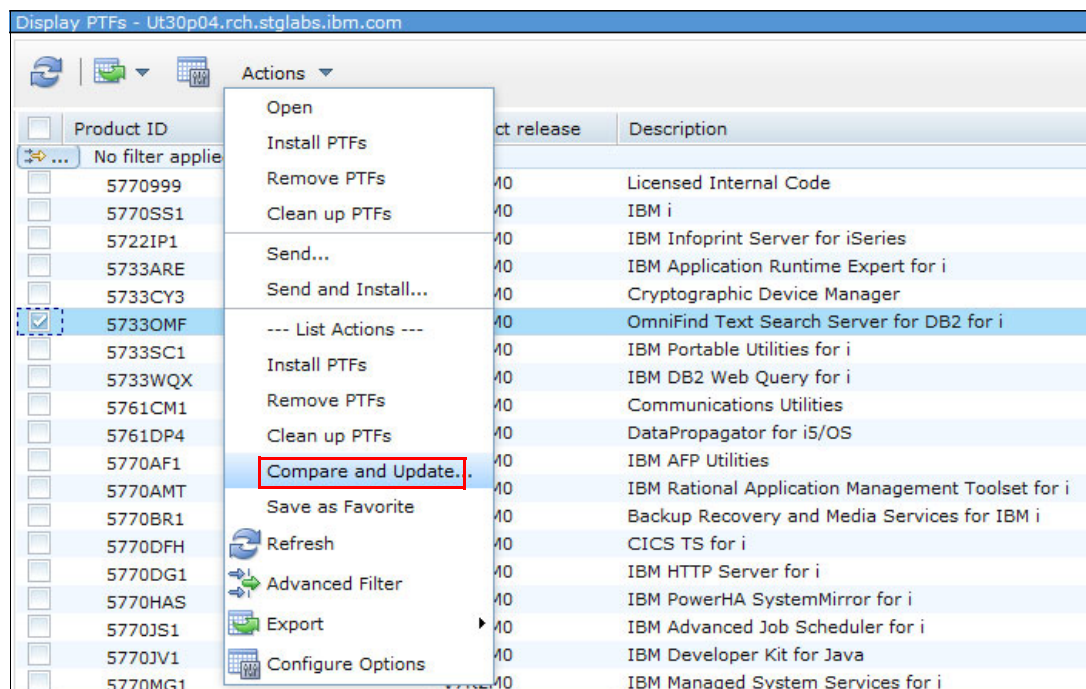


Figure 2-47 Select the Compare and update PTFs option

2. The Compare and Update Wizard starts, as shown in Figure 2-48. This wizard can compare the PTF and PTF group levels of a source system to the levels of one or more target systems. Click **Next**.

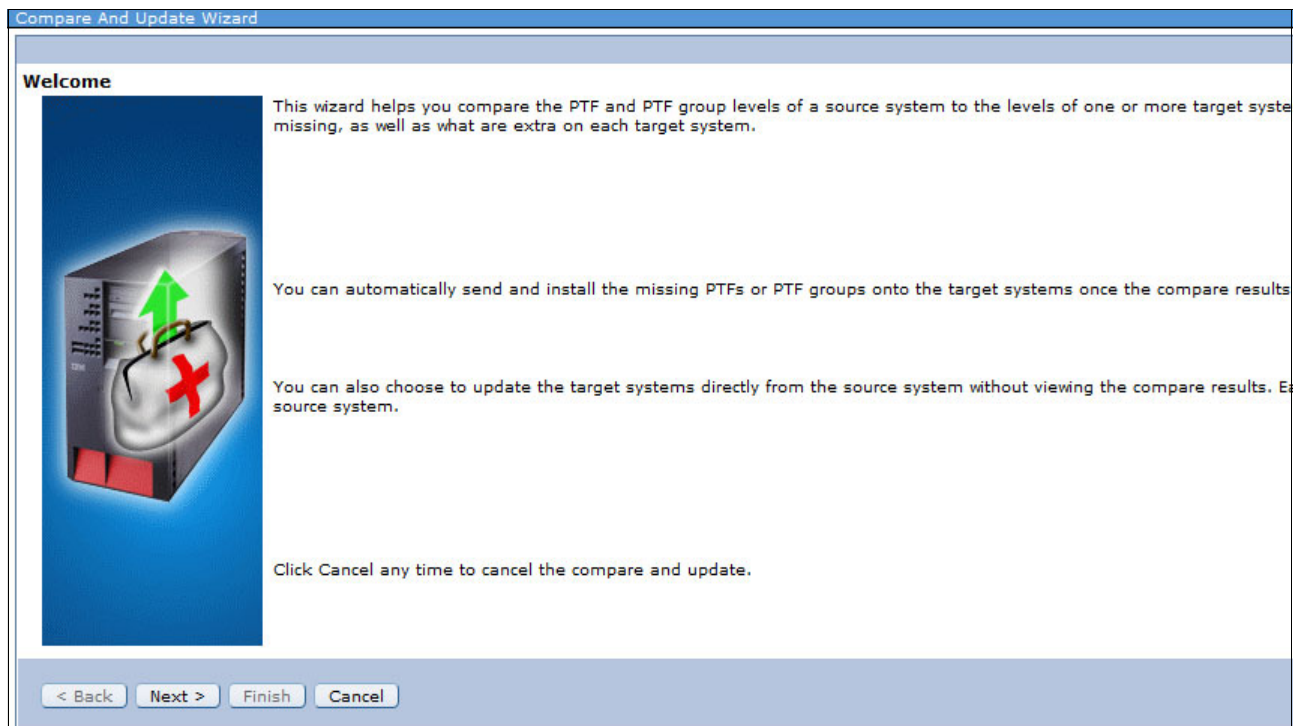


Figure 2-48 Compare and Update Wizard

3. As shown in Figure 2-49, you have the following options available:
- Update the target system directly from the source system without viewing the compare results.
 - View compare results to see the difference for PTFs or PTF groups for each target system.
 - What types of PTFs or PTF groups would you like the compare to find.
- Click **Next**.

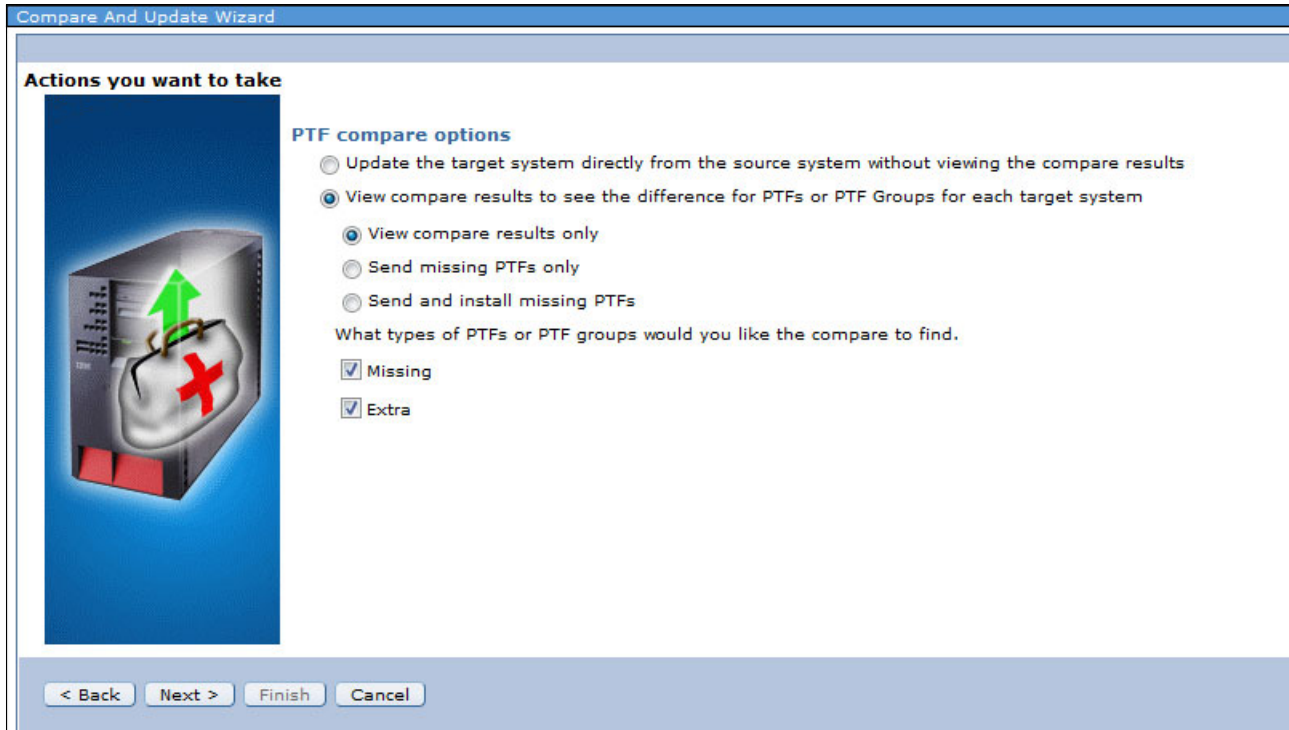


Figure 2-49 Compare and Update Wizard: options

4. In the Target Systems and Groups window (Figure 2-50), select the target system to compare the PTFs or PTF groups with and click **Next**.

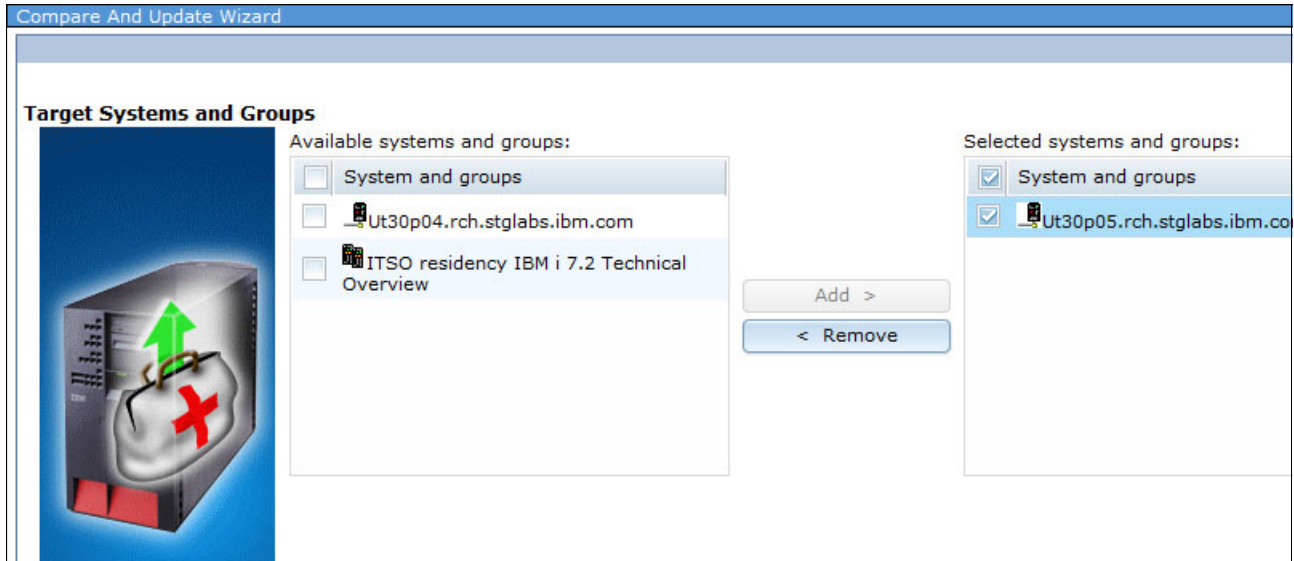


Figure 2-50 Compare and Update Wizard: add the target system

5. In the Select Products window (Figure 2-51), select one of the following options:
- **All products:** PTFs for all installed licensed programs are compared.
 - **Selected products:** PTFs for the selected licensed programs are compared.
- Click **Next**.

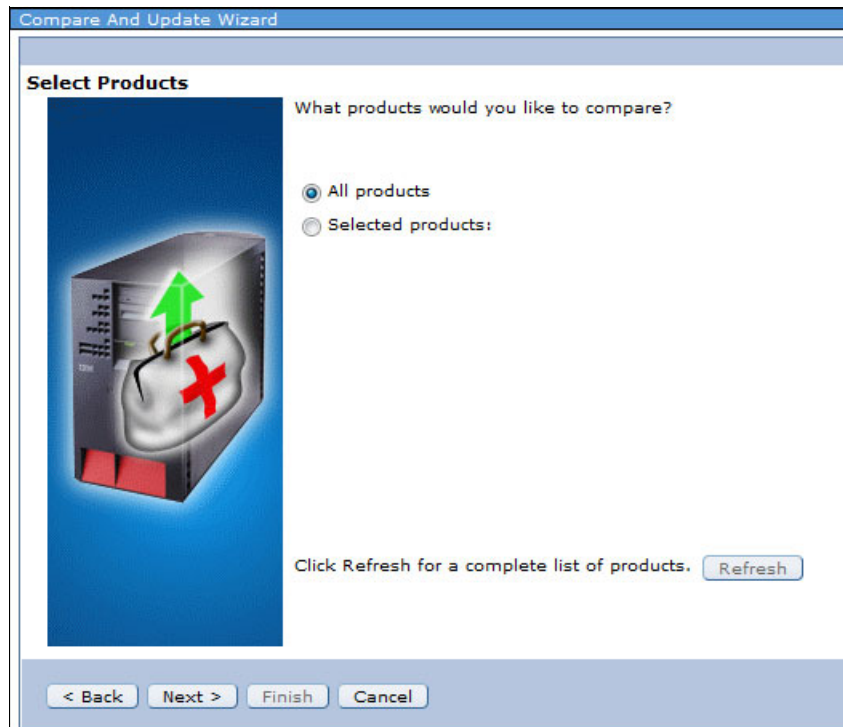


Figure 2-51 Compare and Update Wizard: select products to compare

- On the Select the PTFs or PTF Groups you want to update window (Figure 2-52), click the specified **Target Systems and Groups** link.

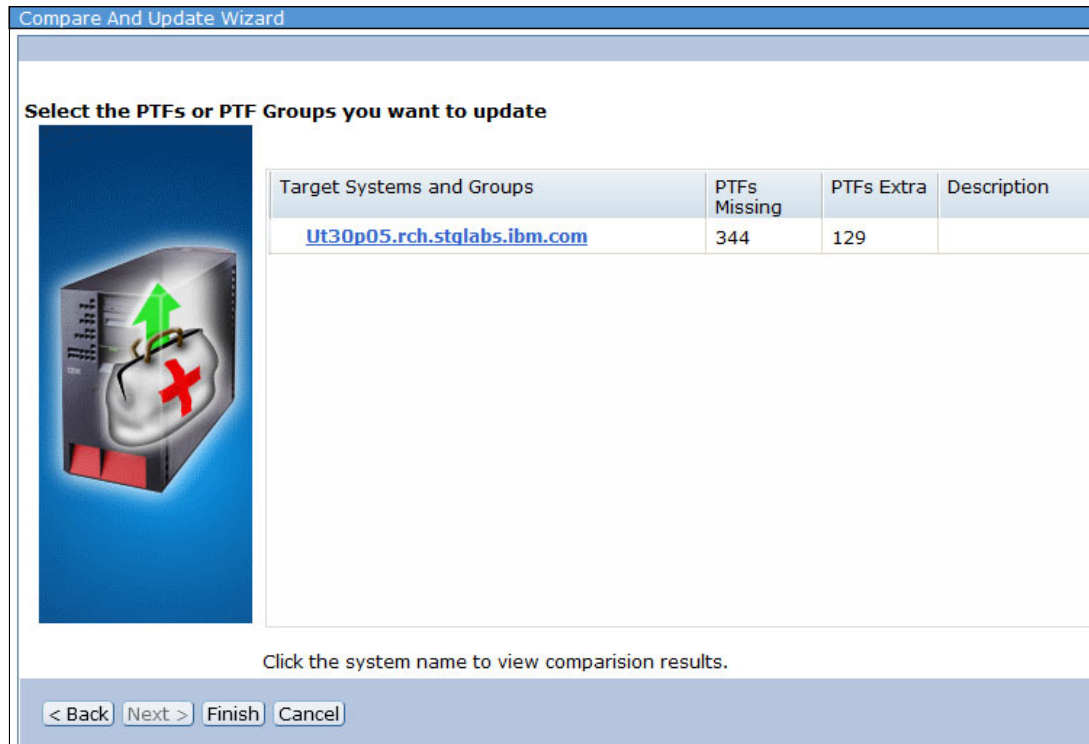


Figure 2-52 Compare and Update Wizard: link to target system results

- As shown in Figure 2-53, the comparison results with missing PTFs and extra PTFs are displayed.

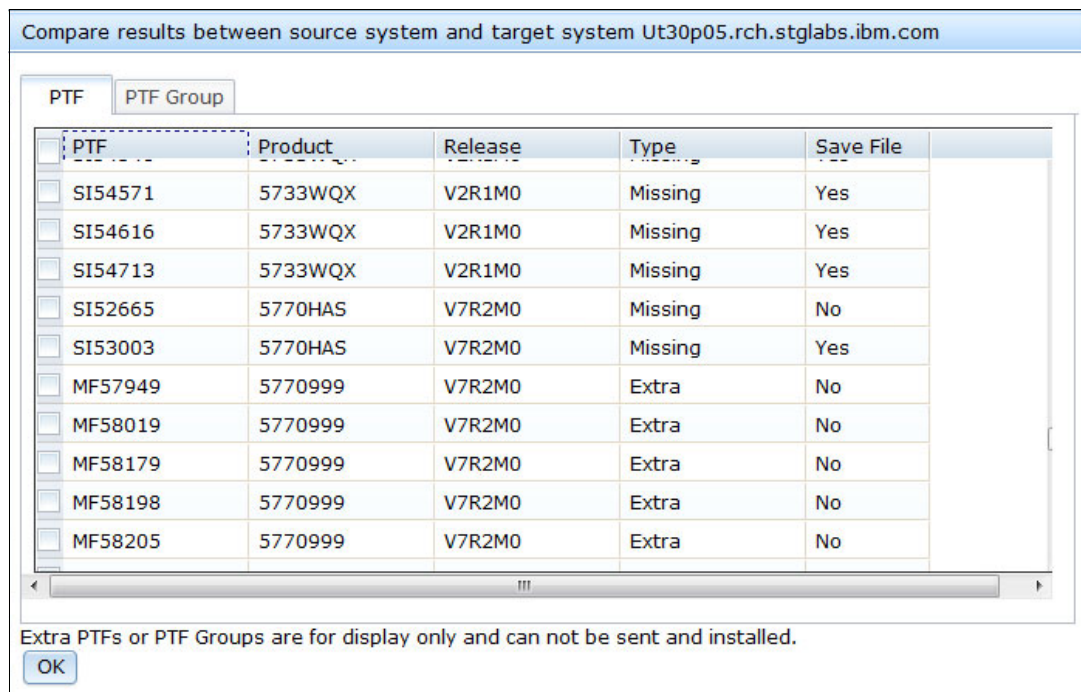


Figure 2-53 Compare and Update Wizard: results for the target system

The window that is shown in Figure 2-53 on page 48 shows the comparison results between the source system and the specified target system (or system group). This result contains the following information:

- ▶ **Missing PTFs:** PTFs that are on the source system and not on the target system (or system group).
- ▶ **Extra PTFs:** PTFs that are on the target system (or system group) and not on the source system.

Note: The extra PTFs or PTF groups that are listed are for display only and cannot be sent and installed to the target system or system group.

Multi-system PTF comparison

With IBM Navigator for i in IBM i 7.2, you can compare and update PTFs between one source system and multiple targets where the targets can be systems or system groups.

2.1.8 Message and system monitors

With IBM Navigator for i 7.2, you can define, run, and respond to message and system monitors.

Message monitors

With IBM i 7.2 Navigator for i, you can create a message monitor to monitor any message queue on the system. Message monitors can be used to monitor when an application completes successfully or unsuccessfully or to monitor for other specific messages that are critical to your business needs.

For each message queue, you can specify two separate and independent message sets to monitor. For each message set, you can specify the following items:

- ▶ A threshold that triggers an event.
- ▶ An operating system command that runs when the event is triggered.

The following steps describe how to set up a message monitor to display any inquiry messages in a message queue that occur on a system:

1. From IBM Navigator for i, click **Monitors** → **Message Monitors**.
2. From the Actions menu in the Message Monitors window, select **Create New Message Monitor**, as shown in Figure 2-54.

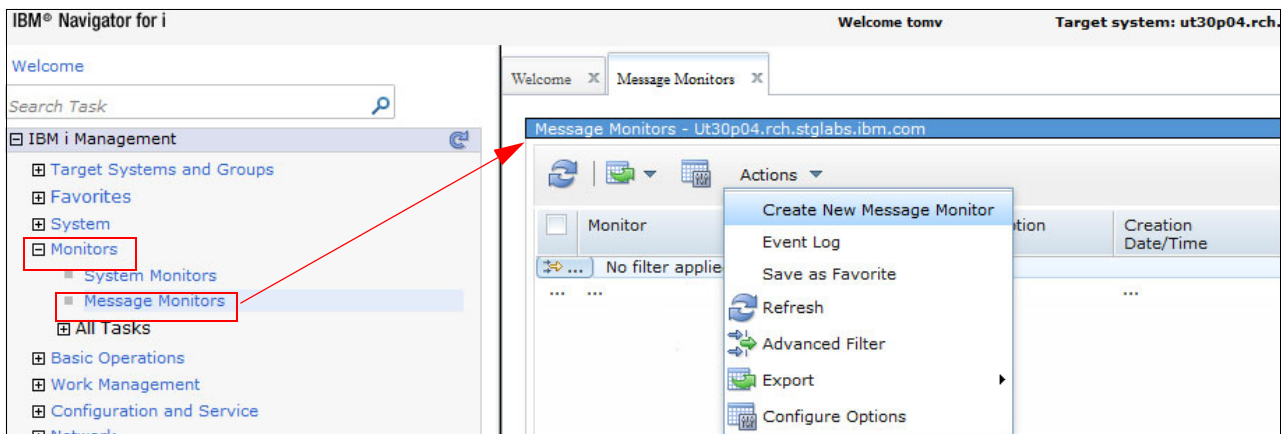
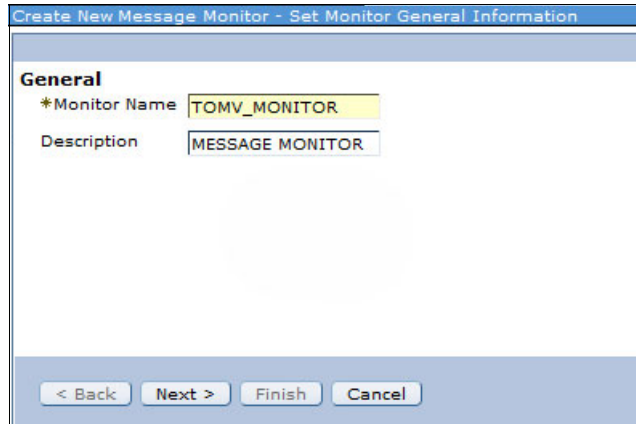


Figure 2-54 Create a message monitor

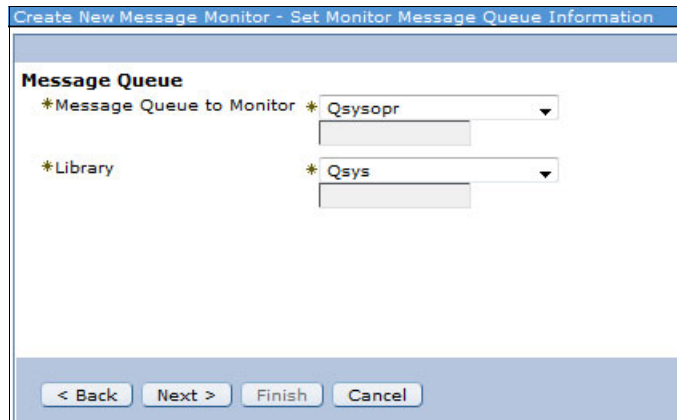
3. In the Create New Message Monitor - General window that is shown in Figure 2-55, enter a name and description for this monitor. Click **Next**.



The screenshot shows a dialog box titled "Create New Message Monitor - Set Monitor General Information". The "General" section has two input fields: "*Monitor Name" containing "TOMV_MONITOR" and "Description" containing "MESSAGE MONITOR". The bottom of the dialog features four buttons: "< Back", "Next >", "Finish", and "Cancel".

Figure 2-55 Specify the monitor name

4. In the Create New Message Monitor - Message Queue window that is shown in Figure 2-56, enter the following values:
- For Message Queue to Monitor, specify **QSYSOPR**.
 - For Library, specify **QSYS**.
- Click **Next**.



The screenshot shows a dialog box titled "Create New Message Monitor - Set Monitor Message Queue Information". The "Message Queue" section has two dropdown menus: "*Message Queue to Monitor" set to "Qsysopr" and "*Library" set to "Qsys". The bottom of the dialog features four buttons: "< Back", "Next >", "Finish", and "Cancel".

Figure 2-56 Specify the message queue to monitor

- In the Create New Message Monitor - Message Set window that is shown in Figure 2-57, click **Add** in the Message Set 1 tab.

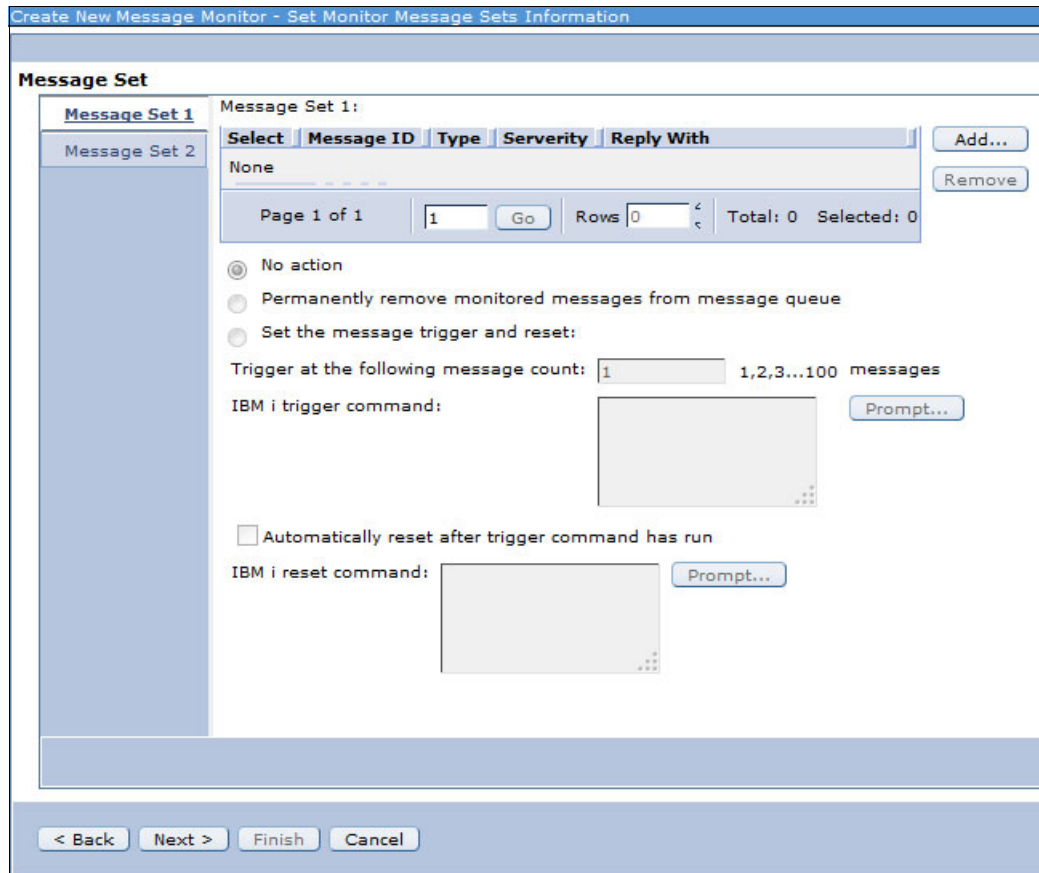


Figure 2-57 Create a message monitor: Message set 1

- In the Add A Message Set window (Figure 2-58), click **Add a user defined set of messages** and set the Message Type to **Inquiry**. Click **OK**.

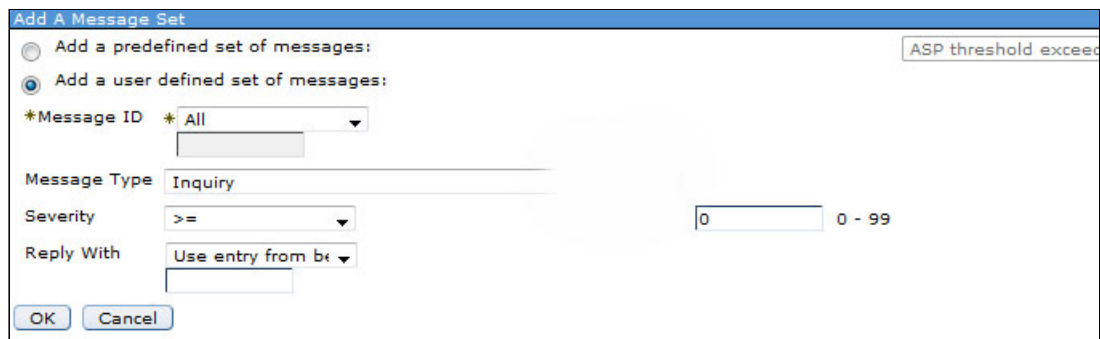


Figure 2-58 Create message monitor: add a message set

- Back in the Message Set 1 tab of the Message Set window (Figure 2-59), click **Set the message trigger and reset** option and specify **1** for Trigger at the following message count. Click **Next**.

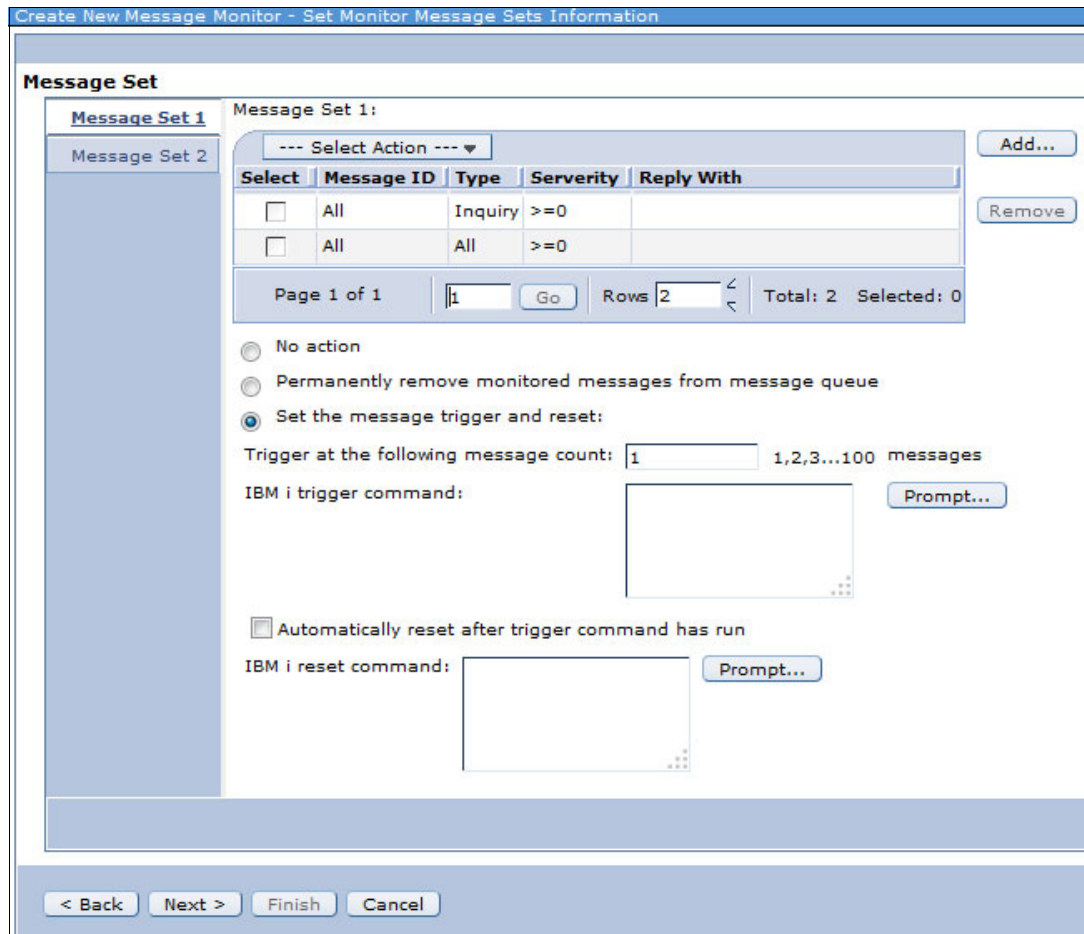


Figure 2-59 Set the message trigger

8. In the Create New Message Monitor Actions window (Figure 2-60), click **Next**.

Create New Message Monitor - Set Monitor Actions Information

Actions

Actions for all monitored messages

Trigger: Reset:

Log event

Run Command

Apply thresholds and actions

Apply Always

Apply

The whole day on Monday

The specify time slot on Tuesday

From: Example: 12:30:00 PM Wednesday

To: Example: 12:30:00 PM Thursday

Friday

Saturday

Sunday

Notes: Replying to messages and removing messages will occur when thresholds and actions are applied.

< Back Next > Finish Cancel

Figure 2-60 Create a message monitor: set monitor actions information

9. In the Create New Message Monitor Actions Summary window (Figure 2-61), click **Finish**.

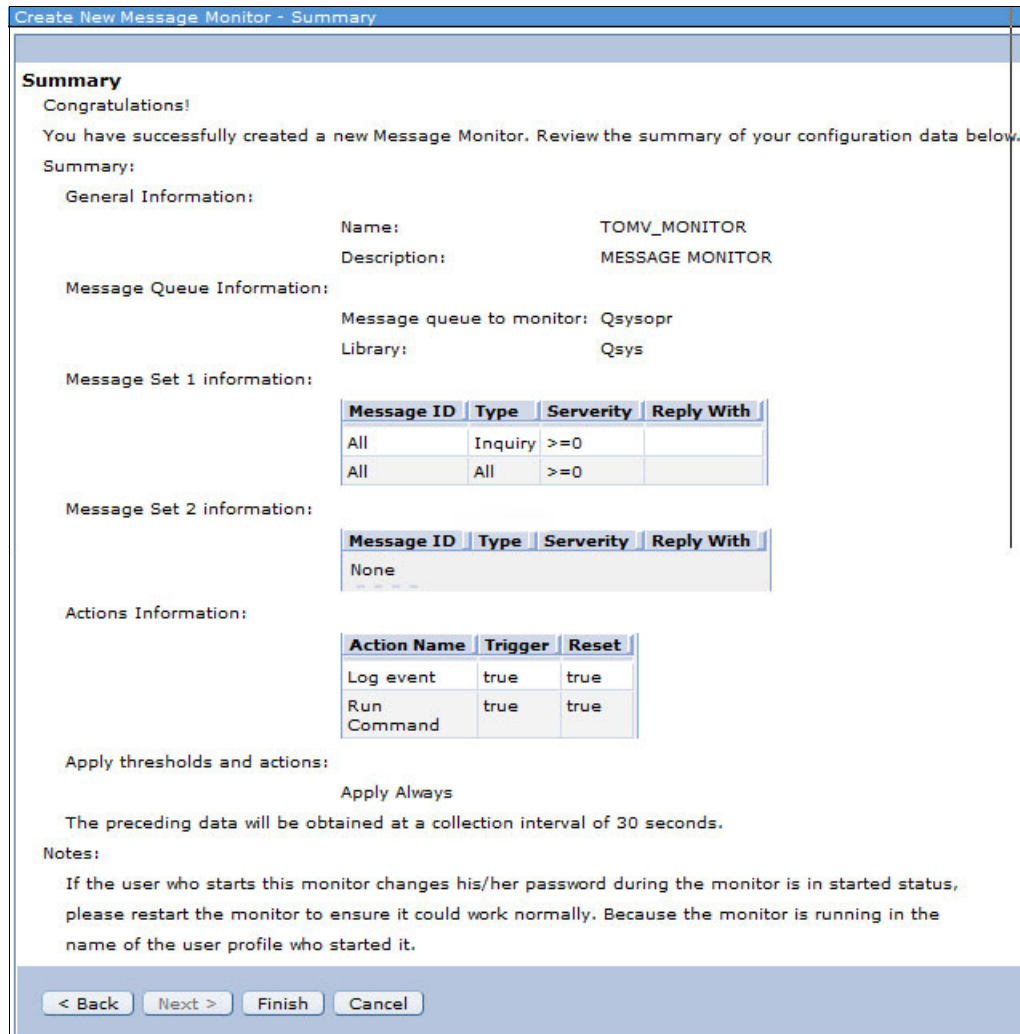


Figure 2-61 Create a message monitor summary

10. From the list of message monitors (Figure 2-62), right-click the new monitor and select **Start**. The new message monitor now shows any inquiry messages that are sent to QSYSOPR.

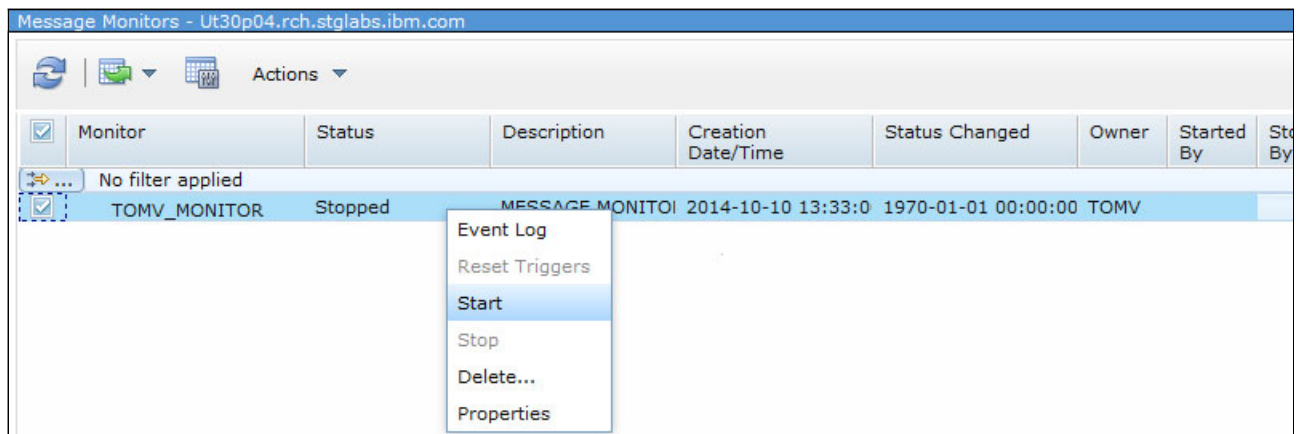


Figure 2-62 Start the message monitor

Note: This message monitor responds to only inquiry messages sent to QSYSOPR. However, you can include two different sets of messages in a single monitor. You can have several message monitors that run at the same time. Message monitors can also run IBM i commands when specific messages are received.

System monitors

To monitor effectively system performance, you must decide which aspects of system performance you want to monitor. Performance metrics are performance measurements that help you pinpoint different aspects of the system performance.

When configuring a system monitor with IBM i 7.2 in IBM Navigator for i, you can use any metric, a group of metrics, or all the metrics, as listed in Table 2-1.

Table 2-1 System monitor metrics

Metric group	Metric description
CPU utilization	The percentage of available processing unit time that is consumed by jobs on the system. You can select from the following types of CPU Utilization metrics for use in your monitors: <ul style="list-style-type: none"> ▶ CPU Utilization (Average) ▶ CPU Utilization (Interactive Jobs) ▶ CPU Utilization (Uncapped) ▶ CPU Utilization (SQL)
Interactive response time (average and maximum)	The response time that interactive jobs experience on the system.
Transaction rate (interactive)	The number of transactions per second completed on the system by interactive jobs (Job type = 'I').
Batch logical database I/O	The average number of logical database input/output (I/O) operations that are performed by batch jobs (Job type = 'B') on the system.
Disk arm utilization (average and maximum)	The disk unit busy percentage.
Disk arm utilization for system, user, and independent ASP (average and maximum)	The disk unit busy percentage for all disks in the system ASP, user ASPs, or independent ASPs.
Disk storage utilization (average and maximum)	The percentage of disk storage that is full on the system during the time data is collected.
Disk storage utilization for system, user, and independent ASP (average and maximum)	The percentage of disk storage that is full in the system ASP, user ASPs, or independent ASPs during the time data is collected.
Disk response time - Read	Read response time. Accumulated read response time for reported disk units in microseconds.
Disk response time - Write	Write response time. Accumulated write response time for reported disk units in microseconds.
Communications Line Utilization (average and maximum)	The amount of data that was sent and received on all the system communication lines.
LAN utilization (average and maximum)	The amount of data that was sent and received on all local area network (LAN) communication lines.
Machine pool faults	The number of faults per second occurring in the machine pool on the system.

Metric group	Metric description
User pool faults (average and maximum)	The number of faults per second per pool.
Temporary storage used	The total amount of temporary storage (megabytes) in use within the system. This includes both system and user temporary storage.
Spool file creation rate	The number of spool files that are created per second.
Shared processor pool utilization (virtual and physical)	The amount of CPU that is consumed in the shared pool by all partitions that are using the pool relative to the CPU that is available within the pool.

The system monitor within IBM Navigator for i uses data from Collection Services to track the elements of system performance of specific interest to you.

Within IBM Navigator for i, you have the following system-monitor-related functions available:

- ▶ **Monitors:**
 - Create a system monitor or create one based on an existing monitor.
 - Change the configuration of a system monitor.
 - Delete a system monitor.
 - Start and stop a system monitor.
- ▶ **Thresholds and event logs:**
 - Capture events and trigger actions when a threshold is reached.
 - List the event log of a selected system monitor.
 - List the event log of all system monitors.
 - Display properties of an event log.
 - Delete an event log.
- ▶ Investigate monitor data by using Performance Data Investigator (PDI).

The following system monitor topics are covered in this section:

- ▶ “Creating a system monitor” on page 57
- ▶ “System monitor graphs in PDI” on page 61
- ▶ “New PDI package” on page 62
- ▶ “Collection Services system monitor support” on page 63
- ▶ “Differences with Management Central monitors” on page 67

Creating a system monitor

The following steps show you how to create a system monitor:

1. From IBM Navigator for i, click **Monitors** → **System Monitors**.
2. From the Actions menu in the System Monitors pane, select **Create New System Monitor**, as shown in Figure 2-63.

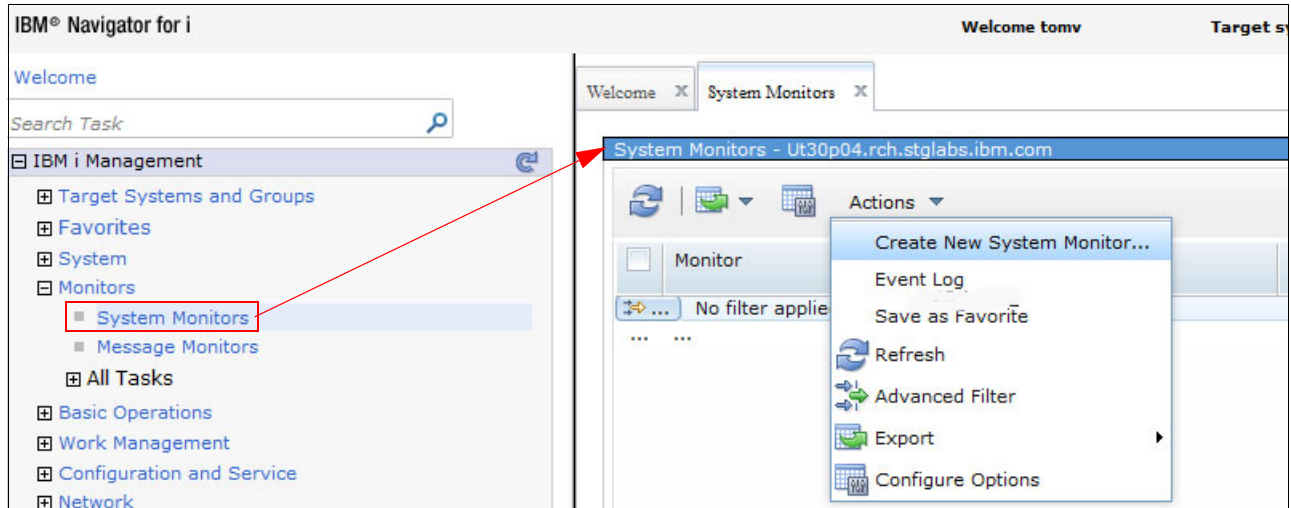


Figure 2-63 Create a system monitor

3. In the Create New System Monitor - General window (Figure 2-64), enter a name and description for this system monitor. Click **Next**.

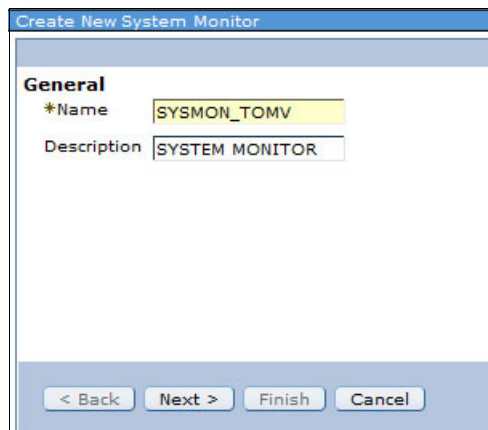


Figure 2-64 Specify the system monitor name

4. In the Create New System Monitor - Metrics window (Figure 2-65), select the **Disk Storage Utilization (Average)** metric and click **Add**. Then, click the **Disk Storage Utilization (Average)** metric that is now listed in the right pane to configure it.

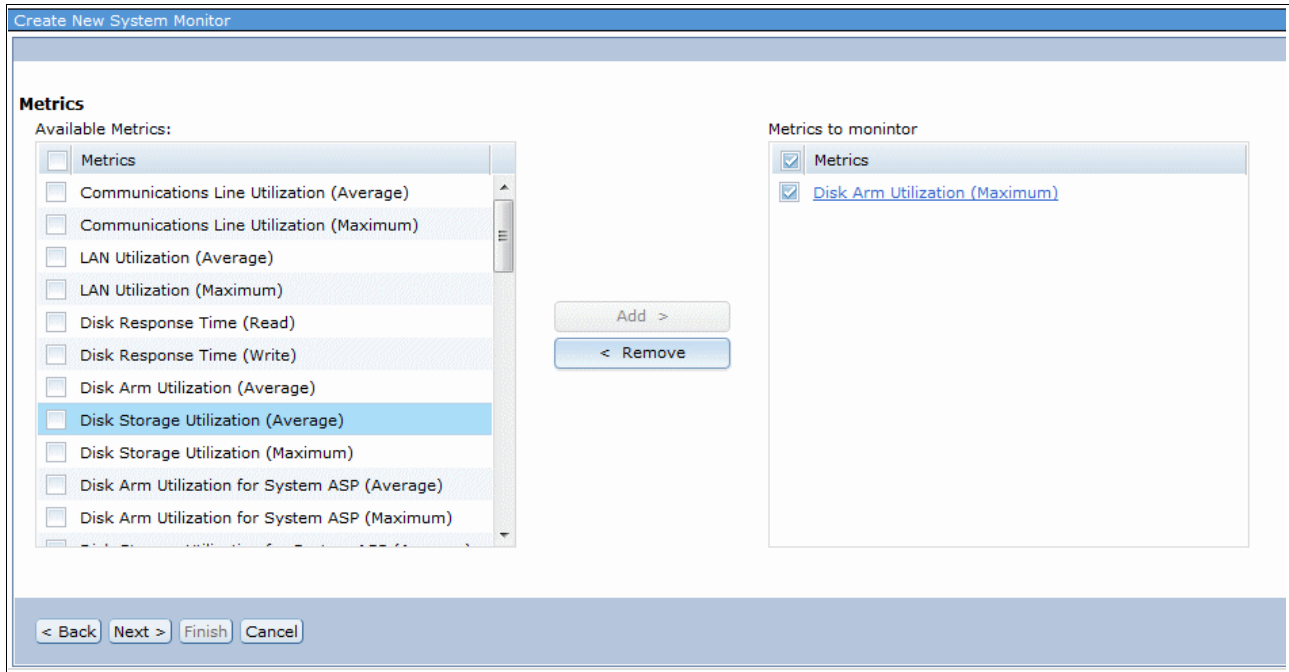


Figure 2-65 Create a system monitor: add a metric

5. On the Configure Metric window that is shown in Figure 2-66, you can configure the following settings for the selected metric:
 - Collection interval.
 - Threshold 1.
 - Threshold 2.

Note: You must enable the thresholds by selecting **Enable Threshold** for each threshold.

The threshold a setting for a metric that is being collected by a monitor with the following details:

- You can use it to specify actions to be taken when a specified value (called the *trigger value*) is reached or a second value (called the *reset value*) is reached.
- An event is added to the Event Log whenever the trigger value or the reset value is reached.
- Set up to two thresholds for each metric that the monitor is collecting:
 - Trigger: Considered bad (usually high but can be low).
 - Reset: Considered good (opposite of trigger).
- When a threshold is reached, IBM Navigator for i captures the event and runs the specified actions.

Click **OK** to return to the window that is shown in Figure 2-65 on page 58 and then click **Next**.

The screenshot shows the 'Configure Metric' dialog box for 'Disk Storage Utilization (Maximum)'. The 'Collection Interval' is set to 15 Seconds. There are two thresholds, both with 'Enable Threshold' checked. Threshold 1 has a Trigger of >= 50 Percent, a Duration of 1 Intervals, and a Reset of < 49 Percent. Threshold 2 has a Trigger of >= 80 Percent, a Duration of 1 Intervals, and a Reset of < 79 Percent. Each threshold has an 'Operating System Command' field with a 'Prompt...' button next to it. At the bottom are 'OK' and 'Cancel' buttons.

Figure 2-66 Configure the system monitor metrics

6. In the Create New System Monitor - Summary window (Figure 2-67), click **Finish**.

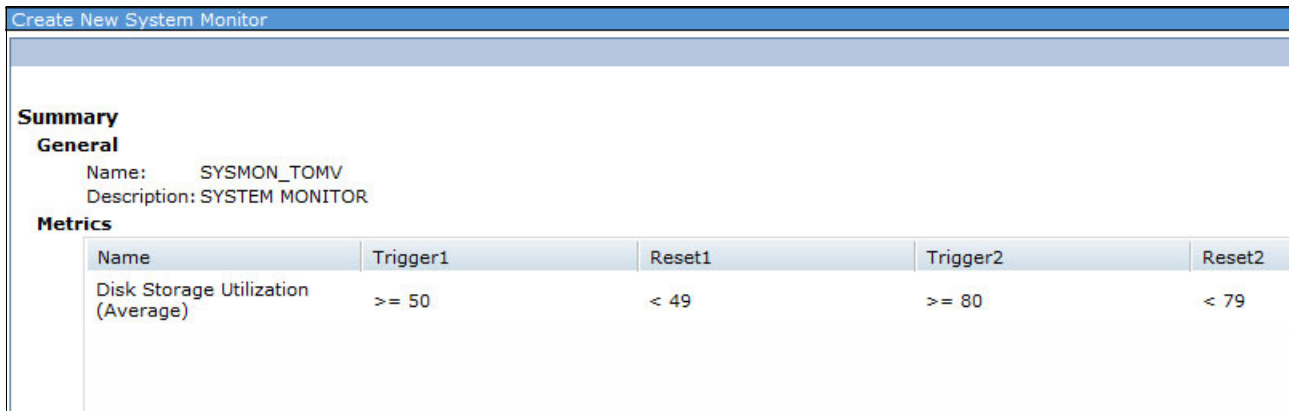


Figure 2-67 Create a system monitor summary

7. The new system monitor is now displayed in the System Monitors window, as shown in Figure 2-68. From the Actions menu in the System Monitors window, the following functions are available:

- Investigate Monitor Data: Use PDI to graph the monitored metrics.
- Event Log: Show the Event Log list for this monitor.
- Start: Start this system monitor.
- Stop: Stop this system monitor.
- New Based On: Create a system monitor based on this system monitor.
- Delete: Delete this system monitor.
- Properties: Displays the attributes of the monitor.

Note: With IBM i 7.2 TR1, the following additional functions are available:

- ▶ Support monitor auto-restart.
- ▶ Support multiple users accessing monitors in the same system concurrently.
- ▶ Support to modify an active monitor.

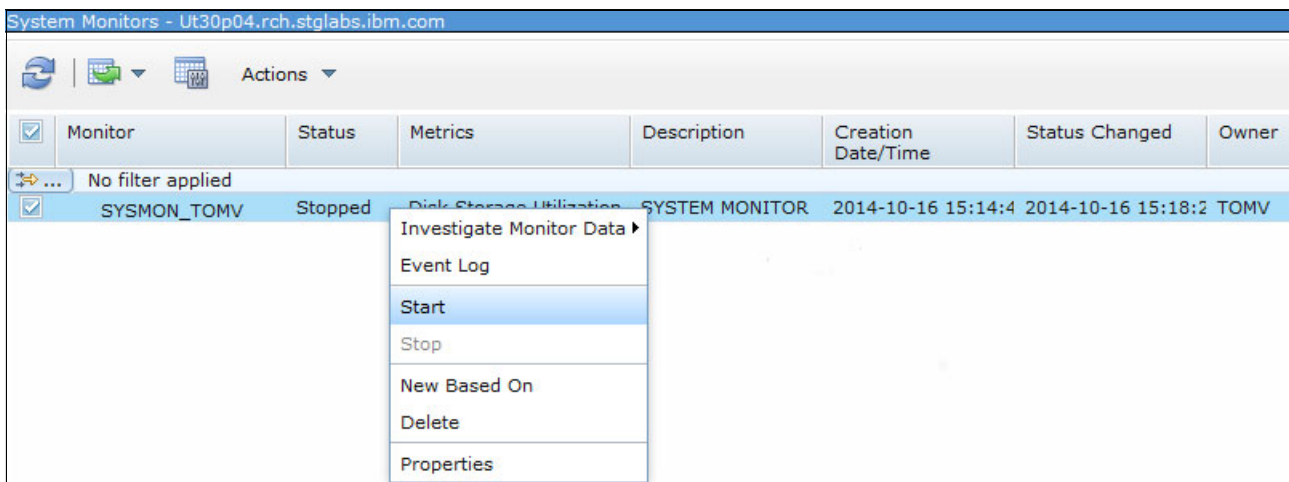


Figure 2-68 System Monitors: Actions menu

System monitor graphs in PDI

From the System Monitor window, you can go to the system monitor Graphs directly in PDI by right-clicking the select system monitor and selecting **Investigate Monitor Data**.

As shown in the Figure 2-69, this is the Disk Storage Utilization (Average) metric that was created in Figure 2-65 on page 58.

Refresh button: The Refresh button is visible when displaying the currently active collected monitor data. The current chart is refreshed with the current monitored data from the active real-time collection.

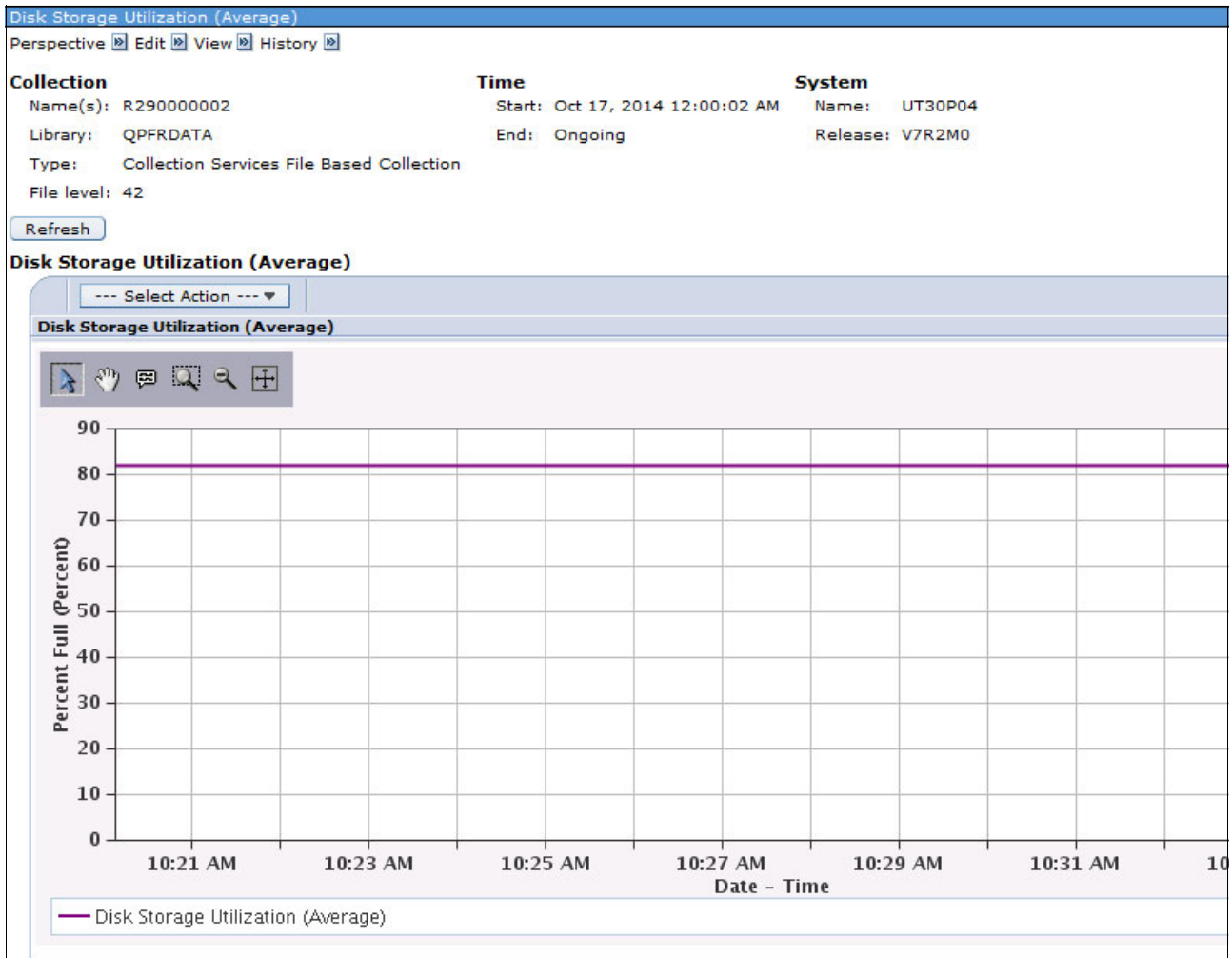


Figure 2-69 System monitor for the Disk Storage Utilization (Average) metric

New PDI package

With IBM i 7.2, there is a new PDI package that is available, as shown in Figure 2-70.

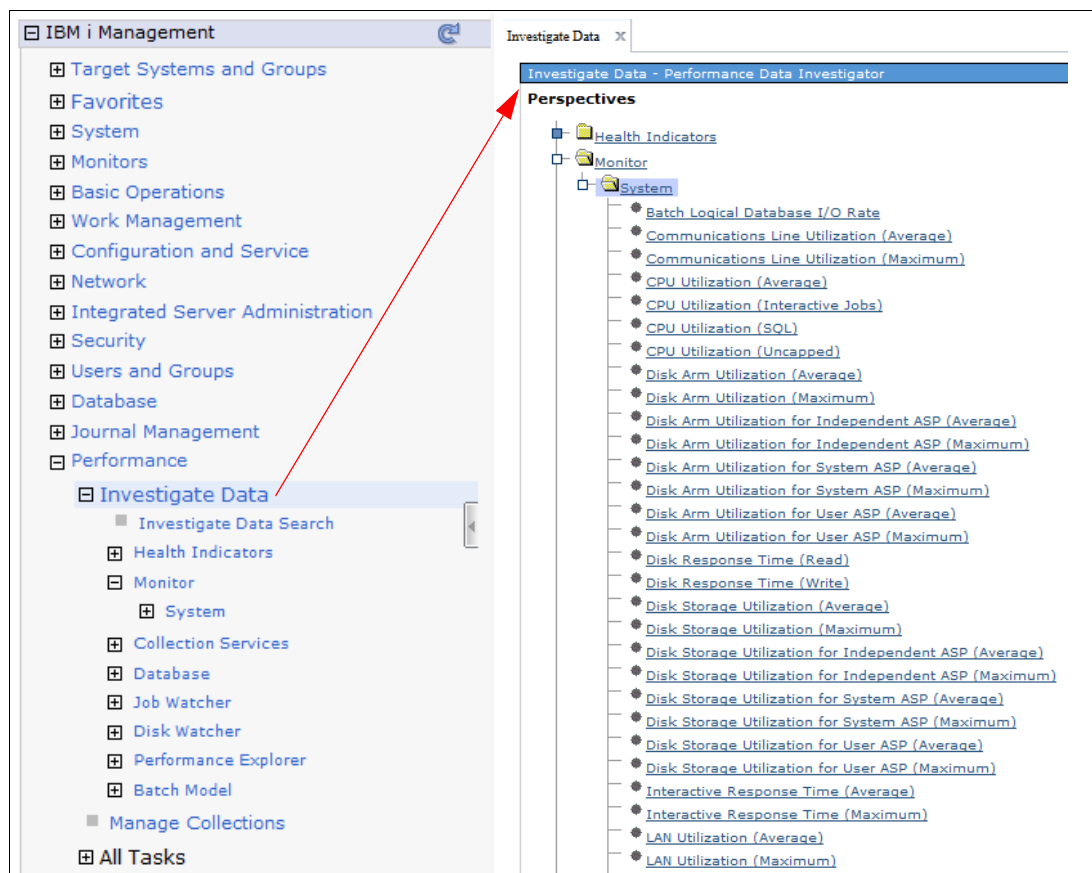


Figure 2-70 Investigate Performance Data

This PDI package provides the following lightweight perspectives for system monitor metrics:

- ▶ Batch Logical Database I/O Rate
- ▶ Communications Line Utilization (Average)
- ▶ Communications Line Utilization (Maximum)
- ▶ CPU Utilization (Average)
- ▶ CPU Utilization (Interactive Jobs)
- ▶ CPU Utilization (SQL)
- ▶ CPU Utilization (Uncapped)
- ▶ Disk Arm Utilization (Average)
- ▶ Disk Arm Utilization (Maximum)
- ▶ Disk Arm Utilization for Independent ASP (Average)
- ▶ Disk Arm Utilization for Independent ASP (Maximum)
- ▶ Disk Arm Utilization for System ASP (Average)
- ▶ Disk Arm Utilization for System ASP (Maximum)
- ▶ Disk Arm Utilization for User ASP (Average)
- ▶ Disk Arm Utilization for User ASP (Maximum)
- ▶ Disk Storage Utilization (Average)
- ▶ Disk Storage Utilization (Maximum)
- ▶ Disk Storage Utilization for Independent ASP (Average)
- ▶ Disk Storage Utilization for Independent ASP (Maximum)
- ▶ Disk Storage Utilization for System ASP (Average)
- ▶ Disk Storage Utilization for System ASP (Maximum)

- ▶ Disk Storage Utilization for User ASP (Average)
- ▶ Disk Storage Utilization for User ASP (Maximum)
- ▶ Interactive Response Time (Average)
- ▶ Interactive Response Time (Maximum)
- ▶ LAN Utilization (Average)
- ▶ LAN Utilization (Maximum)
- ▶ Machine Pool Faults Rate
- ▶ Shared Processor Pool Utilization (Physical)
- ▶ Shared Processor Pool Utilization (Virtual)
- ▶ Spool File Creation Rate
- ▶ Temporary Storage Utilization
- ▶ Transaction Rate (Interactive)
- ▶ User Pool Faults Rate (Average)
- ▶ User Pool Faults Rate (Maximum)

Collection Services system monitor support

With IBM i 7.2, IBM i Collection Services is used to collect system monitor data 24 x 7.

System monitor metrics have the following characteristics:

- ▶ They do not exist in raw collected performance data.
- ▶ They are a function of selection, grouping, and other calculations, including rates, percentages, and maximums.

IBM Navigator for i system monitor metrics are now produced by Collection Services and exported to database files. They are no longer stored in private *MGTCOL files like they are in Management Central. For more information, see “Differences with Management Central monitors” on page 67.

These files contain metrics that are defined for system monitoring along with other supporting data and include metrics that are supported by Management Central and more. Also, existing Collection Services files can be used for drill-down and detailed data. Data is easily accessible by the monitoring function and visualization tools (PDI), and data is also easily accessible to any other consumers and can be used for more in-depth analysis as necessary.

When system monitor data collection is enabled, monitor metrics are exported by Collection Services into a second Collection Services file-based collection for the active collection. A second batch job (CRTPFRDTA2) is submitted to produce the system monitor collection. System monitor file collections contain only database files that are related to the categories that are selected for system monitoring.

The database file interval that is used by CRTPFRDTA2 is always 15 seconds. Data is present based on the interval at which each category was collected. Also, system monitor file collections have a separate retention (expiration) period than standard Collection Services file collections.

Existing PDI perspectives can be used with this collection if all required data is present.

Here are the Collection Services system monitor files:

- ▶ QAPMSMCMN (*CMNBASE)
 - Lines and LANs metrics
 - Still can exclude unwanted lines
 - Includes line count, average and maximum utilization, average kilobits received and sent, and the line with highest utilization

- ▶ QAPMSMSDK (*DISK)
 - Disk metrics, including all units, system ASP, user ASPs, and IASPs
 - Includes number of entries in data, average and maximum busy and device name, average and maximum capacity that is used, and device name
 - Total capacity available and used
 - For both reads and writes: Ops, average response and service time, maximum response time, and maximum device name
- ▶ QAPMSMJMI (*JOBMI)
 - Interactive and batch job metrics depend on the MI
 - Includes job count, total and maximum unscaled CPU consumed and percentage and job, and interactive transaction rate
- ▶ QAPMSMJOS (*JOBOS)
 - Job metrics depend on the OS
 - Includes job count, batch LIO rate, and average and maximum interactive response time and job
 - Spool file creation rate, count, and name of job created the most
- ▶ QAPMSMPOL (*POOL)
 - Pool metrics
 - Includes machine pool fault rate, count of user pools, and average and maximum user pool fault rate and pool
- ▶ QAPMSMSYS (*SYSLVL)
 - System metrics
 - Scaled and unscaled: Configured, uncapped, and virtual CPU percentage
 - Speed percent, and virtual and physical shared pool percentage
 - Temporary storage that is used and percentage, and unscaled SQL CPU percentage

The same system monitor metric data can also be generated without starting a system monitor within IBM Navigator for i.

System monitor files (QAPMSM*) can be generated for your Collection Services collection by specifying the following options:

- ▶ **CRTPFRSUM(*ALL)** on the Configure Performance Collection (**CFGPFRCOL**) CL command.
- ▶ **CRTPFRSUM(*ALL or *SYSMON)** on the Create Performance Data (**CRTPFRDTA**) CL command when running manually.

System monitor data collection can also be enabled through the Configure Performance Collection (**CFGPFRCOL**) CL command by specifying **ENBSYSMON(*YES)**. This does not start any monitors.

Specify the categories that you want collected more frequently by using the **SYSMONCGY** parameter of Configure Performance Collection (**CFGPFRCOL**) CL command. This command starts the CRTPFRDTA2 job that creates the second database file collection starting with an R.

Note: When monitors override the settings of Collection Services to gather performance data more frequently, the settings are *not* undone when a monitor stops. You must manually change the Collection Services settings if you no longer want to collect the data as often.

The following steps show you how to enable system monitor data collection from the Performance tasks in IBM Navigator for i:

1. From IBM Navigator for i, click **Performance** → **All Tasks** → **Collectors** → **Collection Services** → **Configure Collection Services**, as shown in Figure 2-71.

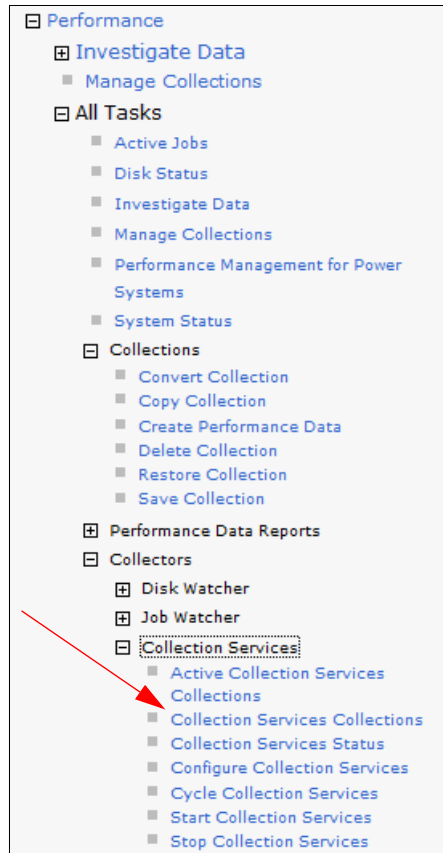


Figure 2-71 Configure Collection Services

- In the Configure Collection Services - General window (Figure 2-72), select the **Enable system monitoring** option.

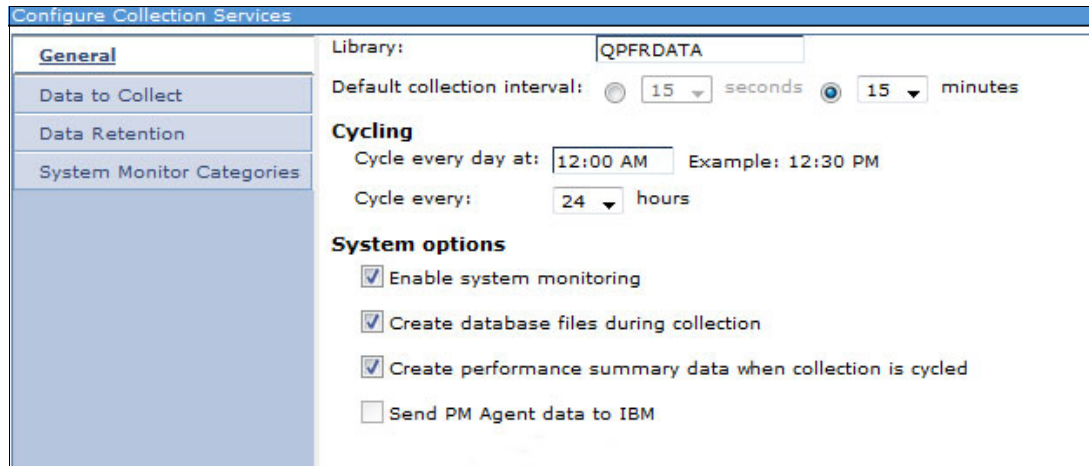


Figure 2-72 Enable system monitoring

- You can also configure data retention, as shown in Figure 2-73.

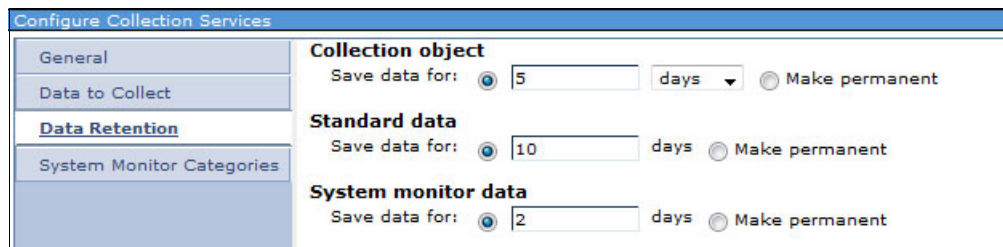


Figure 2-73 Configure data retention

- It is also possible to configure the system monitor categories, as shown in Figure 2-74.

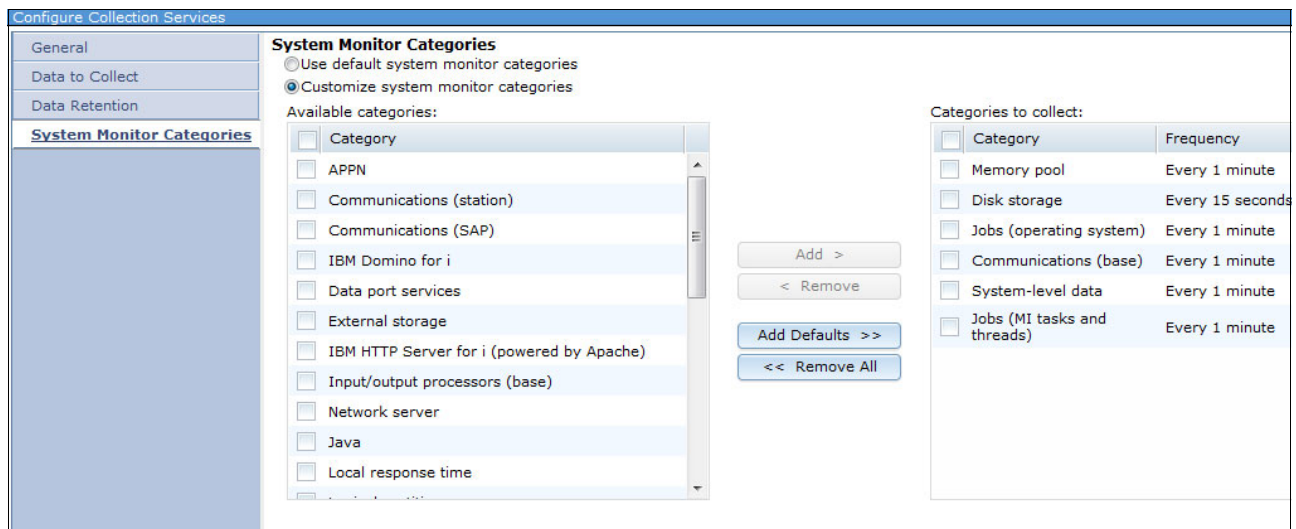


Figure 2-74 System monitor categories customization

Differences with Management Central monitors

IBM Navigator for i system monitors and Management Central monitors are two separate functions.

Management Central monitors (that uses the IBM i Navigator client) still work and run against an IBM i 7.2 system.

Both system monitor functions have dependencies on Collection Services to control what data is collected and at what interval:

- ▶ Management Central uses application override support, which can allow any of the Collection Services data categories to be collected more frequently than what is specified for the configured collection profile.
- ▶ IBM Navigator for i system monitors the usage of the new system monitoring settings that are specified by the Configure Performance Collection (**CFGPFRCOL**) CL command or in the Configure Collection Services GUI in IBM Navigator for i.

Management Central gets and stores the monitor data differently than the IBM Navigator for i system monitoring support:

- ▶ Management Central stores the monitor data in private *MGTCOL objects.
- ▶ IBM Navigator for i system monitors the usage of the monitor data that is exported by Collection Services into DB2 files with file names starting with QAPMSM*.

Note: IBM Navigator for i system monitor functions do not work when an IBM 6.1 or 7.1 target system is specified. The underlying Collection Services support is available only in Version 7.2.

2.1.9 Performance

This section explains the enhancements in IBM Navigator for i that are related to performance tasks. The IBM Navigator for i performance interface includes PDI, Collection Manager, and web-based GUI interfaces for Collection Services, Job Watcher, and Disk Watcher. New functions for Batch Model, System Monitor, and Performance Reports are described in this section.

The following topics are covered in this section:

- ▶ “Performance data reports” on page 67
- ▶ “Drill-down information” on page 69
- ▶ “System Information pane” on page 70
- ▶ “Show SQL error messages option” on page 70
- ▶ “Health indicators” on page 70
- ▶ “Batch model” on page 70
- ▶ “Performance perspectives” on page 76

Performance data reports

A performance data report can be generated for a set of PDI perspectives. You can view the report in IBM Navigator for i or generate a PDF or compressed file. By using performance data reports, you can efficiently export multiple charts or tables for a collection at one time.

For performance data reports, as shown in Figure 2-75, users can perform the following operations:

- ▶ Add a definition.
- ▶ Delete a definition.
- ▶ Add definitions by using existing definitions.
- ▶ View report definitions.

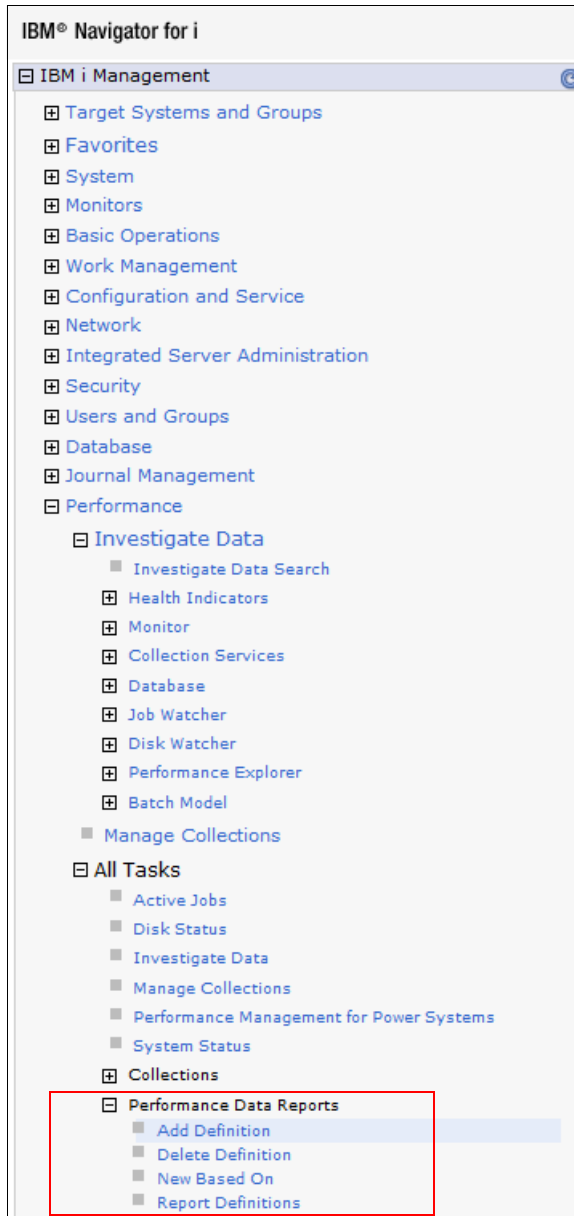


Figure 2-75 Performance data reports tasks

Figure 2-76 shows an example of a performance data report definition.

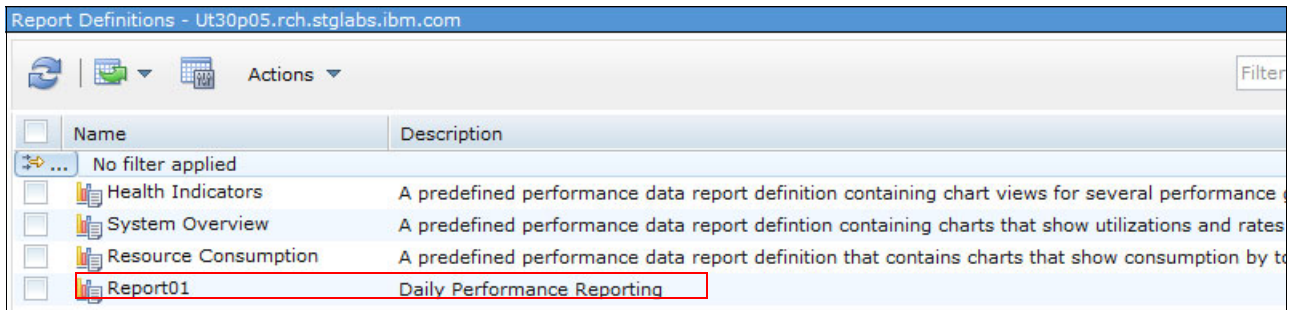


Figure 2-76 Performance data report definition example

Drill-down information

In PDI, users are allowed to view additional information, which is shown in the blue title bar of the window. This is referred to as *drill-down information*. To view the drill-down information, users must select the intervals and do the drill-down action. Additional information in the blue title bar for the drilled-down chart shows what parameters are used for that specific drill-down information.

Figure 2-77 shows the drill-down information when selecting data in PDI.

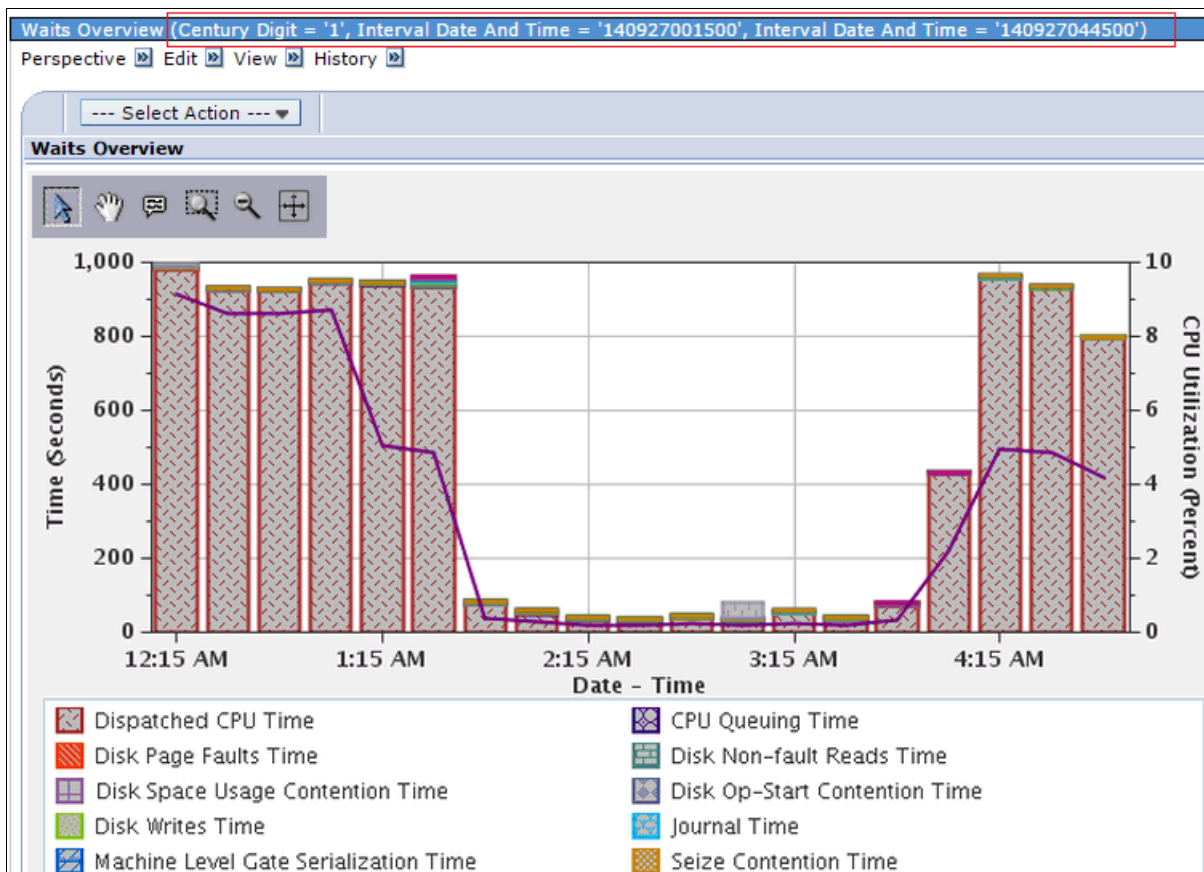


Figure 2-77 Drill-down information in the Performance Data Investigator title bar

System Information pane

In the PDI perspectives display window, the Show System Information view option provides more detailed information for the system from which the displayed collection came. This includes information such as processor, memory, and partition specifications.

Figure 2-78 shows the System Information pane in PDI.

Collection		Time		System	
Name(s):	Q286121148	Start:	Oct 13, 2014 12:11:49 PM	Name:	UT30P05
Library:	QPFRDATA	End:	Oct 14, 2014 12:00:03 AM	Release:	V7R2M0
Type:	Collection Services File Based Collection				
File level:	42				
System Information					
Name:	UT30P05	Total Processors:	128	Interactive Threshold:	100%
Release:	V7R2M0	Processors / Cores Active:	128	System ASP Capacity:	88.89 GB
Type:	9179	Available Processors:	0	Hypervisor Memory:	35,328 MB
Model:	MHD	Virtual Processors:	2	Primary Partition:	0
Serial Number:	10-C1CBT	Installed Processor Count:	128	Partition ID:	5
Processor Feature Code:	EPH2	Processor Units (allocated to partition):	0.5	Partition Count:	14
Processor Feature:	EPH2	Processor Sharing/Capped:	Yes / No	Partition Memory:	4 GB
Generated On:	UT30P05	QPFRADJ System Value:	2		

Figure 2-78 System Information pane in PDI

Show SQL error messages option

The Show SQL error messages option in the Options pane in PDI provides specific error information about SQL errors when the Modify SQL function is used.

Health indicators

The Health Indicators perspective for database health was added to the Health Indicators package.

For more information that is related to the health indicators, see *Accessing IBM i Health Indicators Using Performance Data Investigator*, REDP-5150.

Batch model

IBM Navigator for i 7.2 provides the modeling tool for system utilization and run times of IBM i batch workloads, which is useful for analyzing and predicting batch job performance on IBM i, and helps users to know what improvements that they can do to meet a certain batch window target.

Here are the functions of the batch model in IBM Navigator for i:

- ▶ Helps users to optimize workloads by locating times during the batch window when more efficient job scheduling can improve total system throughput.
- ▶ Models workload increments.
- ▶ Predicts the changes in throughput that results from hardware upgrades (processor or disk).
- ▶ Predicts run times for individual workloads and the overall batch window.
- ▶ Models batch workloads that are CPU- or disk-intensive.

Note: The batch model functions and content package require the installation of IBM Performance Tools for i (5770-PT1) Option 1 - Manager Feature.

To open the batch model function in IBM Navigator for i, click **Performance** → **All Tasks** → **Sizing** → **Batch Model**, as shown in Figure 2-79.

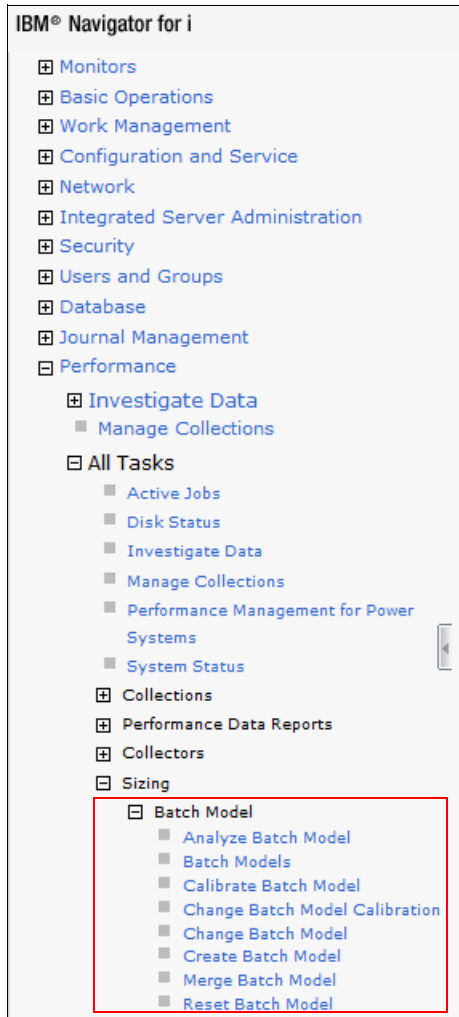


Figure 2-79 IBM Navigator for i Batch Model tasks

Note: You can also view any batch model collections in the main table under the Manage Collections options. It is also possible to use the Create Batch Model function from the Action menu under Manage Collections when selecting a valid CS collection.

Batch model collection is created based on existing performance data that is collected by Collection Services. During the process of creating a batch model, the measured data is analyzed and a model is built over the measured data.

To create a batch model, click **Performance** → **All Tasks** → **Sizing** → **Batch Model** → **Create Batch Model**. The Create Batch Model window opens, as shown in Figure 2-80. Specify the collection name and the library where the performance collection data is and click **OK**.

Figure 2-80 Create a batch model

Note: The Create Batch Model action submits a batch job to create the model. It can sometimes be a long-running operation. The creation is done when the status of the Batch Model collection is in a Complete state.

To check the status of a batch model creation, click **Performance** → **All Tasks** → **Sizing** → **Batch Model** → **Batch Models**. After the batch model creation finishes, it shows a Complete status, as shown in Figure 2-81.

Name	Library	Type	Status	Started
Q223000002	QPFRRDATA	Batch Model File Based Collection	Complete	8/11/14 3:00:02 AM

Figure 2-81 Completed batch model creation

A batch model provides the facility to change the calibration of batch model measured data if it was modeled incorrectly by the system. To do so, click **Performance** → **All Tasks** → **Sizing** → **Batch Model** → **Change Model Calibration**. Specify the batch model name to be changed and click **OK**. Users are allowed to change the storage and workload for batch model calibration. See Figure 2-82.

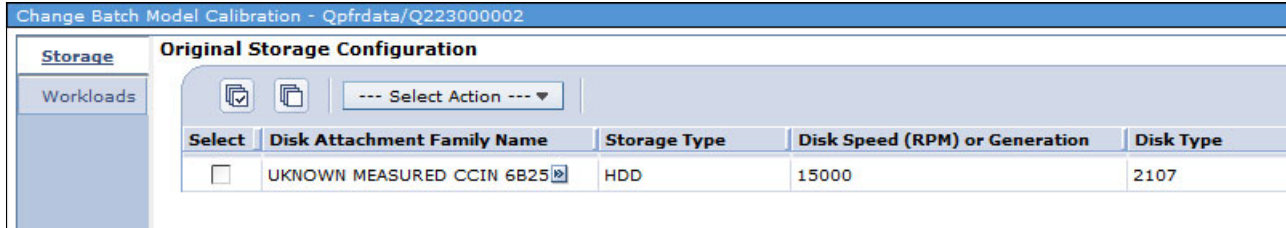


Figure 2-82 Change a batch model calibration

Note: After changing the calibration of a batch model, users are required to perform a Calibrate Batch Model action so that the system can re-create the model after the calibration changes. To calibrate the batch model, click **Performance** → **All Tasks** → **Sizing** → **Batch Model** → **Calibrate Batch Model**. Similar to creating a batch model, calibrating a batch model submits a batch job to re-create the model and can be a long-running operation.

You can use a batch model to change the batch model to model various “what if” scenarios. Users can change a batch model to the following scenarios:

- ▶ Overall system workload growth
- ▶ Processor upgrade
- ▶ Disk upgrade
- ▶ Changes to individual workloads

To specify the above “what if” changes, click **Performance** → **All Tasks** → **Sizing** → **Batch Model** → **Batch Models**, right-click the batch model result, and select **Change Model**. In the Change Batch Model window (Figure 2-83), specify the changes to the batch model and then click **OK** to apply the changes.

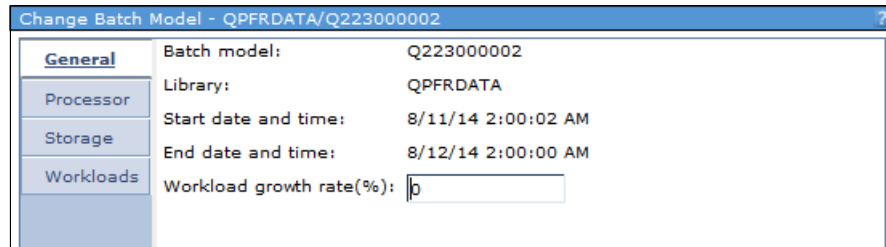


Figure 2-83 Change a batch model

As shown in Figure 2-84, you can start investigating the completed batch model by right-clicking the batch model and selecting **Investigate Results**.

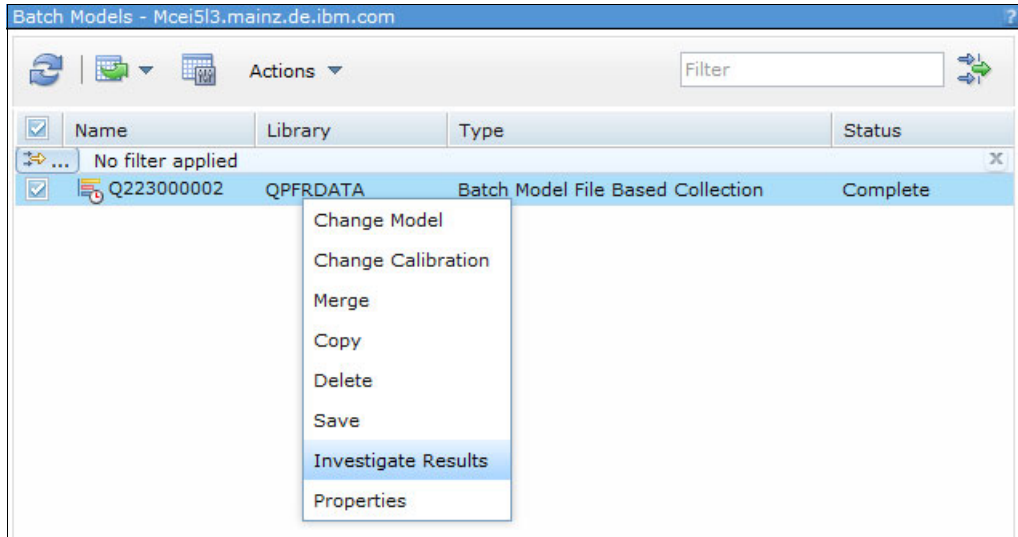


Figure 2-84 Start a batch model investigation

Figure 2-85 shows the investigation result of a batch model. The diagram shows the Measured Workload Timeline Overview, which describes the measured performance data that is collected in the Collection Services.

The diagram in Figure 2-85 shows the Modeled Workload Timeline Overview, which describes the condition of the performance that is modeled with the specified scenario. This diagram is based on PDI, so you can easily explore these diagrams and see the detail of the modeled performance.

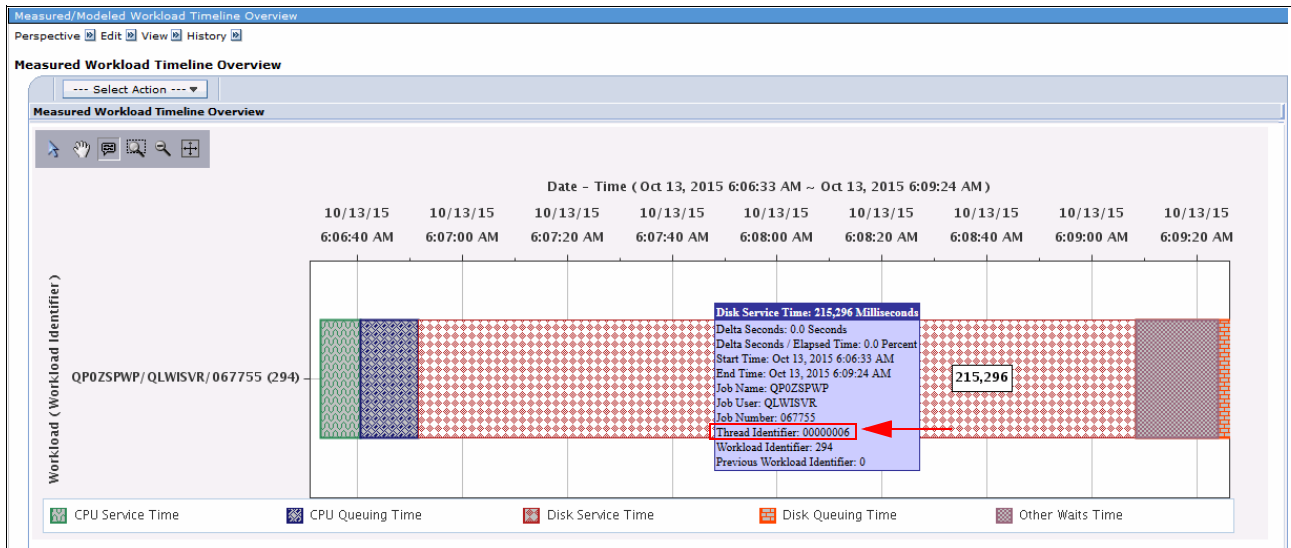


Figure 2-85 Batch model: Measured Workload Timeline Overview

Note: The thread-identifier-related information is available on tooltips.

The diagram that is shown in Figure 2-86 shows the Modeled Workload Timeline Overview, which describes the condition of the performance that is modeled with the specified scenario. This diagram is based on PDI, so you can easily explore these diagrams and see the detail of the modeled performance.

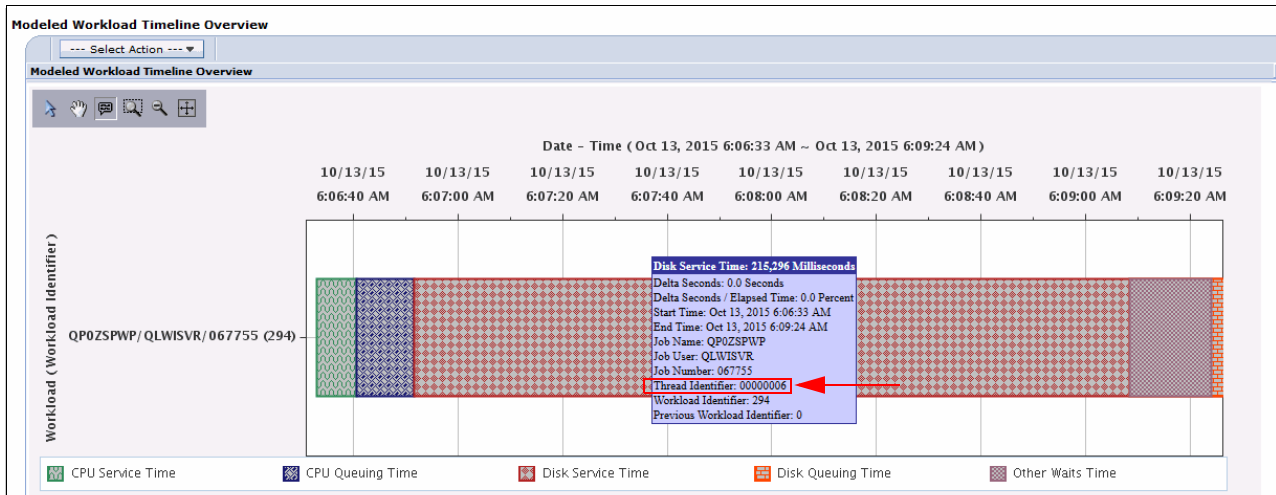


Figure 2-86 Batch model: Modeled Workload Timeline Overview

Note: The thread-identifier-related information is available on tooltips.

For more information about how to use batch model, see the *How to use the Batch Model performance tool* developerWorks article, found at the following website:

<https://www.ibm.com/developerworks/ibmi/library/i-how-to-use-the-batch-model-performance-tool/>

For more information about Batch Model, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahx/rzahxwebnavbatchmodel.htm?lang=en

Performance perspectives

IBM Navigator for i provides the following new perspectives for displaying performance data through PDI:

- ▶ Disk Reads and Writes Detail

In IBM i 7.2, users can display the disk reads and writes details. To view this information, click **Performance** → **Investigate Data** → **Collection Services** → **Disk** → **Disk Reads and Writes Detail**, as shown in Figure 2-87.

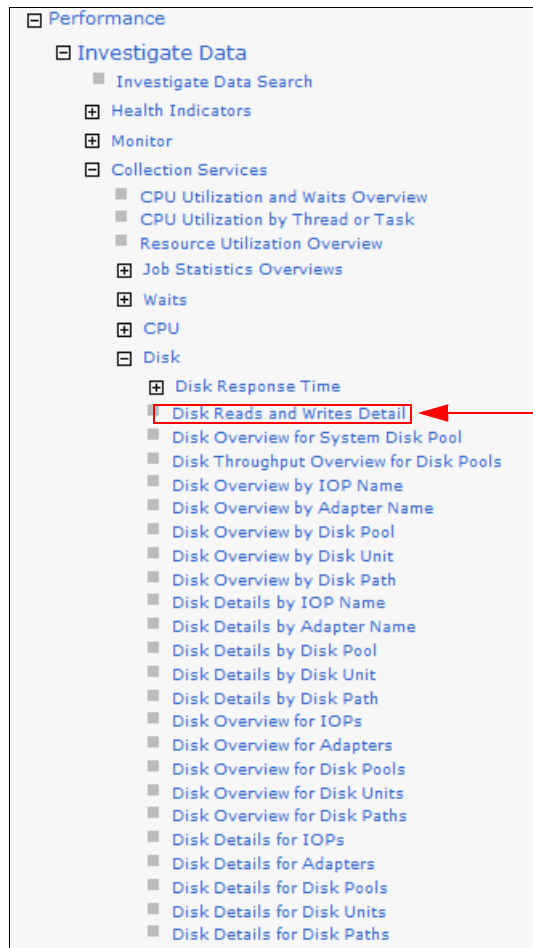


Figure 2-87 Disk Read and Writes Detail option

The Disk Reads and Writes Detail perspective contains interval measurements for Disk Storage Systems. This perspective allows users to have the following views:

- Performance Data Investigator IBM i Model DSS

This table provides details about the disk reads and writes by interval, as shown in Figure 2-88.

The following drilldowns are available:

- Disk I/O Rates Overview - Detailed
- Disk I/O Average Response Time Overview - Detailed
- Disk I/O Rates Overview with Cached Statistics - Detailed
- Disk I/O Total Response Time Overview - Detailed
- Disk I/O Total Service Time Overview - Detailed

Select	MeasureLength (Second) ^	ReadRateRnd ^	ReadRateSeq ^	ReadRate (Operations Per Second) ^	WriteRateRnd ^	WriteRateSeq ^	WriteRate (Operations Per Second) ^	WaitTime (Millisecond)
<input type="checkbox"/>	00:04:45	-1	-1	1980.91	-1	-1	589.52	
<input type="checkbox"/>	00:04:59	-1	-1	503.45	-1	-1	122.91	
<input type="checkbox"/>	00:05:00	-1	-1	415.17	-1	-1	75.24	
<input type="checkbox"/>	00:05:00	-1	-1	601.77	-1	-1	2233.49	
<input type="checkbox"/>	00:05:00	-1	-1	2270.84	-1	-1	1923.02	
<input type="checkbox"/>	00:05:00	-1	-1	3054.98	-1	-1	1562.32	
<input type="checkbox"/>	00:05:00	-1	-1	3206.51	-1	-1	1676.85	
<input type="checkbox"/>	00:04:59	-1	-1	1624.23	-1	-1	941.55	
<input type="checkbox"/>	00:05:00	-1	-1	22.48	-1	-1	4.65	
<input type="checkbox"/>	00:05:00	-1	-1	10.28	-1	-1	5.11	
<input type="checkbox"/>	00:05:00	-1	-1	4.28	-1	-1	4.55	
<input type="checkbox"/>	00:05:00	-1	-1	7.7	-1	-1	4.71	

Figure 2-88 Performance Data Investigator IBM i Model DSS

– Read/Write Rate and Response Time

This chart shows disk rate and response times, as shown in Figure 2-89. Read rate and write rate are shown as bars. Average read response time and average write response time are shown as lines.

The following drilldowns are available:

- Disk I/O Rates Overview - Detailed
- Disk I/O Average Response Time Overview - Detailed
- Disk I/O Rates Overview with Cached Statistics - Detailed
- Disk I/O Total Response Time Overview - Detailed
- Disk I/O Total Service Time Overview - Detailed

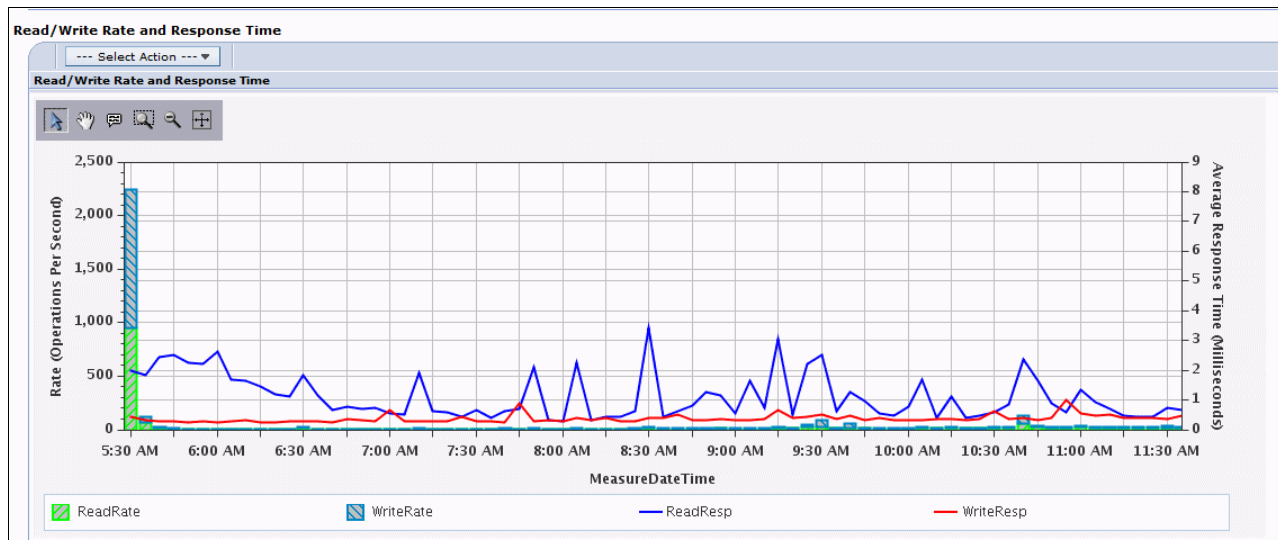


Figure 2-89 Read/Write ratio and Response Time

– Read/Write Transfer Size and Rate

This chart shows transfer size versus read rate, as shown in Figure 2-90. Read transfer size and write transfer size are shown as bars. Read rate and write rate are shown as lines on the chart.

The following drilldowns are available:

- Disk I/O Rate Overview - Detailed
- Disk I/O Average Response Time Overview - Detailed
- Disk I/O Rates Overview with Cached Statistics - Detailed
- Disk I/O Response Time Overview - Detailed
- Disk I/O Total Service Time Overview - Detailed

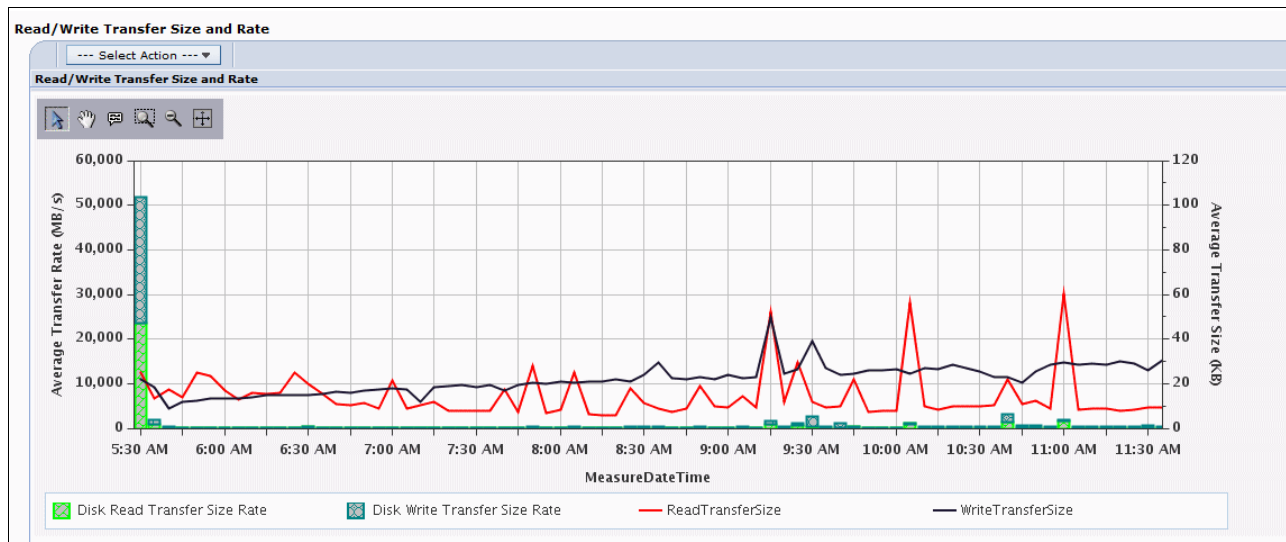


Figure 2-90 Read/Write Transfer Size and Rate

– Installed Disk Hardware

This table provides installed disk hardware information, as shown in Figure 2-91:

- ASP number
- Disk unit type
- Feature code
- RAID type
- Disk unit count
- APS capacity
- Disk used %
- Average unit size

Select	ASP Number	Disk Unit Type	Feature Code	RAID Type	Unit Count
<input type="checkbox"/>	1	SVC or Storwize		None	

Figure 2-91 Installed Disk Hardware

► Storage Allocation/Deallocation

In IBM i 7.2, users can display the storage allocation and deallocation from PDI. To view this information, click **Performance** → **Investigate Data** → **Collection Services** → **Storage Allocation**, as shown in Figure 2-92.

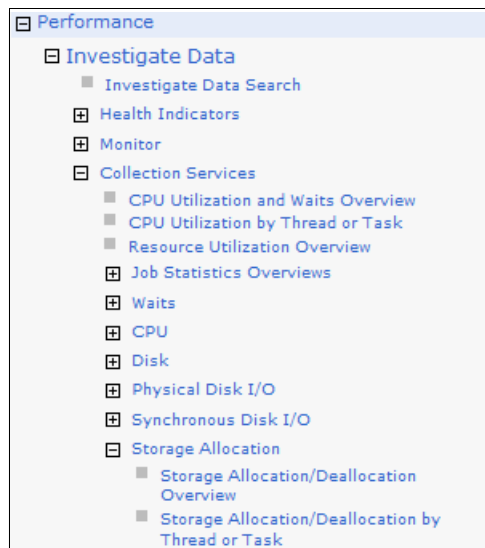


Figure 2-92 Storage Allocation tasks

The storage Allocation/Deallocation perspective allows users to view the following functions:

- Storage Allocation/ Deallocation Overview

This chart shows allocation and deallocation of the temporary and permanent storage for all contributors over time for the selected collections. Use this chart to select a time frame for further detailed investigation.

Figure 2-93 shows the Storage Allocation/Deallocation Overview.

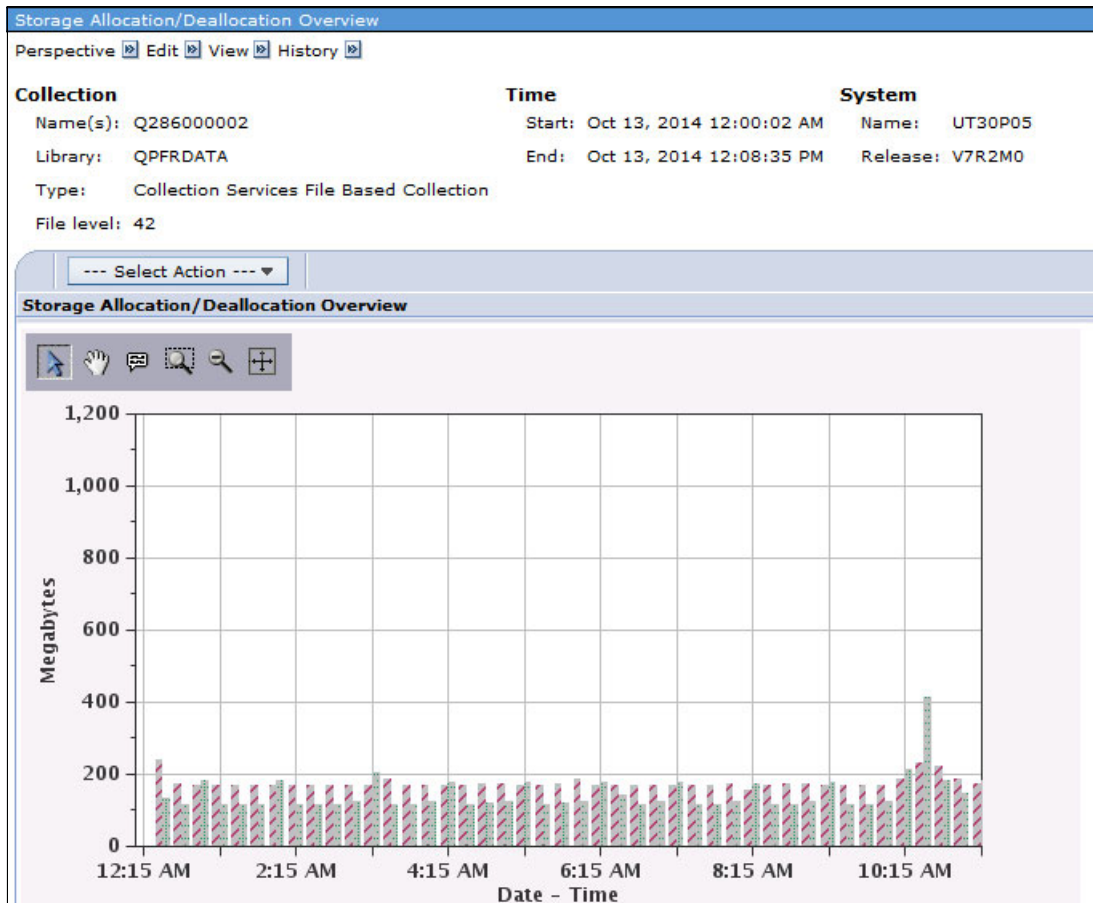


Figure 2-93 Storage Allocation/Deallocation Overview perspective

- Storage Allocation/ Deallocation by Thread or Task

This chart shows allocation and deallocation of the temporary and permanent storage, and the net frames that are requested by thread or task. Use this chart to select a thread or task for viewing its storage statistics over time.

Figure 2-94 on page 83 shows the Storage Allocation/Deallocation by thread or task.

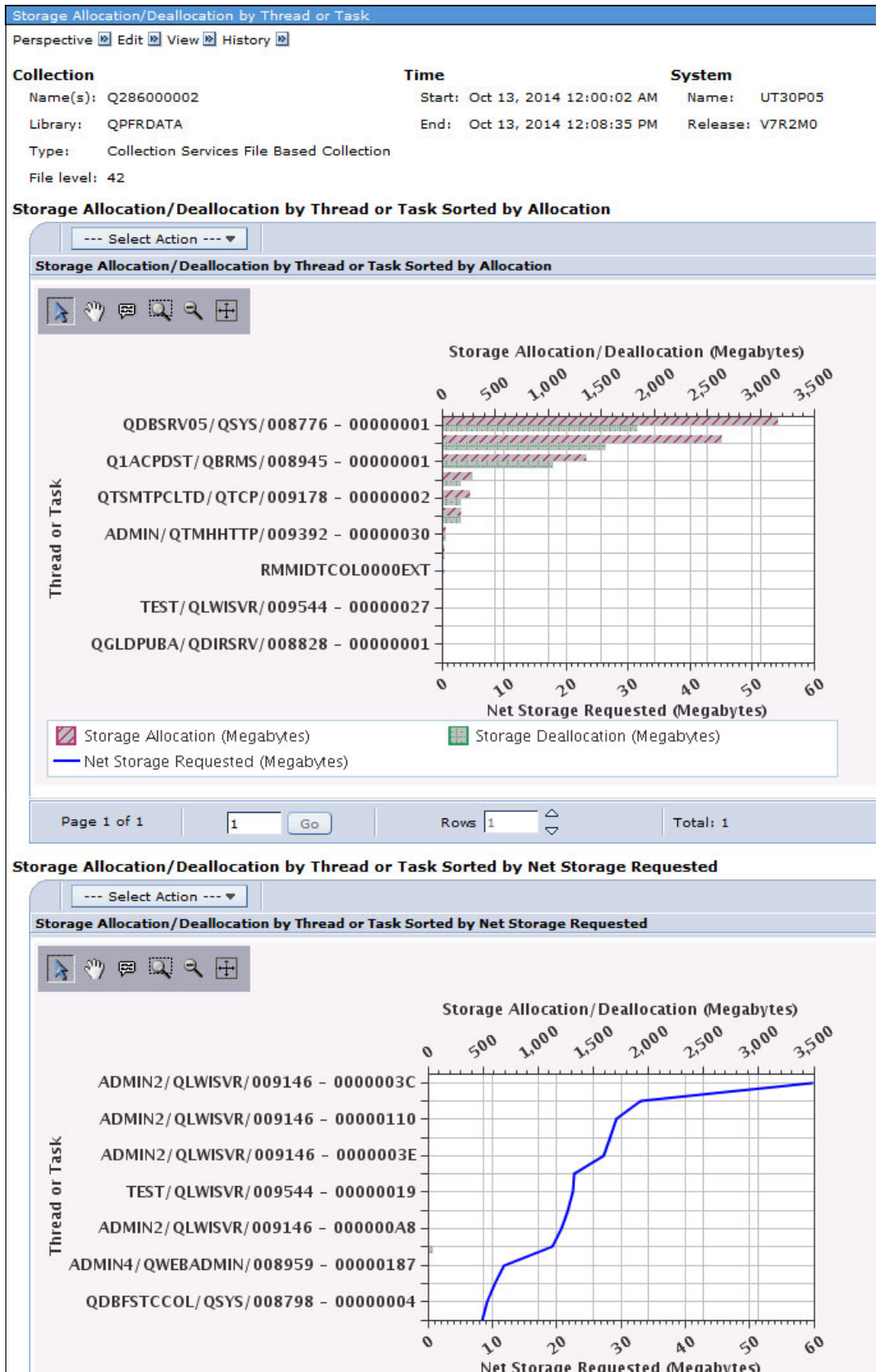


Figure 2-94 Storage Allocation/Deallocation by thread or task

► Memory

IBM Navigator for i provides the capability to view system performance from a memory point of view through PDI. To view the memory perspective, click **Performance** → **Investigate Data** → **Collection Services** → **Memory**, as shown in Figure 2-95.

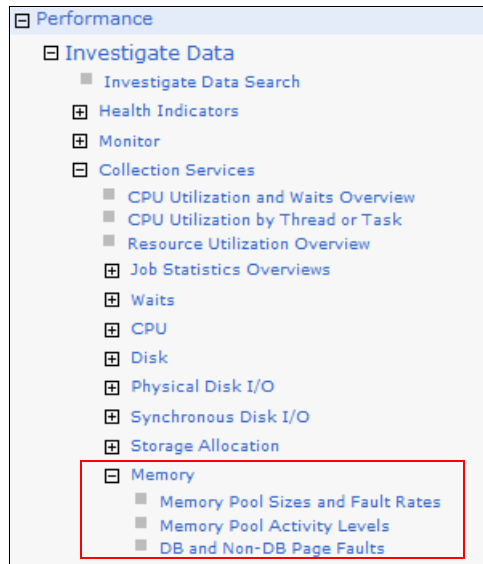


Figure 2-95 Memory perspective in PDI

You can use memory perspective in PDI to view the following memory performance data:

- Memory Pool Sizes and Fault Rates

This chart shows the memory pool sizes and page fault rates for all memory pools on the system over time for the selected collection or collections. Use this chart to select a specific memory pool for further detailed investigation.

Figure 2-96 shows an example of viewing memory pool size and fault rates over time from a system.

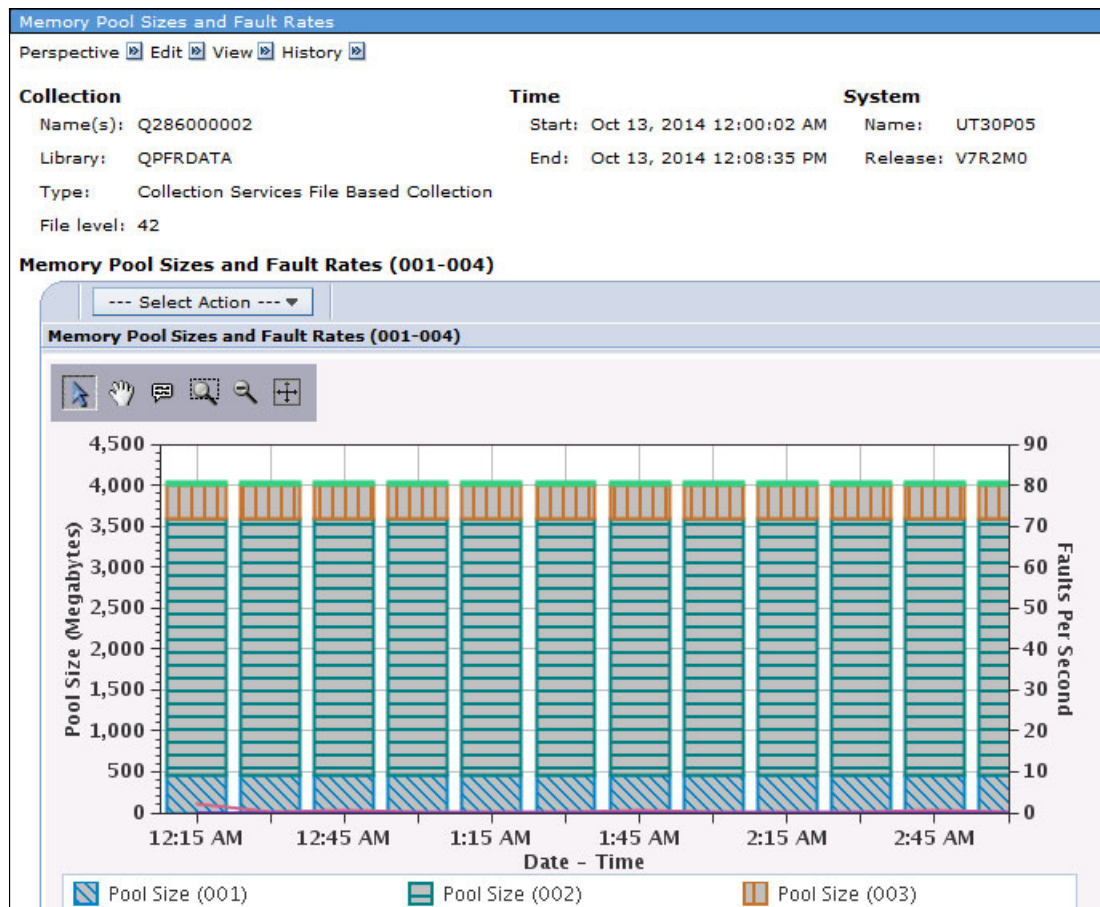


Figure 2-96 Memory pool sizes and fault rates in PDI

– Memory Pool Activity Levels

This chart shows the average memory activity levels and the number of transitions from the active or wait states to the ineligible state per second for all memory pools on the system over time for the selected collection or collections. Use this chart to select a specific memory pool for further detailed investigation.

Figure 2-97 shows an example of viewing memory pool activity level over time from a system.

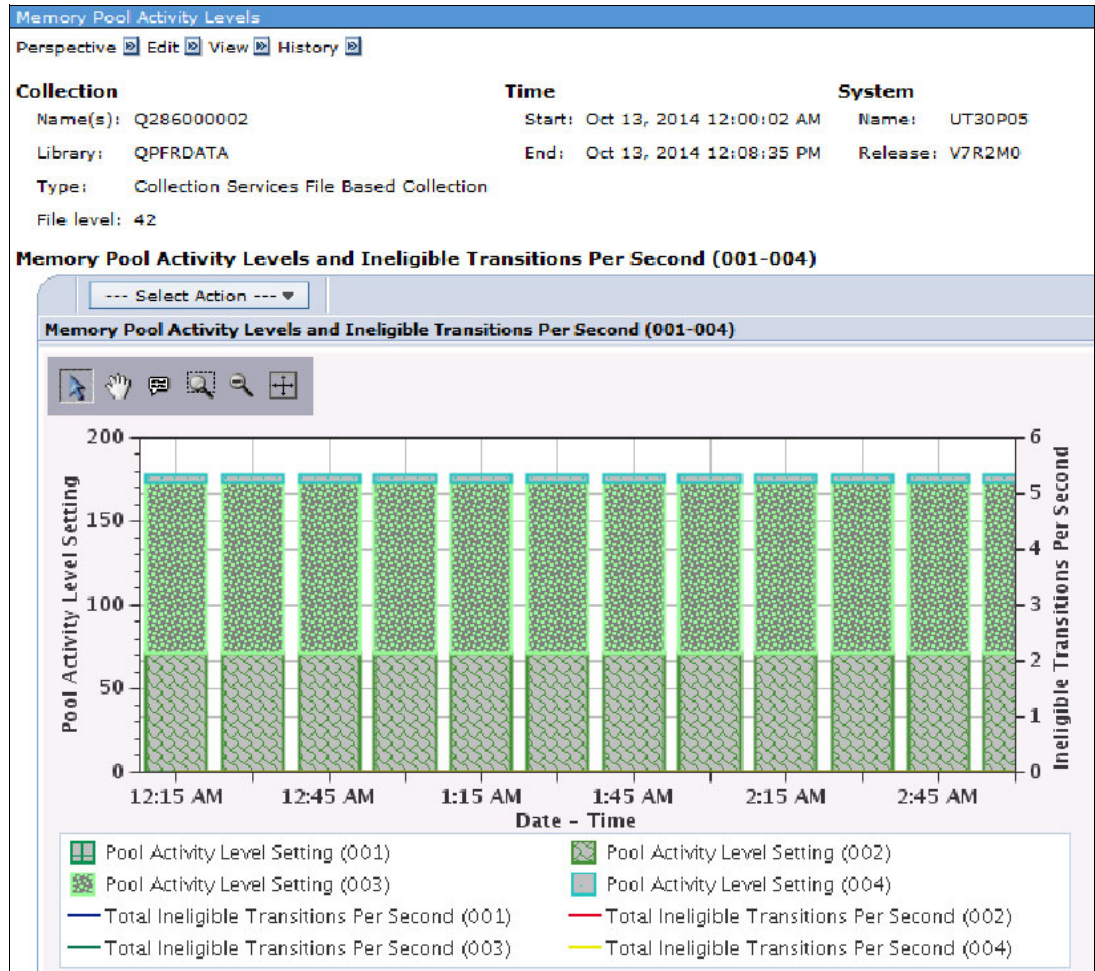


Figure 2-97 Memory pool activity levels over time in PDI

- DB and Non-DB Page Fault

This chart shows the database and non-database page fault rates for all memory pools on the system over time for the selected collection or collections. Use this chart to select a specific memory pool for further detailed investigation.

Figure 2-98 shows an example of viewing database and non-database page fault rates over time in a system.

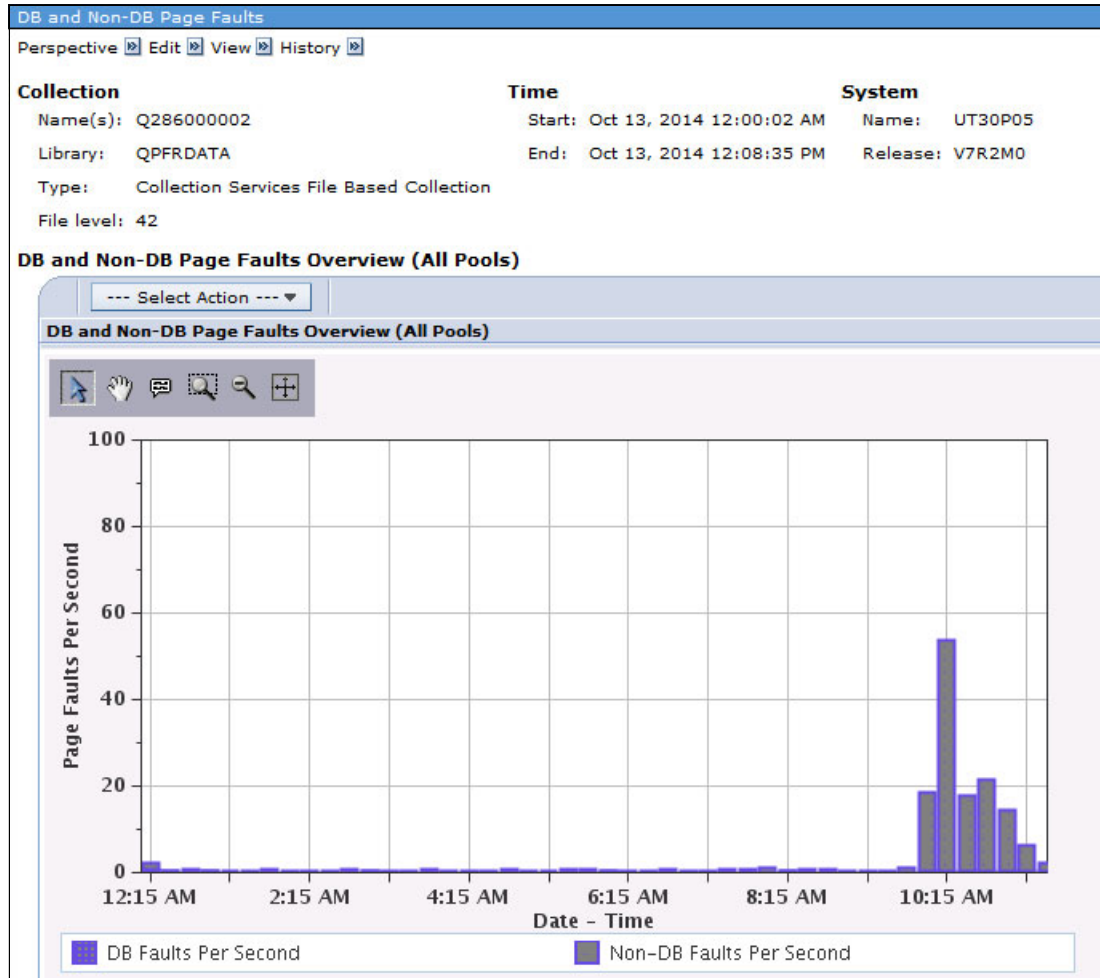


Figure 2-98 Database and non-database page faults overview in PDI

► Java

IBM Navigator for i 7.2 provides the capability of viewing memory that is consumed by IBM Technology for Java through the Java perspective in PDI. This ability enables users to monitor and investigate the performance of their Java application over time.

To view the Java perspective, click **Performance** → **Investigate Data** → **Collection Services** → **Java**, as shown in Figure 2-99.

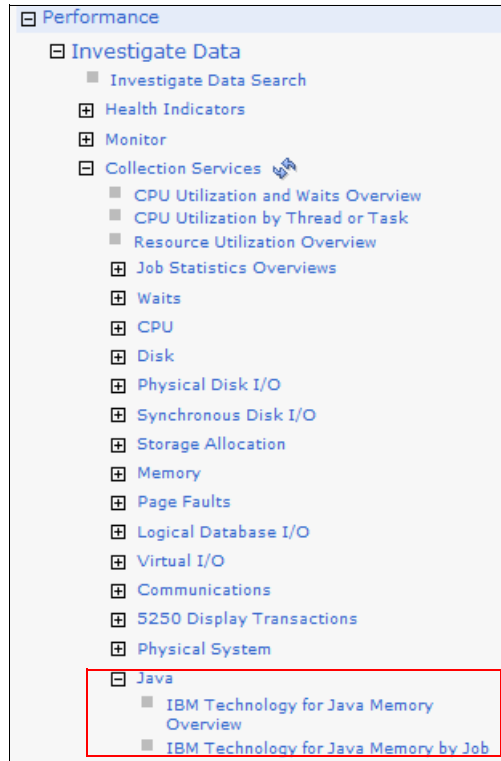


Figure 2-99 Java perspective menu in PDI

You can use Java perspectives to view the following charts:

- IBM Technology for Java Memory Overview

This chart shows garbage collection information, including heap sizes and other general information that is related to JVM memory.

Figure 2-100 shows an example of memory that is consumed by Java over time.

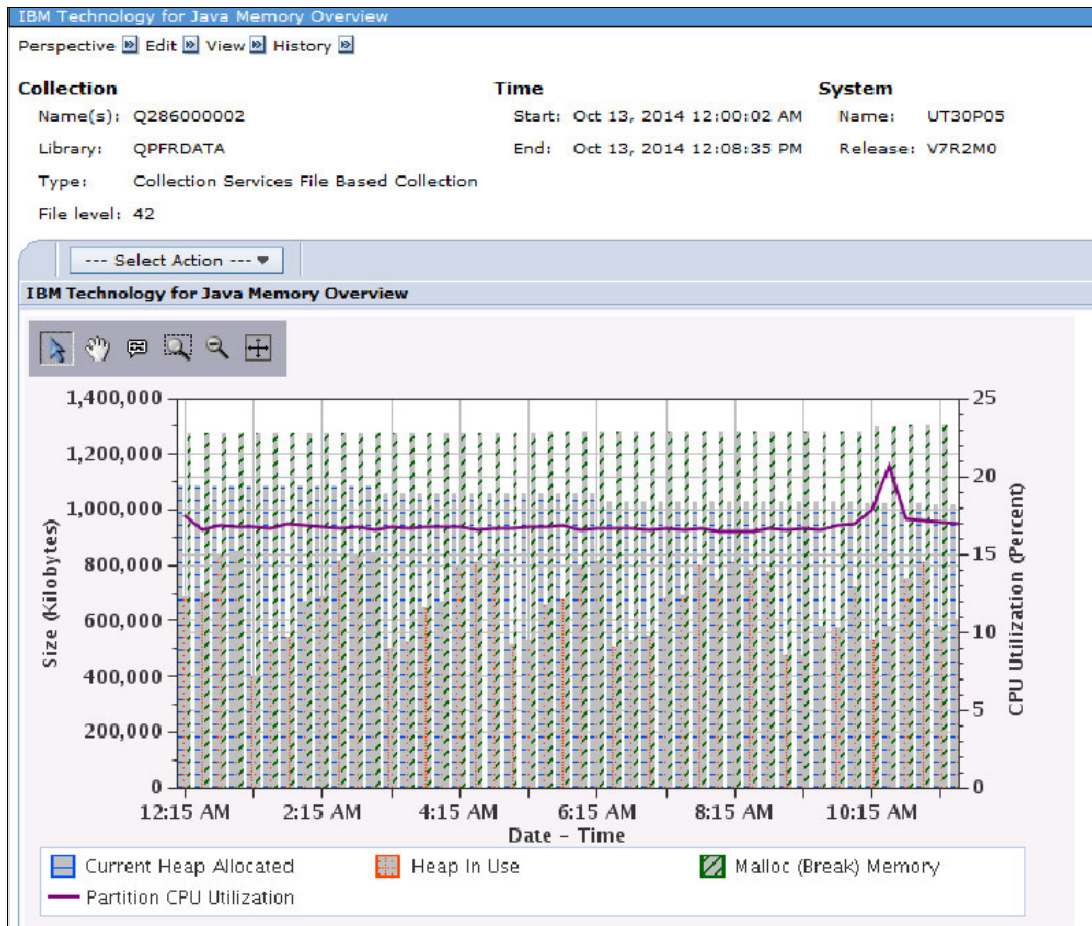


Figure 2-100 Java memory graph in PDI

– IBM Technology for Java Memory by Job

This chart shows average and peak garbage collection information, including heap sizes and other general information that is related to JVM memory by job.

Figure 2-101 shows the Java memory consumption per job.

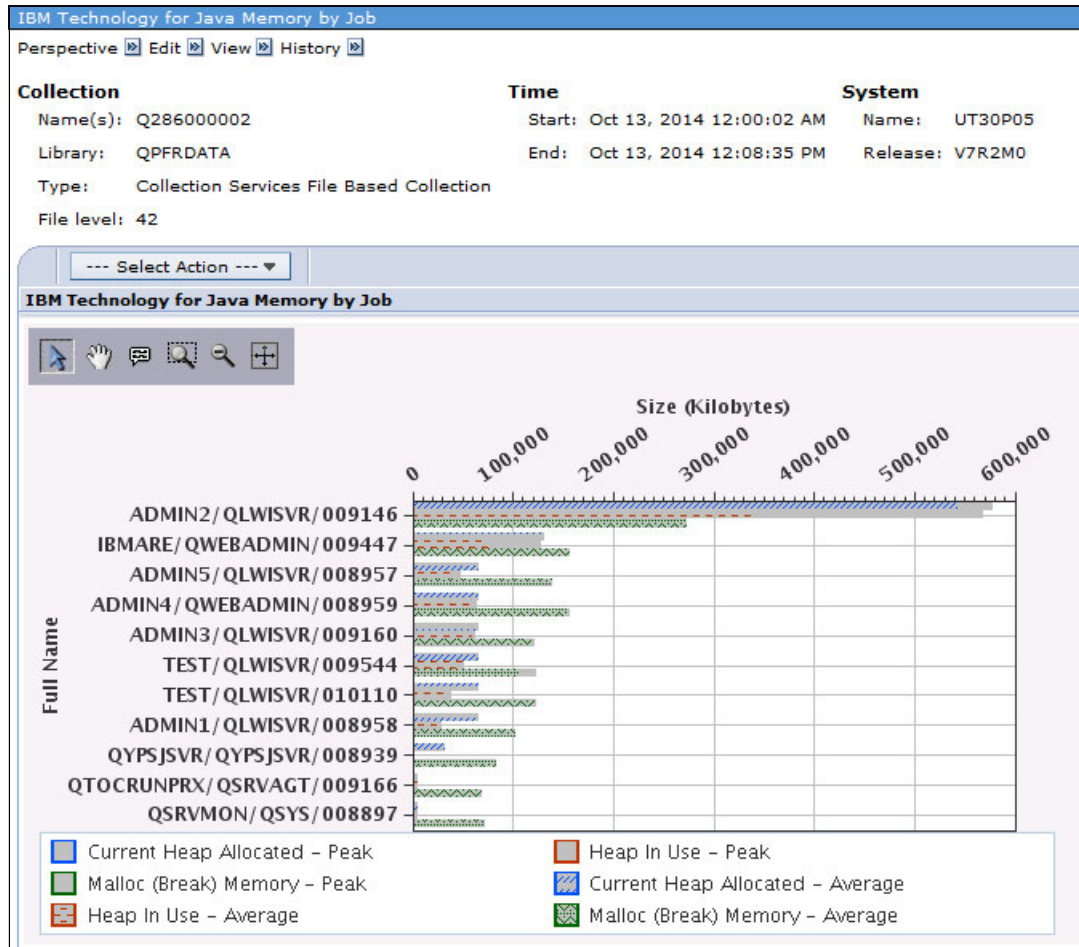


Figure 2-101 Java memory by job in PDI

► Temporary storage

IBM Navigator for i also provides the capability of viewing temporary storage allocation and deallocation through the Temporary Storage perspective in PDI. To view the temporary storage perspective, click **Performance** → **Investigate Data** → **Collection Services** → **Storage Allocation** → **Temporary Storage**, as shown in Figure 2-102.

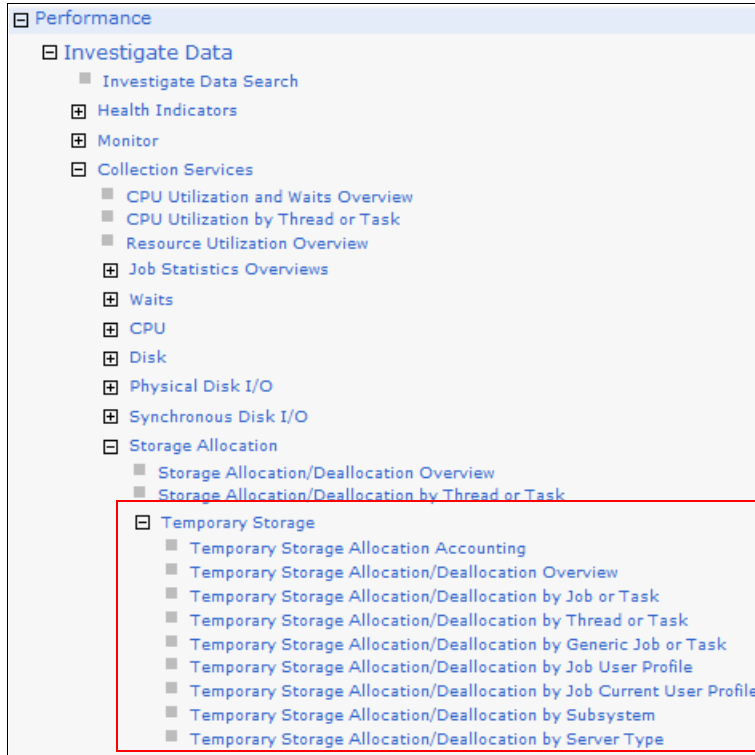


Figure 2-102 Temporary Storage perspective in PDI

You can use Temporary Storage perspectives to view the following charts:

– Temporary Storage Allocation Accounting

This chart shows the amount of temporary storage that is charged to active and ended jobs, the amount of user temporary storage, and the amount of temporary storage that is used for database and non-database operations by the IBM i operating system across the system over time for the selected collections. Use this chart to select a time frame for further detailed investigation.

– Temporary Storage Allocation/Deallocation Overview

This chart shows allocation and deallocation of the temporary storage for all contributors over time for the selected collections. Use this chart to select a time frame for further detailed investigation.

– Temporary Storage Allocation/Deallocation by Job or Task

This chart shows allocation and deallocation of the temporary storage by job or task. Use this chart to select a job or task for viewing its temporary storage statistics over time.

– Temporary Storage Allocation/Deallocation by Thread or Task

This chart shows allocation and deallocation of the temporary storage by thread or task. Use this chart to select a thread or task for viewing its temporary storage statistics over time.

- Temporary Storage Allocation/Deallocation by Generic Job or Task
This chart shows allocation and deallocation of the temporary storage by generic job or task. Use this chart to select a generic job or task for viewing its temporary storage statistics over time.
- Temporary Storage Allocation/Deallocation by Job User Profile
This chart shows allocation and deallocation of the temporary storage by job user profile. Use this chart to select a job user profile for viewing its temporary storage statistics over time.
- Temporary Storage Allocation/Deallocation by Job Current User Profile
This chart shows allocation and deallocation of the temporary storage by job current user profile. Use this chart to select a job current user profile for viewing its temporary storage statistics over time.
- Temporary Storage Allocation/Deallocation by Subsystem
This chart shows allocation and deallocation of the temporary storage by subsystem. Use this chart to select a subsystem for viewing its temporary storage statistics over time.
- Temporary Storage Allocation/Deallocation by Server Type
This chart shows allocation and deallocation of the temporary storage by server type. Use this chart to select a server type for viewing its temporary storage statistics over time.

2.1.10 Security

In IBM i 7.2, the security wizard support can be enabled in IBM Navigator for i by clicking **Security** → **All Tasks** → **Configure**, as shown in Figure 2-103.

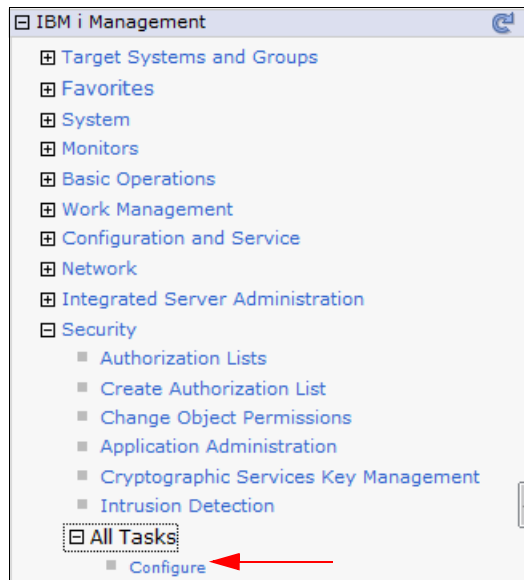


Figure 2-103 Start the Security wizard

This action starts the Security Wizard interface, as shown in Figure 2-104. You can use this wizard to perform the following functions:

- ▶ Create a set of security recommendations.
- ▶ Create reports explaining the security recommendations.
- ▶ Optionally, apply the recommendations to the system.



Figure 2-104 Security wizard

2.1.11 Network

Enterprise Identity Mapping (EIM) support can be enabled in IBM Navigator for i in IBM i 7.2 by clicking **Network** → **Enterprise Identity Mapping**, as shown in Figure 2-105.

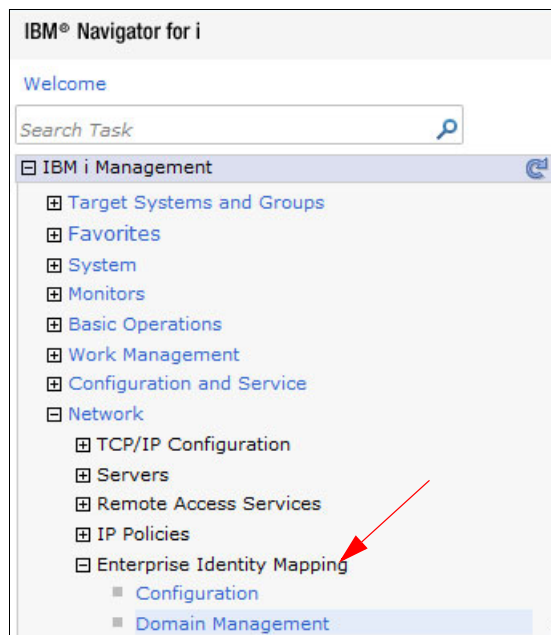


Figure 2-105 Enterprise Identity Mapping

EIM allows administrators and application developers to solve the issue of managing multiple user registries across the enterprise. The EIM migration is described in two parts:

- ▶ EIM configuration
- ▶ EIM domain management

EIM configuration

The EIM configuration includes the following items:

- ▶ EIM configuration wizard
- ▶ Configuration list
- ▶ Configuration actions

The configuration wizard guides you through the configuration of the system to participate in an EIM domain.

EIM domain management

The EIM domain management describes all objects and actions that are related to the EIM domain, which includes the Domain folder actions, the User Registries subfolder actions, the Identifier subfolder actions, the User Registry object actions, and the Identifier object actions.

2.1.12 Omnifind Text Search

The ability to search text from files in the integrated file system (IFS) and spooled files in output queues was added to IBM Navigator for i for IBM i 7.2. To use this function, click **System** → **Search**, as shown in Figure 2-106.

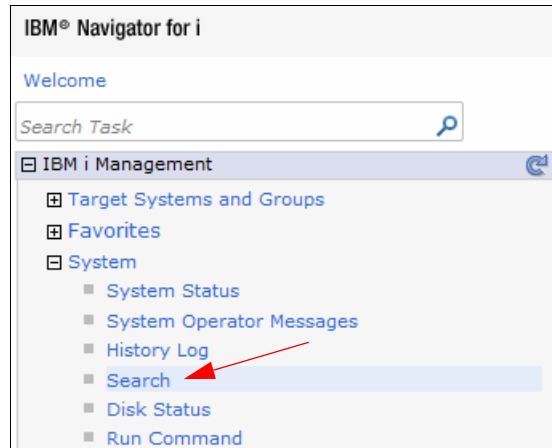


Figure 2-106 Omnifind Text Search

Note: The IBM OmniFind® product (5733-OMF) must be installed on the system to use this function.

In IBM i 7.2, OmniFind supports indexing the files from the top level of the directories and from the subdirectories of the directories recursively. From IBM Navigator for i, there is the possibility to search text from IFS and spool files without needing to understand stored procedures.

For more information about OmniFind Text Search, see 8.9, “OmniFind Text Search Server for DB2 for i” on page 412 and IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzash/rzashkickoff.htm?lang=en

2.1.13 Disk management

In IBM Navigator for IBM i 7.2, the concurrent removal of disk units can be enabled from an ASP and from an IASP that is varied on.

After selecting the disk unit, you are prompted to confirm its removal from the ASP, as shown in Figure 2-107.

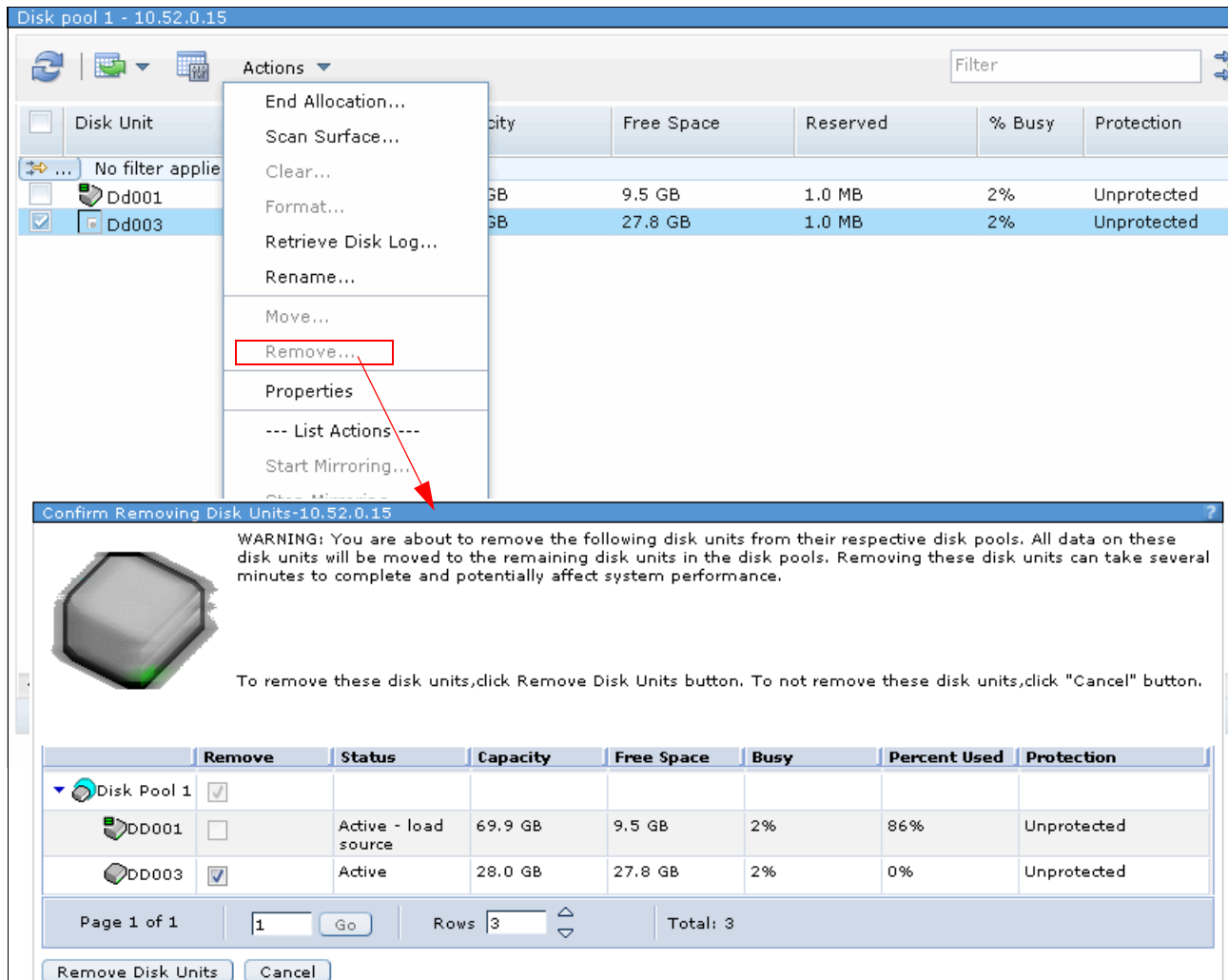


Figure 2-107 Confirmation of the concurrent removal of a disk unit from an ASP

After the removal is started, you can perform the following actions, as shown in Figure 2-108:

- ▶ Pause
- ▶ Resume
- ▶ Cancel

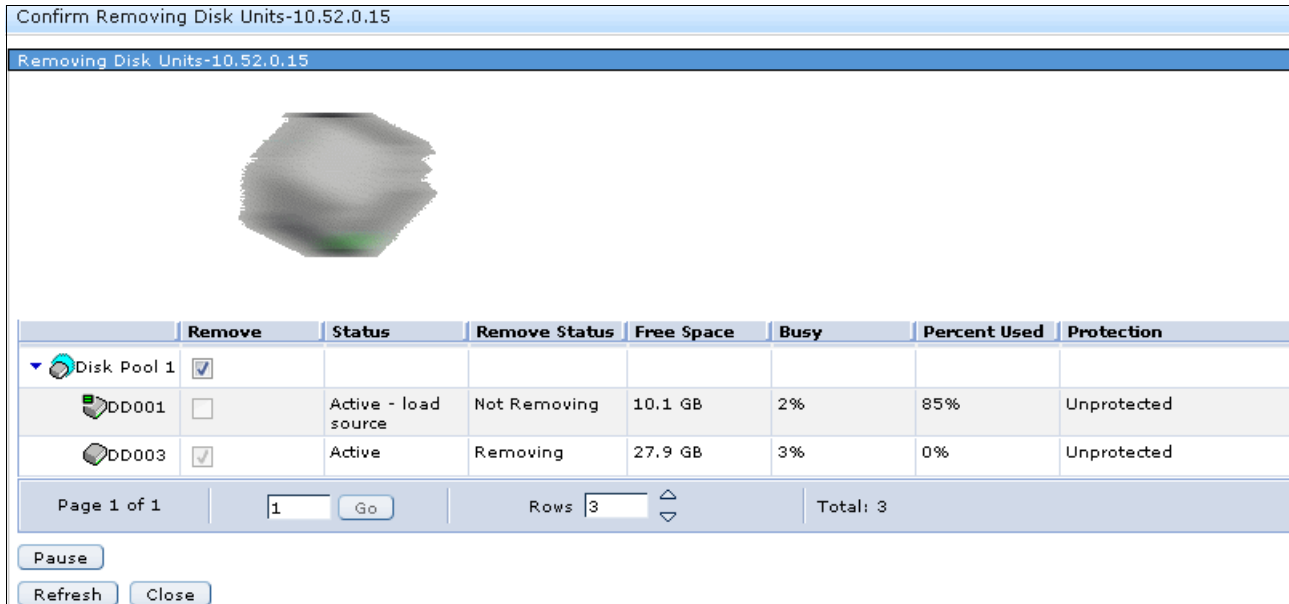


Figure 2-108 Removal of disk units from ASP: available actions

You also can pause the disk unit removal process and afterward cancel the running process if necessary, as shown in Figure 2-109.

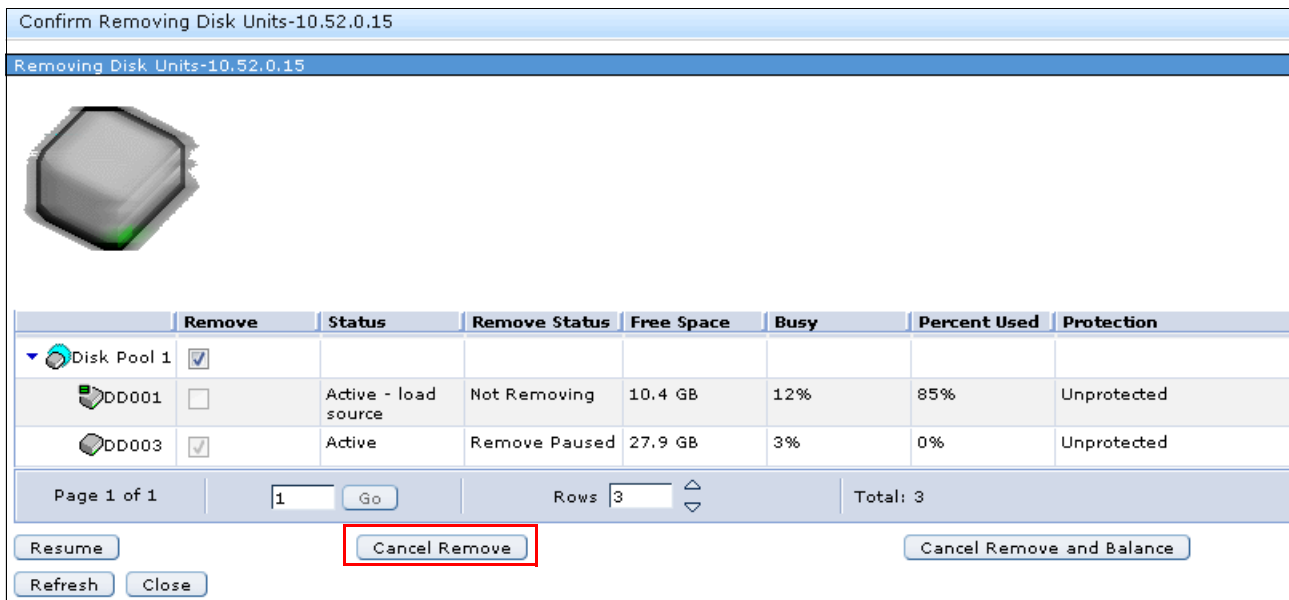


Figure 2-109 Cancel the disk unit removal process

As shown in Figure 2-110, a Solid State Drive column was added to the disk units list to indicate whether the disk unit is a solid-state drive (SSD). Previously, you could not find the SSD information from the type and model of some drives.

Disk Unit	Status	Capacity	Solid State Drive	Free Space	Reserved	% Busy	Protection
No filter applied							
Dd001	Active - load source	69.9 GB	No	10.2 GB	1.0 MB	2%	Unprotected
Dd003	Active	28.0 GB	No	27.9 GB	1.0 MB	2%	Unprotected

Figure 2-110 Solid State Drives column

In IBM Navigator for IBM i 7.2, some of the user access restrictions on IBM Navigator for i were removed, which means users can have a different user ID and password for IBM i and within System Service Tools (SST), as shown in Figure 2-111.

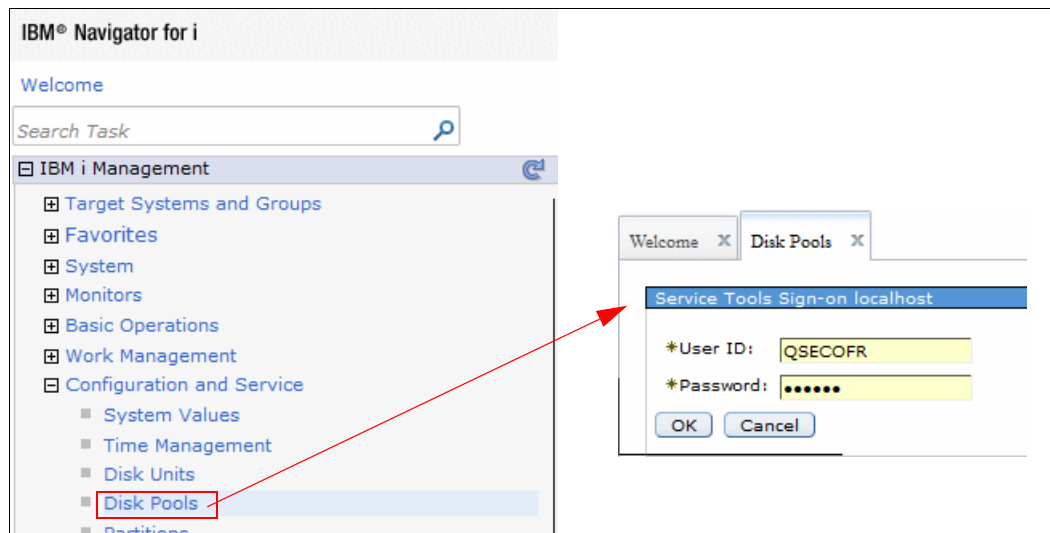


Figure 2-111 Service tools: disk management tasks access

Note: In IBM i 7.2 IBM Navigator for i, a user can access the disk management tasks in the same way they do in IBM i Navigator, that is, by using a service tools user that is independent from the IBM i profile that is used to sign on to the system.

If you have a matching service tools user ID and IBM i user ID, the sign-on window does not open and you access the disk management functions as usual. If that fails, a sign-on window opens asking for the service tool user ID and password.

The first time that you access disk management functions, if your service tools user ID and password do not match your IBM i user ID and password, the sign-on window opens. After you get access to the disk management functions, you do not need to sign on again, even if you log out and log in. If your service tools user ID or password is changed or expired, when you access disk management interface, an error message is displayed and the sign-on window opens again.

As shown in Figure 2-112, the following actions were added for disk pools:

- ▶ Start tracing.
- ▶ Stop tracing.
- ▶ Clear trace.
- ▶ Start balance.

You can use these actions to trace the hot data on each disk unit in the specific disk pool and balance them in the disk pool by different balance types.

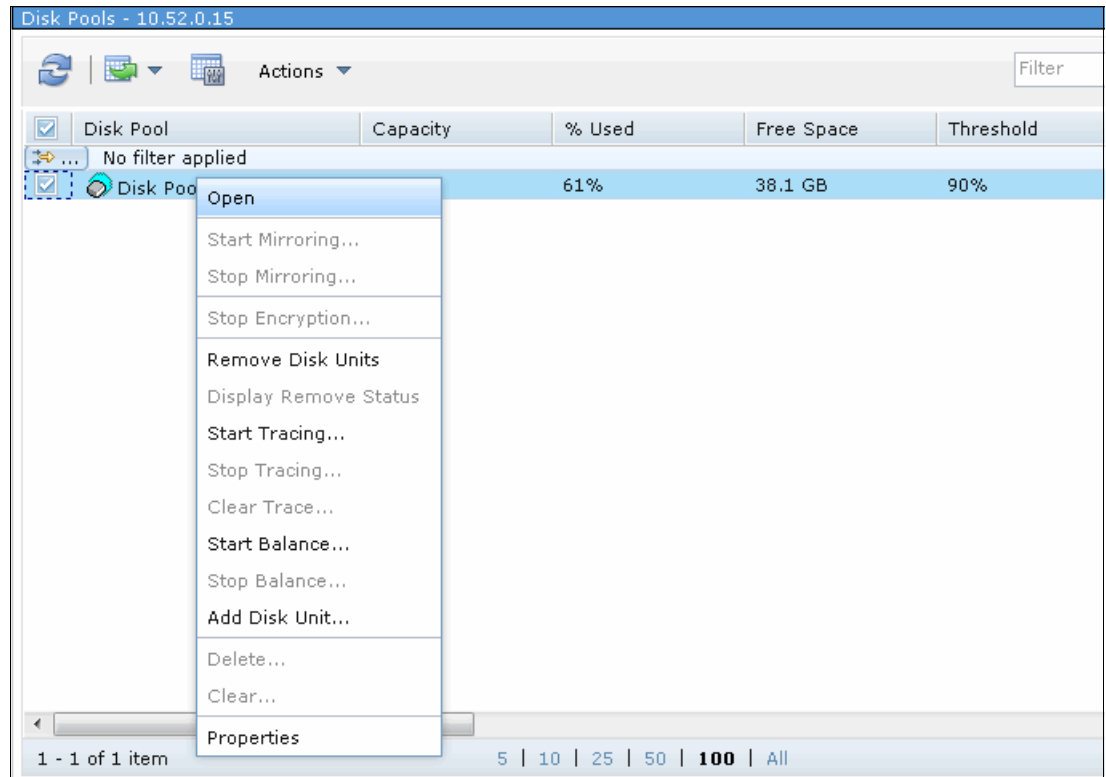


Figure 2-112 Disk pool menu

As shown in Figure 2-113, the rebuild disk unit data action is added for disk units, which users can use to rebuild data on a failed disk unit within a parity set.

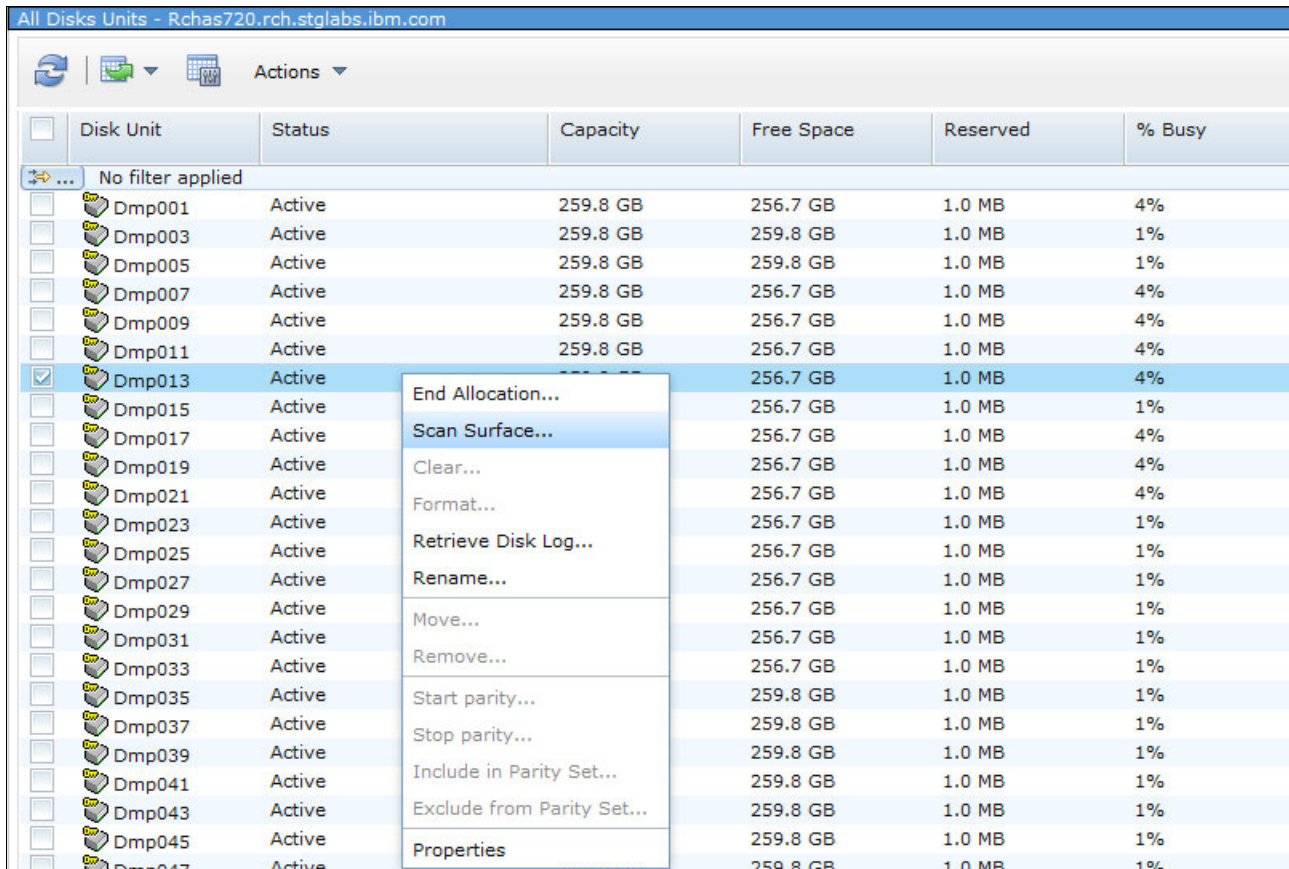


Figure 2-113 Rebuild disk unit data: failed disk within RAID protected set

The following options are available for the user, as shown in Figure 2-114:

- ▶ Stop allocating data on specific disk units.
- ▶ Resume allocating data on specific disk units.

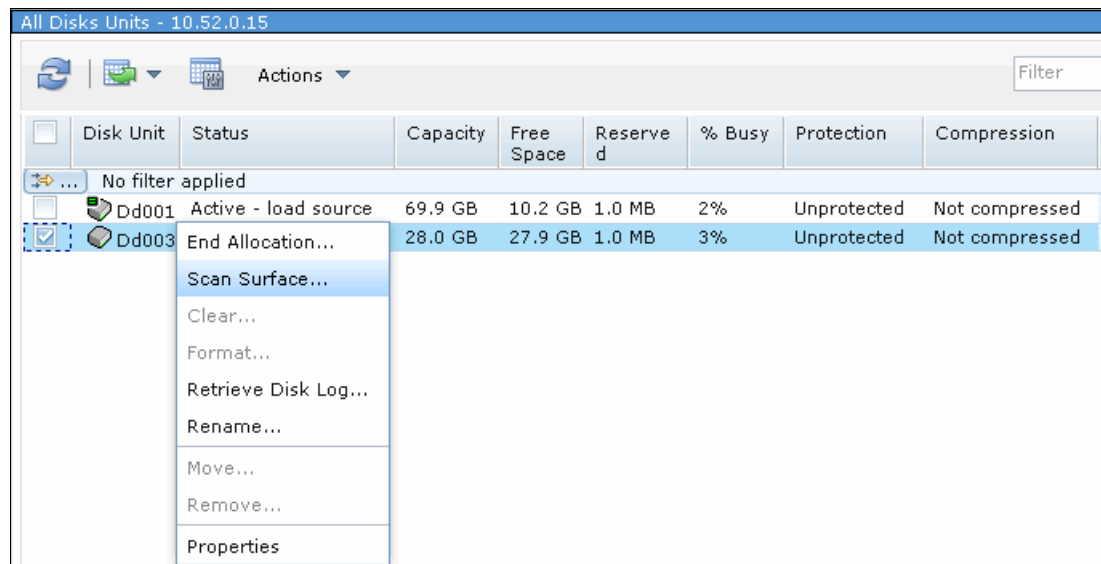


Figure 2-114 Stop and resume allocating data to disk units

2.1.14 Partition management

Within IBM Navigator for i, you can now perform the following partition management tasks:

- ▶ Create a partition.
- ▶ Work with existing partitions.

Creating a partition

In IBM Navigator for i 7.2, you can create a partition, as shown in Figure 2-115, by clicking **Configuration and Service** → **Create Partition**.



Figure 2-115 Create a partition

This starts the Create Partition Wizard, where you can define the partition properties (Figure 2-116).

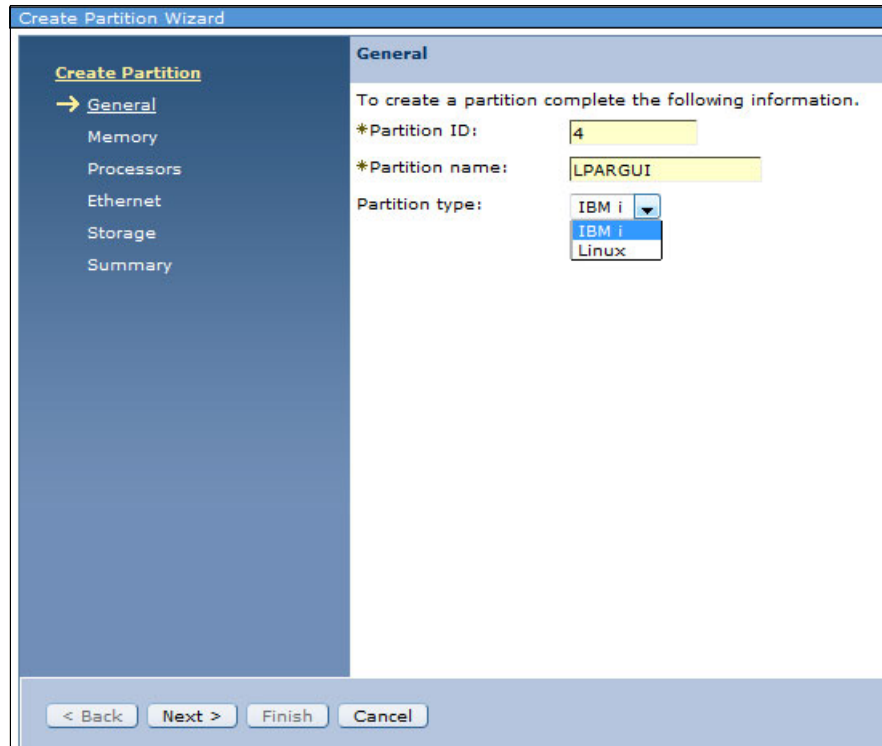


Figure 2-116 Create Partition Wizard

From the Create Partition Wizard, you can define the following parameters for the partition:

- ▶ **General:** Specify the partition ID, partition name, and partition type (IBM i or Linux).
- ▶ **Memory:** Specify the memory to be assigned to the partition. The minimum memory that is needed for a partition to complete successfully an IPL is 128 MB. The maximum allowed memory is the current available memory. Partitions must have memory that is assigned in multiples of the memory region size.
- ▶ **Processors:** Specify the number of processors and the processing mode (dedicated or shared processor pool).
- ▶ **Ethernet:** Configure the virtual Ethernet setup.
- ▶ **Storage:** Select the virtual disk to be assigned to the partition.

Note: Virtual Partition Manager (VPM) does not provide the function of assigning the storage resource to the new partition, such as virtual disk, optical device, and physical disks. You must use the Create Network Server Description (**Create NWSD**) CL command for the new partition and then link the storage device to the new partition by using the Add Server Storage Link (**ADDNWSSTGL**) CL command.

Working with partitions

You can work with the existing partitions within IBM Navigator for i, as shown in Figure 2-117.

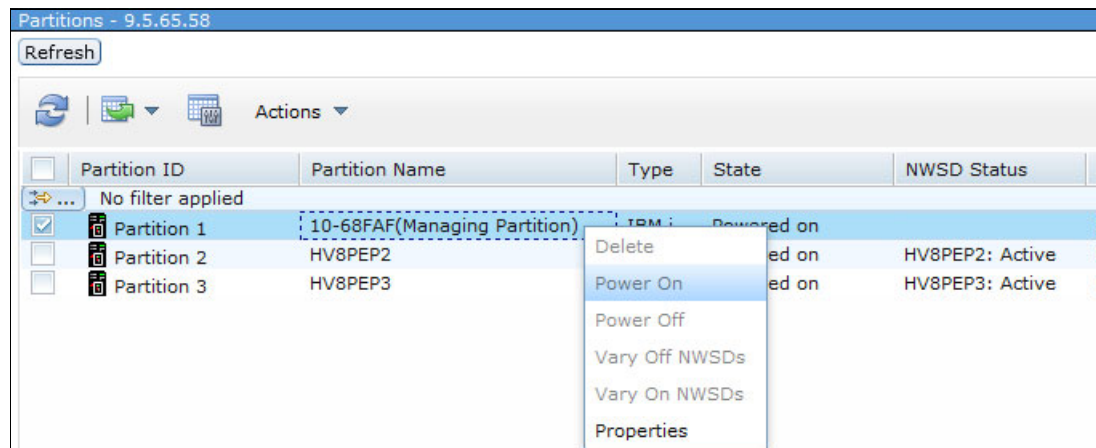


Figure 2-117 Work with partitions in IBM Navigator for i

The following options are available for working with existing partitions on the system:

- ▶ Delete
- ▶ Power on
- ▶ Power off
- ▶ Vary off NWSDs
- ▶ Vary on NWSDs
- ▶ Properties

For more information about the partition management interface in IBM Navigator for i 7.2, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/7.2%20Content%20and%20Changes>

For more information about VPM, see *Creating IBM i Client Partitions Using Virtual Partition Manager*, REDP-4806.

For more information about virtualization in IBM i 7.2, see 3.3.1, “Virtual Partition Manager GUI in IBM Navigator for i” on page 205.

2.1.15 Support for additional system values

A limited number of system values were missing from the IBM Navigator for i interface. With IBM i 7.2, those missing system values are added, including those dealing with network attributes.

Click **Configuration and Service** → **System Values**, as shown in Figure 2-118. Right-click the **Network** category and select **Properties**.

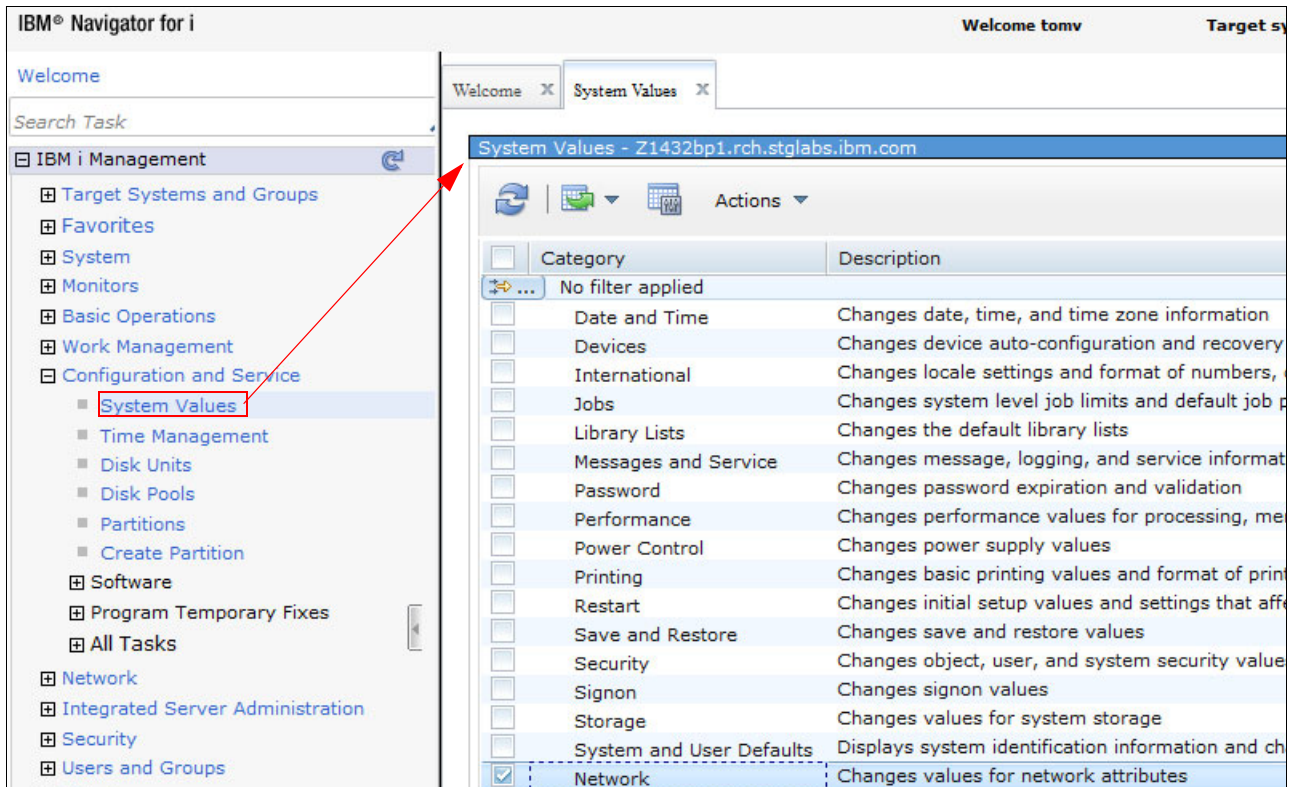


Figure 2-118 Display system values in IBM Navigator for i

The Network Attributes System Values window opens, as shown in Figure 2-119.

Network Attributes System Values - Localhost

Network Attributes

System name (SYSNAME): Z1432BP1

Pending system name (PNDSYSNAME):

Local network ID (LCLNETID): APPN

Local control point name (LCLCPNAME): Z1432BP1

Default local location name (LCLLOCNAME): Z1432BP1

Default mode (DFTMODE): BLANK

Data compression (DTACPR): *REQUIRE

Intermediate data compression (DTACPRINM): *NONE

Maximum intermediate sessions (MAXINTSSN): 200

Route addition resistance (RAR): 128

Node type (NODETYPE): *ENDNODE

Network node servers (NETSERVER)

Server network ID: Add

Control point name: Remove

Current network node servers (<= 5 items):

- *LCLNETID *ANY

Network server domain (NWSDOMAIN): S10AFD8R

Alert primary focal point (ALRPRIFP): *NO

Alert default focal point (ALRDFTFP): *NO

Alert backup focal point (ALRBCKFP)

Network ID: *NONE

Control point name:

Alert focal point to request (ALRRQSFP)

Network ID: *NONE

Control point name:

Alert filter (ALRFTR)

Filter name: *NONE

Library:

Figure 2-119 Network attributes system values

2.1.16 Integrated server administration

The following enhancements that are related to the integrated server support were added to IBM i 7.2:

- ▶ “Resource allocation priority” on page 104
- ▶ “4 K disk units sector support” on page 106
- ▶ “Solid-state drive support” on page 108
- ▶ “Restricted/allowed resources” on page 109
- ▶ “Storage pool size limit” on page 111
- ▶ “Windows Server 2012 support” on page 112
- ▶ “Windows Server 2003 support removed” on page 113
- ▶ “Creating quorum disks function removed” on page 113
- ▶ “No support for IXS and IXA hardware” on page 113
- ▶ “Integrated server cloning” on page 114

Resource allocation priority

The resource allocation priority is used to define the cost of the hosting IBM i resources when formatting the storage spaces that are linked to the client servers.

In IBM i 7.2, when the resource allocation priority parameter is used the Create NWS Storage Space (**CRTNWSSTG**) CL command, it defines a range of 1 - 9 to indicate how many resources should be given to the process that zeros out the disk during a format request:

- ▶ A lower value requires more time to complete a format, but consumes fewer resources from the host system.
- ▶ A higher value completes the format faster, but consumes more resources on the host system.

See Figure 2-120.

```

                                Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . NWSSTG
Size . . . . . NWSSIZE          *CALC
From storage space . . . . . FROMNWSSTG  *NONE
Format . . . . . FORMAT          *NTFS
Auxiliary storage pool ID . . . ASP       1
ASP device . . . . . ASPDEV
Text 'description' . . . . . TEXT        *BLANK

                                Additional Parameters

Data offset . . . . . OFFSET          *FORMAT
Sector size in bytes . . . . . SCTSIZ   512
Preferred storage unit . . . . . UNIT   *ANY
Resource allocation priority . . RSCALCPTY 9

                                                                Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
  
```

Figure 2-120 CRTNWSSTG CL command: resource allocation priority

If you want to perform this action in IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **New Virtual Storage**, as shown in Figure 2-121.

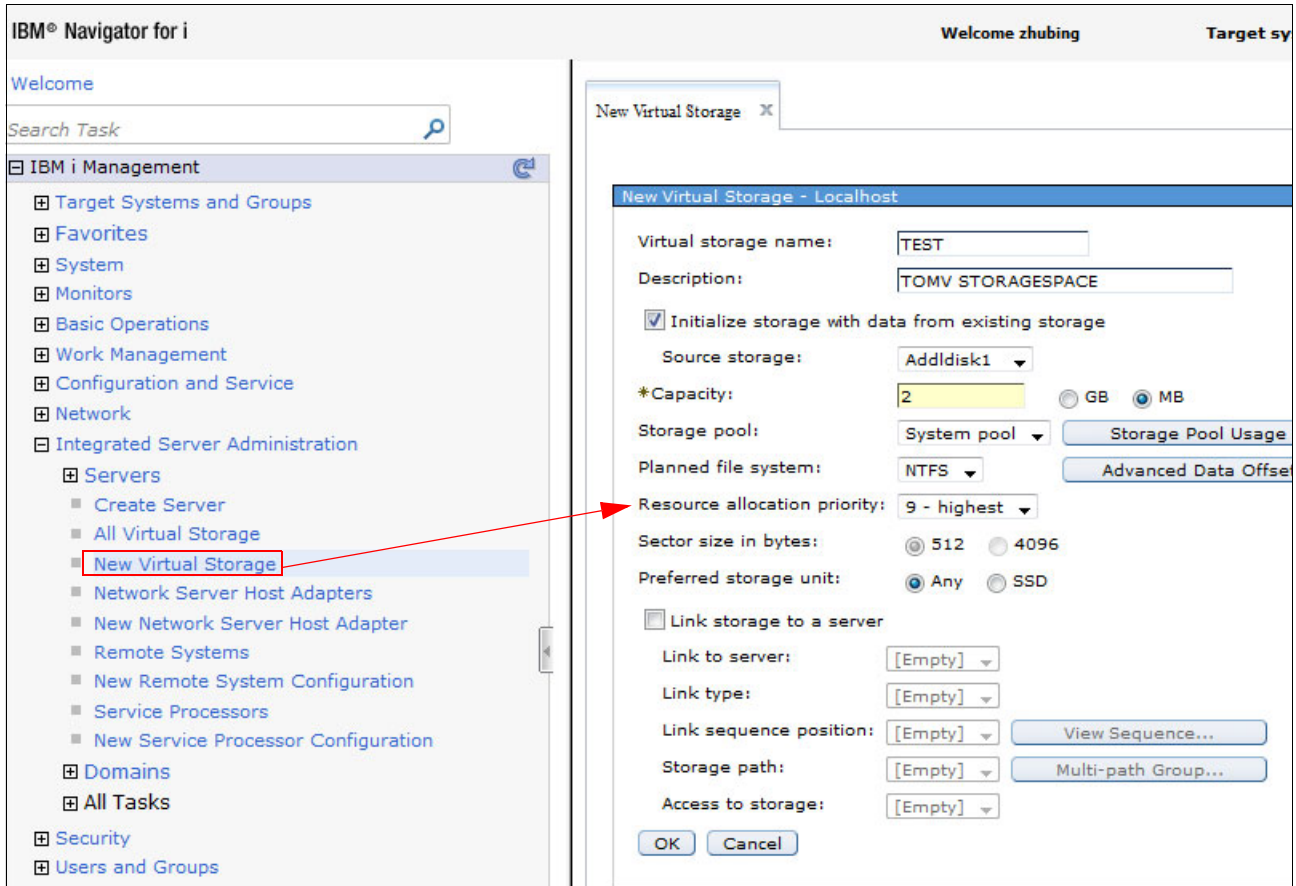


Figure 2-121 Resource allocation priority parameter in IBM Navigator for i

You can change the resource allocation priority parameter to a value 1 - 9. Similar to the Create NWS Storage Space (**CRTNWSSTG**) CL command, a value of 1 completes the format faster, but consumes more resources on the host system, and a value of 9 completes the format slower, but consumes less resources on the host system.

4 K disk units sector support

Disk units with 4 K sectors are now supported when creating a virtual disk.

Here are the options for the Create NWS Storage Space (**CRTNWSSTG**) CL command for the Sector size in bytes parameter:

- ▶ 512: Configure this storage for 512 bytes in each sector.
- ▶ 4096: Configure this storage for 4096 bytes in each sector.

Note: A sector size of 4096 cannot be specified when FORMAT(*FAT) or FORMAT(*FAT32) is specified.

See Figure 2-122.

```
                                Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . NWSSTG
Size . . . . . NWSSIZE          *CALC
From storage space . . . . . FROMNWSSTG *NONE
Format . . . . . FORMAT          *NTFS
Auxiliary storage pool ID . . . ASP      1
ASP device . . . . . ASPDEV
Text 'description' . . . . . TEXT      *BLANK

                                Additional Parameters

Data offset . . . . . OFFSET          *FORMAT
Sector size in bytes . . . . . SCTSIZ    512
Preferred storage unit . . . . . UNIT      *ANY
Resource allocation priority . . RSCALCPTY  9

                                                                Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
```

Figure 2-122 CRTNWSSTG CL command: sector size support parameter

If you want to perform this action within IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **New Virtual Storage**, as shown in Figure 2-123.

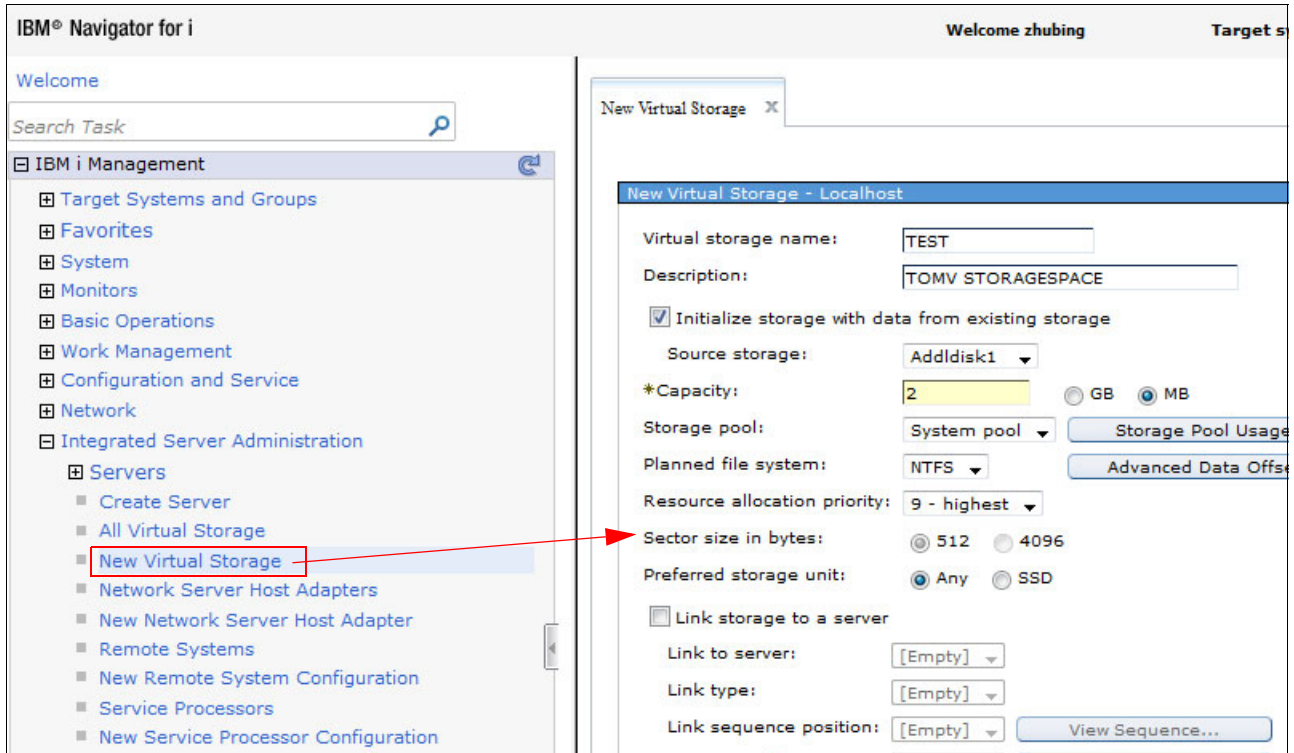


Figure 2-123 Sector size in bytes parameter in IBM Navigator for i

Solid-state drive support

In IBM i 7.2, an SSD disk unit type can be selected as a preference when creating a network server storage space, as shown in Figure 2-124.

The following options of the Create NWS Storage Space (**CRTNWSSTG**) CL command for the Preferred storage unit parameter are available:

- ▶ **SSD**: Solid-state drive storage media is preferred. Storage should be allocated from solid-state drive storage media if available.
- ▶ ***ANY**: No storage media is preferred. Storage is allocated from any available storage media.

```

                                Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . NWSSTG
Size . . . . . NWSSIZE          *CALC
From storage space . . . . . FROMNWSSTG  *NONE
Format . . . . . FORMAT          *NTFS
Auxiliary storage pool ID . . . ASP       1
ASP device . . . . . ASPDEV
Text 'description' . . . . . TEXT        *BLANK

                                Additional Parameters

Data offset . . . . . OFFSET          *FORMAT
Sector size in bytes . . . . . SCTSIZ   512
Preferred storage unit . . . . . UNIT   SSD
Resource allocation priority . . RSCALCPTY 9

                                                                Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
  
```

Figure 2-124 CRTNWSSTG CL command: SSD support added

If you want to perform this action in IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **New Virtual Storage**, as shown in Figure 2-125 on page 109.

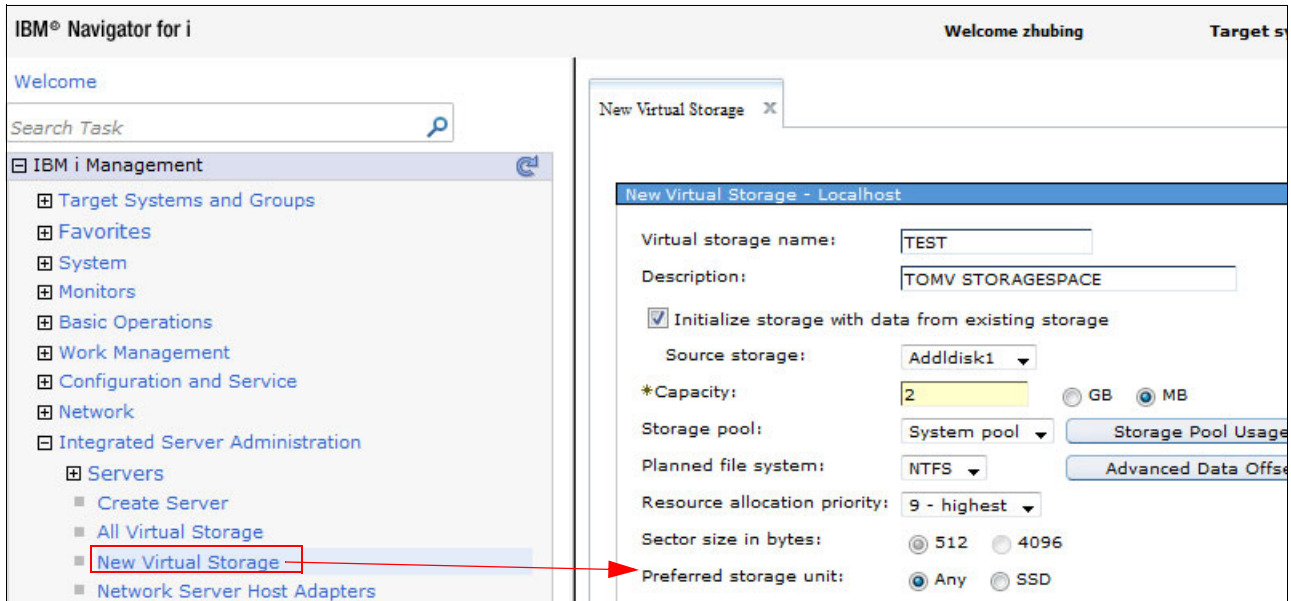


Figure 2-125 Preferred storage unit parameter in IBM Navigator for i

Restricted/allowed resources

In IBM i 7.2, you can select either restricted devices to restrict access or allowed device resources to allow access for tape and optical device resource names, as shown in Figure 2-126.

```

Create Network Server Desc (CRTNWS)

Type choices, press Enter.

Virtual Ethernet path:          VRTETHPTH
Port number . . . . .
Network server host adapter .   *DFTSTGPTH
IP security rules:
Remote interface 1 rule . . .   *DFTSECRULE
Remote interface 2 rule . . .   *DFTSECRULE
Remote interface 3 rule . . .   *DFTSECRULE
Remote interface 4 rule . . .   *DFTSECRULE
                               + for more values
Allowed device resources . . . . ALWDEVRS   *UNRSTD
                               + for more values
Restricted device resources . . RSTDDEVRS   *NONE
                               + for more values
Network server configuration:   NWSCFG
Remote system name . . . . .   *DFT
Connection security name . . .   *DFT

More...

F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
Messages pending on other displays.

```

Figure 2-126 CRTNWD CL command: allowed and restricted tape or optical device resources

The following values are available for Allowed device resources (**ALWDEVRS**):

- ▶ *UNRSTD
- ▶ *ALLTAPE
- ▶ *ALLOPT

The following values are available for Restricted device resources (**RSTDEVRS**):

- ▶ *NONE
- ▶ *ALL
- ▶ *ALLTAPE
- ▶ *ALLOPT

Note: **ALWDEVRS** is mutually exclusive with **RSTDEVRS**. If a value other than *UNRSTD is specified with **ALWDEVRS**, *NONE must be specified with **RSTDEVRS**.

In IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **Your server**. From the list of server in right pane, select **Properties** from the Actions drop-down menu, as shown in Figure 2-127.

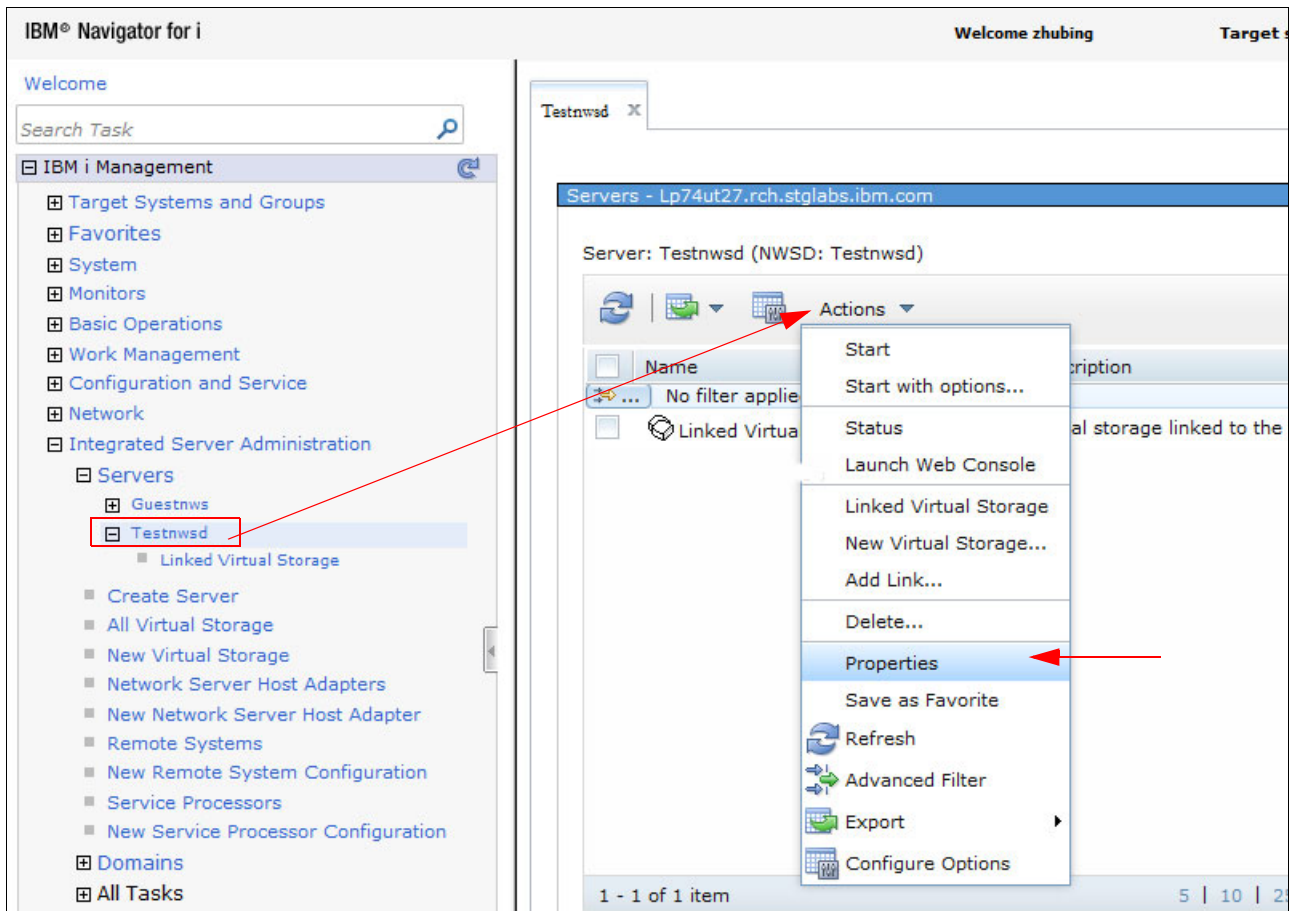


Figure 2-127 Select server properties in IBM Navigator for i

From the server Properties window, click **Advanced** in the System tab. In the Advanced Properties window, under IBM i Devices, you can either restrict access or allow access for the tape and optical devices, as shown in Figure 2-128.

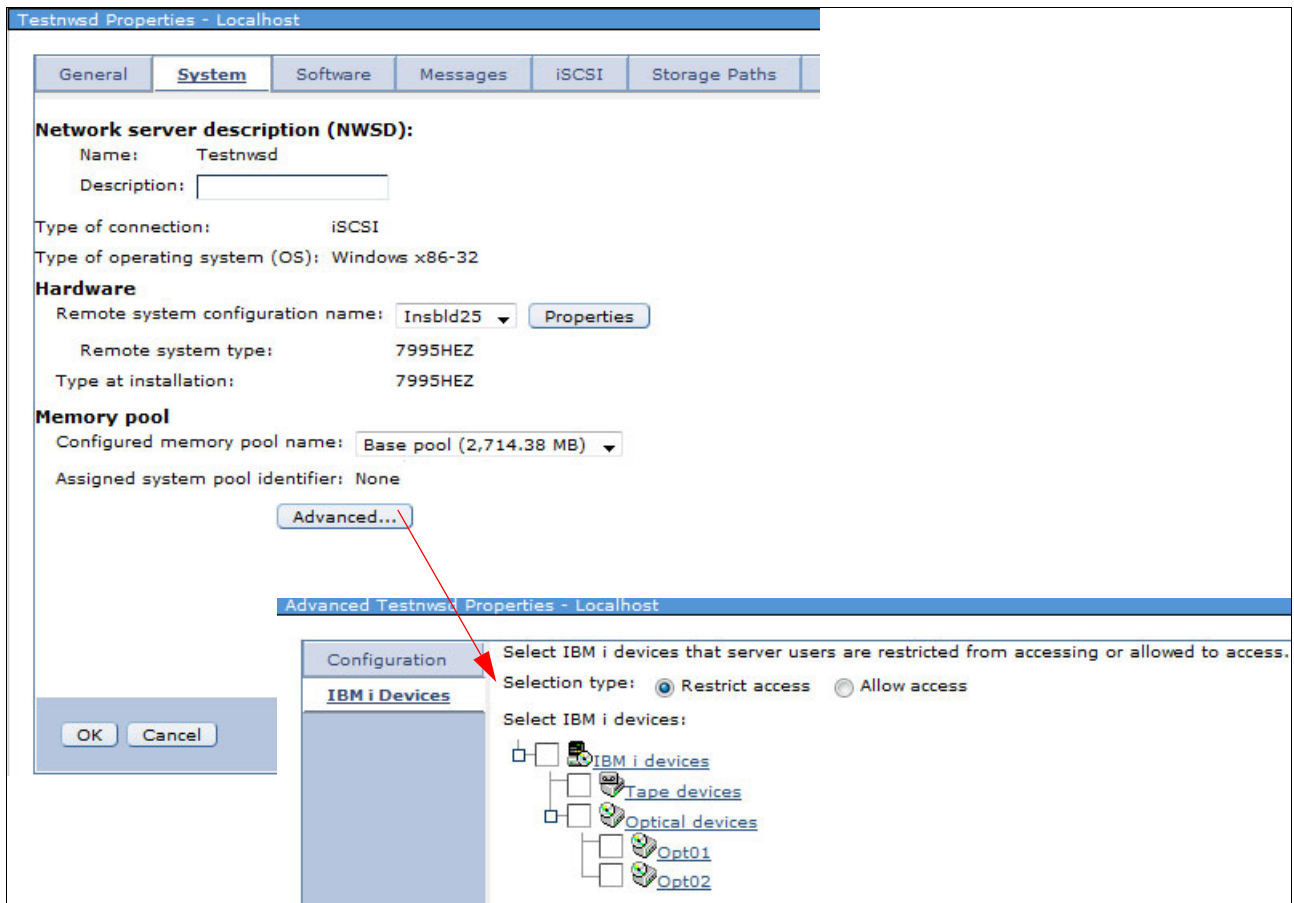


Figure 2-128 Allow or restrict access to tape and optical devices

Storage pool size limit

In IBM i 7.2, the storage pool size limit is increased to use an 8-byte integer.

Note: The Retrieve System Status (QWCRSSTS) API change is supported within IBM Navigator for i.

Windows Server 2012 support

Support is added for Windows Server 2012, including a new ReFS file system type for storage and shared disk linking. See Figure 2-129.

ReFS is a new file system that was introduced in Microsoft Windows 2012 as the next generation file system after NTFS. If you install an NWSD with Windows 2012, you can create a network server storage space, which can be formatted as ReFS in Windows.

```
                                Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . NWSSTG
Size . . . . . NWSSIZE          *CALC
From storage space . . . . . FROMNWSSTG    *NONE
Format . . . . . FORMAT          *REFS
Auxiliary storage pool ID . . . ASP        1
ASP device . . . . . ASPDEV
Text 'description' . . . . . TEXT          *BLANK

                                Additional Parameters

Data offset . . . . . OFFSET            *FORMAT
Sector size in bytes . . . . . SCTSIZ    512
Preferred storage unit . . . . . UNIT    *ANY
Resource allocation priority . . RSCALCPTY 9

                                                                Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
```

Figure 2-129 Windows Server 2012 support

If you want to perform this action within IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **New Virtual Storage**, as shown in Figure 2-130 on page 113. In the Planned file system parameter, you can select a format of NTFS, ReFS, FAT-32, FAT, or Open source.

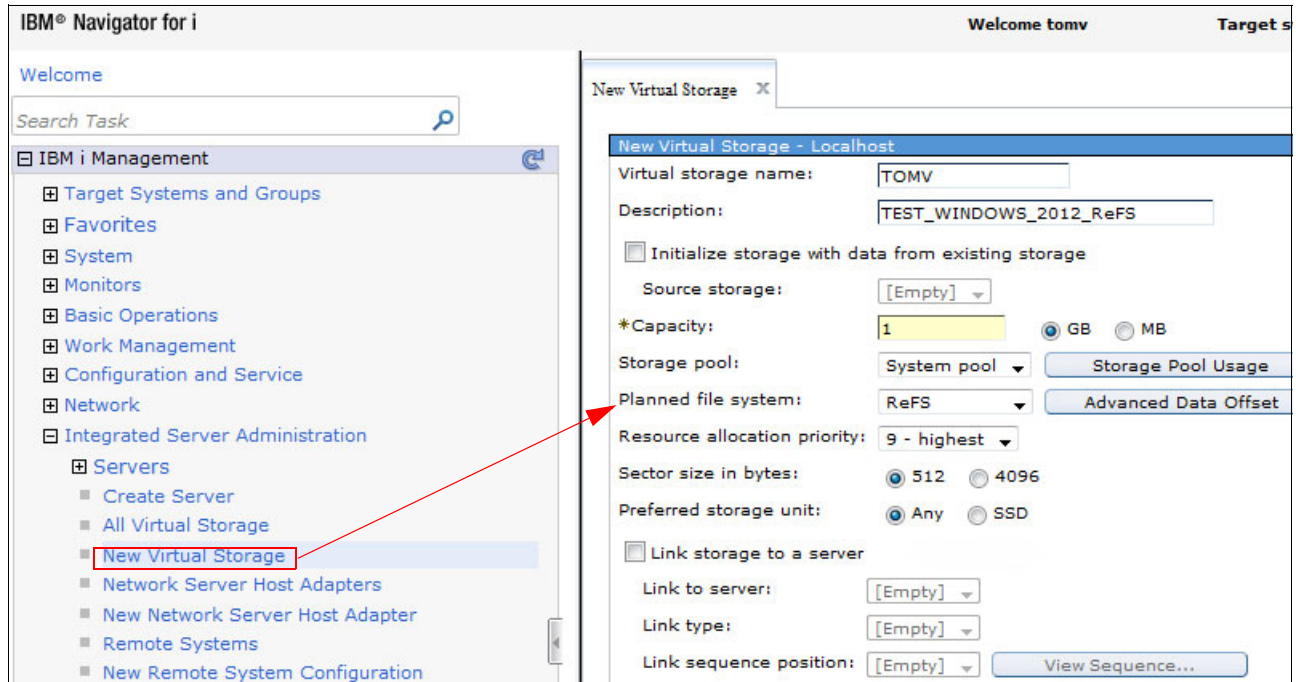


Figure 2-130 New ReFS file system for Windows 2012

Windows Server 2003 support removed

In IBM i 7.2, support for Windows Server 2003 was removed.

Note: No new integrated Windows Server 2003 (and R2) servers can be installed or cloned in IBM i 7.2. Integrated Windows Server 2003 (and R2) servers that were installed on prior IBM i releases and then migrated to IBM i 7.2 can continue to run as is, but without service support. The suggested migration path for these servers is to upgrade to Windows Server 2008 or newer version.

Creating quorum disks function removed

In IBM i 7.2, the ability to create quorum disks was removed.

No support for IXS and IXA hardware

With IBM i 7.2, Integrated xSeries Server (IXS) and System x servers that are attached by using the Integrated xSeries Adapter (IXA) are no longer supported.

Integrated server cloning

Support was added to select the storage pool where virtual storage should be created. See Figure 2-131.

You can specify where the storage space should be created:

- ▶ Auxiliary storage pool ID: Select an ASP ID 1 - 255.
- ▶ ASP device: Specify the ASP device name in case there is an Independent ASP.

Note: Data offset is used to specify how IBM i should align the disk, that is, either align the first logical partition or logical disk. For *ReFS, use the default align first logical partition (*ALIGNLGLPTN), which is the same as the NTFS format.

```

                                Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . NWSSTG          TOMV
Size . . . . . NWSSIZE          *CALC
From storage space . . . . . FROMNWSSTG        FROMTEST
Format . . . . . FORMAT          > *REFS
Auxiliary storage pool ID . . . ASP          1
ASP device . . . . . ASPDEV
Text 'description' . . . . . TEXT          *BLANK

                                Additional Parameters

Data offset . . . . . OFFSET          *FORMAT
Sector size in bytes . . . . . SCTSIZ          512
Preferred storage unit . . . . . UNIT          *ANY
Resource allocation priority . . RSCALCPTY      9

                                                                Bottom
F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel   F13=How to use this display
F24=More keys
  
```

Figure 2-131 CRTNWSSTG CL command: storage pool selection

If you want to perform this action in IBM Navigator for i, click **Integrated Server Administration** → **Servers** → **New Virtual Storage**, as shown in Figure 2-132.

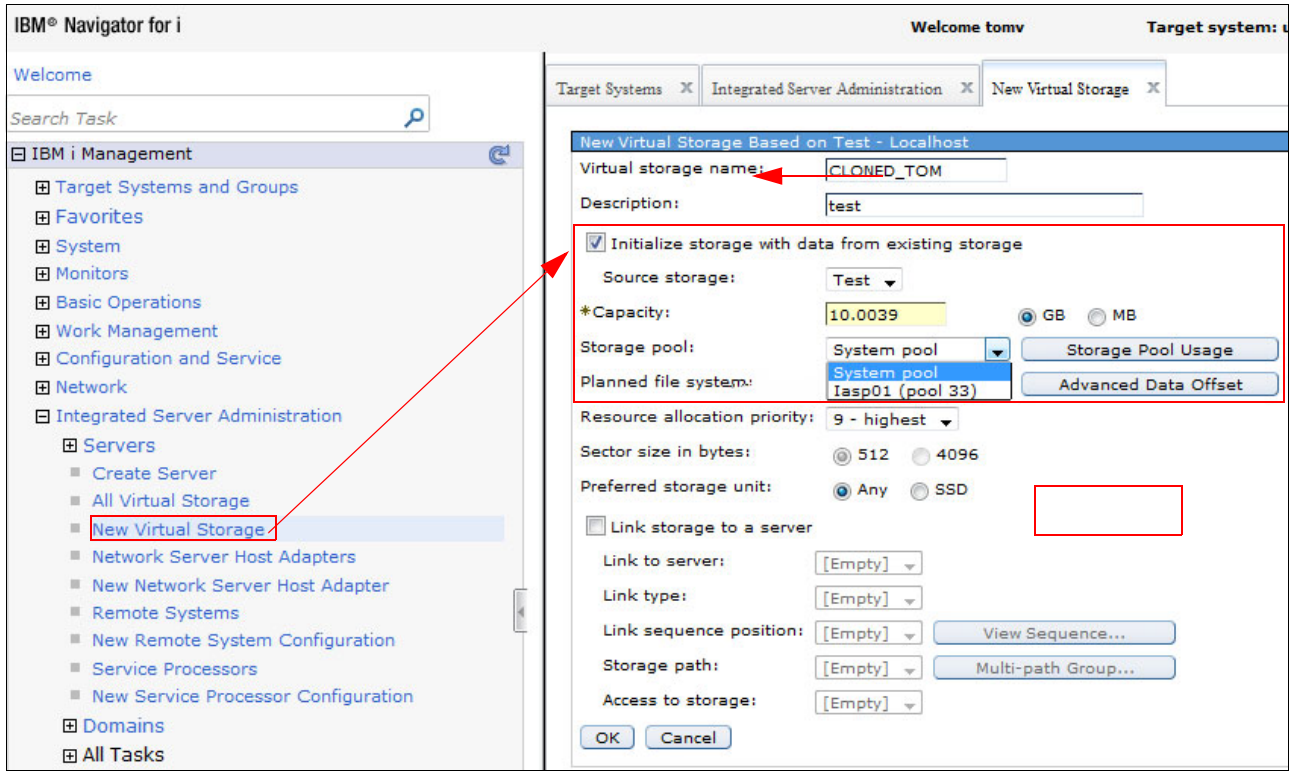


Figure 2-132 Storage pool selection

For more information about the IBM i iSCSI-attached servers, see IBM Knowledge Center:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahq/rzahqntspo.htm?lang=en

2.1.17 Database

For information about the database enhancements for IBM i 7.2 in IBM Navigator for i, see 8.7.2, “IBM Navigator for i: DB2 related functions” on page 403.

2.1.18 Printers and printer output

The following printer and printer output functions were added or updated in IBM i 7.2:

- ▶ Automatic and silent printing
- ▶ Virtual Printers task category
- ▶ Exporting spooled files as PDFs

Automatic and silent printing

You can use automatic and silent printing support to print automatically and silently spooled files in one output queue to client printers. This support also allows an IBM i ISV moving their business application towards a cloud environment to print output to any printer that a client might have attached to their PC.

Virtual printers task category

A new Virtual Printers task category was added under the Printers task category in the navigation area, as shown in Figure 2-133.

Note: The Virtual Printers task function appears only when you are managing a system with IBM i 7.1 or later.

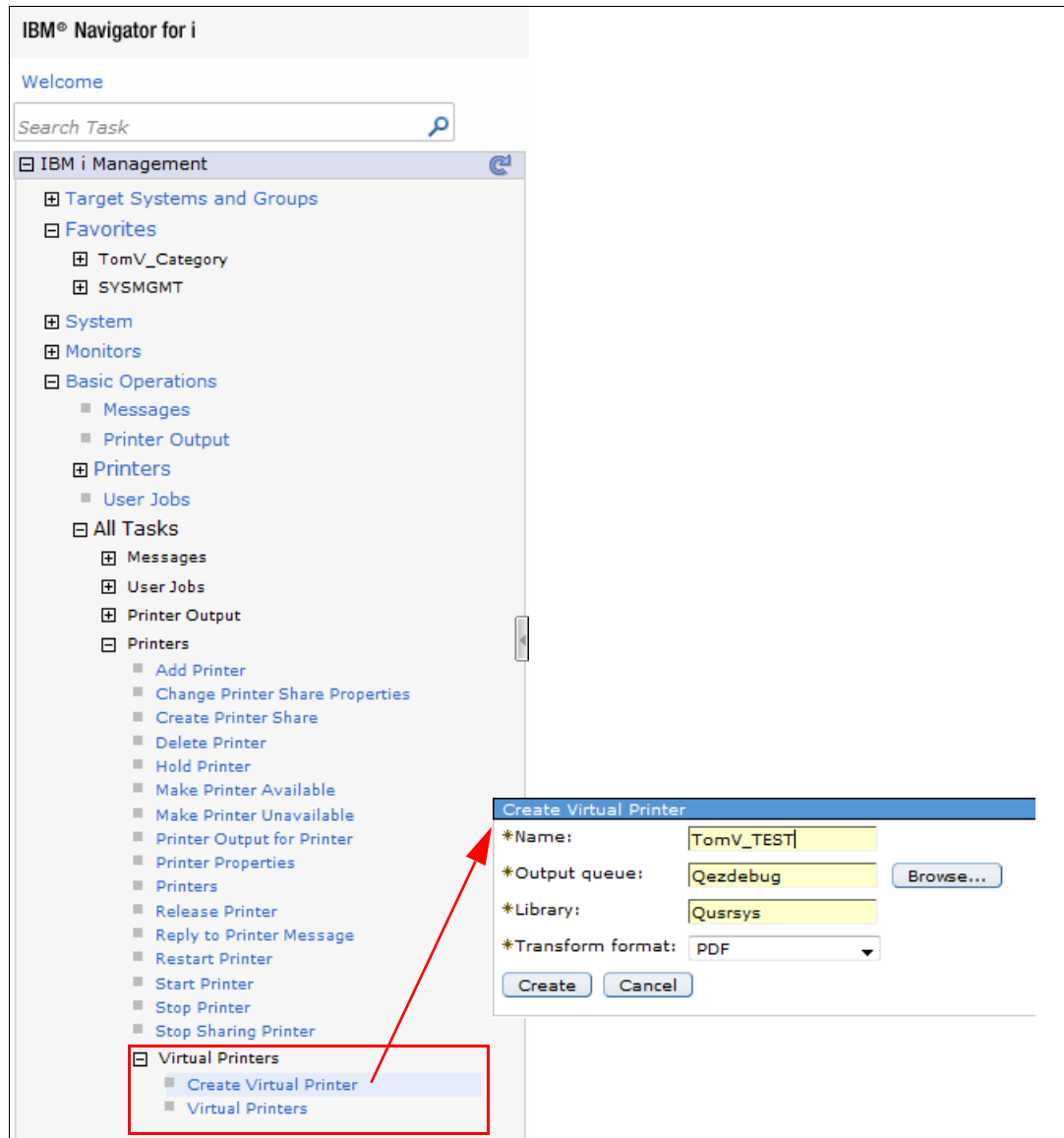


Figure 2-133 Virtual printer support in IBM Navigator for i

Exporting spooled files as PDFs

The functions of exporting spooled files as PDFs by using the Infoprint Server 5722-IP1 licensed product to an output queue, integrated file system, or to an email were simplified in IBM i 7.2.

These functions were previously implemented as wizards. Figure 2-134 shows that these actions are now implemented as a single window with as many options set to defaults as possible.

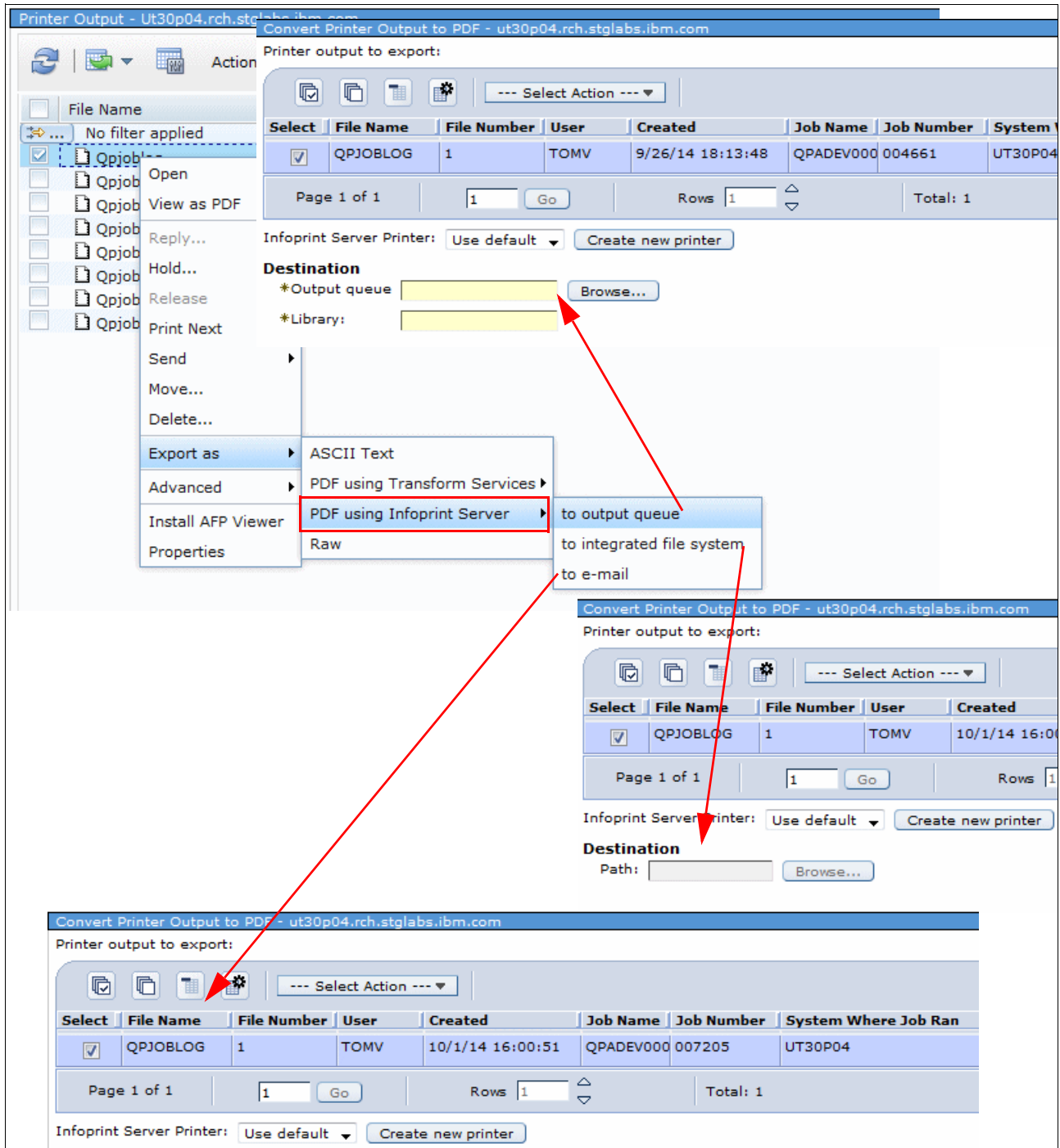


Figure 2-134 Export spool files as PDFs by using Infoprint Server

2.2 IBM i Access

IBM i 7.2 provides several enhancements to the IBM i Access Family. These enhancements were made to deliver robust, reliable, and easy to use interfaces for accessing IBM i and include the following features:

- ▶ Simplicity of setup, use, and operations
- ▶ Cross-platform infrastructure support
- ▶ Support for access from web-enabled mobile devices
- ▶ Continuous support and maintenance

The IBM i 7.2 Access Family provides the following products, which are covered in this section:

- ▶ 2.2.1, “IBM i Access Client Solutions” on page 118
- ▶ 2.2.2, “IBM i Access for Windows” on page 144
- ▶ 2.2.4, “IBM i Mobile Access” on page 152

2.2.1 IBM i Access Client Solutions

IBM i Access Client Solutions is the newest member of the IBM i Access Family. Originally announced with IBM i 7.1 TR 6, as shown in Figure 2-135, the IBM i Access Client Solutions has three components:

- ▶ Core offering (platform-independent)
- ▶ Windows Application Package
- ▶ Linux Application Package



Figure 2-135 IBM i Access Client Solutions components

The core offering of the IBM i Access Client Solutions product offers platform independence through a Java based implementation. This portion of the product does not require a platform-centric installer. To use it, you can extract the contents of the file that you download from IBM and start using it.

The Windows Application Package and Linux Application Package offerings are platform-specific packages for Windows and Linux. They inherited a subset of functions from IBM i Access for Windows and IBM i Access for Linux, including middleware for developing client applications.

The following topics are covered in this section:

- ▶ “IBM i Access Client Solutions: Core offering (platform-independent)” on page 119
- ▶ “IBM i Access Client Solutions: Windows Application Package” on page 143
- ▶ “IBM i Access Client Solutions: Linux Application Package” on page 144

For more information about IBM i Access Client Solutions, see the IBM i Access product website:

<http://www.ibm.com/systems/power/software/i/access/solutions.html>

IBM i Access Client Solutions: Core offering (platform-independent)

The IBM i Access Client Solutions core offering is built as a Java based, platform-independent interface that runs on most operating systems that support Java. This includes Linux, Apple Mac OS, Microsoft Windows, IBM AIX®, and IBM i. This product is an easy-to-use, simple, yet powerful tool, which consolidates the most commonly used tasks for managing your IBM i systems into one simplified location.

The core offering of Access Client Solutions provides the following advantages:

- ▶ Supported in multiplatform environments.
- ▶ Can be run from any type of media, including USB sticks, CDs or DVDs, and network shares.
- ▶ Easy to install, deploy, and update.
- ▶ The configuration can be stored on any media.

IBM i Access Client Solutions V1.1.3 has the following enhancements:

- ▶ Ability for the administrator to restrict and hide features.
- ▶ Support for using a `.netrc` file in place of manually entering credentials when using “prompt once”.
- ▶ Virtual Control Panel that supports both LAN and HMC consoles.
- ▶ The console bar status is available for both LAN and HMC consoles from a 5250 session.
- ▶ 5250 display emulation enhancements:
 - Insert paste support
 - Double and triple click text selection
 - Option to wrap on line boundary
 - Option to scale automatically a font when resizing a display
 - Option to enable displaying Unicode characters on panels with Unicode fields
 - Improved compatibility when converting macros from IBM Personal Communications
 - Character Backspace and Character Advance support
 - Support for up to 52 sessions
- ▶ Data Transfer enhancements:
 - Option to download column headings, instead of column names
 - Option to change line ending on download to CRLF, CR, or LF
 - Option to upload and round decimals
- ▶ Command-line plug-in enhancements for **cfg**, **ping**, **download**, **upload**, **restrict**, and **restrictview** commands.

IBM i Access Client Solutions V1.1.4.x has the following enhancements:

- ▶ Enhanced installation script for Windows for easier customization and deployment
- ▶ HMC Probe utility for finding all partitions that are managed by an HMC

- ▶ 5250 display emulation enhancements:
 - Support for up to 100 sessions
 - Tab support for multiple 5250 sessions (Control + T for Windows and Linux, and Command + T for Mac)
 - Option to save a view of multiple 5250 sessions for easy restart of multiple sessions
 - Additional watermark customizations
 - Additional raster fonts from IBM Personal Communication and support for user provided fonts
 - Printer Definition Table (PDT) support for DBCS
 - Migration wizard support for PCOMM.ws profiles, and .kmp and .pmp files
 - Support for Host Code pages of 1130, 1132, 1164, and 1377
 - Optional input character validation based on host code page
 - Print emulation enhancements
 - Additional mouse wheel customization
 - Cursor customization when doing a paste
 - Additional keyboard mapping options, such as character backspace, character advance, and APL screen attributes

IBM i Access Client Solutions V1.1.5 has the following enhancements:

- ▶ Added feature to run SQL scripts
- ▶ Added feature to run SQL Performance Center
- ▶ Better integration between IBM Navigator for i with IBM i Access Client Solutions for improved performance and usability

Note: IBM i Access Client Solutions connect to any supported IBM i release. Most features also work with IBM i 5.4. except for the 5250 console and Virtual Control Panel.

The following topics are covered in this section:

- ▶ “Prerequisites” on page 121
- ▶ “Program downloads” on page 121
- ▶ “Program launchers” on page 121
- ▶ “Main user interface” on page 122
- ▶ “5250 emulation console bar” on page 123
- ▶ “Virtual Control Panel” on page 123
- ▶ “Improved macro conversion capability” on page 124
- ▶ “Additional mouse wheel customization” on page 125
- ▶ “Using the HMC Probe Utility for finding all the managed partitions of an HMC” on page 126
- ▶ “Saving multiple sessions for an easy restart” on page 128
- ▶ “Tabbed 5250 sessions” on page 129
- ▶ “Deployment wizard for easy customization and deployment” on page 130
- ▶ “New database section” on page 131

Prerequisites

Java 6.0 or higher should be installed on the system, which might be running any number of operating systems, including Linux, Apple Mac OS, Microsoft Windows, AIX, and IBM i.

Tip: To check the version of Java that is installed on your system, go to your system command prompt, terminal, or shell and run `java -version`.

For more information about connecting IBM i Access Client Solutions to IBM i systems, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajr/rzajropconoverview.htm

Program downloads

IBM i Access Client Solutions can be downloaded from the following link by using your IBM ID login information:

<https://www.ibm.com/services/forms/preLogin.do?source=swg-ia>

Program launchers

Table 2-2 shows the launcher locations for IBM i Access Client Solutions.

Table 2-2 Program launcher locations for IBM i Access Client Solutions

Operating system	Program launcher location
Windows 32-bit	Start_Programs\Windows_i386-32\acs1aunch_win-32.exe
Windows 64-bit	Start_Programs\Windows_x86-64\acs1aunch_win-64.exe
Linux 32-bit	Start_Programs/Linux_i386-32/acs1aunch_linux-32
Linux 64-bit	Start_Programs/Linux_x86-64/acs1aunch_linux-64
Macintosh	Start_Programs/Mac_i386-32_x86-64/acs1aunch_mac

Main user interface

Figure 2-136 shows the main user interface of the IBM i Access Client Solutions V 1.1.5.

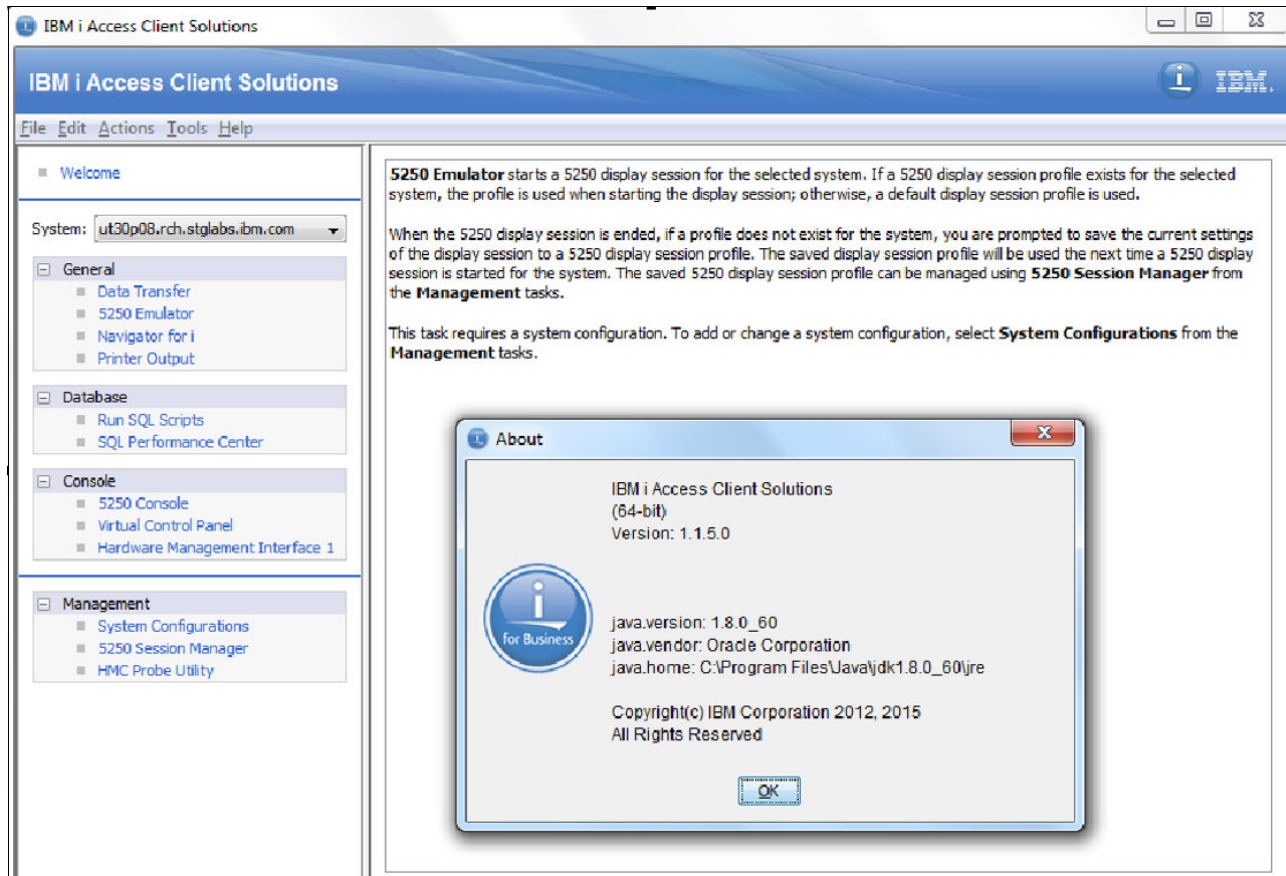


Figure 2-136 Main user interface of IBM i Access Client Solutions

5250 emulation console bar

In IBM i Access Client Solutions, there is a new feature in the 5250 console that is called a *console bar*. The console bar shows the current state of IPL type, System Reference Codes (SRCs), and so on. To display the console bar of a 5250 console, click **View** → **Console bar**, as shown in Figure 2-137. This function works on both HMC and LAN consoles.

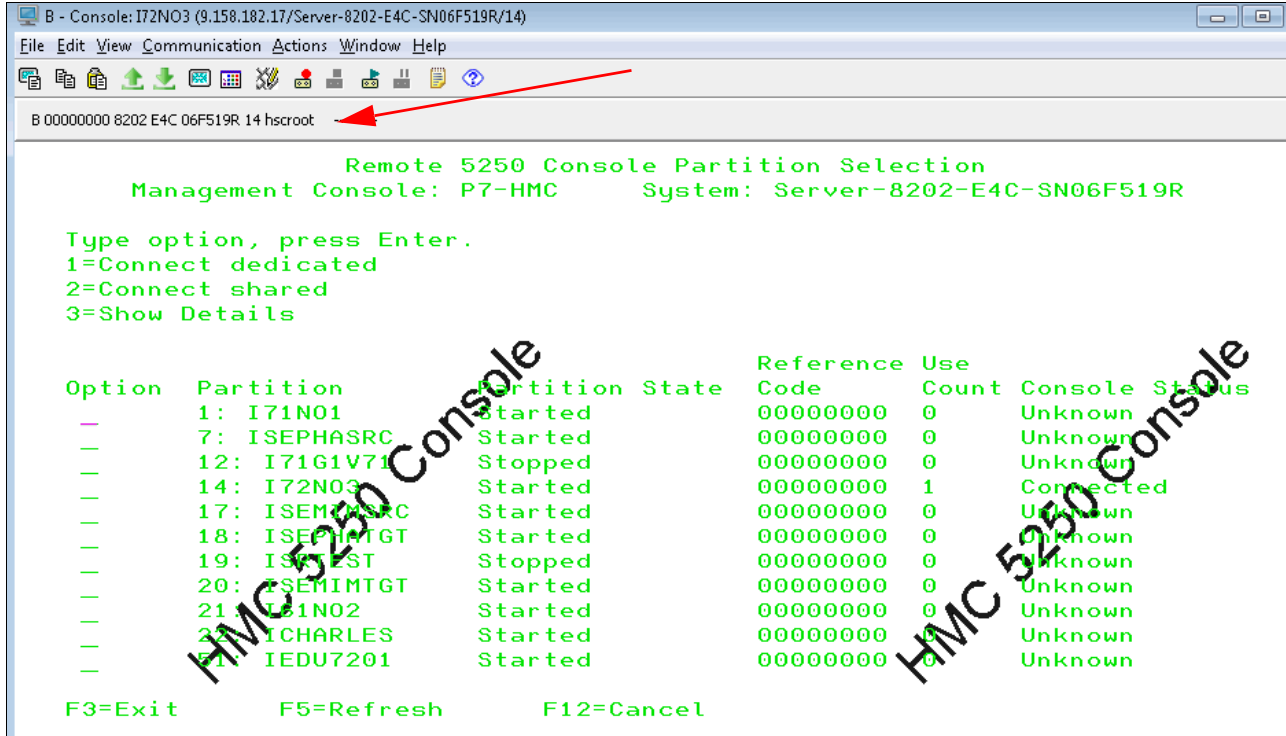


Figure 2-137 Console bar in a 5250 console

Virtual Control Panel

The Virtual Control Panel capability is enhanced in IBM i Access Client Solutions to support the connection to an HMC console in addition to LAN console. The Virtual Control Panel to an HMC console is shown in Figure 2-138.

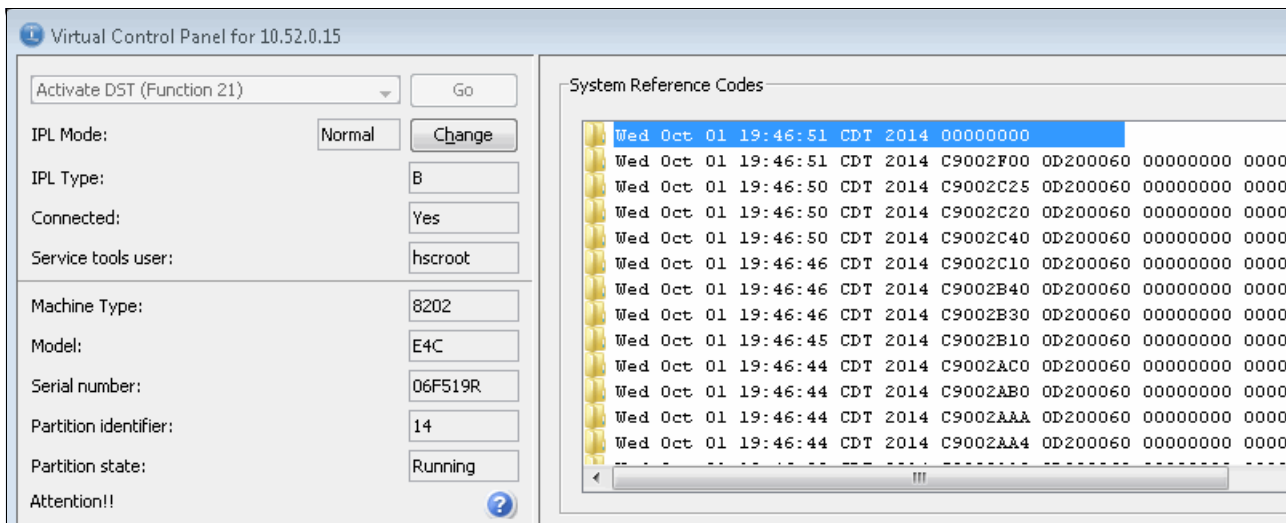


Figure 2-138 Virtual Control Panel connection to an HMC console

Improved macro conversion capability

You can use IBM i Access Client Solutions to convert macros that are made in Personal Communications to IBM Host-on-Demand. This feature helps IBM i users to migrate from Personal Communications to Host-on-Demand in IBM i Access Client Solutions. Macro conversion compatibility is improved to support the conversion of more keystrokes.

To convert a macro, click **5250 Session Manager** from IBM i Access Client Solutions. Then, click **File** → **Convert Macro** in the 5250 Session Manager window, as shown in Figure 2-139.

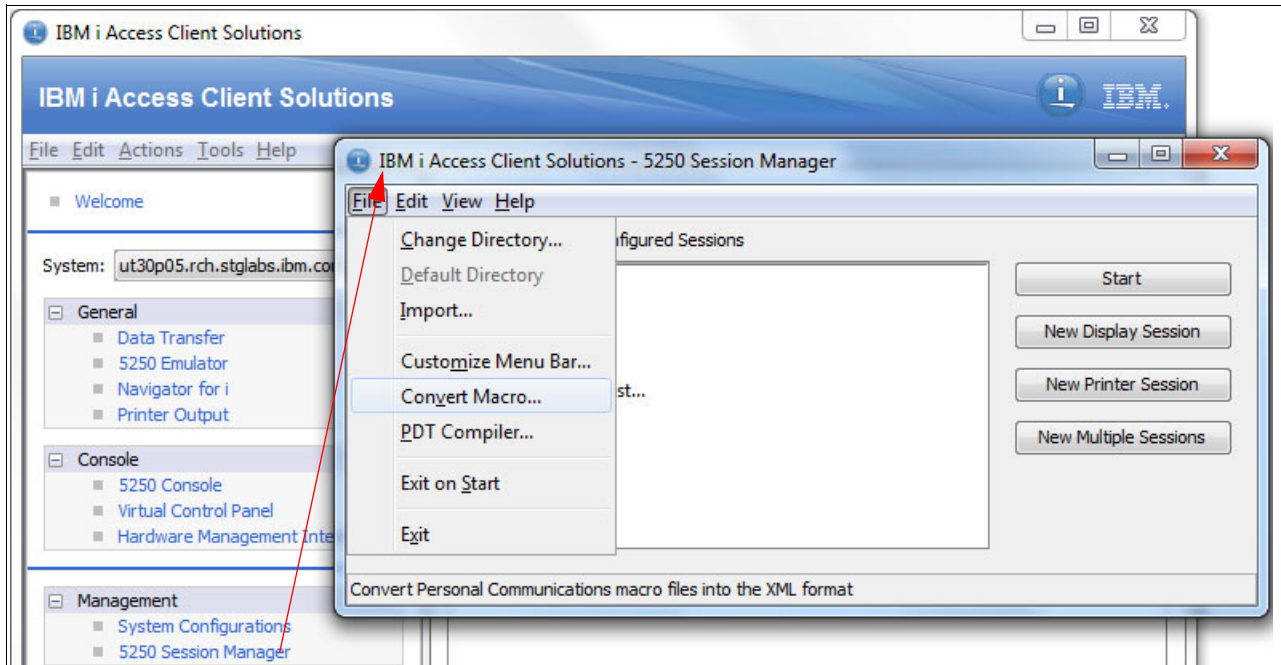


Figure 2-139 Convert Macro menu in the 5250 Session Manager

In the Convert Macro window, as shown in Figure 2-140, you can specify the location of the original macro file (*.mac) and the target location of the newly converted macro. Click **Convert** to start the conversion process.

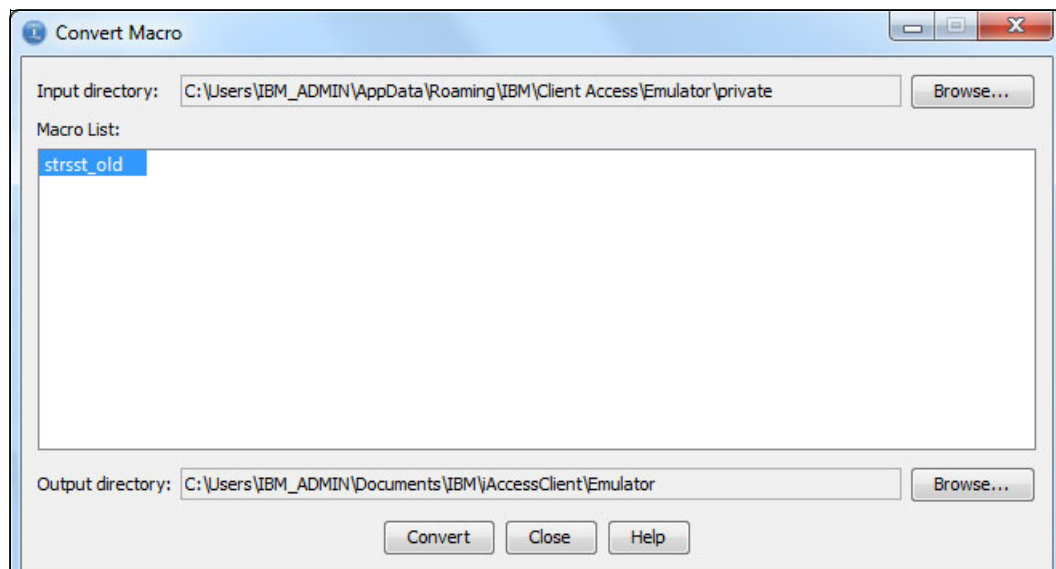


Figure 2-140 Convert Macro window in IBM i Access Client Solutions

Additional mouse wheel customization

In prior releases, mouse wheel functions worked with page up and page down in the 5250 emulator panel. In the current release, the customization of mouse wheel functions is enhanced. Now, users can also combine Shift and Control buttons with mouse wheel up and down to perform various functions in 5250 emulators. Figure 2-141 shows the Mouse Wheel customizations window.

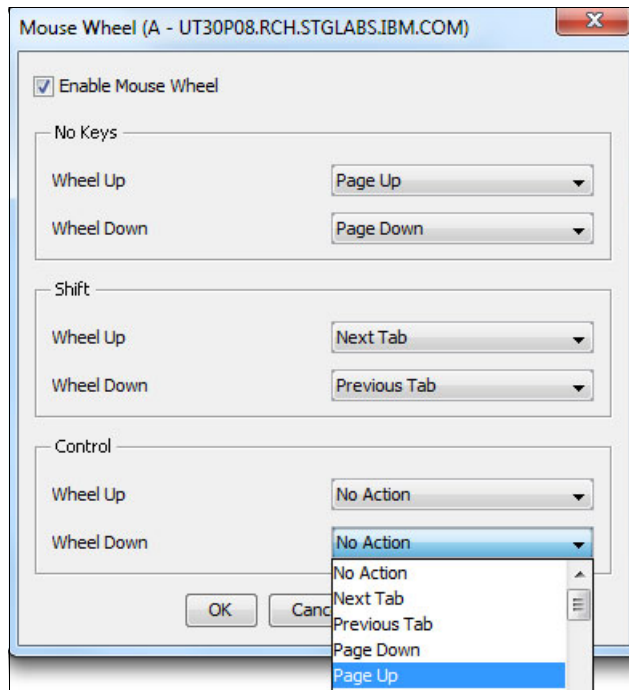


Figure 2-141 Mouse wheel customizations in 5250 emulator preferences

Using the HMC Probe Utility for finding all the managed partitions of an HMC

Users can use the HMC Probe Utility to add system console connections from an HMC to IBM i Access Client Solutions. This function can be called by clicking **HMC Probe Utility**, as shown in Figure 2-142.

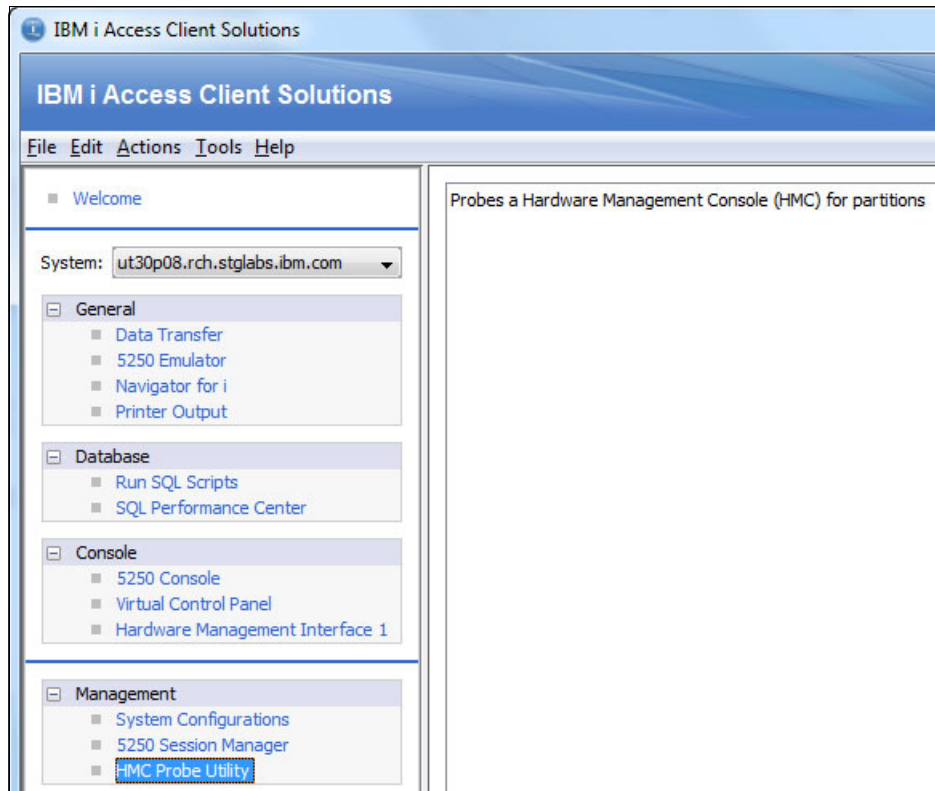


Figure 2-142 Select the HMC Probe Utility on IBM i Access Client Solutions

The HMC Probe Utility asks for the HMC information, such as IP address or host name and user ID. Click **Probe** and the utility prompts you for a password to log in.

Figure 2-143 shows the result of the HMC Probe Utility, showing all the systems and their partitions that are managed by the HMC. Users can easily connect to their 5250 console sessions, see the Virtual Control Panel of each system, or save the connections for future use.

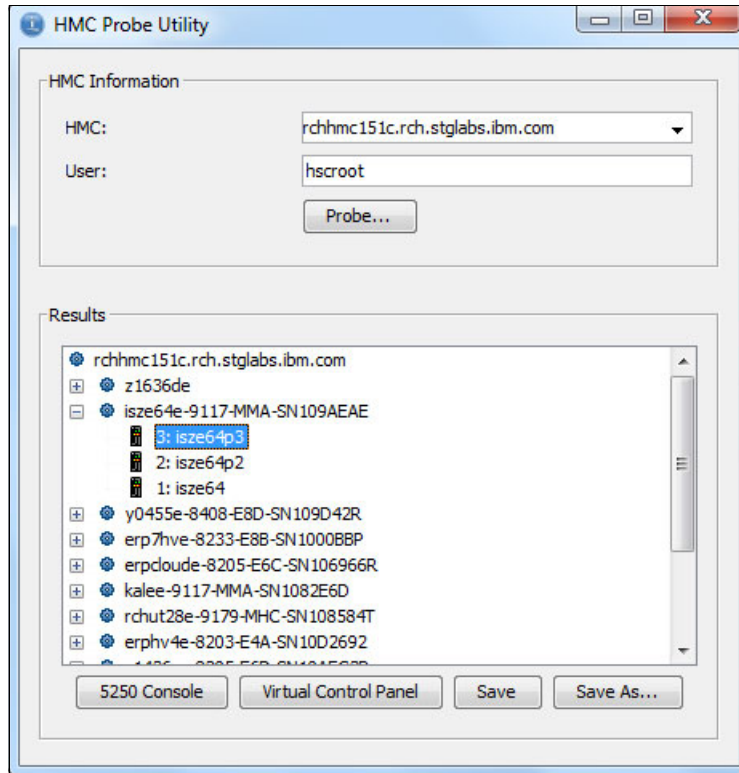


Figure 2-143 HMC Probe Utility result

Saving multiple sessions for an easy restart

Users can use IBM i Access Client Solutions to save multiple sessions of 5250 emulators. With this feature, users can easily save all of their active sessions and re-open them when needed. Figure 2-144 shows the Save as Multiple Sessions option on the File menu.

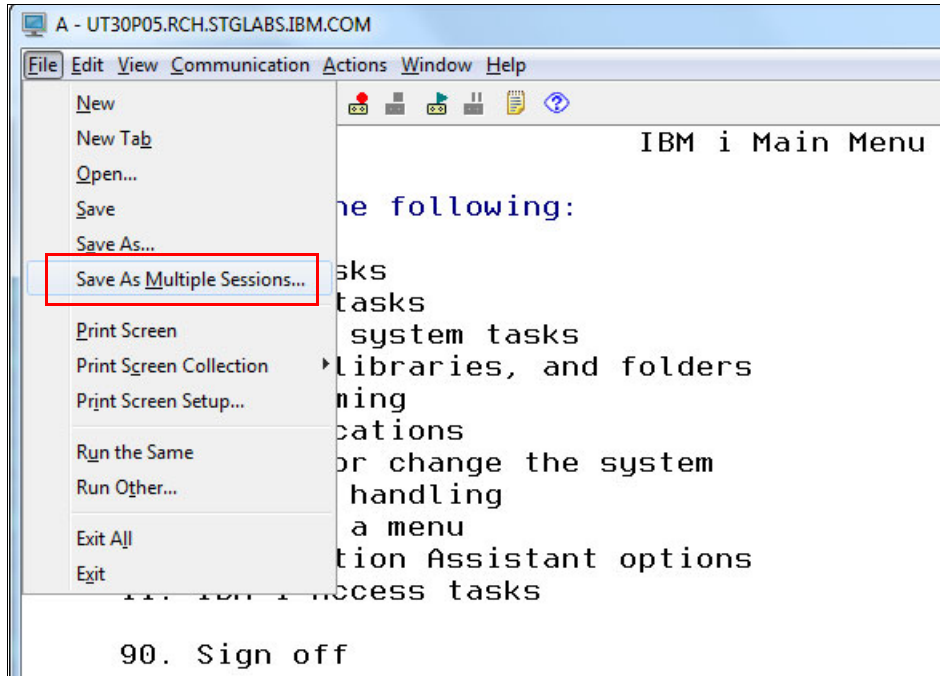


Figure 2-144 Save as multiple sessions on 5250 emulator window

Before saving multiple 5250 sessions, make sure that each session has its saved session profile (.hod file), unless the Save As Multiple Session does not include the session as part of the multiple session files. Figure 2-145 shows the warning message when a user tries to save sessions as a multiple-sessions profile without having an individual saved profile (.hod file).

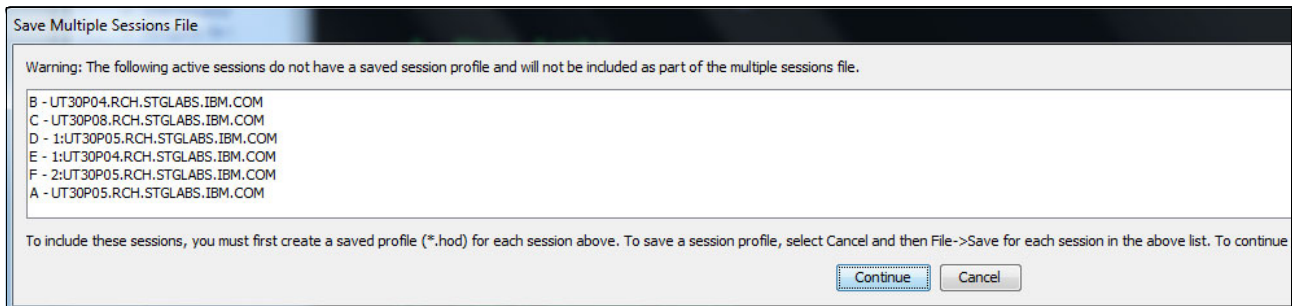


Figure 2-145 Warning message when saving multiple sessions without having individual .hod files

To re-open the multiple-sessions profile, go to 5250 session manager, then start the saved multiple-sessions file (.bchx files) as shown in Figure 2-146.

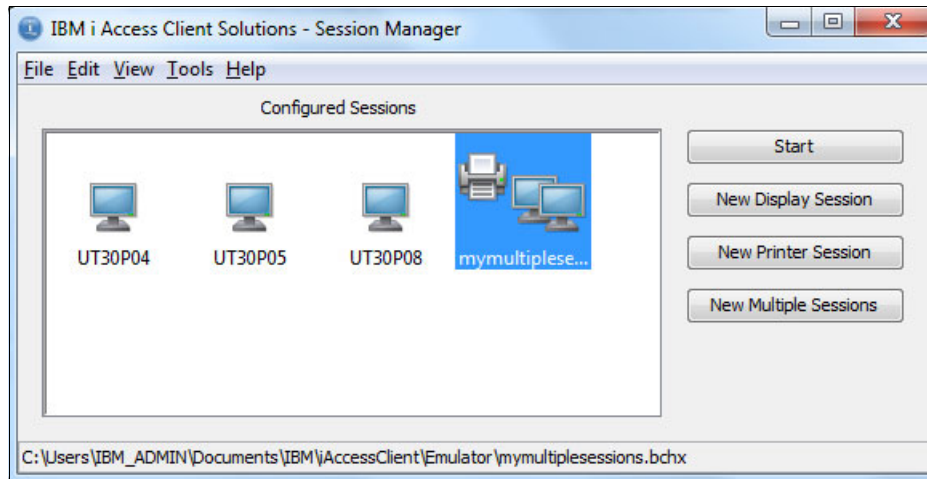


Figure 2-146 Example of saved multiple sessions in 5250 session manager

Tabbed 5250 sessions

To improve the usability of IBM i Access Client Solutions when working with many sessions, tab support is added to the 5250 emulator. To use this feature, click **File** → **New tab**, or press Ctrl + T on Windows or Command + T on Mac.

Figure 2-147 shows the tabbed sessions of a 5250 emulator.

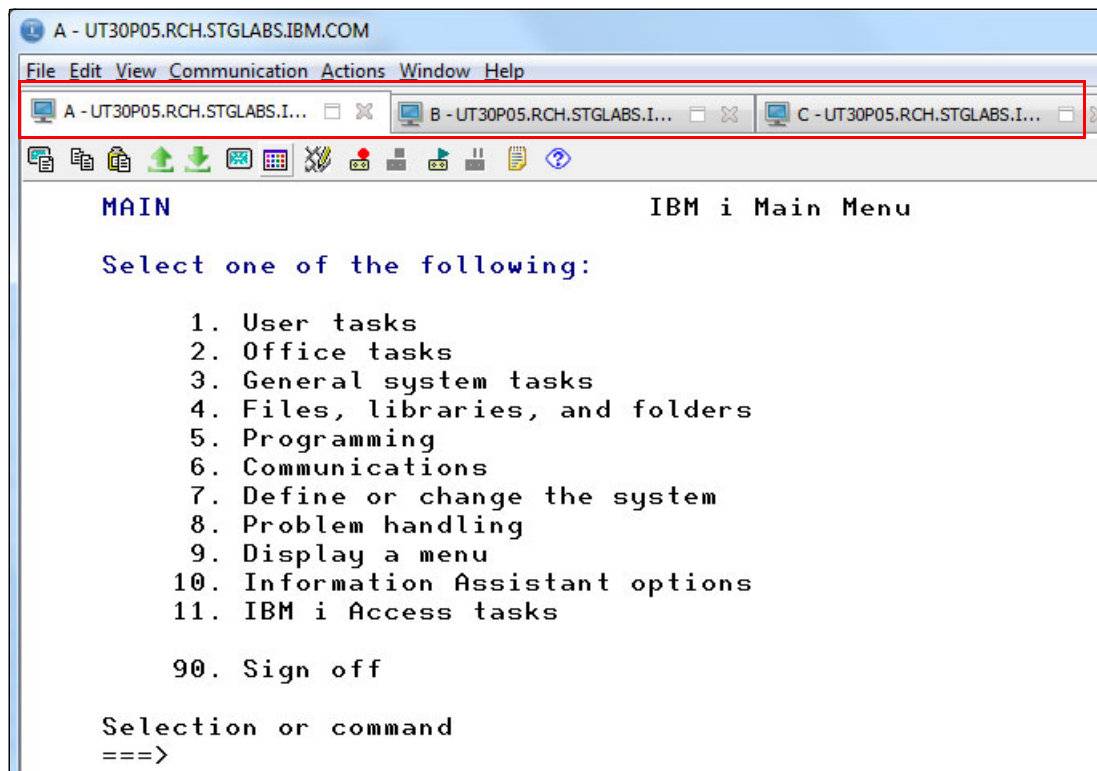


Figure 2-147 Tabbed sessions of a 5250 emulator

Deployment wizard for easy customization and deployment

In a large-scale deployment, it is hard for the IT administrators to deploy IBM i Access Client Solutions and customize its functions on a large number of PCs. Therefore, a deployment wizard feature was added to provide simplicity of customizations and deployments. This deployment wizard leads the administrator through a series of questions, asking which function should be available for users.

IBM i Access Client Solutions wizards are inside the `Windows_Application` directory and are named as follows:

- ▶ `install_acs_32.js` for the 32-bit version of Windows
- ▶ `install_acs_64.js` for the 64-bit version of Windows

There are two types of IBM i Access Client Solutions deployments:

- ▶ **Local deployment**

Local deployment means that the product files must be copied and stored on the PC where the product will be deployed.

- ▶ **Remote deployment**

Remote deployment means that the product files are not copied to the PC. Instead, they are accessed remotely from the PC, which means that the product files can be shared by multiple users.

Customization and deployment of IBM i Access Client Solutions can be done in the following ways, depending on the user requirements:

1. **Local and user customized**

The IBM i Access Client Solutions product files are copied and locally stored in each user PC and each user decides which functions are available for themselves.

2. **Local and administration customized**

The IBM i Access Client Solutions product files are copied and locally stored in each user PC, but instead of the users, the PC administrator decides which functions are available for the users.

3. **Remote and administration customized**

The IBM i Access Client Solutions product files are accessed from a shared central location (for example, IFS directories and network shared drives) and the PC administrator decides which functions are available for the users.

To customize easily the installation of IBM i Access Client Solutions, the installation package comes with an editable configuration file that is named `AcsConfig.properties`. This file contains the properties of configuration, which enables the administrator to determine several preferences of how IBM i Access Client Solutions are deployed to the clients. This configuration file also provides examples that guide the administrator to modify the preferences easily.

The properties that are available include the following ones:

- ▶ `com.ibm.iaccess.AcsBaseDirectory`, which determines the configuration location
- ▶ `com.ibm.iaccess.ExcludeComps`, which is used to restrict the usage of specific functions to be deployed
- ▶ `com.ibm.iaccess.Fonts`, which enables the administrators to override the default font setting
- ▶ `com.ibm.iaccess.autoimport`, which is used to set up automatically a configuration for new users or to update a configuration for existing users

Example 2-1 shows the usage of the `AcsConfig.properties` file to exclude several functions and modify the default font path in an IBM i Access Client Solutions deployment.

Example 2-1 Example of a configuration in the `AcsConfig.properties` file

```
com.ibm.iaccess.ExcludeComps=KEYMAN,OPCONSOLE,HWCONSOLE,L1CPLUGIN
com.ibm.iaccess.Fonts=/Users/IBM_ADMIN/MyFonts
```

For more information about how to customize and deploy IBM i Access Client Solutions by using the deployment wizard, see *IBM i Access Client Solutions: Customization and deployment made easy*, found at:

<https://www.ibm.com/developerworks/ibmi/library/i-ibmi-access-client-solutions-customization-trs/>

New database section

The IBM i Access Client Solutions product is extended to include some database functions that were previously found only within IBM i Access for Windows. The following options are available, as shown in Figure 2-148:

- ▶ Run SQL scripts
- ▶ SQL Performance Center

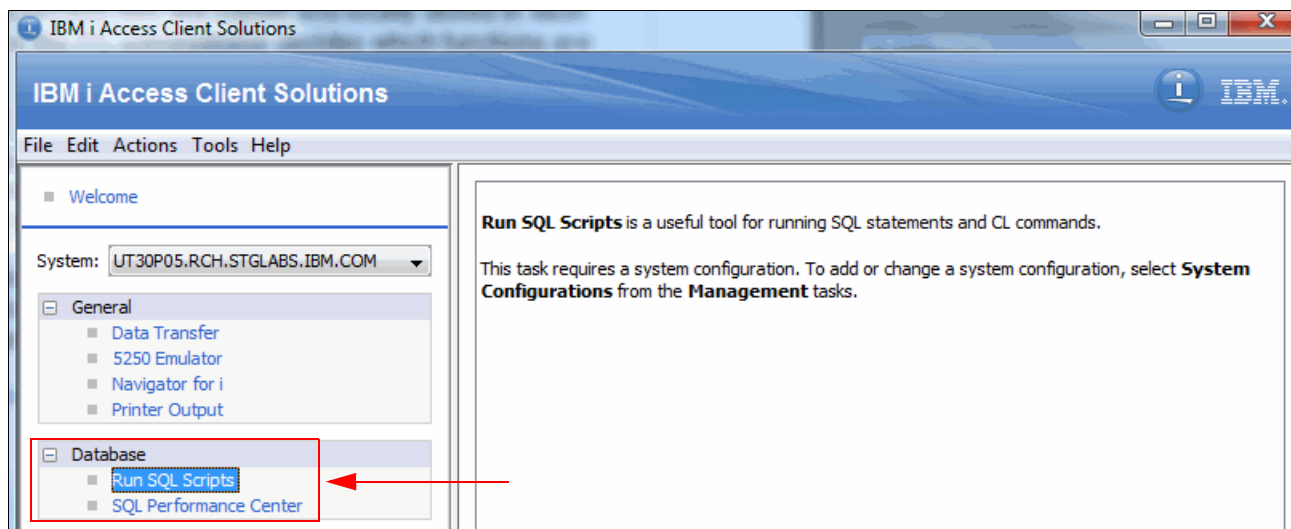


Figure 2-148 Database task within ACS

The Run SQL Scripts option in IBM i Access Client Solutions is a Java based solution that contains the following features, as shown in Figure 2-149:

- ▶ Color highlighting
- ▶ Faster startup
- ▶ Other usability features:
 - Line numbers
 - Color coding
 - Status bar

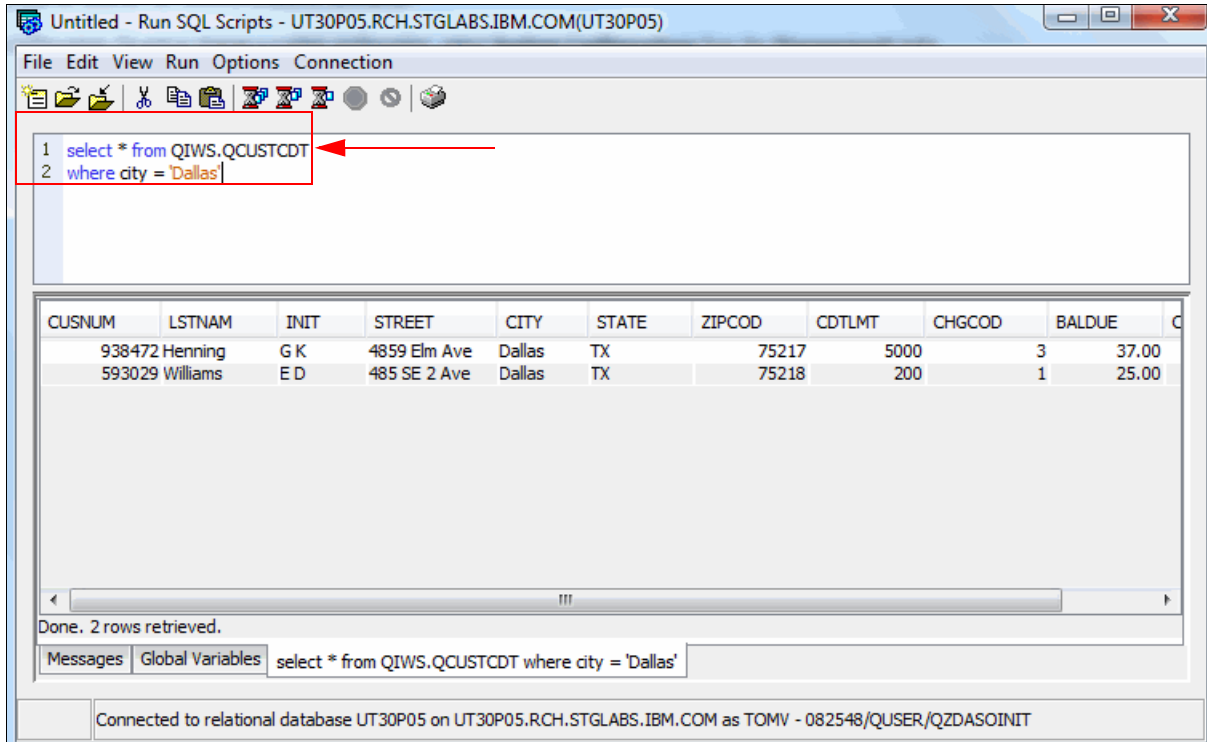


Figure 2-149 Run SQL Scripts in IBM i Access Client Solutions

From within the Run SQL script environment in IBM i Access Client Solutions, it is possible to get the following corresponding information in IBM Navigator for i:

- ▶ Job log
- ▶ Job details
- ▶ SQL details
- ▶ Compare

Note: There is now a better integration between IBM Navigator for i and IBM i Access Client Solutions for improved performance and usability.

Within IBM i Access Client Solutions, click **View** → **Job Log** and you get the corresponding Job Log information within IBM Navigator for i, as shown in Figure 2-150.

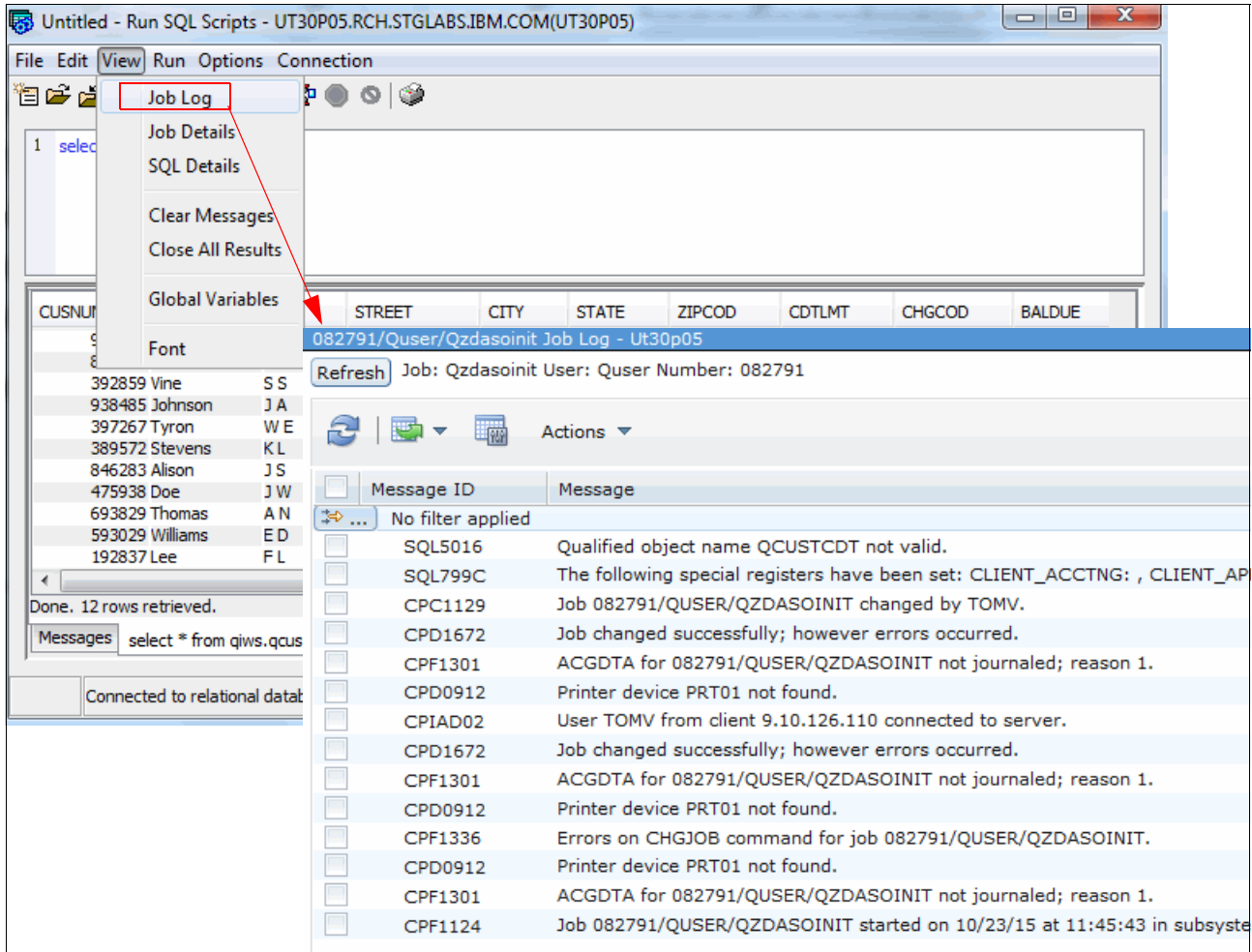


Figure 2-150 Run SQL Scripts: View: Job Log

Within IBM i Access Client Solutions, click **View** → **Job Details** and you get the corresponding Job Details information within IBM Navigator for i, as shown in Figure 2-151.

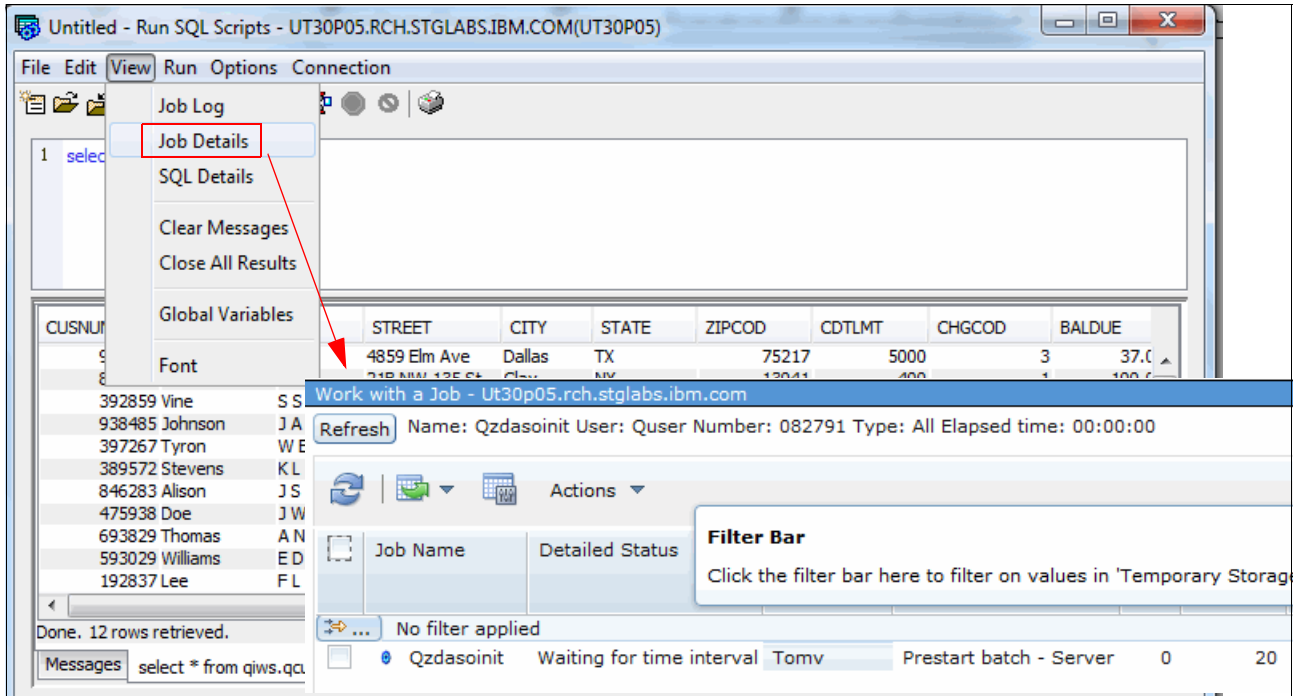


Figure 2-151 Run SQL Scripts: View: Job Details

Within IBM i Access Client Solutions, click **View** → **SQL Details** and you get the corresponding SQL Details for Jobs information within IBM Navigator for i, as shown in Figure 2-152.

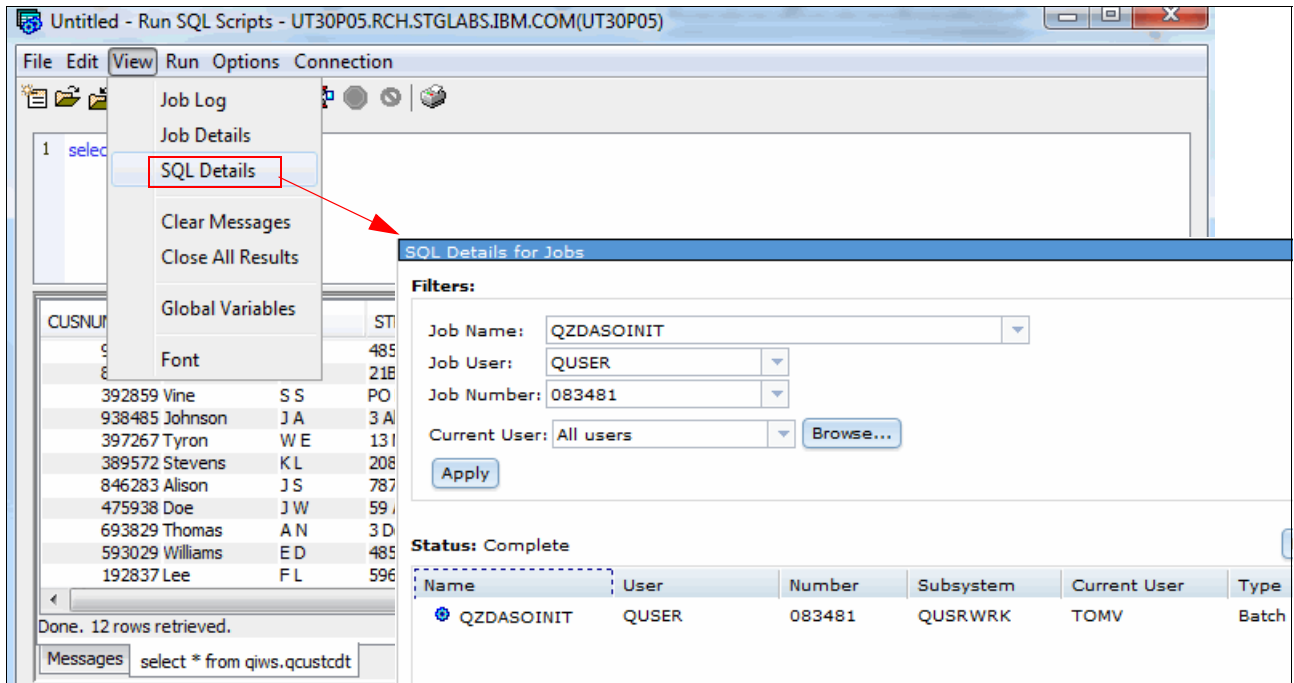


Figure 2-152 Run SQL Scripts: View: SQL Details

The SQL Performance Center in IBM i Access Client Solutions contains the following tabs to access DB2 for i performance artifacts, as shown in Figure 2-153:

- ▶ SQL Performance Monitor: Traces database applications.
- ▶ SQL Plan Cache Snapshots: Contains a point-in-time capture of queries that are run.
- ▶ SQL Plan Cache Event Monitors: Contains details for those queries that were removed or pruned from the plan cache.

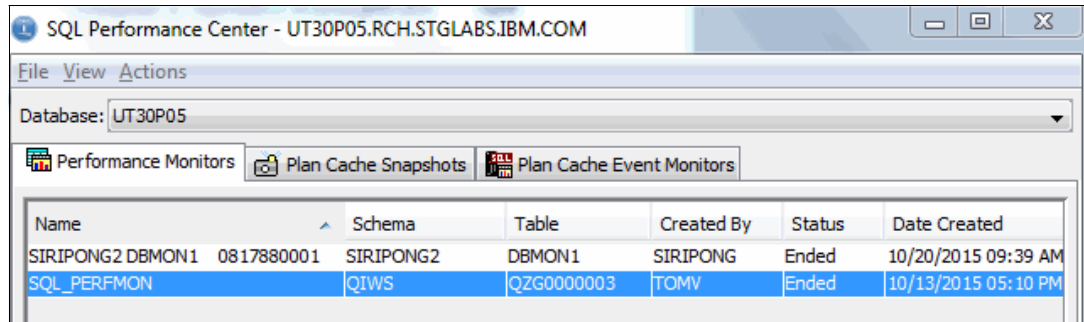


Figure 2-153 SQL Performance Center interface within IBM i Access Client Solutions

Note: There is now a better integration between IBM Navigator for i and IBM i Access Client Solutions for improved performance and usability.

Within IBM i Access Client Solutions, from the Performance Monitors tab, click **Actions** → **Analyze** and you get the SQL Analysis information, as shown in Figure 2-154.

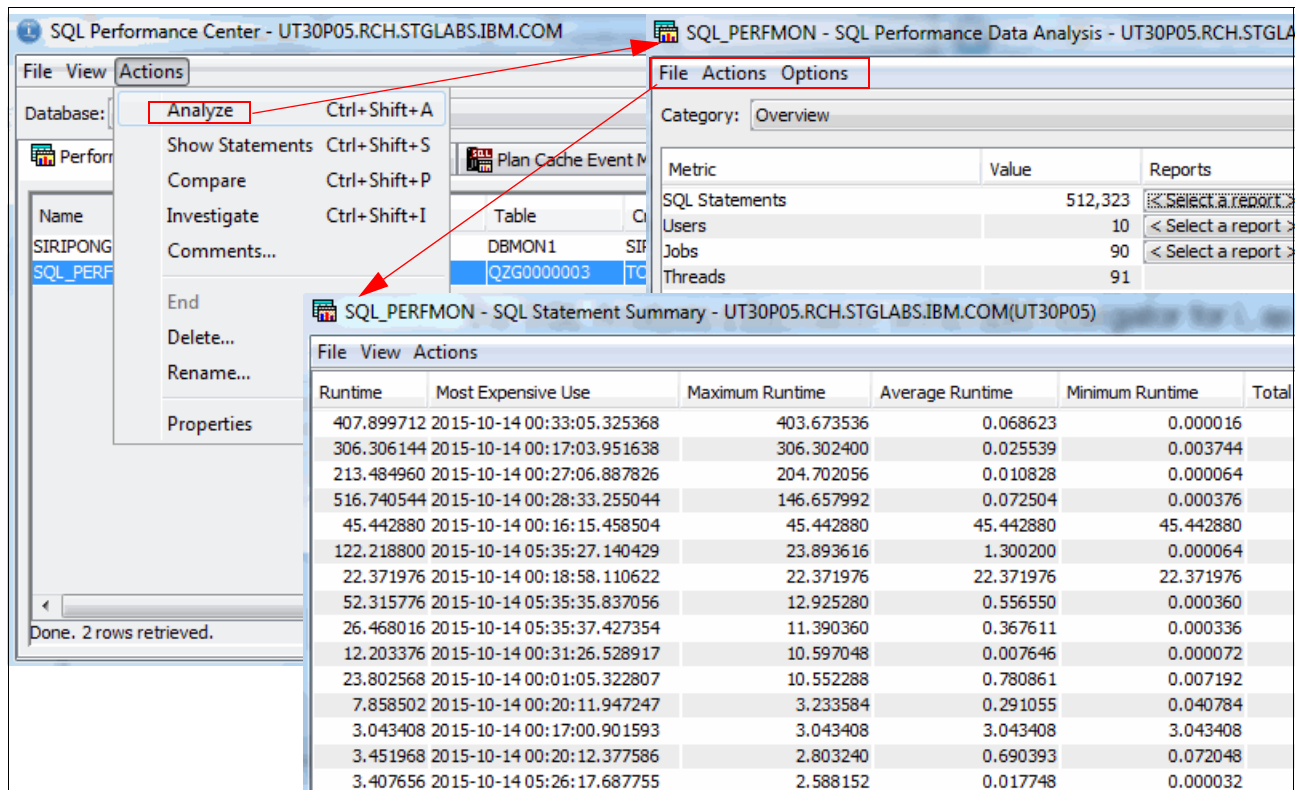


Figure 2-154 Performance Monitors: Analyze

Within IBM i Access Client Solutions, from the Performance Monitors tab, click **Actions** → **Show Statements** and you get the SQL Statements information within IBM Navigator for i, as shown in Figure 2-155.

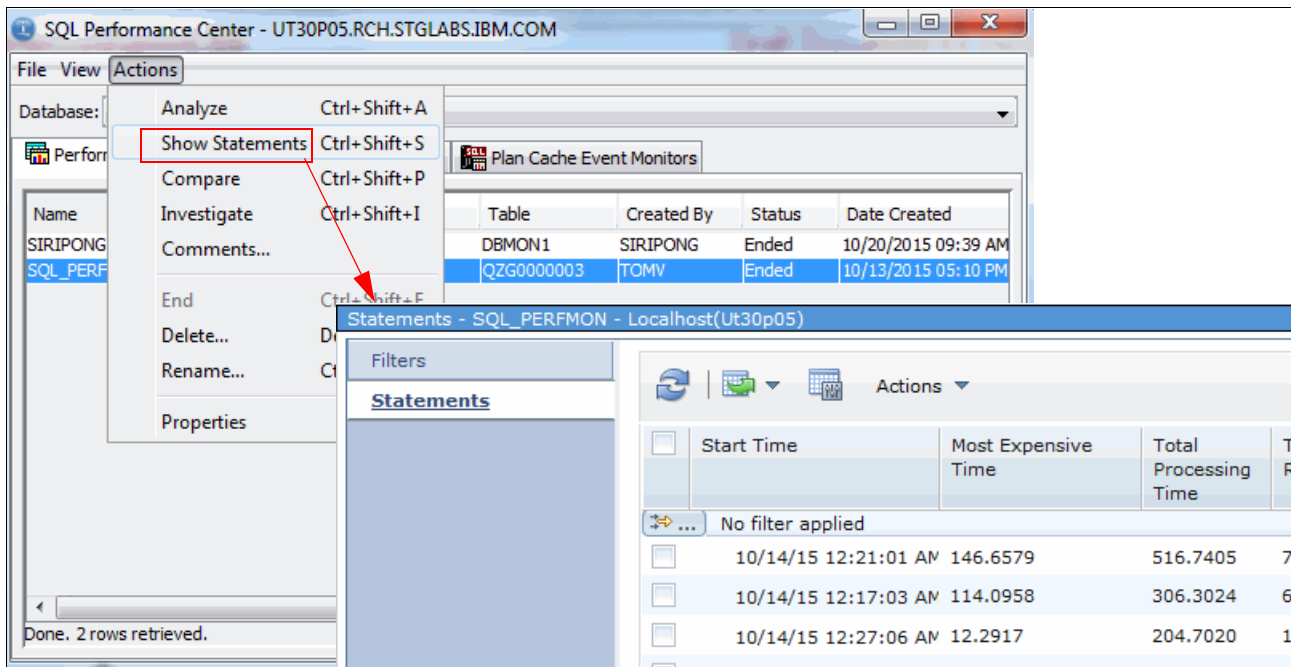


Figure 2-155 Performance Monitors: Show Statements

Within IBM i Access Client Solutions, from the Performance Monitors tab, click **Actions** → **Compare** and you get the corresponding SQL Performance Data Comparison information within IBM Navigator for i, as shown in Figure 2-156.

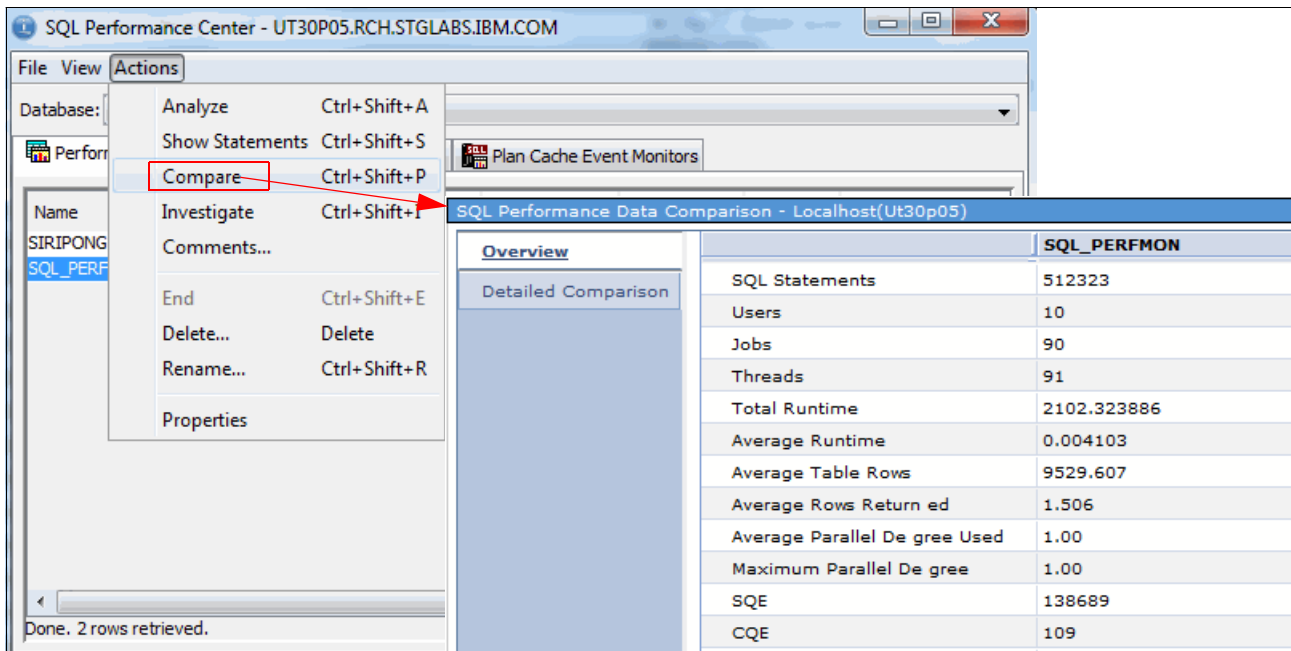


Figure 2-156 Performance Monitors: Compare

Within IBM i Access Client Solutions, from the Performance Monitors tab, click **Actions** → **Investigate** and you get the following corresponding SQL related charts within IBM Navigator for i:

- ▶ Query Time Summary
- ▶ Open Summary
- ▶ Open Type Summary
- ▶ Statement Usage Summary
- ▶ Index Used Summary
- ▶ Index Create Summary
- ▶ Index Advised
- ▶ Statistics Advised
- ▶ MQT Use
- ▶ Access Plan Use
- ▶ Parallel Degree Usage

As shown in Figure 2-157, you can see the Query Time Summary information from the SQL Overview details.

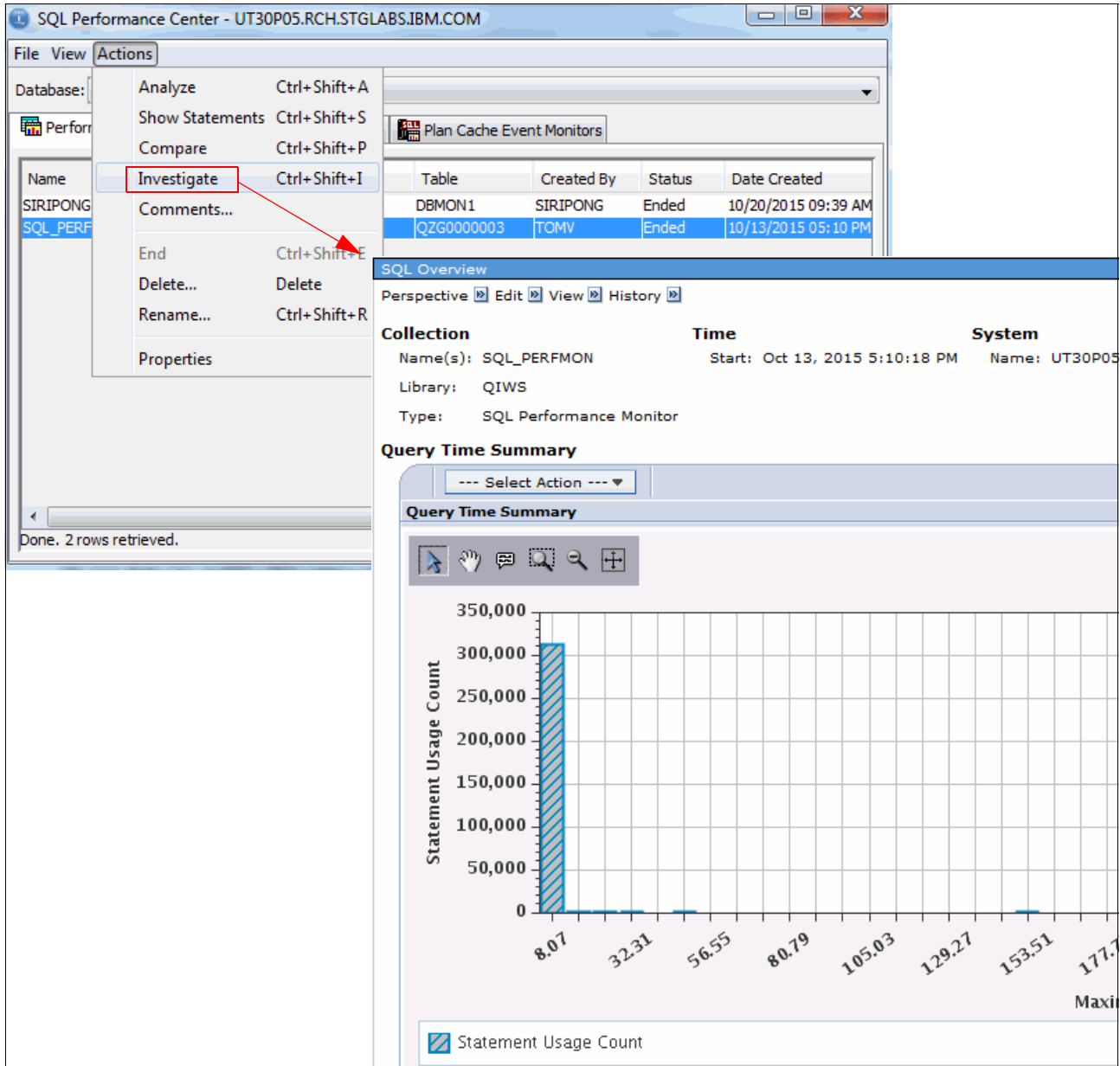


Figure 2-157 Performance Monitors: Investigate

Within IBM i Access Client Solutions, from the Plan Cache Snapshots tab, click **Actions** → **Analyze** and you get the SQL Plan Cache Analysis information within IBM Navigator for i, as shown in Figure 2-158.

The screenshot displays the IBM Navigator for i interface. The 'Actions' menu is open, with 'Analyze' highlighted. The 'snapshot1 - SQL Performance Data Analysis' window is visible, showing an overview of performance metrics. The 'snapshot1 - SQL Statement Summary' window is also open, displaying a table of statement performance data.

Runtime	Most Expensive Use	Maximum Runtime	Average Runtime	Minimum Runtime	Total Runtime
2.646592	2014-10-02 13:37:00.243355	2.498532	1.323296	-	2.646
1.136714	2014-10-01 19:59:49.134293	1.136714	1.136714	-	1.136
0.890255	2014-10-02 13:15:14.234118	0.890255	0.890255	-	0.890
0.905885	2014-10-01 16:00:56.438148	0.888671	0.301961	-	0.905
1.083293	2014-10-02 14:03:37.909697	0.560713	0.541646	-	1.083
0.790699	2014-10-02 14:06:09.162740	0.530688	0.395349	-	0.790
1.033514	2014-10-02 14:06:12.835544	0.525841	0.516757	-	1.033
0.478706	2014-10-02 13:31:53.927092	0.474123	0.239353	-	0.478
0.454605	2014-10-03 01:40:10.266939	0.454605	0.454605	-	0.454
0.305823	2014-10-02 10:53:49.110084	0.305823	0.305823	-	0.305
0.292273	2014-10-02 13:31:55.505573	0.291968	0.146136	-	0.292
0.250077	2014-10-02 13:32:46.046048	0.250077	0.250077	-	0.250

Figure 2-158 Plan Cache Snapshots: Analysis

Within IBM i Access Client Solutions, from the Plan Cache Snapshots tab, click **Actions** → **Show Statements** and you get the corresponding SQL Plan Cache Statements information within IBM Navigator for i, as shown in Figure 2-159.

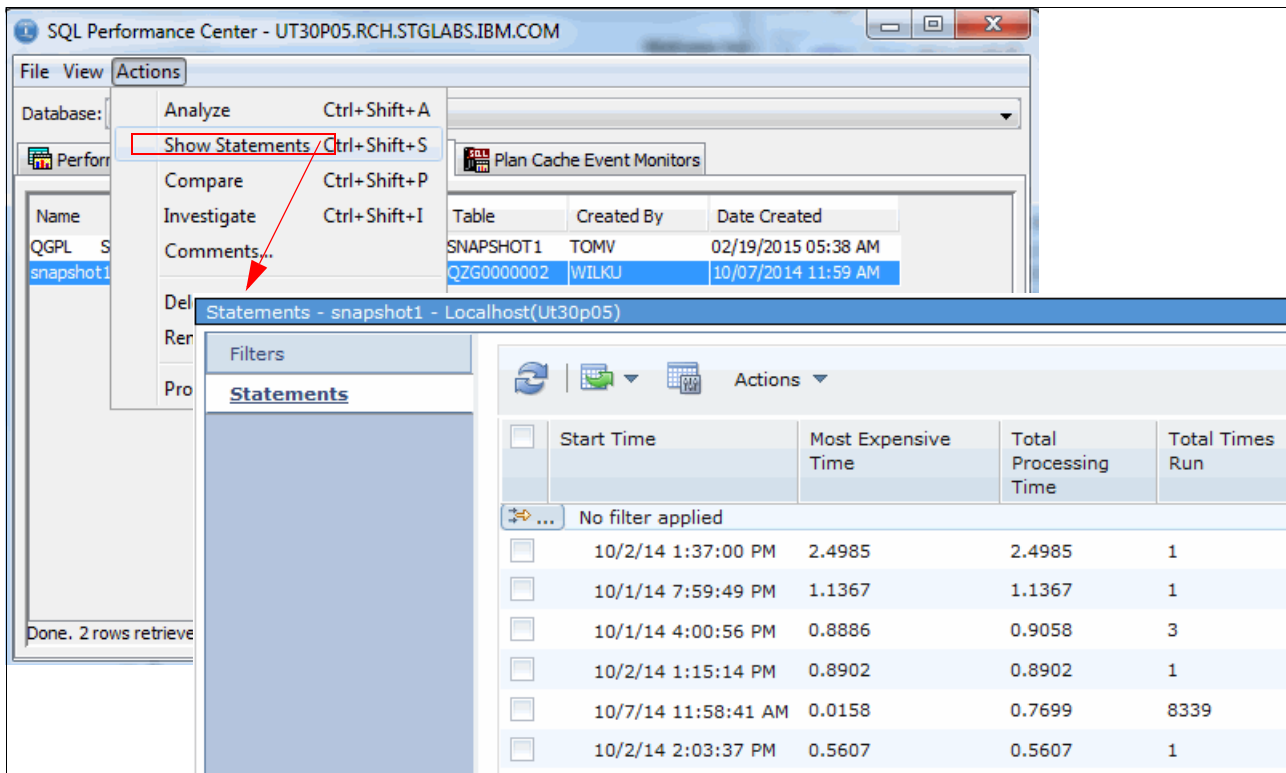


Figure 2-159 Plan Cache Snapshots: Show Statements

Within IBM i Access Client Solutions, from the Plan Cache Snapshots tab, click **Actions** → **Compare** and you get the corresponding SQL Performance Monitor Compare information within IBM Navigator for i, as shown in Figure 2-160 on page 141.

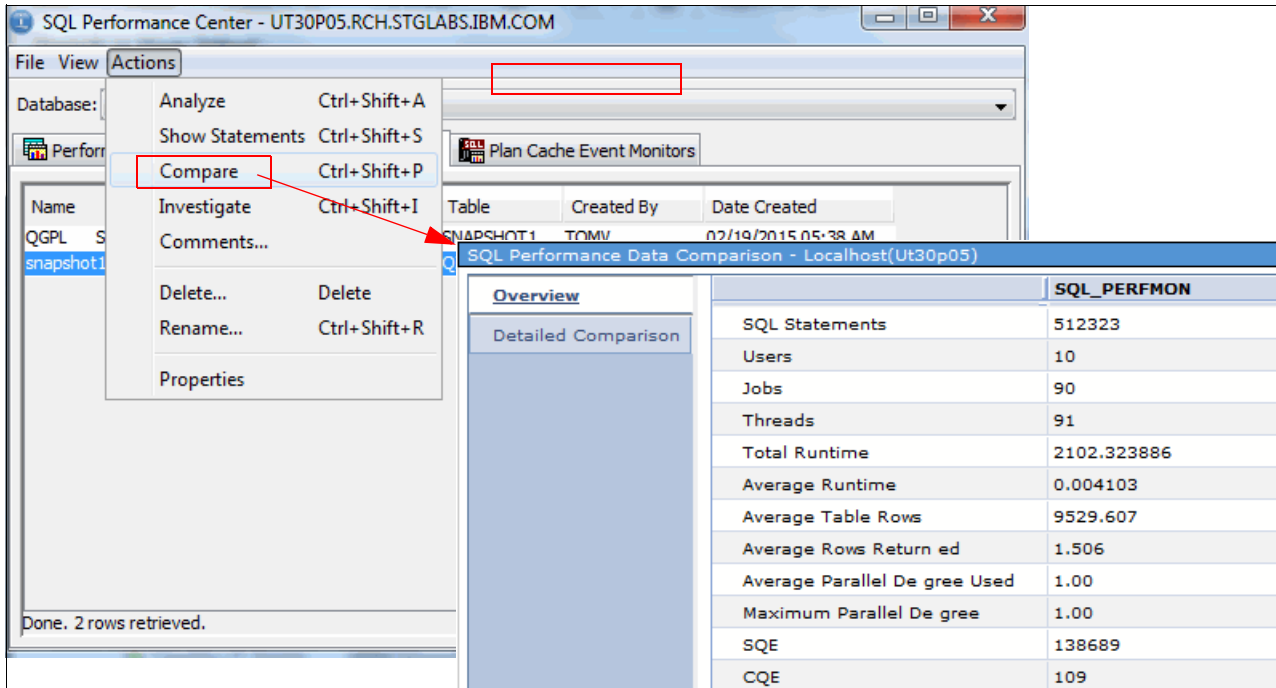


Figure 2-160 Plan Cache Snapshot: Compare

Within IBM i Access Client Solutions, from the Plan Cache Event Monitors tab, click **Actions** → **Analyze** and you get the SQL Analysis information, as shown in Figure 2-161.

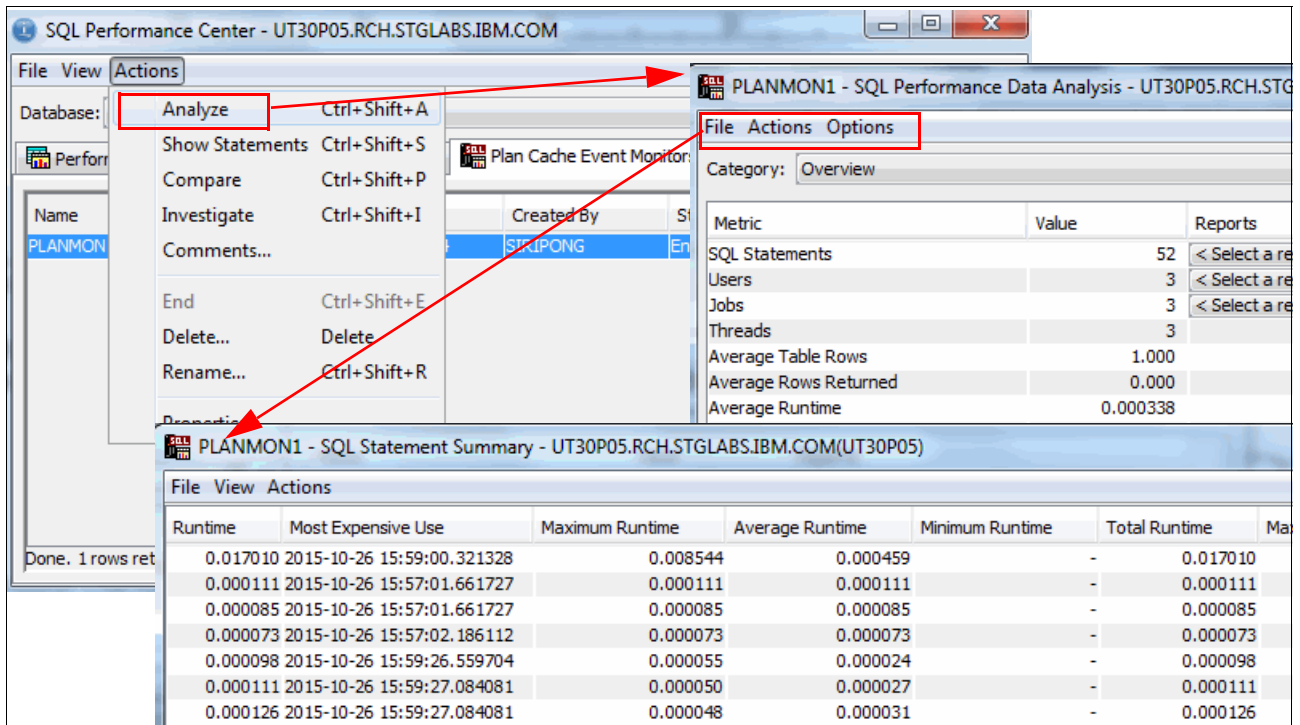


Figure 2-161 Plan Cache Event Monitors: Analyze

Within IBM i Access Client Solutions, from the Plan Cache Event Monitors tab, click **Actions** → **Show Statements** and you get the SQL Analysis information within IBM Navigator for i, as shown in Figure 2-162.

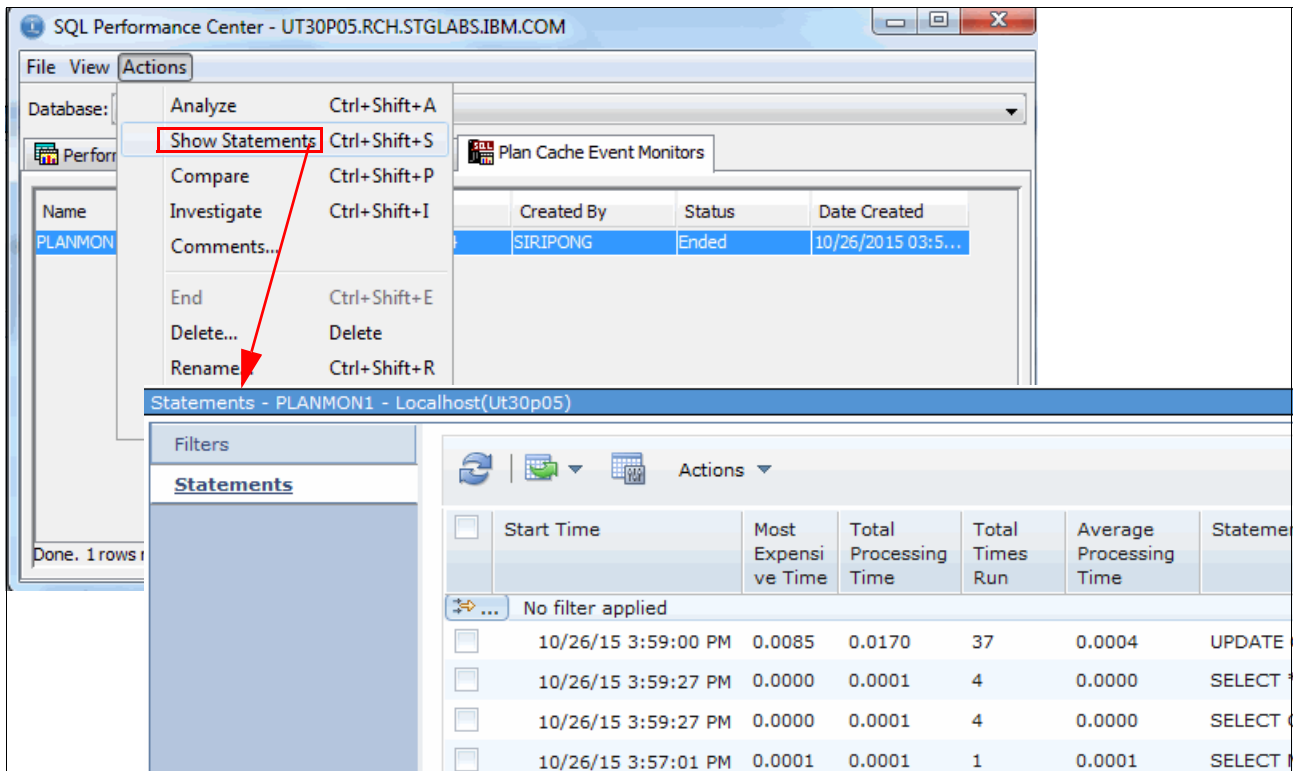


Figure 2-162 Plan Cache Event Monitors: Show Statements

Within IBM i Access Client Solutions, from the Plan Cache Event Monitors tab, click **Actions** → **Compare** and you get the corresponding SQL Performance Monitor Compare information within IBM Navigator for i, as shown in Figure 2-163.

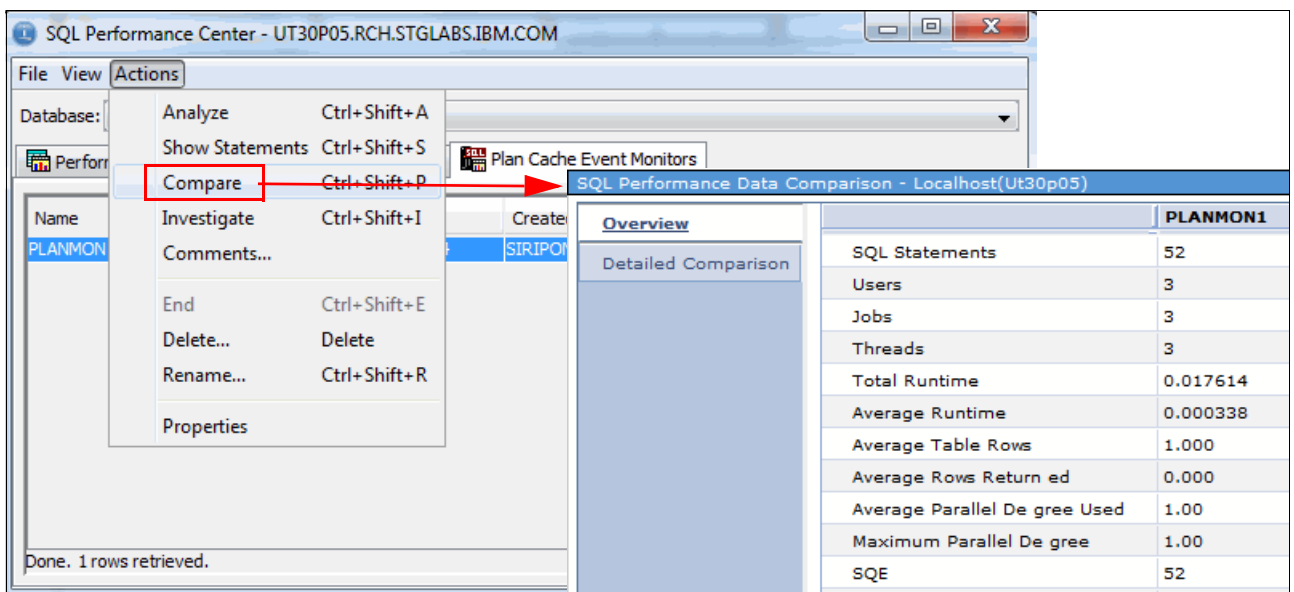


Figure 2-163 Plan Cache Event Monitors: Compare

Within IBM i Access Client Solutions, from the Plan Cache Event Monitors tab, click **Actions** → **Investigate** and you get the following corresponding SQL related charts within IBM Navigator for i:

- ▶ Query Time Summary
- ▶ Open Summary
- ▶ Open Type Summary
- ▶ Statement Usage Summary
- ▶ Index Used Summary
- ▶ Index Create Summary
- ▶ Index Advised
- ▶ Statistics Advised
- ▶ MQT Use
- ▶ Access Plan Use
- ▶ Parallel Degree Usage

In Figure 2-164, you can see the Query Time Summary information from the SQL Overview details.

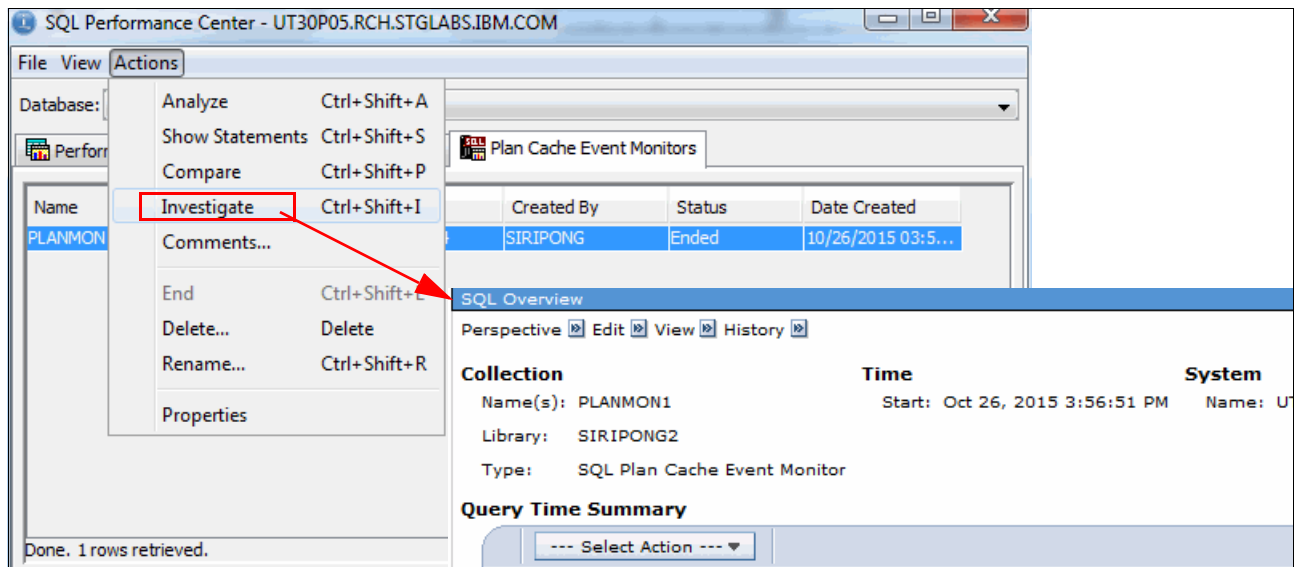


Figure 2-164 Plan Cache Event Monitors: Investigate

IBM i Access Client Solutions: Windows Application Package

The IBM i Access Client Solutions Windows Application Package provides middleware for using and developing client applications for Windows operating systems. Windows Application Package is an optional package for Windows that is part of the IBM i Access Client Solutions product. Users and application programmers can use Windows Application Package to use business information, applications, and resources across an enterprise by extending the IBM i resources to the PC desktop.

IBM i Access Client Solutions Windows Application Package provides the following features:

- ▶ An extensive number of application programming interfaces (APIs).
- ▶ Provides accessibility to DB2 for i by using ODBC, .NET, and OLE DB.
- ▶ Secure connection to IBM i by using Secure Sockets Layer (SSL).
- ▶ Federal Information Processing Standard (FIPS) compliance.

Note: The Advanced Function Presentation (AFP) Printer Driver for Windows 8.1 and Windows Server 2012 R2 can be obtained from the Ricoh website. For more information about this support, see the IBM Support Portal document:

<http://www.ibm.com/support/docview.wss?uid=nas8N1011940>

IBM i Access Client Solutions: Linux Application Package

Similar to the Windows Application Package, the Linux Application Package is an optional package for Linux platforms that contains the following features:

- ▶ Full 64-bit ODBC support
- ▶ Both RPM and deb packages for Debian and Ubuntu distributions
- ▶ Linux on Power support

When combined with the IBM i Access Client Solutions core offering, the Linux Application Package provides a complete replacement for IBM i Access for Linux. In addition, the core product offering provides several additional features that are not available in IBM i Access for Linux.

2.2.2 IBM i Access for Windows

Within a journaled environment, you can now select multiple rows and view the data. This makes it easier to compare the before and after situation. This topic is described in “Adding multiple view entries support to the journal viewer” on page 402.

2.2.3 IBM i Access for Web

IBM i Access for Web offers web-based access to IBM i. You can use IBM i Access for Web to use business information, applications, and resources across an enterprise by extending the IBM i resources to the client desktop or a mobile device through a web browser.

Feature enhancements

In IBM i 7.2, IBM i Access for Web provides the following enhancements:

- ▶ Viewing active jobs on the system in three different views, which is similar to what the Work with Active Jobs (**WRKACTJOB**) CL command does.
- ▶ Viewing PTFs and PTF Groups, which is similar to what the Display PTF (**DSPPTF**) and Work with PTF Groups (**WRKPTFGRP**) CL commands do.
- ▶ A new System category for displaying installed products, system values, and other system-related information.
- ▶ IBM Integrated Web Application Server for i V8.5.
- ▶ RC4 and AES encryption types with SPNEGO environments.
- ▶ Password expiration based on the QPWDEXPWRN system value.

In addition to the above features, PTF SI54619 for IBM i Access for Web provides the following enhancements:

- ▶ A filter box for row context-based filtering.
- ▶ Support for secure telnet when connecting to port 992.

Supported environments

IBM i Access for Web in 7.2 is supported on the following web application servers:

- ▶ IBM Integrated Web Application Server for i
- ▶ WebSphere Application Server Express V8.5 for IBM i, WebSphere Application Server V8.5 for IBM i, and WebSphere Application Server V8.5 Network Deployment for IBM i
- ▶ WebSphere Application Server Express V8.0 for IBM i, WebSphere Application Server V8.0 for IBM i, and WebSphere Application Server V8.0 Network Deployment for IBM i
- ▶ WebSphere Application Server Express V7.0 for IBM i, WebSphere Application Server V7.0 for IBM i, and WebSphere Application Server V7.0 Network Deployment for IBM i
- ▶ WebSphere Application Server Express V6.1 for i5/OS, WebSphere Application Server V6.1 for i5/OS, and WebSphere Application Server V6.1 Network Deployment for i5/OS

In addition, IBM i Access for Web can be used with any of the following WebSphere Portal servers:

- ▶ WebSphere Portal V8.0
- ▶ WebSphere Portal V7.0
- ▶ WebSphere Portal for Multiplatforms V6.1

Note: IBM i Access for Web V7.2 is supported on IBM i 7.2, 7.1, and 6.1. For customers running 7.1 and 6.1 IBM i Access Family (57xx-XW1), it is possible to acquire IBM i Access for Web 7.2 and stay on their current release of IBM i.

For more information about configuring IBM i Access for Web by using the various supported application server environments, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzamm/rzammaccessweb.htm

Main user interface

Figure 2-165 shows the main user interface of IBM i Access for Web in IBM i 7.2. The main navigation menus are in the left side of the window.

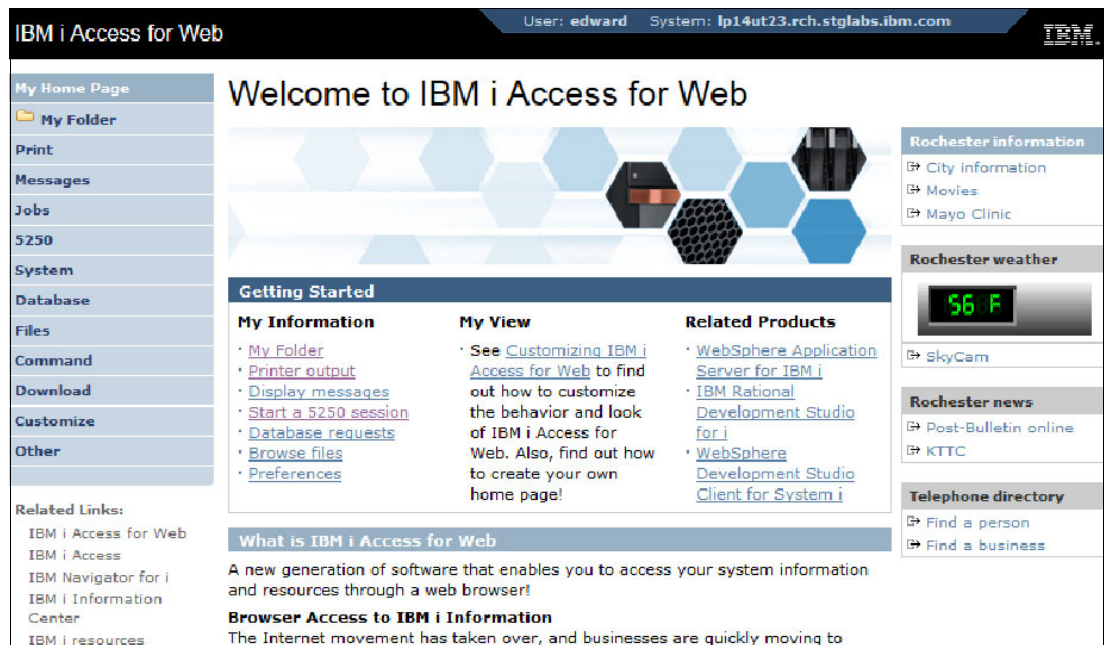


Figure 2-165 IBM i Access for Web main user interface

Displaying active jobs

You can use IBM i Access for Web in IBM i 7.2 to view active jobs in the system. There are three different views, which is similar to how the Work with Active Jobs (**WRKACTJOB**) CL command works, such as status, elapsed data, and thread data.

To view the active jobs, click **Jobs** → **Active jobs** in the left side of the window. These views are shown in Figure 2-166. Choose the list action at the top of the table to select alternative views for displaying the active jobs.

The screenshot shows the 'Active Jobs - Status' page. The left sidebar has 'Jobs' selected, with 'Active jobs' highlighted. The main content area shows a table with the following columns: Subsystem/Job, CPU %, Function, Status, and Action. A dropdown menu is open over the 'Action' column, showing options: '--- Select List Action ---', 'Refresh statistics', 'Reset statistics', 'Display elapsed data', and 'Display thread data'. The table data is as follows:

Subsystem/Job	Job	Pool	Pty	CPU %	Function	Status	Action
QBATCH	SBS	2	0	.0	DEQW	DEQW	
QCMN	QSYS	SBS		.0	DEQW	DEQW	
QACSOTP	QUSER	PJ		.0	PSRW	PSRW	
QLZPSERV	QUSER	PJ		.0	PSRW	PSRW	
QNMAPPINGD	QUSER	PJ		.0	PSRW	PSRW	
QNMAREXECD	QUSER	PJ		.0	PSRW	PSRW	

Figure 2-166 IBM i Access for Web page showing alternative views of active jobs

Figure 2-167 shows the elapsed data information from active jobs.

The screenshot shows the 'Active Jobs - Elapsed Data' page. The left sidebar has 'Jobs' selected, with 'Active jobs' highlighted. The main content area shows a table with the following columns: Subsystem/Job, Type, Pool, Pty, CPU, Int, Rsp, AuxIO, CPU %, and Action. The table data is as follows:

Subsystem/Job	Type	Pool	Pty	CPU	Int	Rsp	AuxIO	CPU %	Action
QBATCH	SBS	2	0	.0			0	.0	
QCMN	SBS	2	0	.1			0	.0	
QACSOTP	PJ	2	20	.0			0	.0	
QLZPSERV	PJ	2	20	.0			0	.0	
QNMAPPINGD	PJ	2	25	.0			0	.0	
QNMAREXECD	PJ	2	25	.0			0	.0	

Figure 2-167 IBM i Access for Web page showing elapsed data for active jobs

Figure 2-168 shows the thread data information from active jobs.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

Active Jobs - Thread Data

Information time: Oct 7, 2014 11:13:23 AM
Elapsed time: 00:00:01
CPU %: .8

Filter

Page 1 of 10 Jump to page: 1 Total: 246

Subsystem/Job	User	Number	Type	CPU %	Threads	Temporary Storage	Action
QBATCH	QSYS	172228	SBS	.0	2	5	
QCMN	QSYS	172231	SBS	.0	2	5	
QACSOTP	QUSER	172253	PJ	.0	1	0	
QLZPSERV	QUSER	172266	PJ	.0	1	0	
QNMAPINGD	QUSER	172243	PJ	.0	1	2	
QNMAREXCD	QUSER	172250	PJ	.0	1	3	

Figure 2-168 IBM i Access for Web page showing thread data for active jobs

Viewing system information

You also can use IBM i Access for Web in IBM i 7.2 to view system information, such as installed products and system values. To do this task, click **System** in the left side of the window. The submenu of System tasks opens. Figure 2-169 shows the installed products from IBM i Access for Web.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

Installed Products

Filter

Page 1 of 4 Jump to page: 1 Total: 100

Product	Option	Release	Status	Description
5770999	0000	V7R1M0	*INSTALLED	Licensed Internal Code
5770SS1	0000	V7R1M0	*INSTALLED	IBM i
5770SS1	0001	V7R1M0	*INSTALLED	Extended Base Support
5770SS1	0002	V7R1M0	*INSTALLED	Online Information
5770SS1	0003	V7R1M0	*INSTALLED	Extended Base Directory Support
5770SS1	0005	V7R1M0	*INSTALLED	System/36 Environment
5770SS1	0006	V7R1M0	*INSTALLED	System/38 Environment
5770SS1	0007	V7R1M0	*INSTALLED	Example Tools Library
5770SS1	0008	V7R1M0	*INSTALLED	AFP Compatibility Fonts
5770SS1	0009	V7R1M0	*INSTALLED	*PRV CL Compiler Support
5770SS1	0012	V7R1M0	*INSTALLED	Host Servers
5770SS1	0013	V7R1M0	*INSTALLED	System Openness Includes
5770SS1	0014	V7R1M0	*INSTALLED	GDDM

Figure 2-169 IBM i Access for Web page showing installed products

You can use IBM i Access for Web in IBM 7.2 to view the PTF status, which presents a similar view to what is displayed when you run the Display PTF (DSPPTF) CL command. Click **System** → **PTFs** on the left side of the window to view the PTF status, as shown in Figure 2-170.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

PTFs - PTF Status

Product ID: 5770SS1
 IPL source: ##MACH##B
 Release level: V7R1M0 L00
 Product option: *ALL

Filter

--- Select List Action ---

Page 1 of 250 Jump to page: 1 Total: 6230

PTF ID	Status	IPL Action
TC14143	Temporarily applied	None
TC13298	Permanently applied	None
TC13037	Superseded	None
TC12279	Superseded	None
TC12115	Superseded	None
TC11270	Superseded	None
TC11116	Superseded	None
TC10229	Superseded	None
TC10096	Superseded	None

Figure 2-170 IBM i Access for Web page showing PTF status

In addition to PTF status, you can list the PTF Groups that are installed on the IBM i system. Click **System** → **PTF groups** in the left side of the window. The PTF Groups window opens, as shown in Figure 2-171 on page 149.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

My Home Page
My Folder
Print
Messages
Jobs
5250
System
Installed products
PTFs
PTF groups
System values
Extract IBM i data
Database
Files
Command
Download
Customize
Other

PTF Groups

Filter

Page 1 of 1 Jump to page: 1 Total: 15

PTF Group	Level	Status	Text
SF99710	14143	Installed	CUMULATIVE PTF PACKAGE C4143710
SF99710	13298	Installed	CUMULATIVE PTF PACKAGE C3298710
SF99701	30	Installed	DB2 FOR IBM I
SF99701	29	Installed	DB2 FOR IBM I
SF99572	17	Installed	JAVA
SF99572	16	Installed	JAVA
SF99381	9	Installed	WEBSPPHERE APP SERVER V8.5
SF99381	8	Installed	WEBSPPHERE APP SERVER V8.5
SF99380	11	Installed	WEBSPPHERE APP SERVER V8.0
SF99380	10	Installed	WEBSPPHERE APP SERVER V8.0
SF99368	29	Installed	IBM HTTP SERVER FOR I
SF99368	28	Installed	IBM HTTP SERVER FOR I
SF99364	9	Installed	WEBSPPHERE APP SERVER V6.1

Figure 2-171 IBM i Access for Web page showing PTF groups

You can use IBM i Access for Web to display the system values of the IBM i system. Click **System** → **System values** in the left side of the window. The System Value Categories window, as shown in Figure 2-172. Click the wanted category to display the system values.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

My Home Page
My Folder
Print
Messages
Jobs
5250
System
Installed products
PTFs
PTF groups
System values
Extract IBM i data
Database
Files
Command
Download
Customize

System Value Categories

Filter

Page 1 of 1 Jump to page: 1 Total: 10

Category	Description
Allocation	Allocation system values
Date and Time	Date and time system values
Editing	Editing system values
Library List	Library list system values
Message and Logging	Message and logging system values
Security	Security system values
Storage	Storage system values
System Control	System control system values
Network Attributes	Network attributes of the system
All	All system values in the system

Page 1 of 1 Jump to page: 1 Total: 10

Figure 2-172 IBM i Access for Web page showing system values categories

You can also extract other IBM i object data and store it in a database table. After the table is created, it can be queried or modified like any other database table. However, the created table contains only the snapshot of the object information. Therefore, to access the most recent information, you must run the extract request again. Figure 2-173 shows the IBM i object data extraction menu.

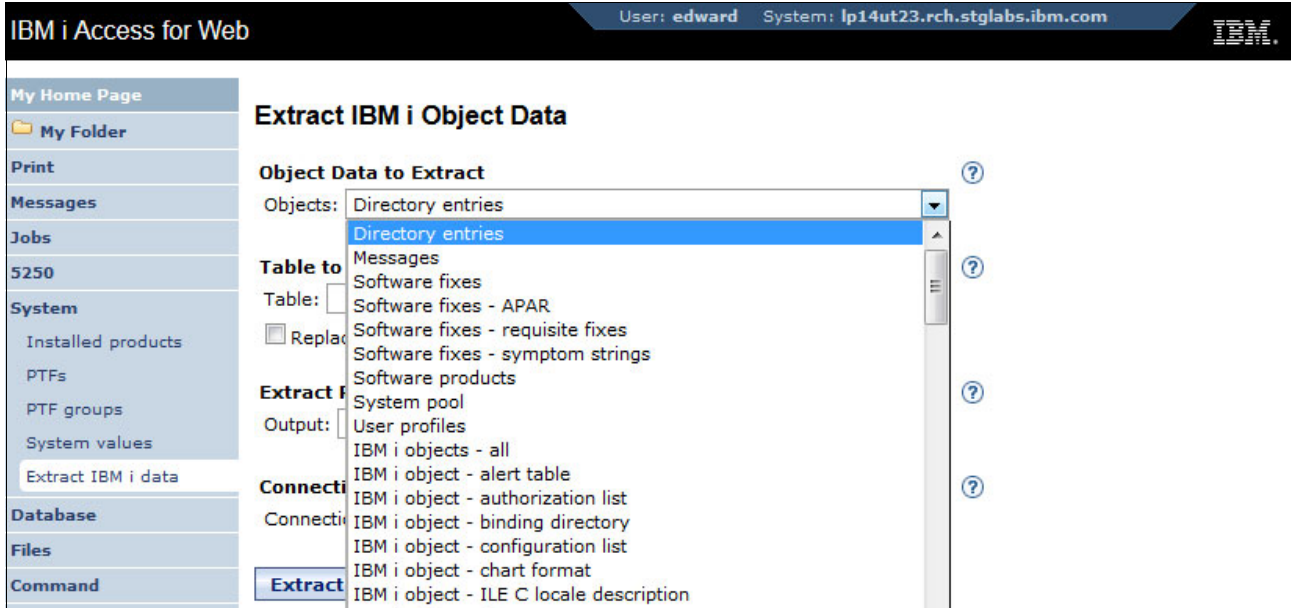


Figure 2-173 IBM i Access for Web page showing the list of IBM i object data that can be extracted

Context-based filtering

IBM i Access for Web in IBM i 7.2 provides a filter box for context-based filtering. This filter box is available through various features in IBM i Access for Web, such as displaying messages, jobs, PTF, and system values. You can use it to search easily the information within the table based on the entered text.

Figure 2-174 on page 151 shows the example of filtering a PTF ID by entering TC in to the filter box.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

PTFs - PTF Status

Product ID: 5770SS1
 IPL source: ##MACH##B
 Release level: V7R1M0 L00
 Product option: *ALL

TC

--- Select List Action ---

Page 1 of 250 Jump to page: 1 Total: 6230

PTF ID	Status	IPL Action
TC14143	Temporarily applied	None
TC13298	Permanently applied	None
TC13037	Superseded	None
TC12279	Superseded	None
TC12115	Superseded	None
TC11270	Superseded	None
TC11116	Superseded	None
TC10229	Superseded	None
TC10096	Superseded	None

Figure 2-174 Filter box for context-based filtering in IBM i Access for Web

Secure telnet in a 5250 session

IBM i Access for Web in IBM i 7.2 added support for making a secure telnet connection. When specifying port 992 for a 5250 display session, a secure telnet connection is made pending certificate validation. The secure telnet session validates the certificate chain, but does not perform server authentication or client authentication.

To start secure telnet in a 5250 session, click **5250** → **Start session**. The Start Session window, as shown in Figure 2-175. Specify port 992 in the Port field.

IBM i Access for Web User: edward System: lp14ut23.rch.stglabs.ibm.com

Start Session

System

System: lp14ut23.rch.stglabs.ibm.com
 Port: 992
 Code page: 37

Workstation ID

Use user ID
 Specify workstation ID
 Avoid duplicates for this user
 Avoid duplicates with other users

General

Initial macro:

Figure 2-175 Start session parameter for secure telnet

Secure telnet in a 5250 session, which is shown in Figure 2-176, can be identified by the SSL label at the bottom of the 5250 panel.

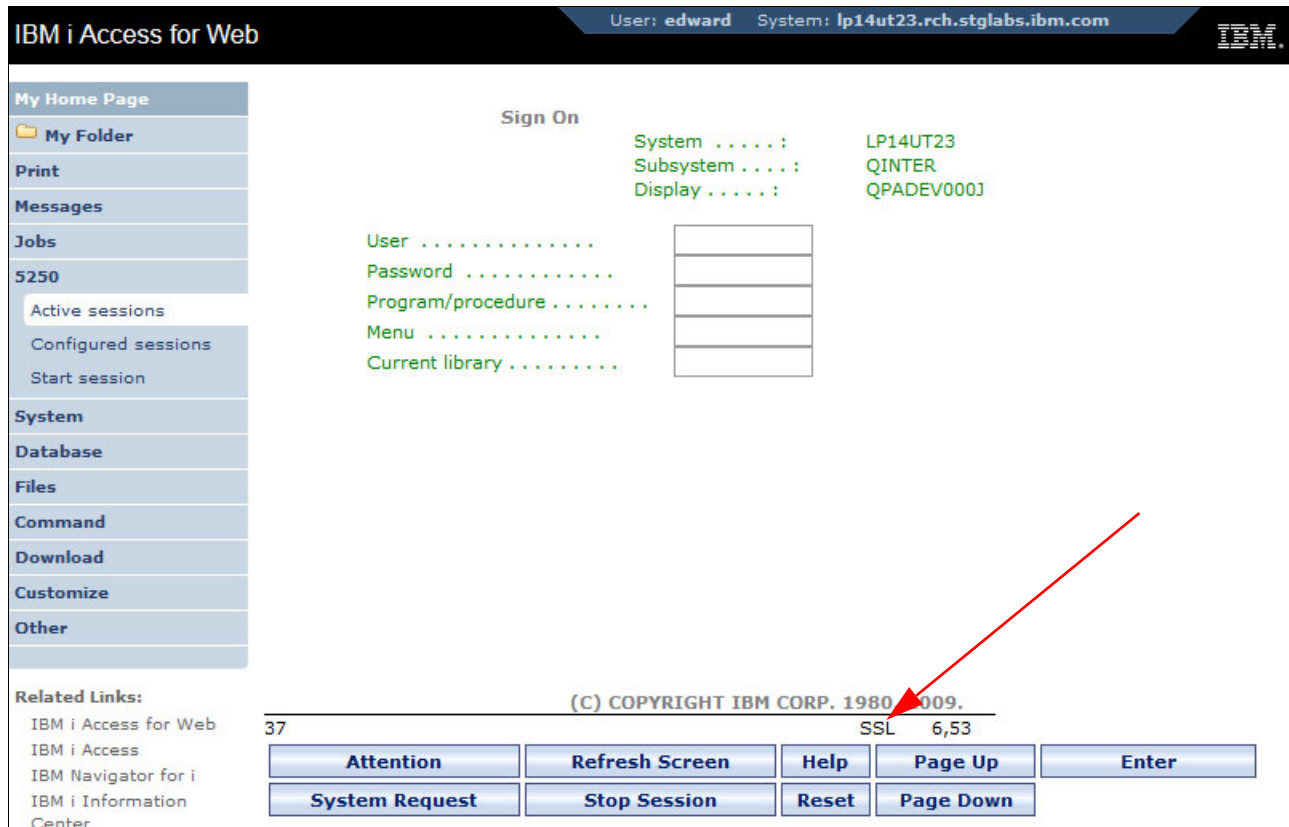


Figure 2-176 Secure telnet in a 5250 session

2.2.4 IBM i Mobile Access

IBM i Access for Web (5770-XH2) has also added support for mobile devices, which enables IBM i users to access IBM i resources from web-enabled mobile devices in a mobile-friendly view.

Mobile features

The same features that are available from IBM i Access for Web are now available from a mobile device, such as:

- ▶ View and manage jobs, messages, output queues, files, and printers.
- ▶ View PTFs and PTF groups.
- ▶ View, add, insert, and update database records.
- ▶ Build, run, and save SQL statements with an SQL wizard.
- ▶ Start one or more emulation sessions with the ability to reconnect even after a device power down.
- ▶ Extract data from various IBM i resources into a table by using optional column selection.
- ▶ Distribute and manage files to other users from a common download location.
- ▶ Support for making secure telnet connections.

With PTF SI54619 (or its supersedents), the following additional features are enabled:

- ▶ Enhanced mobile navigation menu.
- ▶ Filter box for row context-based filtering.
- ▶ Action buttons appear in a menu when the row is selected.

Prerequisites and configuration

Here are the prerequisites and steps that are required to enable IBM i Mobile Access:

1. Install IBM i Access for Web (5770-XH2) on the system.
2. Load 5770-XH2 PTF SI53292 (or its supersedents).
3. Load the current IBM i HTTP Group PTF for the IBM i release that you are using:
 - Release 7.2: SF99713 (level 1 or later)
 - Release 7.1: SF99368 (level 27 or later)
 - Release 6.1: SF99115 (level 38 or later)
4. Start the HTTP *ADMIN server on the system by running the following CL command:
`STRTCPSVR SERVER(*HTTP) HTTPSVR(*ADMIN)`
5. Configure the mobile instance by running the following command:
`CFGACCWEB APPSVRTYPE(*INTAPPSVR) INSTANCE(*MOBILE)`
6. Access the following URL from a web-enabled mobile device:
`http://your_system_name:2001/iamobile/`
7. Sign on with a valid user ID and password.

Note: This feature is provided as part of IBM i Access for Web 7.2 (5770-XH2) which can be installed on IBM i 7.2, 7.1, and 6.1. If you are using IBM i 6.1 or 7.1, it is available on the Entitled Software Support (ESS) website as Feature Code 6289 under SS1 or licensed program publication number: LCD8-1965-00:

<https://www.ibm.com/servers/eserver/ess/index.wss>

Mobile user interface

Figure 2-177 shows the user interface for IBM i Mobile Access. It provides a navigation menu that is similar to IBM i Access for Web in a mobile-friendly web page.

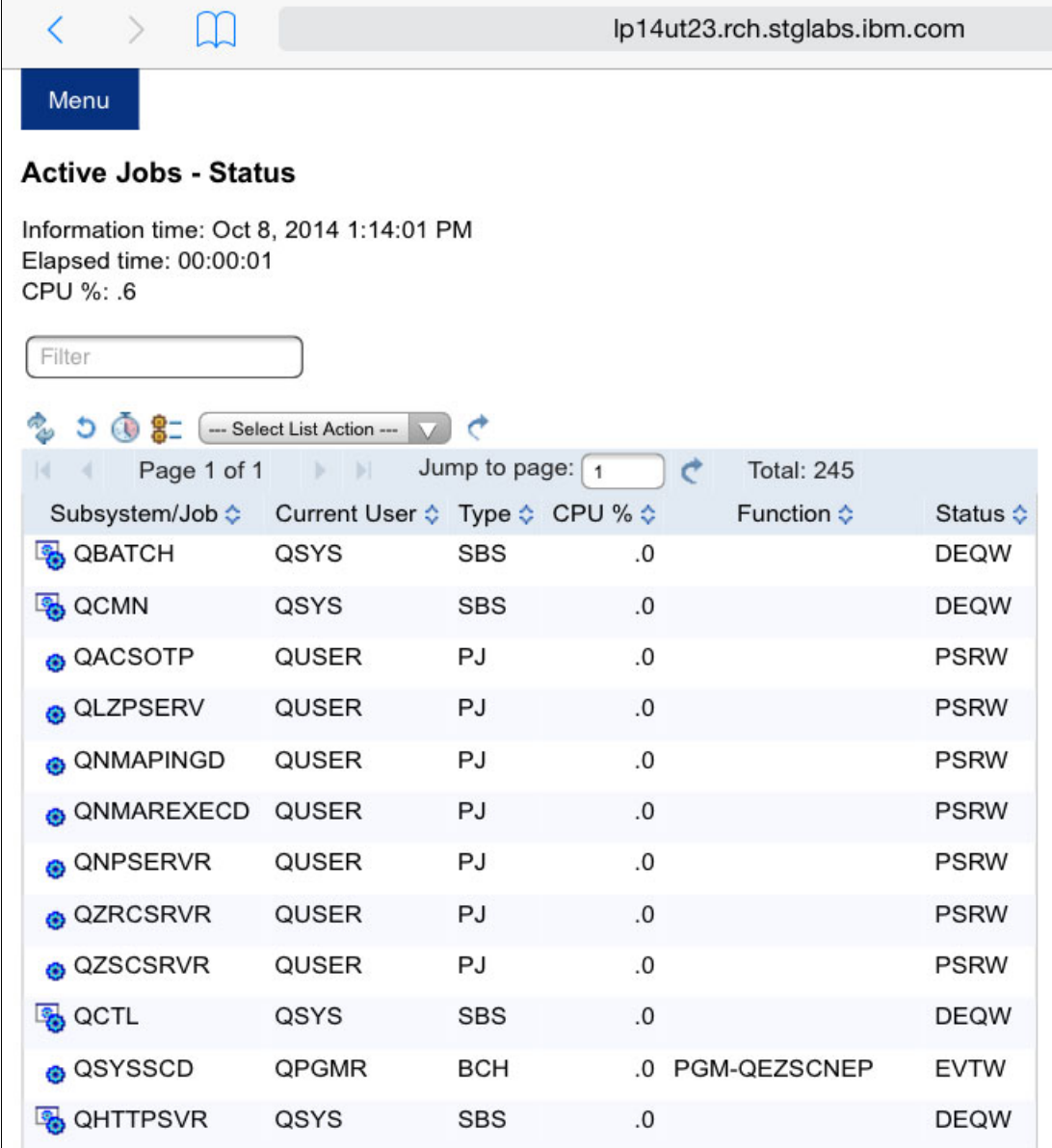


Figure 2-177 Main user interface of IBM i Mobile Access

Working with active jobs

You can display active jobs in IBM i Mobile Access to view various job information, which is similar to what the Work with Active Jobs (**WRKACTJOB**) CL command does in a 5250 session.

To view the active jobs, click **Jobs** → **Active jobs**. Figure 2-178 shows the interface of working with active jobs in IBM i Mobile Access.



Menu

Active Jobs - Status

Information time: Oct 8, 2014 1:14:01 PM
Elapsed time: 00:00:01
CPU %: .6

Filter

--- Select List Action ---

Page 1 of 1 Jump to page: 1 Total: 245

Subsystem/Job	Current User	Type	CPU %	Function	Status
QBATCH	QSYS	SBS	.0		DEQW
QCMN	QSYS	SBS	.0		DEQW
QACSTOP	QUSER	PJ	.0		PSRW
QLZPSERV	QUSER	PJ	.0		PSRW
QNMAPINGD	QUSER	PJ	.0		PSRW
QNMAREXECD	QUSER	PJ	.0		PSRW
QNPSEVR	QUSER	PJ	.0		PSRW
QZRCSRVR	QUSER	PJ	.0		PSRW
QZSCSRVR	QUSER	PJ	.0		PSRW
QCTL	QSYS	SBS	.0		DEQW
QSYSSCD	QPGMR	BCH	.0	PGM-QEZSCNEP	EVTW
QHTTSPVR	QSYS	SBS	.0		DEQW

Figure 2-178 Work with active jobs in IBM i Mobile Access

Action buttons pop-up menu

IBM i Mobile Access in IBM i 7.2 provides enhancements to the user interface where you can easily select an entry in a view and then select operations that are related to it.

Figure 2-179 shows an example of action buttons for a row entry for working with active jobs. When you click a specific row, a pop-up menu containing action buttons opens.

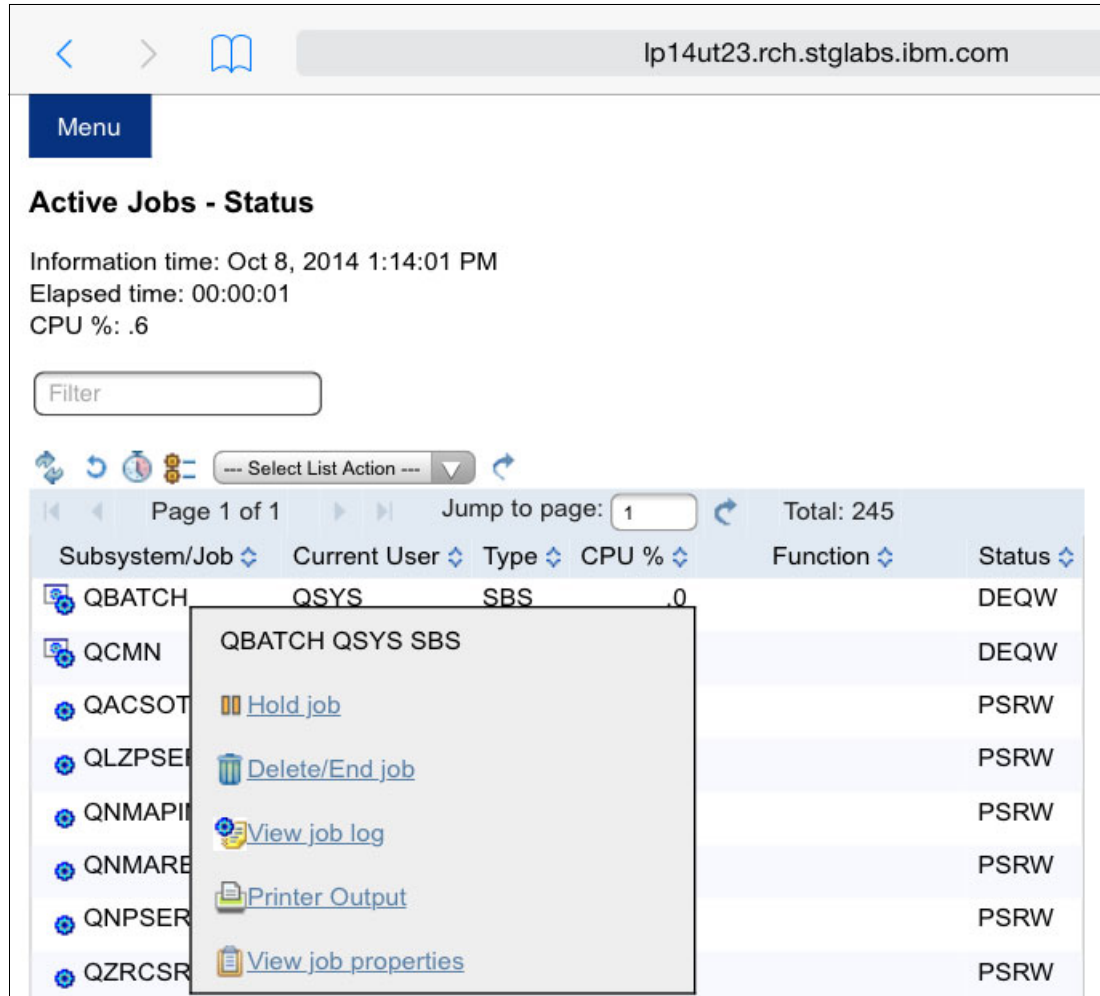


Figure 2-179 Action buttons pop-up menu in IBM i Mobile Access

SQL functions

You can use IBM i Mobile Access to run SQL statements and view the results in the mobile browser. To run SQL, click **Database** → **Run SQL**, which opens the Run SQL page, as shown in Figure 2-180. An SQL wizard is available for building SQL statements.

The screenshot shows a mobile browser interface for the 'Run SQL' page. At the top, there is a navigation bar with a back arrow, a forward arrow, a book icon, and the URL 'lp14ut23.rch.stglabs.ibm.com'. Below the navigation bar is a blue 'Menu' button. The main content area is titled 'Run SQL' and contains several sections:

- SQL Statement:** A text area containing the SQL query:

```
SELECT
  "AUTHORIZATION_NAME", "PREVIOUS_SIGNON"
FROM
  QSYS2.USER_INFO
```

 To the right of this section is a help icon (?). Below the text area is a blue 'SQL Wizard' button.
- SQL Output:** A section with a help icon (?). It includes a 'Type:' dropdown menu set to 'Preview' and a 'Settings' button. Below it is a 'Destination:' dropdown menu set to 'Browser' and another 'Settings' button.
- Format:** A section with a help icon (?). It includes a 'Date:' dropdown menu set to '10/8/14' and a 'Time:' dropdown menu set to '1:17:53 PM'.
- Connection:** A section with a help icon (?). It includes a 'Connection:' dropdown menu set to 'IBM Toolbox for Java - lp14ut23.rch.stglabs.ibm.com'.

At the bottom of the page, there are two blue buttons: 'Run SQL' and 'Save Request...'.

Figure 2-180 Run SQL on IBM i Mobile Access

Figure 2-181 shows the SQL output page on a mobile browser.

Menu

SQL Output

Page 1 of 1 Jump to page: 1 Total: 72

AUTHORIZATION_NAME	PREVIOUS_SIGNON
CZZ62690	2014-09-25 10:46:28.000000
CZZ626901	2014-09-26 13:35:15.000000
DAH1	2014-10-01 19:54:39.000000
DHQB	2014-10-01 19:50:42.000000
HEDWARD	2014-10-01 19:59:47.000000
NAKAMURA	2014-10-01 15:31:20.000000
NAKATEST	-
NAKATEST2	-
QANZAGENT	-
QAUTPROF	-
QBRMS	-
QCLUMGT	-
QCLUSTER	-
QCOLSRV	-
QDBSHR	-
QDBSHRDO	-
QDBTS	-
QDFTOWN	-
QDIRSRV	-
QDLFM	-

Figure 2-181 SQL output that is viewed in IBM i Mobile Access

5250 sessions

Similar to IBM i Access for Web, you can use IBM i Mobile Access to start 5250 sessions to access IBM i.

To start a 5250 session, click **5250** → **Start session**. The Start Session window opens, as shown in Figure 2-182. In this window, you can configure the parameters for your 5250 session.

The screenshot shows a web browser window with the URL `lp14ut23.rch.stglabs.ibm.com`. The page has a blue 'Menu' button at the top left. The main content area is titled 'Start Session' and contains three sections, each with a help icon (question mark in a circle):

- System**:
 - System:
 - Port:
 - Code page: (dropdown)
- Workstation ID**:
 - Use user ID
 - Specify workstation ID
 - Avoid duplicates for this user
 - Avoid duplicates with other users
- General**:
 - Initial macro: (dropdown)
 - Bypass signon
 - Display HTML data in fields

At the bottom of the form is a blue 'Start Session' button. Below the button is a link for [Active sessions](#) and the text 'Work with your active sessions.'

Figure 2-182 Start a 5250 session on IBM i Mobile Access

Figure 2-183 shows the interface of the 5250 telnet session from a mobile browser.

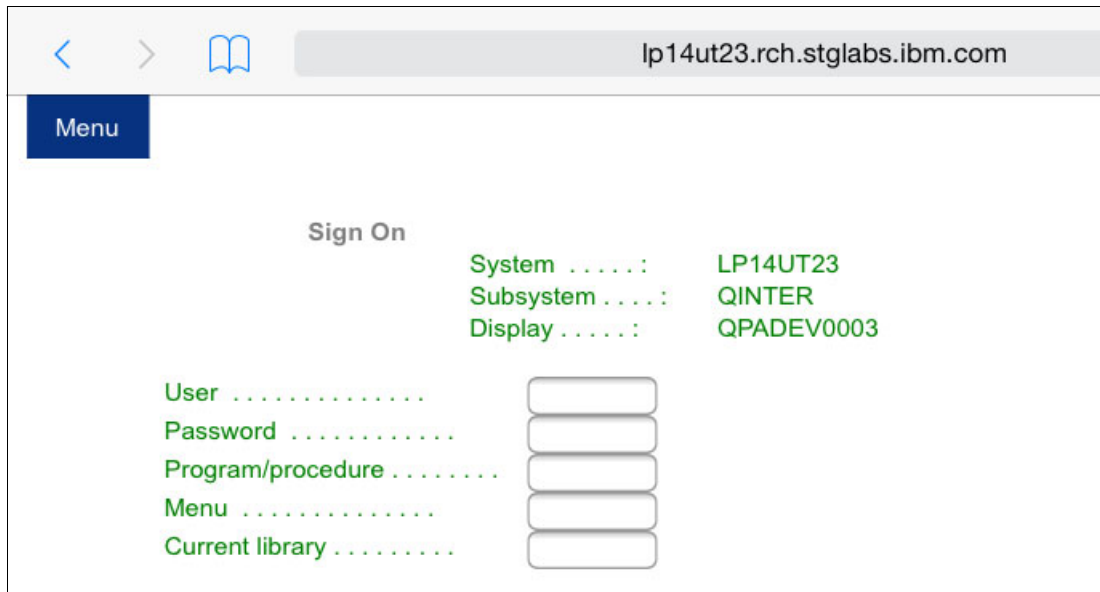


Figure 2-183 5250 telnet session on IBM i Mobile Access

Secure telnet in a 5250 session

Similar to IBM i Access for Web, you can use IBM i Mobile Access to start secure telnet in a 5250 session by using SSL. This function derives its support from the same support in IBM i Access for Web, where the secure telnet connection is made pending certificate validation and its session validates the certificate chain, but does not perform server authentication or client authentication.

Click **5250** → **Start session** and specify port 992 in the Port field. Figure 2-184 shows an example of secure telnet started in a mobile browser. The SSL keyword at the bottom of the panel identifies that the telnet session is secured by using SSL.

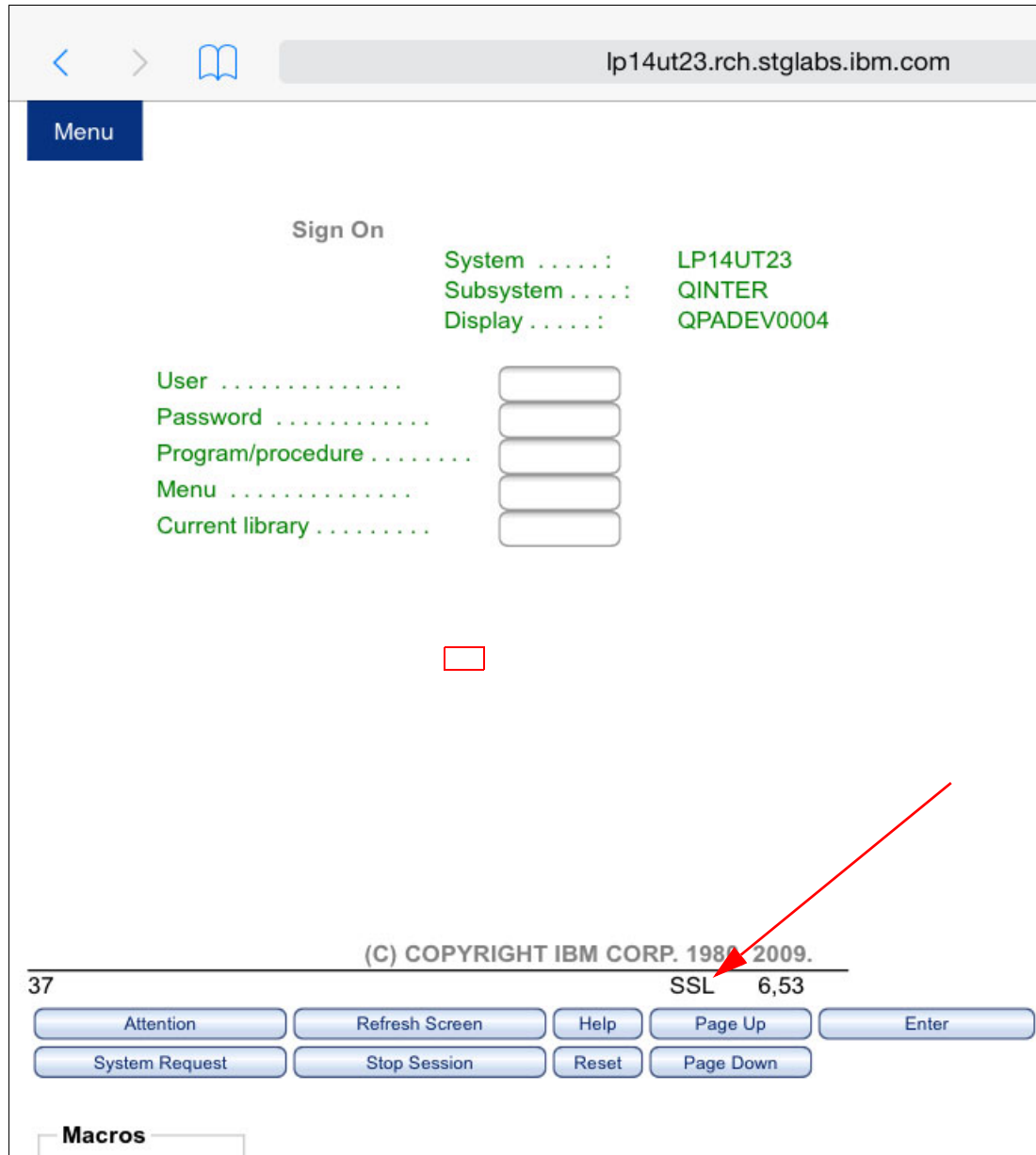


Figure 2-184 5250 secure telnet session on IBM i Mobile Access

2.3 Application Runtime Expert for i

Application Runtime Expert for i is a product that was first introduced in IBM i 7.1 that helps users to ensure consistent performance and deployment for any workload that is running on the system.

For more information about Application Runtime Expert for i, see the following publications:

- ▶ *Uncovering Application Runtime Expert - IBM i 7.1*, REDP-4805
- ▶ *IBM i 7.1 Technical Overview with Technology Refresh Updates*, SG24-7858

2.4 Journal management

This section describes the journal enhancements that are implemented in IBM i 7.2. The following topics are covered:

- ▶ 2.4.1, “STRJRN parameter for restore CL commands” on page 162
- ▶ 2.4.2, “Deferred journal restore” on page 162
- ▶ 2.4.3, “Secure remote journal” on page 163
- ▶ 2.4.4, “QJOSJRNE API change” on page 163
- ▶ 2.4.5, “Journal conversion after an IBM i 7.2 installation” on page 163
- ▶ 2.4.6, “Journal limits changes” on page 164
- ▶ 2.4.7, “New journal entry types” on page 164
- ▶ 2.4.8, “Displaying journal information” on page 164
- ▶ 2.4.9, “Journal Sizing and Planning tool” on page 167

2.4.1 STRJRN parameter for restore CL commands

A new parameter called Start journaling (**STRJRN**) was added to Restore Object (**RSTOBJ**) and Restore Library (**RSTLIB**) CL commands. This parameter controls whether the journaling is automatically started for the new objects after restore. Journal information that was saved is restored regardless of the value of the parameter. Existing objects are not affected. This parameter takes precedence over QDFTJRN data area and journal inheritance.

2.4.2 Deferred journal restore

In IBM i 7.2, restore processing is enhanced to allow the start of journaling to be deferred for database files, data areas, data queues, and libraries when the object or library is restored before the journal. After the journal is restored, the object that deferred start of journaling is reestablished and resumes journaling.

To use this feature, you must specify the Defer ID (**DFRID**) parameter on the restore operation. The **DFRID** parameter is an optional parameter for the Restore Library (**RSTLIB**) CL command, Restore Object (**RSTOBJ**) CL command, and Restore Object List (QSRRSTO) API. Currently, the **DFRID** parameter is used to defer the restore of views (logical files) and materialized query tables (MQTs) that are restored before they are being based on files. This enhancement allows the Defer ID support to be used to defer starting journaling on an object.

To use explicitly this enhancement, the new Restore Deferred Objects (**RSTDFROBJ**) CL command can be called directly by using the same Defer ID (**DFRID**) value that was used with the **RSTOBJ** or **RSTLIB** CL commands.

The following restore operations are configured to use the Defer ID support:

- ▶ **GO RESTORE** option 21
- ▶ Start Recovery by using the BRM (**STRRCYBRM**) CL command

For more information about deferred journal restore, see *Deferred Journal Restore* topic in the IBM i Technology Updates website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Deferred%20Journal%20Restore>

2.4.3 Secure remote journal

Starting in IBM i 7.2, remote journaling now acknowledges the secure connection field in a Relational Database (RDB) Directory Entry panel (**ADDRDBDIRE** and **CHGRDBDIRE** CL commands). Secure remote journaling uses the default TCP/IP port 3889 and the cipher that is defined in Digital Certificate Manager under the application ID:

- ▶ IBM i Remote Journaling Source (as application client)
- ▶ IBM i Remote Journaling Target (as application server)

Note: To make secure remote journaling work, both the source and the target systems must be at IBM i 7.2.

Depending on the cipher that is used under DCM, a performance impact and a remote entry synchronization delay can occur.

For more information about secure remote journaling, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaq9/rzaq9osJRNrjsecureconnect.htm?lang=en

2.4.4 QJOSJRNE API change

The force journal entry key now accepts a new value of 2, which means that the journal receiver is forced to auxiliary storage, but no journal entry is sent.

For more information about the Send Journal Entry (QJOSJRNE) API, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apis/QJOSJRNE.htm?lang=en

2.4.5 Journal conversion after an IBM i 7.2 installation

After IBM i 7.2 is installed or updated, a Change Journal (**CHGJRN**) CL command is issued once for all journals on the system. This action supports a conversion, which is required for internal information of the journal and journal receiver objects.

2.4.6 Journal limits changes

The following journal limits changes were implemented in IBM i 7.2:

- ▶ The maximum number of journal receivers that are allowed in a range of receivers on a journal command was increased from 1024 to 2045.
- ▶ The maximum number of active commitment definitions with object-level changes that can be processed concurrently by an `APYJRNCHG` or `APYJRNCHGX` CL command was increased from 1023 to 32767 if commitment control is already active.
- ▶ The maximum number of journal receivers that can be associated with one journal was added and its value is 131036.

For more information about journal limits, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzamp/rzampjournal.htm?lang=en

2.4.7 New journal entry types

The following new journal entry types were added in IBM i 7.2:

- ▶ D code new types (row and column access control):
 - M1 for create mask
 - M2 for drop mask
 - M3 for alter mask
 - P1 for create permission
 - P2 for drop permission
 - P3 for alter permission
- ▶ T code new types (audit journal):
 - X2 for query manager profile changes
 - AX for row and column access control
 - PF for PTF operations
 - PU for PTF object changes

For more information about journal entry codes and types, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaki/rzakijournalfinderal12.htm?lang=en

2.4.8 Displaying journal information

This section describes the changes that were made in IBM i 7.2 to retrieve journal information more easily.

Journal information for a table on IBM Navigator for i

IBM Navigator for i has been extended with an option to display journal information for a table. A new menu option that is called Journaling was added to the menu of the Tables window, as shown in Figure 2-185.

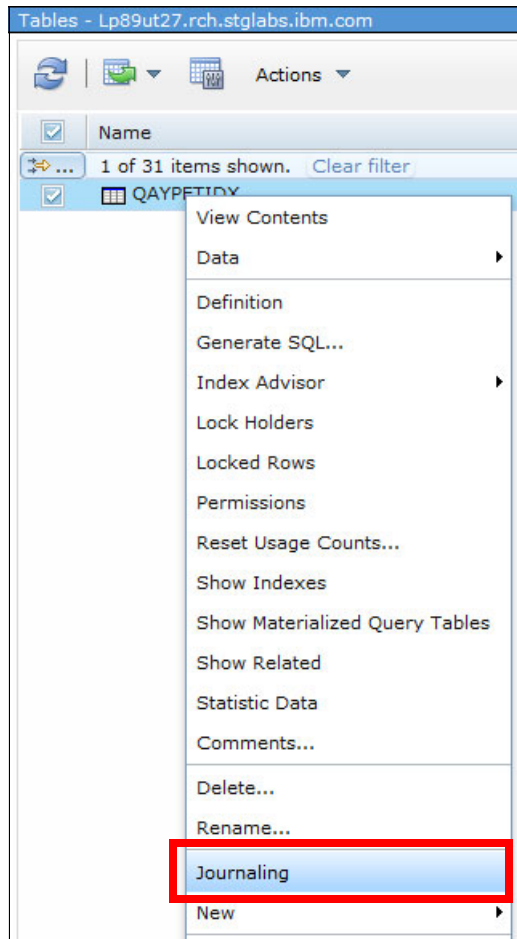


Figure 2-185 Journaling information that is available for a particular table in the Tables window

The Journaling menu option opens a detailed journaling information window for the selected table, as shown in Figure 2-186.

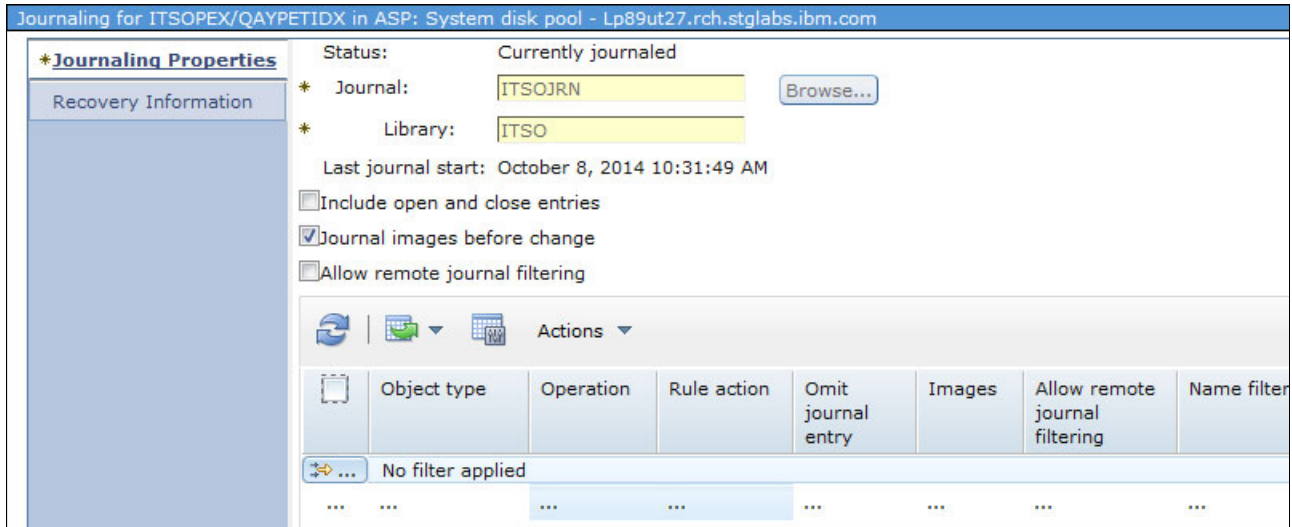


Figure 2-186 Detailed journaling information for a database table

You can now view journal entries by using IBM i Navigator for i. The Journals window was enhanced with a new menu option called View Entries for a selected journal, as shown in Figure 2-187.

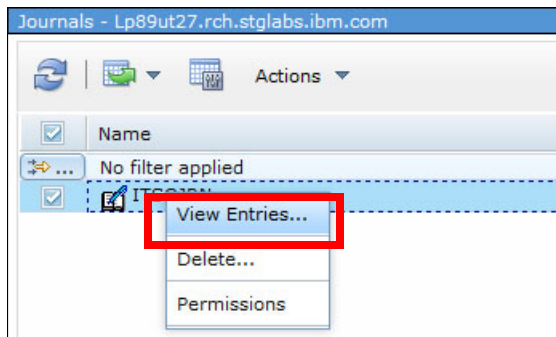


Figure 2-187 New View Entries menu option in the Journals window

The View Entries menu option opens the Journal Viewer window, where you can filter and present journal entries for the selected journal, as shown in Figure 2-188. Viewing entry-specific data is also possible in from this window.

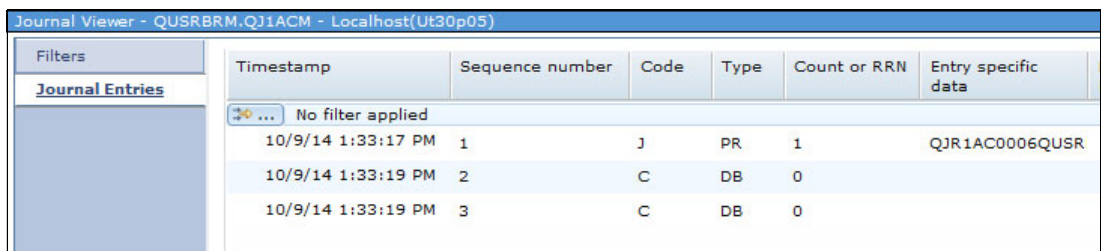


Figure 2-188 Journal Viewer window

For more information about displaying journal information for a table by using IBM Navigator for i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaki/rzakidspjrni.htm?lang=en

Display_Journal table function

You can use the QSYS2/Display_Journal SQL table function to view journal entries. This function is more efficient than displaying journal entries to an output file by using the Display Journal (**DSPJRN**) CL command and then querying the resulting file.

For more information about the QSYS2/Display_Journal SQL table function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqudfdisplayjournal.htm

2.4.9 Journal Sizing and Planning tool

The Journal Sizing and Planning tool is available for IBM i 7.2. This tool can be used to determine the amount of additional I/O workload that might be generated by journaling one or more database files.

Note: The Journal Sizing and Planning tool predicts workloads only for database files and not for any other object types.

For more information about downloading and using the Journal Sizing and Planning tool, search for Journal Sizing and Planning Tool at the following website:

<http://www.ibm.com/systems/power/software/i/db2/support/code/journal-utilities.html>

2.5 Work management enhancements

This section describes the following IBM i 7.2 work management enhancements:

- ▶ 2.5.1, “Temporary storage enhancements” on page 167
- ▶ 2.5.2, “PTF-related changes” on page 179
- ▶ 2.5.3, “IBM i command changes” on page 181
- ▶ 2.5.4, “API changes” on page 182

2.5.1 Temporary storage enhancements

Temporary storage in IBM i system, also called *unprotected storage*, is a place in the system storage where programs, running under jobs and system functions, put objects that are required during run time. It is used to keep automatic, static, heap, and teraspace storage for programs, temporary objects that are created by programs either for a single job or reused across multiple jobs, or working storage for the Licensed Internal Code (LIC) to support the operating system. Temporary storage is reclaimed on each IPL.

IBM i 7.2 introduces significant temporary storage enhancements, which allows for accurate temporary storage usage tracking system-wide and at a job level. The following sections describe the new features that are related to temporary storage in IBM i 7.2:

- ▶ “Storage management buckets” on page 168
- ▶ “Controlling temporary storage” on page 170
- ▶ “Temporary storage limits” on page 176
- ▶ “Temporary storage enhancements within IBM Navigator for i” on page 179
- ▶ “Collection Services enhancements” on page 179

Storage management buckets

Before IBM i 7.2, retrieving information about temporary storage that is used by the system or a particular job was not easy and often required using multiple tools or IBM support. The information might have been misleading or inaccurate, especially when the storage was allocated by one job or task and then returned by another one.

In IBM i 7.2, storage management was changed to use new buckets to collect storage usage information. The buckets track temporary storage for the following tasks:

- ▶ Scoped to a single job
- ▶ Scoped to multiple jobs
- ▶ Scoped to the system
- ▶ For LIC allocations (so-called “no charge”)
- ▶ For allocations that persist after a job ends

The total value of all buckets should match to the Current temporary storage value on the Work with System Status (**WRKSYSSTS**) panel.

Figure 2-191 on page 170 shows temporary storage in megabytes that is used by the system.

The SYSTMPSTG file in the QSYS2 library can be queried for the current size of all available storage buckets on the system as shown in Example 2-2. Running an SQL query over this file is a quick way to find the biggest temporary storage consumers during a problem determination situation.

Example 2-2 Display the content of temporary storage buckets in the SYSTMPSTG file

```
SELECT * FROM QSYS2/SYSTMPSTG ORDER BY BUCKET_CURRENT_SIZE DESC
```

BUCKET_NUMBER	GLOBAL_BUCKET_NAME	JOB_NAME	JOB_USER_NAME	JOB_NUMBER	BUCKET_CURRENT_SIZE
1	*MACHINE	-	-	-	690,081,792
65,981	-	ADMIN2	QLWISVR	001418	427,245,568
9	*DATABASE SQE Heap	-	-	-	195,182,592
65,724	-	ADMIN4	QWEBADMIN	001163	188,657,664
65,726	-	ADMIN1	QLWISVR	001162	167,432,192
65,878	-	ADMIN3	QLWISVR	001315	163,217,408
65,699	-	QUSRDIR	QDIRSRV	001136	155,234,304
65,572	-	QTCPWRK	QSYS	001014	151,543,808
65,683	-	Q1ACPDST	QBRMS	001120	129,605,632
65,641	-	QYPSFRCOL	QSYS	001078	98,832,384
65,714	-	QYPSJSVR	QYPSJSVR	001151	91,832,320
65,537	-	SCPF	QSYS	000000	87,728,128
3	*PASE	-	-	-	76,705,792
65,671	-	QSRVMON	QSYS	001108	64,876,544
65,543	-	QDBSRV05	QSYS	000985	61,415,424
8	*DATABASE Segment Cache	-	-	-	60,076,032
65,542	-	QDBSRV04	QSYS	000984	58,044,416

66,010 -	QZRCRSVS	QUSER	001447	54,501,376
4,096 *OS	-	-	-	53,792,768
				More...

The same information is now available through IBM Navigator for i by clicking **System** → **System Status**, as shown in Figure 2-189.

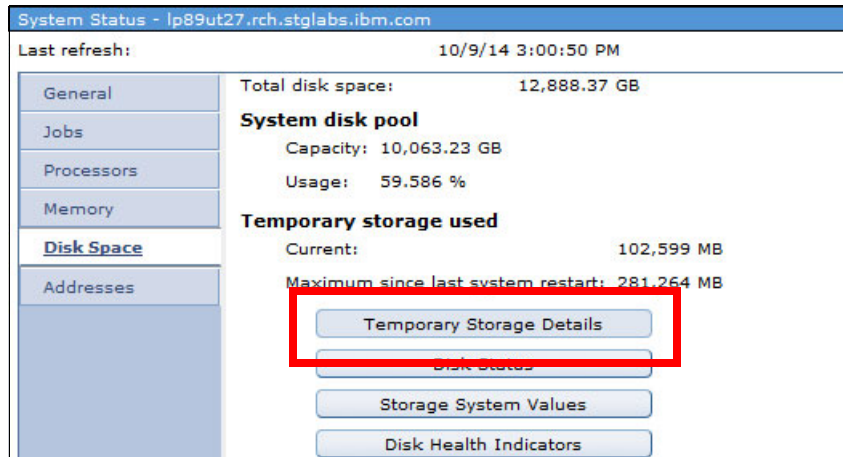


Figure 2-189 Access temporary storage buckets information

Clicking **Temporary Storage Details** under the Disk Space tab of the System Status window opens the Temporary Storage Details window, as shown in Figure 2-190.

Bucket Number	Global Bucket Name	Job Name	Job User Name	Job Number	Bucket Current Size	Bucket Limit Size
<input checked="" type="checkbox"/>	1	*MACHINE	-	-	77,524,594,688	
<input type="checkbox"/>	9	*DATABASE SQE Heap	-	-	8,239,337,472	
<input type="checkbox"/>	8	*DATABASE Segment Cache	-	-	5,017,493,504	
<input type="checkbox"/>	65819	-	QYSPFRCOL	QSYS	991,456	2,342,981,632
<input type="checkbox"/>	6	*IFS VNODE	-	-	1,775,144,960	
<input type="checkbox"/>	121185	-	ADMIN4	QWEBADMIN	212,505	684,412,928
<input type="checkbox"/>	121186	-	ADMIN2	QLWISVR	213,401	592,842,752
<input type="checkbox"/>	7	*IFS File System Buffer	-	-	564,613,120	
<input type="checkbox"/>	4098	*ACTJOB	-	-	233,086,976	228,589,568
<input type="checkbox"/>	121221	-	ADMIN1	QLWISVR	212,504	219,881,472
<input type="checkbox"/>	121214	-	ADMIN5	QLWISVR	212,506	217,051,136
<input type="checkbox"/>	121215	-	ADMIN3	QLWISVR	212,679	198,946,816
<input type="checkbox"/>	65890	-	Q1ACPDST	QBRMS	991,517	180,006,912
<input type="checkbox"/>	66332	-	QJVAEXEC	QDBTS	991,960	177,233,920
<input type="checkbox"/>	65956	-	QUMEPRVAGT	QSECOFR	991,583	173,924,352
<input type="checkbox"/>	65941	-	QUSRDIR	QDIRSRV	991,568	164,122,624

Figure 2-190 Temporary Storage Details window

Controlling temporary storage

In IBM i 7.2, the following panels were changed or extended with temporary storage information:

- ▶ Work with System Status (**WRKSYSSTS**)
- ▶ Work with Active Jobs (**WRKACTJOB**)
- ▶ Display Job Run Attributes (**DSPJOB**)
- ▶ Display Job Tables (**DSPJOBTL**)

Work with System Status (**WRKSYSSTS**)

The Work with System Status panel was changed to new field names, as shown in Table 2-3.

Table 2-3 Field name changes on the Work with System Status panel

IBM i V7R1 and earlier	IBM i V7R2
Current unprotect used	Current temporary used
Maximum unprotect	Peak temporary used

The Work with System Status panel is shown in Figure 2-191.

```

                                Work with System Status                                UT30P05
                                                                                   09/26/14 15:51:56
% CPU used . . . . . :          3.9   Auxiliary storage:
Elapsed time . . . . . :    00:09:06   System ASP . . . . . :    95.44 G
Jobs in system . . . . . :          492   % system ASP used . . :    40.3456
% perm addresses . . . . . :         .007   Total . . . . . :    95.44 G
% temp addresses . . . . . :         .010   Current temporary used :    4259 M
                                           Peak temporary used . :    4344 M

Type changes (if allowed), press Enter.

System   Pool   Reserved   Max   -----DB-----   ---Non-DB---
Pool    Size (M)  Size (M)  Active  Fault  Pages  Fault  Pages
   1     471.41  222.58  +++++  .0    .0    .1    .1
   2    3134.42   7.21    71     .0    .1    .0    .8
   3     405.14   .00    102    .0    .0    .3    .6
   4      40.51   .00     5      .0    .0    .0    .0

                                                                                   Bottom

Command
====>
F3=Exit   F4=Prompt   F5=Refresh   F9=Retrieve   F10=Restart   F12=Cancel
F19=Extended system status   F24=More keys
    
```

Figure 2-191 System-wide temporary storage usage

The Extended System Status panel (which you can access by pressing F19 from the **WRKSYSSTS** panel) was extended with new fields that show the percentage of temporary storage that is used and the limit, as shown in Figure 2-192.

For more information about temporary storage limits, see “Temporary storage limits” on page 176.

Note: The % temporary storage used and % temporary storage limit fields on the Extended System Status panel are visible only when the notification limit is set for system ASP. For more information about temporary storage limits, see “Temporary storage limits” on page 176.

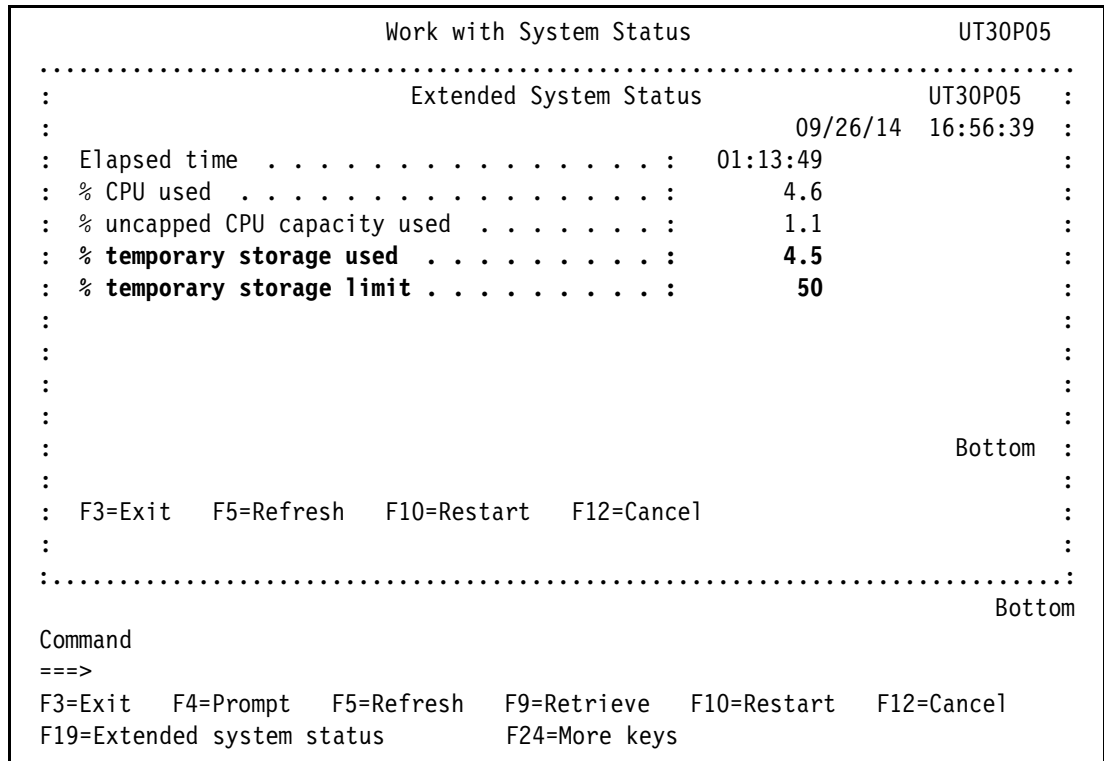


Figure 2-192 Temporary storage information in the Extended System Status panel

Work with Active Jobs (WRKACTJOB)

The Work with Active Jobs (WRKACTJOB) panel was extended with temporary storage information for every job, which you can use to sort jobs according to temporary storage that is used for ease of control. Sorting can be done by using either the **SEQ(*TMPSTG)** parameter with the **WRKACTJOB** CL command or by pressing F16 with the cursor on the Temporary Storage column.

Figure 2-193 shows the temporary storage that is used by jobs in megabytes.

Work with Active Jobs							UT30P05				
CPU %: 4.1			Elapsed time: 04:10:31		Active jobs: 227		09/26/14 17:38:37				
Type options, press Enter.											
2=Change		3=Hold		4=End		5=Work with		6=Release		7=Display message	
8=Work with spooled files		13=Disconnect		...							
Opt	Subsystem/Job	User	Number	Type	CPU %	Threads	Temporary Storage				
	ADMIN2	QLWISVR	001418	BCI	.2	93	405				
	ADMIN4	QWEBADMIN	001163	BCI	.0	41	176				
	ADMIN1	QLWISVR	001162	BCI	.0	34	157				
	QUSRDIR	QDIRSRV	001136	BCH	.0	12	148				
	QTCPWRK	QSYS	001014	SYS	.0	2	145				
	ADMIN3	QLWISVR	001315	BCI	.0	33	141				
	QYPSJSVR	QYPSJSVR	001151	BCH	.0	39	87				
	SCPF	QSYS	000000	SYS	.0	1	84				
	QYPSFRCOL	QSYS	001078	BCH	.0	30	79				
							More...				
Parameters or command											
====>											
F3=Exit		F5=Refresh		F7=Find		F10=Restart statistics		F11=Display status			
F12=Cancel		F17=Top		F18=Bottom		F23=More options		F24=More keys			

Figure 2-193 Temporary storage information in the Work with Active Jobs panel

The same information is now available through IBM Navigator for i by clicking **Work Management** → **Active Jobs**, as shown in Figure 2-194.

Job Name	Detailed Status	Current User	CPU %	Run Priority	Temporary Storage Used (MB)
Qypspfrcol	Waiting for dequeue	Qsys	0	1	2,233
Admin4	Waiting for thread	Qwebadmin	0	25	652
Admin2	Waiting for thread	Qlwisvr	0	25	564
Admin1	Waiting for thread	Qlwisvr	0	25	209
Admin5	Waiting for thread	Qlwisvr	0	25	206
Admin3	Waiting for thread	Qlwisvr	0	25	189
Q1acpdst	Delayed 60 seconds	Qbrms	0	30	171
Qjvaexec	Waiting for thread	Qdbts	0	50	169

Figure 2-194 Active Jobs window with temporary storage information for every job

Display Job Run Attributes (DSPJOB)

The Display Job Run Attributes (DSPJOB) panel was extended with the Peak temporary storage used field, which shows the maximum temporary storage that is used by the job. Figure 2-195 shows the peak temporary storage that is used by a job in megabytes.

```

Display Job Run Attributes
System: UT30P05
Job: QPADEV0002 User: WILKU Number: 002154

Run priority . . . . . : 20
Time slice in milliseconds . . . . . : 2000
Eligible for purge . . . . . : *YES
Default wait time in seconds . . . . . : 30
Maximum CPU time in milliseconds . . . . . : *NOMAX
CPU time used . . . . . : 5
Maximum temporary storage in megabytes . . . . . : *NOMAX
Temporary storage used . . . . . : 2
Peak temporary storage used . . . . . : 2
Maximum threads . . . . . : *NOMAX
Threads . . . . . : 1
Thread resources affinity:
  Group . . . . . : *NOGROUP
  Level . . . . . : *NORMAL
Resources affinity group . . . . . : *NO

Press Enter to continue.

F3=Exit F5=Refresh F9=Change job F12=Cancel F16=Job menu

```

Figure 2-195 Peak temporary storage value on the Display Job Run Attributes panel

Display Job Tables (DSPJOBTL)

The Display Job Tables (DSPJOBTL) panel was extended with the Storage used value, which represents temporary storage in megabytes for both active and available temporary job structures.

Figure 2-196 shows the storage that is used in megabytes on the Display Job Tables panel.

Permanent job structures:		Temporary job structures:	
Initial	200	Initial	200
Additional	30	Additional	30
Available	6	Available	21
Total	500	Storage used	24.00 M
Maximum	163520		

-----Entries-----					
Table	Size	Total	Available	In-use	Other
1	529152	500	6	493	1

Bottom

Press Enter to continue.

F3=Exit F5=Refresh F11=In-use entries F12=Cancel

Figure 2-196 Temporary storage information in the Display Job Tables panel

Message CPF1164

When a job ends, message CPF1164 is sent to QHST and the job's job log. In IBM i 7.2, the message was extended with the maximum temporary storage value for the job, as shown in Figure 2-197.

```
Display Formatted Message Text
System:  UT30P05
Message ID . . . . . :  CPF1164
Message file . . . . . :  QCPFMSG
Library . . . . . :  QSYS

Message . . . . . :  Job &3/&2/&1 ended on &14 at &15; &10 seconds used; end
code &8 &13.
Cause . . . . . :  Job &3/&2/&1 completed on &14 at &15 after it used &10
seconds processing unit time. The maximum temporary storage used was &18
megabytes. The job had ending code &8. The job ended after &7 routing steps
with a secondary ending code of &9. The job ending codes and their meanings
are as follows:
    0 - The job completed normally.
    10 - The job completed normally during controlled ending or controlled
subsystem ending.
    20 - The job exceeded end severity (ENDSEV job attribute).
    30 - The job ended abnormally.
    40 - The job ended before becoming active.

More...

Press Enter to continue.

F3=Exit  F11=Display unformatted message text  F12=Cancel
```

Figure 2-197 Maximum temporary storage information in a CPF1164 message

Temporary storage limits

As in previous releases, maximum temporary storage for a job can be controlled by the **MAXTMPSTG** parameter in the class description (**CRTCLS** and **CHGCLS** CL commands). In IBM i 7.2, the same parameter was added to the Change Job (**CHGJOB**) CL command, allowing a user to change that limit after the job starts.

To change the maximum temporary storage limit for a job to 20 MB, substituting *NUMBER*, *JOBUSER*, and *JOBNAME* with proper values, run the following CL command:

```
CHGJOB JOB(NUMBER/JOBUSER/JOBNAME) MAXTMPSTG(20)
```

This parameter is especially useful with changed system behavior when a job reaches the maximum temporary storage limit. IBM i 7.2 now holds the job, instead of ending it. You are given the opportunity to examine the held job and decide whether it should be ended, released, or investigated further. You can use the **CHGJOB** CL command to extend the temporary storage limit and release the job for further execution.

When a job reaches the maximum temporary storage limit, a new CPI112E message is sent to QHST and the job's job log, as shown in Figure 2-198.

```
Display Formatted Message Text
System:  UT30P05
Message ID . . . . . :  CPI112E
Message file . . . . . :  QCPFMSG
Library . . . . . :  QSYS

Message . . . . . :  Job &3/&2/&1 held by the system, MAXTMPSTG limit exceeded.
Cause . . . . . :  The current routing step for job &3/&2/&1 specifies a
maximum temporary storage limit of &4 megabytes.
Recovery . . . . . :
    If you want the job to continue, use the Change Job (CHGJOB) command to
specify a larger MAXTMPSTG value for the job and then use the Release Job
(RLSJOB) command.
    If the application is in error, use the End Job (ENDJOB) command to end
the job.
    To avoid this condition in the future, use the Change Class (CHGCLS)
command to specify a larger MAXTMPSTG value or use the Change Routing Entry
(CHGRTGE) command to specify a different class.

Bottom

Press Enter to continue.

F3=Exit  F11=Display unformatted message text  F12=Cancel
```

Figure 2-198 Message text for CPI112E

Control Temporary Storage API

IBM i 7.2 introduces a new Control Temporary Storage (QWCCTLTS) API. You can use this API to do the following tasks:

- ▶ Set the temporary storage notification threshold for system ASP as a percentage of the total system ASP.
- ▶ Set the temporary storage notification threshold for a specific storage bucket in megabytes or gigabytes.
- ▶ Reset a previously set threshold.
- ▶ Display a current threshold value.

Exceeding the threshold for system ASP triggers a new CPF090A message, as shown in Figure 2-199.

```

                                     Display Formatted Message Text
                                     System:  UT30P05
Message ID . . . . . :  CPF090A
Message file . . . . . :  QCPFMSG
  Library . . . . . :  QSYS

Message . . . . :  Temporary storage threshold reached.
Cause . . . . . :  The amount of storage used for temporary objects in the
                    system ASP is &4 percent. This is a serious system condition. The temporary
                    storage used is &6 &5 (&1 bytes). The storage available is &7 &5 (&2 bytes).
                    This message will be repeated until the amount of storage used is reduced to
                    less than &3 percent.
Recovery . . . . :  Use the WRKSYSSTS command to monitor storage used. To
                    reduce the amount of temporary storage, use the Work with Active Jobs
                    command (WRKACTJOB SEQ(*TMPSTG)) to find jobs that are consuming large
                    amounts of storage. Storage used by a job can be released by ending the job
                    (ENDJOB). Holding a job (HLDJOB) will stop a job from consuming more
                    storage.

                                     Bottom

Press Enter to continue.

F3=Exit  F11=Display unformatted message text  F12=Cancel
```

Figure 2-199 CPF090A message that is triggered when the ASP temporary storage threshold is reached

Exceeding the threshold for one of the buckets triggers a new CPI11AB message, as shown in Figure 2-200.

Note: Threshold notification messages are sent once per hour while the threshold is exceeded.

```
Display Formatted Message Text
System: UT30P05
Message ID . . . . . : CPI11AB
Message file . . . . . : QCPFMSG
Library . . . . . : QSYS

Message . . . . : Storage limit reached for temporary storage bucket &1.
Cause . . . . . : The amount of auxiliary storage used for temporary storage
bucket &1 has reached &2 &4 which is &5 percent of all disk storage in the
system auxiliary storage pool. The limit is &3 &4 (&6 percent).
Recovery . . . . : You can run the STRSQL command to start the interactive
SQL program and then run SQL statement SELECT * FROM QSYS2.SYSTMPSTG to see
the amount of temporary storage for &1 and the other temporary storage
buckets on the system. &7
Technical description . . . . . : Use the Control Temporary Storage
(QWCCTLTS) API to change the storage limit for the temporary storage bucket.

Bottom

Press Enter to continue.

F3=Exit F11=Display unformatted message text F12=Cancel
```

Figure 2-200 CPI11AB message when the temporary storage bucket threshold is reached

Here are usage examples for the QWCCTLTS API showing how to set, reset, and display threshold notifications limits for temporary storage:

- ▶ Set a temporary storage notification threshold for system ASP to 40% of the size by running the following CL command:
CALL QWCCTLTS PARM(*SETLMPCT *ALL 40)
- ▶ Set the temporary storage notification threshold to 50 GB for Save/Restore storage bucket (category) by running the following CL command:
CALL QWCCTLTS PARM(*SETLMTG *SR 50)
- ▶ Remove the temporary storage notification limit system-wide by running the following CL command:
CALL QWCCTLTS PARM(*SETLMPCT *ALL 0)
- ▶ Display the temporary storage notification threshold by running the following CL command:
CALL QWCCTLTS PARM(*DSPLMT *ALL)

For more information about the QWCCTLTS API and temporary storage categories, search for *QWCCTLTS* in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/ic-homepage.htm

Temporary storage enhancements within IBM Navigator for i

IBM i 7.2 introduces significant enhancements to temporary storage in IBM Navigator for i. For more information, see “Work with Active Jobs (WRKACTJOB)” on page 172.

Collection Services enhancements

New fields were added to the job level (QAPMJOBMI) and system level (QAPMSYSTEM) performance data files to keep temporary storage information on a job and system level.

For more information about the collection services file description, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahx/rzahxcatfilerelation.htm?lang=en

2.5.2 PTF-related changes

This section describes the following IBM i 7.2 PTF-related changes:

- ▶ “Conditional immediate PTFs” on page 179
- ▶ “Display PTF Apply Information (DSPPTFAPYI) CL command” on page 181

Conditional immediate PTFs

In IBM i 7.2, there is now something called *conditional immediate PTFs*.

PTFs are identified with a type of either delayed or immediate. A delayed PTF must be applied or removed during IPL. An immediate PTF can be applied or removed either while the system is active or during IPL.

Before IBM i 7.2, when a new PTF superseded a delayed PTF, the new PTF was required to be delayed even if only immediate parts or objects are being changed or added. Within IBM i 7.2, you can now have superseded PTFs immediately applied when only immediate parts or objects are being changed. When the PTF is applied or removed, PTF management determines whether the PTF can be applied or removed immediately or not, depending on whether the most recent delayed superseded PTFs are permanently applied.

The Display Program Temporary Fix (**DSPPTF**) CL command adds an option 12 (Delayed superseded PTFs) to the Display PTF Details panel for delayed superseded PTFs, as shown in Figure 2-201.

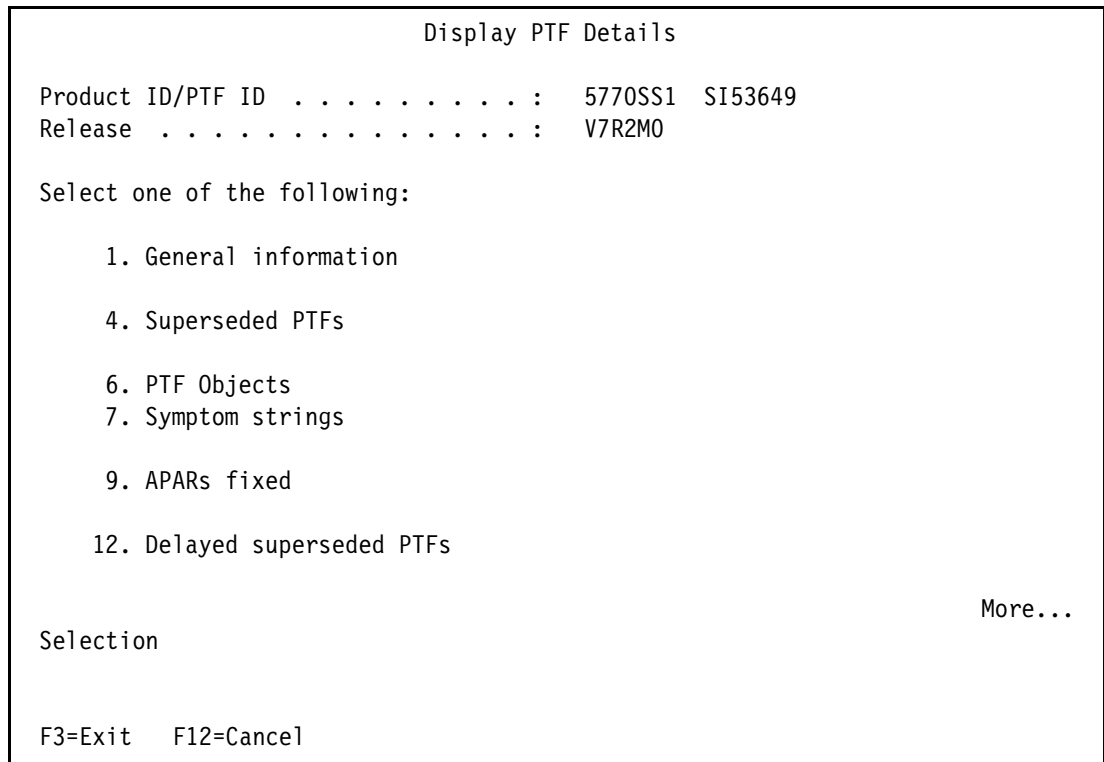


Figure 2-201 Display PTF panel

When option 12 is selected, a new Display Delayed Superseded PTFs panel opens and lists the delayed superseded PTFs for the conditional immediate PTF, as shown in Figure 2-202.

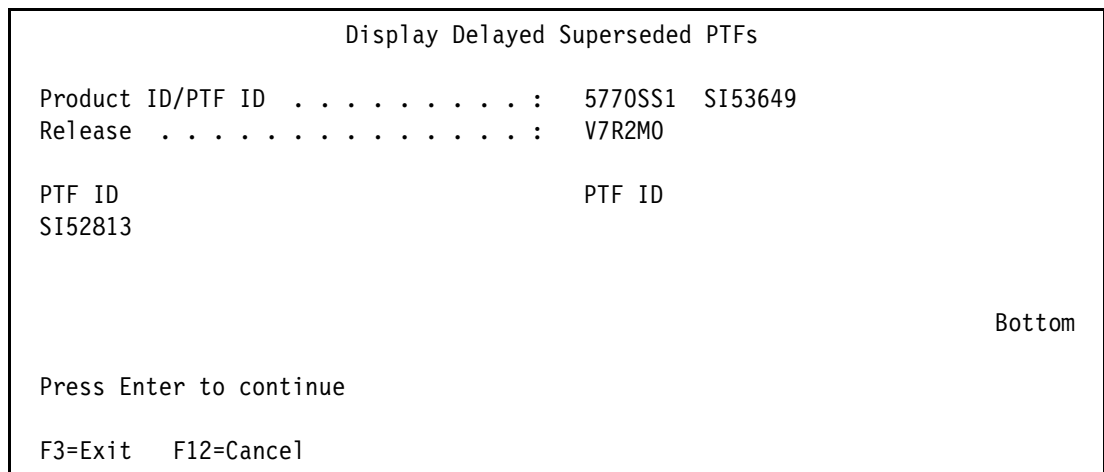


Figure 2-202 Display Delayed Superseded PTFs

The QPZRTVFX API supports a new format PTFR1100 to return the list of delayed superseded PTF IDs for a conditional immediate PTF.

For **OUTPUT (*PRINT)**, the new delayed superseded PTFs section was added to the spool file.

Note: A conditional immediate PTF is not identified by a new type (immediate or delayed), but rather by the presence of the new delayed superseded PTFs list. This new list is used at apply and remove time to determine whether the PTF can be applied or removed immediately or if the operation must be delayed. This is consistent with immediate PTFs that specify delayed prerequisite PTFs. If the delayed prerequisite PTFs have a status of temporarily or permanently applied, the dependent PTF can be applied immediately. Otherwise, the dependent PTF is set for delayed apply. Also, if an immediate PTF has preconditions that are not satisfied, the PTF is set for delayed apply.

Display PTF Apply Information (DSPPTFAPYI) CL command

The Display PTF Apply Information (**DSPPTFAPYI**) CL command indicates whether the selected PTFs can be applied immediately from *SERVICE. All selected PTFs and their prerequisite PTFs that are not applied are displayed. If a PTF has a status of Superseded, the PTF it is superseded by is displayed in place of the superseded PTF.

Each PTF that is displayed has the Apply Type field set to one of the following statuses:

- ▶ *IMMED: The PTF can be applied immediately. For Licensed Internal Code (LIC) PTFs, the PTF installation must be done from the ##MACH#B IPL source.
- ▶ *DELAYED: The PTF requires an IPL to apply because it has a PTF type of delayed.
- ▶ *PRECND: The PTF can be applied immediately if all of its preconditions are met.
- ▶ *ACTRQD: The PTF has an action that is required if the selected PTFs are installed.
- ▶ *DLYSPR: The immediate PTF requires an IPL to apply because it supersedes a delayed PTF that is not temporarily or permanently applied.
- ▶ *REQUIPLRQD: The PTF has a prerequisite PTF that requires an IPL to apply.
- ▶ *REQPRECND: The PTF has a prerequisite PTF that has a precondition.

The selected PTFs and prerequisite PTFs that will be installed must exist in *SERVICE. Save files must exist for the selected PTFs that have not been loaded. The specified PTF group must exist on the system along with its PTFs and prerequisite PTFs that are not yet installed.

If the PTFs and PTF groups are on physical media or in an image catalog, use one of the following methods to copy the PTF save files and PTF groups into *SERVICE before running this command:

- ▶ Use the QPZCPYSV API to copy the PTF save files and PTF groups into *SERVICE.
- ▶ Use the Copy PTF (**CPYPTF**) CL command to copy the PTF save files from media into *SERVICE. Use the Copy PTF Group (**CPYPTFGRP**) CL command to copy the PTF groups into *SERVICE.

Note: This command is shipped with exclude (*EXCLUDE) public authority, and the QPGMR, QSYSOPR, QSRV, and QSRVBAS user profiles are shipped with private authorities to use this command.

2.5.3 IBM i command changes

This section describes changes that are made to the following IBM i 7.2 commands:

- ▶ “Create Image Catalog (CRTIMGCLG) CL command” on page 182
- ▶ “Other command changes” on page 182

Create Image Catalog (CRTIMGCLG) CL command

The Create Image Catalog (CRTIMGCLG) CL command can now add all .ISO and .BIN image files from the image catalog directory to the image catalog as virtual volumes.

To do this task, use the *DIR value for the **ADDVRTVOL** parameter and *ALL for the **IMGTYPE** parameter. Other options for the **IBMTYPE** parameter include the following ones:

- ▶ *BIN for all binary images
- ▶ *ISO for all ISO images

For more information about the Create Image Catalog (CRTIMGCLG) CL command, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/crtimgclg.htm?lang=en

Other command changes

For information about changes to other IBM i commands, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgmtu.htm

2.5.4 API changes

For a detailed description of IBM i 7.2 API changes, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgmtu.htm

2.6 Operating system limitation changes

Various system limitations were changed in IBM i 7.2. Exceeding system limits can cause application or system outages. Be aware of these limitations during system planning, configuration, and application design.

For more information about current system capacities, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzamp/rzampoverview.htm

2.7 IBM Advanced Job Scheduler for i

IBM i 7.2 provides several enhancements of IBM Advanced Job Scheduler for i, especially for integration with IBM Navigator for i. The enhancements in IBM Navigator for i that are related to IBM Advanced Job Scheduler for i include the following ones:

- ▶ Support for configuring application/job controls, library lists, command variables, permissions, data libraries, and calendars in the Advanced Job Scheduler properties.
- ▶ Work Flow Manager added for workflow management.

2.7.1 Advanced Job Scheduler properties

In IBM 7.2, IBM Navigator for i provides more configurations in the Advanced Job Scheduler properties.

To access the Advanced Job Scheduler properties from IBM Navigator for i, click **Work Management** → **All Tasks** → **Advanced Job Scheduler** → **Properties**.

Note: For more information about accessing IBM Navigator for i, see 2.1, “IBM Navigator for i” on page 14.

As shown in Figure 2-203, there are several new tabs that are now available in IBM Navigator for i that are related to Advanced Job Scheduler:

- ▶ “Job Controls/Applications” on page 184
- ▶ “Library Lists” on page 185
- ▶ “Command Variables” on page 186
- ▶ “Permissions” on page 187
- ▶ “Data libraries” on page 188
- ▶ “Calendars” on page 189

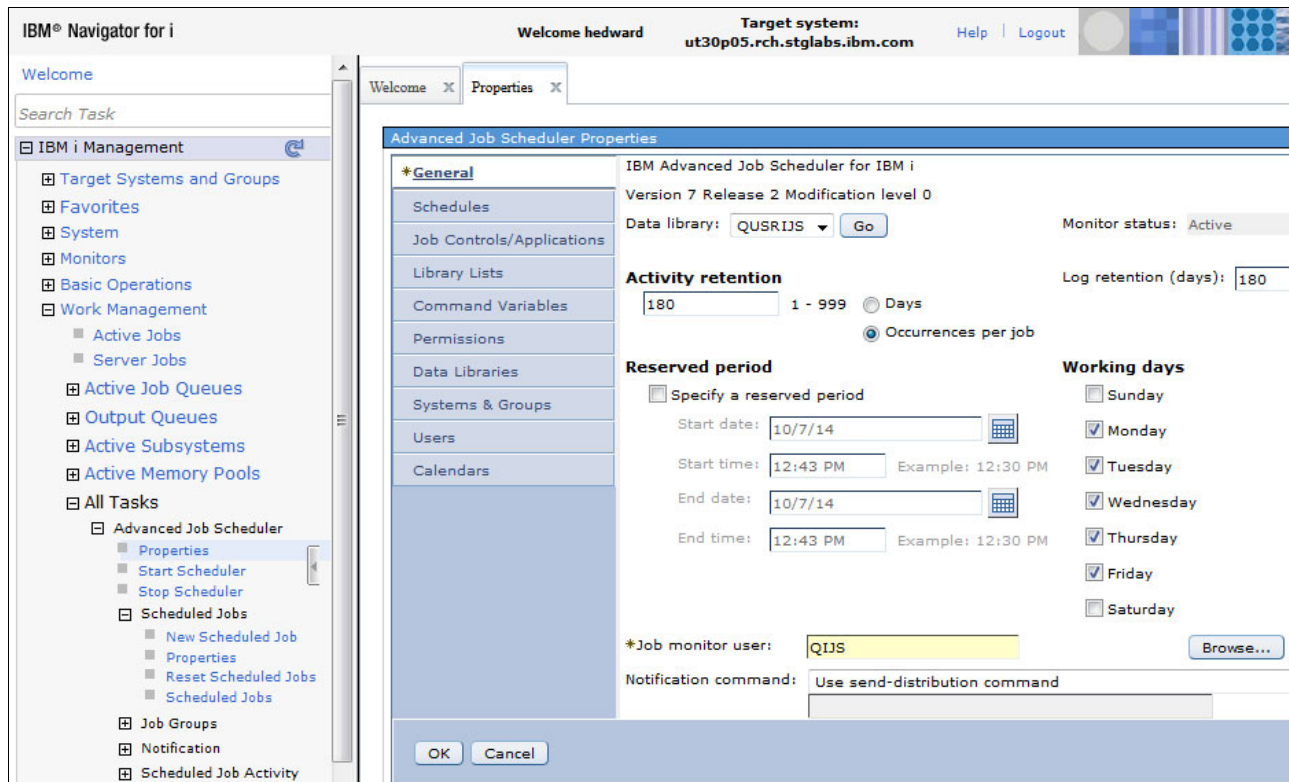


Figure 2-203 Advanced Job Scheduler Properties in IBM Navigator for i

Job Controls/Applications

Applications are jobs that are grouped for processing. Job controls are the defaults that are assigned to a job when you add it to the job scheduler. Job control defaults include such things as default application, calendar, and holiday calendar. Each application contains job control information. The application that is specified in the definition of a job is used to determine the job controls that are used by the job when the job is submitted. If the job does not contain an application, the job uses the job controls in the system default.

Figure 2-204 shows the Job Controls/Applications tab in the Advanced Job Scheduler Properties. You can create, delete, and modify the job control on this page.

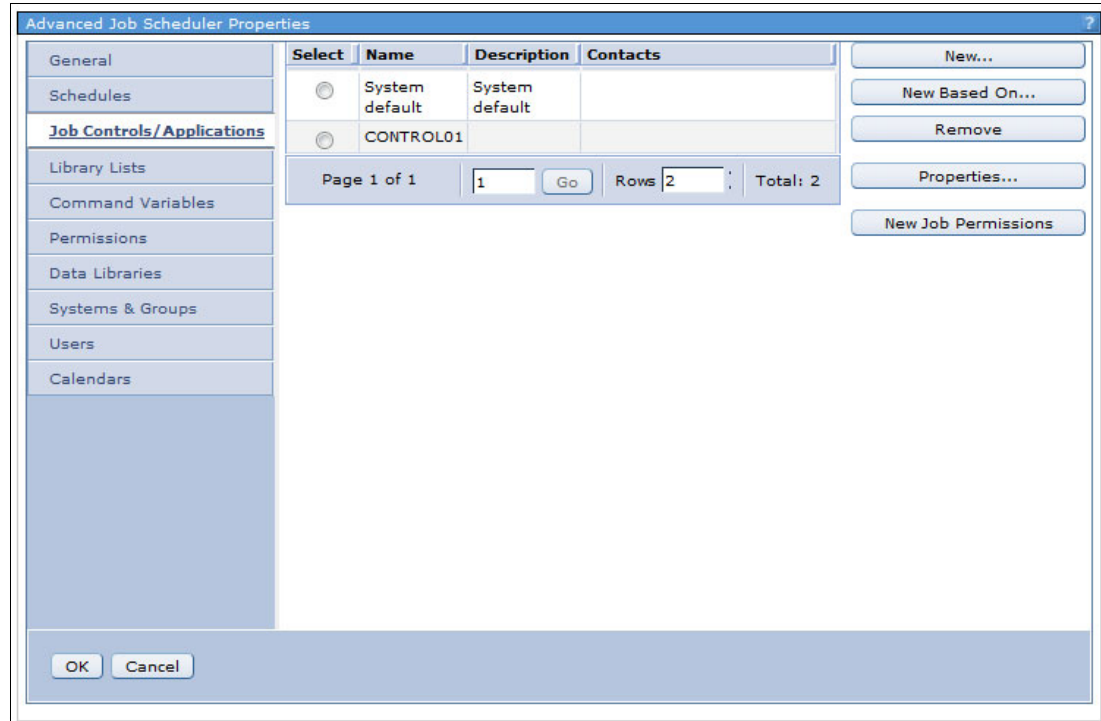


Figure 2-204 Job Controls/Applications page in the Advanced Job Scheduler properties

Library Lists

Library Lists (Figure 2-205) contains user-defined lists of libraries that are used by an Advanced Job Scheduler job when it is processing. From this window, you can add a library list, add a library list based on an existing one, or remove a library list, if it is not being used by a scheduled job. You can also select a list and display its properties to make changes.

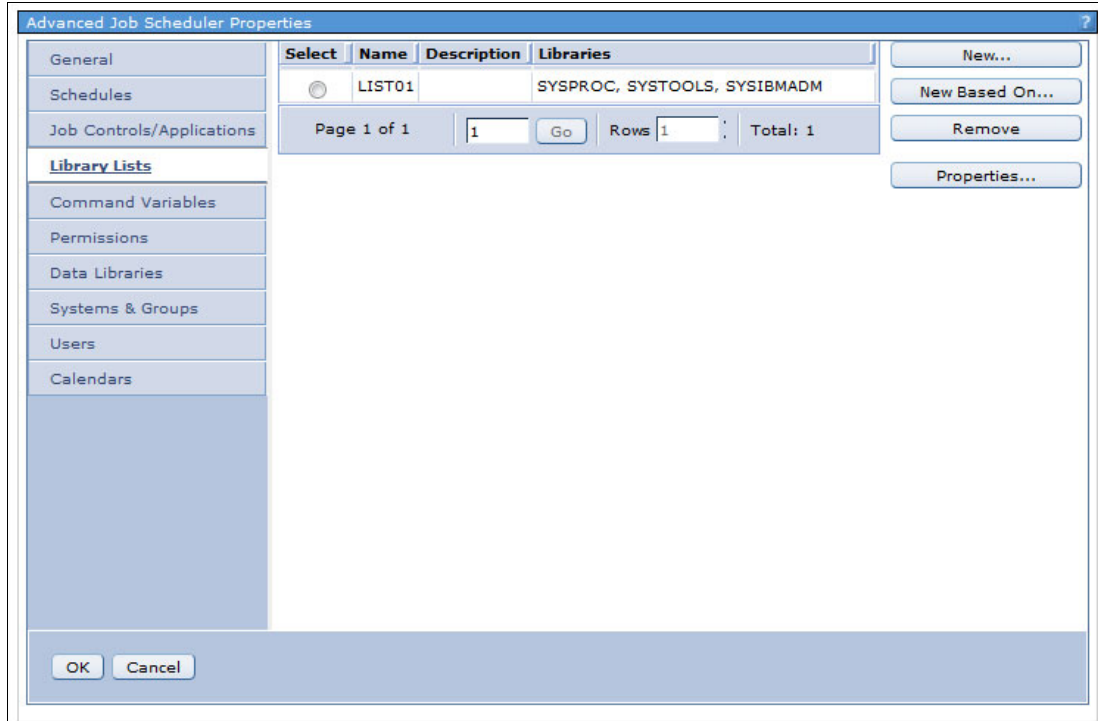


Figure 2-205 Library Lists window in the Advanced Job Scheduler properties

Command Variables

As shown in Figure 2-206, you can use the Command Variables window in Advanced Job Scheduler Properties to display all the existing command variables on the system. Command variables are variables that can be stored in Advanced Job Scheduler and used in jobs that are submitted through Advanced Job Scheduler. Examples of command variables include the beginning of each month, a division number, a company number, and so on. From this page, you can add variables, add variables based on existing ones, and remove or modify them.

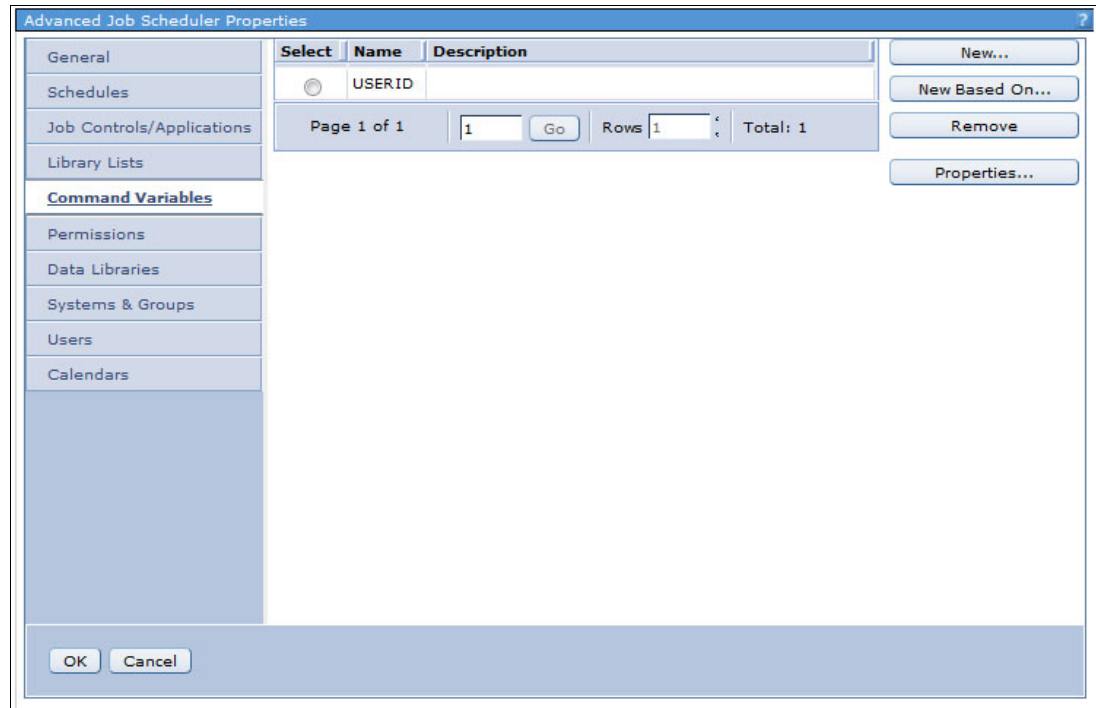


Figure 2-206 Command Variables window in the Advanced Job Scheduler properties

Permissions

You can use the Permissions window to add or modify permissions for functions.

Figure 2-207 shows the Permission window with various default functions whose authorities can be changed for the Advanced Job Scheduler. The name of the function and a description is shown. If your user profile has the proper authority, you can add, remove, or edit the authorities for functions. If not, you can still view the function authority properties, but cannot change them.

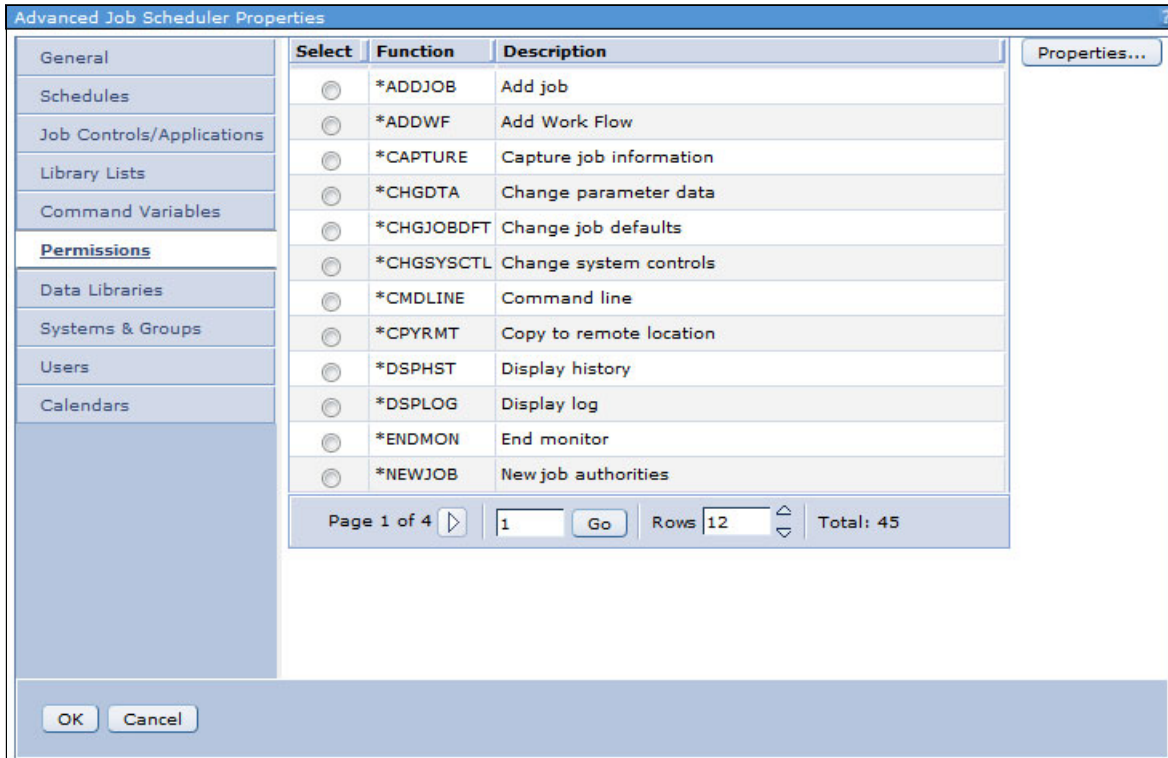
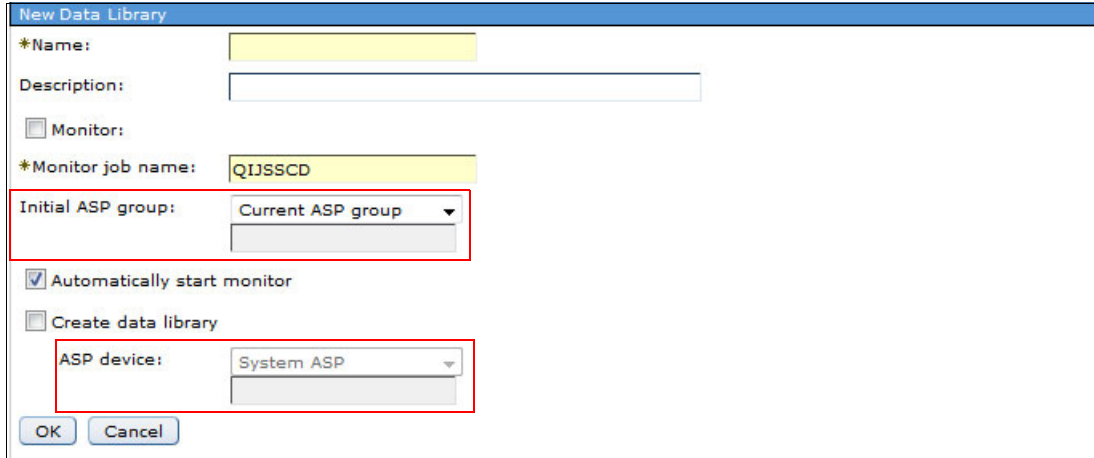


Figure 2-207 Permissions window in the Advanced Job Scheduler properties

Data libraries

The data libraries in IBM Navigator for i are enhanced with several new parameters that you can use to specify easily new data library parameters that are used for the Advanced Job Scheduler. The new parameters are Initial ASP group and ASP device, as shown in Figure 2-208.

You can use these enhancements to specify the initial ASP group and ASP device where your library is.



The screenshot shows a dialog box titled "New Data Library". It contains several fields and checkboxes. The "Initial ASP group" and "ASP device" fields are highlighted with red boxes. The "Initial ASP group" field is a dropdown menu with "Current ASP group" selected. The "ASP device" field is a dropdown menu with "System ASP" selected. Other fields include "Name", "Description", "Monitor job name" (set to "QIJS CD"), "Automatically start monitor" (checked), and "Create data library" (unchecked). There are "OK" and "Cancel" buttons at the bottom.

Figure 2-208 New Data Library enhanced parameters

Calendars

In addition to holiday calendar access in IBM Navigator for i in previous releases, you can use IBM Navigator for i V7.2 to also access the fiscal calendar from the web. A fiscal calendar is a calendar of selected days that can be used by users for scheduling a job or a job group. Users can configure their start and end dates for each period in the fiscal year on this web page.

Figure 2-209 shows the Fiscal Calendars page in Advanced Job Scheduler Properties.

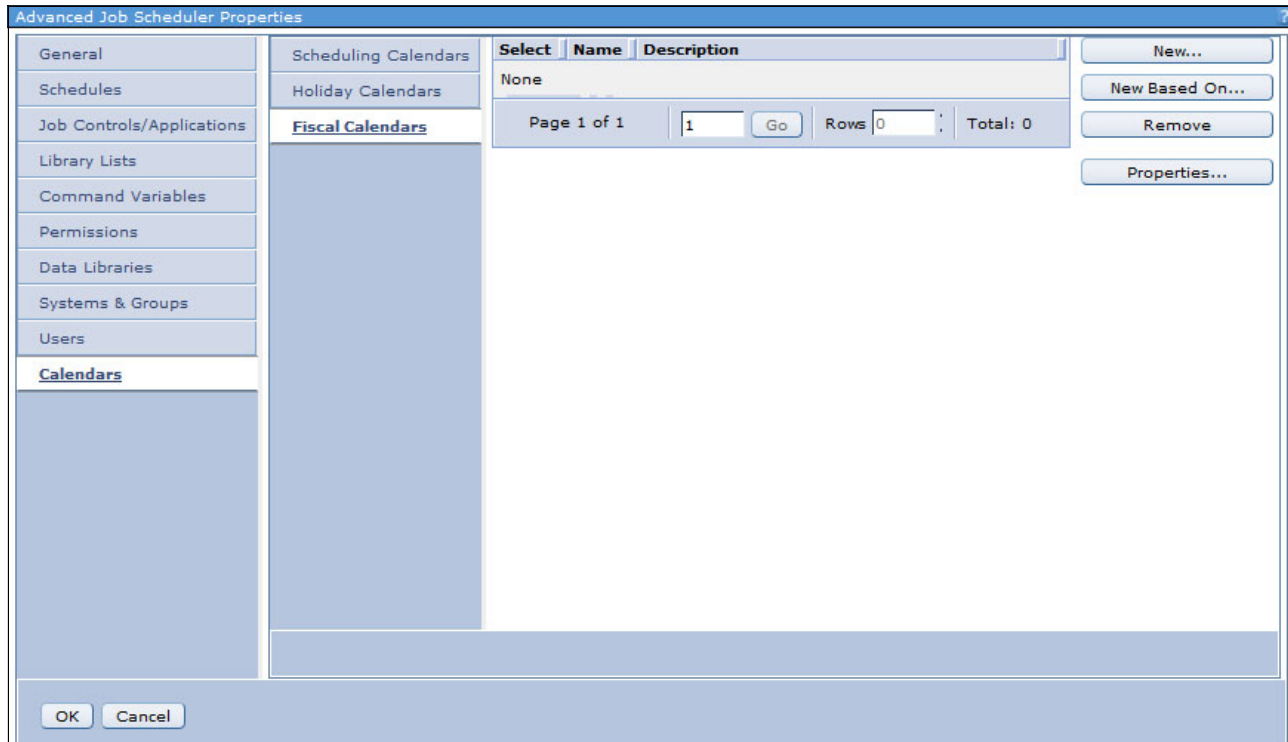


Figure 2-209 Fiscal Calendars page in the Advance Job Scheduler properties

2.7.2 Work Flow Manager

Scheduling a job in IBM Advanced Job Scheduler for i is more enhanced in IBM i 7.2 because IBM Navigator for i now provides a feature that you can use to specify a predecessor and successor of each Advanced Job Scheduler job. This feature is called *Work Flow Manager*. In Work Flow Manager, you can define units of work that consist of automated or manual steps that can then be scheduled or run interactively.

Each step within the work flow can have one or more predecessor Advanced Job Scheduler jobs and one or more successor Advanced Job Scheduler jobs. When a work flow starts, the first step is flagged to run. When it completes, the next step is flagged to run.

There are several considerations when you use Work Flow Manager:

- ▶ You can manually start a work flow at any step. When you do so, you bypass all previous steps in the work flow.
- ▶ Automatic steps complete after all prior steps complete, which includes all predecessor Advanced Job Scheduler jobs.
- ▶ After a step completes, the successor Advanced Job Scheduler jobs are flagged to run.
- ▶ Manual steps can complete in any sequence after the step's predecessor jobs complete.

- ▶ You can mark completed manual steps as not complete and run them again after there are no subsequent incomplete automatic steps.
- ▶ You can cause a step to wait until the job completes by specifying predecessor jobs that are the same as the successor jobs of the previous step.
- ▶ You can notify other users when a particular step starts, stops, did not start by a specific time, or is taking too long. For example, you can notify a user who is responsible for a particular manual step that the previous automated steps complete.

Figure 2-210 shows the Work Flow Manager page in IBM Navigator for i. It displays all the existing work flows in the system.

To display the Work Flow Manager, click **Work Management** → **All Tasks** → **Advanced Job Scheduler** → **Work Flow Manager** → **Work Flow Manager**.

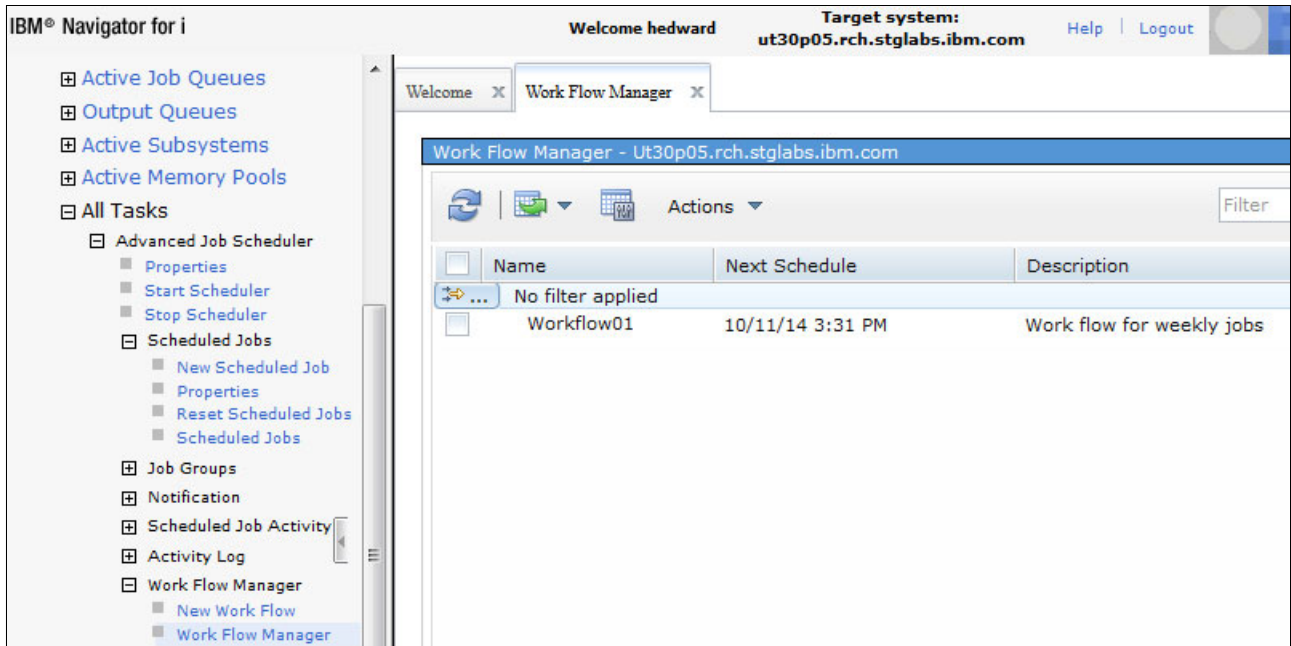


Figure 2-210 Work Flow Manager in IBM Navigator for i

For more information about how to create and manage work flow by using the Work Flow Manager in IBM Advanced Job Scheduler for i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasn/rzasnajsworkflowabout.htm?lang=en

For more information about IBM Advanced Job Scheduler for i, see *IBM i 7.1 Technical Overview with Technology Refresh Updates*, SG24-7858 and IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasn/rzasnajsmanage.htm?cp=ssw_ibm_i_72%2F17-8-3-4-1&lang=en

2.8 Performance

IBM i 7.2 provides some enhancements to performance that you can use to monitor and manage system performance easily and to ensure that you are keeping pace with the changing business demands.

This section describes the following IBM i 7.2 performance-related enhancements:

- ▶ 2.8.1, “Collection Services” on page 191
- ▶ 2.8.2, “Job Watcher metrics” on page 194

2.8.1 Collection Services

Here are the Collection Services enhancements in IBM i 7.2 that are related to Collection Services data files:

- ▶ “Collection Services metrics” on page 191
- ▶ “Enhanced database files to support IBM Navigator for i” on page 192

Collection Services metrics

Table 2-4 shows the changed files that are related to the Collection Services enhancements.

Table 2-4 Changed files for Collection Services enhancements

Changed files	Collection Services enhancements
QAPMJOBOS	<ul style="list-style-type: none"> ▶ Number of spool files that are created by a job ▶ Number of jobs that are submitted or created by a job ▶ Job level activity metrics plus connection data for server jobs
QAPMJOBMI	<ul style="list-style-type: none"> ▶ Activation group metrics per thread: Groups created and PGM / SRVPGM activation created ▶ Temporary storage metrics per job: Allocated, deallocated, maximum allowed, peak, and current
QAPMSYSTEM	<ul style="list-style-type: none"> ▶ Temporary storage metrics for the system: OS, active jobs, and ended jobs ▶ System level SQL CPU time
QAPMPOOLB	Memory usage metric enhancement to include many new metrics along with separately reporting metrics for 4-K versus 46-K page sizes.
QAPMDISK	<ul style="list-style-type: none"> ▶ RAID 10 support: New field to indicate the level of mirrored protection ▶ SSDs: New DSCAT value to identify a unit as an SSD ▶ Log Sense command: New fields for counts and response times
QAPMETHP	SR-IOV Ethernet physical ports: New file for physical Ethernet ports of an SR-IOV adapter. (This feature is also available with IBM i 7.1 TR 8 and PTF SI47870.)
QITAMON	WRKSYSACT replaced DB CPU with SQL CPU.
QAPMSQLPC	SQL plan cache collection category (*SQL) and file (QAPMSQLPC).

To support the POWER8 Instruction Count and Virtual Time Base, new metrics such as QAPMJOBMI, QAPMSYSTEM, QAPMLPARJH, and QAPMSYSVP also were improved to track thread level, system level, partition level, and processor level.

Enhanced database files to support IBM Navigator for i

To support the performance functions in IBM Navigator for i, several new files in Collection Services are enhanced to summarize those collected data. Here are the new system monitor files:

- ▶ QAPMSMCMN
This database file contains summarized metrics from communication protocol data (*CMNBASE collection category) that can be used in support of system monitoring.
- ▶ QAPMSMSDK
This database file contains summarized metrics from disk data (*DISK collection category) that can be used in support of system monitoring.
- ▶ QAPMSMJMI
This database file contains summarized metrics from job data (*JOBMI collection category) that can be used in support of system monitoring.
- ▶ QAPMSMJOS
This database file contains summarized metrics from job data (*JOBOS collection category) that can be used in support of system monitoring.
- ▶ QAPMSMPOL
This database file contains summarized metrics from pool data (*P00L collection category) that can be used in support of system monitoring.
- ▶ QAPMSMSYS
This database file contains summarized metrics from system data (*SYSLVL collection category) that can be used in support of system monitoring.

To produce the above files, the Create Performance Data (CRTPFRDTA) CL command exports the data when the Create standard summary data (CRTPFRSUM) parameter is set to *SYSMON or *ALL, as shown in Figure 2-211.

Even without running monitors, you can still create these files to view system monitoring perspectives within PDI.

For more information about performance data files, see the *Collection Services data files* topic in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahx/rzahxperpdatafiles1.htm?lang=en

```

                                Create Performance Data (CRTPFRDTA)

Type choices, press Enter.

From collection . . . . . > Q123456789   Name, *ACTIVE, *SELECT
  Library . . . . .          QPFRDATA     Name
To member . . . . .          *FROMMGTCOL  Name, *FROMMGTCOL
To library . . . . .          *FROMMGTCOL  Name, *FROMMGTCOL
Text 'description' . . . . . *SAME

Categories to process . . . . . *FROMMGTCOL  Name, *FROMMGTCOL, *APPN...
      + for more values
Time interval (in minutes) . . . *FROMMGTCOL  *FROMMGTCOL, 0.25, 0.5, 1...
Create standard summary data . . > *SYSMON      *NONE, *ALL, *PFRSUM, *SYSMON

Starting date and time:
  Starting date . . . . .          *FROMMGTCOL  Date, *FROMMGTCOL
  Starting time . . . . .          Time

                                                                More...
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys

```

Figure 2-211 CRTPFRSUM parameter of the CRTPFRDTA CL command

2.8.2 Job Watcher metrics

Some of the database files for performance are also enhanced in IBM i 7.2. Table 2-5 shows the list of changed files for supporting Job Watcher enhancements.

Table 2-5 Changed files for Job Watcher enhancements

Changed files	Job Watcher enhancements
QAPYJWTDE QAPYJWPRC	<ul style="list-style-type: none"> ▶ SQL metrics: <ul style="list-style-type: none"> – I/O counts for database, non-database, and logical – Clock time – Statements – Thread scaled and unscaled CPU ▶ Miscellaneous information: <ul style="list-style-type: none"> – Number of spooled files created – Number of jobs submitted – Number of job instructions changed – Wait object library
QAPYJWTDE	POWER8 Instruction Count and Virtual Time Base
QAPYJWPRC	<ul style="list-style-type: none"> ▶ Support for temporary storage in Job Watcher collection ▶ Support for memory usage



Cloud and virtualization

Many improvements and enhancements have been implemented since the first logical partition was allowed in the IBM i family of servers. This chapter describes the virtualization options that are available in IBM i 7.2 running on IBM Power Systems. Additionally, with the industry-wide push for “the cloud,” this chapter covers topics that are available to help implement and manage IBM i in a cloud environment.

This chapter describes the following topics:

- ▶ 3.1, “Cloud and IBM i” on page 196
- ▶ 3.2, “IBM Power Virtualization Performance for Power Systems” on page 202
- ▶ 3.3, “IBM i virtualization enhancements” on page 204
- ▶ 3.4, “Live Partition Mobility” on page 207
- ▶ 3.5, “Licensing and service provider accommodations” on page 208

For more information about the IBM i 7.2 virtualization enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

3.1 Cloud and IBM i

Although the current cloud enhancements on IBM i are not strictly related to the IBM i 7.2, this section describes the following most recent cloud capabilities and offerings regarding IBM i:

- ▶ 3.1.1, “IBM PowerVM” on page 196
- ▶ 3.1.2, “OpenStack” on page 197
- ▶ 3.1.3, “IBM Power Virtualization Center” on page 197
- ▶ 3.1.4, “IBM SmartCloud Entry for Power Systems” on page 199
- ▶ 3.1.5, “IBM Cloud Manager with OpenStack” on page 199
- ▶ 3.1.6, “IBM Power Systems Solution Edition for Cloud” on page 200
- ▶ 3.1.7, “IBM i cloud offering summary” on page 201
- ▶ 3.1.8, “VMware vRealize Automation for Power” on page 201

All available options provide IBM i as an Infrastructure as a Service (IaaS) cloud model where IBM i partitions are infrastructure services. No cloud management, provisioning, and automation software are supported natively on the IBM i operating system. However, the IBM i operating system is a supported operating system on virtual machines (VMs) that can be managed by the software products that are described in this section.

IBM i has been a cloud-ready server platform for years because of its hypervisor-managed logical partitions and robust virtualization capabilities. When using the cloud management software that is described in this section, it has been a fully cloud-enabled platform since 2012.

Note: To use the cloud capabilities on Power Systems, the environment that hosts the VMs must be fully virtualized with VIOS.

3.1.1 IBM PowerVM

IBM PowerVM® provides a secure and scalable server virtualization environment for AIX, IBM i, and Linux applications that are built on the advanced reliability, availability, and serviceability (RAS) features and leading performance of the Power platform.

PowerVM is a building block for all current IBM cloud on Power Systems solutions.

Here are some key features of PowerVM:

- ▶ Deliver services with superior economics by consolidating virtualized workloads.
- ▶ Deliver services that are built for the cloud faster by automating the deployment of VMs and storage.
- ▶ Optimize the usage of server and storage resources to control cost and boost return on investment (ROI).
- ▶ Scale out or scale up virtualized deployments without paying underlying performance penalties.
- ▶ Eliminate scheduled downtime by deploying live mobility between servers.
- ▶ Deliver higher-quality services by improving virtual resource management.

For more information about PowerVM, see the Server virtualization with IBM PowerVM website:

<http://www.ibm.com/systems/power/software/virtualization/index.html>

3.1.2 OpenStack

OpenStack provides open source software for creating and managing private and public cloud environments.

OpenStack is a global collaboration of developers and cloud-computing technologists working to produce a ubiquitous IaaS open source cloud computing platform for public and private clouds. The OpenStack software provides tools and standards that are required to manage the storage, processor, and network resources that compose a cloud solution. IBM, among other entities, has been a key player in developing the OpenStack software.

OpenStack is a building block for IBM PowerVC software and other cloud solutions that are described in the following sections of this publication.

For more information about OpenStack, see the OpenStack website:

<http://www.openstack.org/>

3.1.3 IBM Power Virtualization Center

IBM Power Virtualization Center (PowerVC) is an advanced virtualization management offering that is built on OpenStack (see 3.1.2, “OpenStack” on page 197) and provides simplified virtualization management for IBM AIX, IBM i, and Linux VMs running on Power Systems.

PowerVC is designed to improve administrator productivity and simplify the management of VMs and LPARs on Power Systems servers. PowerVC provides the foundation for Power Systems scalable cloud management, including integration with higher-level cloud managers that are based on OpenStack technology.

After registering resources in PowerVC, the following capabilities are available:

- ▶ Creating VMs by deploying images and then resizing and attaching volumes to them.
- ▶ Importing existing VMs and volumes so they can be managed by PowerVC.
- ▶ Monitoring the utilization of the resources that are used in the environment.
- ▶ Migrating VMs while they are running Live Partition Mobility (LPM). For more information about LPM, see 3.4, “Live Partition Mobility” on page 207.
- ▶ Capturing a VM that is configured for later deployment elsewhere in the environment.
- ▶ Deploying images quickly to create VMs in response to changing business needs.
- ▶ Automatically deploying or migrating VMs based on the specified criteria.

PowerVC is a building block for the IBM SmartCloud® Entry for Power Systems cloud solution. For more information, see 3.1.4, “IBM SmartCloud Entry for Power Systems” on page 199.

PowerVC V1.3.0

At the time of writing, the latest version of PowerVC is Version 1.3.0. Power VC Version 1.3.0 supports the following IBM i versions as guest operating systems:

- ▶ IBM i V7.2 TR1 or later
- ▶ IBM i V7.1 TR8 or later

For more information about the PowerVC Lifecycle, see the following website:

<http://www.ibm.com/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&htmlfid=POW03150USEN&attachment=POW03150USEN.PDF>

What is new in PowerVC for IBM i

PowerVC V1.2.2 contains the following new functions for IBM i:

- ▶ PowerVC officially supports IBM i as a client.
- ▶ Support for connecting IBM System Storage® SAN Volume Controller to IBM i through VSCSI.
- ▶ Support for connecting IBM XIV® Storage System to IBM i through VSCSI.

PowerVC V1.2.3 contains the following new functions for IBM i:

- ▶ Supports capturing multiple volumes that are attached to an IBM i VM, resulting in a single deployable image. Also, an IBM i image that is composed of more than one volume can be deployed as a new VM.
- ▶ Remote restart is introduced for IBM i. You can use PowerVC to restart remotely VMs from a failed host to another healthy host.
- ▶ Support for connecting an EMC Symmetrix VMAX storage system to IBM i through VSCSI.
- ▶ Support for connecting an EMC VNX storage system to IBM i through VSCSI.
- ▶ SAN Volume Controller mirroring support allows a customer to create a local mirror in a second pool on the same SAN Volume Controller or Storwize controller, which can provide a degree of disaster recovery.
- ▶ Redundant HMC support for PowerVC allows customers to switch to the redundant HMC in case of an HMC failure or upgrade.
- ▶ Support for PowerVM Multiple Shared Processor Pools is provided in PowerVC 1.2.3 FP2. This support allows you to share a group of processors between multiple VMs. This feature is supported during VM deployment, resize, and migration.

PowerVC V1.3.0 contains the following new functions for IBM i:

- ▶ A new Dynamic Resource Optimizer (DRO) component that uses policy-based control to automatically move workloads to available resources by using VM migration.
- ▶ PowerVC storage connectivity groups contain the following new enhancements:
 - Support for new Fabrics section. This support allows you to control how much fabric redundancy is required in your environment.
 - Connect to up to 26 fabrics.
 - Specify how many ports to connect per fabric on each VIOS.
- ▶ Support for connecting IBM System Storage DS8000 to IBM i through VSCSI. NPIV support for DS8000 with IBM i will be provided in a future release.

For more information about new enhancements of PowerVC, see the following websites:

- ▶ What's new in Version 1.2.2:

http://www.ibm.com/support/knowledgecenter/SSXK2N_1.2.2/com.ibm.powervc.standard.help.doc/powervc_whats_new_hmc.html?lang=en

- ▶ What's new in Version 1.2.3:

http://www.ibm.com/support/knowledgecenter/SSXK2N_1.2.3/com.ibm.powervc.standard.help.doc/powervc_whats_new_hmc.html?lang=en

- ▶ What's new in Version 1.3.0:

http://www.ibm.com/support/knowledgecenter/en/SSXK2N_1.3.0/com.ibm.powervc.standard.help.doc/powervc_whats_new_hmc.html

For detailed hardware and software requirements for PowerVC, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/SSXK2N_1.2.3/com.ibm.powervc.kvm.help.doc/powervc_hwandsw_reqs_kvm.html

Note: PowerVC is meant to replace IBM Systems Director VMControl™. There is no migration support of an IBM Systems Director VMControl installation to the new PowerVC configuration.

For more information about PowerVC, see the IBM PowerVC - Virtualization Center websites:

<http://www.ibm.com/systems/power/software/virtualization-management/index.html>

3.1.4 IBM SmartCloud Entry for Power Systems

IBM SmartCloud Entry for Power Systems has evolved to become IBM Cloud Manager with OpenStack, which is described in 3.1.5, “IBM Cloud Manager with OpenStack” on page 199.

Documentation for IBM SmartCloud Entry was merged with documentation for IBM Cloud Manager with OpenStack, and is available on the IBM Cloud Manager with OpenStack wiki:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/W21ed5ba0f4a9_46f4_9626_24cbbb86fbb9/page/Documentation

For more information about IBM SmartCloud Entry for Power Systems, see the IBM Cloud Manager with OpenStack for Power Systems website:

<http://www.ibm.com/systems/power/solutions/cloud/smartcloudentry/>

3.1.5 IBM Cloud Manager with OpenStack

IBM Cloud Manager with OpenStack is a robust IaaS software offering that simplifies management of a virtualized environment that is driven by the IBM SmartCloud Entry product.

IBM Cloud Manager with OpenStack helps convert virtualized environments to a cloud quickly and easily. Users can request and provision an environment quickly through an easy-to-use web-based interface. IT managers can monitor and manage this environment for improved efficiency and utilization of data center resources.

IBM Cloud Manager with OpenStack includes heterogeneous server architecture support from a single user interface. You have the flexibility to manage the following platforms with a single, consolidated image of IBM Cloud Manager with OpenStack software:

- ▶ IBM Power System
- ▶ System x
- ▶ IBM BladeCenter
- ▶ IBM NeXtScale System
- ▶ IBM Flex System®
- ▶ PureFlex System

IBM Cloud Manager with OpenStack supports multiple virtualization environments, including VMware, Hyper-V, and KVM, and IBM PowerVM and IBM z/VM® environments.

Here are some of the capabilities of IBM Cloud Manager with OpenStack:

- ▶ Managing images:
 - Easily create “golden master” images and software appliances by using corporate-standard operating systems.
 - Convert images from physical systems or between various x86 hypervisors.
 - Reliably track images to ensure compliance and minimize security risks.
 - Optimize resources, reducing the number of virtualized images and the storage that is required for them.
- ▶ Deploying VMs:
 - Deploy application images across compute and storage resources.
 - User self-service for improved responsiveness.
 - Enable security through VM isolation and project-level user access controls.
 - Easy to use, with no need to know all the details of the infrastructure.
 - Investment protection from full support of existing virtualized environments.
- ▶ Operating a cloud:
 - Delegate provisioning to authorized users to improve productivity.
 - Maintain full oversight to ensure an optimally running and safe cloud through automated approval/rejection.
 - A built-in workload metering delivers the foundation for a pay-per-use model.
 - Standardize deployment and configuration to improve compliance and reduce errors by setting policies, defaults, and templates.
 - Simplify administration with an intuitive interface for managing projects, users, workloads, resources, billing, approvals, and metering.
 - Integrated platform management allows easy transition between physical or virtual resource views to facilitate diagnosis and maintenance.
 - Manage automated approvals, metering, billing, users, and projects from a single pane.

The current available version is IBM Cloud Manager with OpenStack Version 4.3.

For detailed hardware and software requirements for IBM Cloud Manager with OpenStack, see the IBM Cloud Manager with OpenStack wiki:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/W21ed5ba0f4a9_46f4_9626_24cbbb86fbb9/page/Documentation

For more information about IBM Cloud Manager with OpenStack, see the IBM Cloud Manager with OpenStack website:

<http://www.ibm.com/systems/power/solutions/cloud/smartcloudentry/>

3.1.6 IBM Power Systems Solution Edition for Cloud

IBM Power Systems Solution Edition for Cloud is a pre-built and preinstalled solution of hardware, software, and implementation services for private cloud implementations.

IBM Power Systems Solution Edition for Cloud helps speed up and simplify the deployment of a cloud with OpenStack based cloud management software that is delivered on a ready-to-use appliance.

The Solution Edition is easy to order, and includes configurable hardware choices to address a customer's needs and preferences. Building on PowerVM virtualization and PowerVC management, the IBM Power Systems Solution Edition for Cloud provides cloud capabilities based on a flexible and extensible OpenStack platform with fast and automated installation, an intuitive and easy-to-use interface, automated deployment, image management, workload metering, and the self-service features of cloud.

For more information about IBM Power Systems Solution Edition for Cloud, see the IBM Power System Solution Edition for Cloud website:

<http://www.ibm.com/systems/power/hardware/solutioneditions/cloud/>

For more information about IBM Power Systems Solution Edition for Cloud, see the IBM Power Systems Solution Edition for Cloud website:

<http://www.ibm.com/systems/power/solutions/cloud/resources.html>

3.1.7 IBM i cloud offering summary

For environments where just VM management, deployment, and migration are the case, PowerVC is sufficient in most cases. It is also a required step and starting point for using robust cloud capabilities with IBM Cloud Manager with OpenStack.

IBM Cloud Manager with OpenStack provides the most comprehensive capabilities, including automated cloud service management process, cloud oversight, workload metering, billing, and much more. Using IBM Cloud Manager with OpenStack requires skilled professionals for implementation and operation. If this is a problem or low time-to-market (TTM) factor is important, then the best option is IBM Power Systems Solution Edition for Cloud. IBM Power Systems Solution Edition for Cloud is a preinstalled and pre-configured appliance based on customer needs. It can also come with optional implementation services.

3.1.8 VMware vRealize Automation for Power

IBM and VMware each announced a cooperative effort to give their shared clients the ability to provision and manage VMs and applications running on IBM Power Systems with the VMware vRealize Automation (vRA) solution through OpenStack enabled APIs.

vRA sits on top of your existing PowerVC or IBM Cloud Manager OpenStack environment, as shown in Figure 3-1. vRA passes workload management requests through OpenStack APIs to IBM PowerVM, PowerKVM, and z/VM and KVM on IBM z™. vRA also can use images that are already created in PowerVC.

This new capability provides IBM Systems customers more choice and flexibility in deciding what orchestration tool to use.

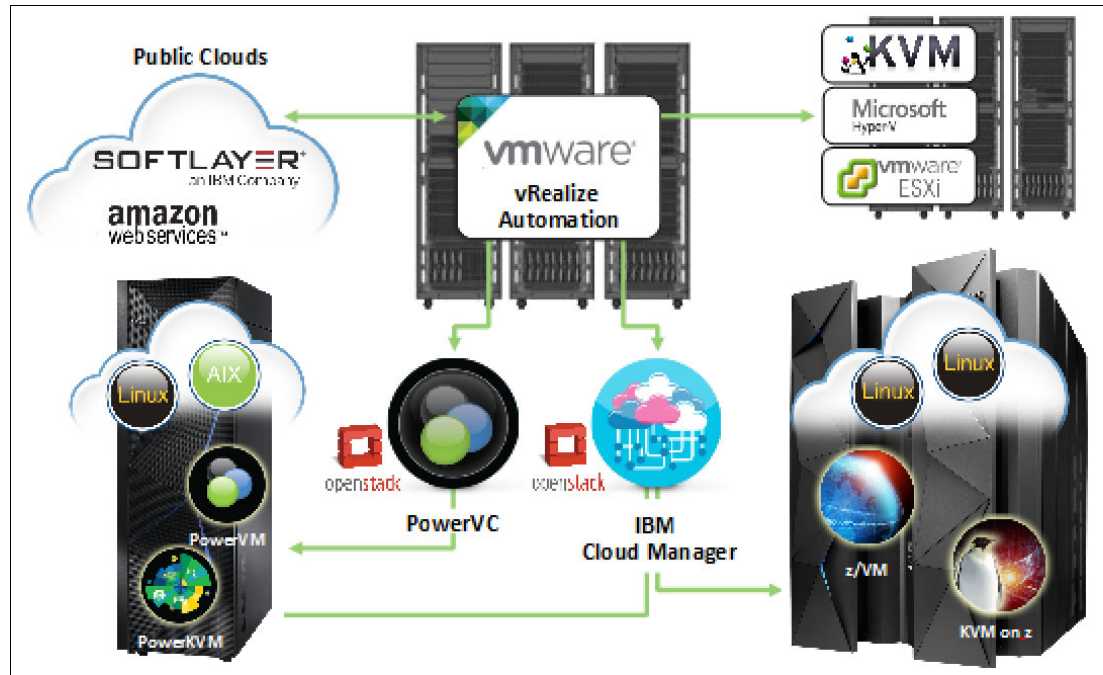


Figure 3-1 VMware vRealize Virtualization for Power

3.2 IBM Power Virtualization Performance for Power Systems

IBM Power Virtualization Performance (PowerVP) for Power Systems is a licensed program that provides a performance view into the PowerVM virtualized environment.

PowerVP displays graphically in real time the utilization of individual cores and their mapping to logical partitions on Power Systems. The dashboard view of PowerVP gives a simple to understand snapshot of resource usage that can be used by system administrators to understand resource usage by different applications that run on logical partitions.

Customers who are using Power Systems in Cloud computing with large and small enterprises with PowerVM features now can use PowerVP to understand resource distribution among the virtual workloads and plan for business demands.

PowerVP collects performance data directly from the hypervisor, which offers the most accurate performance information about logical partitions that are running on Power Systems. This performance information is then displayed on a real-time, continuous graphical dashboard. Data collection is available for historical review.

PowerVP can also be used along with existing operating system performance utilities to identify performance bottlenecks on Power Systems. System administrators can use PowerVP to diagnose resource contention issues quickly.

3.2.1 PowerVP components

The architecture of PowerVP includes components that interact with the PowerVM Hypervisor, the operating system, a graphical user interface (GUI), and a Java JAR file that is used for data recording without the use of the GUI.

Here are the components of PowerVP:

- ▶ System-level agent: A central point to collect system-wide resource utilization data.
- ▶ Partition-level agent: Collects partition resource utilization data and interacts with the system-level agent.
- ▶ GUI: A Java based application that connects to the system-level agent and displays the PowerVP dashboard.
- ▶ Background recorder: A Java based application that is used to collect system-level resource utilization data without the GUI.

Figure 3-2 shows the high-level architecture of PowerVP and the data flow between the components of PowerVP and PowerVM.

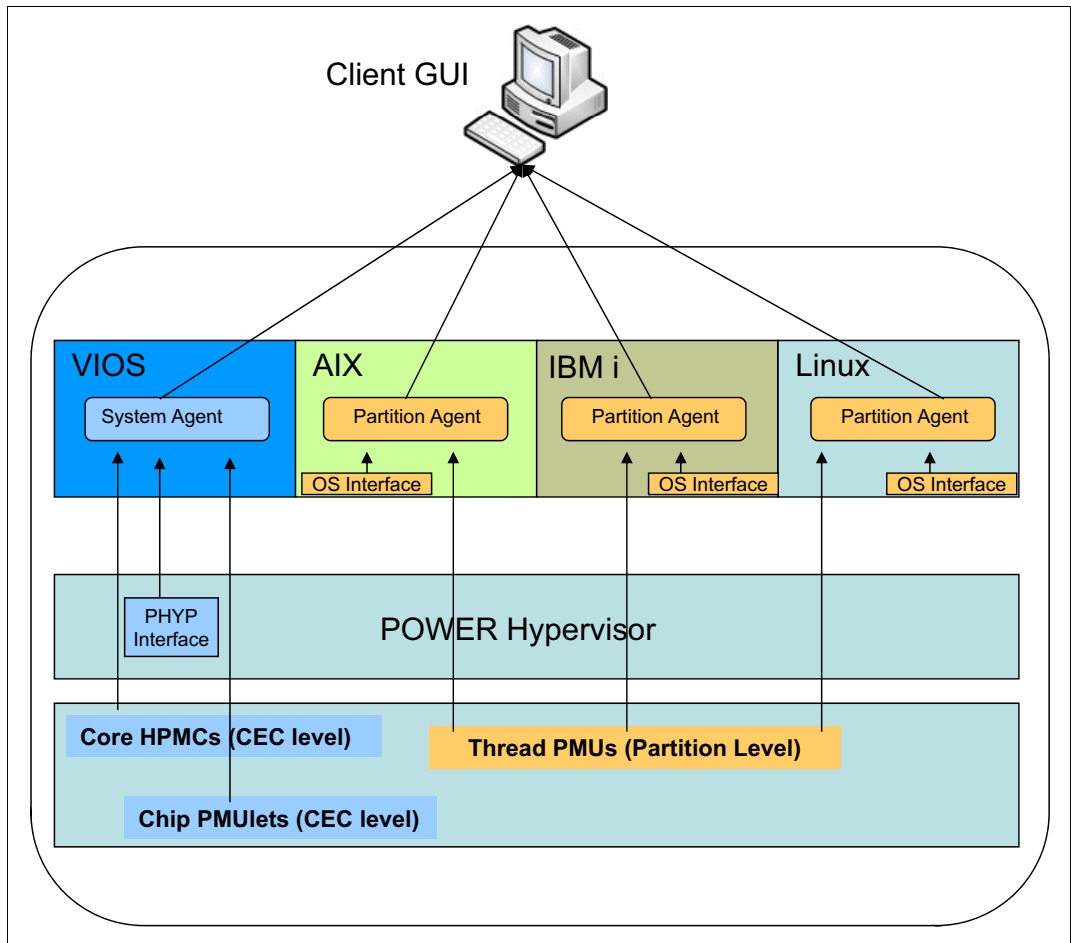


Figure 3-2 PowerVP architecture showing system agents communicating with the GUI

3.2.2 PowerVP dashboard

System and partition resource utilization data that is collected by the PowerVP agents is accessed and displayed on the GUI. You can use the PowerVP dashboard to access system-wide performance data and data for a particular VM, and then drill down to get a detailed view of the data.

You also can use the PowerVP dashboard to record and playback performance metrics on the workstation where the GUI runs.

A sample PowerVP CPU resource affinity view is shown in Figure 3-3.

For more information about PowerVP implementation in an IBM i environment, see *IBM PowerVP: Introduction and Technical Overview*, REDP-5112.

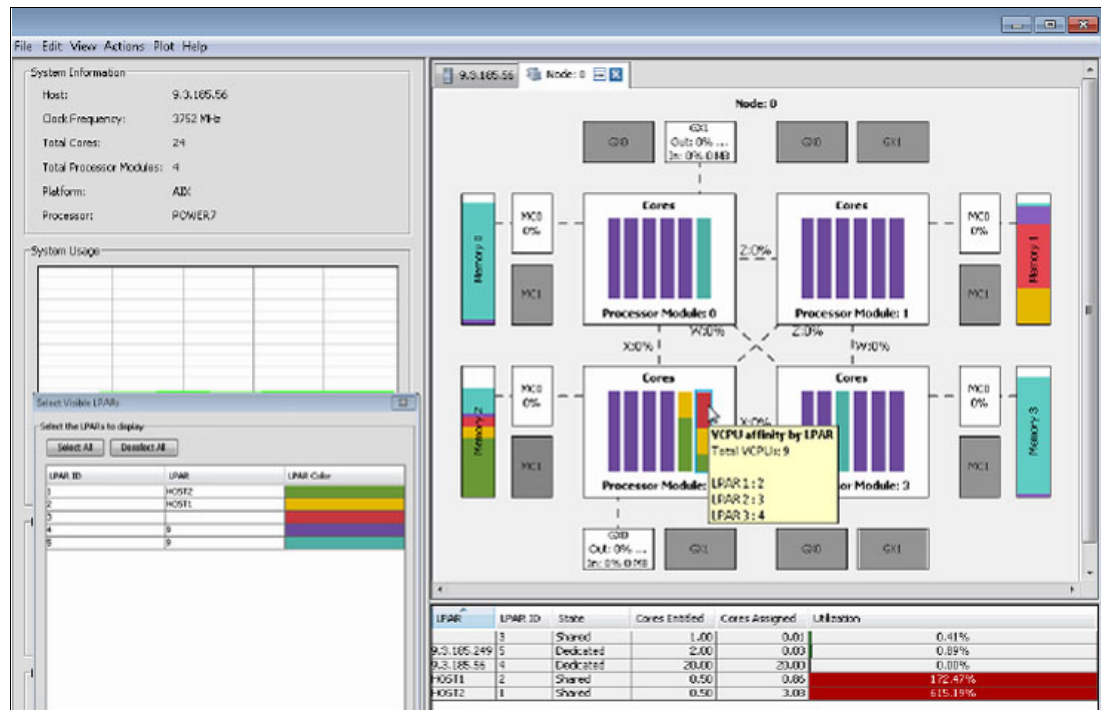


Figure 3-3 PowerVP dashboard: CPU affinity view

3.3 IBM i virtualization enhancements

Many new features were added in IBM i 7.2 that are related to iVirtualization and non-hosted partitions and virtualization that use VIOS.

iVirtualization: When referring to an IBM i partition hosting another IBM i instance, this is known as *iVirtualization*.

For an overview of various IBM i virtualization methods and helpful tips, see the *IBM i Virtualization and Open Storage (read-me first)* document, found at:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/beb2d3aa-565f-41f2-b8ed-55a791b93f4f/page/IBM%20i%20Virtualization%20and%20Open%20Storage>

3.3.1 Virtual Partition Manager GUI in IBM Navigator for i

IBM Navigator for i provides a GUI for Virtual Partition Manager. To create a logical partition by using IBM Navigator for i, complete the following steps:

1. In IBM Navigator for i, expand **Configuration and Services**.
2. Click **Create Partition** to start the wizard.
3. Follow the steps in the wizard to create an IBM i or Linux partition.

Important: You cannot use Virtual Partition Manager on an IBM i server that is configured by an HMC. You can use Virtual Partition Manager only on the hosting IBM i partition. PowerVM Standard or Enterprise edition is required to support up to four client partitions that use VPM.

For more information about creating and managing partitions with IBM Navigator for i, see 2.1.14, “Partition management” on page 100.

3.3.2 iVirtualization release support

Various releases of IBM i running on Power Systems support hosting of other releases. For a list of supported combinations when using iVirtualization, see Table 3-1.

Table 3-1 Supported iVirtualization combinations

Processor family	Host IBM i versions	Client IBM i versions
POWER5	Not available	Not available
POWER6	6.1, 7.1, and 7.2	6.1, 7.1, and 7.2
IBM POWER7®	6.1, 7.1, and 7.2	6.1, 7.1, and 7.2
POWER8	7.1 and 7.2	7.1 and 7.2

Important: Machine code release 6.1.1 is required for any host or client at IBM i 6.1. IBM i 7.1 and 7.2 requires specific Technology Refresh levels based on the hardware on which the partitions are running.

Little Endian Linux partitions are now supported on POWER8 with IBM i 7.2 TR3 and IBM i 7.1 TR11. You can configure a Little Endian Linux partition as a client that uses as IBM i 7.2 or IBM i 7.1 partition as a host partition. Both HMC and VPM configurations are supported.

For more information about supported Linux distributions for POWER8, see IBM Knowledge Center:

<https://www.ibm.com/support/knowledgecenter/linuxonibm/1iaam/1iaamdistros.htm>

3.3.3 Using solid-state drives for network storage spaces

By using the Create NWS Storage Space (CRTNWSSTG) CL command, you can select affinity for solid-state drives (SSDs) for iVirtualization partitions, and anything else that uses a network storage space.

Figure 3-4 shows an example of how to create a network storage space and set its preference for SSD by using the Preferred storage unit parameter.

For more information about SSD support, see “Solid-state drive support” on page 108.

```

Create NWS Storage Space (CRTNWSSTG)

Type choices, press Enter.

Network server storage space . . > NEW001      Name
Size . . . . . > 100000      *CALC, 1-1024000 megabytes
From storage space . . . . . *NONE      Name, *NONE
Format . . . . . > *OPEN      *NTFS, *OPEN, *REFS...
Auxiliary storage pool ID . . . 1      1-255
ASP device . . . . .      Name
Text 'description' . . . . . > 'Storage space which should go to SSD'

Additional Parameters

Data offset . . . . . *FORMAT      *FORMAT, *ALIGNLGLPTN...
Sector size in bytes . . . . . 512      512, 4096
Preferred storage unit . . . . . > *SSD      *ANY, *SSD
Resource allocation priority . . 9      1, 2, 3, 4, 5, 6, 7, 8, 9

```

Figure 3-4 Create a network storage space with a preferred storage unit of *SSD

3.3.4 Support of additional disks that are attached through VSCSI

In IBM i 7.2, 32 virtual disks can now be attached through a VSCSI link. The previous limitation was 16 virtual disks. This setting allows for a potentially less complex setup and easier expansion of an existing environment when needed.

3.3.5 Less-complex assignment of tape and optical resources

In previous releases, all optical and tape devices were available to client partitions when using iVirtualization, unless they were restricted individually in the network server description.

When running IBM i 7.2 as the host, the following two parameters are available on the Create Network Server Description (**CRTNWS**) and Change Network Server Description (**CHGNWS**) CL commands to specify only the devices that are allowed to be used. These parameters can be of great assistance in environments with a significant quantity of optical and tape resources.

- ▶ Allowed device resources (**ALWDEVRSC**)
- ▶ Restricted device resources (**RSTDDEVRSC**)

Important: You cannot specify the same resources on the allowed and restricted lists at the same time. If resources are being specifically allowed, the restricted resources must be *NONE. If resources are being restricted, the allowed resources must be *UNRSTD. For more information about this requirement, see the command’s help text.

3.3.6 Defining system resource usage during storage space creation

On systems running IBM i 7.2, a new parameter was added to the Create Network Server Storage Space (**CRTNWSSTG**) and Change Network Server Storage Space (**CHGNWSSTG**) CL commands. The parameter is called Resource Allocation Priority (**RSCALCPTY**), and you can use it to use the process to use a variable amount of system resources during creation of the storage space. See Figure 3-4 on page 206.

In the past, during creation of a storage space, the system attempted to use as much system resources as possible, which might have potentially affected other processes on the system in a negative manner. You can use this new parameter to modify the create priority to reduce the chance of significant delays to other jobs on the system.

This parameter can accept values 1 - 9, with 9 being the maximum and 1 being the minimum. Setting the value to the default of 9 creates the storage space in a manner equal to prior release behaviors. Modifying the value from 9 to any other setting reduces the resources that are used during creation.

Note: Setting a lower priority can reduce server resource utilization, but ultimately causes the creation of the storage space to take a longer amount of time.

For more information about resource allocation priority, see “Resource allocation priority” on page 104.

3.4 Live Partition Mobility

Live Partition Mobility (LPM) is part of the base functions of IBM i 7.2.

With the release of IBM i 7.2 with Technology Refresh 1, a customer can migrate from a POWER7 or POWER7+ system to all POWER8 systems with no downtime by simply performing a move with LPM and accommodating for licensing changes on the new server.

Note: For partitions running IBM i 7.2, Technology Refresh 1 is required for Live Partition Mobility to move to or from POWER8 systems.

LPM is the recommended “no downtime” maintenance strategy for IBM i customers running on POWER8 Enterprise servers. There is no longer any option for CEC Hot Add Repair Maintenance (CHARM) on the POWER8 Enterprise systems. Therefore, certain maintenance items that might have been concurrent in the past now require a central electrical complex outage to perform.

To ensure the most stability when using LPM, it is a good idea to review firmware and OS updates for the central electrical complex, HMC, and IBM i environments. Specific fixes might be released that are necessary to ensure a stable and seamless transition among CECs.

Remember: Live Partition Mobility requires that all resources that are allocated to the mobile partition are virtual through a Virtual I/O Server (VIOS). The partition can own no physical hardware if it is to be mobile.

For more information about LPM with IBM i, see *IBM PowerVM Virtualization Introduction and Configuration*, SG24-7940.

3.5 Licensing and service provider accommodations

Ever since the release of the Power Systems servers, impressive advances have been made in relation to performance and virtualization. At the same time, businesses are constantly striving to streamline operations and use their servers in the most cost-effective manner.

Certain systems are available from IBM that are pre-configured in a manner to better support a cloud infrastructure. For more information about IBM Power Systems solution editions that are optimized for cloud, see the IBM Power Systems Solution Edition for Cloud website:

<http://www.ibm.com/systems/power/hardware/solutioneditions/cloud/>

The IBM i operating system is also positioned strategically for implementation in cloud. Advances in virtualization and tape technologies have made it much easier to migrate environments from an on-premises system to a remote location.

Additionally, IBM has multiple offerings for both customers and managed Service Providers to help defray some costs during a migration to a new operating environment. For more information about these offerings and the benefits that are available to support cloud services on Power Systems, see the IBM Power Systems for Service Providers website:

<https://www.ibm.com/msp/us/en/powersystems>



Security

With the announcement of IBM i 7.2, this release of IBM i provides significant new security enhancements and enhances many other integrated components and licensed programs that are security-related.

This chapter describes the following topics:

- ▶ 4.1, “Single sign-on” on page 210
- ▶ 4.2, “Password rule and user profile enhancements” on page 211
- ▶ 4.3, “Intrusion detection” on page 212
- ▶ 4.4, “Vector Scalar eXtension and cryptographic acceleration” on page 214
- ▶ 4.5, “Cryptographic key management enhancements” on page 215
- ▶ 4.6, “Cryptography enhancements” on page 217
- ▶ 4.7, “DB2 security” on page 223
- ▶ 4.8, “Networking security” on page 223

For more information about IBM i 7.2 security enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

4.1 Single sign-on

In IBM i 7.2, support was added to use a Kerberos ticket for automatic sign-on. Both the File Transfer Protocol (FTP) and Telnet servers are enhanced to support authenticating with Kerberos by using single sign-on (SSO).

There are new functions in the integrated IBM i security that enable SSO between a Kerberos-enabled FTP client and an IBM i FTP server and between a Kerberos-enabled Telnet client and an IBM i Telnet server. These functions open the door for more applications to participate in an SSO environment.

With Kerberos authentication, you can eliminate the exposure of transmitting passwords and data in the clear when using the FTP server with an FTP client that uses Kerberos authentication. The “Kerberized” FTP server, with Enterprise Identity Mapping, can support an SSO environment. For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaiq/rzaiqkerberos.htm?lang=en

Figure 4-1 shows the Start TCP/IP Telnet (**STRTCPTELN**) CL command prompt. Notice the ***KERBEROS** option for the Remote user parameter.

```

Start TCP/IP TELNET (STRTCPTELN)

Type choices, press Enter.

ASCII full screen options . . . *NONE          *NONE, *ALL, *LOCALECHO...
      + for more values
Display character attributes . . *YES          *NO, *YES
ASCII page scroll feature . . . *NO           *NO, *YES
ASCII answerback feature . . . *NONE
ASCII tab stops . . . . . *DFT          0-133, *DFT, *NONE
      + for more values
Coded character set identifier *MULTINAT    1-65533, *MULTINAT...
ASCII operating mode ID . . . *VT220B7     *VT220B7, *VT220B8, *VT100...
Remote virtual display . . . . *DFT          Name, *DFT
Remote user . . . . . *NONE          Name, *NONE, *KERBEROS...
Remote password . . . . . *NONE

Remote password encryption . . . *DES7        *DES7, *SHA1, *NONE
Remote initial program . . . . *RMTUSRPRF   Name, *RMTUSRPRF, *NONE
                                                    More...

F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
  
```

Figure 4-1 Start TCP/IP Telnet (STRTCPTELN) CL command prompt

Figure 4-2 shows the Start TCP/IP File Transfer (FTP) CL command prompt. Notice the *KERBEROS option for the Secure connection parameter.

```

Start TCP/IP File Transfer (FTP)

Type choices, press Enter.

Remote system . . . . .

Internet address . . . . .

Coded character set identifier      *DFT      1-65533, *DFT
Port . . . . .                    *DFT      1-65535, *DFT, *SECURE
Secure connection . . . . .      *DFT      *DFT, *NONE, *SSL...
                                      *IMPLICIT, *KERBEROS
Data protection . . . . .          *DFT      *DFT, *CLEAR, *SAFE, *PRIVATE

Additional Parameters

Outgoing EBCDIC/ASCII table . .    *CCSID    Name, *CCSID, *DFT
Library . . . . .                  Name, *LIBL, *CURLIB

More...
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys

```

Figure 4-2 Start TCP/IP File Transfer (FTP) CL command prompt

For more information about Telnet on IBM i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaiw/rzaiwrzaiwwhatnew.htm?lang=en

For an example of creating an SSO test environment, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzamz/rzamzenablesso.htm?lang=en

4.2 Password rule and user profile enhancements

In IBM i 7.2, the following systems values that are related to password rules were added or changed:

- ▶ New system values:
 - **QPWRULES**: Define new password rules.
 - **QPWDEXPWRN**: Define the password expired warning interval.
 - **QPWDCHGBLK**: Prevent passwords from being changed repeatedly.
- ▶ Changed system values:
 - QLMTDEVSSN**: Limit device sessions. The options are *NONE or 1 - 9 sessions.

The following user profile parameters are updated in IBM i 7.2:

- ▶ **LMTDEVSSN**: Limit device sessions (1 - 9 sessions).
- ▶ **PWDCHGBLK**: Block password changes (1 - 99 hours).

4.3 Intrusion detection

When an intrusion detection system (IDS) is active, it reports the suspected intrusions and extrusions that are defined by the enabled IDS policies. The production and service stacks detect these intrusions and extrusions. When an intrusion or extrusion event occurs that exceeds user-defined or default thresholds, IDS writes an intrusion monitor record to the audit journal, and optionally sends a notification to a message queue and sends an email message.

As shown in Figure 4-3, IDS behavior is defined as policies in a policy file, with audit events logged to the security audit journal. When an intrusion is detected, it is logged in the message queue and an optional email notification can be sent.

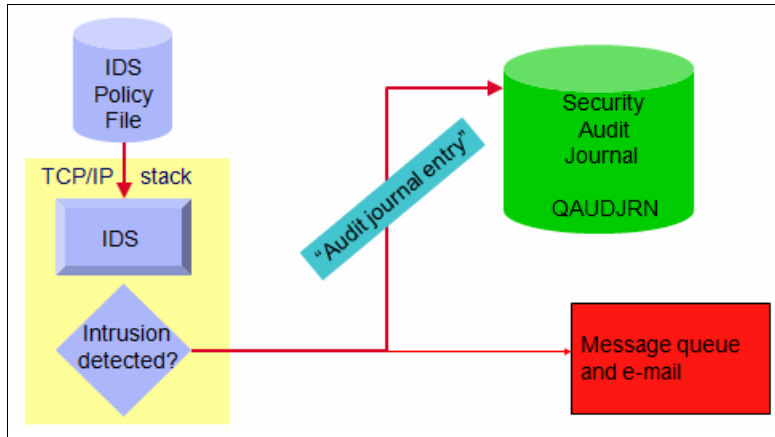


Figure 4-3 Intrusion detection implementation

An intrusion detection policy defines the parameters that the IDS uses to monitor for potential intrusions and extrusions on the system. If a potential intrusion or extrusion is detected, an intrusion event is logged in an intrusion monitor record in the security audit journal and displayed as intrusion events in the IDS GUI. Table 4-1 shows the format of an intrusion monitor journal record.

Table 4-1 Format of an intrusion monitor record in the security audit journal

Journal value	Description
P	Potential intrusion event detected.
2006-01-11-13.19.42.329688	Timestamp (11 Jan 2006, 13:19:42.329688).
1107	Detection point identifier.
02	Local address family.
119	Local port number.
9.5.92.48	Local IP address that is associated with the detected event.
02	Remote address family.

Journal value	Description
3511	Remote port number.
9.5.92.102	Remote IP address that is associated with the detected event.
SCANE	Probe type identifier (SCANE = Scan Event).
0020	Unique identifier for this specific intrusion event. You can use this identifier to correlate this audit record with other intrusion detection information.

For more information about IDS support on IBM i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaub/rzaubidsoperation.htm?lang=en

In IBM i 7.2, the following enhancements are enabled for IDS:

- ▶ Intrusion events that are detected or audited. This includes well-known attacks such as “Smurf”, “Fraggle”, ACK storms, address poisoning (both IPv4 ARP poisoning, and IPv6 neighbor discovery poisoning), and Ping-Of-Death, which can now be detected.
- ▶ Extrusions detected, which includes attacks, scans, and other traffic regulation anomalies initiating from your IBM i server, which can now be detected.
- ▶ IPv4 and IPv6 support.
- ▶ Real-time notification enablement that uses email, messages, and other options (for example, pagers and ISV solutions) can be used in addition to IM records for real-time notification. See Figure 4-4.

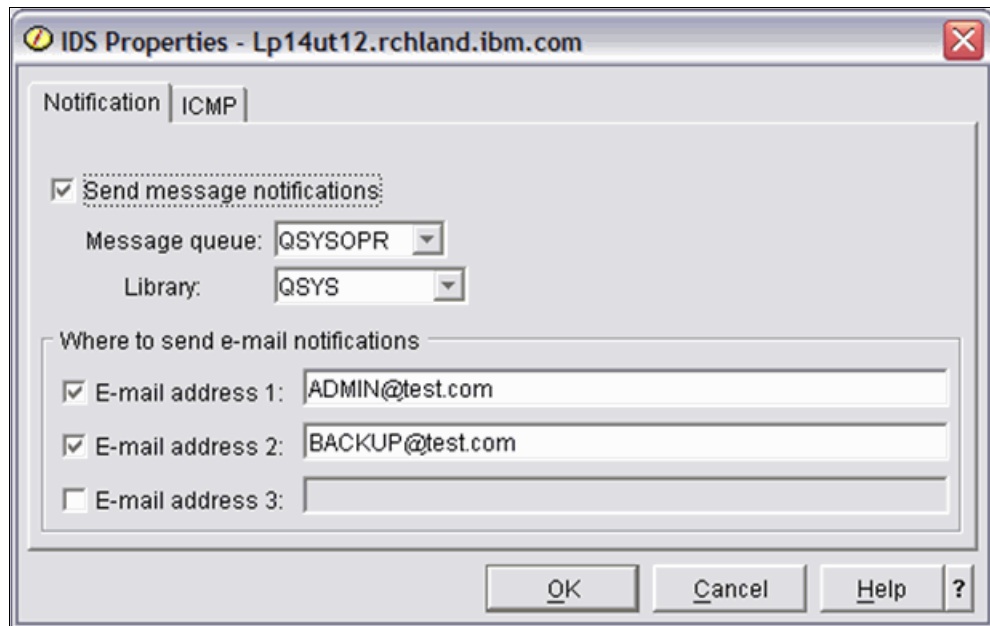


Figure 4-4 IBM Navigator for i GUI interface for the configuration of real-time notification

- ▶ Graphical User Interface (GUI) is available for the management of IDS policies and displaying intrusion events as an alternative to viewing the audit journal. See Figure 4-5.

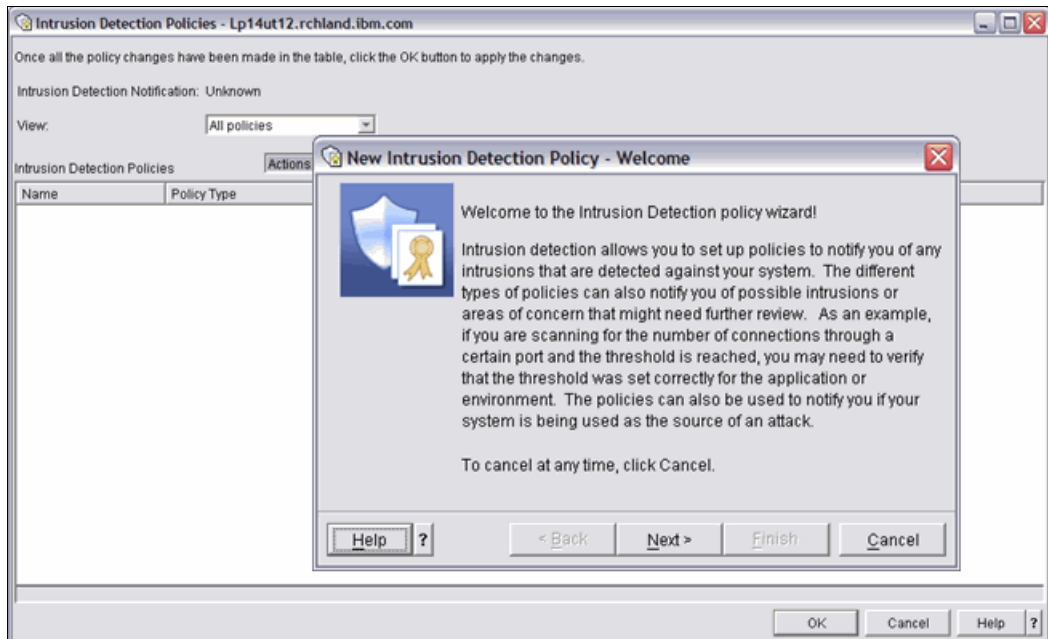


Figure 4-5 IBM Navigator for i GUI interface for the configuration of IDS policies

4.4 Vector Scalar eXtension and cryptographic acceleration

In IBM i 7.2, POWER8 vector instructions can be used to improve the performance of cryptographic operations. In particular, Advanced Encryption Standard (AES) encryption and decryption performance for electronic codebook (ECB) and cipher-block chaining (CBC) modes were improved. These improvements are used by the internal software cryptographic library, and are automatically used for the particular cryptographic algorithms in the cryptographic services APIs and other system-provided encryption functions.

The use of vector instructions is not directly available, such as by using a new hardware provider that uses cryptographic services APIs. However, IBM i Portable Application Solutions Environment (PASE) applications can use Vector Scalar eXtension (VSX) instructions. This function can be unlocked when SLIC PTF MF58198 is applied.

POWER8 in-core cryptographic performance acceleration includes the following functions:

- ▶ Support within the processor itself. No additional products or hardware is required.
- ▶ Automatic performance acceleration for certain cryptographic algorithms (AES and SHA-2 message digest).
- ▶ Does not support cryptographic key storage. In some instances, the Cryptographic Coprocessor card still is required.
- ▶ Performance gains are realized in support of the following items:
 - Customer applications that use the cryptographic services APIs
 - Secure Sockets Layer (SSL)
 - Virtual Private Network (VPN)
 - Software tape encryption

POWER8 has enhanced Vector Scalar eXtension (VSX) capabilities, including new instructions to accelerate some frequently used cryptographic operations. VSX in Power Systems supports vector and scalar binary floating point operations conforming to the Institute of Electrical and Electronics Engineers Standard for Floating Point Arithmetic (IEEE-754).

VSX can be used to increase parallelism by providing single-instruction, multiple-data (SIMD) execution function for floating point double-precision operations, greatly improving the performance of some applications. IBM i PASE applications running on IBM i 7.2 with POWER8 processors can now take advantage of VSX.

IBM i 7.2 uses the enhanced POWER8 vector processing capabilities to accelerate AES cryptographic operations when operating in the POWER8 processor compatibility mode. Cryptographic services APIs, SSL, VPN, Backup Recovery and Media Services (BRMS) tape encryption, and SQL encryption functions automatically use POWER8 enhanced vector processing capabilities to deliver significant increases in performance.

For more information, see the following IBM i 7.2 and IBM POWER8 developerWorks article:

http://www.ibm.com/developerworks/ibmi/library/i-ibmi-7_2-and-ibm-power8/

4.5 Cryptographic key management enhancements

A data encryption key can be used to encrypt important or sensitive data, such as social security numbers or credit card numbers, and should be well-protected, or the data will be at risk for exposure. It is considered a preferred practice to encrypt the data encryption key with a *key encrypting key (KEK)*. A *master key* can then be used to encrypt all KEKs.

In IBM i 7.2, the following cryptographic key management enhancements are included:

- ▶ GUI and CL command interfaces to manage master keys
- ▶ GUI and CL command interfaces to manage keystores and keys:
 - Create keystore files
 - Create encryption keys

Managing master keys by using IBM Navigator for i

To manage master keys in IBM Navigator for i (see Figure 4-6), click **Security** → **Cryptographic Services Key Management** → **Master Keys**.

Note: The SAVRST Master Key is not yet set in the example that is shown in Figure 4-6. However, a default key is in place to provide minimal protection until the key is set. This means that the master keys are not “in the clear” on the SAVSYS tape, but any IBM i system can decrypt them.

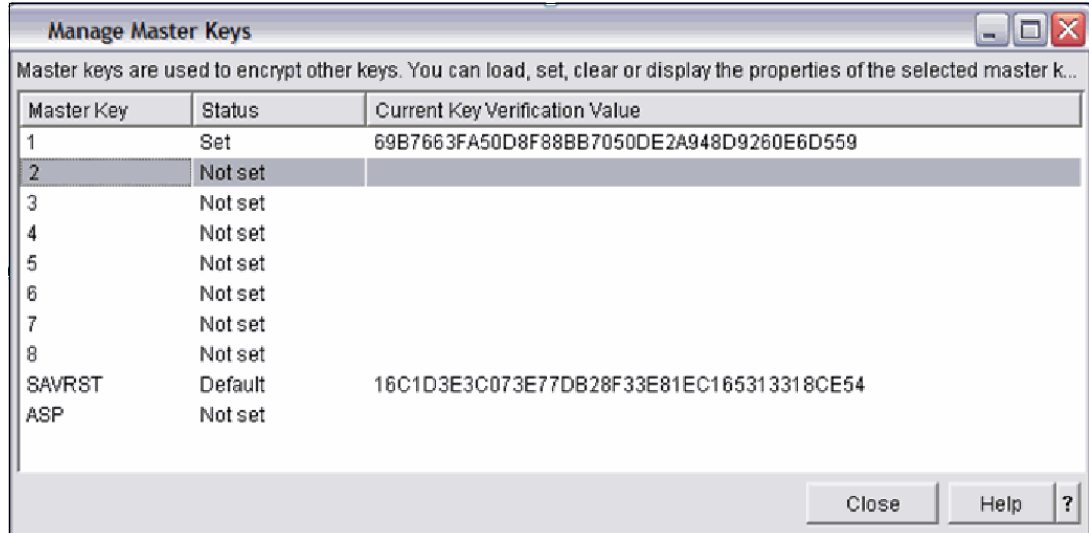


Figure 4-6 Manage master keys in IBM Navigator for i

Creating keystore files by using IBM Navigator for i

Keystores are protected by master keys. A single keystore file can be encrypted only under one master key, but one master key can encrypt multiple keystore files.

KEKs and data keys are stored in the keystore file. A keystore is a database file with the normal file access methods disabled. Figure 4-7 shows an example of a keystore.

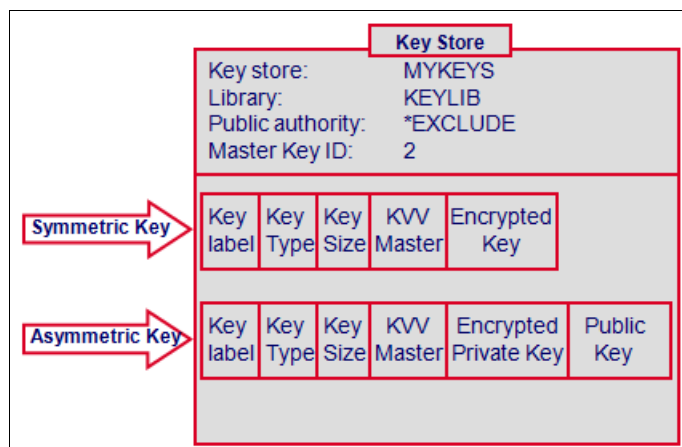


Figure 4-7 Keystore file

To create a keystore by using IBM Navigator for i, click **Security** → **Cryptographic Services** **Key Management** → **Keystores**. In the Manage Keystores window (Figure 4-8), click **Create New Keystore** to create a keystore file and then click **Add Keystore** to add encryption key entries.

In the example that is shown in Figure 4-8, the keystore Q1AKEYFILE in library QUSRBRM is for BRMS tape encryption. Application keystore files can be assigned any file name.

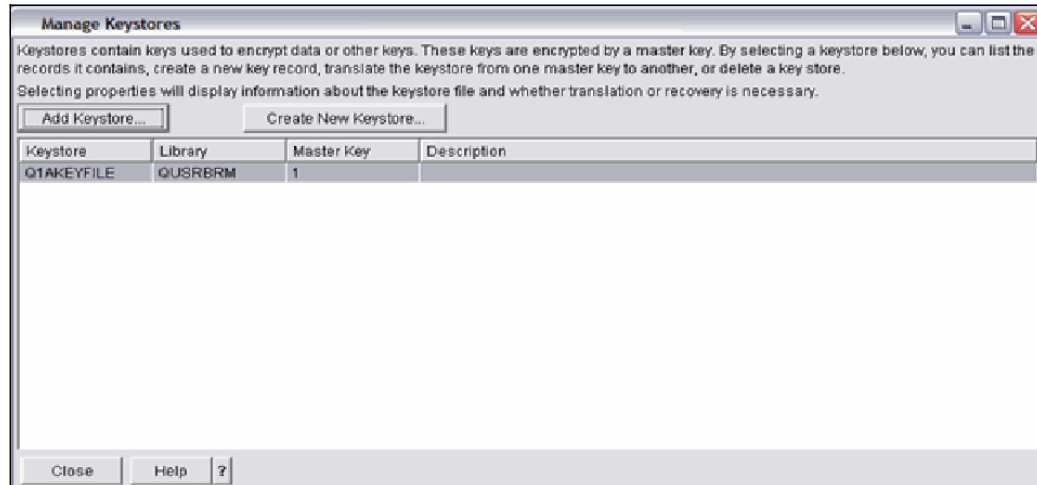


Figure 4-8 Create a keystore in IBM Navigator for i

4.6 Cryptography enhancements

This section describes the enhancements for cryptography, system values that are related to cryptography, and Digital Certificate Manager.

The following topics are covered in this section:

- ▶ 4.6.1, “Default value for the QSSLPCL system value” on page 217
- ▶ 4.6.2, “Cipher specification list changes” on page 218
- ▶ 4.6.3, “Elliptic Curve Cryptography” on page 218
- ▶ 4.6.4, “Multiple server certificates” on page 219
- ▶ 4.6.5, “Digital Certification Manager local certificate authority” on page 220
- ▶ 4.6.6, “Default cipher specification list” on page 220
- ▶ 4.6.7, “Signature and hash algorithms” on page 222

4.6.1 Default value for the QSSLPCL system value

The Secure Sockets Layer protocol system value, **QSSLPCL**, controls the TLS versions that are supported by system SSL, with the special value ***OPSYS** indicating the default behavior. In IBM i 7.2, the TLSv1.2 and TLSv1.1 protocols are on and SSLv3 is off by default. Changing the setting for **QSSLPCL** or the value of ***OPSYS** influences every system SSL-consuming application on the system.

When migrating from an earlier release, a user-defined **QSSLPCL** value is retained, preventing the new default behavior for this release from being in effect. In this case, after the migration, the system administrator can set the **QSSLPCL** system value to ***OPSYS** if its definition for the release meets their security policy requirements.

For information about how to determine the SSL protocol and cipher suite that are used for each system SSL connection to the IBM i, see the following website:

<http://www.ibm.com/support/docview.wss?uid=nas8N1020594&context=SGYQGH>

Here are the **QSSLPCL *OPSYS** definitions by release:

- ▶ IBM i 7.2: ***TLSV1.2**, ***TLSV1.1**, and ***TLSV1**
- ▶ IBM i 7.1: ***TLSV1** and ***SSLV3**

If an application must continue to use SSLv3 with an IBM i 7.2 system, the administrator is forced to update the QSSLPCL system value to include ***SSLV3**. The application with a dependency on ***SSLV3** can now be configured to allow ***SSLV3**. For the core IBM i networking applications, this task can be controlled by using the Digital Certificate Manager (DCM) Application Definition. If SSLv3 has been enabled, create an action plan to eliminate the external dependency on SSLv3 so it can be turned off again.

IBM i 7.2 enables TLSv1.2 and TLSv1.1 for applications that are coded to use TLSv1.0 because of the focus on improving the default security position without requiring client intervention.

Note: The possibility exists that an application's internal code will not tolerate negotiation of a new protocol it does not know. In this situation, the mitigation is to turn off the new protocols at the application layer if possible. This task is accomplished through changing the application definition in DCM or by changing the application code to turn off explicitly TLSv1.2. The last option is to disable TLSv1.2 with **QSSLPCL** for the entire system until the application can be updated to tolerate TLSv1.2.

4.6.2 Cipher specification list changes

The Secure Sockets Layer cipher specification list system value, **QSSLCSLCTL**, determines who controls the values in system value **QSSLCSL**. The ***OPSYS** value indicates that the operating system determines the list and the ***USRDFN** value indicates that the system administrator controls the **QSSLCSL** values.

The new definition of the cipher suite list in **QSSLCSL**, when **QSSLCSLCTL** is set to ***OPSYS**, also has an impact on clients. **QSSLCSL** governs both the supported and default cipher suites. In IBM i 7.2, ***OPSYS** introduces over a dozen new cipher suites for the first time. The default cipher suites are a release-restricted subset of the supported cipher suites. Some cipher suites previously in the restricted default subset were removed from the subset. The order of some suites in the default subset also changed, which can impact which cipher suite is negotiated.

For more information, see 4.6.6, "Default cipher specification list" on page 220.

4.6.3 Elliptic Curve Cryptography

Elliptic Curve Cryptography (ECC) is a new function that is available for the first time with IBM i 7.2. ECC is an asymmetric encryption algorithm, and in simplistic terms, it is similar to RSA. One of the attributes of ECC is that it has smaller key sizes than RSA to obtain the same strength. ECC encompasses many different elliptic curve types, families, and strengths.

System SSL and DCM support five named elliptic curves:

- ▶ Secp521r1
- ▶ Secp384r1
- ▶ Secp256r1
- ▶ Secp224r1
- ▶ Secp192r1

All five of the named curves are enabled by default. System SSL support for one or more of the named curves can be disabled at the system level by using the System Service Tools advanced analysis **SSLCONFIG** command.

As it relates to TLS, there are two components to ECC:

- ▶ The first part of ECC is Elliptic Curve Digital Signature Algorithm (ECDSA) certificates. These certificates use ECDSA for the key type rather than RSA.
- ▶ The second part is the Elliptic Curve Diffie-Hellman Ephemeral (ECDHE) key exchange. The ephemeral part means that a key that is associated with a certificate is not used, but rather new anonymous key pairs are used for each handshake.

ECDHE does not use the key in the certificate, so it works with both RSA and ECDSA certificates. The keyword ECDHE in a cipher suite name indicates that ECDHE is used for the key exchange. The keywords RSA or ECDSA in the cipher suite indicate which certificate type to use. If ECDHE is not in the cipher suite name, this means that there is an unwritten RSA keyword to indicate RSA key exchange. RSA key exchange uses the key from the RSA certificate and does not work with ECDSA certificates. ECDSA certificates can be used only with the ECDHE key exchange.

The transition to ECDHE for the key exchange in TLS connections is painless. It requires that each side supports the same ECDHE cipher suite and has one supported named curve in common. The server's ordered cipher suite list also must prefer the ECDHE cipher suite over any RSA key exchange cipher suites for it to be selected.

The transition to ECDSA is more complicated because in addition to the ECDHE requirements, ECDSA requires a new certificate be generated and assigned to the application. A server application cannot migrate from RSA certificates to ECDSA certificates until all of its potential clients can negotiate ECDSA and ECDHE cipher suites. This is a long-term consideration when negotiating with previous IBM i releases that do not support ECC.

4.6.4 Multiple server certificates

To assist with the interoperability issues of migrating to ECDSA certificates, IBM i 7.2 server applications can now have multiple server certificates that are assigned at one time. The new multiple certificates infrastructure supports up to four concurrent certificates, although two certificates are typical. An administrator rolling out the use of ECDSA assigns both an RSA certificate and an ECDSA certificate to the server configuration.

Servers with a DCM application definition use the DCM Update Certificate Assignment window to assign multiple certificate labels. GSKit based servers can configure multiple certificate labels to be used by setting the **GSK_KEYRING_LABEL_EX** attribute.

The Telnet server DCM Update Certificate Assignment window is shown in Figure 4-9. In this example, Telnet has one certificate that is assigned, although the four certificates with the check mark next to the label names are about to be assigned instead.

Note: Assigning two or more certificates that have the exact same cryptographic properties adds unnecessary processing because only the first one (as determined internally) is selected.

The certificate that is selected for a secure connection is determined by the server configuration that is paired with each client’s advertised capabilities. The certificate selection logic is deterministic and is described in detail in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzain/rzainmultcert.htm?cp=ssw_ibm_i_72

Digital Certificate Manager

Update Certificate Assignment

Application type: Server
 Application ID: QIBM_QTV_TELNET_SERVER
 Application description: IBM i TCP/IP Telnet Server

Certificate currently assigned: RSA-4096 SHA1 with RSA

Select up to four certificates that you want to assign to the application.

	Certificate	Common name		
<input type="checkbox"/>	RSA-768 SHA512 with RSA Expired	RSA-768 SHA512 with RSA Expired	View	Validate
<input checked="" type="checkbox"/>	RSA-4096 SHA512 with RSA	RSA-4096 SHA512 with RSA	View	Validate
<input checked="" type="checkbox"/>	ECDSA-384 SHA1 with ECDSA	ECDSA-384 SHA1 with ECDSA	View	Validate
<input checked="" type="checkbox"/>	RSA-4096 SHA256 with ECDSA	RSA-4096 SHA256 with ECDSA	View	Validate
<input type="checkbox"/>	ECDSA-224 SHA256 with ECDSA	ECDSA-224 SHA256 with ECDSA	View	Validate
<input checked="" type="checkbox"/>	RSA-1024 SHA512 with ECDSA	RSA-1024 SHA512 with ECDSA	View	Validate
<input type="checkbox"/>	ECDSA-521 SHA512 with ECDSA	ECDSA-521 SHA512 with ECDSA	View	Validate

Figure 4-9 Digital Certificate Manager: update certificate assignments

4.6.5 Digital Certification Manager local certificate authority

IBM i 7.2 DCM supports creating ECDSA local certificate authorities (CAs) and ECDSA certificates. Multiple local CAs can exist on the same partition, and which one signs a new certificate is selected when the certificate is created.

An RSA server certificate can be signed by an ECDSA CA and vice versa. An early phase of the rollout of ECDSA can include signing an ECDSA server certificate with an existing RSA local CA. The peer clients (user PCs) trust the new certificate chain because they already trust the root RSA local CA. Otherwise, the new ECDSA local CA must be distributed to all the peers so they can trust a pure ECDSA certificate chain.

4.6.6 Default cipher specification list

As mentioned in 4.6.3, “Elliptic Curve Cryptography” on page 218, the list of values for the QSSLCSL system value when QSSLCSLCTL is *OPSYS changed in IBM i 7.2.

The default cipher suites for each release are shown in Figure 4-10 as the shaded values. A system administrator can alter the default list for the system in three ways:

- ▶ If a default cipher suite is removed from the QSSLCSL list, it is no longer supported, which removes it from the default list at the same time.
- ▶ For the default cipher suites, the order they appear in the list is the order they are preferred by server applications. By rearranging the order in **QSSLCSL**, the order is changed for all applications that use the default list.
- ▶ If a default suite is added or removed from the eligible default cipher suite list by using the System Service Tools (SST) Advanced Analysis Command (**SSLCONFIG**), the **SSLCONFIG** option **-eligibleDefaultProtocols** changes which cipher suites are shaded in Figure 4-10.

The **SSLCONFIG** command is described in more detail in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzain/rzainsslconfigmacro.htm

IBM i 7.2 QSSLCSL *OPSYS	IBM i 7.1 QSSLCSL *OPSYS
*ECDHE_ECDSA_AES_128_CBC_SHA256	*RSA_AES_128_CBC_SHA256
*ECDHE_ECDSA_AES_256_CBC_SHA384	*RSA_AES_128_CBC_SHA
*ECDHE_ECDSA_AES_128_GCM_SHA256	*RSA_AES_256_CBC_SHA256
*ECDHE_ECDSA_AES_256_GCM_SHA384	*RSA_AES_256_CBC_SHA
*RSA_AES_128_CBC_SHA256	*RSA_3DES_EDE_CBC_SHA
*RSA_AES_128_CBC_SHA	*RSA_RC4_128_SHA
*RSA_AES_256_CBC_SHA256	*RSA_RC4_128_MD5
*RSA_AES_256_CBC_SHA	*RSA_DES_CBC_SHA
*RSA_AES_128_GCM_SHA256	*RSA_EXPORT_RC4_40_MD5
*RSA_AES_256_GCM_SHA384	*RSA_EXPORT_RC2_CBC_40_MD5
*ECDHE_RSA_AES_128_CBC_SHA256	*RSA_NULL_SHA
*ECDHE_RSA_AES_256_CBC_SHA384	*RSA_NULL_MD5
*ECDHE_RSA_AES_128_GCM_SHA256	
*ECDHE_RSA_AES_256_GCM_SHA384	
*ECDHE_ECDSA_3DES_EDE_CBC_SHA	
*ECDHE_RSA_3DES_EDE_CBC_SHA	
*RSA_3DES_EDE_CBC_SHA	
*ECDHE_ECDSA_RC4_128_SHA	
*ECDHE_RSA_RC4_128_SHA	
*RSA_RC4_128_SHA	
*RSA_RC4_128_MD5	
*RSA_DES_CBC_SHA	
*RSA_EXPORT_RC4_40_MD5	
*RSA_EXPORT_RC2_CBC_40_MD5	
*ECDHE_ECDSA_NULL_SHA	
*ECDHE_RSA_NULL_SHA	
*RSA_NULL_SHA256	
*RSA_NULL_SHA	
*RSA_NULL_MD5	

Eligible default cipher suites with latest security PTFs applied are shaded

Figure 4-10 Default IBM i 7.2 ciphers

As shown in Figure 4-10 on page 221, four new ECDHE_ECDSA_AES-based cipher suites are positioned first. This is the first time a new cipher suite is added to the top position in the list. This positioning is due to this set of cipher suites remaining dormant for a server until the administrator assigns an ECDSA certificate. If an administrator goes to the effort to configure ECDSA, it is assumed they want it to be used whenever possible.

Because ECDHE requires no explicit configuration, the ECDHE_RSA_AES based cipher suites are positioned after the RSA_AES set to prevent a new (to System SSL) cipher suite from being the primary cipher suite that is used by most of the server applications without administrator action.

When migrating from an earlier release, a user-defined **QSSLCSL** value is retained to prevent the new cipher suites from being supported. In that case, after the migration, the system administrator can set **QSSLCSLCTL** to *OPSYS to have **QSSLCSL** primed with the new list. Working with the full list, the administrator can then modify the list as needed to meet their security requirements.

4.6.7 Signature and hash algorithms

The TLSv1.2 protocol made the signature algorithm and the hash algorithm that are used for digital signatures independent attributes. In previous protocol versions, the negotiated cipher suite and certificate determined these algorithms.

System SSL has a default ordered list of allowed signature/hash algorithm pairs. The list serves two purposes for TLSv1.2 and has no meaning for prior protocols:

- ▶ The first use is that the ordered signature algorithm list is sent to the peer when the System SSL requests a certificate during the handshake. The peer uses the received list to guide its certificate selection process when it has more than one certificate from which to pick.
- ▶ The second use is that the list of algorithm pairs restricts which signature and hash algorithms can be used for handshake message signatures. A TLSv1.2 handshake message signature algorithm can be different from the signature algorithm of the certificate that is used for the session. For example, the handshake message can be protected by SHA512 even though an MD5 certificate is selected for the session. This increases the security attributes of the handshake without requiring a new certificate.

There are two methods of setting this list for an application:

- ▶ Applications with a DCM application definition can use the DCM Update Application Definition window to configure the list.
- ▶ GSKit based applications can configure the list by setting the **GSK_SSL_EXTN_SIGALG** attribute.

There is no system value for this property, but the entries in the system list can be removed or reordered by using **SSLCONFIG**. Anytime a value is removed from a supported list, the potential exists to introduce interoperability issues. The typical user does not care about this list, but it might be important for the most restrictive security policies.

Here is the IBM i 7.2 default System SSL signature algorithm list:

- ▶ ECDSA_SHA512
- ▶ ECDSA_SHA384
- ▶ ECDSA_SHA256
- ▶ ECDSA_SHA224
- ▶ ECDSA_SHA1

- ▶ RSA_SHA512
- ▶ RSA_SHA384
- ▶ RSA_SHA256
- ▶ RSA_SHA224
- ▶ RSA_SHA1
- ▶ RSA_MD5

4.7 DB2 security

DB2 security enhancements are described in Chapter 8, “IBM DB2 for i” on page 321, which includes the following topics:

- ▶ 8.2, “Separation of duties concept” on page 323
- ▶ 8.2.2, “Row and Column Access Control support” on page 325
- ▶ 8.3, “DB2 security enhancements” on page 332

4.8 Networking security

Security improvements in networking are described in Chapter 5, “Networking” on page 225, which includes the following topics:

- ▶ 5.1.1, “Domain Name System Security Extensions” on page 226
- ▶ 5.2, “Simple Network Management Protocol” on page 227
- ▶ 5.4, “System SSL enhancements” on page 229
- ▶ 5.5, “Virtual private networks” on page 230
- ▶ 5.5.2, “Internet Key Exchange version 2 protocol” on page 231
- ▶ “IKEv2 troubleshooting” on page 234



Networking

This chapter describes the following networking enhancements that are enabled in IBM i 7.2:

- ▶ 5.1, “Domain Name System” on page 226
- ▶ 5.2, “Simple Network Management Protocol” on page 227
- ▶ 5.3, “SR-IOV” on page 229
- ▶ 5.4, “System SSL enhancements” on page 229
- ▶ 5.5, “Virtual private networks” on page 230
- ▶ 5.6, “Virtual local area network” on page 241
- ▶ 5.7, “Retrieving and updating TCP/IP information” on page 244
- ▶ 5.8, “IPv6 proxy neighbor discovery for virtual Ethernet and PPP” on page 245
- ▶ 5.9, “Single sign-on for FTP and TELNET” on page 245
- ▶ 5.10, “Virtual Network Interface Controller” on page 245
- ▶ 5.11, “Ethernet device server support (WAN over LAN)” on page 248

For more information about the IBM i 7.2 networking enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

5.1 Domain Name System

For IBM i 7.2, the Domain Name System (DNS) services are based on the industry-standard DNS implementation that is known as Berkeley Internet Name Domain (BIND) Version 9. For previous IBM i releases, DNS services were based on an older BIND Version 9 or BIND Version 8.

To use the new BIND Version 9 DNS server in IBM i 7.2, you must have the following options installed on your system:

- ▶ IBM i option 31 (DNS)
- ▶ IBM i option 33 (Portable Application Solutions Environment (PASE))
- ▶ IBM i 5733-SC1 option 1 (OpenSSH, OpenSSL, zlib)

Note: Starting with IBM i V6R1, for security reasons, BIND Version 4 and Version 8 are replaced with BIND Version 9. Therefore, the migration to BIND Version 9 is required for your DNS server.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzakk/rzakkkickoff.htm

5.1.1 Domain Name System Security Extensions

Domain Name System Security Extensions (DNSSEC) provides a means to secure DNS data by using digital signatures and public key cryptography. The DNSSEC Server available on IBM i now has DNSSEC capabilities. DNSSEC is a suite of IETF RFC specifications that adds security extensions to the DNS.

DNSSEC allows a resolver or name server to verify the authenticity and integrity of DNS response data by establishing a “chain of trust” to the source of the DNS data and validating the digital signatures.

The main function of DNSSEC is to protect the user from forged data in the following ways:

- ▶ Validate the origin of a DNS response and trust that the data came from the expected source.
- ▶ Validate the integrity of a DNS response and trust that the data itself is correct.
- ▶ Validate a denial of existence and trust a “no records to return” response.

DNSSEC does not provide any of the following functions:

- ▶ Encryption of data (for example, SSL)
- ▶ Protection from denial of service attacks
- ▶ Protection from going to phishing sites

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzakk/rzakkconceptdnssec.htm

5.1.2 IBM i resolver

DNSSEC support in the IBM i resolver can be enabled by using the following Change TCP/IP Domain (**CHGTCPDMN**) CL command:

```
CHGTCPDMN DNSSEC(*YES)
```

In DNSSEC terms, the IBM i resolver is a non-validating security-aware stub resolver, which means that when DNSSEC is enabled, the IBM i resolver sets the DNSSEC OK bit in its query messages to indicate that it can handle DNSSEC fields in responses. However, it relies on the name server to do the actual authentication and validation of the DNS response data. This dependency implies that to have a secure DNS solution, IBM i must trust the name server and also have a secure communication channel to the name server.

One option to secure the communication channel is to configure the DNS server on the same partition as the resolver and have them communicate by using the loopback address (127.0.0.1 for IPv4 or ::1 for IPv6). Another option is to use IP Security (IPSec) to secure the communication channel between IBM i and the name server.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzab6/dnssec.htm

5.2 Simple Network Management Protocol

Simple Network Management Protocol (SNMP) provides a system or network management application with the ability to gather information about network devices and to monitor them. To accomplish this task, SNMP defines a set of operations for retrieving and setting data and monitoring for conditions being reported by the managed devices.

The following SNMP topics are covered in this section:

- ▶ 5.2.1, “Configuring storage pools and disk block sizes” on page 227
- ▶ 5.2.2, “SNMP enhancements” on page 228
- ▶ 5.2.3, “GetBulk operation support” on page 228
- ▶ 5.2.4, “SNMP manager APIs” on page 228

5.2.1 Configuring storage pools and disk block sizes

As the storage sizes for both storage pools and individual disk units have increased, the limits of the original SNMP design have been reached or in some cases exceeded. For example, the size that SNMP returns for an 8 TB disk unit on an IBM i system might show up as a negative number in some systems management applications, or it might be flagged as invalid.

Enhancements to SNMP allow the configuration of block sizes to be used for returning storage size information for both storage pools and disk units.

Note: Using this support for disk units can cause IBM i to be non-compliant with RFC 1514, which defines a disk unit block size as 1024 bytes.

A larger block size can be configured by using the new block size (**BLKSIZE**) parameter with the Change SNMP Attributes (**CHGSNMPA**) CL command.

By using an appropriate block size, you can avoid the confusion that is related to the incorrect storage size value or a disk unit being flagged as invalid by a systems management application.

5.2.2 SNMP enhancements

In the past, IBM i received SNMP requests through UDP port 161 and then sent a response by using a random ephemeral port. An ephemeral port is a short-lived transport protocol port for internet protocol (IP) communications that is allocated automatically from a predefined range by the IP software. This made it difficult to configure firewalls and still allow SNMP traffic to flow between an IBM i SNMP agent and an SNMP-based system or network management application running remotely. The SNMP agent was changed so that responses to SNMP requests are now sent through UDP port 161. Traps that originate on an IBM i partition are now also sent through port 161.

5.2.3 GetBulk operation support

The SNMP GetBulk operation was introduced in SNMP version 2 (SNMPv2) and provides a method to get a relatively large amount of data with a single SNMP request. Although IBM i does not support SNMPv2, it does support SNMPv3, which provides improved security and privacy for SNMP messages. The IBM i agents now fully support the GetBulk requests for SNMPv3. You can use the SNMP manager API `snmpGetbulk_v3` to send a GetBulk request to an SNMPv3 agent.

The following PTFs are required for setting up SNMPv3 on an IBM i system:

- ▶ SI55537 or supersedent
- ▶ SI55539 or supersedent
- ▶ SI55766 or supersedent
- ▶ SI55787 or supersedent
- ▶ SI55966 or supersedent

For more information about GetBulk, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/ibmi/library/i-snmv-getbulk-data-retrieval/#google>

5.2.4 SNMP manager APIs

A new set of Simple Network Management Protocol (SNMP) manager APIs are now available in IBM i 7.2. An IBM i SNMP manager application can use this new set of APIs to take advantage of the security features for authentication and data privacy that are associated with SNMP version 3 (SNMPv3). The APIs support SNMPv3 agent discovery and the **GET**, **GETNEXT**, and **SET** operations by using the SNMPv3 protocol.

Here are the SNMPv3 APIs:

- ▶ These APIs perform SNMPv3 agent discovery and manage authentication:
 - `snmpDiscovery_v3()`
 - `snmpFreeAuthCB_v3()`
- ▶ These APIs perform the SNMP operations of **GET**, **GETNEXT**, and **SET**:
 - `snmpGet_v3()`
 - `snmpGetnext_v3()`
 - `snmpSet_v3()`

For more information about the SNMPv3 APIs, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apis/unix6b.htm?lang=en

For an example of using the SNMPv3 APIs, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apis/snmpexmp.htm

5.3 SR-IOV

SR-IOV is PCI standard architecture that enables PCIe adapters to become self-virtualizing. It enables adapter consolidation, through sharing, much like logical partitioning enables server consolidation. With an adapter capable of SR-IOV, you can assign virtual slices of a single physical adapter to multiple partitions through logical ports without the need for a Virtual I/O Server (VIOS).

The following adapters are supported:

- ▶ FC EN0H; CCIN 2B93
- ▶ FC EN0L; CCIN 2CC1
- ▶ FC EN10; CCIN 2C4C
- ▶ FC EN11; CCIN 2C4D
- ▶ FC EN0M, CCIN 2CC0
- ▶ FC EN15, CCIN 2CE3
- ▶ FC EN16, CCIN 2CE3
- ▶ FC EN17, CCIN 2CE4
- ▶ FC EN18, CCIN 2CE4

For more information about SR-IOV, see the following references:

- ▶ *IBM Power Systems SR-IOV: Technical Overview and Introduction*, REDP-5065
- ▶ The *IBM i IO Support Details* topic in the IBM i Technology Updates developerWorks wiki:
<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20IO%20Support%20Details>

5.4 System SSL enhancements

System SSL is a set of services that is provided in the IBM i Licensed Internal Code to protect TCP/IP communications by using the SSL/TLS protocol. System SSL is accessible to application developers from the following programming interfaces and Java Secure Socket Extension (JSSE) implementation:

- ▶ Global Security Kit (GSKit) APIs
- ▶ Integrated IBM i SSL_ APIs (*not* recommended; use GSKit APIs instead.)
- ▶ Integrated IBM i JSSE implementation

SSL applications that are created by clients or by IBM that use an interface that is listed above use System SSL. FTP and Telnet are examples of IBM applications that use System SSL. Not all SSL enabled applications running on IBM i use System SSL.

In IBM i 7.2, System SSL underwent the most significant updates since Transport Layer Security (TLS) Version 1.0 was originally introduced in V4R5 over a decade ago. System SSL added support for the Transport Layer Security Version 1.2 (TLSv1.2) protocol and the TLSv1.1 protocol.

The new TLSv1.2 support includes Elliptic Curve Diffie-Hellman (ECDHE) key exchange cipher suites. With the Digital Certificate Manager (DCM), support was added for Elliptic Curve Digital Signature Algorithm (ECDSA) certificates.

Online Certificate Status Protocol (OCSP) support was also added to System SSL. OCSP is a method to determine the revocation status for a digital certificate.

For more information about these new cryptographic features, see 4.6, “Cryptography enhancements” on page 217.

5.5 Virtual private networks

Virtual private networks (VPNs) on IBM i are used to extend securely private intranets over public networks. The VPN enhancements in IBM i 7.2 give clients new security options and management and configuration flexibility and includes the following new functions:

- ▶ 5.5.1, “New commands for VPN management and configuration” on page 230
- ▶ 5.5.2, “Internet Key Exchange version 2 protocol” on page 231
- ▶ 5.5.3, “New cryptographic algorithms” on page 240

VPN is configurable by using IBM Navigator for i.

5.5.1 New commands for VPN management and configuration

Four new commands are provided in IBM i 7.2 to assist clients with VPN configuration and management actions that were previously only possible through IBM Navigator for i:

- ▶ Load/Unload IP Filter (**LODIPFTR**) CL command

The **LODIPFTR** CL command is used to load and unload the Internet Protocol (IP) filter rules. The VPN rules that are included in the load or unload are the rules that are in the following directory and are generated by IBM Navigator for i:

```
/QIBM/UserData/OS400/TCPIP/OPNAVRULES/VPNPOLICYFILTERS.I3P
```

Example 5-1 shows an example of using the **LODIPFTR** CL command load filter rules on all interfaces, including VPN rules.

Example 5-1 Load filter rules on all interfaces, including VPN rules

```
LODIPFTR OPTION(*LOAD) LIND(*ALL)
          STMF('/QIBM/UserData/OS400/TCPIP/PacketRules/test.i3p')
          INCVPN(*YES)
```

- ▶ Copy VPN Configuration File (**CPYVPNCFGF**) CL command

The **CPYVPNCFGF** CL command provides the following new functions to import, export, or validate all VPN configurations on a system:

- When used to import, all of the VPN connections on the system, except the IBM Universal Connection Wizard (UCW) connections QVPN01IBM1 and QVPN01IBM2, are deleted and replaced with the imported configuration. The command cannot be used to import or export individual connections. Importing the VPN configuration file with **CPYVPNCFGF** does not import the filter rules. The filter rules must be re-created to be used with the imported connections.

- Exported VPN configuration information is stored in an XML file in the same schema that is used by AIX, which creates instant cross-platform compatibility with AIX for VPN configurations. AIX provides an XML schema mapping tool that can convert the AIX XML schema to the Linux XML schema, providing the capability for cross-platform compatibility with Linux.
- Another consideration for using **CPYVPNCFGF** is that you can create VPN configurations on one system, then use **CPYVPNCFGF** to export the configuration to be distributed to other systems. The XML VPN configuration file can be modified as necessary for different systems and locations without requiring IBM Navigator for i to re-create the configuration for each system.
- **CPYVPNCFGF** is a simple method that you can use to help debug VPN configuration issues. The **OPTION(*VALIDATE)** parameter verifies whether the VPN configuration in the stream file is correct. The exported configuration file can be used to confirm each VPN connection’s configuration without using IBM Navigator for i.

Example 5-2 shows an example of exporting a VPN configuration to a stream file.

Example 5-2 Export a VPN configuration to a stream file

```
CPYVPNCFGF OPTION(*EXPORT) STMF('/mydir/vpncfg')
```

- ▶ Retrieve TCP/IP Information (**RTVTCPIINF**) and Update TCP/IP Information (**UPDTCPIINF**) CL commands

The **RTVTCPIINF** and **UPDTCPIINF** CL commands can be used in IBM i 7.2 to save and restore the TCP/IP configuration of a system, which includes the VPN configuration files. In the background, **RTVTCPIINF** uses **CPYVPNCFGF** to retrieve the VPN configuration information.

For more information, see 5.7, “Retrieving and updating TCP/IP information” on page 244. Also, see the “New IBM i 7.2 and 7.1 VPN Enhancements” post in the IBM Systems Magazine i Can, Technical Tips for i blog:

<http://www.ibmssystemsmag.com/ibmi/administrator/networks/i71-i72-vpn-enhancements/>

- ▶ Start VPN Connection (**STRVPCNN**) and End VPN Connection (**ENDVPCNN**) CL commands

The **STRVPCNN** and **ENDVPCNN** CL commands start and end VPN connections (see Example 5-3).

Example 5-3 Start and end a VPN connection

```
STRVPCNN CNN(conn1)
ENDVPCNN CNN(conn1)
```

5.5.2 Internet Key Exchange version 2 protocol

The Internet Key Exchange (IKE) version 2 (IKEv2) protocol is an enhancement to the Internet Key Exchange protocol and is supported starting in IBM i 7.1. IKEv2 enhances the function of performing dynamic key exchange and partner authentication for VPN. IKEv2 simplifies the message flow for key exchange negotiations and introduces measures to fix ambiguities and vulnerabilities that are inherent in IKE version 1 (IKEv1). IKEv2 is the basis for future enhancements to the key exchange protocol for VPN. Despite the differences, IKEv1 and IKEv2 both negotiate a security association (SA) to protect data between two endpoints.

IKEv2 configuration

IKEv2 has a minimal impact on IBM Navigator for i and current VPN configuration objects. IBM i 7.1 or 7.2 is required to use an IKEv2 connection.

To enable IKEv2, complete the following steps:

1. From IBM Navigator for i, change the Internet Key Exchange version by clicking **Network** → **All Tasks** → **IP Policies** → **Virtual Private Networking** → **Secure Connections** → **Connections**, as shown in Figure 5-1. Then, on the Connections window that is shown in the right pane, right-click **All Connections** and select **Open**.

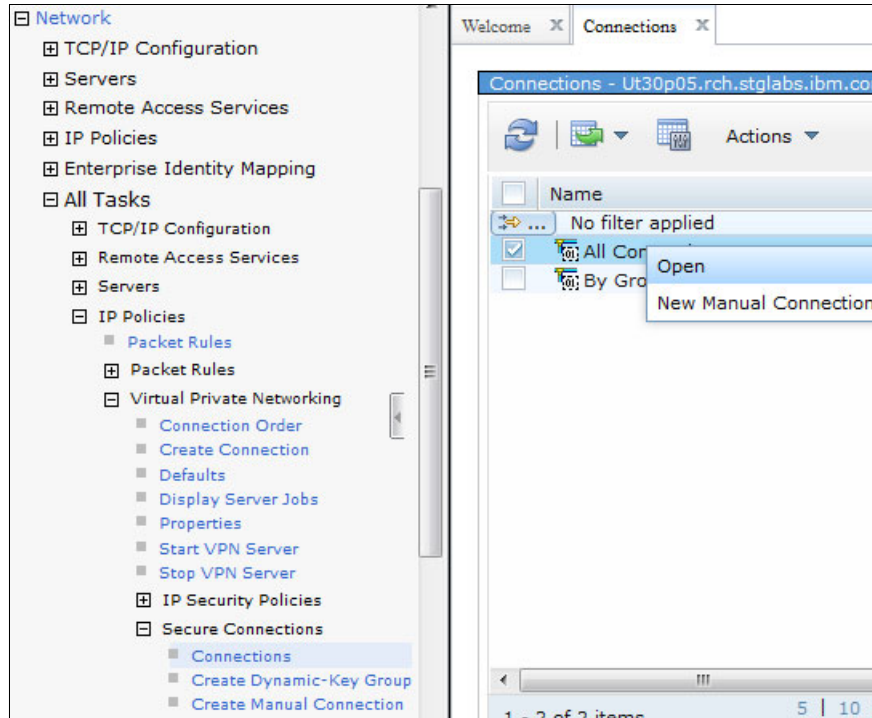


Figure 5-1 Change the Internet Key Exchange version

2. Click the **All Connections** tab, right-click the existing **VPN connection**, and select **Properties**, as shown in Figure 5-2.

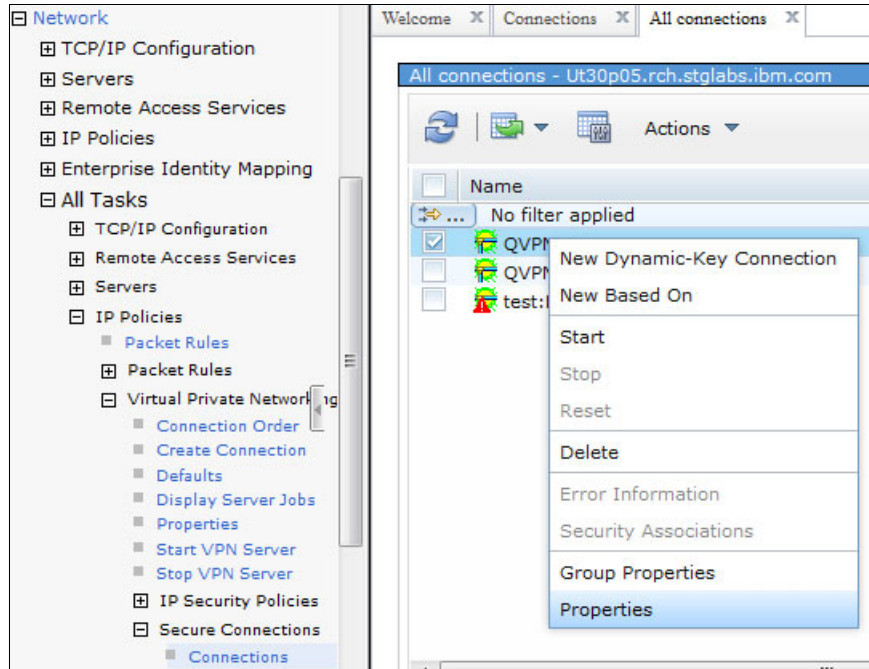


Figure 5-2 Select the VPN properties

3. From the Properties window, click the **General** tab to display or change the **Internet Key Exchange version**, as shown in Figure 5-3.

Note: Key exchange and data policies can be used for either IKEv1 or IKEv2. If the key exchange policy is used with IKEv2, the settings for main mode and aggressive mode are ignored because they are valid only for IKEv1 negotiations.

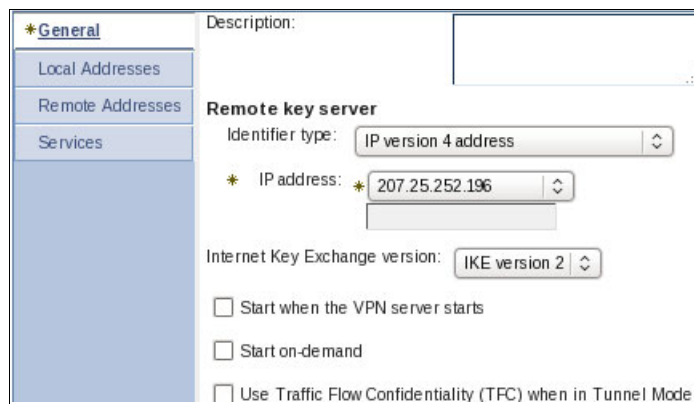


Figure 5-3 Display the Internet Key Exchange version

IKEv2 troubleshooting

Troubleshooting issues for IKEv2 connections is similar to troubleshooting issues for IKEv1 connections. The VPN jobs run in the subsystem QSYSWRK. VPN connection management and IKEv1 processing are handled under the jobs QTOVMAN and QTOKVPNIKE. IKEv2 processing is handled under a new key manager job, QTOKVPNIK2. The VPN key manager listens to UDP port 500 to perform the IKEv2 protocol processing. The logs for these jobs are accessible from IBM Navigator for i or from the command-line interface (CLI).

IKEv2 uses the same diagnostic tools that are used for VPN in previous releases. The VPN job logs for QTOVMAN, QTOKVPNIKE, and QTOKVPNIK2 display successes and failures during connection negotiation, which can be analyzed for problems with VPN connections. **TRCTCPAPP *VPN** traces the VPN connection manager and both key manager servers. Separate trace files are created for the connection manager and key manager servers.

IBM i 7.2 IKEv2 enhancements

Here are the IKEv2 enhancements in IBM i 7.2:

- ▶ NAT-compatible IPsec negotiation support

VPN support for network address translation traversal (NAT-T) is essential for IKE negotiations across NAT devices because conventional NAT does not work with IPsec. IBM i previously supported NAT-T for IKEv. IBM i 7.2 now supports NAT-T for IKEv2.

NAT-T uses UDP encapsulation to wrap an IPsec packet inside a IP/UDP header so that the packet is correctly translated. This UDP encapsulation applies only to VPN implementations that use IPsec encapsulating security payload (ESP) packets in tunnel mode or transport mode. To enable NAT-compatible IPsec negotiation for IKEv2, use the new option for IPsec through NAT in the VPN Properties window.

- ▶ IKE_SA Rekey

Like IKEv1, the IKEv2 key negotiation operates in two phases. The IKE_SA rekey option in IBM i 7.2 allows IKEv2 to regenerate the IKE_SA keys that are negotiated during the first phase of the key exchange without doing a full reauthentication. The IKE_SA rekey operation takes place as an independent exchange when one side determines the IKE_SA has expired. A new IKE_SA key is regenerated in time for the rekey attempt of the CHILD_SA, which is generated during the second phase negotiations. The key life times of IKE_SA and CHILD_SA are managed independently of the peer system. To enable the IKE_SA rekey, use the new rekey setting on the VPN Properties window.

- ▶ HTTP certificate lookup by using a URL

IKE negotiation partners can send a URL link to a certificate being used to authenticate the key exchange with the new HTTP lookup of certificates by using the URL option. The purpose of using the URL lookup is to save bandwidth in the IKE negotiation payload. IKEv2 on IBM i supports peers sending the URL lookup of certificates, but does not implement sending a URL itself.

Allowing URL lookup of certificates is enabled by default. To disable the URL lookup of certificates, from Navigator for i, click **Network** → **All Tasks** → **IP Policies** → **Virtual Private Networking** → **Properties**. See Figure 5-4.

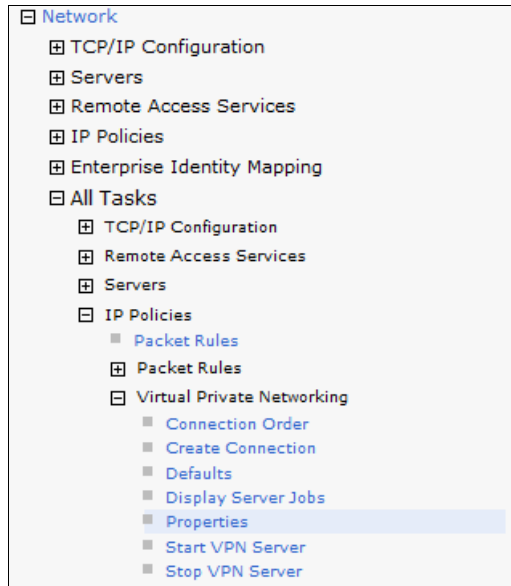


Figure 5-4 VPN properties

On the Virtual Private Networking Properties window, clear the **Allow HTTP lookup of certificates sent by the remote system** check box in the VPN Properties window. See Figure 5-5.

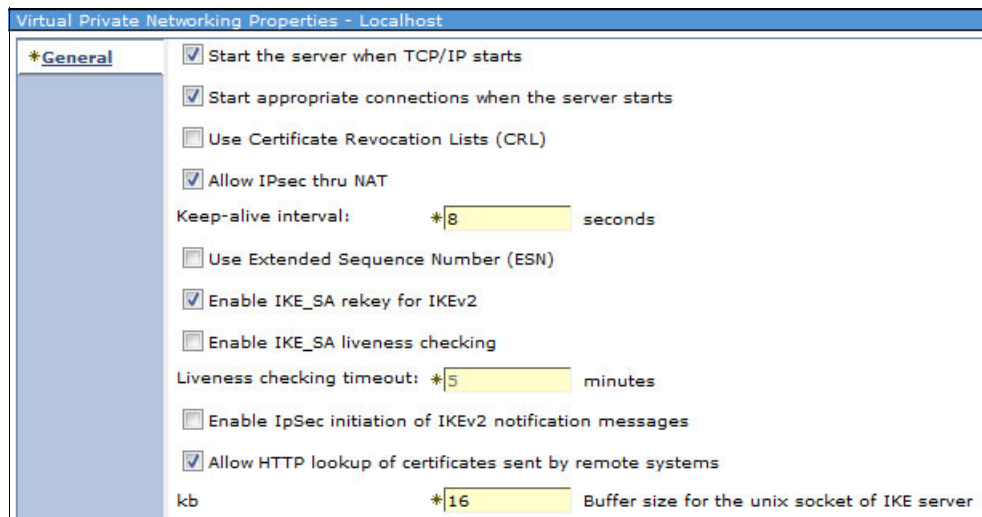


Figure 5-5 VPN Properties window

► Elliptic Curve Digital Signature Algorithm (ECDSA)

IKE processing requires that both sides authenticate each other by using a negotiated authentication method. Before IBM i 7.2, the two options for the authentication method were pre-shared keys or public key cryptography with RSA authentication. ECDSA signatures are available in IBM i 7.2 as a third method for authentication. ECDSA signatures are smaller than RSA signatures of similar strength. IKE authentication methods in key exchange policies now support ECDSA-256, ECDSA-384, and ECDSA-521 in addition to pre-shared keys and public key cryptography with RSA. See Figure 5-6.

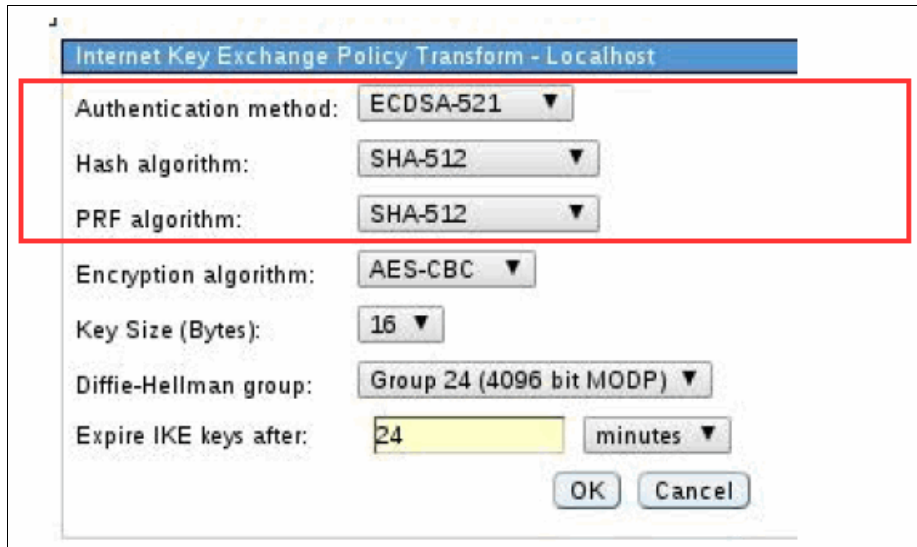


Figure 5-6 Specify the ECDSA authentication method

Port range support

Users can specify and negotiate a range of ports for the destination and source when defining the data endpoints of a VPN connection. Filter rules also allow a port range to be specified for the destination and source ports. See Example 5-4.

Example 5-4 Filter rules

```
FILTER SET porttest ACTION = PERMIT DIRECTION = INBOUND SRCADDR = *6 DSTADDR = *6
PROTOCOL = TCP
DSTPORT = 300-400 SRCPORT = 100-200 JRN = OFF
FILTER_INTERFACE LINE = ETHLINE SET = porttest
```

Using the IBM Navigator for i to create a connection

To create a connection from Navigator for i, click **Network** → **All Tasks** → **IP Policies** → **Virtual Private Networking** → **Create Connection**, as shown in Figure 5-7. Follow the prompts to set up a new VPN connection and select a port range when you get to the window to define your services.

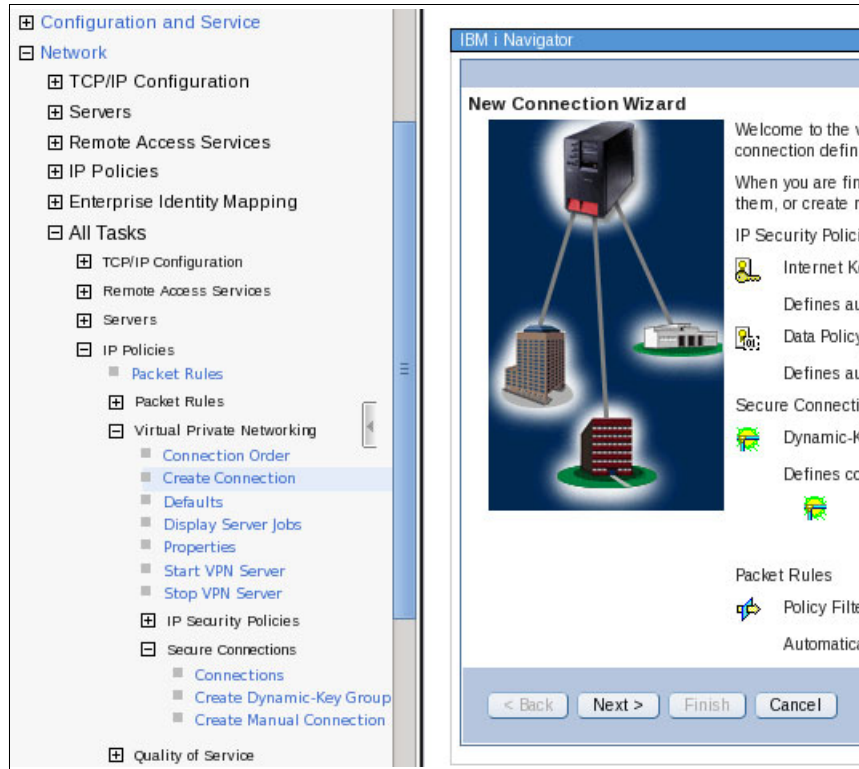


Figure 5-7 IKEv2 port configuration

Using the IBM Navigator for i to set the port range

Users can specify and negotiate a range of ports for the destination and source when defining the data endpoints of a VPN connection. Filter rules also allow a port range to be specified for the destination and source ports.

To do this task, complete the following steps:

1. From Navigator for i, click **Network** → **All Tasks** → **IP Policies** → **Virtual Private Networking** → **Secure Connections** → **Connections**, and then right-click **All Connections** and select **Open**, as shown in Figure 5-8.

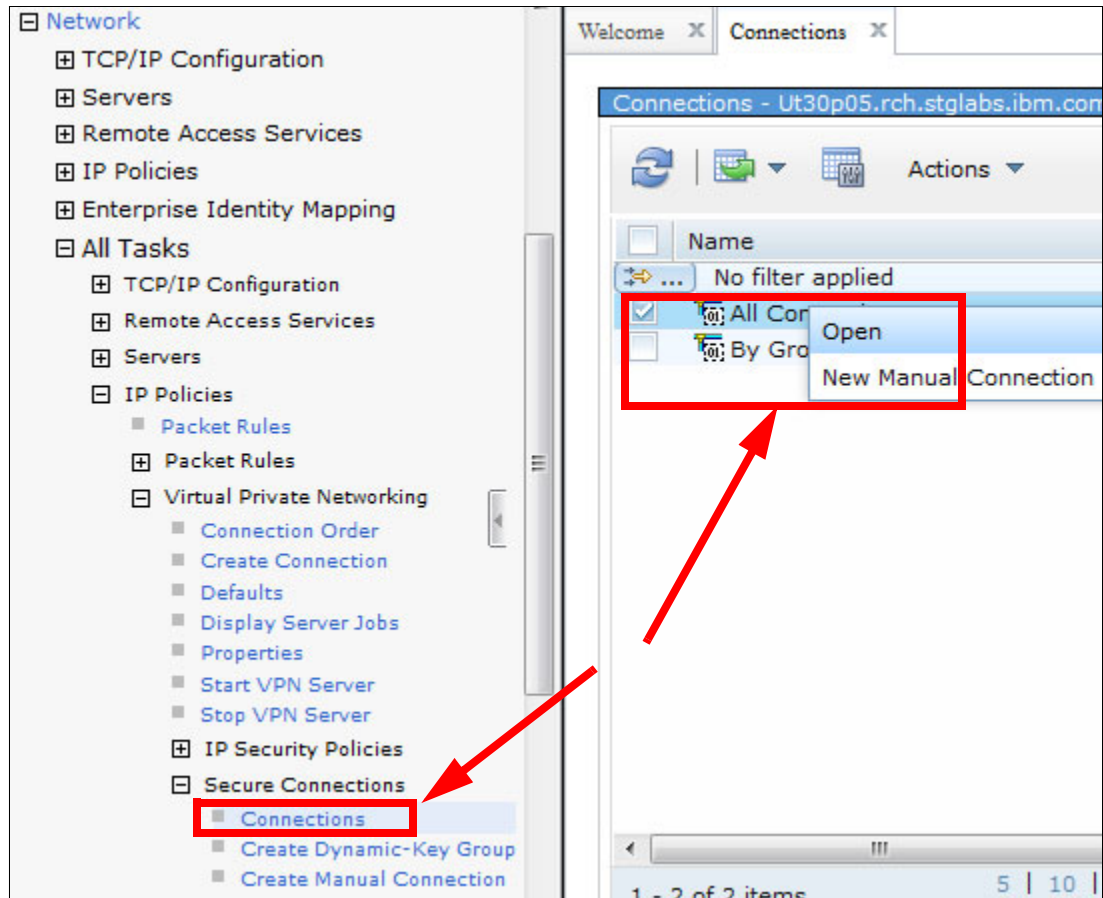


Figure 5-8 Select all VPN connections

- To set the port range for the local or remote endpoints, from the **All Connections** tab, right-click the existing VPN connection and select **Properties**, as shown in Figure 5-9.

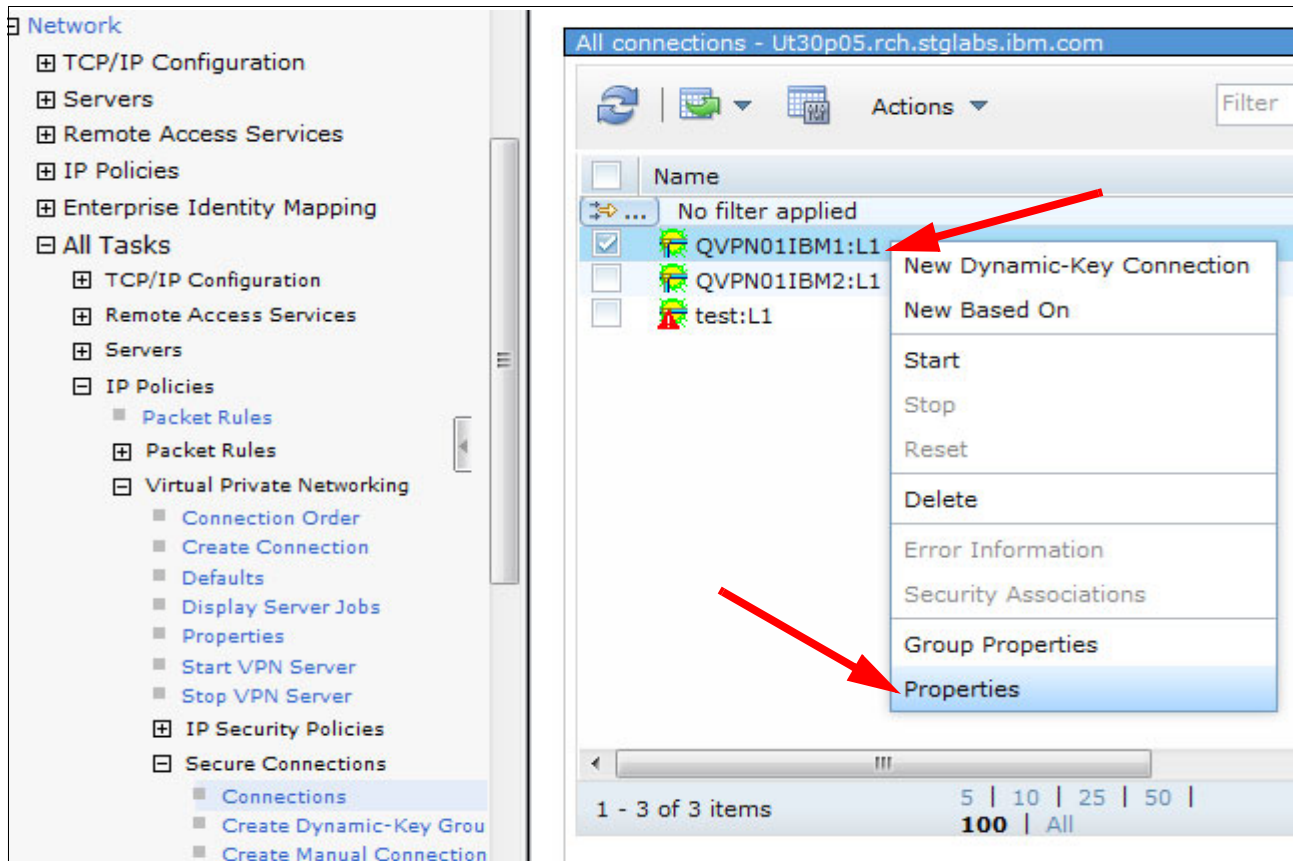


Figure 5-9 Select the VPN connection properties

- From the VPN Properties window, the ports on the Services tab are shown. See Figure 5-10.

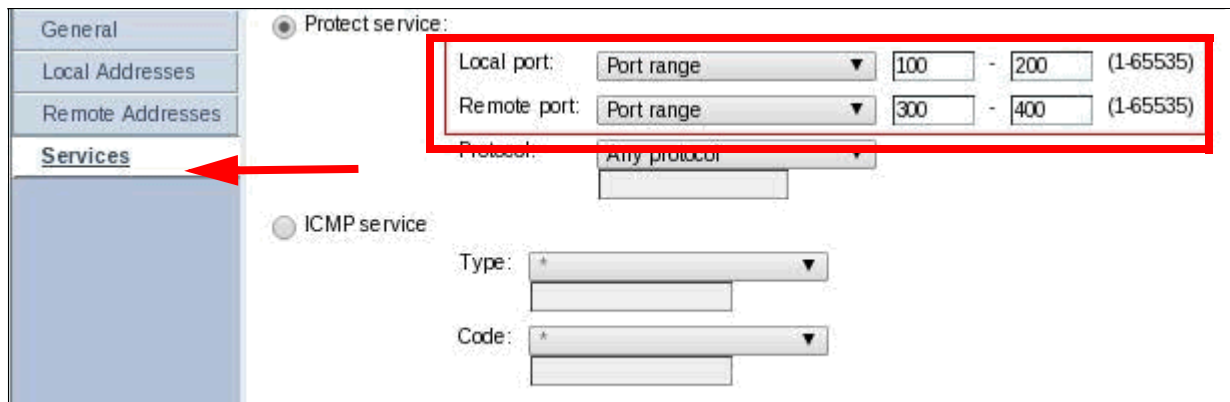


Figure 5-10 VPN properties: port range

5.5.3 New cryptographic algorithms

Stronger encryption and integrity algorithms might be required for VPN compliance with security policies. These algorithms are available for both IKEv1 and IKEv2 negotiations starting with IBM i 7.1. Additional algorithms are provided in IBM i 7.2 for IKEv2 negotiations for further flexibility and interoperability. The new cryptographic algorithms are listed in the following tables. Table 5-1 lists the new key exchange policy algorithms.

Table 5-1 New key exchange policy algorithms

Algorithm type	Algorithm	IBM i 7.1		IBM i 7.2	
		IKEv1	IKEv2	IKEv1	IKEv2
Encryption Confidentiality algorithms that are used to encrypt the data.	AES-CBC (128-bit)	X	X	X	X
	AES-CBC (192- and 256-bit)				X
	AES-CTR (128-, 192-, and 256-bit)				X
Hash Integrity algorithms that are used to protect data against tampering.	AES-XCBC-MAC (Hash 96-bit/PRF 128-bit)	X	X	X	X
	HMAC-SHA-256	X	X	X	X
Pseudo Random Function (PRF) Used for generating keying material and authentication of the IKE SA.	HMAC-SHA-384				X
	HMAC-SHA-512				X
Diffie-Hellman Used to generate a shared secret key to encrypt further IKE communications.	Group 14 (2048-bit MODP)	X	X	X	X
	Group 24 (4096-bit MODP)	X	X	X	X
	Group 19 (256-bit ECP)				X
	Group 20 (384-bit ECP)				X

Table 5-2 lists the new data policy algorithms.

Table 5-2 New data policy algorithms

Algorithm type	Algorithm	IBM i 7.1		IBM i 7.2	
		IKEv1	IKEv2	IKEv1	IKEv2
Encryption Confidentiality algorithms that are used to encrypt the data.	3DES-CBC				X
	AES-CBC (128-, 192-, and 256-bit)				X
	AES-GCM (128-, 192-, and 256-bit)				X
	AES-CCM (128-, 192-, and 256-bit)				X
	AES-GCM (128-, 192-, and 256-bit)				X
	AES-GMAC (128-, 192-, and 256-bit)				X
Authentication Method that is used to verify the identity of each peer (pre-shared keys, RSA authentication, and ECDSA authentication).	AES-XCBC-MAC	X	X	X	X
	HMAC-SHA-256	X	X	X	X
	HMAC-SHA-384				X
	HMAC-SHA-512				X

Algorithm type	Algorithm	IBM i 7.1		IBM i 7.2	
		IKEv1	IKEv2	IKEv1	IKEv2
Diffie-Hellman for Perfect Forward Secrecy (PFS) The group that is used to generate random public keys when negotiating the IPSec SA to ensure that it is not derived from any other secret.	Group 14 (2048-bit MODP)	X	X	X	X
	Group 24 (4096-bit MODP)	X	X	X	X
	Group 19 (256-bit ECP)				X
	Group 20 (384-bit ECP)				X

Note: The pre-existing algorithms are still supported for use with VPN. However, the new key exchange and data policy encryption and hash algorithms are recommended over the older algorithms that are listed in Table 5-3.

Table 5-3 Legacy key exchange and data policy algorithms

Algorithm type	Algorithm	IBM i 7.1		IBM i 7.2	
		IKEv1	IKEv2	IKEv1	IKEv2
Encryption Confidentiality algorithms that are used to encrypt the data.	DES	X	X	X	X
	RC4	X	X	X	X
	RC5	X	X	X	X
Hash Integrity algorithms that are used to protect data against tampering. Pseudo Random Function (PRF) is used for generating keying material and authentication of the IKE SA.	MD5	X	X	X	X

5.6 Virtual local area network

IBM i now supports IEEE 802.1Q virtual local area network (VLAN) tagging to allow access to multiple VLANs on a single adapter.

A VLAN allows a single LAN to be subdivided so that broadcast and multicast traffic that is targeted to a specific VLAN is not seen or processed by other systems on that LAN that are not part of the same VLAN. This technology provides performance improvement and an isolation level, which improves security. With VLAN support, it is possible to assign configured IP interfaces to a particular VLAN and access multiple VLANs with a single adapter.

IBM i TCP/IP Virtual LAN support now allows you to use a single adapter to connect to multiple VLANs and supports the following functions:

- ▶ Add redundant network connections without adding additional adapters.
- ▶ Connect to a new network VLAN without adding another adapter.
- ▶ Supported by all IBM i Ethernet and Virtual Ethernet adapters.
- ▶ Supported for IPv4 and IPv6 IBM i VLAN configurations.

IBM i VLAN configuration can be done from either IBM Navigator for i or by running commands. For more information, see 5.6.1, “VLAN configuration by using IBM Navigator for i” on page 242.

5.6.1 VLAN configuration by using IBM Navigator for i

To configure VLAN by using IBM Navigator for i, click **Network** → **TCP/IP Configuration** → **IPv4** → **IPv4 Interfaces**. From the **Actions** menu, select **New Interface** → **Local Area Network**, as shown in Figure 5-11.

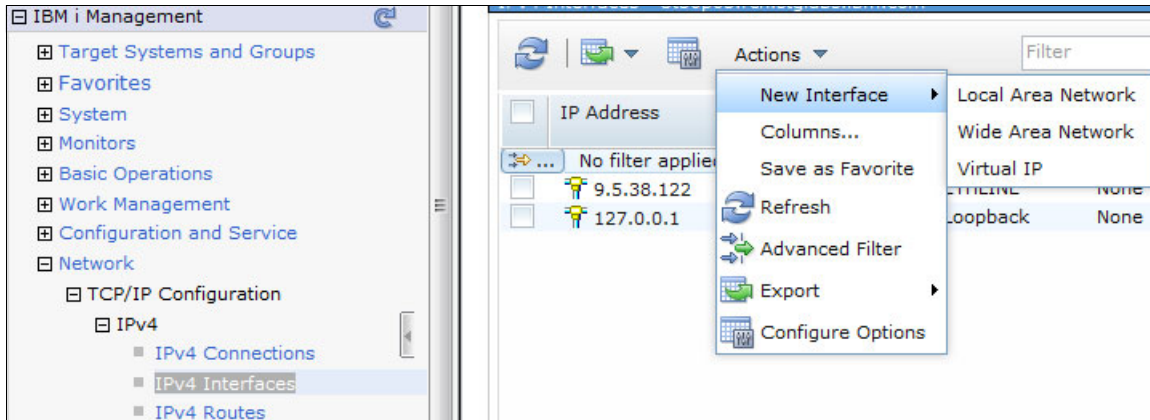


Figure 5-11 IBM i VLAN configuration

Figure 5-12 shows an example of a VLAN configuration in IBM Navigator for i.

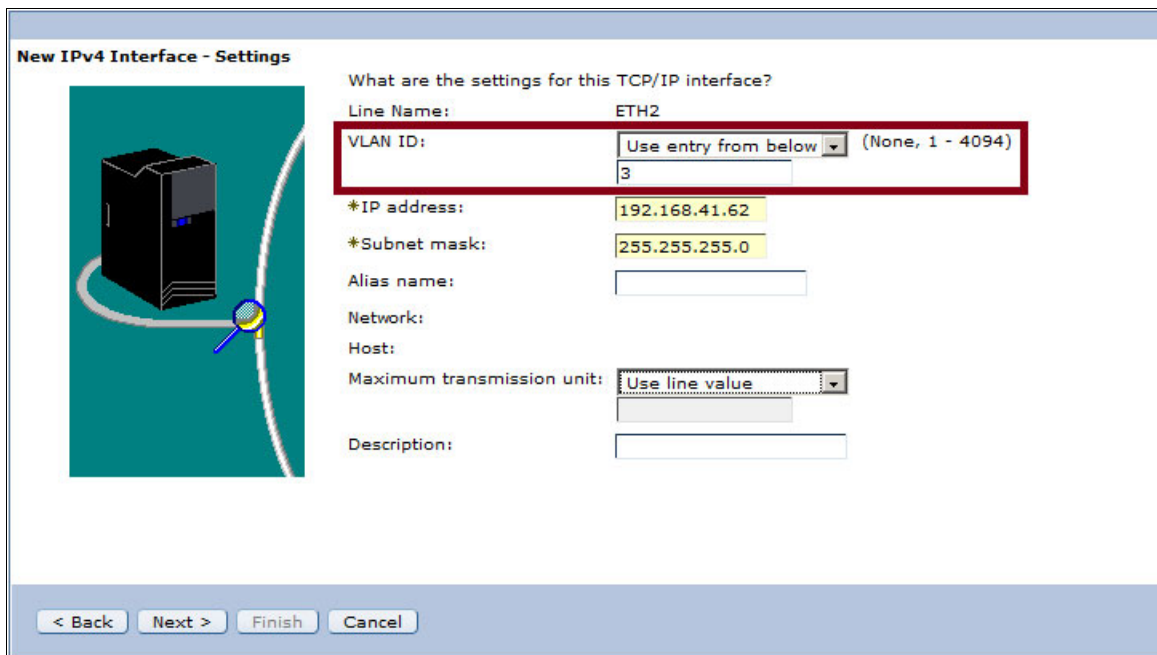


Figure 5-12 IBM i VLAN configuration in IBM Navigator for i

Figure 5-13 shows the new VLAN ID column in the interfaces list in IBM Navigator for i.

Note: Interfaces that use native VLAN (for example, 192.168.31.12, as shown in Figure 5-13) are configured with no VLAN identifier.

IP Address	Subnet Mask	Line Name	VLAN ID	Status	Interface Type
9.5.10.216	255.255.255.0	ETHLINE	None	Active	Broadcast capable
127.0.0.1	255.0.0.0	Loopback	None	Active	Non-broadcast capa
192.168.1.12	255.255.255.0	VETH1	None	Active	Broadcast capable
192.168.31.12	255.255.255.0	ETH2	None	Active	Broadcast capable
192.168.31.62	255.255.255.0	ETH3	2	Active	Broadcast capable
192.168.41.12	255.255.255.0	ETH3	None	Active	Broadcast capable
192.168.41.62	255.255.255.0	ETH2	3	Active	Broadcast capable

Figure 5-13 New VLAN ID column in the IBM Navigator for i Interfaces list to display VLAN ID assignments

5.6.2 VLAN configuration by using CL commands

Use the Add TCP/IP Interface (**ADDTCPIFC**) command to do a VLAN configuration. For example:

```
ADDTCPIFC INTNETADR('192.168.41.62') LIND(ETH2 3) SUBNETMASK('255.255.255.0')
```

As shown in Figure 5-14, the **NETSTAT** (CL command) interface list also displays the VLAN ID. You must press F11 to display the VLAN ID.

```

Work with TCP/IP Interface Status
System: UT30P05

Type options, press Enter.
 5=Display details  8=Display associated routes  9=Start  10=End
12=Work with configuration status  14=Display multicast groups
Virtual
Opt  Internet      Network      Line      LAN
     Address      Address      Description ID
     9.5.10.216    9.5.19.0    ETHLINE   *NONE
     127.0.0.1    127.0.0.0   *LOOPBACK *NONE
     192.168.1.12  192.168.1.0 VETH1     *NONE
     192.168.31.12 192.168.31.0 ETH2       *NONE
     192.168.31.62 192.168.31.0 ETH3       2
     192.168.41.12 192.168.41.0 ETH3       *NONE
     192.168.41.62 192.168.41.0 ETH4       3

Bottom
F3=Exit  F9=Command line  F11=Display Virtual LAN ID  F12=Cancel
F13=Sort by column  F20=Work with IPv6 interfaces  F24=More keys

```

Figure 5-14 Work with TCP/IP Interface Status display showing the VLAN ID

VPN policy filters and IP packet rules use the format of *linename.vlanid*. For example, as shown in Figure 5-14, ETH2.3 is VLAN ID 3 online description ETH2.

Sockets APIs taking an interface name also use the format of *linename.vlanid*. For example:

```
if_nametoindex("ETH2.3")  
fe80::1234%eth2.3 (IPv6 link-local address with scope identifier)
```

Note: If VLANs are used, do not use line description names with periods. For example, with two line descriptions of ETH2.3 and ETH2, VPN and sockets interpret ETH2.3 as line ETH2.3 rather than VLAN 3 online ETH2.

5.7 Retrieving and updating TCP/IP information

The following new commands are available to save and restore the sets of configuration files and settings that are used by the IBM i TCP/IP configuration and selected TCP/IP application servers:

- ▶ Retrieve TCP/IP Information (**RTVTCPIINF**)
- ▶ Update TCP/IP Information (**UPDTCPINF**)

These commands help address the complexities of managing TCP/IP and application server configuration files. The new commands are modeled from the Retrieve System Information (**RTVSYSINF**) and Update System Information (**UPDSYSINF**) CL commands, which perform a similar function for general system information.

5.7.1 Retrieve TCP/IP Information (RTVTCPIINF) CL command

The Retrieve TCP/IP Information (**RTVTCPIINF**) CL command retrieves selected TCP/IP configuration and application information. The retrieved information is stored as save files and user spaces in a user-selected library.

The **RTVTCPIINF** CL command allows for easy backup of TCP/IP related information, which can be restored later or propagated to another system.

5.7.2 Update TCP/IP Information (UPDTCPINF) CL command

The Update TCP/IP Information (**UPDTCPINF**) CL command updates selected TCP/IP configuration and application information. This command uses objects that are generated by the **RTVTCPIINF** (CL command). This command provides a simple way to move application configuration files from one system to another.

The following information types are supported by the **UPDTCPINF** (CL command):

- ▶ TCP/IP configuration
- ▶ Bootstrap protocol
- ▶ Dynamic Host Configuration Protocol (DHCP)
- ▶ File Transfer Protocol (FTP)
- ▶ HTTP administration server
- ▶ Internet daemon
- ▶ IP packet filtering
- ▶ Line printer daemon
- ▶ NetServer
- ▶ OMPROUTE daemon
- ▶ Point-to-point
- ▶ Post Office Protocol (POP)
- ▶ Quality of service

- ▶ Remote execution
- ▶ Router daemon
- ▶ Simple Mail Transfer Protocol (SMTP)
- ▶ Simple Network Management Protocol (SNMP)
- ▶ Service and support proxy
- ▶ Telnet
- ▶ Trivial File Transfer Protocol (TFTP)
- ▶ Virtual Private Network (VPN)

Note: User data for applications such as SMTP and POP is not supported. Only configuration-related data for these servers is supported.

5.8 IPv6 proxy neighbor discovery for virtual Ethernet and PPP

The neighbor discovery (ND) proxy allows two separate links to operate as though nodes on each link are on a single common link. This is similar to bridging two networks at the link layer, but operates instead at the IP level. This allows nodes on different types of networks (for example, Ethernet and PPP) to operate as though they are on the same network. The ND proxy provides a function similar to the Transparent Subnet Proxy for IPv4, allowing virtual Ethernet and point-to-point links to be proxied on a physical Ethernet link.

5.9 Single sign-on for FTP and TELNET

Single sign-on (SSO) for FTP and TELNET is described in 4.1, “Single sign-on” on page 210.

5.10 Virtual Network Interface Controller

Virtual Network Interface Controller (vNIC) is a new PowerVM virtual networking technology that delivers enterprise capabilities and simplifies network management. It is a high-performance, efficient technology that, when combined with single root I/O virtualization (SR-IOV) NIC, provides bandwidth-control quality of service (QoS) capabilities at the virtual NIC level.

vNIC reduces virtualization processing impact, which results in lower latencies and less server resources (processor and memory) that are required for network virtualization. A vNIC is a type of virtual Ethernet adapter that can be configured on client logical partitions. Each vNIC is backed by an SR-IOV logical port that is owned by the VIOS. LAN console is supported on Virtual Ethernet Adapter (VLAN). A virtual Ethernet adapter is defined by using VIOS.

Figure 5-15 shows the control and data flow differences between the current virtual Ethernet and the new vNIC support.

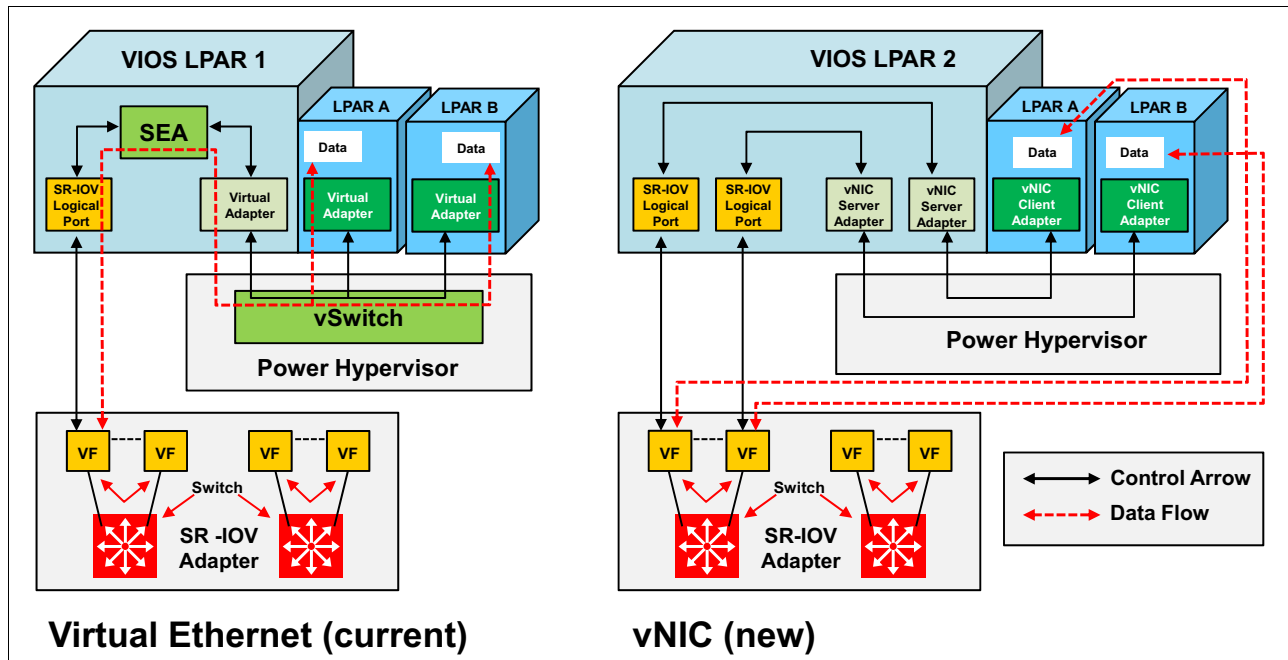


Figure 5-15 Comparison of virtual Ethernet and vNIC control and flows

For more information about vNIC, see the following website:

<https://ibm.biz/Bdsx77>

5.10.1 Configuring the quality of service priority for a virtual Ethernet adapter

You can dynamically configure the QoS priority of a virtual Ethernet adapter of a running logical partition by using the HMC.

You can prioritize the logical partition network traffic by specifying the value of the IEEE 802.1Q priority level for each virtual Ethernet adapter. Table 5-4 lists the Virtual Ethernet QoS priority level values.

Table 5-4 Virtual Ethernet QoS priority level values

VLAN user priority level	Quality of service priority
0 (default)	Best effort
1	Background
2	Spare
3	Excellent effort
4	Controlled load
5	Video < 100 ms latency and jitter
6	Video < 10 ms latency and jitter
7	Network control

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/P8DEA/p8hat/p8hat_configvirtethqost.htm

5.10.2 Viewing the vNIC properties by using the HMC

You can view the properties of a vNIC in a partition profile by using the HMC.

From the navigation pane, click **Systems Management** → **Servers** and select the name of the managed system in the work pane. Click the logical partition whose partition profile you want to view, and then click **Tasks** → **Configuration** → **Manage Profiles** → **Partition profile** → **Actions** → **Edit**.

In the Logical Partition Profile Properties page, click the **Virtual Adapters** tab. If there are vNICs in the profile, they are displayed.

In the Virtual NIC Adapter Properties window, you can view the following information in the General tab:

- ▶ Adapter ID
- ▶ Type
- ▶ Hosting VIOS
- ▶ SR-IOV Adapter ID
- ▶ SR-IOV Physical Port ID
- ▶ SR-IOV Physical Port Label
- ▶ SR-IOV Logical Port Capacity (%)

In the Virtual NIC Adapter Properties window, click the Advanced tab to view the following items:

- ▶ Port VLAN ID
- ▶ PVID Priority
- ▶ VLAN Restrictions
- ▶ MAC Address
- ▶ MAC Address Restrictions fields

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/8247-21L/p8hat/p8hat_viewvnicpro.htm

5.10.3 Configuring the quality of service by using IBM Navigator for i

IBM Navigator for i provides an interface for the web-enabled IBM i management tasks to view or change the QoS. To use it, click **Network** → **All Tasks** → **IP Policies** → **Quality of Service** → **Change Configuration**. See Figure 5-16.

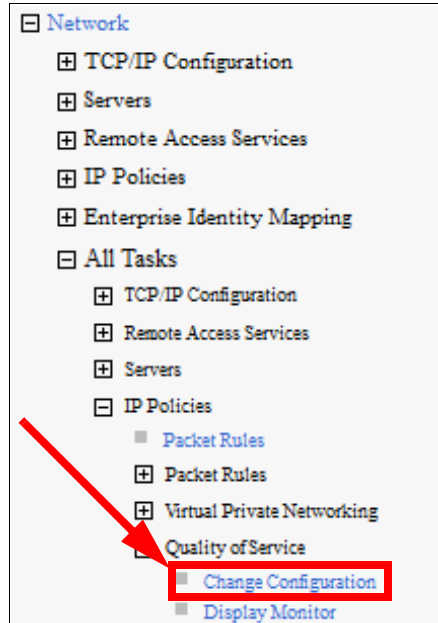


Figure 5-16 Configure the quality of service by using IBM Navigator for i

5.11 Ethernet device server support (WAN over LAN)

IBM i 7.2 added support for connections to Ethernet device servers, which are also known as Ethernet serial servers or Ethernet terminal servers and are referred to as *WAN over LAN*. These devices are external non-IBM equipment that are Ethernet-attached and contain one or more serial ports to which external modems can be attached. A compatible Ethernet device server must support RFC 2217, *Telnet COM Port Control Protocol*. An IBM i RFC 2217 session provides a virtual COM port for an Async or PPP line.

RFC 2217 is an extension of the Telnet Protocol that provides a method for device servers to accept Telnet sessions and pass the Telnet data that is received to a COM port, and pass data that is received from the COM port to the client. It also allows the device server to send the client any serial line status changes, and allows the client to manage flow control with the device server. It also allows a client to send configuration information to a device server.

Here are some benefits of the Ethernet device servers:

- ▶ This new support for WAN over LAN asynchronous configurations expands advanced virtualization capabilities.
- ▶ Saves PCI slots for applications requiring a modem and therefore reduces configuration cost.
- ▶ Provides WAN connectivity for servers that do not have available PCIe slots.

- ▶ Allows IBM i client partitions with virtual I/O to use FAX and other WAN asynchronous applications.
- ▶ Allows the same Ethernet adapter that provides TCP/IP connectivity for an IBM i partition to provide WAN asynchronous connectivity.

IBM i asynchronous applications that have traditionally run on PCIe WAN adapters now run seamlessly over an Ethernet connection to an Ethernet device server without application changes. For an existing IBM i configuration definition, the only change is that the Async or PPP line description must be modified to specify that it is for an Ethernet device server, and specify the Ethernet device server IP address and port. IBM i clients requiring many serial ports or running on systems without PCIe adapter slots (such as IBM PureSystems® or BladeCenter devices) now can run IBM i Communication Applications on their systems.

A compatible Ethernet device server must support RFC 2217. An IBM i RFC 2217 session provides a virtual COM port for an Async or PPP line. Ethernet device servers with RFC 2217 support are available from various vendors, in models containing 1 - 48 serial ports. IBM i has been tested with the following Ethernet device servers:

- ▶ Digi PortServer TS 4 (firmware version 82000747_V2 01/29/2013).
- ▶ Perle IOLAN SDS4 (firmware version 4.5) Ethernet device servers. Each serial port on an Ethernet device server has an assigned TCP port number.
- ▶ Facsimile Support for IBM i has been tested with the MT9234ZBA modem attached to these Ethernet device servers.

Figure 5-17 shows the WAN over LAN configuration.

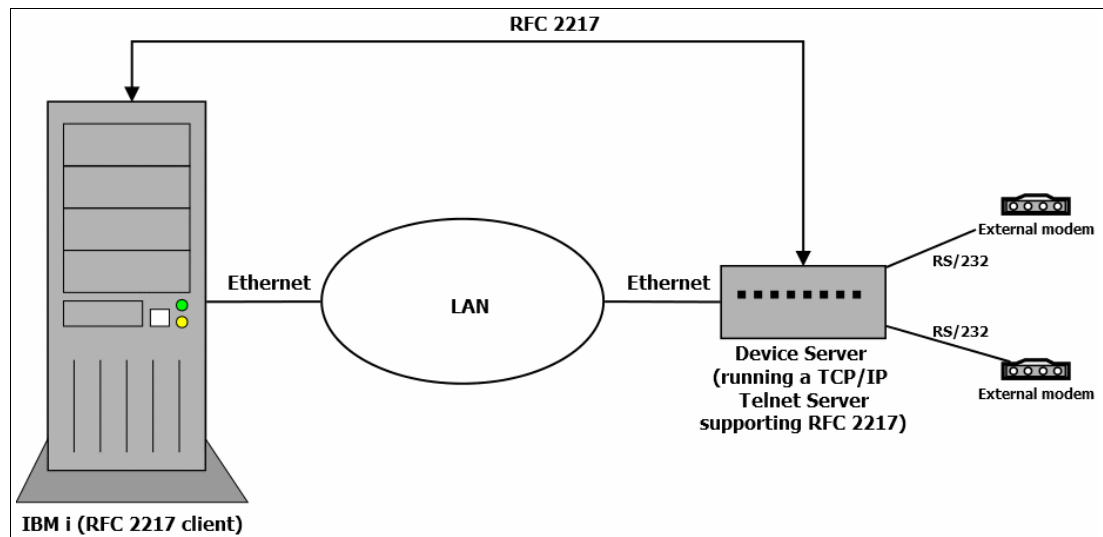


Figure 5-17 WAN over LAN

Ethernet device servers typically provide a web-based interface for configuration and management. For example, if a Digi PortServer has an IP address of 9.5.80.73, then entering `http://9.5.80.73` in a web browser accesses the configuration and management interface. A specific serial port is accessed by establishing a Telnet session to the Ethernet device server IP address and the TCP port number that is assigned to the serial port, for example, `9.5.80.73:2001`.

Here are the WAN over LAN requirements:

- ▶ Ethernet device server to support RFC 2217, *COM Port Control Protocol* for transport of serial data and RS-232 control signals
- ▶ IBM i 7.2 PTFs:
 - 5770SS1 PTF SI54771 or supersede
 - 5770999 PTF MF57686 or supersede
- ▶ PTFs for Licensed Product 5798FAX V5R8M0:
 - SI54319 or supersede
 - SI52896 or supersede

Note: Fax Support 5798-FAX V5R8M0 also works on V7R1, but does not support the *ETHDEVSrv resource name.

Figure 5-18 shows an example of using the Create Line Description (**CRTLINASC**) CL command to configure a WAN over LAN line description.

```

                                Create Line Desc (Async) (CRTLINASC)

Type choices, press Enter.

Line description . . . . . FAXLINE      Name
Resource name . . . . . *ETHDEVSVR    Name, *ETHDEVSVR
Online at IPL . . . . . *YES          *YES, *NO
Connection type . . . . . *NONSWTPP   *NONSWTPP, *SWTPP...
Switched network backup . . . . . *NO    *NO, *YES
Data bits per character . . . . . 8      8, 7
Type of parity . . . . . *NONE        *NONE, *ODD, *EVEN
Stop bits . . . . . 1                 1, 2
Duplex . . . . . *FULL                *FULL, *HALF
Echo support . . . . . *NONE          *NONE, *ALL, *CNTL
Line speed . . . . . 1200             50, 75, 110, 150, 300, 600...
Modem type supported . . . . . *NORMAL  *NORMAL, *V54, *IBMWRAP
Remote internet address _____
Remote port. . . . . _____        1-65535
Maximum buffer size . . . . . 896      128-4096

More...

F3=Exit  F4=Prompt  F5=Refresh  F10=Additional parameters  F12=Cancel
F13=How to use this display          F24=More keys
  
```

Figure 5-18 Create a WAN over LAN line description by using the CRTLINASC CL command



High availability

This chapter describes the enhancements to IBM PowerHA SystemMirror® for i and related high availability functions in IBM i 7.2.

This chapter describes the following topics:

- ▶ 6.1, “Introduction to IBM PowerHA SystemMirror for i” on page 252
- ▶ 6.2, “IBM PowerHA SystemMirror for i enhancements” on page 253
- ▶ 6.3, “Administrative domain” on page 261
- ▶ 6.4, “Independent Auxiliary Storage Pools” on page 262
- ▶ 6.5, “Support for SAN Volume Controller and Storwize HyperSwap volumes” on page 267

For more information about the IBM i 7.2 high availability enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#/wiki/IBM%20PowerHA%20SystemMirror%20for%20i/page/PowerHA%20SystemMirror%20Technology%20Updates>

6.1 Introduction to IBM PowerHA SystemMirror for i

To realize a high availability (HA) and a disaster recovery (DR) IBM i environment, IBM provides PowerHA SystemMirror for i. PowerHA SystemMirror for i provides a hardware-based (disk-level) data and application resiliency solution that is an integrated extension of the IBM i operation-system and storage-management architecture, as shown in Figure 6-1

PowerHA SystemMirror for i also supports IBM i replication (Geographic Mirroring) and external storage, such as IBM DS8000, IBM Storwize, and SAN Volume Controller replication. PowerHA SystemMirror for i offers solutions covering a simple data center to a multiple-site configuration, enables 24 x 7 operational availability, and provides automation for planned and unplanned outages.

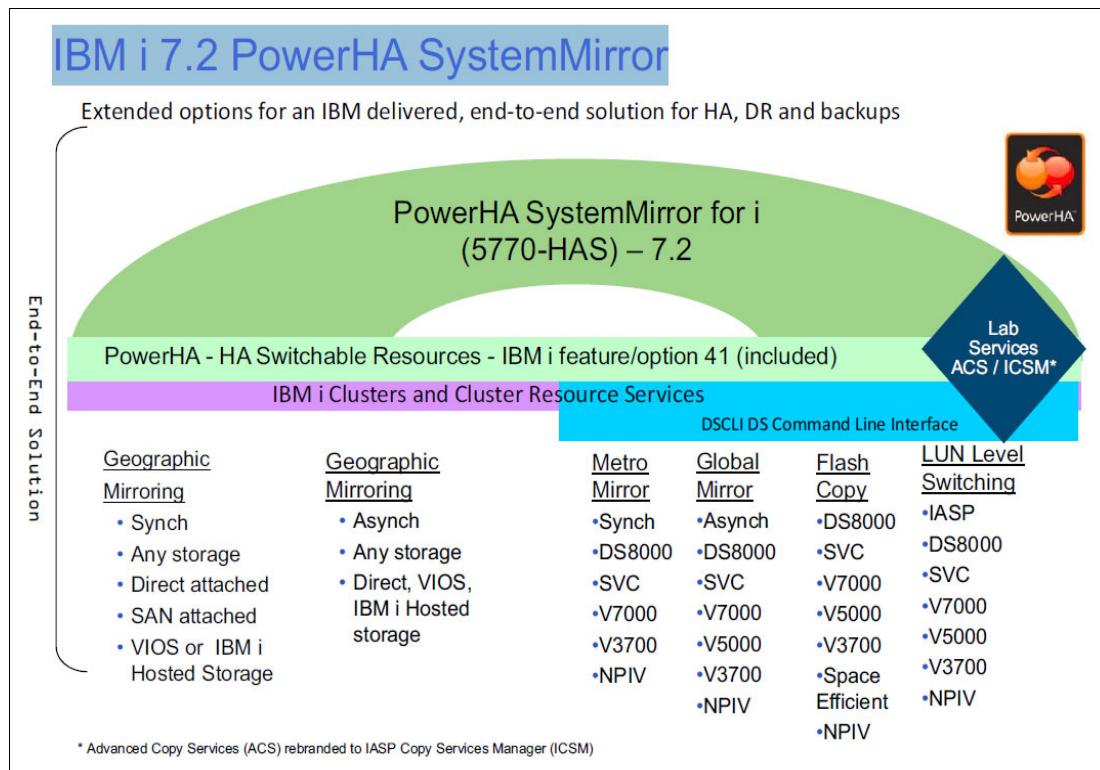


Figure 6-1 PowerHA SystemMirror for i architecture

The levels of the replication technology by PowerHA SystemMirror for i are divided into five levels, as described in Figure 6-2 on page 253:

- ▶ Level 1 technology is one-site shared-storage technology. The solution in this level is called *LUN-level switching*. LUN-level switching supports DS8000, Storwize, and SAN Volume Controller.
- ▶ Level 2 is one-site replication technology. IBM i based second-level replication is realized by *Synchronous Geographic Mirroring*. An external storage-based replication is realized by *Metro Mirror*. These two level technologies are applied as a high availability solution for a simple data center.
- ▶ Level 3 of the replication technology is two-site replication. This level is achieved by asynchronous replication technology, namely *Asynchronous Geographic Mirroring* as an IBM i based technology and *Global Mirror* as an external storage-based technology.

- ▶ Level 4 is a two-site HA and DR configuration. This level is accomplished by combining Level 1 technology and Level 3 technology. On the production site, one storage is shared by a production system and an HA standby system. When the outage of the production system occurs, the storage is switched to the HA standby system. When the production site shutdown occurs, the DR standby system is raised to a primary node by role swapping.
- ▶ Level 5 is three-site replication. This configuration is a combination of Level 2 and Level 3 technologies. By aligning the HA standby system with the different site from the production site, a higher level of availability can be accomplished than by Level 4 technology. This level is supported only on DS8000.

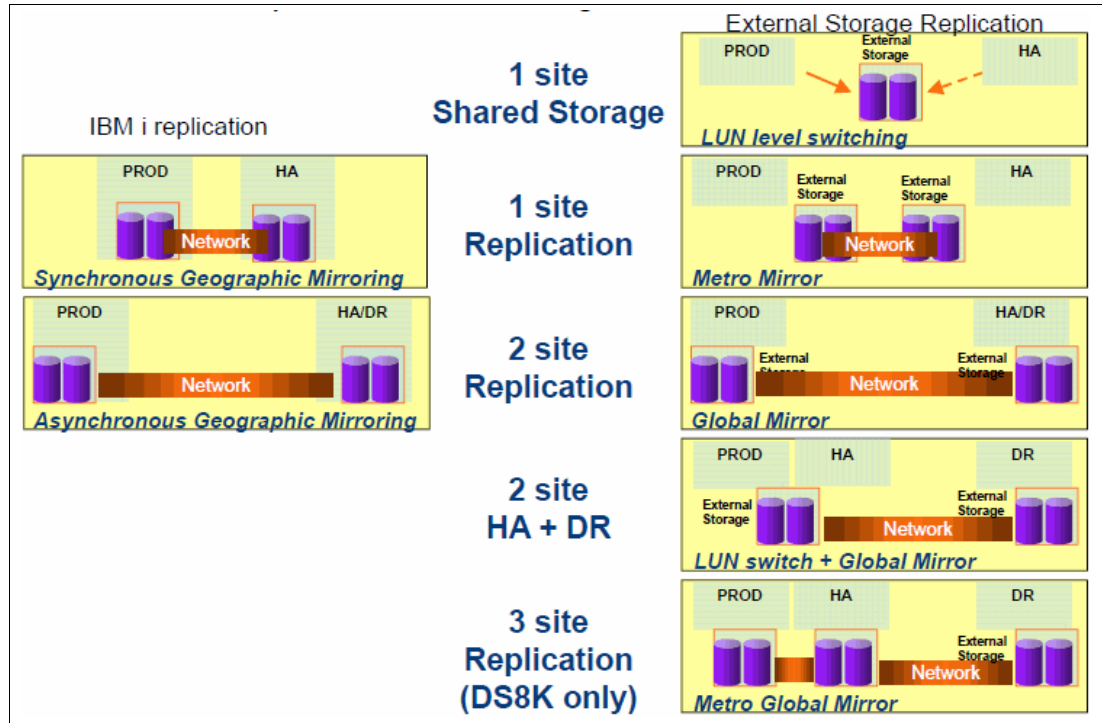


Figure 6-2 PowerHA SystemMirror for i Replication levels of replication technology

For more information about PowerHA SystemMirror for i, see *PowerHA SystemMirror for IBM i Cookbook*, SG24-7994.

6.2 IBM PowerHA SystemMirror for i enhancements

This section describes the following IBM i 7.2 enhancements for IBM PowerHA SystemMirror:

- ▶ 6.2.1, “PowerHA SystemMirror for i packaging” on page 254
- ▶ 6.2.2, “DS8000 HyperSwap support with PowerHA for i 7.2 Express Edition” on page 254
- ▶ 6.2.3, “Support for SVC/Storwize Global Mirror with Change Volumes” on page 257
- ▶ 6.2.4, “GUI changes in IBM Navigator for i” on page 258
- ▶ 6.2.5, “Minimum cluster and PowerHA versions for upgrading nodes to IBM i 7.2” on page 258
- ▶ 6.2.6, “DS8000 IASP-based HyperSwap Technology Preview” on page 259

6.2.1 PowerHA SystemMirror for i packaging

In IBM i 7.2, PowerHA SystemMirror for i has the following three editions:

- ▶ Enterprise Edition (5770-HAS Option 1)
- ▶ Standard Edition (5770-HAS Option 2)
- ▶ Express Edition (5770-HAS Option 3)

Enterprise Edition has a multiple-site DR solution, and Standard Edition is for a simple data center HA solution. Both of these editions are available in IBM i 7.1. In IBM i 7.2, Express Edition was added to the lineup of PowerHA SystemMirror for i.

6.2.2 DS8000 HyperSwap support with PowerHA for i 7.2 Express Edition

With PowerHA SystemMirror for i 7.2, the first stage of the Express Edition offering enables single-node, full-system IBM HyperSwap® with the DS8700 system (or above). This provides customers with continuously available storage through either planned or unplanned storage outage events.

HyperSwap provides an instant switching capability between DS8000 servers that use Metro Mirror. After HyperSwap is configured, switching occurs automatically if there is a DS8000 outage with no downtime. There is also a command that is available for switching a storage node, which provides for planned outage events on the DS8000 side, as shown in Figure 6-3.

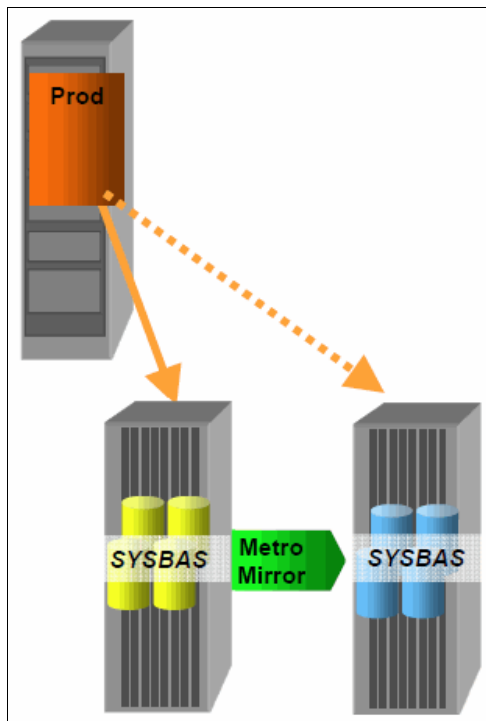


Figure 6-3 PowerHA SystemMirror for i Express Edition with DS8000 HyperSwap

To configure PowerHA SystemMirror for i Express Edition with DS8000 HyperSwap, complete the following steps:

1. Create LUNs (Logical Unit Numbers) on the source DS8000 system.
2. Assign LUNs on the source DS8000 system to the IBM i system.
3. Create LUNs on the target DS8000 system.

Note: Do not assign target LUNs to the IBM i system until after Metro Mirror is configured on the DS8000 side.

4. Configure Metro Mirror between the source and target DS8000 systems.
5. Assign the LUNs on the target DS8000 system to the same IBM i system.
6. Verify the HyperSwap configuration with the Display HyperSwap Status (**DSPHYSSTS**) CL command.

Figure 6-4 shows an example of result of the **DSPHYSSTS** CL command. The direction of arrows in the Copy Status column indicates the direction of mirroring between LUNs.

Display HyperSwap Status					Y319BP17
					10/15/14 12:18:04
Resource	Volume Identifier	Copy Status	Resource	Volume Identifier	
DMP366	IBM.2107-75TT911/3F00	---->	DMP004	IBM.2107-75BPF81/3D00	
DMP006	IBM.2107-75TT911/3F01	---->	DMP005	IBM.2107-75BPF81/3D01	
DMP013	IBM.2107-75TT911/3F02	---->	DMP007	IBM.2107-75BPF81/3D02	
DMP369	IBM.2107-75TT911/3F03	---->	DMP009	IBM.2107-75BPF81/3D03	
DMP371	IBM.2107-75TT911/3F04	---->	DMP010	IBM.2107-75BPF81/3D04	
DMP373	IBM.2107-75TT911/3F05	---->	DMP011	IBM.2107-75BPF81/3D05	
DMP376	IBM.2107-75TT911/3F06	---->	DMP012	IBM.2107-75BPF81/3D06	
DMP393	IBM.2107-75TT911/3F07	---->	DMP014	IBM.2107-75BPF81/3D07	
DMP380	IBM.2107-75TT911/3F08	---->	DMP016	IBM.2107-75BPF81/3D08	
DMP395	IBM.2107-75TT911/3F09	---->	DMP017	IBM.2107-75BPF81/3D09	
DMP384	IBM.2107-75TT911/3F0A	---->	DMP018	IBM.2107-75BPF81/3D0A	
DMP386	IBM.2107-75TT911/3F0B	---->	DMP020	IBM.2107-75BPF81/3D0B	
DMP388	IBM.2107-75TT911/3F0C	---->	DMP021	IBM.2107-75BPF81/3D0C	
DMP390	IBM.2107-75TT911/3F0D	---->	DMP023	IBM.2107-75BPF81/3D0D	
DMP392	IBM.2107-75TT911/3F0E	---->	DMP025	IBM.2107-75BPF81/3D0E	
					More...
Press Enter to continue					
F3=Exit F5=Refresh F11=View 2 F12=Cancel					

Figure 6-4 Results of the Display HyperSwap Status (**DSPHYSSTS**) CL command

The Change HyperSwap Status (**CHGHYSSTS**) CL command that is shown in Figure 6-5 can be used for suspending and resuming mirror operations between a storage node and for switching a storage node manually. This solution can also be used for planned outage events on a storage node side.

```

Change HyperSwap Status (CHGHYSSTS)

Type choices, press Enter.

Option . . . . . _____ *STOP, *START, *SWAP

```

Figure 6-5 Change HyperSwap Status (**CHGHYSSTS**) CL command prompt

When you suspend mirroring by running the **CHGHSSTS CL** command, the Copy Status column in **DSPHYPSTS** panel changes from '--->' to '-\->', as shown in Figure 6-6.

Display HyperSwap Status					Y319BP17
					10/15/14 12:19:11
Resource	Volume Identifier	Copy Status	Resource	Volume Identifier	
DMP366	IBM.2107-75TT911/3F00	-\->	DMP004	IBM.2107-75BPF81/3D00	
DMP006	IBM.2107-75TT911/3F01	-\->	DMP005	IBM.2107-75BPF81/3D01	
DMP013	IBM.2107-75TT911/3F02	-\->	DMP007	IBM.2107-75BPF81/3D02	
DMP369	IBM.2107-75TT911/3F03	-\->	DMP009	IBM.2107-75BPF81/3D03	
DMP371	IBM.2107-75TT911/3F04	-\->	DMP010	IBM.2107-75BPF81/3D04	
DMP373	IBM.2107-75TT911/3F05	-\->	DMP011	IBM.2107-75BPF81/3D05	
DMP376	IBM.2107-75TT911/3F06	-\->	DMP012	IBM.2107-75BPF81/3D06	
DMP393	IBM.2107-75TT911/3F07	-\->	DMP014	IBM.2107-75BPF81/3D07	
DMP380	IBM.2107-75TT911/3F08	-\->	DMP016	IBM.2107-75BPF81/3D08	
DMP395	IBM.2107-75TT911/3F09	-\->	DMP017	IBM.2107-75BPF81/3D09	
DMP384	IBM.2107-75TT911/3F0A	-\->	DMP018	IBM.2107-75BPF81/3D0A	
DMP386	IBM.2107-75TT911/3F0B	-\->	DMP020	IBM.2107-75BPF81/3D0B	
DMP388	IBM.2107-75TT911/3F0C	-\->	DMP021	IBM.2107-75BPF81/3D0C	
DMP390	IBM.2107-75TT911/3F0D	-\->	DMP023	IBM.2107-75BPF81/3D0D	
DMP392	IBM.2107-75TT911/3F0E	-\->	DMP025	IBM.2107-75BPF81/3D0E	
					More...
Press Enter to continue					
F3=Exit F5=Refresh F11=View 2 F12=Cancel					

Figure 6-6 *DSPHYSSTS CL* command when mirroring is suspended

HyperSwap also can be combined with IBM i Live Partition Mobility (LPM), as shown in Figure 6-7 on page 257. By using HyperSwap with LPM, you can realize a minimal downtime solution to migrate from one server/storage combination to another.

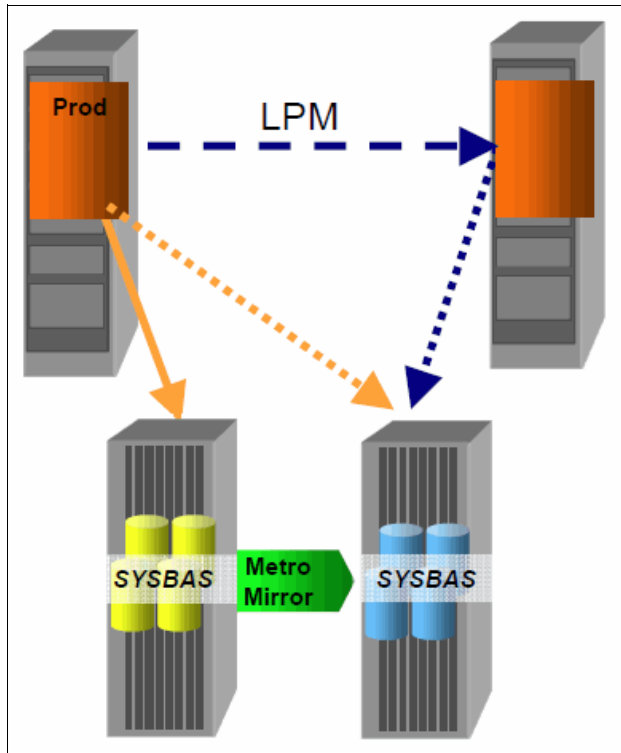


Figure 6-7 HyperSwap with Live Partition Mobility

After the affinity between a Power Systems server and a DS8000 server is defined, moving a partition by LPM also triggers switching a DS8000 server by HyperSwap when appropriate. To define the affinity between a Power Systems server and a DS8000 server, run the Add HyperSwap Storage Desc (**ADDHYSSTGD**) CL command, as shown in Figure 6-8.

```

Add HyperSwap Storage Desc (ADDHYSSTGD)

Type choices, press Enter.

System Serial Number . . . . . _____ Character value
IBM System Storage device . . . _____

```

Figure 6-8 Add HyperSwap Storage Desc (ADDHYSSTGD) CL command prompt

For more information about how to configure and manage the PowerHA SystemMirror for i with a HyperSwap environment, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Power%20SystemMirror%20for%20i/page/7.2%20Enhancements>

6.2.3 Support for SVC/Storwize Global Mirror with Change Volumes

IBM PowerHA SystemMirror for i supports Global Mirror with Change Volumes (GCMV) of SAN Volume Controller and Storwize by applying a PTF. Here are the PTFs for each release of IBM PowerHA SystemMirror for i Version 7 supporting this enhancement:

- ▶ 5770HAS V7R1M0 SI52687
- ▶ 5770HAS V7R2M0 SI53476

GMCV was introduced in Version 6.3 for SAN Volume Controller and Storwize. Before this release, Global Mirror ensured a consistent copy on the target side, but the recovery point objective (RPO) was not tunable.

This solution requires enough bandwidth to support the peak workload. GMCV uses IBM FlashCopy® internally to ensure the consistent copy, but offers a tunable RPO, called a *cycling period*. GMCV can be appropriate when bandwidth is an issue, although if bandwidth cannot support the replication, the cycling period might need to be adjusted from seconds up to 24 hours.

Configuring GMCV is done from the SAN Volume Controller / Storwize user interface or Global Mirror. After the required PTFs are applied, IBM PowerHA SystemMirror for i recognizes that GMCV is configured and manages the replication environment.

For more information about Global Mirror with Change Volumes, see *IBM System Storage SAN Volume Controller and Storwize V7000 Replication Family Services, SG24-7574*.

6.2.4 GUI changes in IBM Navigator for i

In IBM Navigator for i, the High Availability Solution Manager GUI and the Cluster Resource Services GUI were removed. Alternatively, the PowerHA GUI can be used for configuring and managing a high availability environment, as shown in Figure 6-9.

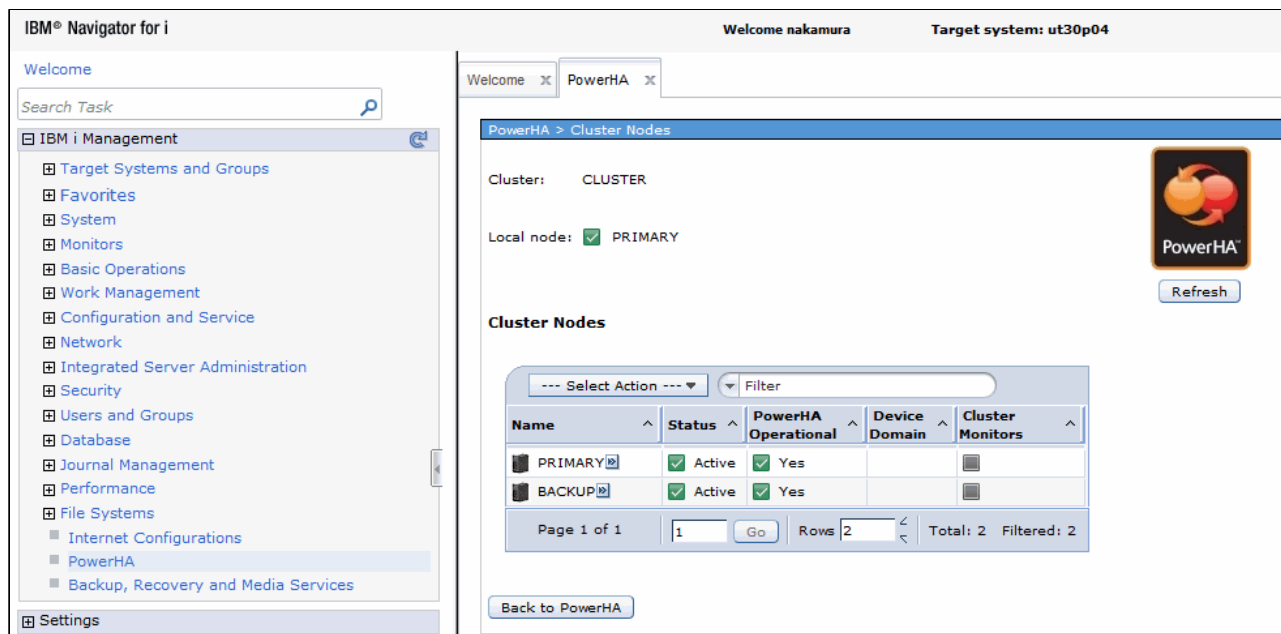


Figure 6-9 PowerHA GUI in IBM Navigator for i

6.2.5 Minimum cluster and PowerHA versions for upgrading nodes to IBM i 7.2

When upgrading an existing IBM i cluster node to IBM i 7.2, you must consider the version of the cluster and PowerHA. In IBM i 7.2, the cluster version is 8 and the PowerHA version is 3.0, as shown in Figure 6-10 on page 259. The Change Cluster Version (**CHGCLUVER**) CL command can be used to adjust the cluster and PowerHA versions.


```

                                Display Cluster Information
Cluster . . . . . : CLUSTER
Consistent information in cluster . . . : Yes
Current PowerHA version . . . . . : 3.0
Current cluster version . . . . . : 8
Current cluster modification level . . . : 0
Configuration tuning level . . . . . : *NORMAL
Number of cluster nodes . . . . . : 2
Number of device domains . . . . . : 0
Number of administrative domains . . . . : 0
Number of cluster resource groups . . . : 0
Cluster message queue . . . . . : *NONE
  Library . . . . . : *NONE
Failover wait time . . . . . : *NOWAIT
Failover default action . . . . . : *PROCEED

Press Enter to continue.

F1=Help      F3=Exit   F5=Refresh  F7=Change versions  F8=Change cluster
F12=Cancel   F13=Work with cluster menu

```

Figure 6-10 Display Cluster Information CL command showing the cluster and PowerHA versions

6.2.6 DS8000 IASP-based HyperSwap Technology Preview

In IBM i 7.2, the PowerHA SystemMirror for i product supports full system DS8000 HyperSwap as part of the Express Edition of PowerHA. This is not compatible with IASP-based replication because the HyperSwap relationship is defined at the system level, not at the ASP group level.

In a future IBM i 7.2 Technology Refresh, the HyperSwap relationship can be defined on an ASP within the partition, allowing SYSBAS and the IASPs to be in separate HyperSwap relationships.

A Technology preview of the IBM PowerHA SystemMirror for i IASP-based HyperSwap function is now available to interested customers who meet the criteria.

Important: This function is available only through the Technology Preview program currently.

Figure 6-11 shows the general configuration of DS8000 IASP-based HyperSwap, where SYSBAS and IASP can be defined in separate HyperSwap relationships.

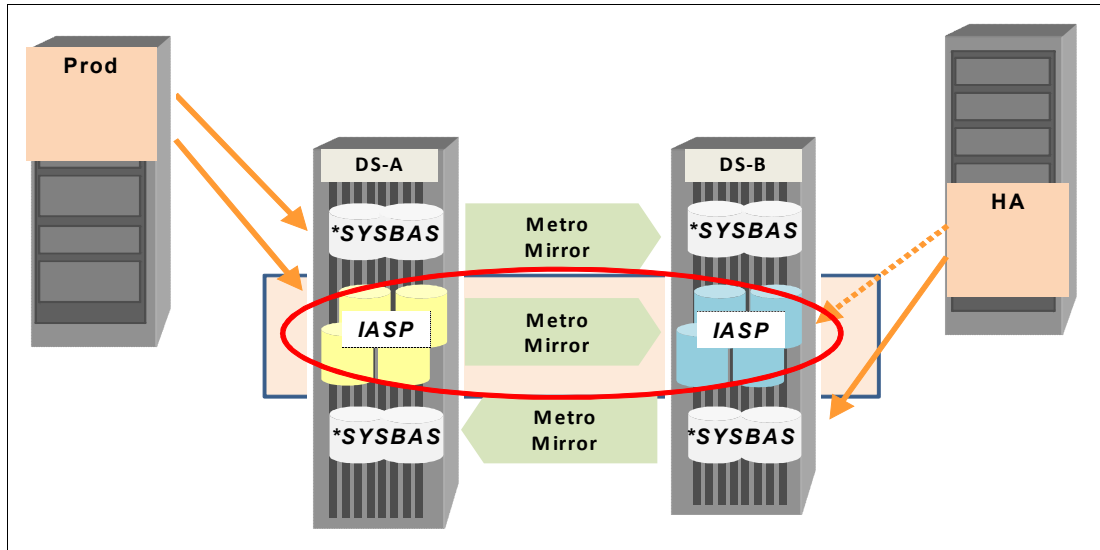


Figure 6-11 DS8000 with IASP-based HyperSwap

With this support, HyperSwap can be used as near-zero downtime storage for outages. After HyperSwap is configured, the application I/O can automatically switch to use the auxiliary storage system if the primary storage system fails, as shown in Figure 6-12.

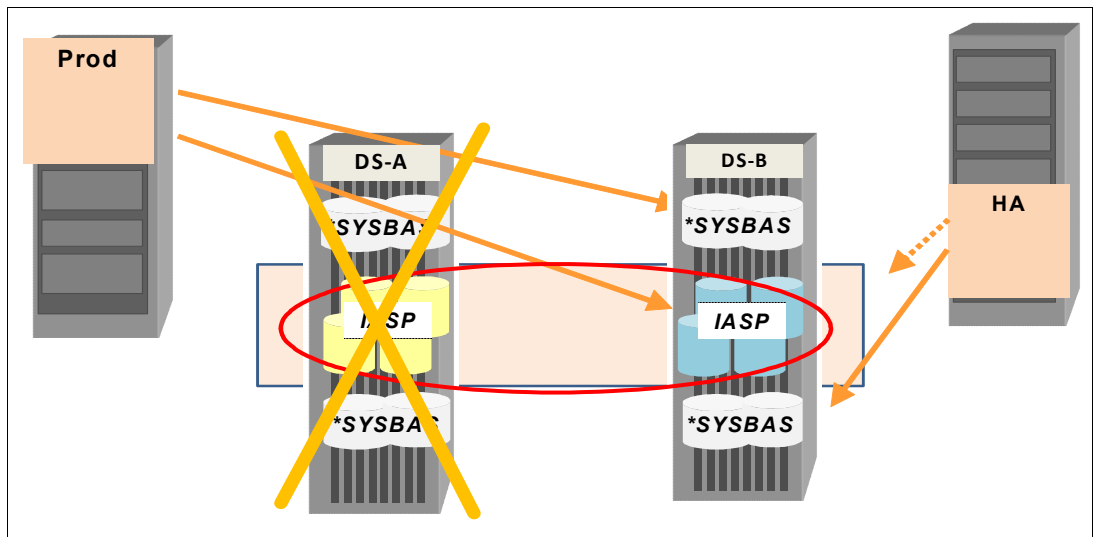


Figure 6-12 HyperSwap automatically switches when a storage outage occurs

If there is an operating system outage or disaster, PowerHA does a vary off/vary on of the IASP and switches to the secondary site, as shown in Figure 6-13.

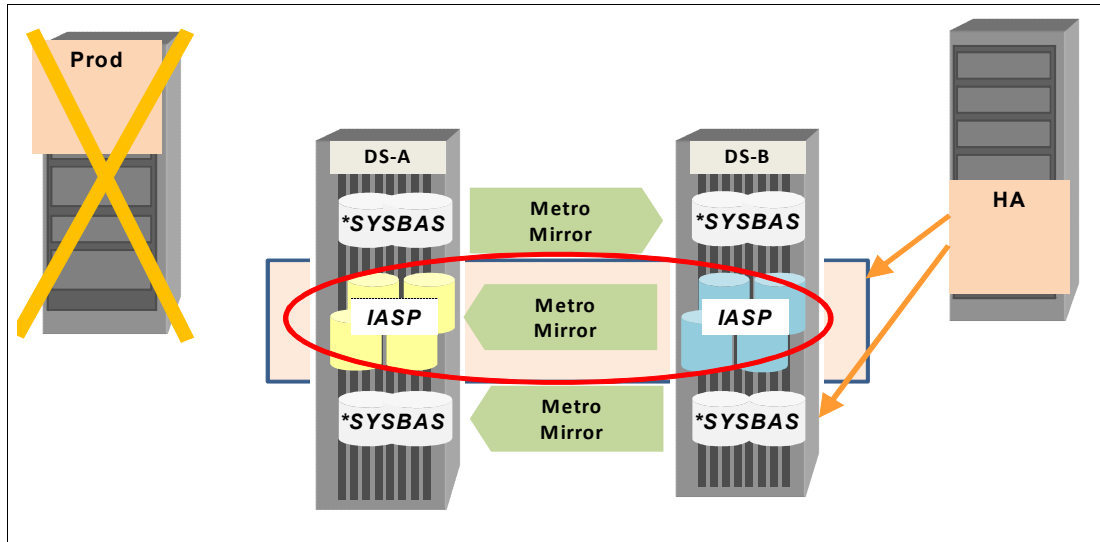


Figure 6-13 PowerHA vary off/vary on of the IASP and a switch of the connection to a secondary site

Live Partition Mobility (LPM) can be used with IASP- based HyperSwap to migrate a partition to the secondary server due to a planned server outage or maintenance.

For more information about DS8000 HyperSwap with IASP Technology Preview, see the IBM PowerHA SystemMirror for i wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Power%20SystemMirror%20for%20i/page/IASP%20HyperSwap>

6.3 Administrative domain

To maintain the consistency of objects in SYSBAS in a clustering environment, IBM i provides the administrative domain function. This section covers the following enhancements of the administrative domain in IBM i 7.2:

- ▶ 6.3.1, “Increased administrative domain limit” on page 261
- ▶ 6.3.2, “Synchronization of object authority and ownership” on page 262

For more information about the IBM PowerHA SystemMirror for i enhancements in IBM i 7.2, see the IBM PowerHA SystemMirror for i wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Power%20SystemMirror%20for%20i/page/7.2%20Enhancements>

6.3.1 Increased administrative domain limit

Before IBM i 7.2, the supported number of monitored resources entries (MREs) was 25,000. In IBM i 7.2, the number of MREs is increased to 45,000.

To maintain MREs, you can use the Work with Monitored Resources (**WRKCADMRE**) CL command or PowerHA GUI in IBM Navigator for i.

For more information about the **WRKCADMRE** CL command, see IBM Knowledge Center:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/wrkadmre.htm

6.3.2 Synchronization of object authority and ownership

Object authority and ownership can be monitored and synchronized with the administrative domain. The supported object attributes of these entries are object owner, authority entry, authorization list, and primary group. If you add new MREs in the IBM i 7.2 administrative domain, these four attributes are added by default. For existing MREs that were added with *ALL attributes, these four attributes will be synchronized after upgrading the PowerHA version to 3.0.

MREs are marked as inconsistent until a source node for the new attributes is determined. If you want to synchronize these attributes instantly, run the Remove Admin Domain MRE (**RMVADMRE**) CL command followed by the Add Admin Domain MRE (**ADDCADMRE**) CL command for the specific objects or you can use the PowerHA GUI in IBM Navigator for i, which enables selecting a source node when synchronizing, as shown in Figure 6-14.

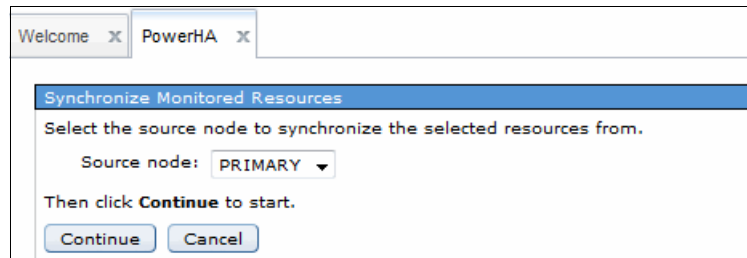


Figure 6-14 Manage MRE options in the IBM Navigator for i PowerHA GUI

For more information about the **RMVADMRE** and **ADDCADMRE** CL commands, see IBM Knowledge Center:

- ▶ Remove Admin Domain MRE (**RMVADMRE**) CL command:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/rmvadmre.htm
- ▶ Add Admin Domain MRE (**ADDCADMRE**) CL command:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/addcadmre.htm

6.4 Independent Auxiliary Storage Pools

This section describes the following enhancements that are related to Independent Auxiliary Storage Pools (IASPs) in IBM i 7.2:

- ▶ 6.4.1, “DSPASPSTS improvements for better monitoring of vary-on time” on page 263
- ▶ 6.4.2, “Reduced UID/GID processing time during vary-on” on page 264
- ▶ 6.4.3, “IASP assignment for consolidated backups” on page 264

6.4.1 DSPASPSTS improvements for better monitoring of vary-on time

The Display ASP Status (**DSPASPSTS**) CL command now can preserve and display up to 64 vary histories and show additional information, such as UDFS and STATFS. Figure 6-15 shows an example of the **DSPASPSTS ENTRIES(*ALL)** CL command, which lists several histories of varying on and off an IASP.

```
Display ASP Vary Status

ASP Device . . . . : 033 IASP01      Current time . . . : 00:00:22
ASP State . . . . : AVAILABLE      Previous time . . . : 00:00:32
Step . . . . . : / 35              Start date . . . . : 10/14/14

Step                                     Elapsed time
Cluster vary job submission
Waiting for devices - none are present    00:00:00
Waiting for devices - not all are present 00:00:00
DASD checker                             00:00:00
Storage management recovery
Synchronization of mirrored data
Synchronization of mirrored data - 2     00:00:00
Scanning DASD pages

More...

Press Enter to continue
-----
Display ASP Vary Status

ASP Device . . . . : 033 IASP01      Current time . . . : 00:00:24
ASP State . . . . : VARIED OFF      Previous time . . . : 00:00:30
Step . . . . . : / 5              Start date . . . . : 10/14/14

Step                                     Elapsed time
Cluster vary job submission                00:00:00
Ending jobs using the ASP
Waiting for jobs to end
Image catalog synchronization            00:00:03
Writing changes to disk                  00:00:21

Bottom

Press Enter to continue
```

Figure 6-15 Display ASP Vary Status CL command displaying records of previous varying operations

Figure 6-16 shows an example of displaying UDFS information by using the Display User-Defined FS (DSPASPSTS) CL command.

For more information about the DSPASPSTS CL command, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/dspaspsts.htm

```
Display User-Defined FS

User-defined file system . . . : /dev/IASP01/qdefault.udfs

Owner . . . . . : QSYS
Coded character set ID . . . . : 37
Case sensitivity . . . . . : *MONO
Preferred storage unit . . . . : *ANY
Default file format . . . . . : *TYPE2
Default disk storage option . . : *NORMAL
Default main storage option . . : *NORMAL
Creation date/time . . . . . : 10/14/14 13:27:15
Change date/time . . . . . : 10/14/14 13:27:15
Path where mounted . . . . . : /IASP01

Description . . . . . :

Press Enter to continue.
F3=Exit F12=Cancel

Bottom
```

Figure 6-16 Display UDFS information by using the DSPASPSTS CL command

6.4.2 Reduced UID/GID processing time during vary-on

In IBM i 7.2, the processing time for /QSYS.LIB objects is eliminated and the processing time for IFS objects is minimized during the vary-on of an IASP. In addition, the processing time for correcting the mismatch of UID and GID is also reduced.

Note: It is still considered a preferred practice to synchronize the UID/GID between cluster nodes by using the administrative domain to eliminate all UID/GID processing time during vary-on.

6.4.3 IASP assignment for consolidated backups

In IBM i 7.2, an existing IASP that is not in the cluster device domain can be attached to a partition. This enhancement provides a benefit to an environment that uses FlashCopy for minimizing a backup window.

Before IBM i 7.2, an IASP as a FlashCopy target must be attached to a partition within the cluster device domain. For the environment that is configured with multiple production clusters and is using FlashCopy in each cluster, each cluster requires a backup partition for attaching the FlashCopy target and must perform a backup operation on it. With this enhancement, only one partition is needed as a backup partition for multiple different clusters, as shown in Figure 6-17 on page 265.

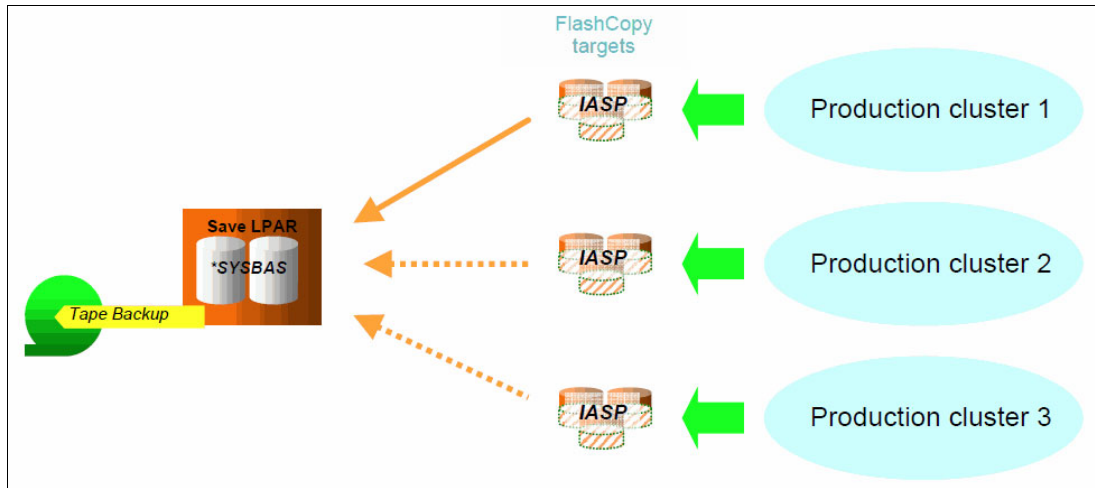


Figure 6-17 Attach IASPs out of the cluster device domain to a single partition

Note: Only one IASP can be attached to a single backup partition at a time, and an IPL of that partition is required before a different IASP is attached.

Before attaching a different IASP to a partition, remove any existing IASPs and run the **CFGDEVASP ASPDEV(*ALL) ACTION(*PREPARE)** CL command that is shown in Figure 6-18 on that partition and then perform an IPL.

```

                                Configure Device ASP (CFGDEVASP)

Type choices, press Enter.

ASP device . . . . . *ALL_____ Name, *ALL
Action . . . . . *PREPARE *CREATE, *DELETE, *PREPARE
  
```

Figure 6-18 CFGDEVASP ASPDEV(*ALL) ACTION(*PREPARE) CL command

After the IPL completes, a FlashCopy IASP can be recognized on a single backup partition by connecting it. Figure 6-19 shows the direct-attached IASP disk units panel of SST of a single backup partition. In Figure 6-19, disk unit DD003 is the target FlashCopy LUN that contains the IASP data on the production partition. By pressing Enter, the IASP, which consists of DD003, is configured.

Confirm Configure IASPs						
Press Enter to confirm Configure IASPs. Press F12=Cancel to return.						
ASP Unit	Serial Number	Type	Model	Resource Name	Protection	Hot Spare Protection
1					Unprotected	
	1 Y9D7RD3HCKHG	6B22	050	DMP002	Unprotected	N
70					Unprotected	
	4002 50-050340F	2107	A81	DD003	Unprotected	N

Figure 6-19 Direct-attached IASP disk units panel of SST

Figure 6-20 shows the Display Disk Configuration Status panel of SST, which shows that the IASP exists and that disk unit DD003 is assigned to it.

Display Disk Configuration Status						
ASP Unit	Serial Number	Type	Model	Resource Name	Status	Hot Spare Protection
1					Unprotected	
	1 Y9D7RD3HCKHG	6B22	050	DMP002	Configured	N
70					Unprotected	
	4001 50-050340F	2107	A81	DD003	Configured	N

Figure 6-20 Display Disk Configuration Status panel of SST

For more information about multiple IASPs assignments to a single backup partition, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaly/rzalyattachiasp.htm

6.5 Support for SAN Volume Controller and Storwize HyperSwap volumes

IBM i 7.2 now supports the HyperSwap function of the IBM SAN Volume Controller and IBM Storwize product family V5000 and V7000 hardware platform.

The HyperSwap function in the SAN Volume Controller software works with the standard multipathing drivers that are available on a wide variety of host types that support Asymmetric Logical Unit Access (ALUA).

The SCSI protocol allows a storage device to suggest to a host the preferred port to submit I/O. By using the ALUA state for a volume, a storage controller can know which path is active and which path is preferred for the host.

A quorum disk is required for the SAN Volume Controller HyperSwap configuration to provide two functions:

- ▶ Act as a tiebreaker in split-brain scenarios.
- ▶ Save critical configuration metadata.

The SAN Volume Controller quorum algorithm distinguishes between the active quorum disk and quorum disk candidates. There are three quorum disk candidates. At any time, only one of these candidates acts as the active quorum disk. All three quorum disks store configuration metadata, but only the active quorum disk acts as a tiebreaker for split-brain scenarios.

Figure 6-21 show the general setup of the Storwize HyperSwap implementation.

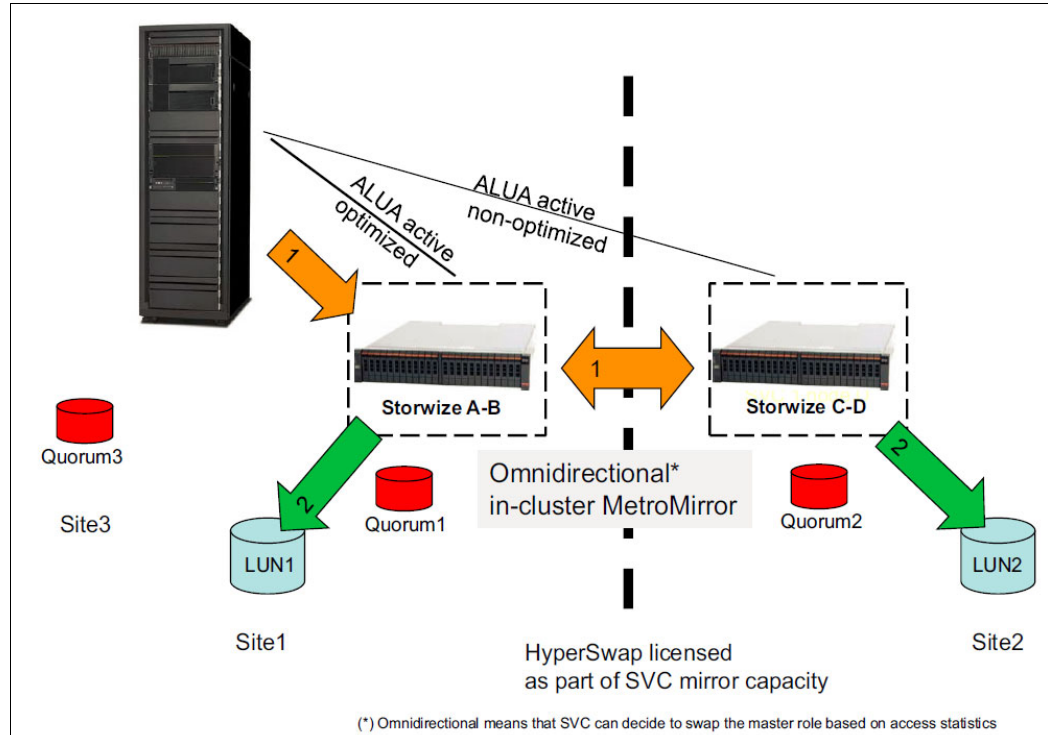


Figure 6-21 HyperSwap general setup

For more information, see *IBM Spectrum Virtualize HyperSwap configuration*, found at:
<http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102538>



Backup and recovery

This chapter describes the following enhancements to the backup and recovery functions in IBM i 7.2:

- ▶ 7.1, “Hardware support and connectivity” on page 270
- ▶ 7.2, “General save and restore functions” on page 272
- ▶ 7.3, “Backup, Recovery, and Media Services” on page 277

For more information about the IBM i 7.2 backup and recovery enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#/wiki/IBM%20Backup%2C%20Recovery%20and%20Media%20Services%20%28BRMS%29%20for%20i/page/Enhancements>

7.1 Hardware support and connectivity

The following hardware and connectivity topics are covered in this section:

- ▶ 7.1.1, “Support for IBM 3592-E08 tape drive” on page 270
- ▶ 7.1.2, “Support for LTO Ultrium 7 tape drive” on page 271
- ▶ 7.1.3, “SAN multipath and automatic fail-over support for tape drives” on page 272

7.1.1 Support for IBM 3592-E08 tape drive

IBM has released a new tape drive 3592 model E08 (3592-E08), which is also called the TS1150 tape drive or Jaguar-5 drive. It is supported in IBM i 7.2 for backup and recovery purposes, which allows improvements in capacity, performance, and functions.

Table 7-1 lists the general specifications of the 3592-E08 tape drive as compared to previous models.

Table 7-1 3592-E08 tape drive specifications as compared to previous models

3592 model	Jag-1 3592	Jag-2 TS1120	Jag-3 TS1130	Jag-4 TS1140	Jag-5 TS1150
Maximum cartridge capacity	300 GB	700 GB	1.0 TB	4.0 TB	8 - 10 TB
Data rate	40 MBps	100 MBps	160 MBps	250 MBps	Up to 360 MBps
Cartridge support	JA/JJ/JW/ JR	JA/JJ/JW/ JR/JB/JX	JA/JJ/JW/ JR/JB/JX	JA/JJ/JW/ JR/JB/JX JC/JY/JK	JC/JY/JK JD/JZ/JL
Encryption	N/A	Yes	Yes	Yes	Yes
Partitioning / LTFS	N/A	N/A	N/A	Yes	Yes
Server attachment	Fibre IBM FICON® ESCON	Fibre FICON ESCON	Fibre FICON ESCON	Fibre FICON ESCON	Fibre FICON

Media types

The IBM TS1150 tape drive introduces the following new media types:

- ▶ IBM 3592 Advanced Data Cartridge, Type D (JD)
 - Read/Write (R/W) Data Media
 - Up to 10 TB native capacity
- ▶ IBM 3592 Advanced WORM Cartridge, Type D (JZ)
 - Write-Once Read-Many (WORM) Media
 - Up to 10 TB native capacity
- ▶ IBM 3592 Economy Cartridge, Type D (JL)
 - Read/Write (R/W) Data Media
 - Up to 2 TB native capacity

In addition to new media types, the following two new logical formats are also introduced:

- ▶ Jag-5 or EFMT5 for Base Jaguar 5 logical format
- ▶ Jag-5 or EEFMT5 for Encrypted Jaguar 5 logical format

Media compatibility

The overall media support for 3592-E08 includes the following items:

- ▶ JD, JZ, and JL media types with Read/Write support in the new Jag-5
- ▶ JC/JY/JK (Type C) media types with Read/Write support in Jag-5 format at improved capacity and performance
- ▶ JC/JY/JK (Type C) media types with Read/Write support in Jag-4 format

Important: The JA and JB media types (including short and WORD versions) are *not* supported on the 3592-E08 tape drives.

Encryption capability

Compared to the previous model, there are no changes to the supported encryption methods for 3592-E08. The supported encryption method in IBM i is Library Managed Encryption (LME) that uses IBM Security Key Lifecycle Manager (SKLM), previously known as IBM Tivoli® Key Lifecycle Manager (TKLM).

For more information about the TS1150, see the IBM TS1150 product page:

<http://www.ibm.com/systems/storage/tape/ts1150/index.html>

For more information about removable media on IBM i, see the IBM developerWorks IBM Removable Media on the IBM i wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Removable%20Media%20on%20IBM%20i/page/IBM%20Removable%20Media%20on%20IBM%20i>

7.1.2 Support for LTO Ultrium 7 tape drive

IBM has released a new IBM LTO Ultrium 7 tape drive (LTO7 tape drive). It is supported in IBM i 7.2 for backup and recovery purposes, which allows improvements in capacity, performance, and functions. The LTO7 tape drive offers significant improvements over the LTO6 tape drives.

Note: The rule of compatibility matrix of new LTO devices remains unchanged. LTO7 tape drives support read and write operations to LTO7 and LTO6 data cartridges, but support only read operations to LTO5 data cartridges.

Here are some of the features of the LTO7 tape drives:

- ▶ Increased performance
The maximum throughput of the native data rate performance in LTO7 drives is up to 300 MBps. Data tracks are written 32 tracks at a time.
- ▶ Increased tape cartridge capacity
The compressed physical capacity of LTO7 cartridge is up to 15 TB, more than double from LTO6. This is achieved by increasing the linear density, track density, and the media length.
- ▶ Attachment options
The LTO7 tape drive comes with 8 Gbps Fibre Channel attachments in two LC duplex connectors.

For more information about removable media on IBM i, see the IBM developerWorks IBM Removable Media on IBM i wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Removable%20Media%20on%20IBM%20i/page/IBM%20Removable%20Media%20on%20IBM%20i>

7.1.3 SAN multipath and automatic fail-over support for tape drives

IBM i 7.2 provides support to allow most Fibre Channel tape and tape library devices to be attached by multiple paths to the same IBM i partition. These multiple paths work together in an automatic failover mechanism, which means that the SAN multipath configuration can be automatically recovered by using the alternate path when one of the paths is broken. The operating system manages this automatic fail-over process by switching the I/O connection to the other alternate path. This enhancement reduces the chances of tape backups failing to complete due to SAN path failure.

There are some limitations for this SAN multipath and automatic fail-over feature:

- ▶ IBM i 7.2 supports up to eight paths for each device.
- ▶ The SAN multipath functions that are available depend on the capability of the attached tape and tape library devices. Here are the supported devices for this feature:
 - Fibre Channel LTO5 and LTO6 drives in the 7226 enclosure
 - TS3100/TS3200 (3573) with LTO5 and LTO6 Fibre Channel drives
 - TS3310 (3576) with LTO5 and LTO6 Fibre Channel drives
 - TS3500/TS4500 with LTO5, LTO6, 3592-E07, and 3592-E08 Fibre Channel drives
 - IBM ProtecTIER® virtual tape library, code level 3.3.5.1 or newer
- ▶ Tape devices are sequential access devices, which means only one path to the device can be active at a time (active-passive mechanism).
- ▶ This feature uses the persistent reservation for the attached devices.
- ▶ SAN multipath attachment to IBM i partitions can be done to native IBM i, VIOS NPIV configuration, or a mix of both.
- ▶ SAN multipath attachment is not supported for the following devices:
 - SCSI attached tape devices
 - 3494 tape library
- ▶ In any case where automatic recovery is not possible, the manual procedure of failover by using vary off and vary on can be done.

Note: The device driver utilizes persistent reservation for drives that are supported by multipath. If the attached device is a device that emulates a supported IBM tape drive but does not support persistent reservation as expected, the result can be unpredictable.

7.2 General save and restore functions

IBM i 7.2 introduced new native save and restore function that can improve the recoverability of systems and assist with reducing the time that is necessary to perform saves and restores. More granular control of system backup and recovery also is implemented. Minor changes relating to features that are obsolete also occurred.

The following general save and restore function topics are covered in this section:

- ▶ 7.2.1, “Better control over journaling during restoration of objects” on page 273
- ▶ 7.2.2, “Faster configuration of independent disk pools with CFGDEVASP” on page 273
- ▶ 7.2.3, “Spooled file save enhancements” on page 275
- ▶ 7.2.4, “Select parameter (SELECT) added to various commands and APIs” on page 275
- ▶ 7.2.5, “TCP/IP configuration data that is saved automatically” on page 276
- ▶ 7.2.6, “Better IFS save performance with Asynchronous Bring” on page 276
- ▶ 7.2.7, “Modifications of the SAVE and RESTORE menus” on page 276
- ▶ 7.2.8, “Removal of obsolete functions” on page 277
- ▶ 7.2.9, “Improving single object restore performance” on page 277

7.2.1 Better control over journaling during restoration of objects

The following enhancements to allow better control over journaling during the restoration of objects were added:

- ▶ **Defer ID (DFRID)** during restore now includes journal start requests.

In IBM i 7.2, new functions are added that allows for the DFRID processing to also include journal start requests. This accommodates easier restoration of objects in libraries that are on the system before the library containing the journal to which they should be assigned being restored.

The types of objects whose journal start requests can be deferred are file, data area, data queue, and library. When the deferred objects are processed in subsequent commands, journaling is started if the journals are available then.

- ▶ **Start journaling (STRJRN)** parameter added to commands and APIs.

Multiple restore commands and APIs now include the parameter **STRJRN**, which can be applied to new objects during restore. The default is *YES, but if *NO is specified, the following two caveats to the restore operation apply:

- Journaling information is restored whether journaling is selected to be started or not.
- Journaling is not changed for any existing objects. The parameter applies to new objects only.

7.2.2 Faster configuration of independent disk pools with CFGDEVASP

Before IBM i 7.2, when you perform a disaster recovery of a system with independent disk pools, an IPL was required to start IBM Navigator for i. The IPL was required because the function for the creation of the disk pool was available only through the web interface.

At the base release of IBM i 7.2, the Configure Device ASP (**CFGDEVASP**) CL command was included and removes the requirement for an IPL during the recovery. Using this command, ASPs can be created by using the CL command interface. Use of this function has also been included in the BRMS reports for supporting a system restoration containing multiple ASPs.

Point of technical clarification: The **CFGDEVASP** CL command was introduced in IBM i 7.1, Technology Refresh 4. It is not included in the base release of IBM i 7.1, but it is included in the base release of IBM i 7.2. Also, the *PREPARE action is not available at any level of IBM i 7.1.

The **CFGDEVASP** CL command allows for the creation, deletion, and preparation of a new ASP. Figure 7-1 shows an example of how an ASP can be created by using the CL command interface.

```

                                Configure Device ASP (CFGDEVASP)

Type choices, press Enter.

ASP device . . . . . > MYNEWASP      Name, *ALL
Action . . . . . > *CREATE           *CREATE, *DELETE, *PREPARE
ASP type . . . . . > *PRIMARY        *PRIMARY, *SECONDARY, *UDFS
Protection . . . . . *NO             *NO, *YES
Encryption . . . . . *NO             *NO, *YES
Disk units . . . . . *SELECT         Name, *SELECT
                                + for more values
  
```

Figure 7-1 Initial display of the Configure Device ASP (CFGDEVASP) CL command

If ***SELECT** is specified for the **Disk units** parameter, pressing **Enter** allows for the selection of non-configured disk units. Figure 7-2 shows the selection of the non-configured disk units and the processing of the ASP creation, as indicated at the bottom of the display.

After the command processing is complete, a message stating the results is presented. The ASP can then be varied on and used.

```

                                Select Non-Configured Disk Units

ASP device . . . . . : MYNEWASP
Selected capacity . . . . . : 55929
Selected disk units . . . . . : 3

Type options, press Enter.
  1=Select

Resource
Opt  Name      Serial Number  Type Model  Capacity  Rank  Eligible
  1  DPH001    Y77MMXCMPQE5  6B22 0050  18643    002   Yes
  1  DPH002    Y3PL6FPHL33X  6B22 0050  18643    002   Yes
  1  DPH003    YZUG2T3V6YG8  6B22 0050  18643    002   Yes

                                Bottom

F1=Help  F9=Calculate Selection  F11=View 2  F12=Cancel
Configuration of ASP device MYNEWASP is 99% complete.
  
```

Figure 7-2 Display allowing selection of non-configured disk units for ASP creation

7.2.3 Spooled file save enhancements

The following spooled file save enhancements are added in IBM i 7.2:

- ▶ Save Changed Object (**SAVCHGOBJ**) supports saving spooled files.

Saving of spooled files is now supported by the **SAVCHGOBJ** CL command in IBM i 7.2 by specifying ***NEW** for the **SPLFDTA** parameter. There are various requirements and situations that might apply depending on the Reference Date (**REFDATE**) and Reference Time (**REFTIME**) parameters that are specified on the command:

- For each output queue that is saved, spooled file data that is created since the Reference Date and Reference Time is saved.
- Output queues that contain spooled files that are created after the Reference Date and Reference Time are considered changed and are saved.
- Output queues that contain spooled files with creation dates and times before the Reference Date and Reference Time are not considered changed and are not saved.

- ▶ Save Object List API can now specify spooled file expiration.

A new function is added to the Save Object List (**QSRSAVO**) API, which allows for expiry of spooled files after they are saved. For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apis/qsrsave.htm

7.2.4 Select parameter (**SELECT**) added to various commands and APIs

The Select (**SELECT**) parameter is added to many save and restore commands and APIs.

This new parameter allows for more granular saves and restores. Figure 7-3 shows an example of the new parameter in a Save Object (**SAVOBJ**) CL command.

The **SELECT** parameter can be used up to 300 times per command or with a ***USRSPC** input, but the 300 item limit still applies when using a user space.

When using a user space, you must define the parameters in the format that is used by the Save Object List (**QSRSAVO**) API. For more information about the Object List (**QSRSAVO**) API, see 7.2.3, “Spooled file save enhancements” on page 275.

```
Save Object (SAVOBJ)

Type choices, press Enter.

Select:
  Include or omit . . . . . *USRSPC, *INCLUDE, *OMIT
  Object . . . . . *ALL      Name, generic*, *ALL
  Library . . . . . *ALL     Name, generic*, *ALL
  Object type . . . . . *ALL  *ALL, *ALRTBL, *BNDDIR...
  Object attribute . . . . . *ALL Character value, *ALL, *BLANK
  File member . . . . . *ALL  Name, generic*, *ALL, *ALLMBR
      + for more values
```

Figure 7-3 Save Object (**SAVOBJ**) CL command with the new **SELECT** parameter

7.2.5 TCP/IP configuration data that is saved automatically

Whenever the QUSRSYS library is saved with the Save Library (**SAVLIB**) or Save Changed Objects (**SAVCHGOBJ**) CL commands, the current TCP/IP configuration information is also retrieved and saved. The command that is performed automatically to gather the system's current configuration information is Retrieve TCP/IP Information (**RTVTCPIF**).

If a system must be reloaded from distribution media, the TCP/IP configuration information can be updated by restoring the QUSRSYS library as part of the user data restore, and then running the following Update TCP/IP Information (**UPDTCPINF**) CL command (see Figure 7-4):

```
UPDTCPINF LIB(QUSRSYS)
```

```
Update TCP/IP Information (UPDTCPINF)

Type choices, press Enter.

Library . . . . . > QUSRSYS      Name
Type of information . . . . . *ALL      *ALL, *TCP, *TCPCFG...
```

Figure 7-4 Update TCP/IP Information (UPDTCPINF) CL command

Additional subsetting of what is restored during **UPDTCPINF** can be performed by specifying the required items on the Type of information parameter.

For more information about the **UPDTCPINF** CL command, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/updtcpinf.htm

Important: TCP/IP must be inactive when you run the **UPDTCPINF** CL command.

7.2.6 Better IFS save performance with Asynchronous Bring

The Asynchronous Bring (**ASYNCBRING**) parameter is part of the base function of IBM i 7.2 and is included in the **SAV** CL command. By specifying ***YES** on the **ASYNCBRING** parameter, there is the potential to improve the performance of some save operations. Asynchronous Bring attempts to preload items into memory to improve save performance.

Note: In situations where many objects are in a single directory, few objects qualify for a save, or the system is memory-constrained, the **ASYNCBRING** parameter being set to ***YES** might degrade performance. Testing is recommended to ensure that the correct results are achieved.

7.2.7 Modifications of the SAVE and RESTORE menus

Various items were changed on the **SAVE** and **RESTORE** menus:

- ▶ Removed from **SAVE** menu: Save storage and save calendars.
- ▶ Removed from **RESTORE** menu: Restore calendars.

In addition, new prompting fields are added to some of the commands when run from the **SAVE** or **RESTORE** menu to increase the customization of the particular save or restore command.

7.2.8 Removal of obsolete functions

The Save Storage (**SAVSTG**) and Restore Storage (**RSTSTG**) CL commands were removed in IBM i 7.2.

7.2.9 Improving single object restore performance

When restoring a single object from a tape sequence with several million blocks, most of the restore time is spent locating the object on tape. The **POSITION** keyword can be used to skip some blocks to reduce the time to locate the object. However, due to I/O restrictions for early tape technologies, there is a maximum value that can be skipped per request. The locating time might still be high if there are many requests.

IBM i 7.2 is enhanced to increase the maximum number of blocks that can be skipped per request to reduce the locating time for the object.

7.3 Backup, Recovery, and Media Services

Many new functions are introduced for Backup, Recovery, and Media Services (BRMS) in IBM i 7.2. The following BRMS topics are covered in this section:

- ▶ 7.3.1, “BRMS Enterprise” on page 277
- ▶ 7.3.2, “Usability improvements” on page 282
- ▶ 7.3.3, “Backup function enhancements” on page 282
- ▶ 7.3.4, “Recovery function enhancements” on page 289
- ▶ 7.3.5, “Media services enhancements” on page 290
- ▶ 7.3.6, “Maintenance enhancements” on page 300
- ▶ 7.3.7, “BRMS GUI in IBM Navigator for i enhancements” on page 302
- ▶ 7.3.8, “Migration enhancements” on page 310
- ▶ 7.3.9, “Miscellaneous BRMS enhancements” on page 315

Also, see the following IBM Backup, Recovery, and Media Services (BRMS) for i developerWorks wiki for BRMS detailed examples and usability tips. This wiki also includes the current information for new PTFs and enhancements.

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Backup%20and%20Media%20Services%20%28BRMS%29%20for%20i>

7.3.1 BRMS Enterprise

The following BRMS Enterprise enhancements in IBM i 7.2 are covered in this section:

- ▶ “New Q1ABRMENT subsystem for specific BRMS Enterprise functions” on page 278
- ▶ “Auto-refresh of the node status in IBM Navigator for i” on page 278
- ▶ “Print Report using BRM (PRTRPTBRM) CL command support for reporting” on page 279
- ▶ “Failed control group view to identify backup problems faster” on page 279

Reminder: BRMS Enterprise considers the system managing the remaining systems in the group as the “hub.” All other systems participating are “nodes.” It is not necessary for systems to be in a BRMS network for them to participate in BRMS Enterprise. In fact, even systems in various BRMS networks can participate in the same BRMS Enterprise instance.

New Q1ABRMMENT subsystem for specific BRMS Enterprise functions

A new subsystem that is called Q1ABRMMENT processes specific jobs and tasks that are related to BRMS Enterprise, which is in addition to the standard Q1ABRMNET subsystem that used for BRMS networking.

Auto-refresh of the node status in IBM Navigator for i

In IBM i 7.2, BRMS Enterprise provides an automatic refresh interval for the list of nodes. Default configurations have no automatic refresh selected; automatic refresh must be manually configured post installation. The base installation value is shown in Figure 7-5.

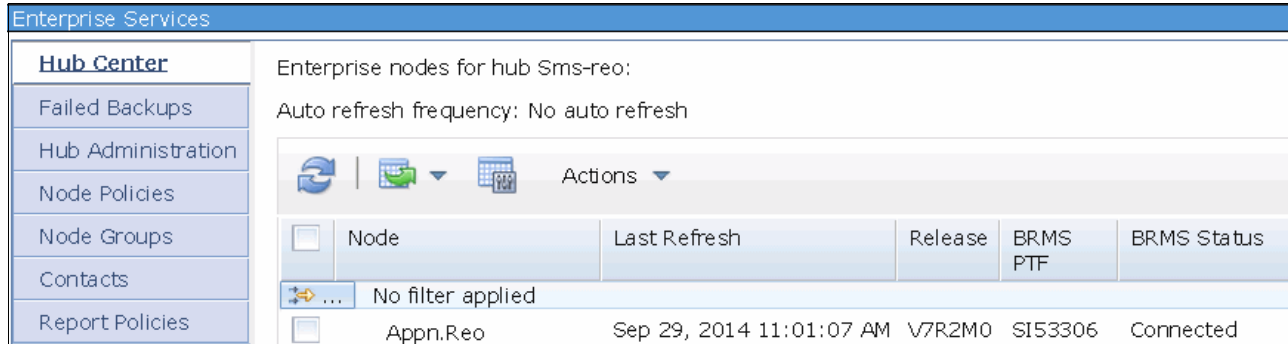


Figure 7-5 IBM Navigator for i window showing the default value for automatic refresh in BRMS Enterprise

To modify the value of the automatic refresh frequency, complete the following steps:

1. From BM Navigator for i, select **Backup, Recovery, and Media Services**.
2. In the Backup, Recovery, and Media Services section, select **Enterprise Services**.
3. In the Enterprise Services window, click the **Hub Administration** tab and specify the Auto refresh frequency setting, as shown in Figure 7-6. Click **OK**.

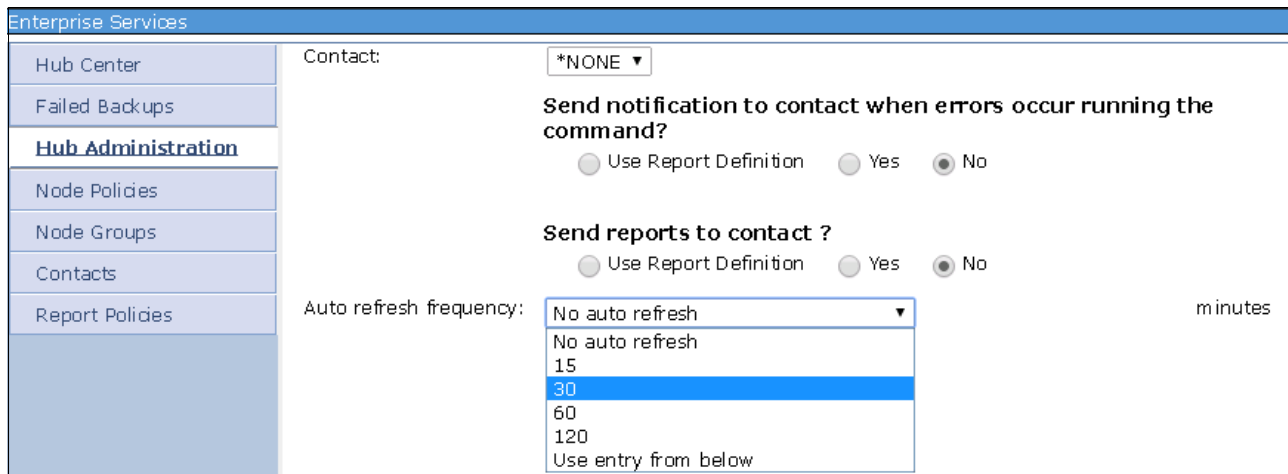


Figure 7-6 Specify the auto refresh value

4. The Auto refresh frequency selection is now displayed at the top of the window, as shown in Figure 7-7 on page 279.

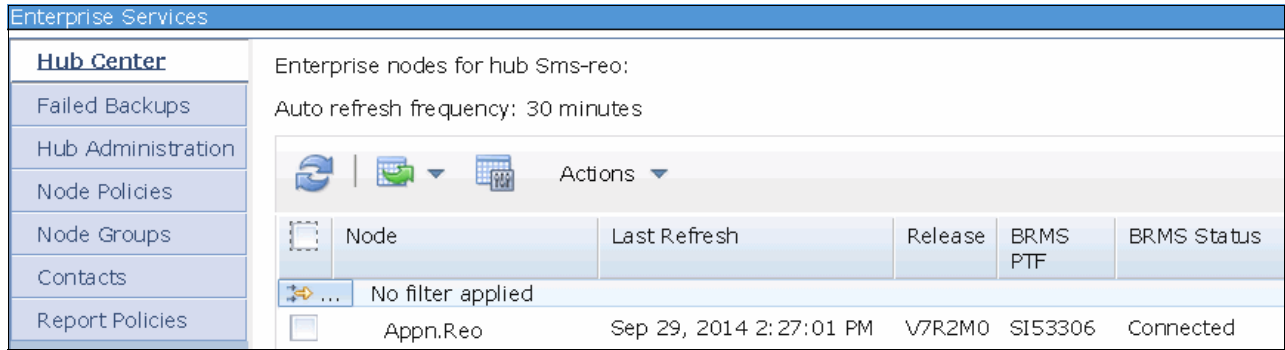


Figure 7-7 BRMS Enterprise hub center with an automatic refresh of 30 minutes specified

Print Report using BRM (PRTRPTBRM) CL command support for reporting

In addition to new options being added to the Print Report using BRM (PRTRPTBRM) CL command in IBM i 7.2, the report is available with additional options in BRMS Enterprise. Reports can be defined in BRMS Enterprise and processed against all nodes in the enterprise, not just nodes in a particular system BRMS network.

Note: The function to perform reporting for all systems in the BRMS Enterprise group exists only through the GUI.

To process the reports against systems in the BRMS Enterprise configuration, select ***ENT** as the target system, as shown in Figure 7-8.

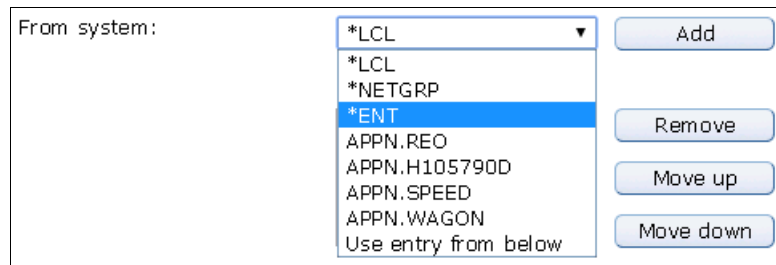


Figure 7-8 Select *ENT as an option for reporting within BRMS Enterprise

Failed control group view to identify backup problems faster

BRMS Enterprise provides a consolidated view of the backup status for multiple systems, which you can use to determine quickly whether backups are occurring properly, and if not, make it simpler to take steps to correct the situation.

To view the list of failed backups, complete the following steps:

1. From BM Navigator for i, select **Backup, Recovery, and Media Services**.
2. In the Backup, Recovery, and Media Services section, select **Enterprise Services**.

- In the Enterprise Services window, click the **Failed Backups** tab. The window that is shown in Figure 7-9 opens and shows that one of the systems, Appn.reo, had a failed backup on the current day.

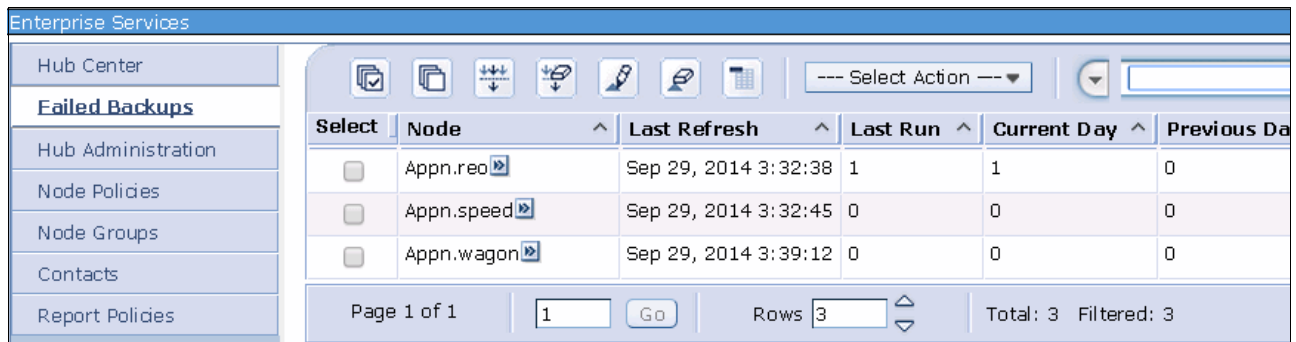


Figure 7-9 View of a BRMS Enterprise group containing a system with a failed backup

- More detail about the system and its failed backups can be reviewed by clicking the widget to the right of the system name and selecting **View failed backups**, as shown in Figure 7-10.

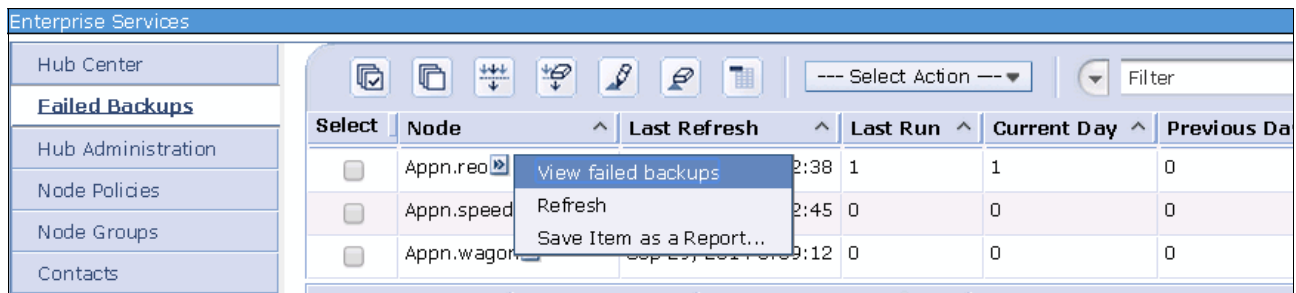


Figure 7-10 Select the view failed backups option

- The Failed Backups - Include window opens, which you can use to select various options for subsetting the view. You can specify a date range or the most recent failure, as shown in Figure 7-11. Click **OK**.

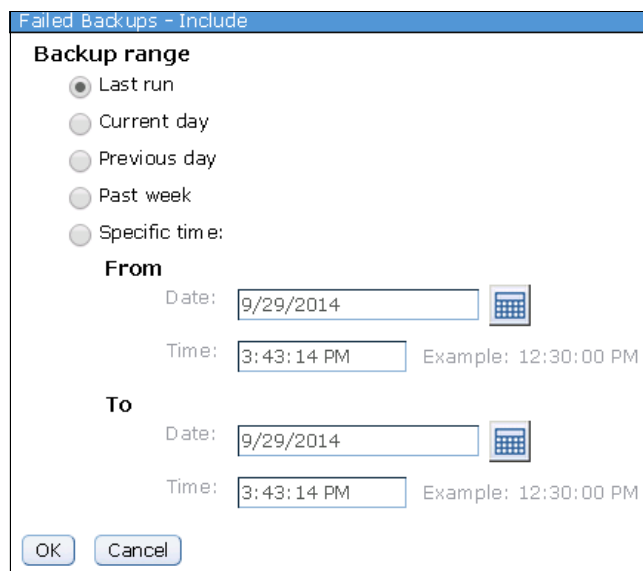


Figure 7-11 Options that are available for subsetting a view of failed backups

- The window that is shown in Figure 7-12 opens. You can use this window to use options such as viewing the BRMS logs, backup histories, failed backup histories, and producing a report of the failure.

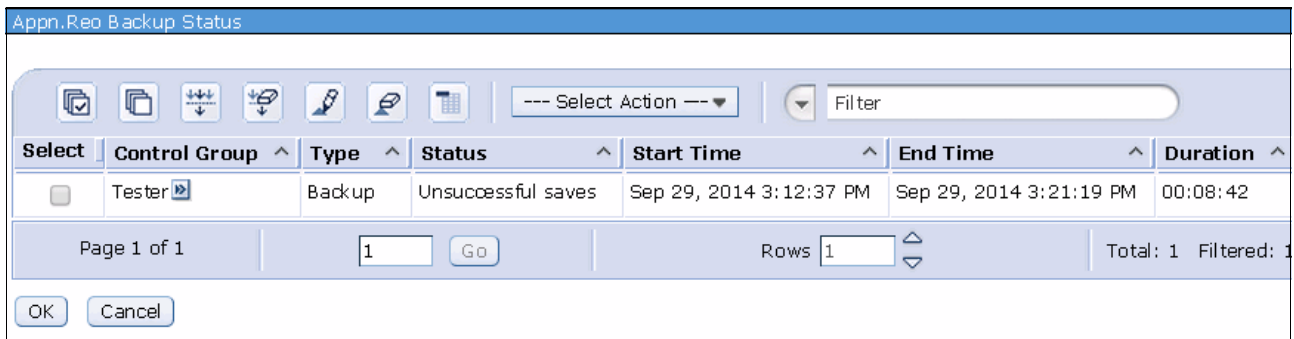


Figure 7-12 BRMS Enterprise view of an unsuccessful control group on a node

In IBM i 7.2, the consolidated view of the backup status in BRMS Enterprise is now enhanced to display more than 100 entries of backup processes, as shown in Figure 7-13. This improves the usability of BRMS users to view and manage more BRMS jobs in a single view.

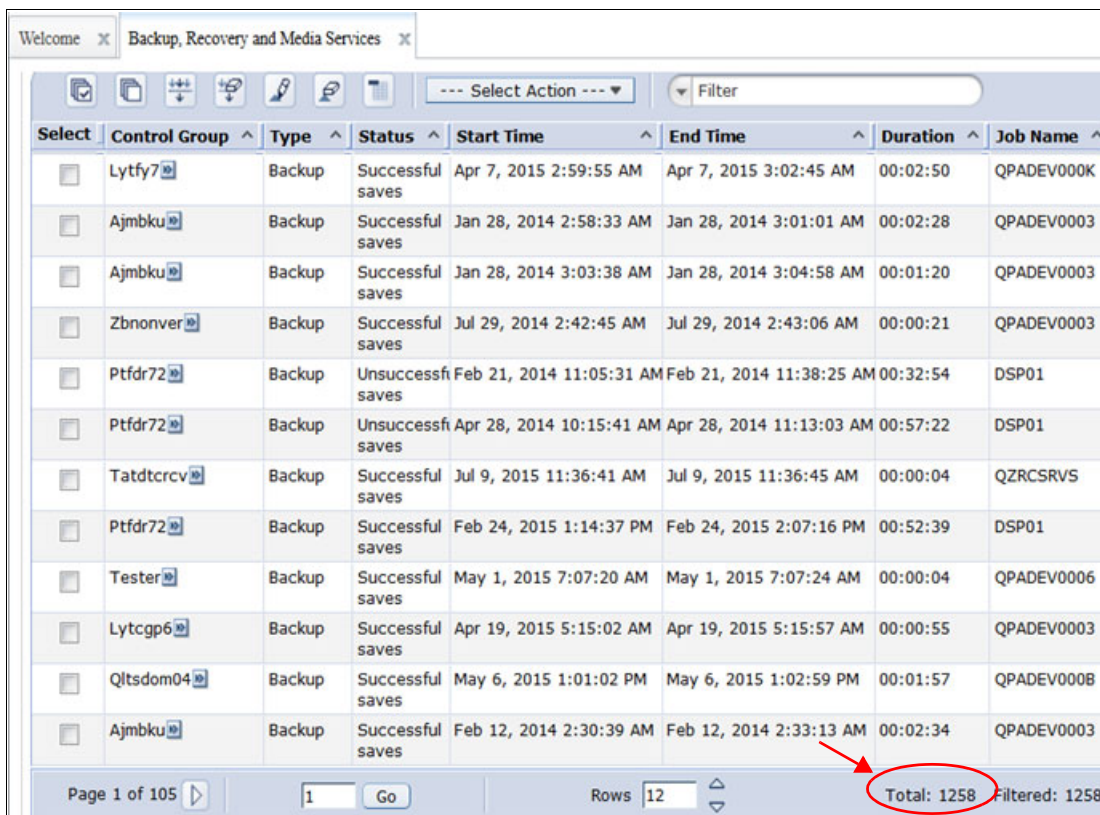


Figure 7-13 Backup status in BRMS Enterprise displays more than 100 entries

7.3.2 Usability improvements

Many BRMS features that in prior releases were addressed by running programs or creating data areas are now a part of the BRMS GUI and commands in IBM i 7.2. Some of these usability improvements are listed in Table 7-2.

Table 7-2 BRMS usability improvements in IBM i 7.2

Function	Prior release	IBM i 7.2
Modification of BRMS Flight Recorder size.	Call programs with various parameters.	Available in System policy.
Allow volumes that are marked for duplication to be moved.	Call programs with various parameters.	Available in Move policies.
Restore of spooled files from different time zones.	Creation of data areas required based on needs.	BRMS now handles time zone data automatically.
Disable the deleted library block on recovery reports.	Creation of data area.	Parameter within report creation command.

7.3.3 Backup function enhancements

This section reviews the following backup function enhancements in IBM i 7.2:

- ▶ “Backup lists now allow for *ALLUSR” on page 282
- ▶ “Object-level omits available in 5250 interface” on page 283
- ▶ “Control groups can save libraries in order of size” on page 284
- ▶ “Save contents of data queues” on page 284
- ▶ “Failure to reach restricted state recovery options” on page 284
- ▶ “Journal receiver save exclusions” on page 286
- ▶ “Incremental spool file backup support” on page 286
- ▶ “New message CPF3741 in BRMS log when an object is not saved” on page 286
- ▶ “Enhanced WRKMEDIBRM and RSTxxxBRM commands to support systems in FlashCopy mode” on page 287
- ▶ “Incremental saves on a spooled file with *ALL for the SPLFDTA parameter” on page 288

Backup lists now allow for *ALLUSR

To support more granular saves, a backup list can now support an entry of *ALLUSR. You can specify *ALLUSR as the main inclusion and then omit specific objects or groups of objects. Additionally, by putting *ALLUSR in a backup list, libraries reflect their individual save times rather than all libraries within the *ALLUSR selection showing the same save time stamp.

For more information about performing object-level omits, see “Object-level omits available in 5250 interface” on page 283.

Object-level omits available in 5250 interface

Before IBM i 7.2, excluding specific objects within libraries required using the BRMS GUI. In IBM i 7.2, this GUI is no longer required. However, any control groups with object-level omits that are defined by the BRMS GUI in IBM i 7.1 or an earlier release must continue to be managed with the BRMS GUI. To manage a control group's object-level omits in either the 5250 interface or the GUI, the control group must be re-created in IBM i 7.2 and exclusions that use BRMS lists must be implemented.

Note: Omits that are specified by using the BRMS Backup policy are ignored by any control group that uses a BRMS list with object omits.

Figure 7-14 shows an example of an object list that saves the *ALLUSR set of libraries, but excludes specific objects within various libraries.

Seq	Library	Object	Type	Attribute	Member	Inc/Exc
10	*ALLUSR	*ALL	*ALL	*ALL	*ALL	*INC
20	ARCHIVE	BIGFILE*	*FILE	*ALL	*ALL	*EXC
30	YEAREND	PREMERGER	*FILE	*ALL	*ALL	*EXC
40	MUSIC	*ALL	*ALL	*ALL	*ALL	*EXC

Figure 7-14 BRMS object list containing the *ALLUSR value along with specific exclusions

The same list can be accessed and modified by using IBM Navigator for i. Figure 7-15 shows the same ALLUSROMIT object list that is shown in Figure 7-14.

Selected Objects:

Select	Omit	Library	Object	Object Type	Attribute	Member
<input type="radio"/>	<input type="checkbox"/>	*Allusr	All objects	All object types	All	All members
<input type="radio"/>	<input checked="" type="checkbox"/>	Archive	Bigfile*	File	All	All members
<input type="radio"/>	<input checked="" type="checkbox"/>	Yearend	Premerger	File	All	All members
<input type="radio"/>	<input checked="" type="checkbox"/>	Music	All objects	All object types	All	All members

Figure 7-15 View for the same omit object list within IBM Navigator for i

Note: In IBM i 7.2, to enable the function for include/exclude within BRMS object lists, PTF SI53306 or its most current supersedent is required.

Control groups can save libraries in order of size

By default, BRMS saves libraries alphabetically. In an effort to improve potentially save performance, especially in environments where multiple tape devices are used in parallel, a value of *SIZE can be chosen.

When specifying *SIZE for the Sort By parameter in the control group attributes, or alternatively in the Backup policy if the control group specifies *BKUPCY for its attribute retrieval, the system saves the libraries in order of largest to smallest based on the size attributes that are acquired during prior save operations.

Note: If a save by *SIZE is selected and a new library that has not been saved by BRMS is selected to be saved, the new library is saved after all libraries with known sizes are processed. BRMS cannot acquire the size and include the new library in a sort order until it is saved once and its size is determined.

Save contents of data queues

In addition to the data queue objects themselves, BRMS can now be instructed to save the contents of the data queues.

To activate this option, change the control group attribute of Save Queue Data to *DTAQ. If this is required on a system-wide level, ensure that the control group is set to *BKUPCY for the Save Queue Data parameter and change the parameter in the Backup policy instead.

Failure to reach restricted state recovery options

Certain situations exist where intentions for a restricted statesave do not function as required. In this case, the system can potentially become hung in a manner where it is not entirely down, but cannot restart. This situation usually results in a skipped Save System (SAVSYS) section of the backup, and unpredictable results when the save completes.

BRMS has the following new options that you can use to handle these situations in a more automatic manner:

- ▶ Abnormal end delay time option in System policy.

BRMS includes a new option in IBM i 7.2 that can issue abnormal job ends against processes that fail to terminate during normal shutdown processes. The option is available in the System policy, as shown in Figure 7-16.

V7R2M0	Change System Policy	REO
Type choices, press Enter.		
End all subsystems options		
Controlled end delay time	1200	1-99999 seconds,*IMMED
Abnormal end delay time	30	10-999 minutes,*NOLIMIT
End servers wait time	0	0-9999 seconds

Figure 7-16 Subsystem end options in IBM i 7.2 in BRMS System Policy

By using this function, the system can issue End Job Abnormal (ENDJOBABN) CL commands against jobs that have not ended normally through the use of controlled options.

The Controlled end delay time parameter is used to determine how long to wait before ending active jobs immediately. After active jobs have started to end with the end job immediate option, the Abnormal end delay time parameter is used to determine how long to wait before ending active jobs abnormally.

Note: Issuing **ENDJOBABN** in any situation causes the subsequent IPL to be flagged as abnormal. This can increase the amount of time for the IPL to process.

- ▶ Alternative option for BRMS behavior when unable to restrict system.

BRMS can now be configured to fail rather than bypass the Save System (**SAVSYS**) CL command if the system cannot reach a restricted state. To enable this function on a system-wide basis, run the following command:

```
CRTDTAARA DTAARA(QUSRBRM/Q1ANOSYSBP) TYPE(*CHAR) LEN(1)
```

To enable this function for only a specific job (for example, create the data area in a control group exit before running the **SAVSYS CL** command), run the following CL command:

```
CRTDTAARA DTAARA(QTEMP/Q1ANOSYSBP) TYPE(*CHAR) LEN(1)
```

Note: When requiring this function in a specific job, a good example is creating the data area in a control group exit before running the **SAVSYS CL** command.

- ▶ BRMS can automatically undergo an IPL if the controlling subsystem cannot start.

BRMS can also be configured to perform automatically an IPL of the system if CPF1099 is received when attempting to restart the controlling subsystem. This message is received if the system previously attempted to restrict the system, but has thus far been unable to reach a restricted state. The only recovery option in this situation is to perform an IPL. BRMS can handle this task on its own now, potentially saving hours of downtime.

If BRMS receives a CPF1099 when it tries to start the controlling subsystem and data area QUSRBRM/Q1AIPLSUB exists, the system undergoes IPL. IPL options from the control group are used. These options can reference the BRMS Backup policy or even the BRMS System policy.

Important: The control group does not need to be set to IPL *YES in order for this IPL to occur.

To enable this function, run the following CL command:

```
CRTDTAARA DTAARA(QUSRBRM/Q1AIPLSUB) TYPE(*CHAR) LEN(1)
```

- ▶ Automatic restart on abnormal ends of **STRBKUBRM**.

The following parameters now exist for the **STRBKUBRM CL** command to allow for automatic retries if the backup ends abnormally:

- Allow Retry (**ALWRTY**)
Provides choices of *NO or *YES.
- Retry Time Limit (**RTYTIMLMT**)

If the Allow Retry parameter is set to *YES, and an abnormal end occurs within the specified time limit after the control group begins processing, then the backup control group is retried. Allowable values are *NOMAX and 1 - 99999, where 1 - 99999 are in minutes.

– **Retry Starting Sequence (RTYSTRSEQ)**

Three choices are available for the Retry Starting Sequence (RTYSTRSEQ) parameter, which are *ERRSEQ, *STRSEQ, or *NXTSEQ:

- If *ERRSEQ is selected, the sequence that received the abnormal end is retried.
- If *STRSEQ is selected, the entire control group is started from the beginning.
- If *NXTSEQ is selected, the next sequence in the control group is processed, skipping the one that ended abnormally.

Journal receiver save exclusions

Function exists in BRMS across multiple versions of IBM i to allow saving of only changed or detached journal receivers by using the values of *CHGJRNRCV or *DTCJRNRCV in a control group. These special values are modified to process journals from libraries with names that start with the letter Q.

In IBM i 7.2, excluded entries can be specified in object list QCHGJRNRCV or QDTCJRNRCV to exclude certain journals from the save.

Numerous customization options exist for this particular feature. The most current information and required PTFs are available on the IBM Backup, Recovery, and Media Services (BRMS) for i DeveloperWorks wiki at the BRMS wiki page:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Backup%20Recovery%20and%20Media%20Services%20%28BRMS%29%20for%20i>

Incremental spool file backup support

In IBM i 7.2, BRMS now can perform incremental spooled file saves without requiring the use of a BRMS *SPL list.

Users who have previously handled spool file saves by using BRMS lists might find that simply changing the attribute on a different control group (one that contains the out queues that are needed) to save spool data will meet their needs of saving spool files. This can potentially save time and effort by reducing the number of save operations that are required.

New message CPF3741 in BRMS log when an object is not saved

In IBM 7.2, a new message is added to the BRMS log when there is a condition where an object is not saved during the save operation. This is a helpful feature for users to know about the unsaved objects from the BRMS log. The details of this message are shown in Figure 7-17 on page 287.

```
Display Formatted Message Text
System: IBMSYS1
Message ID . . . . . : CPF3741
Message file . . . . . : QCPFMSG
Library . . . . . : QSYS

Message . . . . : &2 &1 in &3 not saved.
Recovery . . . : Press F10 or use the Display Job Log (DSPJOBLOG) command
to see the previously listed messages. Correct any errors and try the
request again.

Bottom

Press Enter to continue.

F3=Exit F11=Display unformatted message text F12=Cancel
```

Figure 7-17 CPF3741 message description

Enhanced WRKMEDIBRM and RSTxxxBRM commands to support systems in FlashCopy mode

The parameter **FROMSYS** in the **WRKMEDIBRM** command is enhanced to support systems that are in FlashCopy mode. With this enhancement, users can see the media information of the FlashCopy system by running the **WRKMEDIBRM** command on the primary partition. This enhanced **FROMSYS** parameter also applies to the **RSTxxxBRM** commands so that users can easily restore an object from a FlashCopy system to the primary partition.

Figure 7-18 shows the example of the **RSTOBJBRM** command with the **FROMSYS** parameter pointing to a FlashCopy system.

```

Restore Object using BRM (RSTOBJBRM)

Type choices, press Enter.

Allow object differences . . . . ALWOBJDIF      *NONE
                               + for more values
Private authorities . . . . . PVTAUT          *NO
Restore to library . . . . . RSTLIB          *SAVLIB
Auxiliary storage pool . . . . . RSTASP      *SAVASP
From system . . . . . FROMSYS          APPN.UT30P05

Additional Parameters

Output . . . . . OUTPUT          *NONE
File to receive output . . . . . OUTFILE
Library . . . . . LIBL          *LIBL
Output member options:      OUTMBR
Member to receive output . . . . . *FIRST
Replace or add records . . . . . *REPLACE

Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys

```

Figure 7-18 FROMSYS parameter on the RSTOBJBRM command

Incremental saves on a spooled file with *ALL for the SPLFDTA parameter

You can use IBM i 7.2 to perform incremental saves on a spooled file. This save operation is based on the creation date of the spooled file. The incremental save backs up all specified spooled files with a created date after the last incremental save reference date.

This incremental save on a spooled file can be performed with the **SAVxxxBRM** commands by using a control group with spooled file list (***SPL**) entries, ***ALL** for the spooled file data (**SPLFDTA**) parameter, and ***INCR** for Type of save (**SAVTYPE**) parameter, as shown in the example in Figure 7-19 on page 289.

```

                                Save Object using BRM (SAVOBJBRM)

Type choices, press Enter.

Data compression . . . . . DTACPR          *DEV
Data compaction . . . . . COMPACT         *DEV
Save contents of save files . . SAVFDTA   *YES
Spooled file data . . . . . SPLFDTA     > *ALL
Queue data . . . . . QDTA                *NONE
Type of save . . . . . SAVTYPE       > *INCR
Reference date . . . . . REFDATE         *REF
Reference time . . . . . REFTIME         *REF
Journaled objects . . . . . OBJJRN       *NO
Objects to omit:
  Object . . . . .                      *NONE
  Library . . . . .                      *ALL
  Object type . . . . .                  *ALL
                                + for more values
Auxiliary storage pool . . . . . ASPDEV   *SYSBAS
Expiration date . . . . . EXPDATE       *MEDPCY
                                                                More...

F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel   F13=How to use this display
F24=More keys

```

Figure 7-19 SAVOBJBRM command showing the ability to save a spooled file incrementally

7.3.4 Recovery function enhancements

This section reviews the following recovery function enhancements in IBM i 7.2:

- ▶ “Recovery reports now use commands for ASP creation” on page 289
- ▶ “Spool file restore based on time zone” on page 289
- ▶ “Restoring libraries by using BRM (RSTLIBBRM) with *RSTLST” on page 290

Recovery reports now use commands for ASP creation

In IBM i 7.2, recovery reports that are created by using the Start Recovery using BRM (**STRRCYBRM**) or Start Maintenance for BRM (**STRMNTBRM**) CL commands are enhanced to use the Configure Device ASP (**CFGDEVASP**) CL command to configure independent auxiliary storage pools (IASPs). The step where you performed an IPL of the system to configure IASPs was removed from recovery reports.

For more information about the Configure Device ASP (**CFGDEVASP**) CL command and how it can improve recovery time, see 7.2.2, “Faster configuration of independent disk pools with CFGDEVASP” on page 273.

Spool file restore based on time zone

BRMS now tracks the time zone in which a spooled file was created, which assists with the restoration of spooled files based on time, especially when being performed on a system in a different time zone. The time zone is tracked within the saved spooled file details file in the field OQTIMZON.

Note: The time zone in which the spooled file was created is not available for viewing from standard BRMS panels.

Restoring libraries by using BRM (RSTLIBBRM) with *RSTLST

When performing a library restoration by using BRMS, a list of libraries can be specified in a BRMS list. After that list is defined, the list can be specified and the restoration processed. To create the list, run the **WRKLIBRM** CL command and create a *BKU list of type *OBJ. Specify each library for restore in the newly created list.

One example where this function can be useful is if a restore is integral to a compiled program. Rather than needing to modify the program code each time a library needed to be removed or added to the process, all that is necessary is to modify the BRMS object list.

Example 7-1 shows the command syntax for saving 15 libraries.

Example 7-1 Restoration of 15 libraries by using RSTLIBBRM

```
RSTLIBBRM SAVLIB(DATALIB001 DATALIB002 DATALIB003 OBJLIB001A OBJLIB002A
OBJLIB003A CUSTOM123 ARCH_2013 ARCH_2012 ARCH_2011 ARCH_2010 SECURE UNSECURE
MISC_STUFF MYNEWDATA) DEV(TAPMLB01)
```

As shown in Example 7-2, using a BRMS *RSTLST, the command is smaller and now can easily be modified by using the BRMS list rather than needing to modify a program.

*Example 7-2 Restoration of libraries that are specified in a *RSTLST by using RSTLIBBRM*

```
RSTLIBBRM SAVLIB(*RSTLST) DEV(TAPMLB01) RSTLST(MYRSTLST)
```

7.3.5 Media services enhancements

This section reviews the following media services enhancements in IBM i 7.2:

- ▶ “Resetting the move cycle in the Move policy”
- ▶ “Support for moving media that are marked for duplication” on page 292
- ▶ “Initializing media on expiration in a media class” on page 292
- ▶ “Submitting DUPMEDBRM in a batch job” on page 293
- ▶ “CHGMEDBRM command with the Location and Container parameters” on page 294
- ▶ “Support to eject a tape media library volume on remote systems” on page 295
- ▶ “Enhanced assigned alternate media when the original is not available” on page 296
- ▶ “Support media expiration date after 12/31/2038” on page 296
- ▶ “Marking a volume for duplicate and marking history for duplicate” on page 297
- ▶ “Support for checking the number of expired media for a save operation” on page 298

Resetting the move cycle in the Move policy

The Move policy in IBM i 7.2 introduces *RESET as a new value for Duration field. The *RESET value indicates that the media remains in that location sequence until it expires or until another save is written to the media. If no writes are done to the media, the media stays in this location until it expires and then returns to the home location. Otherwise, if a write is done to the media while in this location, the move pattern is reset to the first move sequence and the creation date of the media is set to the current date and time.

Note: Move policy sequences after a sequence with *RESET duration are not used.

Figure 7-20 shows the example of *RESET in the Change Move Policy CL command.

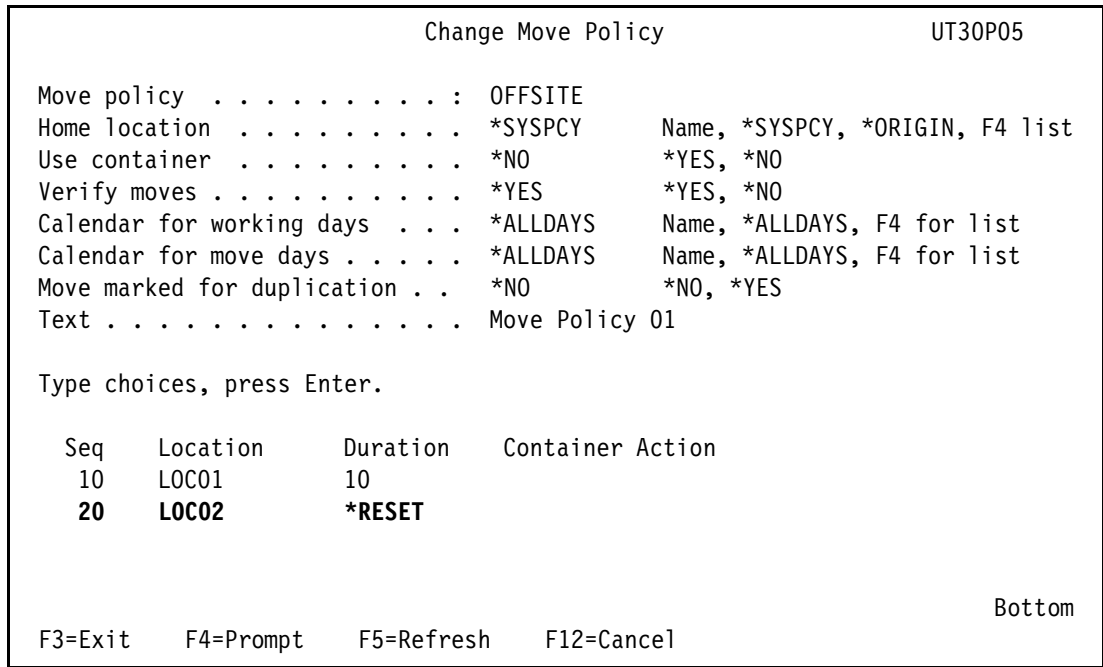


Figure 7-20 Reset a move cycle in the Change Move Policy CL command

This feature is also available in IBM Navigator for i, as shown in Figure 7-21.

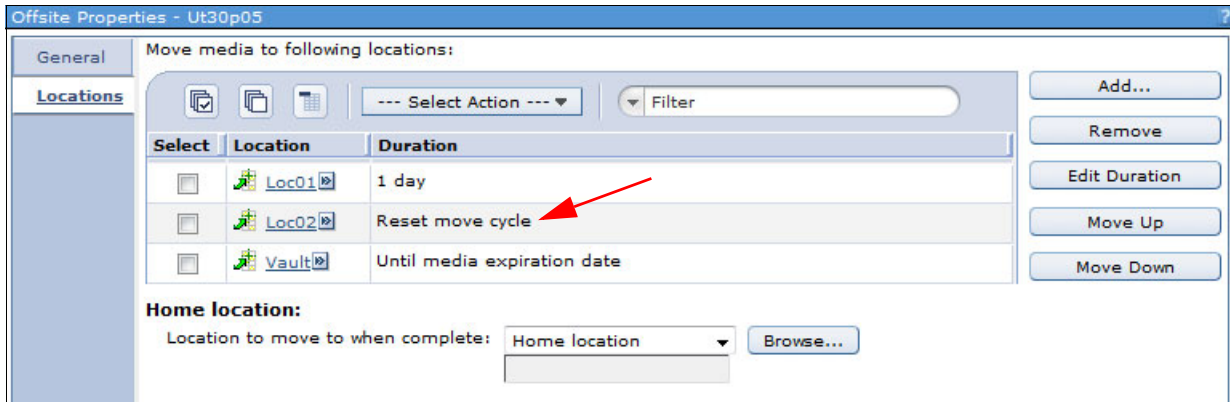


Figure 7-21 Reset a move cycle in IBM Navigator for i

Support for moving media that are marked for duplication

You can use IBM i 7.2 to move the media that is marked for duplication. You can see this feature in the Change Move Policy CL command with the Move marked for duplication parameter, as shown in Figure 7-22. If this parameter is set to *YES, the Move policy includes volumes that are marked for duplication during media movement.

```

Change Move Policy                                     UT30P05

Move policy . . . . . : OFFSITE
Home location . . . . . *SYSPCY      Name, *SYSPCY, *ORIGIN, F4 list
Use container . . . . . *NO         *YES, *NO
Verify moves . . . . . *YES        *YES, *NO
Calendar for working days . . . *ALLDAYS  Name, *ALLDAYS, F4 for list
Calendar for move days . . . . *ALLDAYS  Name, *ALLDAYS, F4 for list
Move marked for duplication . . *YES      *NO, *YES
Text . . . . . Entry created by BRM configuration

Type choices, press Enter.

Seq   Location   Duration   Container Action

  10   VAULT     *EXP

F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel

Bottom
  
```

Figure 7-22 Change Move Policy CL command with the option to move marked for duplication

This feature is also available in IBM Navigator for i, as shown in Figure 7-23.

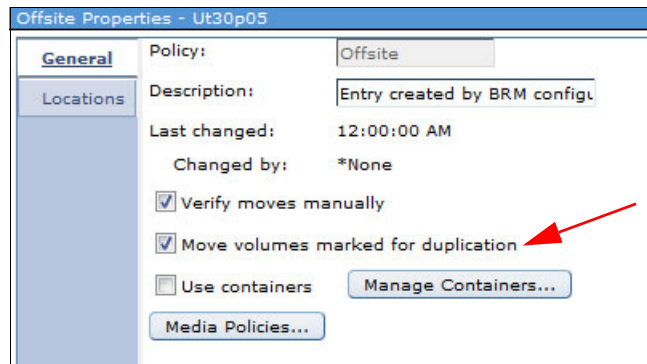


Figure 7-23 Move volumes that are marked for duplication parameter in IBM Navigator for i

Initializing media on expiration in a media class

IBM i 7.2 supports the option to initialize media on expiration when setting up the media class. If this parameter is set to *YES, BRMS automatically initializes the media after it is expired. Initialization occurs during the STRMNTBRM process and requires the media to be mounted on a device.

Figure 7-24 shows the Change Media Class CL command with the Initialize media on expiration parameter set to *NO.

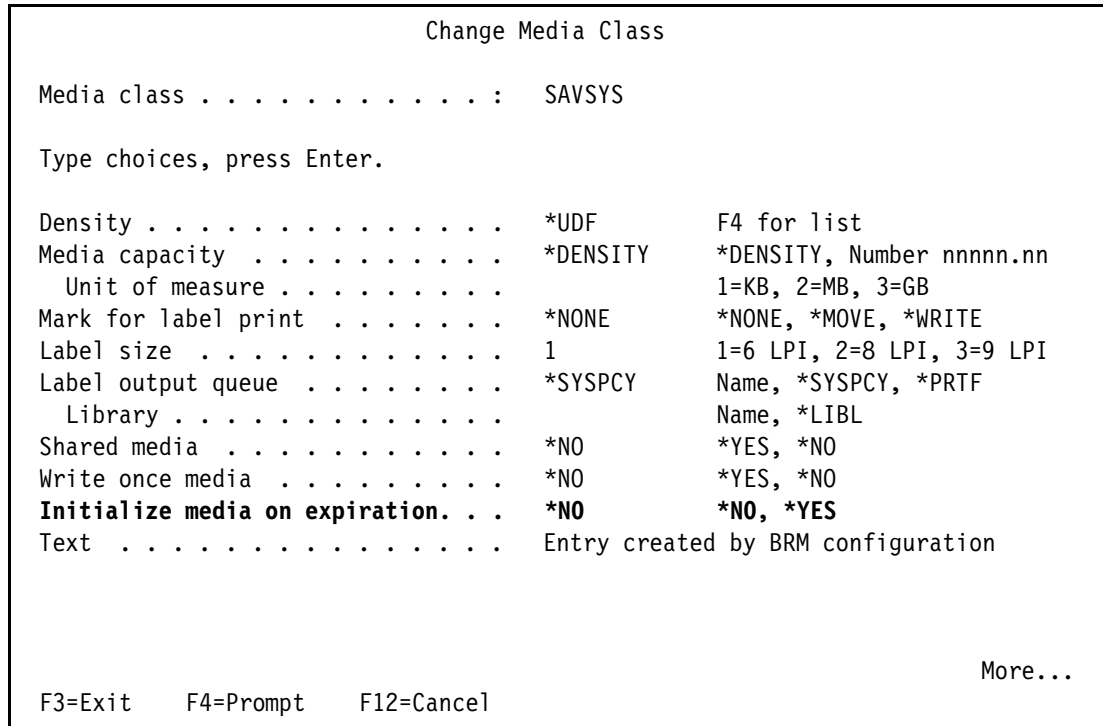


Figure 7-24 Change Media Class CL command with the parameter for expired media initialization

This feature is also available in IBM Navigator for i, as shown in Figure 7-25.

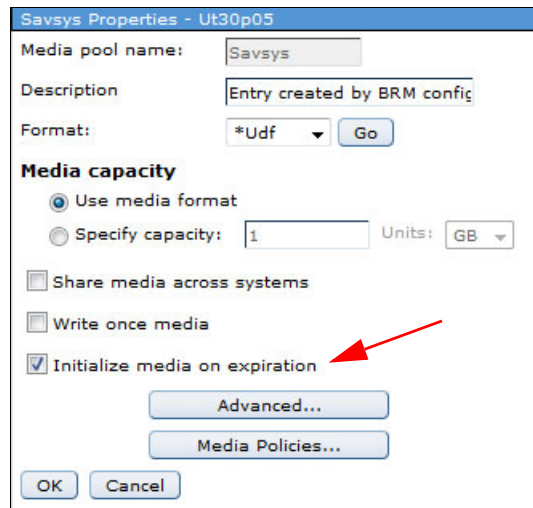


Figure 7-25 Initialize media on expiration in IBM Navigator for i

Submitting DUPMEDBRM in a batch job

IBM i 7.2 enhances the Duplicate Media using BRM (**DUPMEDBRM**) CL command with the Submit batch options parameter, which you can use to run media duplication processes in batch and indicate the number of media sets to be produced. The job queue and the job description for this batch job submission uses the settings that are specified in the System policy.

Figure 7-26 shows the **DUPMEDBRM** CL command with the Submit batch options.

```

Duplicate Media using BRM (DUPMEDBRM)

Type choices, press Enter.

From system . . . . . *LCL
Submit batch options:
  Submit to batch . . . . . > *YES          *NO, *YES
  Media sets . . . . . *MEDSET          1-99, *MEDSET

Additional Parameters

To volume identifier . . . . . *MOUNTED
      + for more values
Retain object detail . . . . . *NO          *NO, *YES
Expiration date . . . . . *MEDPCY         Date, *MEDPCY, *PERM...
Move policy . . . . . *MEDPCY           *MEDPCY, *NONE, OFFSITE
Media class . . . . . *MEDPCY           *MEDPCY, *SYSPCY ...
Location . . . . . *MEDPCY             *MEDPCY, *ANY, *HOME ...
Secure volume . . . . . *MEDPCY        *MEDPCY, *NO, *YES
Required volumes . . . . . *MEDPCY      1-9999, *MEDPCY, *NONE
                                                    More...

F3=Exit   F4=Prompt   F5=Refresh   F12=Cancel   F13=How to use this display
F24=More keys

```

Figure 7-26 **DUPMEDBRM** CL command with Submit batch options

This new **DUPMEDBRM** enhancement is helpful in the following examples:

- ▶ There are multiple media sets that are produced from the backup processes.

To have multiple media sets duplicated by using multiple tape resources, you can easily issue only one **DUPMEDBRM** CL command with the Submit to batch parameter set to ***YES** and the Media sets parameter set to a required number of output media set.
- ▶ Backup and recovery processes that use ProtecTier TS7650 Virtual Tape Library (VTL).

Users that use VTL for their backup and recovery usually have multiple tape resources for parallel save and restore. When duplicating multiple virtual tapes to physical tapes, they usually expect less physical tapes being produced than the virtual ones. With this enhancement, you can use the Media sets parameter to specify the number of output media sets to be less than the number of input media sets. Therefore, they can have less media sets produced as physical tapes.

Note: **DUPMEDBRM** in batch processes does not work for auto-duplication.

For more information about the **DUPMEDBRM** CL command, see IBM Knowledge Center:
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/dupmedbrm.htm?lang=en

CHGMEDBRM command with the Location and Container parameters

IBM i 7.2 enhances the Change Media using BRM (**CHGMEDBRM**) command to support the Location and Container parameters, which allows users to move a single volume to a different location or container.

Figure 7-27 shows the **CHGMEDBRM** command with the Location and Container parameters.

```

Change Media using BRM (CHGMEDBRM)

Type choices, press Enter.

Volume identifier . . . . . > A00001
Media class . . . . . SAVSYS          *SAME, FMTOPTUDF, SAVSYS,...
Expiration date . . . . . '10/31/40'  Date, *SAME, *PERM, *NONE
Last moved date . . . . . *NONE       Date, *SAME, *NONE
Move policy . . . . . *NONE          *SAME, *NONE, OFFSITE
Exempt from movement . . . . . *SAME  0-9999, *SAME
Creation date . . . . . '10/16/15'    Date, *SAME
Secure volume . . . . . *NO          *SAME, *NO, *YES
Slot number . . . . . *NONE          1-999999, *SAME, *NONE
System . . . . . APPN.UT30P05
Text . . . . . *NONE

Image catalog . . . . . *NONE        Name, *SAME, *NONE
Location . . . . . *HOME          *SAME, *HOME, LOC01,...
Container . . . . . *NONE        *SAME, *NONE

Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys

```

Figure 7-27 CHGMEDBRM command with Location and Container parameters

For more information about the **CHGMEDBRM** command, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/chgmedbrm.htm?lang=en

Support to eject a tape media library volume on remote systems

In IBM i 7.2, if media that is being moved is owned by another system and the media is in an MLB that is not configured on the system doing movement, BRMS can be set up to attempt to eject the volume from the tape media library (MLB) on the system that owns the volume.

To enable this function, run the following command:

```
CRTDTAARA DTAARA(QUSRBRM/Q1ARMTEJT) TYPE(*CHAR)
```

Note: When volumes are set for duplications, BRMS does not move or request that these volumes be ejected from MLBs until the duplication process completes. Message ID BRM1364 is posted and the volume remains at the current location.

Enhanced assigned alternate media when the original is not available

Users can select the “Allow alternate input media” option in the System Policy to allow BRMS to use the alternate media as an input when the requested original input media is not available.

For a restore operation, if the media for the restore operation is not found, BRMS attempts to locate and use a duplicate volume to complete the restore operation. In IBM i 7.2, parallel restores try more than five alternate media sets to complete the restore operation.

Figure 7-28 shows the Change System Policy command with the “Allow alternate input media” parameter specified.

```

V7R2M0                      Change System Policy                      UT30P05

Type choices, press Enter.

End all subsystems options
  Controlled end delay time . . . . . 01200          1-99999 seconds,*IMMED
  Abnormal end delay time . . . . . *NOLIMIT        10-999 minutes,*NOLIMIT
  End servers wait time . . . . . 0                0-9999 seconds
Controlling subsystem:
  Allow backups in batch . . . . . *NO              *NO, *YES
  Restricted state time limit . . . . . *NOMAX       5-9999 minutes, *NOMAX
  Allow alternate input media. . . . . *YES        *NO, *YES
  Volume prefix . . . . .                          Prefix
  Enable FlashCopy . . . . . *NO                   *NO, *YES
BRMS submitted jobs:
  Job description. . . . . *USRPRF                 Name, *USRPRF
  Library. . . . .                                     Name, *LIBL, *CURLIB
  Job queue. . . . . *JOBDB                         Name, *JOBDB
  Library. . . . .                                     Name, *LIBL, *CURLIB
  BRMS flight recorder size . . . . . 050          001-999 megabytes
                                                    Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel

```

Figure 7-28 Change System Policy command with the Allow alternate input media option

Support media expiration date after 12/31/2038

Prior to IBM i 7.2, BRMS did not support creating media with an expiration date after 12/31/2038. Even media policies can be set up with a retention type of day for up to 9,999 days, but for media volumes that have an expiration date after 12/31/2038, BRMS converted the expiration to *PERM.

In IBM i 7.2, BRMS now supports creating media with an expiration date 1990 - 2089. The Change Media using BRM (**CHGMEDBRM**) command, the Work Media using BRM (**WRKMEDBRM**) command with option 2, or the Work Media Information (**WRKMEDIIBM**) command with option 2 can be used to change the expiration date of media or media information to a date after 2038.

Figure 7-29 show that BRMS now supports media expiration date after 12-31-2038.

```

Work With Media
System: UT30P05
Position to . . . . . Starting characters
Type options, press Enter.
1=Add 2=Change 4=Remove 5=Display 6=Work with serial set 7=Expire
8=Move 9=Remove volume error status 10=Reinitialize ...

      Volume      Creation Expiration      Move      Media      Dup
Opt  Serial      Status  Date      Date      Location  Date      Class      Sts
      A00001      *ACT  10/16/15  01/01/39 *HOME      *NONE      SAVSYS
      A00002      *ACT  10/16/15  12/31/88 *HOME      *NONE      SAVSYS

Bottom

Parameters or command:
====>
F3=Exit  F4=Prompt  F5=Refresh  F11=Volume system  F12=Cancel  F17=Top
F18=Bottom  F23=More options

```

Figure 7-29 BRMS supporting a media expiration date after 12-31-2038

Marking a volume for duplicate and marking history for duplicate

In IBM i 7.2, BRMS provides two ways to assist the user to produce duplicate media:

- ▶ Set the Mark volumes for duplication field to *YES for save media.
This assists the user in creating duplicate media. The data and save history for all saved items on the media is duplicated.
- ▶ Set the Mask history for duplication field to *YES for save item.
This assists the user in creating duplication saved items. The data and save history for specific saved is duplicated.

Figure 7-30 shows the Change Media Policy window with the Mark volumes for duplication and Mark history for duplication options.

```

Change Media Policy

Media policy . . . . . : TPOLICY

Type choices, press Enter.

Required volumes . . . . . *NONE      *NONE, 1-9999
Mark volumes for duplication . . . *YES      *NO, *YES
Mark history for duplication . . . *YES      *NO, *YES
Text . . . . . *NONE

More

F3=Exit  F5=Refresh  F12=Cancel

```

Figure 7-30 Change Media Policy command

Note: Media duplication and save history duplication are independent. When both the “Mark volumes for duplication” and “Mark history for duplication” options are specified, the following commands must be run:

```
DUPMEDBRM VOL(*LIST/*SEARCH/VOLUME ID)
DUPMEDBRM VOL(SCHHST)
```

Support for checking the number of expired media for a save operation

IBM i 7.2 adds the capability for users to check whether there is enough expired media to satisfy the media requirements of a save operation. This function is available to use in the Check Expired Media for BRM (**CHKEXPBRM**) command.

The **CHKEXPBRM** command calculates the number of media with a specified media class that is available for use in a save operation. It also accounts for the location of the media based on the location that is specified in the media policy or a certain location that is specified by the user. This command is run before running a save operation to make sure that the save operation does not fail because the number of available media is less than the number of required media for a save.

An example of the **CHKEXPBRM** command is shown in Figure 7-31.

```
                                Check Expired Media for BRM (CHKEXPBRM)

Type choices, press Enter.

Required volumes . . . . . > 21           1-9999, *MEDPCY
Media class . . . . . > CLS_DAY01        CLS_DAY01, CLS_SYS01, CLS_...
Location . . . . . > TAPMLB01          *ANY, *HOME, BRMS, ...

                                                                    Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
```

Figure 7-31 Check Expired Media for BRM (CHKEXPBRM) command

The **CHKEXPBRM** message is shown in the BRMS log, as shown in Figure 7-32 on page 299.


```

                                Display BRM Log Information

Current date/time . . . . . : 10/16/15 18:28:35
Position to date . . . . . : 10/16/15

Date sent Time sent Message
10/16/15 6:01:43 Library ZJOA is not included in save strategy.
10/16/15 6:01:43 Library ZJOB is not included in save strategy.
10/16/15 6:01:44 Library ZJ01 is not included in save strategy.
10/16/15 6:01:44 Library ZJ02 is not included in save strategy.
10/16/15 6:01:44 Library ZJ03 is not included in save strategy.
10/16/15 6:01:44 Library ZLWLIB is not included in save strategy.
10/16/15 6:01:44 Library ZZLIB is not included in save strategy.
10/16/15 6:01:44 Library ZZLIB1 is not included in save strategy.
10/16/15 6:01:44 Library ZZLIB2 is not included in save strategy.
10/16/15 6:01:44 Save analysis indicated 1841 libraries not being saved.
10/16/15 6:03:03 BRM maintenance procedure completed.
10/16/15 18:18:42 Request for 21 expired volumes for media class CLS_DAY01
                                                                Bottom

Press Enter to continue.

F3=Exit      F4=Message details      F5=Refresh      F11=Alternate view
F12=Cancel   F17=Top                  F18=Bottom

```

Figure 7-32 Message entry that is generated from the CHKEXPBRM command in DSPLOGBRM

Pressing F4 on the message displays a report that shows whether the required number media for a save operation is available. See Figure 7-33.

```

                                Additional BRM Log Information

Message ID . . . . . : BRM1930          Severity . . . . . : 70

Job . . . : QPADEV000K  User . . : ID010886      Number . . . . . : 493371
Date sent . . . . . : 10/16/15        Time sent . . . . . : 18:18:42
Program . . . . . : Q1ACCEM          Area . . . . . : *BKU

Message . . . . . : Request for 21 expired volumes for media class
CLS_DAY01 was not successful.
Cause . . . . . : The check expired media command requested 21 expired
volumes. 0 expired volumes are available for media class CLS_DAY01 at
location TAPMLB01.
Recovery . . . . . : Make more volumes available by using WRKMEDBRM to expire
volumes, STREXPBRM to expire volumes that have reached expiration, or add
more volumes to the media inventory.

                                                                Bottom

Press Enter to continue

F3=Exit      F12=Cancel

```

Figure 7-33 Detailed results of the CHKEXPBRM command

7.3.6 Maintenance enhancements

This section reviews the following media services enhancements in IBM i 7.2:

- ▶ “Reorganizing the BRMS database by using a batch job”
- ▶ “Additional parameters in RMVMEDIBRM” on page 301
- ▶ “STRMNTBRM command enhancement” on page 302

Reorganizing the BRMS database by using a batch job

When performing BRMS maintenance by using the Start Maintenance for BRM (STRMNTBRM) CL command, you can use IBM i 7.2 to set the Reorganize BRMS database (RGZBRMDB) parameter to *BATCH, as shown in Figure 7-34. By using this setting, you can submit database reorganization to a batch job. The job queue and the job description are specified in the System policy for BRMS submitted jobs.

When this command is used, STRMNTBRM can complete processing much sooner than a batch job that performs the reorganization. Normal BRMS activity can be resumed while the batch job is still active.

```

                                Start Maintenance for BRM (STRMNTBRM)

Type choices, press Enter.

Audit system media . . . . . *NONE
      + for more values
Change BRM journal receivers . . *YES          *YES, *NO
Print expired media report . . . *YES          *YES, *NO
Print version report . . . . . *EXPMED       *EXPMED, *NO, *YES
Print media information . . . . *YES          *YES, *NO
Print recovery reports . . . . . *ALL          *ALL, *NONE, *RCYACT...
      + for more values
Recovery locations . . . . . *ALL          Name, *ALL, *HOME
      + for more values
Print system information . . . . *NO          *NO, *YES
Reorganize BRMS database . . . . > *BATCH    *NO, *YES, *BATCH
Auto-retrieved objects:
  Refree . . . . . *NO          *NO, *YES

                                                                Bottom
F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys
  
```

Figure 7-34 Reorganize BRMS database (RGZBRMDB) parameter in the STRMNTBRM CL command

Figure 7-35 shows the option to run BRMS database reorganization in IBM Navigator for i. To modify the BRMS database reorganization parameter, complete the following steps:

1. From IBM Navigator for i, select **Backup, Recovery, and Media Services** and then click **Advanced**.
2. Click the small arrow beside **Backup, Recovery, and Media Services for IBM i** and then click **Run Maintenance**.
3. In the Run Maintenance Options window, click the **File Management** tab and change the Reorganize BRMS database value, as shown in Figure 7-35.

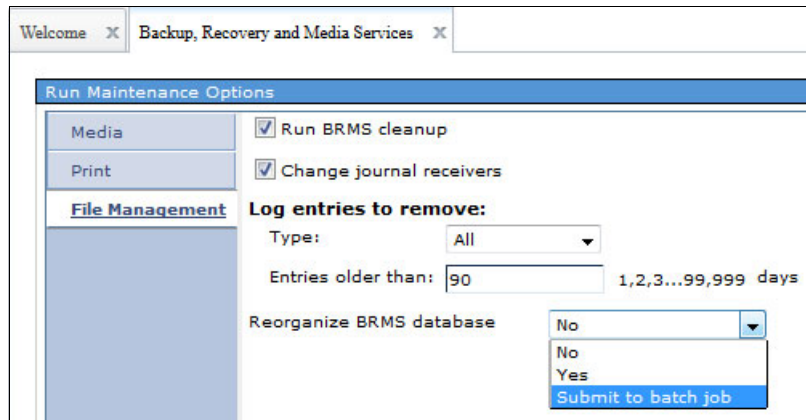


Figure 7-35 Reorganize BRMS database option in IBM Navigator for i

Additional parameters in RMVMEDIBRM

As shown in Figure 7-36, IBM i 7.2 adds more parameters to the Remove Media Info from BRM (**RMVMEDIBRM**) CL command to give users more control over a file's details and how long the users can retain the information.

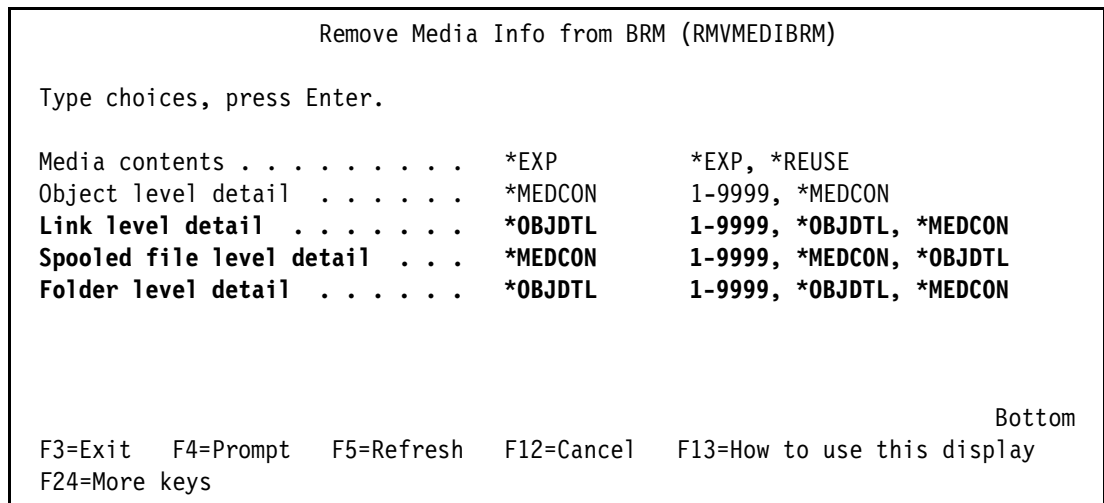


Figure 7-36 Additional parameters of the RMVMEDIBRM CL command

Here are the additional parameters of the **RMVMEDIA** CL command:

- ▶ Link level detail

The Link level detail parameter specifies when you want to remove directory- and file-level details for media records in the media content information.

- ▶ Spooled file level detail

Spooled file level detail specifies when you want to remove spooled file-level detail for media records in the media content information. This parameter applies only to spooled file details that are created by specifying *YES for the Spooled file data (**SPLFDTA**) parameter of the **SAVLIB** or **SAVOBJ** CL commands or in the control group attributes. However, spooled file lists are not affected, as you must have the detail history to restore them.

- ▶ Folder level detail

Folder level detail specifies when you want to remove folder-level detail for media records in the media content information.

For more information about the **RMVMEDIA** CL command and its parameter values, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/rmvmedia.htm?lang=en

STRMNTBRM command enhancement

In IBM i 7.2, the Start Maintenance for BRM (**STRMNTBRM**) command with the parameter Reorganize BRMS database (**RGZBRMDB**) set to *YES is enhanced to input a database message into the job log when a problem is encountered during database reorganization. This helps the DB2 support person better understand the problem.

7.3.7 BRMS GUI in IBM Navigator for i enhancements

In IBM i 7.2, BRMS has GUI enhancements in IBM Navigator for i, which improves the usability of the BRMS GUI functions and its coexistence with functions that have CL commands.

The following topics are covered in this section:

- ▶ “BRMS policies” on page 302
- ▶ “Volume initialization and ignoring active files” on page 308
- ▶ “Ability to select multiple items in backup and archive lists” on page 309

BRMS policies

You can use IBM Navigator for i to view or modify various BRMS policies, including the following ones:

- ▶ System policy
- ▶ Backup policy
- ▶ Archive policy
- ▶ Retrieve policy
- ▶ Recovery policy

Figure 7-37 shows the policy properties that are available in IBM Navigator for i. To view or modify these policies, complete the following steps:

1. From IBM Navigator for i, click **File Systems** → **Backup Recovery and Media Services**.
2. On the Backup, Recovery and Media Services tab, click the small arrow next to Backup, Recovery, and Media Services for IBM i and select the policy that you want to view or modify.

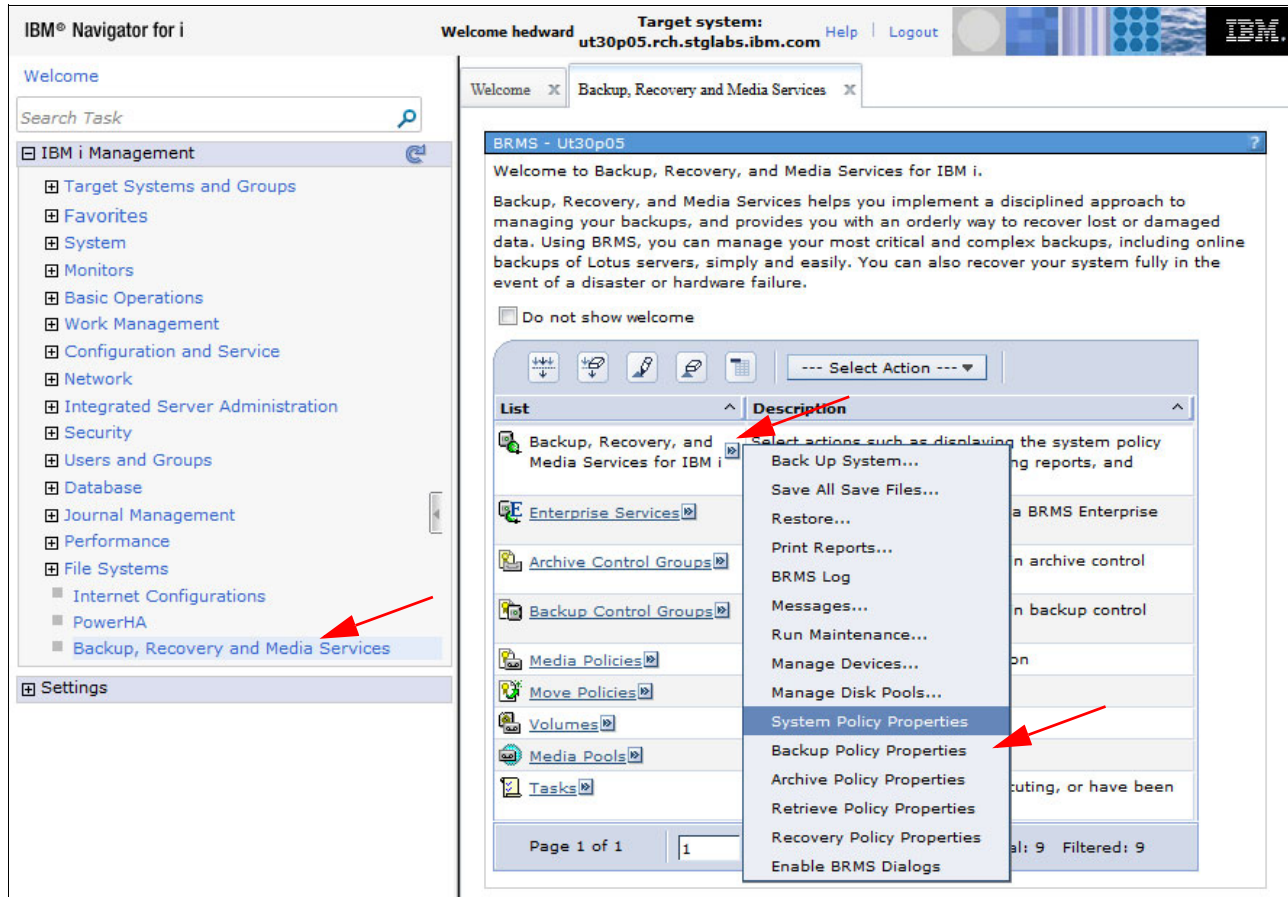


Figure 7-37 Select the BRMS policies in Navigator for i

System policy

The System policy provides the same function as the Work with System Policy (WRKPCYBRM TYPE(*SYS)) CL command. You can use this policy to configure the media, notification, IPL options, presentation, and so on. The overall System Policy Properties in IBM Navigator for i are shown in Figure 7-38.

System Policy Properties - Ut30p05

General

BRMS system name: Use entry from below
Ut30p05

Day start time: 12:00:00 AM Example: 12:30:00 PM

Sign off interactive users

Delay signoff (0-999) 30 minutes

Output queue: Use printer device file

Output queue library: Use entry from below

For saves of Licensed Internal Code and IBM i

Controlled end delay time: 1200 seconds

Abnormal end delay time: No limit minutes

Time to wait for servers to end: 0 0,1,2...9,999 seconds

Maximum time to allow for save: No maximum minutes

Only use interactive console monitor

Note: If the interactive console monitor is not used, the control group run operation must be fully automated and require no user intervention.

Flight recorder size: 50 1,2,3...999 megabytes

Default public usage for functional authority

Enable FlashCopy

FlashCopy status: Not in FlashCopy mode

BRMS submitted jobs:

Job description: User profile

Figure 7-38 BRMS System policy in IBM Navigator for i

Backup policy

You can use the Backup policy to look at what parameters or information are set in the system policy. Figure 7-39 shows an example of seeing system policy values while modifying the Backup policy.

Welcome X Backup, Recovery and Media Services X

Backup Policy Properties - Ut30p05

Media policy for full saves

Use system policy value: Full

Select media policy Browse

Media policy for changes-only saves

Use system policy value: Full

Select media policy Browse

Backup devices:

Automatically select devices

Number of devices to use sequentially: 1,2,3...4

Use devices from system policy:

Use selected devices:

Selected devices:

Name	Category	Type/Model	Location	Description
None				

Default weekly activity

Full

Changes only

Customize

Monday: Friday:

Tuesday: Saturday:

Wednesday: Sunday:

Thursday:

Type of changes-only save

Figure 7-39 BRMS Backup policy in IBM Navigator for i

Archive policy

Similar to the Backup policy, you can use the Archive policy in IBM Navigator for i to look ahead into what parameters or information are set in the System policy, as shown in Figure 7-40.

The screenshot displays the 'Archive Policy Properties - Ut30p05' dialog box. It is divided into several sections:

- Media policy:** Includes radio buttons for 'Use system policy value: Full' and 'Select media policy'. The 'Select media policy' option is chosen, with a text box containing 'Archival' and a 'Browse' button.
- Archive devices:** Includes radio buttons for 'Automatically select devices', 'Use devices from system policy:', and 'Use selected devices'. The 'Use devices from system policy:' option is selected. Below it is a text box for 'Number of devices to use sequentially:' with the value '1' and a range '1,2,3...4'. A 'Selected devices:' table is shown below with one row containing 'None'.
- Default weekly activity:** Includes radio buttons for 'Perform action' and 'Customize'. The 'Perform action' option is selected. Below are dropdown menus for each day of the week, all set to 'Perform action'.
- Include:** Includes a sub-section for 'Disk pool threshold' with radio buttons for 'Use the disk pool threshold' and 'Specify a minimum value:'. The 'Specify a minimum value:' option is selected, with a text box containing '0' and a range '0,1,2...99 %'. Below this is the 'Inactivity type' section with radio buttons for 'Both', 'Since last changed', and 'Since last used'. The 'Both' option is selected.

Figure 7-40 BRMS Archive policy in IBM Navigator for i

Retrieve policy

Figure 7-41 shows the Retrieve policy properties that can be modified in IBM Navigator for i.

The screenshot shows a dialog box titled "Retrieve Policy Properties - Ut30p05" with a help icon in the top right corner. The main instruction reads: "Select options for retrieving objects which have had their storage freed by BRMS." The "Type of media:" is set to "Media (parallel)". Under "Device Selection", "Minimum parallel devices:" is "Same as save" and "Maximum parallel devices:" is "Use minimum value". There are two radio buttons: "Automatically select devices" (selected) and "Use selected devices". Below this is a "Selected devices:" list with a table header "Name" and one entry "None". To the right of the list are buttons for "Add", "Remove", "Move Up", and "Move Down". "Retrieved object retention:" is set to "Use entry from below" with a value of "0" and the unit "days". "Extend retention if reused:" is also set to "0" days. There is a checkbox for "Reset days used count" which is unchecked. At the bottom are "OK", "Cancel", and "Advanced..." buttons.

Figure 7-41 BRMS Retrieve policy in IBM Navigator for i

Recovery policy

Figure 7-42 shows the Retrieve policy properties that can be modified in IBM Navigator for i.

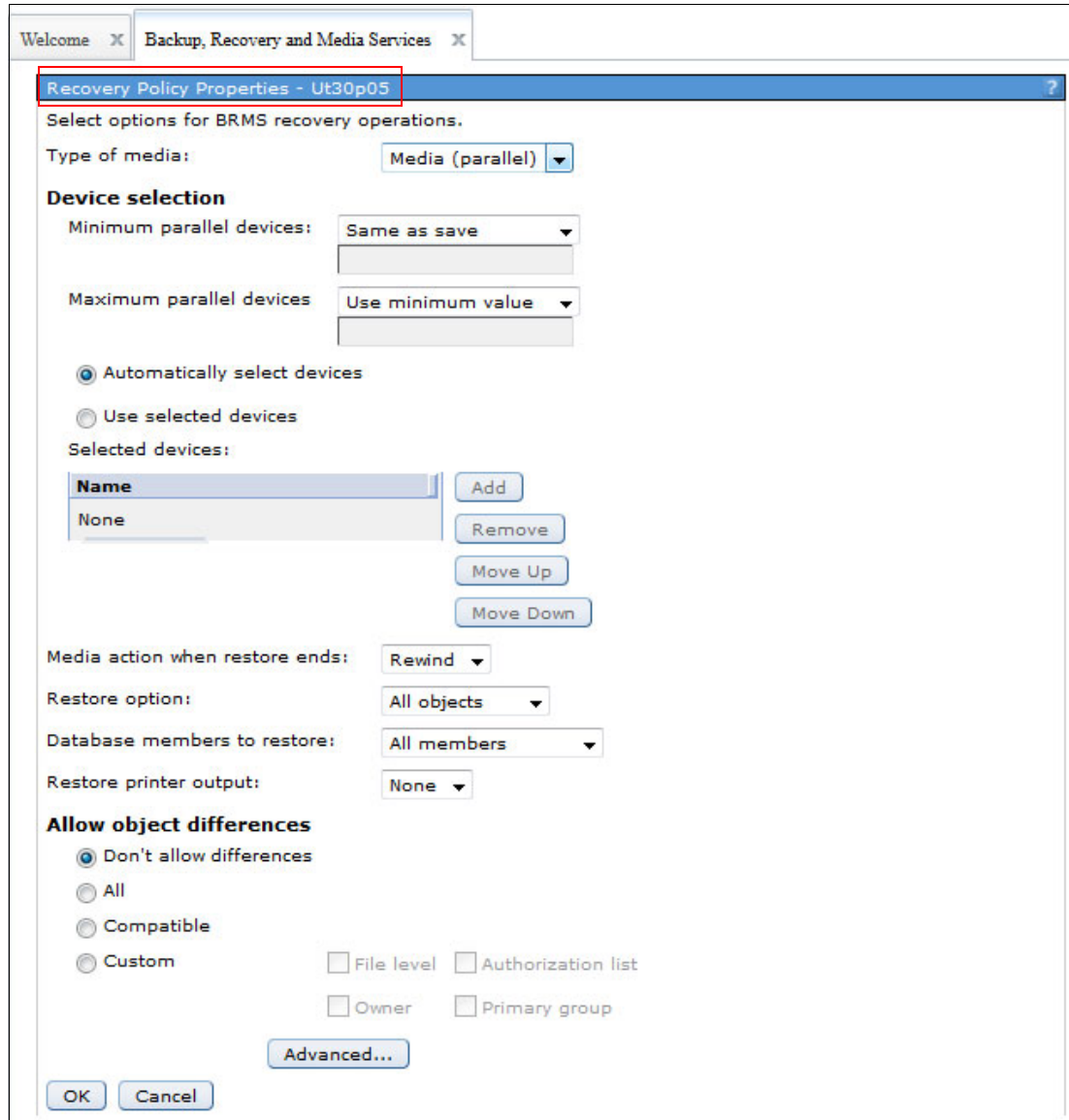


Figure 7-42 BRMS Recovery policy in IBM Navigator for i

Volume initialization and ignoring active files

You can use IBM Navigator for i to select/deselect all volumes for initialization and select/deselect all active files to ignore them. This ability can be useful in the case where you have many volumes for initialization and you want to ignore active files.

To enable this feature, complete the following steps:

1. From IBM Navigator for i, click **File Systems** → **Backup Recovery and Media Services**.
2. On the Backup, Recovery and Media Services tab, click the small arrow next to Volumes and then click **Add**.

3. Figure 7-43 shows the Add Volumes - Initialize Volumes window where you can select the following actions:

- Select all for Initialize
- Deselect all for Initialize
- Select all Ignore Active Files
- Deselect all for Ignore Active Files

These actions check or clear the Initialize or Ignore Active Files check boxes that are shown in the window.

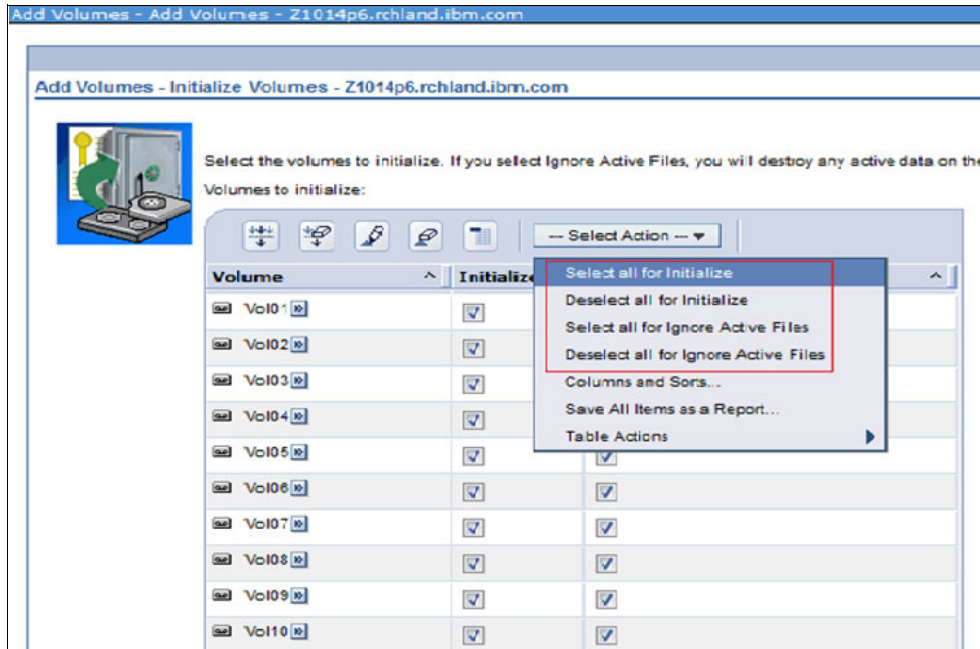


Figure 7-43 Check boxes for marking a volume for initialization and ignoring active files

Ability to select multiple items in backup and archive lists

The BRMS GUI in IBM Navigator for i adds the capability to select multiple items within backup and archive lists. This enables users to change easily the sequence of several entries at a time by using the Move up and Move down buttons. Before this enhancement, users could select only one entry at a time.

This GUI enhancement is shown in Figure 7-44.

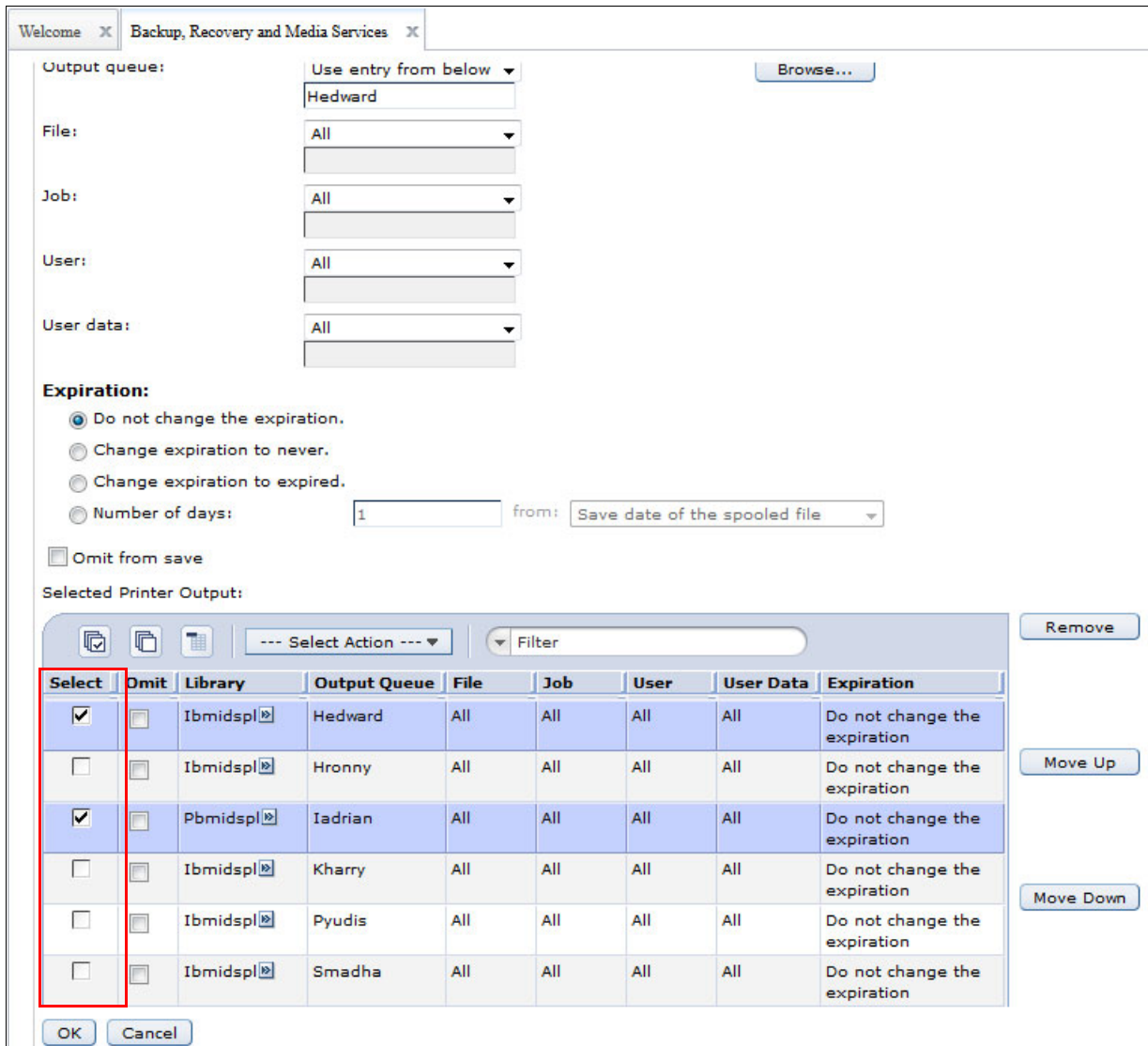


Figure 7-44 BRMS GUI in Navigator for i showing the multiple selection feature in a backup list

7.3.8 Migration enhancements

Major changes in IBM i 7.2 provide the modernization of storage tiering in the BRMS migration function as an enhancement to the existing function. In prior releases, the migration function in BRMS worked only for library migration between Auxiliary Storage Pools (ASPs) based on the specified policies for frequency of use. This function is described in Figure 7-45 on page 311.

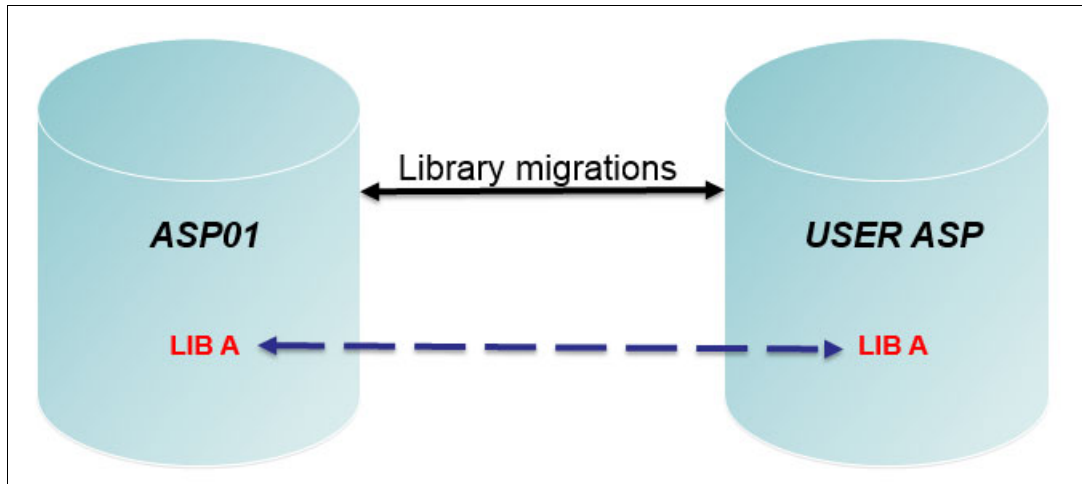


Figure 7-45 BRMS migration function for library migration in prior releases

Now in IBM i 7.2, BRMS migration is enhanced to support the migration to Independent ASPs (IASPs), migration of *LNK lists for IFS files, and migration of database files within the same ASP. These IBM i 7.2 enhancements are described in Figure 7-46.

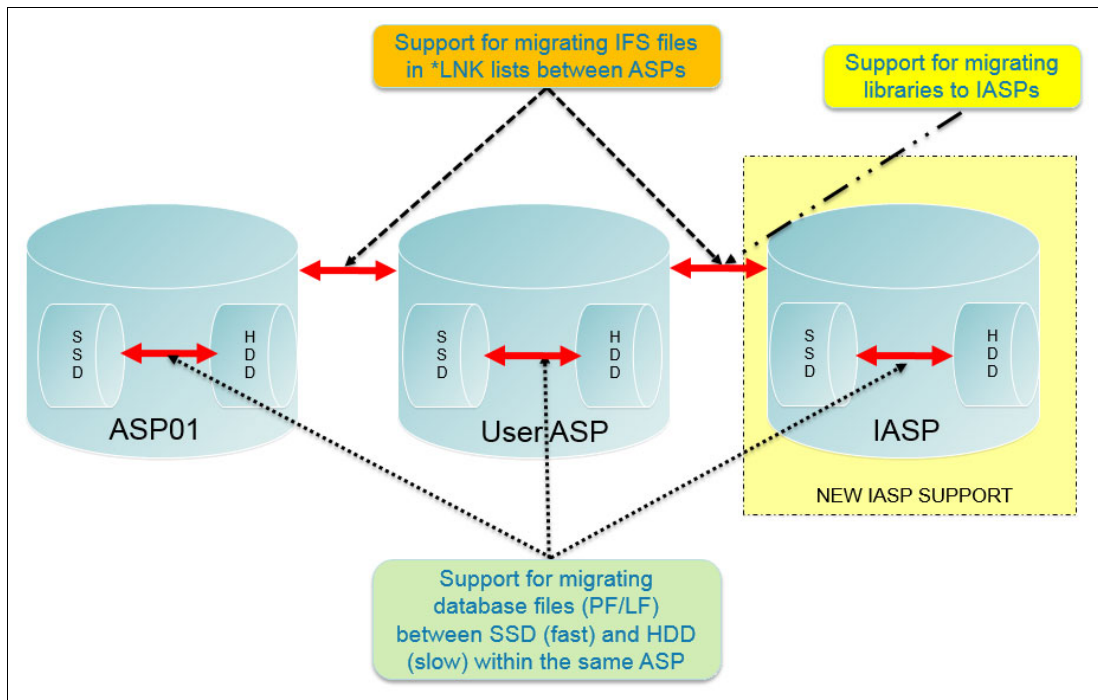


Figure 7-46 Current BRMS migration functions in IBM i 7.2

Similar to the IBM Storage Easy Tier® function, the BRMS storage tiering function within an ASP responds to the presence of flash or SSD drives in a storage pool that also contains hard disk drives (HDDs). Those drives can be either internal or external disk drives. However, unlike IBM storage implementations of Easy Tier, which move small pieces of data to and from faster storage based on patterns of usage, the BRMS migration function operates at a file or library level to automatically migrate frequently accessed database files in their entirety from HDDs to flash or SSDs, placing such files in a faster tier of storage, and vice versa.

A system administrator also can choose to move a file or a library to SSD based on the knowledge that the whole file or library will be needed in the future. This aspect can be useful for the month-end or quarter-end processing by moving the necessary file with periodically having frequent access into faster storage.

Each of these BRMS migration improvements is explained in the following sections:

- ▶ “Added support for migration to independent ASPs” on page 312
- ▶ “Enhanced migration function to migrate *LNK lists (IFS)” on page 312
- ▶ “Enhanced migration function of database files within an ASP” on page 313
- ▶ “MGRBRM command enhancement for force migration” on page 314

Added support for migration to independent ASPs

Migration support is now extended to support migration to IASPs. This enhancement enables users to migrate easily their libraries from a regular ASP to an IASP. With an appropriate migration policy in place, users can also easily manage the migration rule based on the size of the libraries and how many times the libraries are used.

To set an IASP as migration eligible, run the following command:

```
QSYS/CALL QBRM/Q1AOLD PARM('SETMGRELIG' 'asp-name' 'asp-class' 'Y')
```

Figure 7-47 shows the Work with ASP Descriptions (**WRKASPBRM**) command, displaying the Eligible for migration parameter of IASPs as *YES.

Work with ASP Descriptions							System:	UT30P05
Type options, press Enter.								
2=Change								
Opt	ASP Name	ASP Number	ASP Type	ASP Class	Hierarchy Priority	Migration Eligible		
	*SYSTEM	00001	*SYSBAS	CLS1	1	*YES		
	ASP02	00002	*SYSBAS	CLS2	8	*YES		
	IASP01	00033	*PRIMARY	CLS3	68	*YES		
	IASP02	00034	*SECONDARY	CLS3	72	*YES		
							Bottom	
Type command, press Enter.								
====>								
F3=Exit F4=Prompt F5=Refresh F9=Retrieve F11=Show utilization								
F12=Cancel								

Figure 7-47 Work with ASP Descriptions command showing migration eligible for IASPs

Enhanced migration function to migrate *LNK lists (IFS)

BRMS migration in IBM i 7.2 now supports the migration of IFS files in *LNK lists. Use this feature to move the files in the form of a complete directory tree. This is useful for certain situations, such as easily moving a complete directory of an IBM Lotus® Notes application from a slower ASP to another faster ASP with SSDs when needed.

Figure 7-48 shows the example of a *LNK list for BRMS migration.

```

                                Work with Lists                                UT30P05

Position to . . . . .           Starting characters

Type options, press Enter.
  1=Add  2=Change  3=Copy  4=Remove  5=Display  6=Print

Opt  List Name  Use  Type  Text
-----
DAILYDIR  *MGR  *LNK  List of daily directory
HEDWARDSPL *BKU  *SPL  Spooled files for HEDWARD OUTQ
IBMIDSPL   *BKU  *SPL  Daily spooled file for IBMID
NOTESLNK  *MGR  *LNK  List for Notes Application
QALLSPLF   *BKU  *SPL  All printed output
QALLUSRLNK *BKU  *LNK  All user directories
QIBMLINK   *BKU  *LNK  All IBM directories
QLNKOMT    *BKU  *LNK  Associated user omit list for *LINK.

                                                                Bottom

F3=Exit  F5=Refresh  F12=Cancel

```

Figure 7-48 Work with BRMS lists showing a *LNK lists type for migration

Here are some restrictions of using the *LNK list for migration:

- ▶ Only the first-level directory path names are allowed, for example, /dirName.
- ▶ Only one directory entry is allowed in each *LNK list.
- ▶ IBM product directories (directories that are started with /Q) are not supported.
- ▶ Non IBM product directories, such as '/', '/tmp', and '/dev', are not supported.
- ▶ The directory tree contents must have the same file system.

Enhanced migration function of database files within an ASP

BRMS migration now supports the migration of database files (both physical and logical files) within the same ASP. With this capability, the system administrator now has increased control to ensure that the most frequently accessed files have priority placement on a faster tier of storage.

For example, a migration policy can be set up so that after a file has not been viewed for a period (for example, a week or a month), it can be automatically migrated to slower storage of the ASP, and after a period (perhaps a couple months) of being dormant, it can automatically be archived out to tape. With dynamic retrieval from archive storage, when the file is needed again, it can be automatically brought back in to disk storage.

An example of an effective use of this feature is migrating several read-intensive files that are needed by month end processing to SSDs, and then moving them back to HDDs when the process finishes.

Figure 7-49 shows an example of an object list containing database files for BRMS migration.

```

                                Display Object List                                UT30P05
Use . . . . . : *MGR
List name . . . . . : MONTHENDDB
Text . . . . . : List of month-end database files

  Seq  Library  Object  Type  Attribute  Member  Inc/Exc
   10  BEXIHIST *ALL   *FILE  PF        *ALL   *INC
   20  BDNIHIST *ALL   *FILE  PF        *ALL   *INC

                                                                Bottom

Press Enter to continue.

F3=Exit  F12=Cancel

```

Figure 7-49 Object list containing database files for BRMS migration

Here are some restrictions of using a *OBJ list containing database files for migration:

- ▶ Moving database objects by using an object list can be done only within the same ASP or IASP.
- ▶ Specific library names and member names are required. Special values and generic names are not supported.
- ▶ Supports only a database file (*FILE object type with PF or LF attributes).

MGRBRM command enhancement for force migration

The Migrate using BRM (**MGRBRM**) command is enhanced to support force migration for an object in the object list. Option *OBJ is added to parameter Type (**TYPE**) and parameter Object list is added to support force migration.

Figure 7-50 shows the **MGRBRM** command with the Object list parameter to force migration of the *OBJ type.

```

                                Migrate using BRM (MGRBRM)
Type choices, press Enter.

To asp . . . . . > *SSD      Name, 1-32, *SYSTEM
Type . . . . . *OBJ        *LIB, *FLR, *LNK, *OBJ
Library . . . . .          Name
Folder . . . . .          Name
Link list . . . . .        Name
Object list . . . . . MONTHENDDB Name

                                                                Bottom

F3=Exit  F4=Prompt  F5=Refresh  F12=Cancel  F13=How to use this display
F24=More keys

```

Figure 7-50 Command MGRBRM with Object list parameter

7.3.9 Miscellaneous BRMS enhancements

This section reviews the following miscellaneous BRMS enhancements in IBM i 7.2:

- ▶ “Performance enhancement in INZBRM *RUNPRDINZ”
- ▶ “Improved help text in BRMS functions”
- ▶ “Less locking on the QUSRBRM library” on page 317
- ▶ “Enhancement on the BRMS network notification message interval” on page 317
- ▶ “Prompt message to users when a required volume is not available” on page 318
- ▶ “Recovery report includes a user-defined BRMS system name” on page 318
- ▶ “Allowing a backslash to be used as a delimiter in a path name” on page 318
- ▶ “INZBRM enhanced to verify network communication” on page 318

Performance enhancement in INZBRM *RUNPRDINZ

The BRMS product initialization process is required after you perform a product update or when you receive the following message:

```
BRM40A2 - BRMS product initialization required.
```

As this initialization process takes a long time to complete, BRMS is enhanced so that you can perform BRMS product initialization faster than in the previous releases. The new **INZBRM OPTION(*RUNPRDINZ)** CL command rebuilds a logical file only when the whole physical file changes.

If there is no physical file change, BRMS product initialization does not process anything. In addition, this product initialization uses Alter Table on detail files, instead of creating more logical files. These two changes improve the overall BRMS product initialization.

Improved help text in BRMS functions

IBM i 7.2 provides improvements for the help texts in BRMS functions, which provide BRMS users with more detailed and complete explanations of BRMS functions.

Control group in PRTRPTBRM

Figure 7-51 shows the improved help text for the Control Group (CTLGRP) parameter in the Print Report using BRM (PRTRPTBRM) CL command. This improved help text explains the Control Group options for the PRTRPTBRM TYPE(*CTLGRPSTAT) CL command.

```
Print Report using BRM (PRTRPTBRM)
.....
:               Control Group (CTLGRP) - Help               :
:                                                         :
: Specifies which backup control group should be included in the report. :
: This parameter is ignored when parameter Type (TYPE) is not *CTLGRPSTAT. :
: Note: Backups produced by running STRBKUBRM commands will be included in :
: the report for all values except *NONE. :
:                                                         :
: *ALL :
:   All backups produced by running STRBKUBRM will be included in this :
:   report. Note: The output generated by CTLGRP(*NONE) will not be :
:   included in this report. :
:                                                         :
: *SYSTEM :
:   Backups produced by the *SYSTEM control group will be included in :
:   the report. :
:                                                         :
: *BKUGRP :
:                                                         :
:                                                         :
:                                                         :
: F2=Extended help   F3=Exit help   F10=Move to top   F11=Search Index :
: F12=Cancel         F13=Information Assistant   F14=Print help :
:                                                         :
:                                                         :
:.....
```

Figure 7-51 Control Group help text for the PRTRPTBRM TYPE(*CTLGRPSTAT) CL command

Data compaction in DUPMEDBRM

Figure 7-52 on page 317 shows the added help text for the Duplicate Media using BRM (DUPMEDBRM) CL command, which explains the Data compaction parameter in detail.

```

                Duplicate Media using BRM (DUPMEDBRM)

Type choices, press Enter.

Save media information . . . . . SAVMEDINF      *NONE
Data compaction      . . . . . COMPACT        *FROMFILE

:          .....
:          Data Compaction Key (COMPACT) - Help          :
:          :
:          : Specifies whether device data compaction is performed. If :
:          : the device specified does not support compaction, this :
:          : parameter is ignored.                               :
:          :
:          : *FROMFILE                                         :
:          : Device data compaction is performed if the file being :
:          : read from the device specified on the From device :
:          : (FROMDEV) parameter was written using device data :
:          : compaction.                                         :
:          :
:          :                                                     More... :
:          : F2=Extended help   F10=Move to top   F11=Search Index :
F3=Exit  F4= : F12=Cancel       F20=Enlarge     F24=More keys :
F24=More keys :
Messages pend :.....

```

Figure 7-52 Data compaction help text for the DUPMEDBRM CL command

Less locking on the QUSRBRM library

In IBM i 7.2, BRMS using Save While Active (SWA) to perform a Save Media Info using BRM (SAVMEDI~~I~~BRM) needs less locking on the QUSRBRM library and allows other jobs to continue working.

Enhancement on the BRMS network notification message interval

In the BRMS network environment, if a connection cannot be established to the system in the BRMS network, messages are periodically added to the BRMS log based on the notify period field in the System policy.

Before IBM i 7.2, this field has a default value of 30 seconds. In IBM i 7.2, the notify period default value is changed to 3600 seconds (1 hour) and can be changed when option 4 “Change network group” is selected from the System policy panel.

Figure 7-53 shows the Change network group panel with the Notify period field.

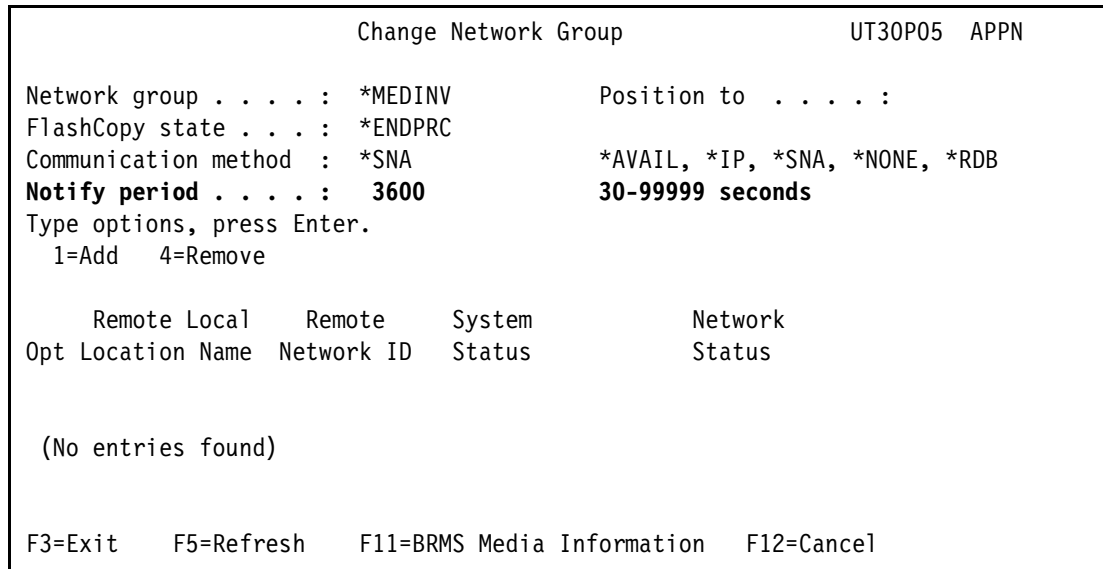


Figure 7-53 Notify period default value changed to 3600 seconds

Prompt message to users when a required volume is not available

In IBM i 7.2, the BRMS restore process is enhanced to prompt the user to load the required volumes when they are not available instead of failing with a message indicating that the volume is not available.

Recovery report includes a user-defined BRMS system name

The recovery report (**QP1ARCY**), created by the Start Recovery using BRM (**STRRCYBRM**) command with ***REPORT** specified for the Action (**ACTION**) parameter is enhanced to include BRMS user-defined system name.

Allowing a backslash to be used as a delimiter in a path name

By default, the Save Object using BRM (**SAVBRM**) command and BRMS lists for integrated file system object (***LNK**) allow only the slash character '/' to be used as a delimiter in a path name. In IBM i 7.2, backslash '\' can also be used as a delimiter in a path name.

To enable this function, run the following command:

```
CRTDTAARA DTAARA(QUSRBRM/Q1ACVTBSLS) TYPE(*CHAR)
```

INZBRM enhanced to verify network communication

The Initialize BRMS (**INZBRM**) command is enhanced through the Option (**OPTION**) parameter to check network communication.

The following values for the **OPTION** parameter are used to check network communication:

- ▶ ***VFYENT**: Verify whether the system is set correctly and communicating with other systems in the BRMS enterprise network. No other INZBRM parameters are used for this option.
- ▶ ***VFYNET**: Verify whether the system is set correctly and communicating with other systems in the BRMS network. No other INZBRM parameters are used for this option.
- ▶ ***VFYSYS**: Verify whether the system is set correctly and communicating with the system that is specified in System name (**SYSNAME**) parameter.

Figure 7-54 show an example of the results of running the `INZBRM` command with option `*VFYSYS`.

```
3>> INZBRM OPTION(*VFYSYS) SYSNAME(NOACTIVE)
      Attempt to map host name to IP address failed with reason code 5.
      Cannot establish DDM connection with remote system.
      Cannot open DDM file @@QA1AAU in QTEMP.
      Object @@QA1AAU in QTEMP type *FILE deleted.
      File @@QA1AAU created in library QTEMP.
      Open of member *N file @@QA1AAU in QTEMP failed.
      Attempt to map host name to IP address failed with reason code 5.
      Cannot establish DDM connection with remote system.
      Cannot open DDM file @@QA1AAU in QTEMP.
      Object @@QA1AAU in QTEMP type *FILE deleted.
      Cannot establish connection with remote system.
      Error found on INZBRM command.
```

*Figure 7-54 Results of the INZBRM OPTION(*VFYSYS) command*



IBM DB2 for i

This chapter describes the following enhancements to the DB2 for i functions in IBM i version 7.2:

- ▶ 8.1, “Introduction to DB2 for i” on page 322
- ▶ 8.2, “Separation of duties concept” on page 323
- ▶ 8.3, “DB2 security enhancements” on page 332
- ▶ 8.4, “DB2 functional enhancements” on page 339
- ▶ 8.5, “DB2 for i services and catalogs” on page 362
- ▶ 8.6, “DB2 performance” on page 377
- ▶ 8.7, “Database engineering” on page 398
- ▶ 8.8, “DB2 Web Query for i” on page 410
- ▶ 8.9, “OmniFind Text Search Server for DB2 for i” on page 412

For more information about the IBM i 7.2 database enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/DB2%20for%20i%20-%20Technology%20Updates>

8.1 Introduction to DB2 for i

DB2 for i is a member of the DB2 family. This database is integrated and delivered with the IBM i operating system. DB2 for i has been enhanced from release to release of IBM i. In addition, DB2 for i is also enhanced by using the DB2 PTF Groups, where PTF Group SF99702 applies to IBM i 7.2 for DB2. This group does not change in V7R2.

IBM i 7.2 brings many DB2 functional, security, performance, and management enhancements. Most of these enhancements are implemented to support agility or what is referred to as a *data-centric* approach for the platform.

A data-centric paradigm requires business application designers, architects, and developers to focus on the database as a central point of modern applications for better data integrity, security, business agility, and a lower time to market factor. This is in contrast to an *application-centric* approach, where data manipulation, security, and integrity is, at least partially, governed by the application code. A data-centric concept moves these responsibilities over the underlying database.

A data-centric approach ensures consistent and secure data access and manipulation regardless of the application and the database interface that are used. Implementing security patterns for business critical data, and data access and manipulation procedures within DB2 for i, is now easier than ever, and more importantly, it removes code complexity and a security-related burden from business applications.

This approach is especially crucial for contemporary IT environments where the same data is being manipulated by web, mobile, and legacy applications at the same time. Moving data manipulation logic over the DB2 for i also uses all the current and future performance enhancements, database monitoring capabilities, and performance problem investigation tools and techniques.

The following key IBM i 7.2 database enhancements support this data-centric approach:

- ▶ Row and column access control (RCAC)
- ▶ Separation of duties
- ▶ DB2 for i services
- ▶ Global variables
- ▶ Named and default parameter support on user-defined functions (UDFs) and user-defined table functions (UDTFs)
- ▶ Pipelined table functions
- ▶ SQL plan cache management
- ▶ Performance enhancements
- ▶ Interoperability and portability
- ▶ LIMIT x OFFSET y clause

This chapter describes all the major enhancements to DB2 for i in IBM i 7.2.

8.2 Separation of duties concept

Separation of duties is a concept that helps companies to stay compliant with standards and government regulations.

One of these requirements is that users doing administration tasks on operating systems (usually they have *ALLOBJ special authority) should not be able to see and manipulate customer data in DB2 databases.

Before IBM i 7.2, when users had *ALLOBJ special authority, they could manipulate DB2 files on a logical level and see the data in these database files. Also, there was a problem because someone who was able to grant permission to other users to work with data in the database had also authority to see and manipulate the data inside the databases.

To separate out the operating system administration permissions and data manipulation permissions, DB2 for i uses the **QIBM_DB_SECADM** function. For this function, authorities to see and manipulate of data can be set up for individual users or groups. Also, a default option can be configured. For more information about the **QIBM_DB_SECADM** function, see 8.2.1, “QIBM_DB_SECADM function usage” on page 323.

Although the **QIBM_DB_SECADM** function usage can decide who can manipulate DB2 security, there is another concept in DB2 for i 7.2, which helps to define which users or groups can access rows and columns. This function is called *Row and Column Access Control (RCAC)*. For more information about RCAC, see 8.2.2, “Row and Column Access Control support” on page 325.

8.2.1 QIBM_DB_SECADM function usage

IBM i 7.2 now allows management of data security without exposing the data to be read or modified.

Users with *SECADM special authority can grant or revoke privileges to any object even if they do not have these privileges. This can be done by using the Work with Function Usage (**WRKFCNUSG**) CL command and specifying the authority of *ALLOWED or *DENIED for particular users of the **QIBM_DB_SECADM** function.

From the Work with Function Usage (**WRKFCNUSG**) panel (Figure 8-1), enter option 5 (Display usage) next to **QIBM_DB_SECADM** and press Enter.

Work with Function Usage		
Type options, press Enter.		
2=Change usage 5=Display usage		
Opt	Function ID	Function Name
	QIBM_DIRSRV_ADMIN	IBM Tivoli Directory Server Administrator
	QIBM_ACCESS_ALLOBJ_JOBLOG	Access job log of *ALLOBJ job
	QIBM_ALLOBJ_TRACE_ANY_USER	Trace any user
	QIBM_WATCH_ANY_JOB	Watch any job
	QIBM_DB_DDMDRDA	DDM & DRDA Application Server Access
5	QIBM_DB_SECADM	Database Security Administrator
	QIBM_DB_SQLADM	Database Administrator

Figure 8-1 Work with Function Usage panel

In the example that is shown in Figure 8-2, in the Display Function Usage panel, you can see that default authority for unspecified user profiles is *DENIED. Also, both the DEVELOPER1 and DEVELOPER2 user profiles are specifically *DENIED.

```

                                Display Function Usage

Function ID . . . . . : QIBM_DB_SECADM
Function name . . . . . : Database Security Administrator

Description . . . . . : Database Security Administrator Functions

Product . . . . . : QIBM_BASE_OPERATING_SYSTEM
Group . . . . . : QIBM_DB

Default authority . . . . . : *DENIED
*ALLOBJ special authority . . . . . : *NOTUSED

User      Type      Usage      User      Type      Usage
DEVELOPER1 User      *DENIED
DEVELOPER2 User      *DENIED

```

Figure 8-2 Display Function Usage panel

If you return back to the Work with Function Usage panel (Figure 8-1 on page 323) and enter option 2 (Change usage) next to QIBM_DB_SECADM and press Enter, you see the Change Function Usage (CHGFCNUSG) panel, as shown in Figure 8-3. You can use the CHGFCNUSG CL command to change who is authorized to use the QIBM_DB_SECADM function.

```

                                Change Function Usage (CHGFCNUSG)

Type choices, press Enter.

Function ID . . . . . > QIBM_DB_SECADM
User . . . . . _____ Name
Usage . . . . . _____ *ALLOWED, *DENIED, *NONE
Default authority . . . . . *DENIED *SAME, *ALLOWED, *DENIED
*ALLOBJ special authority . . . *NOTUSED *SAME, *USED, *NOTUSED

```

Figure 8-3 Change Function Usage panel

In the example that is shown in Figure 8-4, the DBADMINS group profile is being authorized for the QIBM_DB_SECADM function.

```

Change Function Usage (CHGFCNUSG)

Type choices, press Enter.

Function ID . . . . . > QIBM_DB_SECADM
User . . . . . DBADMINS Name
Usage . . . . . *ALLOWED *ALLOWED, *DENIED, *NONE
Default authority . . . . . *DENIED *SAME, *ALLOWED, *DENIED
*ALLOBJ special authority . . . *NOTUSED *SAME, *USED, *NOTUSED

```

Figure 8-4 Allow the DBADMINS group profile access to the QIBM_DB_SECADM function

Showing the function usage for the QIBM_DB_SECADM function now shows that all users in the DBADMINS group now can manage DB2 security. See Figure 8-5.

```

Display Function Usage

Function ID . . . . . : QIBM_DB_SECADM
Function name . . . . . : Database Security Administrator

Description . . . . . : Database Security Administrator Functions

Product . . . . . : QIBM_BASE_OPERATING_SYSTEM
Group . . . . . : QIBM_DB

Default authority . . . . . : *DENIED
*ALLOBJ special authority . . . . . : *NOTUSED

User      Type      Usage      User      Type      Usage
DBADMINS Group    *ALLOWED
DEVELOPER1 User      *DENIED
DEVELOPER2 User      *DENIED

```

Figure 8-5 Display Function Usage panel showing the authority that is granted to DBADMINS group profile

8.2.2 Row and Column Access Control support

IBM i 7.2 is now distributed with option 47, IBM Advanced Data Security for IBM i. This option must be installed before using Row and Column Access Control (RCAC).

RCAC is based on the DB2 for i ability to define rules for *row access control* (by using the SQL statement **CREATE PERMISSION**) and to define rules for *column access control* and *creation of column masks* for specific users or groups (by using the SQL statement **CREATE MASK**).

Note: RCAC is described in detail in *Row and Column Access Support in IBM DB2 for i*, REDP-5110. This section only briefly describes the basic principles of RCAC and provides a short example that shows the ease of implementing the basic separation of duties concept.

Special registers that are used for user identifications

To implement RCAC, special registers are needed to check which user is trying to display or use data in a particular table. To be able to identify users for the RCAC, IBM i uses several special registers that are listed in Table 8-1.

Table 8-1 Special registers for identifying users

Special register	Definition
USER or SESSION_USER	The effective user of the thread is returned.
SYSTEM_USER	The authorization ID that initiated the connection is returned.
CURRENT_USER or CURRENT_USER	The most recently program adopted authorization ID within the thread is returned. When no adopted authority is active, the effective user of the thread is returned.

CURRENT_USER: The CURRENT_USER special register is new in DB2 for IBM i 7.2. For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaq9/rzaq9osDBcurrentuser.htm

VERIFY_GROUP_FOR_USER function

The VERIFY_GROUP_FOR_USER function has two parameters: **userid** and **group**.

For RCAC, the **userid** parameter is usually one of special register values (SESSION_USER, SYSTEM_USER, or CURRENT_USER), as described in “Special registers that are used for user identifications” on page 326.

This function returns a large integer value. If the user is member of group, this function returns a value of 1; otherwise, it returns a value of 0.

RCAC example

This section provides a brief example of implementing RCAC. This example uses an employee database table in a library called HR. This employee database table contains the following fields:

- ▶ Last name
- ▶ First name
- ▶ Date of birth
- ▶ Bank account number
- ▶ Employee number
- ▶ Department number
- ▶ Salary

Another database table that is called CHIEF contains, for each employee number, the employee number of their boss or chief.

You must create the following group profiles, as shown in Example 8-1:

- ▶ EMPGRP, which contains members of all employees
- ▶ HRGRP, which contains members from the HR department
- ▶ BOARDGRP, which contains members of all bosses or chiefs in the company

Example 8-1 Create group profiles for the RCAC example

```
CRTUSRPRF USRPRF(EMPGRP)
          PASSWORD(*NONE)
          TEXT('Employee group')

CRTUSRPRF USRPRF(HRGRP)
          PASSWORD(*NONE)
          TEXT('Human resources group')

CRTUSRPRF USRPRF(BOARDGRP)
          PASSWORD(*NONE)
          TEXT('Chiefs group')
```

Next, create the user profiles, as shown in the Example 8-2. For simplicity, this example assumes the following items:

- ▶ The user profile password is the same as the user profile name.
- ▶ For all employees, the user profile name is the same as employee's last name.

Example 8-2 Create user profiles for the RCAC example

```
CRTUSRPRF USRPRF(JANAJ)
          TEXT('Jana Jameson')
          GRPPRF(EMPNO)
          SUPGRPRF(HRGRP)

-- Jana Jameson works in the HR department

CRTUSRPRF USRPRF(JONES)
          TEXT('George Jones - the company boss')
          GRPPRF(EMPGRP)
          SUPGRPPRF(BOARDGRP)

-- George James is a boss in the company and is an employee as well.

CRTUSRPRF USRPRF(FERRANONI)
          TEXT('Fabrizio Ferranoni')
          GRPPRF(EMPGRP)

CRTUSRPRF USRPRF(KADLEC)
          TEXT('Ian Kadlec')
          GRPPRF(EMPGRP)

CRTUSRPRF USRPRF(NORTON)
          TEXT('Laura Norton')
          GRPPRF(EMPGRP)

CRTUSRPRF USRPRF(WASHINGTON)
          TEXT('Kimberly Washington')
          GRPPRF(EMPGRP)
```

Now, create the DB2 schema (collection) HR and employee table EMPLOYEE. The primary key for the employee table is the employee number. After creating the database table EMPLOYEE, create indexes EMPLOYEE01 and EMPLOYEE02 for faster access. Then, add records to the database by using the SQL **insert** command. See Example 8-3.

Note: When entering SQL commands, you can use either the **STRSQL** CL command to start an interactive SQL session or use IBM Navigator for i. If you use **STRSQL**, make sure to remove the semicolon marks at the end of each SQL statement.

Example 8-3 Create the schema, database table, and indexes, and populate the table with data

```
CREATE TABLE HR/EMPLOYEE
(FIRST_NAME FOR COLUMN FNAME CHARACTER (15 ) NOT NULL WITH DEFAULT,
LAST_NAME FOR COLUMN LNAME CHARACTER (15 ) NOT NULL WITH DEFAULT,
DATE_OF_BIRTH FOR COLUMN BIRTHDATE DATE NOT NULL WITH DEFAULT,
BANK_ACCOUNT CHARACTER (9 ) NOT NULL WITH DEFAULT,
EMPLOYEE_NUM FOR COLUMN EMPNO CHARACTER(6) NOT NULL WITH DEFAULT,
DEPARTMENT FOR COLUMN DEPT DECIMAL (4, 0) NOT NULL WITH DEFAULT,
SALARY DECIMAL (9, 0) NOT NULL WITH DEFAULT,
PRIMARY KEY (EMPLOYEE_NUM)) ;

CREATE INDEX HR/EMPLOYEE01 ON HR/EMPLOYEE
(LAST_NAME ASC,
FIRST_NAME ASC) ;

CREATE INDEX HR/EMPLOYEE02 ON HR/EMPLOYEE
(DEPARTMENT ASC,
LAST_NAME ASC,
FIRST_NAME ASC);

-- Now created the table CHIEF and add data
CREATE TABLE HR/CHIEF
(EMPLOYEE_NUM FOR COLUMN EMPNO CHARACTER(6 ) NOT NULL WITH DEFAULT,
CHIEF_NO CHARACTER(6 ) NOT NULL WITH DEFAULT,
PRIMARY KEY (EMPLOYEE_NUM)) ;

INSERT INTO HR/CHIEF VALUES
(
'G76852', 'G00012') ;

INSERT INTO HR/CHIEF VALUES
(
'G12835', 'G00012');

INSERT INTO HR/CHIEF VALUES
(
'G23561', 'G00012');

INSERT INTO HR/CHIEF VALUES
(
'G00012', 'CHIEF ');

INSERT INTO HR/CHIEF VALUES
(
'G32421', 'G00012');
```

```

-- Load example data into EMPLOYEE table
INSERT INTO HR/EMPLOYEE
      VALUES('Fabrizio', 'Ferraroni',
      DATE('05/12/1959') , 345723909, 'G76852','0001', 96000) ;

INSERT INTO HR/EMPLOYEE
      VALUES('Ian', 'Kadlec',
      DATE('11/23/1967') , 783920125, 'G23561', '0001', 64111) ;

INSERT INTO HR/EMPLOYEE
      VALUES('Laura', 'Norton',
      DATE('02/20/1972') , 834510932, 'G00012', '0001', 55222) ;

INSERT INTO HR/EMPLOYEE
      VALUES('Kimberly', 'Washington',
      DATE('10/31/1972') , 157629076, 'G12435', '0005' , 100000);

INSERT INTO HR/EMPLOYEE
      VALUES('George', 'Jones',
      DATE('10/11/1952') , 673948571, 'G00001', '0000' , 1100000);

INSERT INTO HR/EMPLOYEE
      VALUES('Jana ', 'Jameson',
      DATE('10/11/1952') , 643247347, 'G32421', '0205' , 30000);

```

Now comes the most important and most interesting part of this example, which is defining the row and column access rules. First, specify the row permission access rules, as shown in Example 8-4. The following rules are implemented:

- ▶ Each employee should see only their own record, except for employees from the human resources department (group HRGRP).
- ▶ Chiefs (group BOARDGRP) should have access to all rows.

Example 8-4 Example of row access rule

```

CREATE PERMISSION ACCESS_TO_ROW ON HR/EMPLOYEE
FOR ROWS WHERE
      (VERIFY_GROUP_FOR_USER(SESSION_USER, 'BOARDGRP') = 1)
      OR
      (VERIFY_GROUP_FOR_USER(SESSION_USER, 'EMPGRP') = 1
      AND UPPER(LAST_NAME) = SESSION_USER)
      OR
      (VERIFY_GROUP_FOR_USER(SESSION_USER, 'HRGRP') = 1)

ENFORCED FOR ALL ACCESS
ENABLE ;

-- Activate row access control
ALTER TABLE HR/EMPLOYEE ACTIVATE ROW ACCESS CONTROL ;

```

Here is an explanation of Example 8-4 on page 329:

1. This example creates a rule that is called `ACCESS_ON_ROW`.
2. First, a check is done by using the `VERIFY_GROUP_FOR_USER` function to see whether the user profile of the person who is querying the employee table (`SESSION_USER`) is part of the group `BOARDGRP`. If the user is a member of `BOARDGRP`, the function returns a value of 1 and they are granted access to the row.
3. If the user is member of the `EMPGRP` group, a check is done to see whether this user has records in the file (`UPPER(LAST_NAME) = SESSION_USER`). For example, employee Ian Kadlec cannot see the row (record) of the employee Laura Norton.
4. Another verification is done to see whether the user profile is a member of the group `HRGRP`. If yes, the user profile has access to all employee records (rows).
5. If none of conditions are true, the user looking at the table data sees no records.
6. Finally, using the SQL command `ALTER TABLE...ACTIVATE ROW ACCESS CONTROL`, the row permission rules are activated.

Example 8-5 shows an example of using column masks. The SQL `CREATE MASK` statement is used to hide data in specific columns that contain sensitive personal information, such as a bank account number or salary, and present that data to only authorized people.

Example 8-5 Example of creating column masks

```
-- Following are masks for columns, BANK_ACCOUNT and SALARY
CREATE MASK BANKACC_MASK ON HR/EMPLOYEE FOR
COLUMN BANK_ACCOUNT RETURN
CASE
  WHEN (VERIFY_GROUP_FOR_USER(SESSION_USER, 'BOARDGRP' ) = 1
        AND UPPER(LAST_NAME) = SESSION_USER )
  THEN BANK_ACCOUNT
  WHEN VERIFY_GROUP_FOR_USER(SESSION_USER, 'HRGRP' ) = 1
  THEN BANK_ACCOUNT
  WHEN UPPER(LAST_NAME) = SESSION_USER
        AND
        VERIFY_GROUP_FOR_USER(SESSION_USER, 'EMPGRP' ) = 1
  THEN BANK_ACCOUNT
  ELSE '*****'
END
ENABLE;

CREATE MASK SALARY_MASK ON HR/EMPLOYEE FOR
COLUMN SALARY RETURN
CASE
  WHEN UPPER(LAST_NAME) = SESSION_USER
        AND VERIFY_GROUP_FOR_USER(SESSION_USER, 'EMPNO') = 1
  THEN SALARY
  WHEN VERIFY_GROUP_FOR_USER(SESSION_USER, 'BOARDGRP' ) = 1
  THEN SALARY
  WHEN VERIFY_GROUP_FOR_USER(SESSION_USER, 'HRGRP' ) = 1
  THEN SALARY
  ELSE 0
END
ENABLE;
-- Activate both column masks
ALTER TABLE HR/EMPLOYEE ACTIVATE COLUMN ACCESS CONTROL ;
```

Here is an explanation of Example 8-5 on page 330:

1. This example is creating a column mask that is called BANKACC_MASK, which is related to the BANK_ACCOUNT column.
2. If the user accessing the data is a chief (member of the BORADGRP group), then show only their bank account data.
3. If the user accessing the data is an HR department employee (member of the HRGRP group), then show all employee bank account numbers.
4. All other users should not see the bank account number, so the data is masked with '*****'.
5. Next, create the column mask that is called SALARY_MASK, which is related to the SALARY column.
6. If the user accessing the data is an employee (member of the EMPGRP group), then show only their salary data.
7. If the user accessing the data is an HR employee (member of the HRGRP group), then show all the salary data.
8. If the user accessing the data is a chief (member of the BOARDGRP group), then show all the salary data.
9. All other users should not see the salary data, so the data is masked with '*****'.
10. Finally, using the SQL command ALTER TABLE...ACTIVATE Column ACCESS CONTROL, the column mask rules are activated.

Results

When user JONES logs on (they are a member of the BOARDGRP group), they see the results from the EMPLOYEE table, as shown in Figure 8-6. A chief can see all employees and their salaries, but can see only their own bank account number.

SELECT * FROM HR.EMPLOYEE						
FIRST_NAME	LAST_NAME	DATE_OF_BIRTH	BANK_ACCOUNT	EMPLOYEE_NUM	DEPARTMENT	SALARY
Fabrizio	Ferranoni	1959-05-12	*****	G76852	1	96000
Ian	Kadlec	1967-11-23	*****	G23561	1	64111
Laura	Norton	1972-02-20	*****	G00012	1	55222
Kimberly	Washington	1972-10-31	*****	G12435	5	100000
George	Jones	1952-10-11	673948571	G00001	0	1100000
Jana	Jameson	1952-10-11	*****	G32421	205	30000

Figure 8-6 EMPLOYEE table as seen by the JONES user profile (Chief)

When any employee (in this example, the KADLEC user profile) logs on, they see the results from the EMPLOYEE table, as shown in Figure 8-7. In this case, each employee sees all data, but only data that is related to their person. This is a result of the ACCESS_TO_ROW row permission rule.

SELECT * FROM HR.EMPLOYEE						
FIRST_NAME	LAST_NAME	DATE_OF_BIRTH	BANK_ACCOUNT	EMPLOYEE_NUM	DEPARTMENT	SALARY
Ian	Kadlec	1967-11-23	783920125	G23561	1	0

Figure 8-7 EMPLOYEE table as seen by the KADLEC user profile

When a human resources employee (in this example, the JANAJ user profile) logs on, they see the results from EMPLOYEE table, as shown in Figure 8-8. A human resources employee sees the bank accounts and salaries of all employees.

SELECT * FROM HR.EMPLOYEE						
FIRST_NAME	LAST_NAME	DATE_OF_BIRTH	BANK_ACCOUNT	EMPLOYEE_NUM	DEPARTMENT	SALARY
Fabrizio	Ferraroni	1959-05-12	345723909	G76852	1	96000
Ian	Kadlec	1967-11-23	783920125	G23561	1	64111
Laura	Norton	1972-02-20	834510932	G00012	1	55222
Kimberly	Washington	1972-10-31	157629076	G12435	5	100000
George	Jones	1952-10-11	673948571	G00001	0	1100000
Jana	Jameson	1952-10-11	643247347	G32421	205	30000

Figure 8-8 EMPLOYEE table as seen by the JANAJ user profile (human resources employee)

All other user profiles see an empty database file.

Adding the OR REPLACE clause to masks and permissions

Similar to other Data Definition Language (DDL) statements, the OR REPLACE clause was added to the following SQL commands:

- ▶ CREATE MASK
- ▶ REPLACE MASK
- ▶ CREATE PERMISSION
- ▶ REPLACE PERMISSION

The use of the OR REPLACE clause makes it easier to redeploy the RCAC rule text. For more information about the OR REPLACE clause, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.3 DB2 security enhancements

This section describes the following DB2 security-related enhancements in IBM i 7.2:

- ▶ 8.3.1, “QIBM_DB_ZDA and QIBM_DB_DDMDRDA function usage IDs” on page 333
- ▶ 8.3.2, “Authorization list detail added to authorization catalogs” on page 333
- ▶ 8.3.3, “New user-defined table function: QSYS2.GROUP_USERS()” on page 334
- ▶ 8.3.4, “New security view: QSYS2.GROUP_PROFILE_ENTRIES” on page 334
- ▶ 8.3.5, “New attribute column in the SYSIBM.AUTHORIZATIONS catalog” on page 334
- ▶ 8.3.6, “New QSYS2.SQL_CHECK_AUTHORITY() UDF” on page 335
- ▶ 8.3.7, “Refined object auditing control on QIBM_DB_OPEN exit program” on page 335
- ▶ 8.3.8, “Simplified DDM/DRDA authentication management by using group profiles” on page 336
- ▶ 8.3.9, “IBM InfoSphere Guardium V9.0 and IBM Security Guardium V10” on page 337

8.3.1 QIBM_DB_ZDA and QIBM_DB_DDMDRDA function usage IDs

The **QIBM_DB_ZDA** and **QIBM_DB_DDMDRDA** function usage IDs block database server inbound connections. These function usage IDs ship with the default authority of ***ALLOWED**:

- ▶ You can use the **QIBM_DB_ZDA** function usage ID to restrict ODBC and JDBC Toolbox from the server side, including Run SQL Scripts, System i Navigator, and DB2 specific portions of Systems Director Navigator for i.
- ▶ You can use the **QIBM_DB_DDMDRDA** function usage ID to lock down DDM and IBM DRDA application server access.

These function usage IDs can be managed by the Work with Function Usage (**WRKFCNUSG**) CL command or by using the Change Function Usage (**CHGFCNUSG**) CL command. For an example of using the **CHGFCNUSG** CL command, see Example 8-6.

Example 8-6 Deny user profile user1 the usage of the DDM and DRDA application server access

```
CHGFCNUSG FCNID(QIBM_DB_DDMDRDA) USER(user1) USAGE(*DENIED)
```

8.3.2 Authorization list detail added to authorization catalogs

Using an authorization list eases security management and also improves performance because user profiles do not need to contain a list of objects to which they are authorized. They need to contain the authorization list that contains these objects.

Table 8-2 lists the DB2 for i catalogs that were updated to include the **AUTHORIZATION_LIST** column.

Note: Catalogs **QSYS2/SYSXSROBJECTAUTH** and **QSYS2/SYSVARIABLEAUTH** were already updated in IBM i 7.1 to have the **AUTHORIZATION_LIST** column.

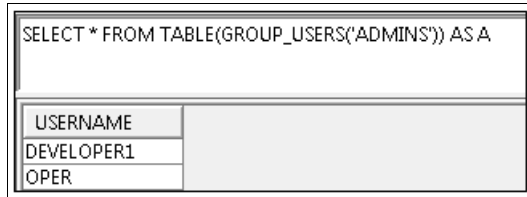
Table 8-2 Catalogs containing the AUTHORIZATION_LIST column

Catalog	Catalog description
QSYS2/SYSPACKAGEAUTH	*SQLPKG - Packages
QSYS2/SYSUDTAUTH	*SQLUDT - User-defined types
QSYS2/SYSTABAUTH	*FILE - Tables
QSYS2/SYSSEQUENCEAUTH	*DTAARA - Sequences
QSYS2/SYSSCHEMAAUTH	*LIB - Schema
QSYS2/SYSROUTINEAUTH	*PGM and *SRVPGM - Procedures and Functions
QSYS2/SYSCOLAUTH	Columns
QSYS2/SYSXSROBJECTAUTH	*XSROBJ - XML Schema Repositories
QSYS2/SYSVARIABLEAUTH	*SRVPGM - Global Variables

8.3.3 New user-defined table function: QSYS2.GROUP_USERS()

QSYS2.GROUP_USERS() is a new UDTF that you can use to create queries that can specify a group profile as its parameter and list user profiles in this group as the output.

The **QSYS2.GROUP_USERS()** function returns user profiles that have the specified group set up as their main or supplemental group. See Figure 8-9.



```
SELECT * FROM TABLE(GROUP_USERS('ADMINS')) AS A
```

USERNAME
DEVELOPER1
OPER

Figure 8-9 Example of the QSYS2.GROUP_USERS() UDTF

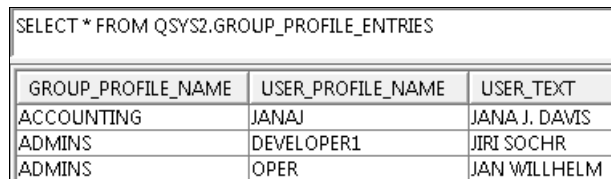
8.3.4 New security view: QSYS2.GROUP_PROFILE_ENTRIES

The new QSYS2.GROUP_PROFILE_ENTRIES security view returns a table with the following three columns:

- ▶ GROUP_PROFILE_NAME
- ▶ USER_PROFILE_NAME
- ▶ USER_TEXT

It accounts for both group and supplemental group profiles.

Figure 8-10 shows an example of using the QSYS2.GROUP_PROFILE_ENTRIES security view.



```
SELECT * FROM QSYS2.GROUP_PROFILE_ENTRIES
```

GROUP_PROFILE_NAME	USER_PROFILE_NAME	USER_TEXT
ACCOUNTING	JANAJ	JANA J. DAVIS
ADMINS	DEVELOPER1	JIRI SOCHR
ADMINS	OPER	JAN WILLHELM

Figure 8-10 Example of the QSYS2.GROUP_PROFILE_ENTRIES security view

8.3.5 New attribute column in the SYSIBM.AUTHORIZATIONS catalog

The SYSIBM.AUTHORIZATIONS view is a DB2 family compatible catalog that contains a row for every authorization ID.

The SYSIBM.AUTHORIZATIONS catalog is extended to include a new column that is called AUTHORIZATION_ATTR, which differentiates users from groups. See Figure 8-11 on page 335.

```
SELECT * FROM SYSIBM.AUTHORIZATIONS;
```

AUTHORIZATION_NAME	AUTHORIZATION_TYPE	AUTHORIZATION_ATTR	AUTHORIZATION_TEXT
ACCOUNTING	USER	GROUP	Accounting group
ADMINS	USER	GROUP	Admins group
CZZ62690	USER	USER	Application functional ID
DEVELOPER1	USER	USER	JIRI SOCHR
JANAJ	USER	USER	JANA J. DAMS
OPER	USER	USER	JAN WILLHELM
QANZAGENT	USER	USER	Trace Analyzer Agent Server
QAUTPROF	USER	USER	IBM-supplied User Profile
QBRMS	USER	GROUP	IBM-supplied User Profile

Figure 8-11 SYSIBM.AUTHORIZATIONS catalog showing the new AUTHORIZATION_ATTR column

8.3.6 New QSYS2.SQL_CHECK_AUTHORITY() UDF

The `QSYS2.SQL_CHECK_AUTHORITY()` UDF is used to determine whether the user calling this function has the authority to object that is specified. The object type must be `*FILE`. The first parameter is the library and the second parameter is the object name. The result type is `SMALLINT`.

There are two possible result values:

- ▶ 1: User has authority
- ▶ 0: User does not have authority

Figure 8-12 shows the user that has authority to the `CZZ62690/QTXTSRC` object.

```
VALUES(QSYS2.SQL_CHECK_AUTHORITY('CZZ62690','QXTSRC'));
```

00001
1

Figure 8-12 Example of user of the `QSYS2.SQL_CHECK_AUTHORITY` UDF

8.3.7 Refined object auditing control on QIBM_DB_OPEN exit program

Previously, an exit program control (`*OBJAUD`) was added to limit exit program calls. Because of the wide use of `*CHANGE` object auditing in some environments, the `*OBJAUD` control did not reduce the calls to the exit program enough in some environments.

The Open Data Base File exit program was enhanced to support two new values for the exit program data: `OBJAUD(*ALL)` and `OBJAUD(*CHANGE)`.

Example 8-7 shows that three approaches are now possible.

Example 8-7 Object auditing control on the QIBM_DB_OPEN exit program

First example: The exit program is called when using **any object auditing**.

```
ADDEXITPGM EXITPNT(QIBM_QDB_OPEN) FORMAT(DBOP0100) PGMNBR(7) PGM(MJATST/OPENEXIT2)
THDSAFE(*YES) TEXT('MJA') REPLACE(*NO) PGMFTA(*JOB *CALC '*OBJAUD')
```

Second example: The exit program is called when using ***ALL object auditing**.

```
ADDEXITPGM EXITPNT(QIBM_QDB_OPEN) FORMAT(DBOP0100) PGMNBR(7) PGM(MJATST/OPENEXIT2)
THDSAFE(*YES) TEXT('MJA') REPLACE(*NO) PGMFTA(*JOB *CALC '*OBJAUD(*ALL)')
```

Third example: The exit program is called when using ***CHANGE object auditing**.

```
ADDEXITPGM EXITPNT(QIBM_QDB_OPEN) FORMAT(DBOP0100) PGMNBR(7) PGM(MJATST/OPENEXIT2)
THDSAFE(*YES) TEXT('MJA') REPLACE(*NO) PGMDTA(*JOB *CALC 'OBJAUD(*CHANGE)')
```

8.3.8 Simplified DDM/DRDA authentication management by using group profiles

The new function of simplified DDM/DRDA authentication management by using group profiles enhances the authentication process when users connect to a remote database by using DDM or DRDA, for example, by using the SQL command **CONNECT TO <database>**.

Before this enhancement, any user connecting to a remote database needed to have a server authentication entry (by using the Add Server Authentication Entry (**ADDSVRAUTE**) CL command) with a password for their user profile.

Note: To use the **ADDSVRAUTE** CL command, you must have the following special authorities:

- ▶ Security administrator (*SECADM) user special authority
- ▶ Object management (*OBJMGT) user special authority

You can use this enhancement to have a server authentication entry that is based on a group profile instead of individual users. When a user is a member of a group profile, or has a group profile set up as supplemental in their user profile, then only the group profile must have a server authentication entry. See Example 8-8.

Example 8-8 Use a group profile authentication entry to access a remote database

First create a group profile called TESTGROUP:

```
CRTUSRPRF USRPRF(TESTGROUP) PASSWORD(*NONE)
```

Then create a user profile TESTUSR and make it a member of TESTGROUP:

```
CRTUSRPRF USRPRF(TESTUSR) PASSWORD(somepasswd) GRPPRF(TESTTEAM)
```

Create the server authentication entry:

```
ADDSVRAUTE USRPRF(TESTGROUP) SERVER(QDDMDRDASERVER or <RDB-name>) USRID(sysbusrid)
PASSWORD(sysbpwd)
```

User TESTUSR then uses the STRSQL command to get to an interactive SQL session and issues the following command, where RDB-name is a remote relational database registered using the command **WRKRDBDIRE**:

```
CONNECT TO <RDB-name>
```

The connection attempt is done to the system with **<RDB-name>** using **<sysbusrid>** user profile and **<sysbpwd>** password.

The following steps define the process of group profile authentication:

1. Search the authentication entries where USRPRF=user profile and SERVER=application server name.
2. Search the authentication entries where USRPRF=user profile and SERVER='QDDMDRDASERVER'.

3. Search the authentication entries where USRPRF=group profile and SERVER=application server name.
4. Search the authentication entries where USRPRF=group profile and SERVER='QDDMDRDASERVER'.
5. Search the authentication entries where USRPRF=supplemental group profile and SERVER=application server name.
6. Search the authentication entries where USRPRF=supplemental group profile and SERVER='QDDMDRDASERVER'.
7. If no entry was found in all the previous steps, a USERID only authentication is attempted.

Note: When the default authentication entry search order (explained in the previous steps) is used, the search order ceases at connect time if a match is found for QDDMDRDASERVER.

The QIBM_DDMDRDA_SVRNAM_PRIORITY environment variable can be used to specified whether an explicit server name order is used when searching for authentication entries.

Example 8-9 shows an example of creating the QIBM_DDMDRDA_SVRNAM_PRIORITY environment variable.

Example 8-9 Create the QIBM_DDMDRDA_SVRNAM_PRIORITY environment variable

```
ADDENVVAR ENVVAR(QIBM_DDMDRDA_SVRNAM_PRIORITY) VALUE('Y') LEVEL(*JOB or *SYS)
```

For more information about how to set up authority for DDM and DRDA, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/ddp/rballsourcesecurity.htm?lang=en

8.3.9 IBM InfoSphere Guardium V9.0 and IBM Security Guardium V10

IBM Security Guardium® (formerly known as IBM InfoSphere® Guardium) is an enterprise information database audit and protection solution that helps enterprises protect and audit information across a diverse set of relational and non-relational data sources. It allows companies to stay compliant with wide range of standards. Here are some of security areas that are monitored:

- ▶ Access to sensitive data (successful or failed **SELECTs**)
- ▶ Schema changes (**CREATE, DROP, ALTER TABLES**, and so on)
- ▶ Security exceptions (failed logins, SQL errors, and so on)
- ▶ Accounts, roles, and permissions (**GRANT** and **REVOKE**)

The Security Guardium product captures database activity from DB2 for i by using the AIX based IBM S-TAP® software module running in PASE. Both audit information and SQL monitor information is streamed to S-TAP. Audit details that are passed to S-TAP can be filtered for both audit data and also DB2 monitor data for performance reasons.

Figure 8-13 shows how Security Guardium collects data from DB2 monitors and the audit journal.

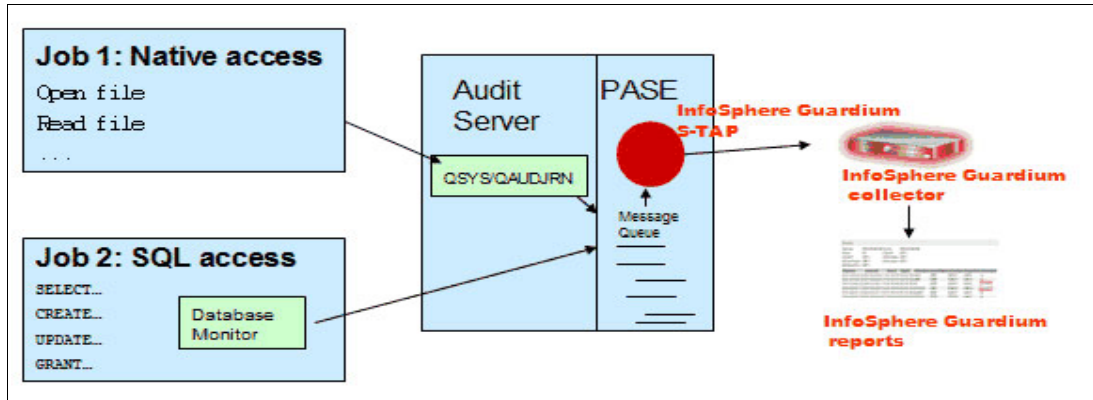


Figure 8-13 InfoSphere Guardium V9.0 Collection Data flow

With InfoSphere Guardium V9.0, DB2 for IBM i can now be included as a data source, enabling the monitoring of accesses from native interfaces and through SQL. Supported DB2 for i data sources are from IBM i 6.1, 7.1, and 7.2.

The Data Access Monitor feature is enhanced in V9.0 with the following capabilities:

- ▶ Failover support for IBM i was added.
- ▶ Support for multiple policies (up to nine), with IBM i side configuration.
- ▶ Filtering improvements, with IBM i side configuration.

For more information about InfoSphere Guardium V9.0 and DB2 for i support, see the following website:

<https://ibm.biz/GuardiumDAMonIBMi>

The successor version of InfoSphere Guardium V9.0 is IBM Security Guardium V10. Version 10 has the Data Access Monitor feature and has a new Vulnerability Assessment (VA) feature. Vulnerability Assessment with IBM i contains a comprehensive set of more than 130 tests that show weaknesses in your IBM i security setup. It allows reporting for IBM i 6.1, 7.1, and 7.2 partitions.

Data Access Monitor Enhancements in IBM Security Guardium V10

The Data Access Monitor feature has the following functions for the IBM i client:

- ▶ Failover support for IBM i was added.
- ▶ Support for multiple policies (up to nine), with IBM i side configuration.
- ▶ Filtering improvements, with IBM i side configuration.
- ▶ Support for S-TAP load balancing (non-enterprise).
- ▶ Encrypted traffic between S-TAP and collector.
- ▶ Closer alignment with other UNIX S-TAP.

Figure 8-14 shows the revised S-TAP architecture and enhanced Guardium topology for IBM Security Guardium V10.

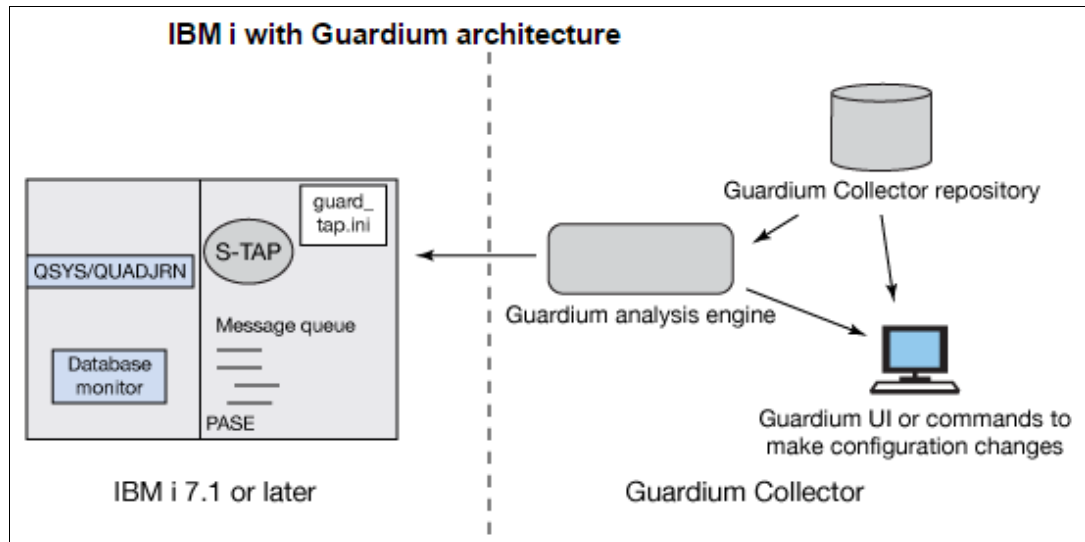


Figure 8-14 IBM Security Guardium V10 Collection Data flow

For more information about Security Guardium V10 and DB2 for i support, see the following website:

<https://ibm.biz/BdsDUJ>

There is also an article in IBM developerWorks covering more details of IBM Security Guardium V10:

<http://www.ibm.com/developerworks/library/se-guardium-v10/index.html>

8.4 DB2 functional enhancements

This section introduces the functional enhancements of DB2 for i 7.2, which include the following items:

- ▶ 8.4.1, "OFFSET and LIMIT clauses" on page 340
- ▶ 8.4.2, "CREATE OR REPLACE table SQL statement" on page 340
- ▶ 8.4.3, "DB2 JavaScript Object Notation store" on page 344
- ▶ 8.4.4, "Remote 3-part name support on ASSOCIATE LOCATOR" on page 344
- ▶ 8.4.5, "Flexible views" on page 344
- ▶ 8.4.6, "Increased time stamp precision" on page 345
- ▶ 8.4.7, "Named and default parameter support for UDF and UDTFs" on page 346
- ▶ 8.4.8, "Function resolution by using casting rules" on page 347
- ▶ 8.4.9, "Use of ARRAYs within scalar UDFs" on page 349
- ▶ 8.4.10, "Built-in global variables" on page 351
- ▶ 8.4.11, "Expressions in PREPARE and EXECUTE IMMEDIATE statements" on page 352
- ▶ 8.4.12, "Autonomous procedures" on page 353
- ▶ 8.4.13, "New SQL TRUNCATE statement" on page 354

- ▶ 8.4.14, “New LPAD() and RPAD() built-in functions” on page 355
- ▶ 8.4.15, “Pipelined table functions” on page 356
- ▶ 8.4.16, “Regular expressions” on page 358
- ▶ 8.4.17, “JOB_NAME and SERVER_MODE_JOB_NAME built-in global variables” on page 359
- ▶ 8.4.18, “RUNSQL control of output listing” on page 359
- ▶ 8.4.19, “LOCK TABLE ability to target non-*FIRST members” on page 360
- ▶ 8.4.20, “QUSRJOB() retrieval of DB2 built-in global variables” on page 360
- ▶ 8.4.21, “SQL functions (user-defined functions and user-defined table functions) parameter limit” on page 360
- ▶ 8.4.22, “New binary scalar functions” on page 360
- ▶ 8.4.23, “Adding and dropping partitions spanning DDS logical files” on page 361
- ▶ 8.4.24, “Direct control of system names for global variables” on page 361
- ▶ 8.4.25, “LOCK TABLE ability to target non-FIRST members” on page 362

8.4.1 OFFSET and LIMIT clauses

In SQL queries, it is now possible to specify OFFSET and LIMIT clauses:

- ▶ The OFFSET clause specifies how many rows to skip before any rows are retrieved as part of a query.
- ▶ The LIMIT clause specifies the maximum number of rows to return.

This support is useful when programming a web page containing data from large tables and the user must page up and page down to see additional records. You can use OFFSET to retrieve data only for a specific page, and use LIMIT to see how many records a page has.

The following considerations apply:

- ▶ This support is possible only when LIMIT is used as part of the outer full select of a **DECLARE CURSOR** statement or a prepared **SELECT** statement.
- ▶ The support does not exist within the Start SQL (**STRSQL**) command.

For more information about the OFFSET and LIMIT clauses, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzpdf.pdf?lang=en

8.4.2 CREATE OR REPLACE table SQL statement

DB2 for i now allows optional **OR REPLACE** capability to the **CREATE TABLE** statement. This improvement gives users the possibility of a much better approach to the modification of tables strategy. Before this support, the only way to modify a table was to use an **ALTER TABLE** statement and manually remove and re-create dependent objects.

The **OR REPLACE** capability specifies replacing the definition for the table if one exists at the current server. The existing definition is effectively altered before the new definition is replaced in the catalog.

Definition for the table exists if the following is true:

- ▶ **FOR SYSTEM NAME** is specified and the system-object-identifier matches the system-object-identifier of an existing table.
- ▶ **FOR SYSTEM NAME** is not specified and table-name is a system object name that matches the system-object-identifier of an existing table.

If a definition for the table exists and table-name is not a system object name, table-name can be changed to provide a new name for the table.

This option is ignored if a definition for the table does not exist in the current server.

When the table already exists, the **CREATE OR REPLACE TABLE** SQL statement can specify behavior that is related to the process of changing the database table by using the **ON REPLACE** clause.

There are three options:

▶ **PRESERVE ALL ROWS**

The current rows of the specified table are preserved. **PRESERVE ALL ROWS** is not allowed if **WITH DATA** is specified with result-table-as.

All rows of all partitions in a partitioned table are preserved. If the new table definition is a range partitioned table, the defined ranges must be able to contain all the rows from the existing partitions.

If a column is dropped, the column values are not preserved. If a column is altered, the column values can be modified.

If the table is not a partitioned table or is a hash partitioned table, **PRESERVE ALL ROWS** and **PRESERVE ROWS** are equivalent.

▶ **PRESERVE ROWS**

The current rows of the specified table are preserved. **PRESERVE ROWS** is not allowed if **WITH DATA** is specified with result-table-as.

If a partition of a range partitioned table is dropped, the rows of that partition are deleted without processing any delete triggers. To determine whether a partition of a range partitioned table is dropped, the range definitions and the partition names (if any) of the partitions in the new table definition are compared to the partitions in the existing table definition. If either the specified range or the name of a partition matches, it is preserved. If a partition does not have a partition-name, its boundary-spec must match an existing partition.

If a partition of a hash partition table is dropped, the rows of that partition are preserved.

If a column is dropped, the column values are not preserved. If a column is altered, the column values can be modified.

▶ **DELETE ROWS**

The current rows of the specified table are deleted. Any existing **DELETE** triggers are not fired.

REPLACE rules

When a table is re-created by **REPLACE** by using **PRESERVE ROWS**, the new definition of the table is compared to the old definition and logically, for each difference between the two, a corresponding **ALTER** operation is performed. When the **DELETE ROWS** option is used, the table is logically dropped and re-created; if objects that depend on the table remain valid, any modification is allowed.

For more information, see Table 8-3. For columns, constraints, and partitions, the comparisons are performed based on their names and attributes.

Table 8-3 Behavior of REPLACE compared to ALTER TABLE functions

New definition versus existing definition	Equivalent ALTER TABLE function
Column	
The column exists in both and the attributes are the same.	No change
The column exists in both and the attributes are different.	ALTER COLUMN
The column exists only in new table definition.	ADD COLUMN
The column exists only in existing table definition.	DROP COLUMN RESTRICT
Constraint	
The constraint exists in both and is the same.	No change
The constraint exists in both and is different.	DROP constraint RESTRICT and ADD constraint
The constraint exists only in the new table definition.	ADD constraint
The constraint exists only in the existing table definition.	DROP constraint RESTRICT
materialized-query-definition	
<i>materialized-query-definition</i> exists in both and is the same.	No change
<i>materialized-query-definition</i> exists in both and is different.	ALTER MATERIALIZED QUERY
<i>materialized-query-definition</i> exists only in the new table definition.	ADD MATERIALIZED QUERY
<i>materialized-query-definition</i> exists only in the existing table definition.	DROP MATERIALIZED QUERY
partitioning-clause	
<i>partitioning-clause</i> exists in both and is the same.	No change
<i>partitioning-clause</i> exists in both and is different.	ADD PARTITION, DROP PARTITION, and ALTER PARTITION
<i>partitioning-clause</i> exists only in the new table definition.	ADD <i>partitioning-clause</i>
<i>partitioning-clause</i> exists only in the existing table definition.	DROP PARTITIONING
NOT LOGGED INITIALLY	
NOT LOGGED INITIALLY exists in both.	No change
NOT LOGGED INITIALLY exists only in the new table definition.	NOT LOGGED INITIALLY

New definition versus existing definition	Equivalent ALTER TABLE function
NOT LOGGED INITIALLY exists only in the existing table definition.	Logged initially
VOLATILE	
The VOLATILE attribute exists in both and is the same.	No change
The VOLATILE attribute exists only in the new table definition.	VOLATILE
The VOLATILE attribute exists only in the existing table definition.	NOT VOLATILE
media-preference	
<i>media-preference</i> exists in both and is the same.	No change
<i>media-preference</i> exists only in the new table definition.	ALTER <i>media-preference</i>
<i>media-preference</i> exists only in the existing table definition.	UNIT ANY
memory-preference	
<i>memory-preference</i> exists in both and is the same.	No change
<i>memory-preference</i> exists only in the new table definition.	ALTER <i>memory-preference</i>
<i>memory-preference</i> exists only in the existing table definition.	KEEP IN MEMORY NO

Any attributes that cannot be specified in the **CREATE TABLE** statement are preserved:

- ▶ Authorized users are maintained. The object owner might change.
- ▶ Current journal auditing is preserved. However, unlike other objects, **REPLACE** of a table generates a ZC (change object) journal audit entry.
- ▶ Current data journaling is preserved.
- ▶ Comments and labels are preserved.
- ▶ Triggers are preserved, if possible. If it is not possible to preserve a trigger, an error is returned.
- ▶ Masks and permissions are preserved, if possible. If it is not possible to preserve a mask or permission, an error is returned.
- ▶ Any views, materialized query tables, and indexes that depend on the table are preserved or re-created, if possible. If it is not possible to preserve a dependent view, materialized query table, or index, an error is returned.

The **CREATE** statement (including the **REPLACE** capability) can be complex. For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.3 DB2 JavaScript Object Notation store

Support for JavaScript Object Notation (JSON) documents was added to DB2 for i. You can store any JSON documents in DB2 as BLOBs. The current implementation for DB2 for i supports the DB2 JSON command-line processor and the DB2 JSON Java API.

The current implementation of DB2 for i matches the subset of support that is available for DB2 for Linux, UNIX, and Windows, and DB2 for z/OS.

The following actions are now supported:

- ▶ Use the JDB2 JSON Java API in Java applications to store and retrieve JSON documents as BLOB data from DB2 for i tables.
- ▶ Create JSON collections (single BLOB column table).
- ▶ Insert JSON documents into a JSON collection.
- ▶ Retrieve JSON documents.
- ▶ Convert JSON documents from BLOB to character data with the `SYSTOOLS.BSON2JSON()` UDF.

For details and examples, see the following article in IBM developerWorks:

<https://www.ibm.com/developerworks/ibmi/library/i-json-store-technology/>

8.4.4 Remote 3-part name support on ASSOCIATE LOCATOR

Before this enhancement, programmers could not consume result sets that were created on behalf of a remote procedure CALL. With this enhancement, the **ASSOCIATE LOCATOR** SQL statement can target **RETURN TO CALLER** style result sets that are created by a procedure that ran on a remote database due to a remote 3-part CALL.

This style of programming is an alternative to the **INSERT** with remote subselect statement.

Requirements:

- ▶ The application requestor (AR) target must be IBM i 7.1 or higher.
- ▶ The application server (AS) target must be IBM i 6.1 or higher.

For more information about how to use this enhancement, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.5 Flexible views

Before the flexible views enhancement, programmers could build static views only by using the **CREATE VIEW** SQL statement, which created a logical file. If a different view or a view with different parameters (**WHERE** clause) was needed, a new static view had to be created again by using the **CREATE VIEW** SQL statement.

This enhancement provides a way to build views that are flexible and usable in many more situations just by changing the parameters. The **WHERE** clause of the flexible view can contain both global built-in variables and the DB2 global variables. These views also can be used for inserting and updating data.

8.4.6 Increased time stamp precision

In IBM i 7.2, up to 12 digits can be set as the time stamp precision. Before IBM i 7.2, only six digits were supported as the time stamp precision. This enhancement applies to DDL and DML. You can specify the time stamp precision in the **CREATE TABLE** statement. You can also adjust existing tables by using the **ALTER TABLE** statement.

Example 8-10 shows the results of mixed precision time in the **CREATE TABLE** and **INSERT** statements.

Example 8-10 Increased time stamp precision

```
CREATE TABLE corpdb.time_travel(
  old_time    TIMESTAMP,
  new_time    TIMESTAMP(12),
  no_time     TIMESTAMP(0),
  Last_Change TIMESTAMP NOT NULL IMPLICITLY HIDDEN FOR EACH ROW ON UPDATE AS
              ROW CHANGE TIMESTAMP);

INSERT INTO corpdb.time_travel
VALUES(current timestamp, current timestamp,
       current timestamp);

INSERT INTO corpdb.time_travel
VALUES(current timestamp, current timestamp(12),
       current timestamp);

SELECT old_time,
       new_time,
       no_time,
       last_change
FROM corpdb.time_travel;

SELECT new_time - last_change as new_minus_last,
       new_time - old_time as new_minus_old,
       new_time - no_time as new_minus_no
FROM corpdb.time_travel;
```

Figure 8-15 shows the results of the first **SELECT** statement in Example 8-10. Notice that the precision of the data of each field varies depending on the precision digits.

OLD_TIME	NEW_TIME	NO_TIME	LAST_CHANGE
2014-09-29 10:29:55.700738	2014-09-29 10:29:55.700738000000	2014-09-29 10:29:55	2014-09-29 10:29:55.704385
2014-09-29 10:29:55.720745	2014-09-29 10:29:55.720745675781	2014-09-29 10:29:55	2014-09-29 10:29:55.723007

Figure 8-15 Results of the first SELECT statement

The second **SELECT** statement in Example 8-10 calculates the difference of **NEW_TIME** and each other field. Figure 8-16 shows the results of this **SELECT** statement. The second record of the result is expressed with the precision as 12 digits because the value that is stored in **NEW_TIME** has 12 digits as its precision.

NEW_MINUS_LAST	NEW_MINUS_OLD	NEW_MINUS_NO
-0.003647000000	0.000000000000	0.700738000000
-0.002261324219	0.000000675781	0.720745675781

Figure 8-16 Results of the second SELECT statement

Note: You can adjust the precision of the time stamp columns of existing tables by using an **ALTER TABLE** statement. However, the existing data in those columns has the remaining initial digits because precision of time stamp data is determined at the time of generation.

For more information about timestamp precision, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzch2timestamp.htm

8.4.7 Named and default parameter support for UDF and UDTFs

Similar to named and default parameters for procedures in IBM i 7.1 TR5, IBM i 7.2 adds this support for SQL and external UDFs. This enhancement provides the usability that is found with CL commands to UDF and UDTFs.

Example 8-11 shows an example of a UDF that specifies a default value to a parameter.

Example 8-11 Named and default parameter support on UDF and UDTFs

```
CREATE OR REPLACE FUNCTION DEPTNAME(  
  P_EMPID VARCHAR(6) , P_REQUESTED_IN_LOWER_CASE INTEGER DEFAULT 0)  
RETURNS VARCHAR(30)  
LANGUAGE SQL  
D:BEGIN ATOMIC  
  DECLARE V_DEPARTMENT_NAME VARCHAR(30);  
  DECLARE V_ERR VARCHAR(70);  
  SET V_DEPARTMENT_NAME = (  
    SELECT CASE  
      WHEN P_REQUESTED_IN_LOWER_CASE = 0 THEN  
        D.DEPTNAME  
      ELSE  
        LOWER(D.DEPTNAME)  
    END CASE  
    FROM DEPARTMENT D, EMPLOYEE E  
    WHERE E.WORKDEPT = D.DEPTNO AND  
          E.EMPNO = P_EMPID);  
  IF V_DEPARTMENT_NAME IS NULL THEN  
    SET V_ERR = 'Error: employee ' CONCAT P_EMPID CONCAT ' was not found';  
    SIGNAL SQLSTATE '80000' SET MESSAGE_TEXT = V_ERR;  
  END IF ;  
  RETURN V_DEPARTMENT_NAME;  
END D;
```

Example 8-12 shows the **VALUES** statement that uses the example UDF in Example 8-11 as specifying different values to the **P_REQUESTED_IN_LOWER_CASE** parameter.

Example 8-12 VALUES statement specifying a different value to the parameter in the UDF

```
VALUES(DEPTNAME('000110'),  
       DEPTNAME('000110', 1 ),  
       DEPTNAME('000110', P_REQUESTED_IN_LOWER_CASE=>1));
```

Figure 8-17 on page 347 shows the results of Example 8-12.

00001	00002	00003
SPIFFY COMPUTER SERVICE DIV.	spiffy computer service div.	spiffy computer service div.

Figure 8-17 Results of the VALUES statement that uses the UDF

8.4.8 Function resolution by using casting rules

Before IBM i 7.2, function resolution looked for only an exact match with the following perspectives:

- ▶ Function name
- ▶ Number of parameters
- ▶ Data type of parameters

With IBM i 7.2, if DB2 for i does not find an exact match when using function resolution, it looks for the best fit by using casting rules. With these new casting rules, if **CAST()** is supported for the parameter data type mismatch, the function is found.

For more information about rules, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzbestfit.htm

Example 8-13 describes a sample function and a **VALUES** statement that uses that function.

Example 8-13 Sample function that casting might have occurred

```
CREATE OR REPLACE FUNCTION MY_CONCAT(
  FIRST_PART VARCHAR(10),
  SECOND_PART VARCHAR(50))
RETURNS VARCHAR(60)
LANGUAGE SQL
BEGIN
  RETURN(FIRST_PART CONCAT SECOND_PART);
END;
VALUES(MY_CONCAT(123,456789));
```

Figure 8-18 shows the results of the `VALUES` statement with an `SQLCODE-204` error before IBM i 7.2.

```
CREATE OR REPLACE FUNCTION MY_CONCAT(  
  FIRST_PART VARCHAR(10),  
  SECOND_PART VARCHAR(50))  
  RETURNS VARCHAR(60)  
  LANGUAGE SQL  
  BEGIN  
    RETURN(FIRST_PART CONCAT SECOND_PART);  
  END;  
VALUES(MY_CONCAT(123,456789));
```

```
> VALUES(MY_CONCAT(123,456789))  
  
SQL State: 42704  
Vendor Code: -204  
Message: [SQL0204] MY_CONCAT in *LIBL type *N not found. Cause . . . .  
. : MY_CONCAT in *LIBL type *N was not found. If the member name is  
*ALL, the table is not partitioned. If this is an ALTER TABLE statement  
and the type is *N, a constraint or partition was not found. If this is  
not an ALTER TABLE statement and the type is *N, a function, procedure,  
trigger or sequence object was not found. If a function was not found,  
MY_CONCAT is the service program that contains the function. The  
function will not be found unless the external name and usage name  
match exactly. Examine the job log for a message that gives more  
details on which function name is being searched for and the name that  
did not match. Recovery . . . : Change the name and try the request  
again. If the object is a node group, ensure that the DB2 Multisystem  
product is installed on your system and create a nodegroup with the  
CRTNODGRP CL command. If an external function was not found, be sure  
that the case of the EXTERNAL NAME on the CREATE FUNCTION statement  
exactly matches the case of the name exported by the service program.  
  
Processing ended because the highlighted statement did not complete  
successfully
```

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Figure 8-18 Results of the `VALUES` statement with an `SQLCODE-204` error before IBM i 7.2

Figure 8-19 shows the results with IBM i 7.2, in which the function is found with casting rules.

```
CREATE OR REPLACE FUNCTION MY_CONCAT(
  FIRST_PART VARCHAR(10),
  SECOND_PART VARCHAR(50))
RETURNS VARCHAR(60)
LANGUAGE SQL
BEGIN
  RETURN(FIRST_PART CONCAT SECOND_PART);
END;
VALUES(MY_CONCAT(123,456789));
```

00001	
123456789	

Figure 8-19 Results of the VALUES statement with the FUNCTION found with casting rules

8.4.9 Use of ARRAYS within scalar UDFs

IBM i 7.2 can create a type that is an array and use it in SQL procedures. In addition to this array support, an array can be used in scalar UDFs and in SQL procedures.

Example 8-14 shows an example of creating an array type and using it in a UDF.

Example 8-14 Array support in scalar UDFs

```
CREATE TABLE EMPPHONE(ID          VARCHAR(6) NOT NULL,
                      PRIORITY    INTEGER NOT NULL,
                      PHONENUMBER VARCHAR(12),
                      PRIMARY KEY (ID, PRIORITY));

INSERT INTO EMPPHONE VALUES('000001', 1, '03-1234-5678');
INSERT INTO EMPPHONE VALUES('000001', 2, '03-9012-3456');
INSERT INTO EMPPHONE VALUES('000001', 3, '03-7890-1234');

CREATE TYPE PHONELIST AS VARCHAR(12) ARRAY[10];

CREATE OR REPLACE FUNCTION getPhoneNumbers (EmpID CHAR(6)) RETURNS VARCHAR(130)
BEGIN
  DECLARE numbers PHONELIST;
  DECLARE i INTEGER;
  DECLARE resultValue VARCHAR(130);
  SELECT ARRAY_AGG(PHONENUMBER ORDER BY PRIORITY) INTO numbers
  FROM EMPPHONE
  WHERE ID = EmpID;

  SET resultValue = '';
  SET i = 1;

  WHILE i <= CARDINALITY(numbers) DO
```

```

    SET resultValue = TRIM(resultValue) || ',' || TRIM(numbers[i]);
    SET i = i + 1;
END WHILE;

RETURN TRIM(L ',' FROM resultValue);
END;

VALUES(getPhoneNumbers('000001'));

```

Figure 8-20 shows the results of creating an array type and using it in a UDF.

```

CREATE TABLE EMPPHONE(ID          VARCHAR(6) NOT NULL,
                      PRIORITY    INTEGER NOT NULL,
                      PHONENUMBER VARCHAR(12),
                      PRIMARY KEY (ID, PRIORITY));

INSERT INTO EMPPHONE VALUES('000001', 1, '03-1234-5678');
INSERT INTO EMPPHONE VALUES('000001', 2, '03-9012-3456');
INSERT INTO EMPPHONE VALUES('000001', 3, '03-7890-1234');

CREATE TYPE PHONELIST AS VARCHAR(12) ARRAY[10];

CREATE OR REPLACE FUNCTION getPhoneNumbers (EmpID CHAR(6)) RETURNS VARCHAR(130)
BEGIN
  DECLARE numbers PHONELIST;
  DECLARE i INTEGER;
  DECLARE resultValue VARCHAR(130);
  SELECT ARRAY_AGG(PHONENUMBER ORDER BY PRIORITY) INTO numbers
  FROM EMPPHONE
  WHERE ID = EmpID;

  SET resultValue = '';
  SET i = 1;

  WHILE i <= CARDINALITY(numbers) DO
    SET resultValue = TRIM(resultValue) || ',' || TRIM(numbers[i]);
    SET i = i + 1;
  END WHILE;

  RETURN TRIM(L ',' FROM resultValue);
END;

VALUES(getPhoneNumbers('000001'));

```

00001
03-1234-5678,03-9012-3456,03-7890-1234

Messages Global Variables VALUES(getPhoneNumbers('000001'))

Figure 8-20 Results of a scalar UDF that uses an array

8.4.10 Built-in global variables

New built-in global variables are supported in IBM i 7.2, as shown in Table 8-4. These variables are referenced-purpose-only variables and maintained by DB2 for i automatically. These variables can be referenced anywhere a column name can be used. Global variables fit nicely into view definitions and RCAC masks and permissions.

Table 8-4 DB2 built-in global variables that are introduced in IBM i 7.2

Variable name	Schema	Data type	Size
CLIENT_IPADDR	SYSIBM	VARCHAR	128
CLIENT_HOST	SYSIBM	VARCHAR	255
CLIENT_PORT	SYSIBM	INTEGER	-
PACKAGE_NAME	SYSIBM	VARCHAR	128
PACKAGE_SCHEMA	SYSIBM	VARCHAR	128
PACKAGE_VERSION	SYSIBM	VARCHAR	64
ROUTINE_SCHEMA	SYSIBM	VARCHAR	128
ROUTINE_SPECIFIC_NAME	SYSIBM	VARCHAR	128
ROUTINE_TYPE	SYSIBM	CHAR	1
JOB_NAME	QSYS2	VARCHAR	28
SERVER_MODE_JOB_NAME	QSYS2	VARCHAR	28

Example 8-15 shows an example of a **SELECT** statement querying some client information.

Example 8-15 Example of a **SELECT** statement to get client information from global variables

```
SELECT SYSIBM.client_host AS CLIENT_HOST,  
       SYSIBM.client_ipaddr AS CLIENT_IP,  
       SYSIBM.client_port AS CLIENT_PORT  
FROM SYSIBM.SYSDUMMY1
```

As for getting client information, TCP/IP services in QSYS2, which were introduced in IBM i 7.1, can be also used, as shown in Example 8-16.

Example 8-16 Get client information from TCP/IP services in QSYS2

```
SELECT * FROM QSYS2.TCPIP_INFO
```

For more information about DB2 built-in global variables, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.11 Expressions in PREPARE and EXECUTE IMMEDIATE statements

In IBM i 7.2, expressions can be used in the **PREPARE** and **EXECUTE IMMEDIATE** statements in addition to variables.

Example 8-17 and Example 8-18 are the statements for getting the information about advised indexes from QSYS2 and putting them into a table in QTEMP. Example 8-17 is an example for before IBM i 7.2 and Example 8-18 is the example for IBM i 7.2. With this enhancement, many **SET** statements can be eliminated from the generation of the **WHERE** clause.

Example 8-17 Example of EXECUTE IMMEDIATE with concatenating strings before IBM i 7.2

```
SET INSERT_STMT = 'INSERT INTO QTEMP.TMPIDXADV SELECT * FROM
                  QSYS2.CONDENSEDINDEXADVICE WHERE ' ;
IF (P_LIBRARY IS NOT NULL) THEN
  SET WHERE_CLAUSE = 'TABLE_SCHEMA = ''' CONCAT
                    RTRIM(P_LIBRARY) CONCAT ''' AND ' ;
ELSE
  SET WHERE_CLAUSE = ' ' ;
END IF ;
IF (P_FILE IS NOT NULL) THEN
  SET WHERE_CLAUSE = WHERE_CLAUSE CONCAT ' SYSTEM_TABLE_NAME = ''' CONCAT
                    RTRIM(P_FILE) CONCAT ''' AND ' ;
END IF ;
IF (P_TIMES ADVISED IS NOT NULL) THEN
  SET WHERE_CLAUSE = WHERE_CLAUSE CONCAT ' TIMES ADVISED >= ' CONCAT
                    P_TIMES ADVISED CONCAT ' AND ' ;
END IF ;
IF (P_MTI_USED IS NOT NULL) THEN
  SET WHERE_CLAUSE = WHERE_CLAUSE CONCAT 'MTI_USED >= ' CONCAT
                    P_MTI_USED CONCAT ' AND ' ;
END IF ;
IF (P_AVERAGE_QUERY_ESTIMATE IS NOT NULL) THEN
  SET WHERE_CLAUSE = WHERE_CLAUSE CONCAT ' AVERAGE_QUERY_ESTIMATE >= ' CONCAT
                    P_AVERAGE_QUERY_ESTIMATE CONCAT ' AND ' ;
END IF ;
SET WHERE_CLAUSE = WHERE_CLAUSE CONCAT ' NLSS_TABLE_NAME = '''*HEX'' ' ;
SET INSERT_STMT = INSERT_STMT CONCAT WHERE_CLAUSE ;
EXECUTE IMMEDIATE INSERT_STMT ;
```

Example 8-18 Example of EXECUTE IMMEDIATE with concatenating strings for IBM i 7.2

```
EXECUTE IMMEDIATE 'INSERT INTO QTEMP.TMPIDXADV SELECT * FROM
                  QSYS2.CONDENSEDINDEXADVICE WHERE ' CONCAT
CASE WHEN P_LIBRARY IS NOT NULL THEN
  ' TABLE_SCHEMA = ''' CONCAT RTRIM(P_LIBRARY) CONCAT ''' AND '
ELSE '' END CONCAT
CASE WHEN P_FILE IS NOT NULL THEN
  ' SYSTEM_TABLE_NAME = ''' CONCAT RTRIM(P_FILE) CONCAT ''' AND '
ELSE '' END CONCAT
CASE WHEN P_TIMES ADVISED IS NOT NULL THEN
  ' TIMES ADVISED >= ' CONCAT P_TIMES ADVISED CONCAT ' AND '
ELSE '' END CONCAT
CASE WHEN P_MTI_USED IS NOT NULL THEN
  ' MTI_USED >= ' CONCAT P_MTI_USED CONCAT ' AND '
ELSE '' END CONCAT
```

```

CASE WHEN P_AVERAGE_QUERY_ESTIMATE IS NOT NULL THEN
    ' AVERAGE_QUERY_ESTIMATE >= ' CONCAT P_AVERAGE_QUERY_ESTIMATE CONCAT ' AND '
ELSE '' END CONCAT
' NLSS_TABLE_NAME = ''*HEX'' ';

```

8.4.12 Autonomous procedures

In IBM i 7.2, an autonomous procedure was introduced. An autonomous procedure is run in a unit of work that is independent from the calling application. A new **AUTONOMOUS** option is supported in the **CREATE PROCEDURE** and **ALTER PROCEDURE** statements.

By specifying a procedure as autonomous, any process in that procedure can be performed regardless of the result of the invoking transaction.

Example 8-19 shows an example of creating an autonomous procedure that is intended to write an application log to a table. In this example, procedure WriteLog is specified as **AUTONOMOUS**.

Example 8-19 Autonomous procedure

```

CREATE TABLE TRACKING_TABLE (LOGMSG VARCHAR(1000),
                             LOGTIME TIMESTAMP(12));

COMMIT;

CREATE OR REPLACE PROCEDURE WriteLog(loginfo VARCHAR(1000))
AUTONOMOUS
BEGIN
    INSERT INTO TRACKING_TABLE VALUES(loginfo, current TIMESTAMP(12));
END;

CALL WriteLog('*****INSERTION 1 START*****');

INSERT INTO EMPPHONE VALUES('000002', 1, '03-9876-5432');

CALL WriteLog('*****INSERTION 1 END*****');

CALL WriteLog('*****INSERTION 2 START*****');

INSERT INTO EMPPHONE VALUES('000002', 2, '03-8765-4321');

CALL WriteLog('*****INSERTION 2 END*****');

/**roll back insertions**/
ROLLBACK;

SELECT * FROM EMPPHONE WHERE ID = '000002';
SELECT * FROM TRACKING_TABLE;

```

Figure 8-21 show the results of creating an array type and using it in a UDF.

```

CREATE TABLE TRACKING_TABLE (LOGMSG VARCHAR(1000),
                             LOGTIME TIMESTAMP(12));
COMMIT;

CREATE OR REPLACE PROCEDURE WriteLog(loginfo VARCHAR(1000))
AUTONOMOUS
BEGIN
  INSERT INTO TRACKING_TABLE VALUES(loginfo, current TIMESTAMP(12));
END;

CALL WriteLog('*****INSERTION 1 START*****');

INSERT INTO EMPPHONE VALUES('000002', 1, '03-9876-5432');

CALL WriteLog('*****INSERTION 1 END*****');

CALL WriteLog('*****INSERTION 2 START*****');

INSERT INTO EMPPHONE VALUES('000002', 2, '03-8765-4321');

CALL WriteLog('*****INSERTION 2 END*****');

/**roll back insertions**/
ROLLBACK;

SELECT * FROM EMPPHONE WHERE ID = '000002';
SELECT * FROM TRACKING_TABLE;

```

ID	PRIORITY	PHONENUMBER
SELECT * FROM EMPPHONE WHERE ID = '000002'		
SELECT * FROM TRACKING_TABLE		

LOGMSG	LOGTIME
*****INSERTION 1 START*****	2014-10-16 10:36:50.275861318847
*****INSERTION 1 END*****	2014-10-16 10:36:50.314959861816
*****INSERTION 2 START*****	2014-10-16 10:36:50.327857244628
*****INSERTION 2 END*****	2014-10-16 10:36:50.345703937988

SELECT * FROM EMPPHONE WHERE ID = '000002'

SELECT * FROM TRACKING_TABLE

Figure 8-21 Results of an AUTONOMOUS procedure

For more information about **AUTONOMOUS**, see the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.13 New SQL TRUNCATE statement

A new SQL **TRUNCATE** statement deletes all rows from a table. This statement can be used in an application program and also interactively.

The **TRUNCATE** statement has the following additional functions:

- ▶ **DROP** or **REUSE** storage
- ▶ **IGNORE** or **RESTRICT** when delete triggers are present
- ▶ **CONTINUE** or **RESTART** identity values
- ▶ **IMMEDIATE**, which performs the operation without commit, even if it is running under commitment control

Figure 8-22 shows the syntax of the **TRUNCATE** statement.

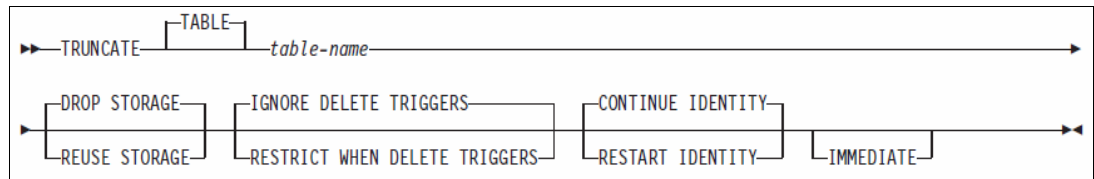


Figure 8-22 Syntax of the **TRUNCATE** statement

For more information about the **TRUNCATE** statement, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafztruncate.htm

8.4.14 New **LPAD()** and **RPAD()** built-in functions

Two new built-in functions, **LPAD()** and **RPAD()**, are introduced in IBM i 7.2. These functions return a string that is composed of strings that is padded on the left or right.

Example 8-20 shows an example of the **LPAD()** built-in function. This example assumes that the **CUSTOMER** table, which has a **NAME** column with **VARCHAR(15)**, contains the values of Chris, Meg, and John.

Example 8-20 **LPAD()** built-in function

```

CREATE TABLE CUSTOMER(CUSTNO CHAR(6), NAME VARCHAR(15));
INSERT INTO CUSTOMER VALUES('000001', 'Chris');
INSERT INTO CUSTOMER VALUES('000002', 'Meg');
INSERT INTO CUSTOMER VALUES('000003', 'John');

SELECT LPAD(NAME, 15, '.') AS NAME FROM CUSTOMER;
  
```

Figure 8-23 show the results of the **SELECT** statement, which pads out a value on the left with periods.

```

CREATE TABLE CUSTOMER(CUSTNO CHAR(6), NAME VARCHAR(15));
INSERT INTO CUSTOMER VALUES('000001', 'Chris');
INSERT INTO CUSTOMER VALUES('000002', 'Meg');
INSERT INTO CUSTOMER VALUES('000003', 'John');

SELECT LPAD(NAME, 15, '.') AS NAME FROM CUSTOMER;
  
```

NAME
.....Chris
.....Meg
.....John

Figure 8-23 Results of the **SELECT** statement with **LPAD()**

Example 8-21 shows the example of **RPAD()** built-in function.

Example 8-21 **SELECT** statement with **RPAD()**

```

SELECT RPAD(NAME, 10, '.') AS NAME FROM CUSTOMER;
  
```

Opposite to **LPAD()**, the results of the **SELECT** statement, which is shown in Figure 8-24, pads out a value on the right with periods. Note that 10 is specified as the length parameter in **RPAD()** so that the result is returned as a 10-digit value.

```
SELECT RPAD(NAME, 15, '.') AS NAME FROM CUSTOMER;
```

NAME
Chris.....
Meg.....
John.....

Figure 8-24 Results of the **SELECT** statement with **RPAD()**

Both **LPAD()** and **RPAD()** can be used on single-byte character set (SBCS) data and double-byte character set (DBCS) data, such as Japan Mix CCSID 5035. DBCS characters can also be specified as a pad string, as can SBCS characters.

Figure 8-25 shows an example of **LPAD()** for DBCS data within a column that is defined as **VARCHAR(15) CCSID 5035** and aligned each row at the right end. A double-byte space (`x'4040'` in CCSID 5035) is used as a pad string in this example. As shown in Figure 8-25, specifying DBCS data as a pad string is required for aligning DBCS data at the right or left end.

```
CREATE TABLE CUSTOMER_5035(CUSTNO CHAR(6) CCSID 5035, NAME VARCHAR(15) CCSID 5035);
INSERT INTO CUSTOMER_5035 VALUES('000001', '織田');
INSERT INTO CUSTOMER_5035 VALUES('000002', '蜂須賀');
INSERT INTO CUSTOMER_5035 VALUES('000003', '長宗我部');
SELECT LPAD(NAME, 15, ' ') AS NAME FROM CUSTOMER_5035;
```

NAME
織田
蜂須賀
長宗我部

Figure 8-25 Results of an example of **LPAD()** for DBCS data

For more information about **LPAD()** and **RPAD()**, including considerations when using Unicode, DBCS, or SBCS/DBCS mixed data, see IBM Knowledge Center:

- ▶ **LPAD()**
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzscalpad.htm
- ▶ **RPAD()**
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzscarpad.htm

8.4.15 Pipelined table functions

Pipelined table functions provide the flexibility to create programmatically virtual tables that are greater than what the **SELECT** or **CREATE VIEW** statements can provide.

Pipelined table functions can pass the result of an SQL statement or process and return the result of UDTFs. Before IBM i 7.2 TR1, creating an external UDTF is required for obtaining the same result as the pipelined table function.

Example 8-22 shows an example of creating a pipeline SQL UDTF that returns a table of CURRENT_VALUE from QSYS2.SYSLIMITS.

Example 8-22 Example of pipeline SQL UDTF

```
CREATE FUNCTION producer()
RETURNS TABLE (largest_table_sizes INTEGER)
LANGUAGE SQL

BEGIN
  FOR LimitCursor CURSOR FOR
    SELECT CURRENT_VALUE
    FROM QSYS2.SYSLIMITS
    WHERE SIZING_NAME = 'MAXIMUM NUMBER OF ALL ROWS'
    ORDER BY CURRENT_VALUE DESC
  DO
    PIPE (CURRENT_VALUE);
  END FOR;
RETURN;
END;
```

Example 8-23 shows an example of creating an external UDTF that returns the same result of a pipeline SQL UDTF, as shown in Example 8-22. These examples show that pipelined functions allow the flexibility to code more complex UDTFs purely in SQL without having to build and manage a compiled program or service program.

Example 8-23 Example of external UDTF

```
CRTSQLCI OBJ(applib/producer) SRCFILE(appsrc/c80) COMMIT(*NONE) OUTPUT(*PRINT)
OPTION(*NOGEN)

CRTCMOD MODULE(applib/producer) SRCFILE(qtemp/qsq1temp) TERASPACE(*YES)
STGMDL(*INHERIT)

CRTSRVPGM SRVPGM(applib/udfs) MODULE(applib/producer) EXPORT(*ALL) ACTGRP(*CALLER)

CREATE FUNCTION producer() RETURNS TABLE (int1 INTEGER) EXTERNAL NAME
applib.udfs(producer) LANGUAGE C PARAMETER STYLE SQL
```

Pipelined table functions can be used in the following cases:

- ▶ UDTF input parameters
- ▶ Ability to handle errors and warnings
- ▶ Application logging
- ▶ References to multiple databases in a single query
- ▶ Customized join behavior

These table functions are preferred in the case where only a subset of the result table is consumed in big data, analytic, and performance scenarios, rather than building a temporary table. Using pipelined table functions provides memory savings and better performance instead of creating a temporary table.

For more information about pipelined table functions, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20T echnology%20Updates/page/Pipelined%20Table%20Functions>

8.4.16 Regular expressions

A regular expression in an SQL statement is supported by IBM i 7.2. A regular expression is one of the ways of expressing a collection of strings as a single string and is used for specifying a pattern for a complex search.

Table 8-5 shows the built-in functions and predicates for regular expressions in DB2 for i.

Table 8-5 Function or predicate for regular expressions

Function or predicate	Description
REGEXP_LIKE predicate	Searches for a regular expression pattern in a string and returns True or False.
REGEXP_COUNT REGEXP_MATCH_COUNT	Returns a count of the number of times that a pattern is matched in a string.
REGEXP_INSTR	Returns the starting or ending position of the matched substring.
REGEXP_SUBSTR REGEXP_EXTRACT	Returns one occurrence of a substring of a string that matches the pattern.
REGEXP_REPLACE	Returns a modified version of the source string where occurrences of the pattern found in the source string are replaced with the specified replacement string.

Example 8-24 shows an example of a regular expression in a pipelined table function that searches and returns URL candidates from a given string.

Example 8-24 Example of a regular expression in a pipelined table function

```
CREATE OR REPLACE FUNCTION FindHits(v_search_string CLOB(1M), v_pattern
varchar(32000) DEFAULT '(\w+\.)+((org)|(com)|(gov)|(edu))')
RETURNS TABLE (website_reference varchar(512))
LANGUAGE SQL
BEGIN
  DECLARE V_Count INTEGER;
  DECLARE LOOPVAR INTEGER DEFAULT 0;
  SET V_Count = REGEXP_COUNT(v_search_string, v_pattern,1,'i');

  WHILE LOOPVAR < V_Count DO
    SET LOOPVAR = LOOPVAR + 1;
    PIPE(values(REGEXP_SUBSTR(v_search_string,v_pattern, 1, LOOPVAR, 'i')));
  END WHILE;

  RETURN;
END;

SELECT * FROM TABLE(FindHits('Are you interested in any of these colleges:
abcd.EDU or www.efgh.Edu. We could even visit WWW.ijkl.edu if we have time.')) A;
```

For more information about regular expressions, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Regular%20Expressions>

8.4.17 JOB_NAME and SERVER_MODE_JOB_NAME built-in global variables

New built-in global variables JOB_NAME and SERVER_MODE_JOB_NAME are supported by IBM i 7.2. JOB_NAME contains the name of the current job and SERVER_MODE_JOB_NAME contains the name of the job that established the SQL server mode connection.

Each of these global variables has the following characteristics:

- ▶ Read-only, with values maintained by the system.
- ▶ Type is VARCHAR(28).
- ▶ Schema is QSYS2.
- ▶ Scope of this global variable is session.

If there is no server mode connection, the value of SERVER_MODE_JOB_NAME is NULL. This means that SERVER_MODE_JOB_NAME is valid for only QSQRV and if it referenced outside of a QSQRV job, the NULL value is returned.

For more information about these global variables, see the following links:

- ▶ IBM i Technology Updates:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/JOB_NAME%20%26%20SERVER_MODE_JOB_NAME%20-%20DB2%20built-in%20global%20variables

- ▶ IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.18 RUNSQL control of output listing

The parameters that are shown in Figure 8-26 are now available in the Run SQL (RUNSQL) CL command. The RUNSQL CL command can be used to run a single SQL statement. These new parameters work the same as described in the RUNSQLSTM CL command.

```
Run SQL (RUNSQL)

Type choices, press Enter.

Source listing options . . . . . OPTION      *NOLIST
Print file . . . . . PRTFILE      QSYSPRT__
Library . . . . . *LIBL__
Second level text . . . . . SECLVLTXT      *NO__
```

Figure 8-26 New parameters on the RUNSQL CL command

For more information about the RUNSQL CL command, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/RUNSQL%20control%20of%20output%20listing>

8.4.19 LOCK TABLE ability to target non-*FIRST members

The **LOCK TABLE** SQL statement is enhanced to allow applications to target specific members within a multiple-member physical file. An application can use the Override Database File (**OVDRBF**) or the **CREATE ALIAS** SQL statements to identify the non-*FIRST member.

For more information about **LOCK TABLE** SQL statement, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm

8.4.20 QUSRJOB() retrieval of DB2 built-in global variables

The QUSRJOB() API JOBI0900 format is extended to allow for direct access to the following DB2 for i built-in global variable values that are mentioned in 8.4.10, “Built-in global variables” on page 351:

- ▶ CLIENT_IPADDR
- ▶ CLIENT_HOST
- ▶ CLIENT_PORT
- ▶ ROUTINE_TYPE
- ▶ ROUTINE_SCHEMA
- ▶ ROUTINE_NAME

For more information about this enhancement, including the position of each value in JOBI0900, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/QUSRJOB%28%29%20retrieval%20of%20DB2%20built-in%20global%20variables>

8.4.21 SQL functions (user-defined functions and user-defined table functions) parameter limit

The maximum number of parameters for user-defined functions and user-defined table functions was increased from 90 to 1024. Also, the maximum number of returned columns was increased from (125 minus the number of parameters) to (1025 minus the number of parameters).

8.4.22 New binary scalar functions

New built-in scalar functions were introduced in IBM i 7.2 to support interaction with Universal Unique Identifiers (UUIDs) across distribute systems:

- ▶ **VARBINARY_FORMAT** scalar function: This scalar function converts character data and returns a binary string.
- ▶ **VARCHAR_FORMAT_BINARY** scalar function: This scalar function converts binary data and returns a character string.

Both scalar functions can specify a *format-string* that is used to interpret a given expression and then convert from or into the UUIDs standard format.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzscale.htm?lang=en

8.4.23 Adding and dropping partitions spanning DDS logical files

In previous IBM i versions, if you wanted to add a partition or drop a partition of a DDS logical file, you had to delete the logical file or all members in that logical file had to be removed before running the **ALTER TABLE** statement.

In IBM i 7.2, the **ALTER TABLE ADD PARTITION** and **DROP PARTITION** statements allow spanning of DDS logical files. If the DDS logical file was created over all existing partitions, DB2 for i manages the automatic re-creation of the logical file to compensate for removed partitions and to include new partitions.

Figure 8-27 shows the **ALTER TABLE ADD PARTITION** support for spanning DDS logical files.

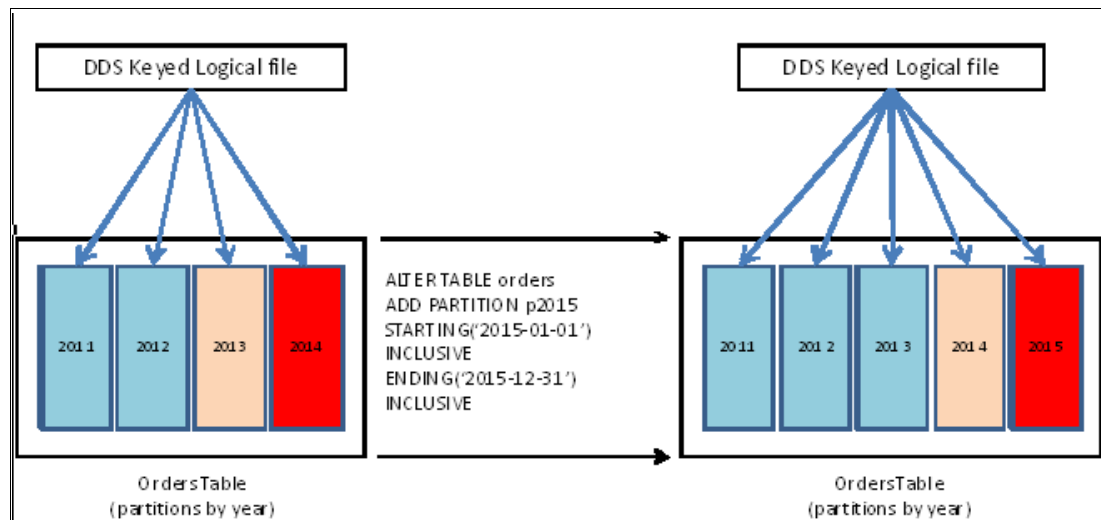


Figure 8-27 Spanning DDS logical files

8.4.24 Direct control of system names for global variables

The optional clause **FOR SYSTEM NAME** was added to the **CREATE VARIABLE** SQL statement. The **FOR SYSTEM NAME** clause directly defines the name for these objects.

In Example 8-25, **LOC** is the *system-object-identifier*, which is assigned as a system object name instead of an operating system-generated one. However, selecting this system-object-identifier has some considerations:

- ▶ The system name must not be the same as any global variable already existing on the same system.
- ▶ The system name must be unqualified.

Example 8-25 Example of a CREATE VARIABLE SQL statement using the FOR SYSTEM NAME clause

```
CREATE VARIABLE MYSCHEMA.MY_LOCATION FOR SYSTEM NAME LOC CHAR(20) DEFAULT (select
LOCATION from MYSCHEMA.locations where USER_PROFILE_NAME = USER);
```

For more information about this topic, see the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/en/ssw_ibm_i_72/db2/rbafzpdf.pdf?view=kc

8.4.25 LOCK TABLE ability to target non-FIRST members

The **LOCK TABLE** SQL statement is enhanced to allow applications to target specific members within a multiple-member physical file. The application can use the Override Database File (**OVRDBF**) command or the **CREATE ALIAS** SQL statement to identify the non-*FIRST member.

8.5 DB2 for i services and catalogs

DB2 for i now allows programmers to use SQL as a query language and a traditional programming language. Over time, the SQL language has gained new language elements that allow traditional programming patterns. Using UDFs, stored procedures, triggers, and referential integrity support, it is now easy to keep part of the programming logic encapsulated within the database itself, reducing the complexity of programming in third-generation programming languages, such as ILE RPG, ILE C/C++, ILE COBOL, and Java.

Moreover, DB2 for i provides a service that allows programmers and system administrators to access system information by using the standard SQL interface. This allows programming and system management to be managed in an easier way.

The following topics are covered in this section:

- ▶ 8.5.1, “DB2 for i catalogs” on page 362
- ▶ 8.5.2, “DB2 for i Services” on page 367
- ▶ 8.5.3, “IBM i Services” on page 371

8.5.1 DB2 for i catalogs

DB2 for i catalogs contain information about DB2 related objects, such as tables, indexes, schemas, columns, fields, labels, and views.

There are three classes of catalog views:

- ▶ DB2 for i catalog tables and views (QSYS2)
The catalog tables and view contain information about all tables, parameters, procedures, functions, distinct types, packages, XSR objects, views, indexes, aliases, sequences, variables, triggers, and constraints in the entire relational database.
- ▶ ODBC and JDBC catalog views (SYSIBM)
The ODBC and JDBC catalog views are designed to satisfy ODBC and JDBC metadata API requests.
- ▶ ANS and ISO catalog views (QSYS2)
The ANS and ISO catalog views are designed to comply with the ANS and ISO SQL standard. These views will be modified as the ANS and ISO standard is enhanced or modified.

Note: IBM i catalogs contain tables or views that are related only to the IBM i operating system.

DB2 for i catalogs can be grouped by related objects, as shown in the following tables.

Table 8-6 lists the catalogs.

Table 8-6 Catalogs

Name	Catalog type	Description
SYSCATALOGS	DB2	Information about relational database
INFORMATION_SCHEMA_CATALOG_NAME	ANS/ISO	Information about relational database

Table 8-7 lists the schemas.

Table 8-7 Schemas

Name	Catalog type	Description
SYSSCHEMAS	DB2	Information about schemas
SQLSCHEMAS	ODBC/JDBC	Information about schemas
SCHEMATA	ANS/ISO	Statistical information about schemas

Table 8-8 lists the database support.

Table 8-8 Database support

Name	Catalog type	Description
SQL_FEATURES	ANS/ISO	Information about the feature that is supported by the database manager
SQL_LANGUAGES	ANS/ISO	Information about the supported languages
SQL_SIZING	ANS/ISO	Information about the limits that are supported by the database manager
CHARACTER_SETS	ANS/ISO	Information about supported CCSIDs

Table 8-9 lists the tables, views, and indexes.

Table 8-9 Tables, views, and indexes

Name	Catalog type	Description
SYSCOLUMNS	DB2	Information about column attributes
SYSCOLUMNS2	DB2	Information about column attributes
SYSFIELDS	DB2	Information about field procedures
SYSINDEXES	DB2	Information about indexes
SYSKEYS	DB2	Information about indexes keys
SYSTABLEDEP	DB2	Information about materialized query table dependencies
SYSTABLES	DB2	Information about tables and views
SYSVIEWDEP	DB2	Information about view dependencies on tables

Name	Catalog type	Description
SYSVIEWS	DB2	Information about definition of a view
SQLCOLUMNS	ODBC/JDBC	Information about column attributes
SQLSPECIALCOLUMNS	ODBC/JDBC	Information about the columns of a table that can be used to uniquely identify a row
SQLTABLES	ODBC/JDBC	Information about tables
COLUMNS	ANS/ISO	Information about columns
TABLES	ANS/ISO	Information about tables
VIEWS	ANS/ISO	Information about views

Table 8-10 lists the constraints.

Table 8-10 Constraints

Name	Catalog type	Description
SYSCHKCST	DB2	Information about check constraints
SYSCST	DB2	Information about all constraints
SYSCSTCOL	DB2	Information about columns referenced in a constraint
SYSCSTDEP	DB2	Information about constraint dependencies on tables
SYSKEYCST	DB2	Information about unique, primary, and foreign keys
SYSREFCST	DB2	Information about referential constraints
SQLFOREIGNKEYS	ODBC/JDBC	Information about foreign keys
SQLPRIMARYKEYS	ODBC/JDBC	Information about primary keys
CHECK_CONSTRAINTS	ANS/ISO	Information about check constraints
REFERENTIAL_CONSTRAINTS	ANS/ISO	Information about referential constraints
TABLE_CONSTRAINTS	ANS/ISO	Information about constraints

Table 8-11 lists the privileges.

Table 8-11 Privileges

Name	Catalog type	Description
SYSCOLAUTH	DB2	Information about column privilege
SYSCONTROLS	DB2	Information about row permissions and column masks
SYSCONTROLSDEP	DB2	Information about row permissions and column masks dependencies
SYSPACKAGEAUTH	DB2	Information about package privilege
SYSROUTINEAUTH	DB2	Information about routine privilege

Name	Catalog type	Description
SYSSCHEMAAUTH	DB2	Information about schema privilege
SYSSEQUENCEAUTH	DB2	Information about sequence privilege
SYSTABAUTH	DB2	Information about table privilege
SYSUDTAUTH	DB2	Information about type privilege
SYSVARIABLEAUTH	DB2	Information about global variable privilege
SYSXSROBJECTAUTH	DB2	Information about XML schema privilege
SQLCOLPRIVILEGES	ODBC/JDBC	Information about privileges granted on columns
SQLTABLEPRIVILEGES	ODBC/JDBC	Information about privileges granted on tables
AUTHORIZATIONS	ANS/ISO	Information about authorization IDs
ROUTINE_PRIVILEGES	ANS/ISO	Information about routine privilege
UDT_PRIVILEGES	ANS/ISO	Information about type privilege
USAGE_PRIVILEGES	ANS/ISO	Information about sequence and XML schema privilege
VARIABLE_PRIVILEGES	ANS/ISO	Information about global variable privilege

Table 8-12 lists the triggers.

Table 8-12 Triggers

Name	Catalog type	Description
SYSTRIGCOL	DB2	Information about columns used in a trigger
SYSTRIGDEP	DB2	Information about objects used in a trigger
SYSTRIGGERS	DB2	Information about trigger
SYSTRIGUPD	DB2	Information about columns in the WHEN clause of a trigger

Table 8-13 lists the routines.

Table 8-13 Routines

Name	Catalog type	Description
SYSFUNCS	DB2	Information about user-defined functions
SYSJARCONTENTS	DB2	Information about JAR files for Java routines
SYSJAROBJECTS	DB2	Information about JAR files for Java routines
SYSPARMS	DB2	Information about routine parameters
SYSPROCS	DB2	Information about procedures

Name	Catalog type	Description
SYSROUTINEDEP	DB2	Information about function and procedure dependencies
SYSROUTINES	DB2	Information about functions and procedures
SQLFUNCTIONSCOLS	ODBC/JDBC	Information about function parameters
SQLFUNCTIONS	ODBC/JDBC	Information about functions
SQLPROCEDURECOLS	ODBC/JDBC	Information about procedure parameters
SQLPROCEDURES	ODBC/JDBC	Information about procedures
PARAMETERS	ANS/ISO	Information about procedure parameters
ROUTINES	ANS/ISO	Information about routines

Table 8-14 lists the XML schemas.

Table 8-14 XML schemas

Name	Catalog type	Description
XSRANNOTATIONINFO	DB2	Information about annotations
XSROBJECTCOMPONENTS2	DB2	Information about components in an XML schema
XSROBJECTHIERARCHIES	DB2	Information about XML schema document hierarchy relationships
XSROBJECTS	DB2	Information about XML schemas

Table 8-15 lists the statistics.

Table 8-15 Statistics

Name	Catalog type	Description
SYSCOLUMSTAT	DB2	Information about column statistics
SYSINDEXSTAT	DB2	Information about index statistics
SYSMQTSTAT	DB2	Information about materialized query table statistics
SYSPACKAGESTAT	DB2	Information about package statistics
SYSPACKAGESTMTSTAT	DB2	Information about the SQL statement in packages
SYSPARTITIONDISK	DB2	Information about partition disk usage
SYSPARTITIONINDEXES	DB2	Information about partition indexes
SYSPARTITIONINDEXDISK	DB2	Information about index disk usage
SYSPARTITIONINDEXSTAT	DB2	Information about partition index statistics
SYSPARTITIONMQTS	DB2	Information about partition materialized query tables

Name	Catalog type	Description
SYSPARTITIONSTAT	DB2	Information about partition statistics
SYSPROGRAMSTAT	DB2	Information about programs, service programs, and modules that contain SQL statements
SYSPROGRAMSTMTSTAT	DB2	Information about SQL statements embedded in programs, service programs, and modules
SYSTABLEINDEXSTAT	DB2	Information about table index statistics
SYSTABLESTAT	DB2	Information about table statistics
SQLSTATISTICS	ODBC/JDBC	Statistical information about tables

Table 8-16 lists the miscellaneous objects.

Table 8-16 Miscellaneous objects

Name	Catalog type	Description
SYSPACKAGE	DB2	Information about packages
SYSSEQUENCES	DB2	Information about sequences
SYSTYPES	DB2	Information about built-in data types and distinct types
SYSVARIABLEDEP	DB2	Information about objects that are used in global variables
SYSVARIABLES	DB2	Information about global variables
SQLTYPEINFO	ODBC/JDBC	Information about types of tables
SQLUDTS	ODBC/JDBC	Information about built-in data types and distinct types
USER_DEFINED_TYPES	ANS/ISO	Information about types
SEQUENCES	ANS/ISO	Information about sequences

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzcatalog.htm

8.5.2 DB2 for i Services

DB2 for i Services is a consistent set of procedures, UDFs, UDTFs, tables, and views that make programming in SQL easier.

DB2 for i Services is grouped by the following related areas:

- ▶ “DB2 for i Services health center procedures”
- ▶ “DB2 for i Services utility procedures”
- ▶ “DB2 for i Services plan cache procedures” on page 369
- ▶ “DB2 for i performance services” on page 370
- ▶ “DB2 for i application services” on page 370

DB2 for i Services health center procedures

You can use DB2 for i Services health center procedures to capture and view information about the database.

Table 8-17 lists the DB2 for i Services health center procedures.

Table 8-17 DB2 for i Services health center procedures

Service name	Type	Descriptions
QSYS2.HEALTH_ACTIVITY	Procedure	Returns summary counts of database and SQL operations over a set of objects within one or more schemas.
QSYS2.HEALTH_DATABASE_OVERVIEW	Procedure	Returns counts of all the different types of DB2 for i objects within the target schemas.
QSYS2.HEALTH_DESIGN_LIMITS	Procedure	Returns detailed counts of design limits over a set of objects within one or more schemas.
QSYS2.HEALTH_ENVIRONMENTAL_LIMITS	Procedure	Returns detail on the top 10 jobs on the system for different SQL or application limits.
QSYS2.HEALTH_SIZE_LIMITS	Procedure	Returns detailed size information for database objects within one or more schemas.
QSYS2.RESET_ENVIRONMENTAL_LIMITS	Procedure	Clears out the environment limit cache for the database.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqhealthcentersqlprocs.htm?lang=en

DB2 for i Services utility procedures

DB2 for i Services utility procedures provide interfaces to monitor and work with SQL in jobs on the current system or to compare constraint and routine information across the system.

Table 8-18 lists the DB2 for i Services utility procedures.

Table 8-18 DB2 for i Services utility procedures

Service name	Type	Descriptions
QSYS2.CANCEL_SQL	Procedure	Requests cancellation of an SQL statement for the specified job.
QSYS2.DUMP_SQL_CURSORS	Procedure	Lists the open cursors for a job.
QSYS2.FIND_AND_CANCEL_QSQSRVR_SQL	Procedure	Finds a set of jobs with SQL activity and safely cancels them.
QSYS2.FIND_QSQSRVR_JOBS	Procedure	Returns information about a QSQSRVR job.
QSYS2.GENERATE_SQL	Procedure	Generates the SQL data definition language statements that are required to re-create a database object.
QSYS2.RESTART_IDENTITY	Procedure	Examines the source-table and determines the identity column and its next value.

Service name	Type	Descriptions
SYSTOOLS.CHECK_SYSCST	Procedure	Compares entries in the QSYS2.SYSCONSTRAINTS table between two systems.
SYSTOOLS.CHECK_SYSROUTINE	Procedure	Compare entries in the QSYS2.SYSROUTINES table between two systems.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqservicesutility.htm?lang=en

DB2 for i Services plan cache procedures

DB2 for i provides procedures for programmatic access to the plan cache and can be used for scheduling plan cache captures or pre-starting an event monitor.

Table 8-19 lists the DB2 for i Services plan cache procedures.

Table 8-19 DB2 for i Services plan cache procedures

Service name	Type	Descriptions
QSYS2.CHANGE_PLAN_CACHE_SIZE	Procedure	Changes the size of the plan cache.
QSYS2.DUMP_PLAN_CACHE	Procedure	Creates a snapshot (database monitor file) of the contents of the cache.
QSYS2.DUMP_PLAN_CACHE_PROPERTIES	Procedure	Creates a file containing the properties of the cache.
QSYS2.DUMP_PLAN_CACHE_topN	Procedure	Creates a snapshot file from the active plan cache containing only those queries with the largest accumulated elapsed time.
QSYS2.DUMP_SNAP_SHOT_PROPERTIES	Procedure	Creates a file containing the properties of the snapshot.
QSYS2.END_ALL_PLAN_CACHE_EVENT_MONITOR	Procedure	Ends all active plan cache event monitors started either through the GUI or uses the start_plan_cache_event_monitor procedures.
QSYS2.END_PLAN_CACHE_EVENT_MONITOR	Procedure	Ends the specific event monitor that is identified by the given monitor ID value.
QSYS2.START_PLAN_CACHE_EVENT_MONITOR (2)	Procedure	Starts an event monitor to intercept or capture plans as they are removed from the cache and generates performance information into the specified database monitor file.
QSYS2.CLEAR_PLAN_CACHE	Procedure	Clears plan cache (alternative to performing a system IPL).
QSYS2.EXTRACT_STATEMENTS	Procedure	Returns details from a plan cache snapshot in the form of an SQL table or a result set.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqplancacheproc.htm?lang=en

DB2 for i performance services

DB2 for i performance services provide interfaces to work with indexes and a view to see information about database monitors.

Table 8-20 lists the DB2 for i performance services.

Table 8-20 DB2 for i performance services

Service name	Type	Descriptions
SYSTOOLS.ACT_ON_INDEX_ADVICE	Procedure	Creates new indexes for a table based on indexes that are advised for the table.
SYSTOOLS.HARVEST_INDEX_ADVICE	Procedure	Generates one or more CREATE INDEX statements in source file members for a specified table based on indexes that are advised for the table.
QSYS2.OVERRIDE_QAQQINI	Procedure	Establishes a temporary version of the QAQQINI file.
QSYS2.RESET_TABLE_INDEX_STATISTICS	Procedure	Clears usage statistics for indexes that are defined over a table or tables.
QSYS2.SYSIXADV	Table	Indexed advised system table.
SYSTOOLS.REMOVE_INDEXES	Procedure	Drops any indexes meeting the specified criteria.
QSYS2.DATABASE_MONITOR_INFO	View	Returns information about database monitors and plan cache event monitors on the server.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqservicesperf.htm?lang=en

DB2 for i application services

DB2 for i application services provide interfaces that are useful for application development.

Table 8-21 lists the DB2 for i application services.

Table 8-21 DB2 for i application services

Service name	Type	Descriptions
QSYS2.OVERRIDE_TABLE	Procedure	Sets the blocking size for a table.
QSYS2.DELIMIT_NAME	UDF	Returns a name with delimiters if the delimiters are needed for use in an SQL statement.
SYSPROC.WLM_SET_CLIENT_INFO	Procedure	Sets values for the SQL client special registers.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqservicesappdb2.htm?lang=en

8.5.3 IBM i Services

IBM i Services are part of the IBM DB2 for i Services. They represent procedures, tables, UDFs, UDTFs, and views that the SQL programmer or user can use to get information about operating system objects such as PTFs, Group PTFs, user profiles, TCP/IP information, and system values. This provides benefits such as a standard interface to work on a cross-platform environment, an easy way to get system information without a coding to call system APIs, and reduce time to market for programming.

Note: IBM i Services provide information that is related only to the IBM i operating system.

To give an example about what information the IBM i Services can provide, some services are described in this section.

GROUP_PTF_CURRENCY

An SQL view GROUP_PTF_CURRENCY can be used to do a comparison of the PTF groups that are installed on the partition against the server level lists on the IBM Preventive Service Planning (PSP) website. The information of this view provides the status of the PTF group on the partition, current level of PTF groups, and the latest level of PTF groups available from IBM. This provides an easy way for a system administrator to manage the currency of PTF groups on the system with a latest information provided.

Note: Connection to the PSP website is required for a correct result of this query.

Example 8-26 show example SQL statement to find available updates for PTF groups.

Example 8-26 SQL statement to find available updates for PTF groups

```
SELECT  
PTF_GROUP_ID,PTF_GROUP_TITLE,PTF_GROUP_LEVEL_INSTALLED,PTF_GROUP_LEVEL_AVAILABLE  
FROM SYSTOOLS.GROUP_PTF_CURRENCY  
WHERE PTF_GROUP_CURRENCY = 'UPDATE AVAILABLE';
```

Figure 8-28 shows the result of using GROUP_PTF_CURRENCY to find available updates for PTF groups.

PTF_GROUP_ID	PTF_GROUP_TITLE	PTF_GROUP_LEVEL_INSTALLED	PTF_GROUP_LEVEL_AVAILABLE
SF99480	720 WebSphere App Server V8.0	4	5
SF99713	720 IBM HTTP Server for i	10	11
SF99715	720 Backup Recovery Solutions	15	16
SF99718	720 Group Security	21	22
SF99719	720 Group Hiper	46	47

Figure 8-28 Query result of GROUP_PTF_CURRENCY IBM i Services

ACTIVE_JOB_INFO and GET_JOB_INFO

ACTIVE_JOB_INFO and GET_JOB_INFO services can be used together to get the information of the job, such as CPU consumption, SQL statement text, and temporary storage. The system administrator can use this information for monitoring purposes or a programmer can use this information to find for a long-running SQL statement.

Example 8-27 shows an example SQL statement to find a long-running SQL statement.

Example 8-27 SQL statement to find a long-running SQL statement

```
WITH ACTIVE_USER_JOBS(Q_JOB_NAME) AS (
SELECT JOB_NAME FROM TABLE
(ACTIVE_JOB_INFO('NO', '', '', '')) X WHERE JOB_TYPE <> 'SYS')
SELECT Q_JOB_NAME, V_SQL_STATEMENT_TEXT,
CURRENT_TIMESTAMP-V_SQL_STMT_START_TIMESTAMP AS SQL_STMT_DURATION,
V_CLIENT_USERID,
B.* FROM ACTIVE_USER_JOBS,
TABLE(QSYS2.GET_JOB_INFO(Q_JOB_NAME)) B
WHERE V_SQL_STMT_STATUS = 'ACTIVE'
ORDER BY SQL_STMT_DURATION DESC;
```

Figure 8-29 shows the result of using ACTIVE_JOB_INFO and GET_JOB_INFO to find a long-running SQL statement.

Q_JOB_NAME	V_SQL_STATEMENT_TEXT	SQL_STMT_DURATION	V_CLIENT_USERID
083521/QUSER/QZDASOINIT	INSERT INTO SESSION/PERFORMANCE_LIS...	113.347651	TOMV
083482/QUSER/QZDASOINIT	WITH ACTIVE_USER_JOBS(Q_JOB_NAME) ...	0.000082	siripongp

Figure 8-29 Query result of ACTIVE_JOB_INFO and GET_JOB_INFO IBM i Services

IBM i Services is grouped by the following related areas:

- ▶ “IBM i Application services” on page 372
- ▶ “IBM i Java services” on page 372
- ▶ “IBM i Journal services” on page 373
- ▶ “IBM i Librarian services” on page 373
- ▶ “IBM i Message handling services” on page 373
- ▶ “IBM i Product services” on page 373
- ▶ “IBM i PTF services” on page 374
- ▶ “IBM i Security services” on page 374
- ▶ “IBM i Spool services” on page 374
- ▶ “IBM i Storage services” on page 375
- ▶ “IBM i System health services” on page 375
- ▶ “IBM i TCP/IP services” on page 375
- ▶ “IBM i Work management services” on page 376

IBM i Application services

This procedure provides an interface that can be used in applications. Table 8-22 lists the IBM i Application services.

Table 8-22 IBM i Application services

Services name	Type	Description
QSYS2.QCMDXEC	Procedure	Runs a CL command.

IBM i Java services

This view and procedure provides Java information and JVM management options. Table 8-23 on page 373 lists the IBM i Java services.

Table 8-23 IBM i Java services

Service name	Type	Description
QSYS2.JVM_INFO	View	Returns information about active Java Virtual Machine (JVM) jobs.
QSYS2.SET_JVM	Procedure	Manages specific JVM jobs by specific actions.

IBM i Journal services

This function and view provides journal information. Table 8-24 lists the IBM i Journal services.

Table 8-24 IBM i Journal services

Service name	Type	Description
QSYS2.DISPLAY_JOURNAL	UDTF	Returns information about journal entries.
QSYS2.JOURNAL_INFO	View	Contains information about journals, including remote journals.

IBM i Librarian services

This service provides object and library lists information. Table 8-25 lists the IBM i Librarian services.

Table 8-25 IBM i Librarian services

Service name	Type	Description
QSYS2.LIBRARY_LIST_INFO	View	Contains information about a current job's library list.
QSYS2.OBJECT_STATISTIC	UDTF	Returns information about objects in a library.

IBM i Message handling services

This function and view provides system message information. Table 8-26 lists the IBM i Message handling services.

Table 8-26 IBM i Message handling services

Service name	Type	Description
QSYS2.JOBLOG_INFO	UDTF	Returns one row for each message in a job log.
QSYS2.REPLY_LIST_INFO	View	Contains information about a current job's reply list.

IBM i Product services

This view provides information about IBM i licensed products. Table 8-27 lists the IBM i Product services.

Table 8-27 IBM i Product services

Service name	Type	Description
QSYS2.LICENSE_INFO	View	Contains information about all products or features that contain license information.

IBM i PTF services

This view provides information about PTFs on IBM i. Table 8-28 lists the IBM i PTF services.

Table 8-28 IBM i PTF services

Service name	Type	Description
SYSTOOLS.GROUP_PTF_CURRENCY	View	Contains a query that implements a live comparison of the PTF Groups that are installed on the partition against the service levels that are listed on the IBM Preventive Service Planning website.
SYSTOOLS.GROUP_PTF_DETAILS	View	Contains a query that implements a live comparison of the PTFs within PTF Groups that are installed on the partition against the service levels that are listed on the IBM Preventive Service Planning website.
QSYS2.GROUP_PTF_INFO	View	Contains information about the group PTFs for the server.
QSYS2.PTF_INFO	View	Contains information about PTFs for the server.

IBM i Security services

This view, procedure, and function provide security information and the ability to managed security attributes. Table 8-29 lists the IBM i Security services.

Table 8-29 IBM i Security services

Service name	Type	Description
QSYS2.DRDA_AUTHENTICATION_ENTRY_INFO	View	Contains user server authentication entry information.
QSYS2.FUNCTION_INFO	View	Contains details about function usage identifiers.
QSYS2.FUNCTION_USAGE	View	Contains details about function usage configuration.
QSYS2.GROUP_PROFILE_ENTRIES	View	Contains one row for each user profile that is a part of group profile.
SYSPROC.SET_COLUMN_ATTRIBUTE	Procedure	Sets the SECURE attribute for a column so the variable value that is used for the column cannot be seen in the database monitor or plan.
QSYS2.SQL_CHECK_AUTHORITY	UDF	Returns an indication of whether the user is authorized to query the specified *FILE object.
QSYS2.USER_INFO	View	Contains information about user profiles.

IBM i Spool services

This view and function provides information about spool files. Table 8-30 lists the IBM i Spool services.

Table 8-30 IBM i Spool services

Service name	Type	Description
QSYS2.OUTPUT_QUEUE_ENTRIES	UDTF	Returns one row for each spooled file in an output queue.
QSYS2.OUTPUT_QUEUE_ENTRIES	View	Returns one row for each spooled file in every output queue.

IBM i Storage services

This view provides information about storage and storage device. Table 8-31 lists the IBM i Storage services.

Table 8-31 IBM i Storage services

Service name	Type	Description
QSYS2.MEDIA_LIBRARY_INFO	View	Returns information the same as the WRKMLBSTS command.
QSYS2.SYSDISKSTAT	View	Contains information about disks.
QSYS2.SYSTMPSTG	View	Contains one row for each temporary storage bucket that is tracking some amount of temporary storage across the system.
QSYS2.USER_STORAGE	View	Contains information about storage by user profile.

IBM i System health services

This table, view, and global variable are combined to provide information about limits on your system. Table 8-32 lists the IBM i System health services.

Table 8-32 IBM i System health services

Service name	Type	Description
QSYS2.SYSLIMTBL	Table	Contains information about limits that are being approached.
QSYS2.SYSLIMITS	View	Contains information about limits. This view builds upon the SYSLIMTBL table with others.
QIBM_SYSTEM_LIMITS_PRUNE_BY_ASP QIBM_SYSTEM_LIMITS_PRUNE_BY_JOB QIBM_SYSTEM_LIMITS_PRUNE_BY_OBJECT QIBM_SYSTEM_LIMITS_PRUNE_BY_SYSTEM QIBM_SYSTEM_LIMITS_SAVE_HIGH_POINTS_BY_ASP QIBM_SYSTEM_LIMITS_SAVE_HIGH_POINTS_BY_JOB QIBM_SYSTEM_LIMITS_SAVE_HIGH_POINTS_BY_OBJECT QIBM_SYSTEM_LIMITS_SAVE_HIGH_POINTS_BY_SYSTEM	Global variables	Used to guide the pruning action perform by DB2 to prevent excess storage consumption within the SYSLIMTBL table. All the global variables are in the SYSIBMADM schema.

IBM i TCP/IP services

This view and procedure provides information about TCP/IP. Table 8-33 lists the IBM i TCP/IP services.

Table 8-33 IBM i TCP/IP services

Service name	Type	Description
SYSIBMADM.ENV_SYS_INFO	View	Contains information about the current server.
QSYS2.NETSTAT_INFO	View	Returns information about IPv4 and IPv6 network connections.
QSYS2.NETSTAT_INTERFACE_INFO	View	Returns information about IPv4 and IPv6 interfaces.
QSYS2.NETSTAT_JOB_INFO	View	Returns information about jobs that use IPv4 and IPv6 network connections.
QSYS2.NETSTAT_ROUTE_INFO	View	Returns information about IPv4 and IPv6 routes.

Service name	Type	Description
QSYS2.SET_SERVER_SBS_ROUTING	Procedure	Allows a user to configure some servers to use alternative subsystems based on the user profile that is establishing the connection.
QSYS2.SERVER_SBS_ROUTING	View	Returns information about the users who have alternate subsystem configurations for some IBM i servers.
QSYS2.TCPIP_INFO	View	Contains TCP/IP information for the current host connection.

IBM i Work management services

This view and function provides system value and job information. Table 8-34 lists the IBM i Work management services.

Table 8-34 IBM i Work management services

Service name	Type	Description
QSYS2.ACTIVE_JOB_INFO	UDTF	Returns one row for each active job.
QSYS2.GET_JOB_INFO	UDTF	Returns one row containing the information about a specific job.
QSYS2.MEMORY_POOL	UDTF	Returns one row for every storage pool.
QSYS2.MEMORY_POOL_INFO	View	Returns one row for every active storage pool.
QSYS2.OBJECT_LOCK_INFO	View	Returns one row for every lock that is held for every object on the partition.
QSYS2.RECORD_LOCK_INFO	View	Returns one row for every record lock for the partition.
QSYS2.SCHEDULED_JOB_INFO	View	Returns information the same as the WRKJOBSCDE command.
QSYS2.SYSTEM.STATUS	UDTF	Returns a single row, contains information about the current partition.
QSYS2.SYSTEM_STATUS_INFO	View	Return a single row, contains information about the current partition.
QSYS2.SYSTEM_VALUE_INFO	View	Contains information about system values.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqservicessys.htm

8.6 DB2 performance

In the IBM i 7.2 release of DB2 for i, a considerable effort was undertaken to enhance the runtime performance of the database, either by extending existing functions or by introducing new mechanisms.

Runtime performance is affected by many issues, such as the database design (the entity-relationship model, which is a conceptual schema or semantic data model of a relational database), the redundancy between functional environments in a composite application environment, the level of normalization, and the size and volumes processed. All of these items influence the run time, throughput, or response time, which is supported by the IT components and is defined by the needs of the business. Performance optimization for database access must address all the components that are used in obtained, acceptable, and sustainable results, covering the functional aspects and the technical components that support them.

This section describes the DB2 for i performance-related enhancements in IBM i 7.2. To benefit from them, application or system configuration changes are not needed in most cases.

The following topics are covered in this section:

- ▶ 8.6.1, “SQE I/O cost model” on page 377
- ▶ 8.6.2, “SQE support for native file opens, Query/400, and OPNQRYF” on page 378
- ▶ 8.6.3, “PDI for DB2” on page 381
- ▶ 8.6.4, “Queries with a long IN predicate list” on page 384
- ▶ 8.6.5, “Index advice and OR predicates” on page 384
- ▶ 8.6.6, “KEEP IN MEMORY for tables and indexes” on page 385
- ▶ 8.6.7, “Collection Services enhancements” on page 392
- ▶ 8.6.8, “Enhanced index build logic for highly concurrent environments” on page 392
- ▶ 8.6.9, “Accepting a priority change for a parallel index build” on page 392
- ▶ 8.6.10, “SQE index merge ordering” on page 393
- ▶ 8.6.11, “QSYS2.DATABASE_MONITOR_INFO view” on page 393
- ▶ 8.6.12, “QAQQINI memory preference by pool name” on page 394
- ▶ 8.6.13, “Index statistical catalogs enhancement” on page 395
- ▶ 8.6.14, “QSYS2.CLEAR_PLAN_CACHE() procedure” on page 396
- ▶ 8.6.15, “Encoded vector indexes only access” on page 396
- ▶ 8.6.16, “STRDBMON command filtering improvement” on page 396

8.6.1 SQE I/O cost model

SQL Query Engine (SQE) uses a structure that is called *access plan* for every database query to retrieve the data in an optimized manner.

An access plan is a control structure that describes the actions that are necessary to satisfy each query request. It contains information about the data and how to extract it. For any query, whenever optimization occurs, the query optimizer develops an optimized plan of how to access the requested data.

Preparing an optimized access plan is a complex task and requires the optimizer to rely on many sources of information. One of these sources of information is the I/O cost for accessing a database object (table scan, index probe, and so on). I/O cost can be described as the amount of time that is needed for all I/O operations that are required to access the object.

Before IBM i 7.2, the I/O cost model was based on the assumption that any I/O operation time was 25 milliseconds, regardless of the configuration of the system and attached storage solution. In response to significant hardware changes, including storage solutions for modern IBM i systems, and the big data paradigm that is often reflected in I/O-intensive database operations, the I/O cost model in IBM i 7.2 has changed.

Table 8-35 compares disk read times for various IBM i storage types with the original SQE I/O cost model.

Table 8-35 Disk read times for storage technologies compared to original SQE cost model

Storage technology	Typical read time in milliseconds ^a
Internal disks	4 -10
External disks/SAN	1 - 6
Solid-state drives (SSDs)	Less than 1
Original SQE model	25

a. Disk read times depend on many factors and can differ between environments.

The SQE optimizer now relies on sample actual access times instead of a fixed value. The optimizer is provided with more accurate disk read times, which results in more accurate I/O cost calculation. More accurate I/O cost prediction means better access plan preparation for faster query execution. Sample access times are measured during every IPL and at independent ASP vary-on time by recording disk read times for sample pages. These sample times are evaluated and updated at appropriate intervals during system operation. This ensures that the optimizer always has a current view of disk performance. This data allows the optimizer to distinguish unique I/O performance characteristics for internal, external, and solid-state drives.

As a result, for modern systems, I/O cost is now often lower (compared to the original SQE cost model based on 25-millisecond read operation, as shown in Table 8-35). The SQE processes I/O in a more intensive manner (more aggressively). In many cases, this results in a moderate performance improvement for I/O-intensive queries compared to IBM i 7.1 running on the same hardware.

8.6.2 SQE support for native file opens, Query/400, and OPNQRYF

Release to release, SQE has been enhanced to support a broader scope of database operations, SQL statements, and IBM i interfaces. The purpose of these efforts has not changed since the introduction of SQE in V5R2. SQE can process database access and run queries faster than the classic query engine (CQE). It also provides more detailed information, kept in the plan cache, about query implementation and statistics. This data can be used by the database application developers and DB2 engineers to optimize query performance. Investigation of DB2 for i performance problems is easier when SQE processes the query instead of CQE.

Accessing data through following DB2 for i interfaces is now supported by SQE, without any application or user change:

- ▶ File open and read operations in programs that are written in high-level languages (such as COBOL, RPG, and C++) for tables with RCAC enabled only
- ▶ Open Data Base File (**OPNDBF**) CL command for native SQL views and partitioned tables opens

- ▶ Open Query File (OPNQRYF) CL command
- ▶ IBM Query for i (formerly Query/400) licensed program 5770QU1

A new option that is called **SQE_NATIVE_ACCESS** is now available in the QAQQINI file that you can use to change the default behavior of IBM i 7.2 and force CQE to process native opens in HLL programs, **OPNDBF**, **OPNQRYF**, or IBM Query for i queries.

Table 8-36 describes the values that are available for the **SQE_NATIVE_ACCESS** option.

Table 8-36 SQE_NATIVE_ACCESS parameter values in the QAQQINI file

Value	Description
*NO	V7R1 native open unless SQE is required. ^a
*YES	SQE attempts to implement a native open of an SQL view or native query.
*DEFAULT	The same as *YES.

a. SQE is required for RCAC-enabled tables, sequence objects, global variables, OLAP, CUBE, and ROLLUP.

Using IBM System i Navigator, you can search the SQL plan cache for statements by using native opens, if the statement was processed by the SQE. Figure 8-30 shows the SQL Plan Cache Statements view for OPNQRYF statements and the Visual Explain view for the selected statement. The highlighted Query Engine Used value is SQE.

Tip: Use the OPNDBF string for searching for **OPNDBF** native open statements and QUERY/400 string for searching for IBM Query for i native open statements.

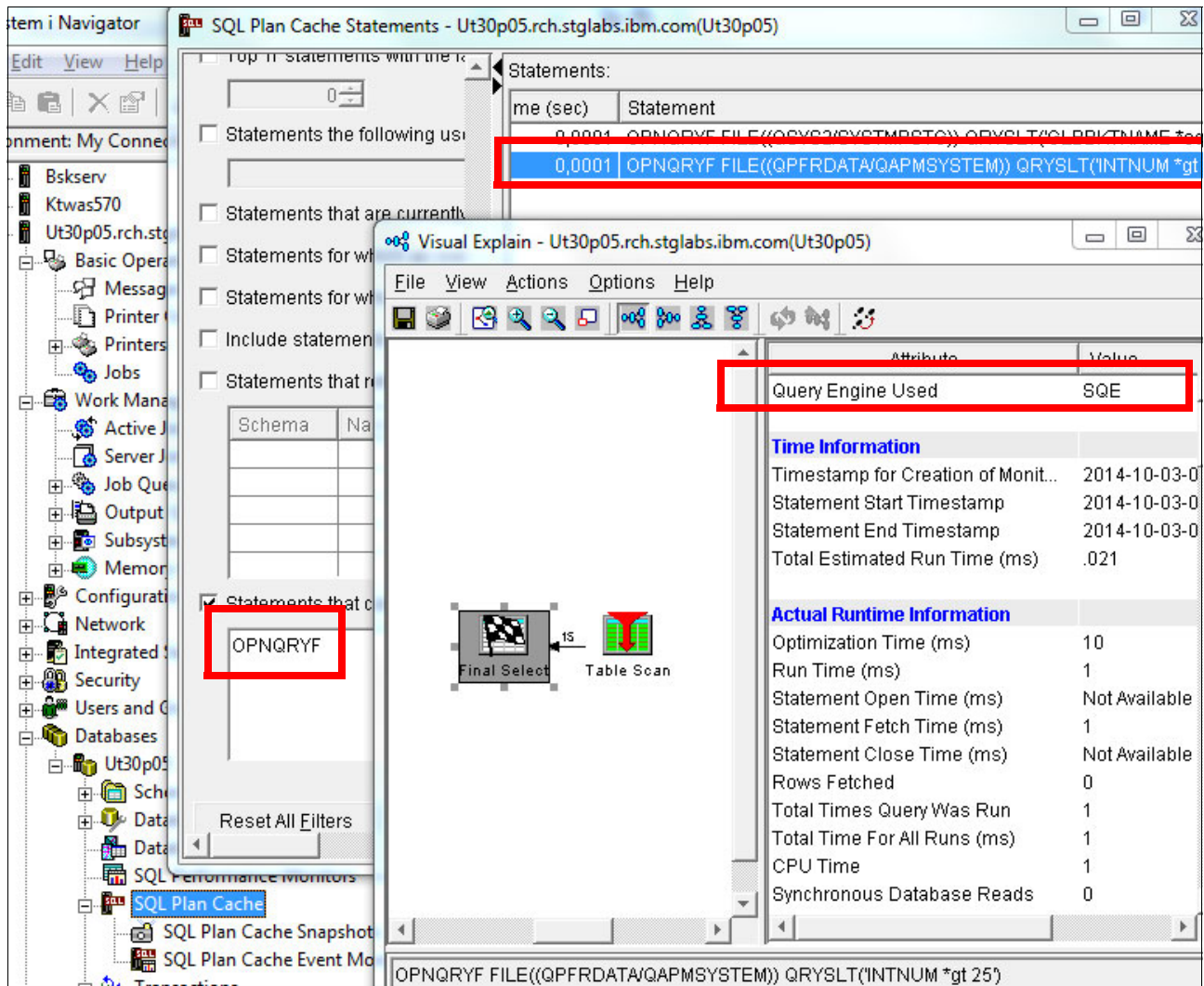


Figure 8-30 SQL Plan Cache Statements and Visual Explain view for OPNQRYF

You can see the same statements by using the IBM Navigator for i web interface. Under the Database section, expand **Databases** and right-click the database of your choice in the Databases tab. Click **SQL Plan Cache** → **Show Statements**. You can use the filters view to filter statements by using the same criteria as for IBM System i Navigator. Visual Explain functions are not available from the web interface at the time of writing. Figure 8-31 shows an example of a filtered view.

Filters	Last Time Run	Most Expensive Time (sec)	Total Processing Time (sec)	Total Times Run	Average Processing Time (sec)	Statement
Statements	No filter applied					
	10/3/14 2:54:14 PM	0.0000	0.0000	1	0.0001	OPNQRYF FILE((QSYS2/SYSTMPSTG)) QRYSLT('GLBBKNAME
	10/3/14 2:54:14 PM	0.0000	0.0000	2	0.0001	OPNQRYF FILE((QPFRDATA/QAPMSYSTEM)) QRYSLT('INTNUM

Figure 8-31 SQL Plan Cache Statements view for OPNQRYF within IBM Navigator for i

For more information about CQE, SQE, query dispatcher, and SQL plan cache, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/queryoptimize.htm?lang=en

For more information about the QAQQINI file and its options, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/qryopt.htm?lang=en

8.6.3 PDI for DB2

Performance Data Investigator (PDI) was enhanced to allow database engineers (DBE) and database administrators (DBA) to access quickly database performance-related information.

PDI is part of IBM Navigator for i and is accessible through the Investigate Data link under the Performance section. PDI is a common interface that is used for various performance data that is collected on an IBM i system.

The database content page of the PDI requires the IBM Performance Tools for i (5770-PT1) Option 1 - Manager Feature licensed program to be installed on your system.

Figure 8-32 shows the perspectives that are available for the Database part of the PDI in IBM i 7.2.

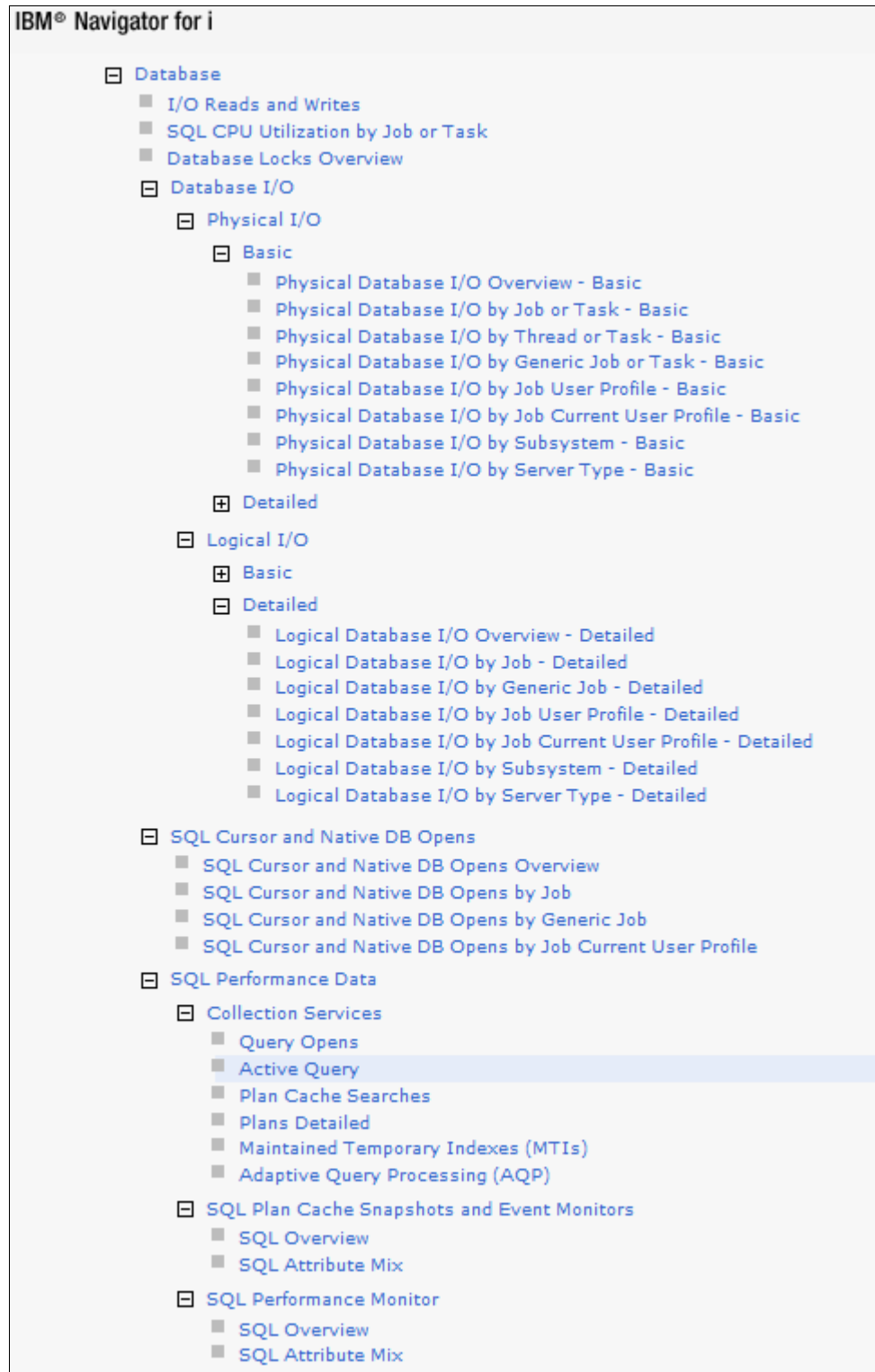


Figure 8-32 New database-related perspectives for PDI

Starting from the top-level system-wide overview, the DBE or DBA can open more detailed sections of the performance data that is related to a particular job or thread or SQL plan cache.

Figure 8-33 shows the PDI view of SQL CPU utilization for jobs and tasks. The following drill-down options are available from within this interface:

- ▶ CPU Utilization for Jobs or Tasks
- ▶ CPU Utilization Overview

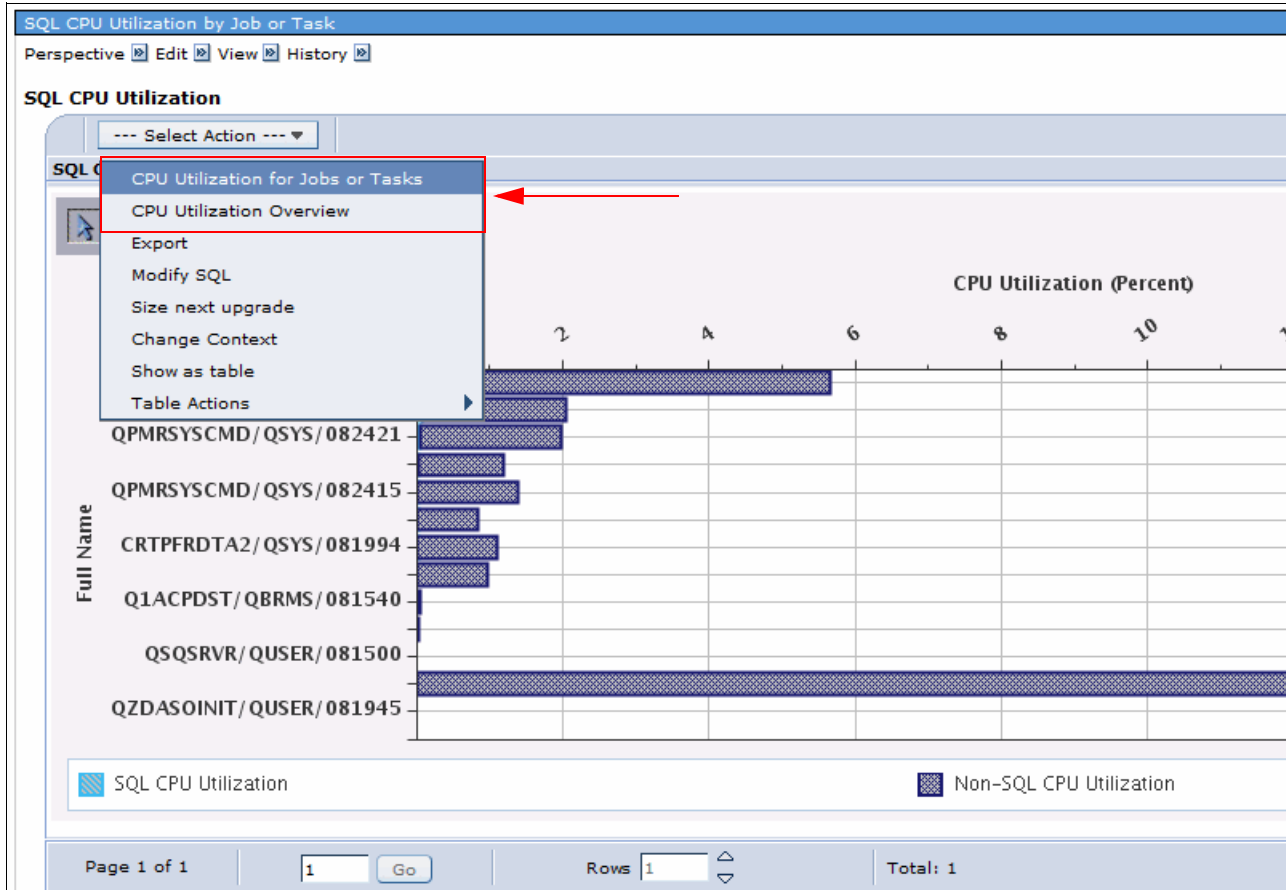


Figure 8-33 SQL CPU utilization by job and task PDI view

PDI data can be presented in graphs or tables. You can choose performance data files (either current or previous), zoom in and out of a range of intervals of interest, or even modify an SQL statement to retrieve other than the default set of data.

The Plan Cache Searches view is shown on Figure 8-34.

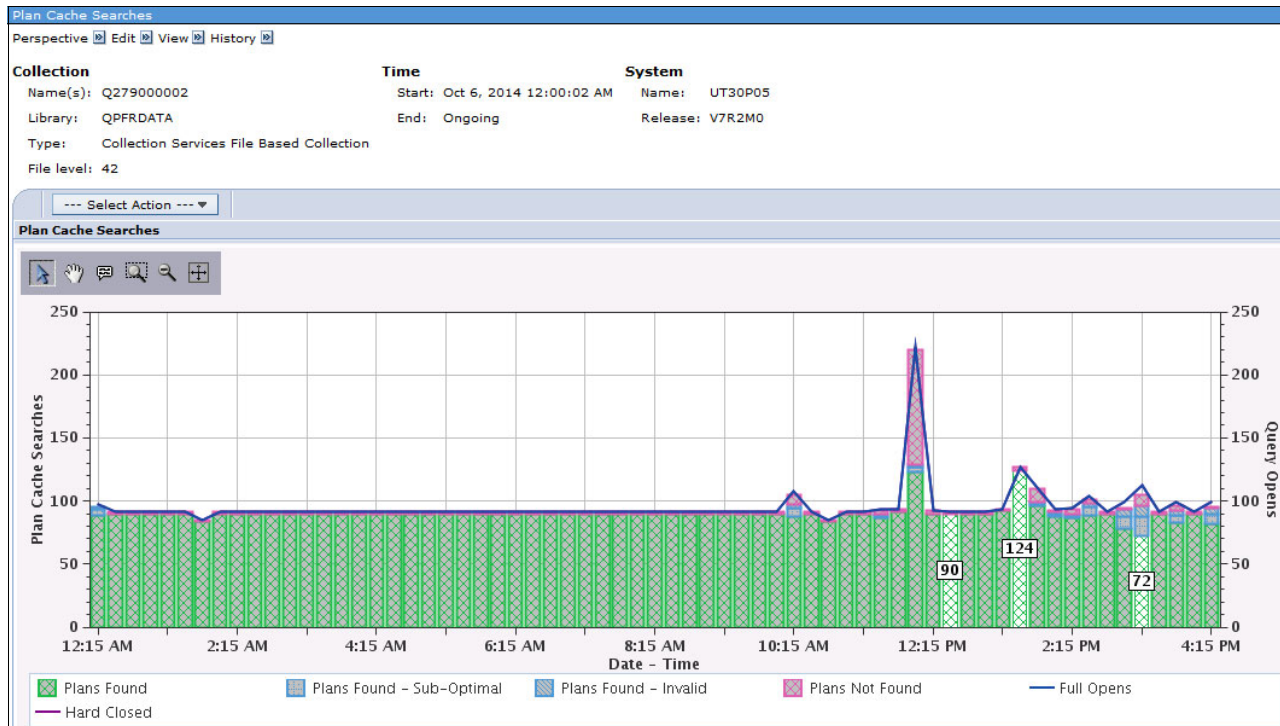


Figure 8-34 Plan Cache Searches PDI view

For more information about PDI, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahx/rzahxpdi-launch.htm?lang=en

8.6.4 Queries with a long IN predicate list

In IBM i 7.2, SQE recognizes when many values are specified on an IN list and automatically converts the IN list to a more efficient INNER JOIN.

8.6.5 Index advice and OR predicates

In IBM i 7.2, the Index Advisor is extended to include queries that OR together local selection (**WHERE** clause) columns over a single table. OR advice requires two or more indexes to be created as a dependent set. If any of the OR'd indexes are missing, the optimizer cannot choose these dependent indexes for implementation of the OR-based query.

This relationship between OR-based indexes in the SYSIXADV index advice table is through a new **DEPENDENT_ADVICE_COUNT** column.

For more information about Index Advisor, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/idxadvisor.htm?lang=en

For more information about index advice and OR predicates, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqidxadvorpred.htm?lang=en

8.6.6 KEEP IN MEMORY for tables and indexes

Before IBM i 7.1, the only way to preinstall an object into a main storage pool was by using the Set Object Access (**SETOBJACC**) CL command. Loading database files or programs in to a main storage pool reduces data access time and results in performance gains. However, the effect of the **SETOBJACC** CL command is temporary and does not persist over an IPL. To remove the object from the main storage, run the **SETOBJACC** CL command with the ***PURGE** option.

In IBM i 7.1, the **CHGPF** and **CHGLF** CL commands were extended with the Keep in memory parameter (**KEEPINMEM**) to allow the operating system to bring automatically a table or index into a main storage pool when the table or index is used in a query. For queries running within SQE, this enhancement results in performance gains. The operating system also automatically purges the objects with the memory-preference from the main store when they are no longer used by the query.

IBM i 7.2 is enhanced with the comprehensive support for the keep-in-memory function. The following SQL statements are extended with the **KEEP IN MEMORY** keyword:

- ▶ **CREATE TABLE**
- ▶ **CREATE INDEX**
- ▶ **ALTER TABLE**
- ▶ **DECLARE GLOBAL TEMPORARY TABLE**

A new option that is called **MEMORY_POOL_PREFERENCE** is now available in the QAQQINI file, which you can use to direct the database engine to attempt to load objects to a specified storage pool. This option does not ensure that a specified storage pool is used.

Table 8-37 describes the values that are available for the **MEMORY_POOL_PREFERENCE** option.

Table 8-37 *MEMORY_POOL_PREFERENCE* parameter values

Value	Description
*JOB	Attempt to use the storage pool of the job
*BASE	Attempt to use the Base storage pool
nn	Attempt to use the Storage pool nn
*DEFAULT	The same as *JOB

The Display File Description (DSPFD) CL command output is extended with the new Keep in memory field, under the Data Base File Attributes section, as shown in Example 8-28.

Example 8-28 DSPFD partial output with Keep in memory field

Access path	:	Arrival
Maximum record length	:	26
Volatile	:	No
Keep in memory	:	KEEPINMEM *YES
File is currently journaled	:	Yes
Current or last journal	:	QSQJRN
Library	:	CORPDB

This enhancement, also known as *memory-preference*, is comprehensive and affects all available BD2 management interfaces, including the following interfaces:

- ▶ CLI commands
- ▶ IBM System i Navigator
- ▶ IBM Navigator for i

Figure 8-35 shows the memory-preference information of a table definition that is available from IBM System i Navigator.

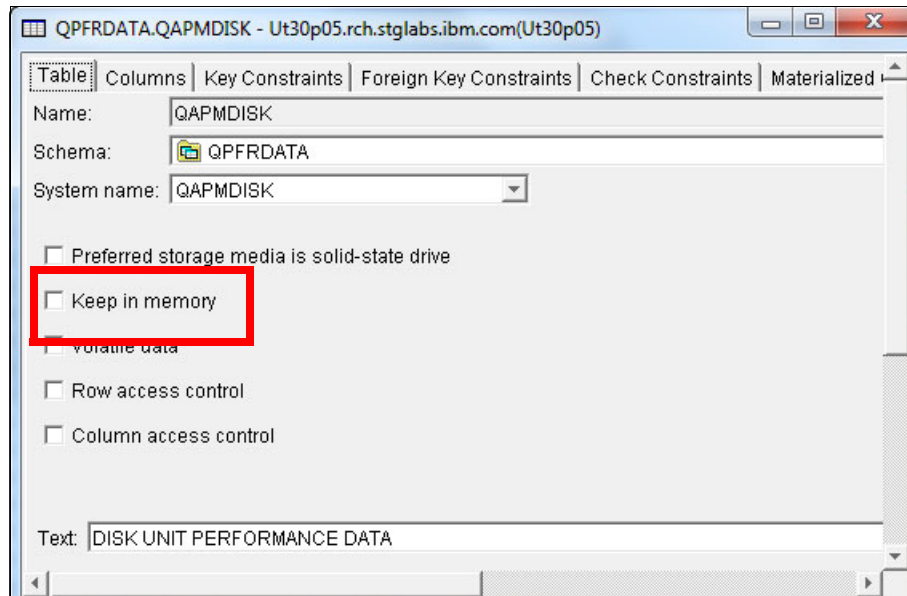


Figure 8-35 Memory-preference information for a table definition in IBM System i Navigator

Figure 8-36 shows the memory-preference information of a table description that is available from IBM System i Navigator.

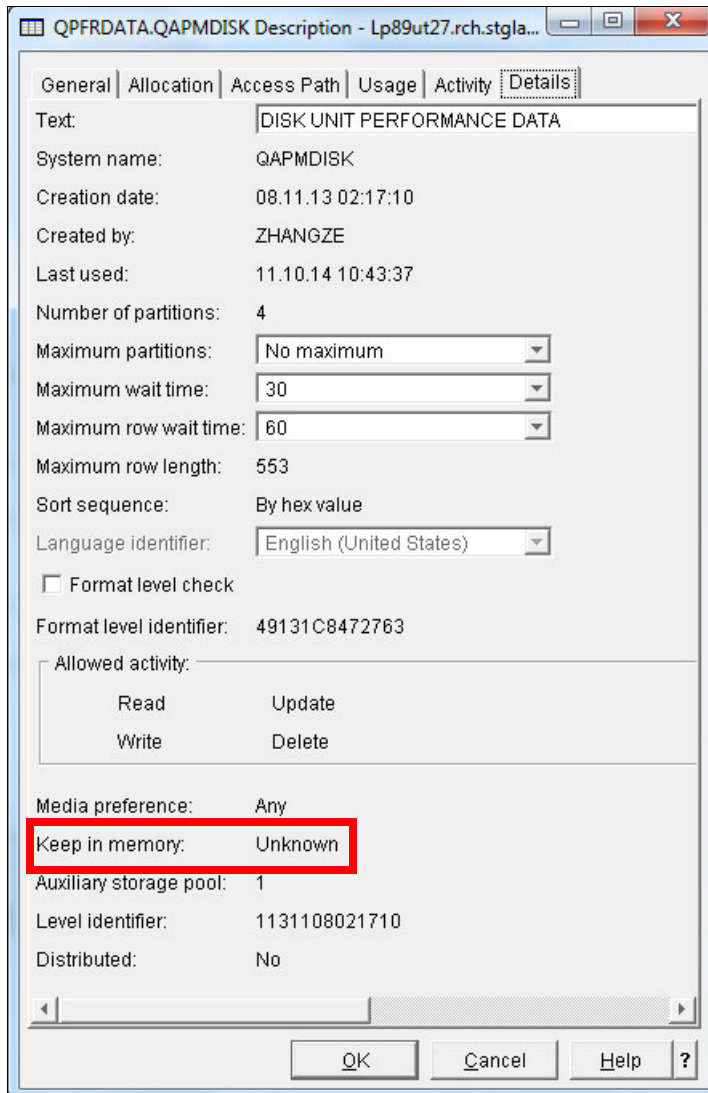


Figure 8-36 Memory-preference information for a table description in IBM System i Navigator

Figure 8-37 shows the memory-preference information of an index definition that is available from IBM System i Navigator.

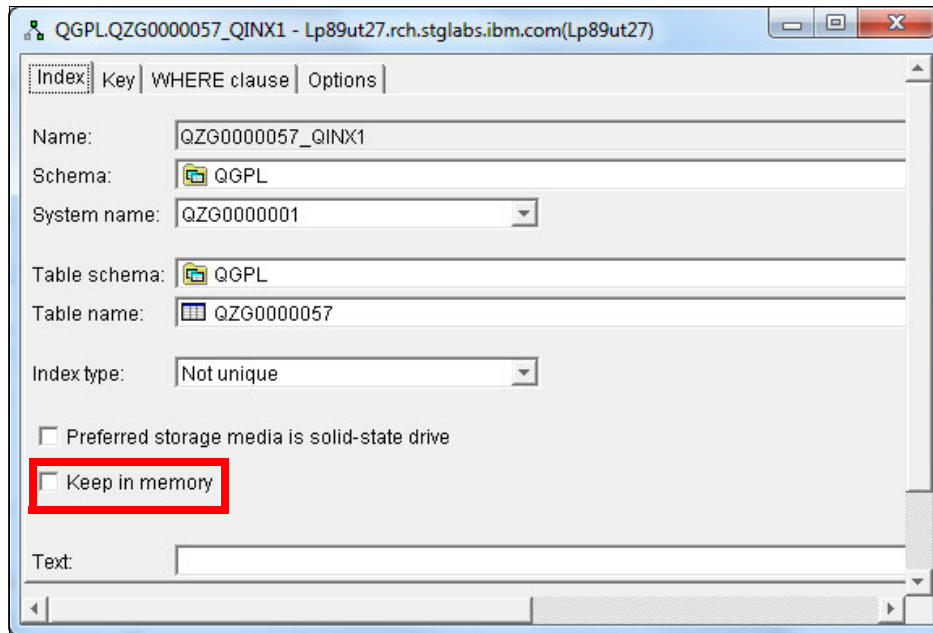


Figure 8-37 Memory-preference information for an index definition in IBM System i Navigator

Figure 8-38 shows the memory-preference information of an index description that is available from IBM System i Navigator. The same information is available from IBM Navigator for i.

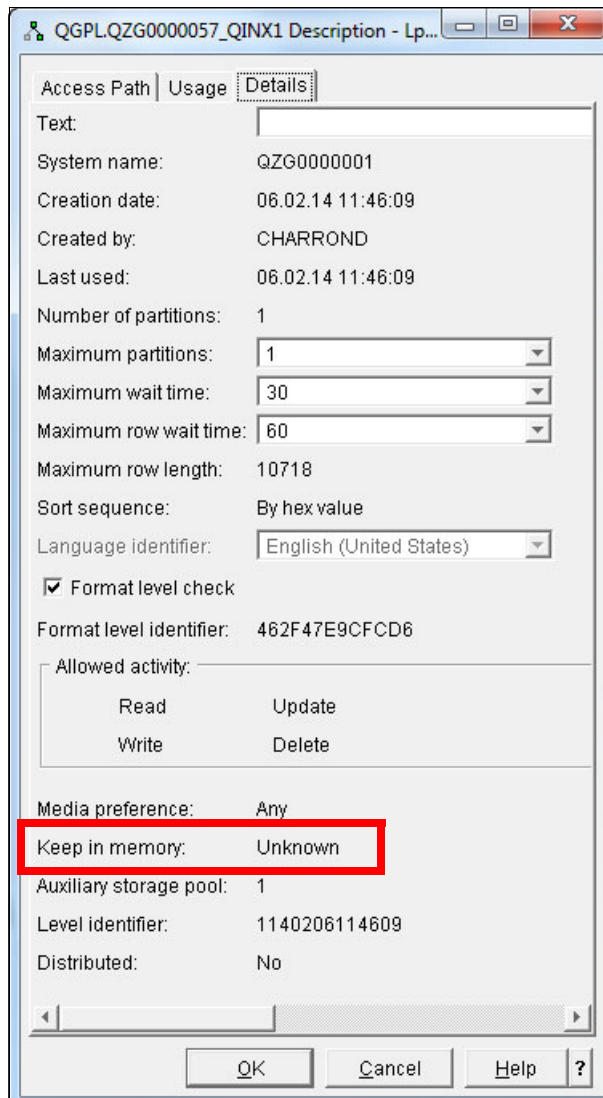


Figure 8-38 Memory-preference information for an index description in IBM System i Navigator

Figure 8-39 shows the memory-preference information of a table definition that is available from IBM Navigator for i.

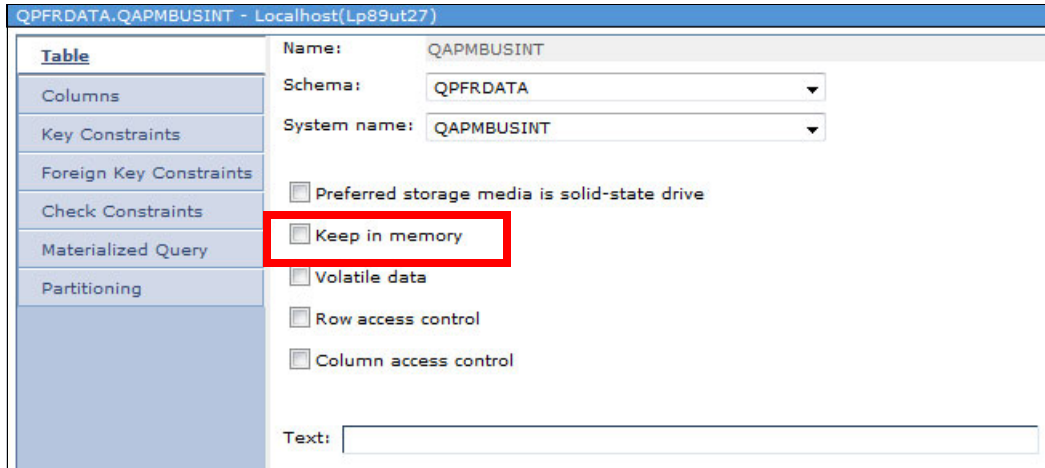


Figure 8-39 Memory-preference information for a table definition in IBM Navigator for i

Figure 8-40 shows the memory-preference information of a table description that is available from IBM Navigator for i.

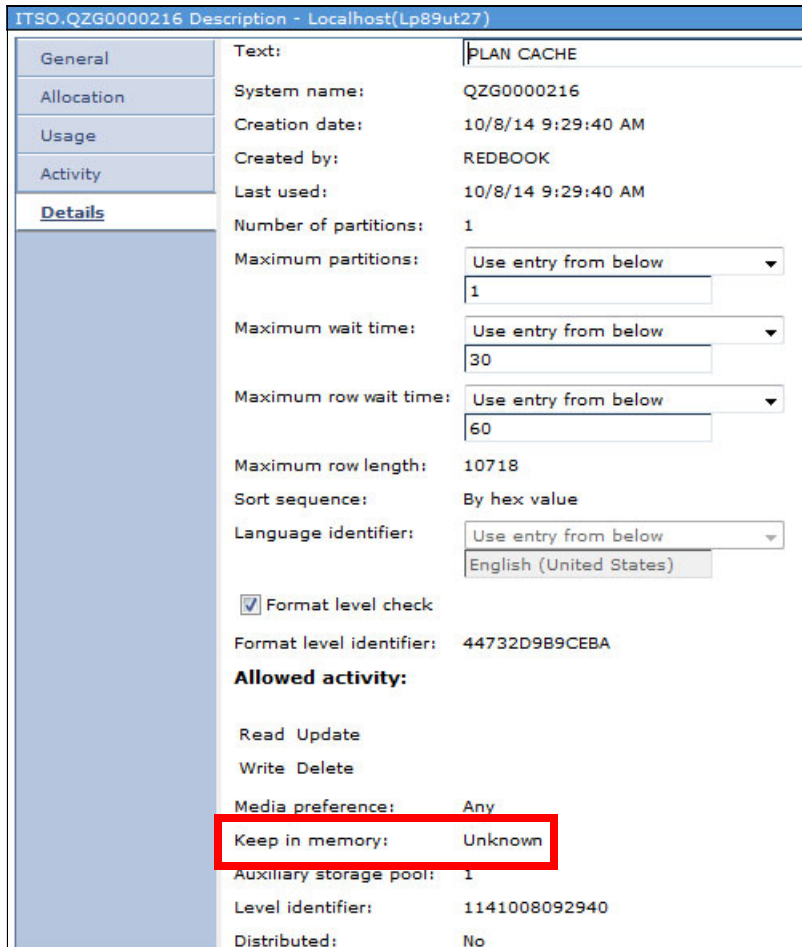


Figure 8-40 Memory-preference information for a table description in IBM Navigator for i

Figure 8-41 shows the memory-preference information of an index definition that is available from IBM Navigator for i.

ITSO.QZG0000216_QINX1 - Localhost(Lp89ut27)	
Index	Name: QZG0000216_QINX1
Key	Schema: ITSO
WHERE clause	System name: QZG0000001
Options	Table schema: ITSO
	Table name: QZG0000216
	Index type: Not unique
	<input type="checkbox"/> Preferred storage media is solid-state drive
	<input type="checkbox"/> Keep in memory
	Text:

Figure 8-41 Memory-preference information for an index definition in IBM Navigator for i

Figure 8-42 shows the memory-preference information of an index description that is available from IBM Navigator for i.

ITSO.QZG0000216_QINX1 Description - Localhost(Lp89ut27)	
Access Path	Text:
Usage	System name: QZG0000001
Details	Creation date: 10/8/14 9:32:15 AM
	Created by: REDBOOK
	Last used: 10/8/14 9:32:16 AM
	Number of partitions: 1
	Maximum partitions: Use entry from below
	1
	Maximum wait time: Use entry from below
	30
	Maximum row wait time: Use entry from below
	60
	Maximum row length: 10718
	Sort sequence: By hex value
	Language identifier: Use entry from below
	English (United States)
	<input checked="" type="checkbox"/> Format level check
	Format level identifier: 44732D9B9CEBA
	Allowed activity:
	Read Update
	Write Delete
	Media preference: Any
	<input type="checkbox"/> Keep in memory: Unknown
	Auxiliary storage pool: 1
	Level identifier: 1141008093215
	Distributed: No

Figure 8-42 Memory-preference information for an index description in IBM Navigator for i

For more information about the memory-preference enhancement, see the IBM i Technology Updates website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Comprehensive%20support%20for%20%E2%80%98Keep%20In%20Memory%E2%80%99>

For more information about DB2 for i SQL statements, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm?lang=en

For more information about the QAQINI file and its options, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/qryopt.htm?lang=en

8.6.7 Collection Services enhancements

Collection Services now collects SQL statistics on a job and system level. Here is a list of performance data files that are extended with SQL information:

- ▶ QAPMJOBOS: Data that is specific to system jobs
- ▶ QAPMSYSTEM: System-wide performance data

A new file that is called QAPMSQLPC is available. It contains the performance data about the SQL Plan Cache that is collected by the *SQL collection category.

For more information about Collection Services files descriptions, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahx/rzahxcatfilerelation.htm?lang=en

8.6.8 Enhanced index build logic for highly concurrent environments

DB2 for i index build processing is enhanced to gauge its aggressiveness for index key processing based upon the run priority of the index build job. The priority is set up for the application job.

Table 8-38 compares the behavior of the index build job when changing the priority.

Table 8-38 Index build behavior based on the run priority

Job priority	Index keys that are processed before looking for held users	Wait time
1 - 19	Process <i>many</i> keys at a time.	Wait <i>less</i> time before trying to get a seize.
20 - 80	Process a <i>few</i> keys at a time (same as before this enhancement).	Wait the <i>same</i> amount of time as before the enhancement.
81 - 99	Process <i>two</i> keys at a time.	Wait a <i>longer</i> time than before the enhancement.

8.6.9 Accepting a priority change for a parallel index build

DB2 for i now allows you to change the priority of index build jobs when using IBM i operating system option 26 - DB2 Symmetric Multiprocessing. Option 26 is a chargeable feature.

The index builds run as part of jobs QDBSRVxx, where xx is in range from 1 to the number of CPU cores that the logical partition has assigned.

Before this enhancement, these jobs ran with priority 52. Now, you can change the run priorities of individual QDBSRVxx jobs.

Changing the run priority of the index build job changes the priority of the SMP tasks.

The Change System Job (**CHGSYSJOB**) command is enhanced to allow priority changes to DB server jobs.

Table 8-39 shows a comparison of behavior of the index build job when changing the priority.

Table 8-39 Index build behavior based on the run priority

Job priority	Index keys that are processed before looking for held users	Wait time
1-19	Process <i>many</i> keys at a time.	Wait <i>less</i> time before trying to get a seize.
20-80	Process a <i>few</i> keys at a time (same as before this enhancement).	Wait the <i>same</i> amount of time as before the enhancement.
81-99	Process <i>two</i> keys at a time.	Wait a <i>longer</i> time than before the enhancement.

8.6.10 SQE index merge ordering

SQE is enhanced to select and use indexes for both selection and ordering queries where the selected row is not an equal predicate on one set of columns and ordering is on another set of columns. The previous version of SQE could select only one index for selection or ordering but not both. This can help reduce CPU and I/O resource consumption compared to the previous method.

The most likely situations that get performance benefits from this enhancement are the following ones:

- ▶ The query is being optimized for first I/O, which is used when a user is waiting for the first set of I/O.
- ▶ The result set is large.
- ▶ An Index Merge Ordering (IMO) eligible index exists.

For more information, see *Index Merge Ordering* at:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20echnology%20Updates/page/SQE%20-%20Index%20Merge%20Ordering>

8.6.11 QSYS2.DATABASE_MONITOR_INFO view

The DATABASE_MONITOR_INFO view is a new DB2 for i Services function that is introduced in IBM i 7.2. This view returns information about database monitors and plan cache event monitors on the server.

Example 8-29 show an SQL statement to select an active database monitor with a data size greater than 200,000 bytes.

Example 8-29 SQL statement to select an active database monitor with a data size greater than 200,000 bytes

```
SELECT MONITOR_ID,MONITOR_TYPE,MONITOR_STATUS,MONITOR_LIBRARY,DATA_SIZE
FROM QSYS2.DATABASE_MONITOR_INFO
WHERE MONITOR_STATUS = 'ACTIVE' AND DATA_SIZE > 200000;
```

Figure 8-43 shows the query result of DATABASE_MONITOR_INFO DB2 for i Services.

MONITOR_ID	MONITOR_TYPE	MONITOR_STATUS	MONITOR_LIBRARY	DATA_SIZE
0835292002	PUBLIC	ACTIVE	SIRIPONG2	10547200
PLANC00001	EVENT	ACTIVE	SIRIPONG2	2281472

Figure 8-43 Query result of DATABASE_MONITOR_INFO

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqservicesperf.htm?lang=en

8.6.12 QAQQINI memory preference by pool name

In IBM i 7.2, the QAQQINI (Query Options) MEMORY_POOL_PREFERENCE is enhanced to support memory pool preference by using a share memory pool name or private memory pool identifiers to direct a database to perform paging into the memory pool when supported for database operation.

Previously, a user could specify a system pool ID for a preferred memory pool. But, using a system pool ID made it difficult where a user needed the database to page the query data into a share pool or private memory pool. The user needed to know the system pool ID associated with that named memory pool, and if there was a change on the system pool ID, the user had to update the new system pool ID in QAQQINI unless the database fell back to use the *BASE memory pool.

With this enhancement, users can specify the shared pool name or the private pool name along with its subsystem and library. DB2 then tracks these changes and makes certain that the preferred memory pool for database operation is really what the user intends.

Example 8-30 shows an SQL statement for updating the QAQQINI MEMORY_POOL_PREFERENCE by shared pool name and private pool name.

Example 8-30 Example SQL statement to update QAQQINI MEMORY_POOL_PREFERENCE

```
----- Shared pool name -----
UPDATE MYLIB.QAQQINI
SET QQVAL = '*NAME *SHRPOOL1'
WHERE QQPARM = 'MEMORY_POOL_PREFERENCE
```

or

```
----- *INTERACT pool -----
UPDATE MYLIB.QAQQINI
SET QQVAL = '*NAME *INTERACT'
```



```
WHERE QQPARM = 'MEMORY_POOL_PERFORMANCE'
```

or

```
----- Private pool name -----  
UPDATE MYLIB.QAQQINI  
SET QQVAL = '*PRIVATE MYLIB/MYSBS 1'  
WHERE QQPARM = 'MEMORY_POOL_PERFORMANCE'
```

For more information, see *QAQQINI memory preference by pool name* at:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20T%20echnology%20Updates/page/QAQQINI%20memory%20preference%20by%20pool%20name>

8.6.13 Index statistical catalogs enhancement

In IBM i 7.2, the following index statistical related catalogs are enhanced:

- ▶ QSYS2.SYSINDEXSTAT
- ▶ QSYS2.SYSPARTITIONINDEXES
- ▶ QSYS2.SYSPARTITIONINDEXSTAT

They are enhanced to include the following information:

- ▶ **LAST_BUILD_TYPE:**
An indication of whether the last index build is related to a complete build or delayed maintenance build.
- ▶ **LAST_INVALIDATION_TIMESTAMP:**
An indication of when an index was last invalidated.

Figure 8-44 shows the query result of the SYSINDEXSTAT catalog with the LAST_BUILD_TYPE and LAST_INVALIDATION_TIMESTAMP columns.

INDEX_SCHEMA	INDEX_NAME	LAST_BUILD_TYPE	LAST_INVALIDATION_TIMESTAMP
QSYS2	QASQSPVDP	1	-
QSYS2	QASQXSROSS	1	-
QSYS2	QAXSROBJ2	1	-
QSYS2	QASQDRDP	1	-
QSYS2	QASQSPDP	1	-
QSYS2	SYSTXTINDI	1	-
QSYS2	SYSTXTCOLI	1	-
QSYS2	QASEQOBJ	1	-
QSYS2	SYSLIMITIX	1	2015-10-13 05:38:23.000000
QSYS2	SYSIXADVIX	1	-

Figure 8-44 Query result of the SYSINDEXSTAT catalog

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzcatalogtbls.htm?lang=en

8.6.14 QSYS2.CLEAR_PLAN_CACHE() procedure

The **CLEAR_PLAN_CACHE()** procedure is a part of DB2 for i Services that is introduced in IBM i 7.2. This procedure provides an alternative way to clear a plan cache instead of performing a system IPL. This procedure can be used by performance analysts to create a consistent environment to evaluate potential database performance changes in a performance test environment or QA environment.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqclearplancache.htm?lang=en

8.6.15 Encoded vector indexes only access

Encoded vector indexes were improved so they can be used for projections of columns by an SQE query optimizer. Encoded vector indexes were originally focused on selection keys in the WHERE clause and aggregation. After this Encoded vector indexes only access (EOA) enhancement, they also can be used for column projection in SELECT list.

Also, Index Advisor recommendations to use Encoded Vector Indexes can be seen with REASON_TYPE set to I8.

8.6.16 STRDBMON command filtering improvement

In IBM i 7.2, a filter operation equal to (*EQ) and not equal to (*NE) was added to the Start Database Monitor (**STRDBMON**) command for the **JOB**, **FTRFILE**, and **FTRUSER** parameters. These allow for more filtering options on the database monitor.

Figure 8-45 on page 397 and Figure 8-46 on page 397 show the filter operations for **JOB** parameter in the **STRDBMON** command.

```

Start Database Monitor (STRDBMON)

Type choices, press Enter.

File to receive output . . . . . Name
Library . . . . . *LIBL Name, *LIBL, *CURLIB
Output member options:
Member to receive output . . . *FIRST Name, *FIRST
Replace or add records . . . . *REPLACE *REPLACE, *ADD
Job name:
Name . . . . . * Name, generic*, *, *ALL
User . . . . . Name, generic*, *ALL
Number . . . . . 000000-999999, *ALL
Filter Operator . . . . . *EQ *EQ, *NE
Type of records . . . . . *DETAIL *DETAIL, *BASIC, *SUMMARY
Force record write . . . . . *CALC 0-32767, *CALC
Initial number of records . . . *NONE 0-2147483646, *NONE
Run time threshold . . . . . *NONE 0-2147483647, *NONE
Storage threshold . . . . . *NONE 0-2147483647, *NONE
Include system SQL . . . . . *NO *NO, *YES, *INI
More...

F3=Exit F4=Prompt F5=Refresh F12=Cancel F13=How to use this display
F24=More keys

```

Figure 8-45 Filter operator for STRDBMON command

```

Start Database Monitor (STRDBMON)

Type choices, press Enter.

Filter by database file:
File . . . . . *NONE

Library . . . . . Name, generic*
Filter Operator . . . . . *EQ *EQ, *NE
+ for more values
Filter by user profile:
User . . . . . *NONE Name, generic*, *NONE...
Filter Operator . . . . . *EQ *EQ, *NE
+ for more values
Filter by internet address . . . *NONE

More...

F3=Exit F4=Prompt F5=Refresh F12=Cancel F13=How to use this display
F24=More keys

```

Figure 8-46 Filter operator for STRDBMON command

For more information, see *Start Database Monitor (STRDBMON) command filtering improvements* at:

<https://ibm.biz/BdsRRD>

8.7 Database engineering

A data-centric approach requires performing various tasks by database engineers (DBE) daily. Examples of these tasks include the following ones:

- ▶ Database security management
- ▶ Database architecture management for particular business applications and goals
- ▶ Database performance analysis and tuning
- ▶ Database problem identification and resolution
- ▶ Database backup and recovery management

The following sections describe the new DB2 for i features and enhancements for DBEs in IBM i 7.2:

- ▶ 8.7.1, “IBM System i Navigator DB2 related functions” on page 398
- ▶ 8.7.2, “IBM Navigator for i: DB2 related functions” on page 403
- ▶ 8.7.3, “Queued exclusive locks” on page 408
- ▶ 8.7.4, “CREATE TABLE AS SELECT from a remote database” on page 409
- ▶ 8.7.5, “Live movement of tables and indexes to SSD” on page 410
- ▶ 8.7.6, “Range partitioned tables” on page 410

8.7.1 IBM System i Navigator DB2 related functions

Although IBM Navigator for i is enhanced with many new features and functions to support database engineers (see 8.7.2, “IBM Navigator for i: DB2 related functions” on page 403), IBM System i Navigator remains a tool of choice for many users.

IBM System i Navigator is the *only* tool that supports the Visual Explain and Run SQL Scripts functions. It continues to be enhanced twice a year by service pack updates. Many of the IBM i 7.2 database enhancements are reflected in the current IBM System i Navigator updates.

Note: To use all the available enhancements of the IBM System i Navigator, you must install the current IBM i Access for Windows service pack for Version 7.1. The Version 7.1 client software contains all the IBM System i Navigator enhancements for IBM i 7.2. Also, you must install the current DB2 PTF Group on the managed system.

The following DB2 related functions were added to IBM System i Navigator:

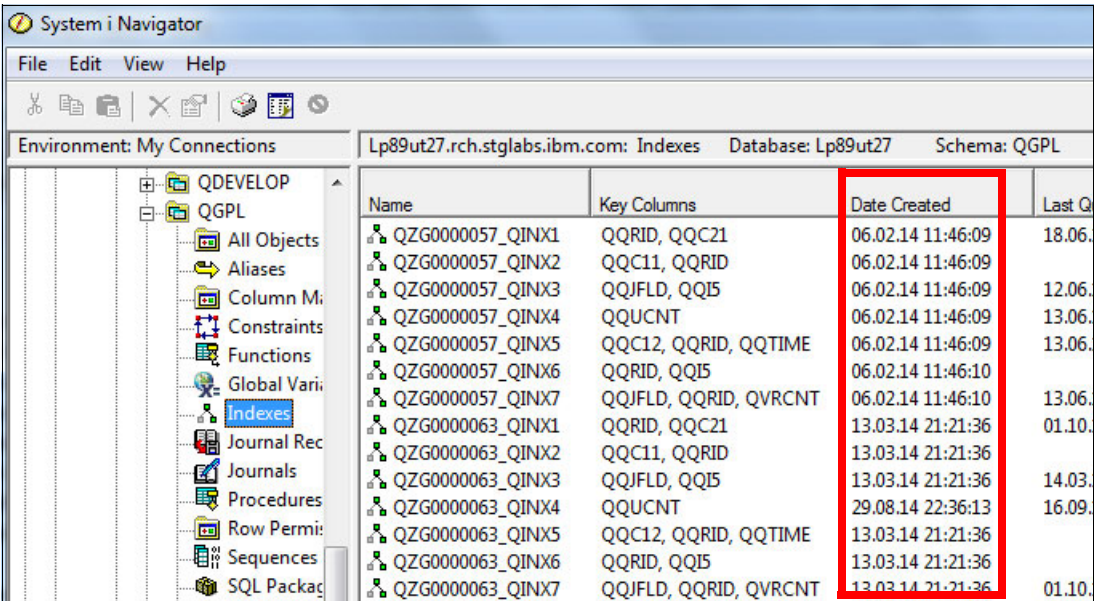
- ▶ “Index creation date” on page 399
- ▶ “New SQL Performance Monitor parameters” on page 399
- ▶ “New fields in the Table Definition window” on page 400
- ▶ “Program statements for user-defined table function in Visual Explain” on page 401
- ▶ “Automating SQL plan cache operations” on page 402

For more information about IBM System i Navigator, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahginav.htm?lang=en

Index creation date

For better manageability, a new Date Created column was added to the Indexes view of a particular schema, as shown in Figure 8-47.



The screenshot shows the IBM System i Navigator interface. The left pane displays a tree view of the database environment, with 'Indexes' selected under the 'QGPL' schema. The main pane shows a table of indexes with columns: Name, Key Columns, Date Created, and Last Q. The 'Date Created' column is highlighted with a red box. The data in the table is as follows:

Name	Key Columns	Date Created	Last Q
QZG000057_QINX1	QQRID, QQC21	06.02.14 11:46:09	18.06.
QZG000057_QINX2	QQC11, QQRID	06.02.14 11:46:09	12.06.
QZG000057_QINX3	QQJFLD, QQI5	06.02.14 11:46:09	13.06.
QZG000057_QINX4	QQUCNT	06.02.14 11:46:09	13.06.
QZG000057_QINX5	QQC12, QQRID, QQTIME	06.02.14 11:46:09	13.06.
QZG000057_QINX6	QQRID, QQI5	06.02.14 11:46:10	13.06.
QZG000057_QINX7	QQJFLD, QQRID, QVRCNT	06.02.14 11:46:10	13.06.
QZG000063_QINX1	QQRID, QQC21	13.03.14 21:21:36	01.10.
QZG000063_QINX2	QQC11, QQRID	13.03.14 21:21:36	14.03.
QZG000063_QINX3	QQJFLD, QQI5	13.03.14 21:21:36	16.09.
QZG000063_QINX4	QQUCNT	13.03.14 21:21:36	16.09.
QZG000063_QINX5	QQC12, QQRID, QQTIME	13.03.14 21:21:36	16.09.
QZG000063_QINX6	QQRID, QQI5	13.03.14 21:21:36	16.09.
QZG000063_QINX7	QQJFLD, QQRID, QVRCNT	13.03.14 21:21:36	01.10.

Figure 8-47 New Date Created column in the Indexes list window

For more information about the index creation date within the IBM System i Navigator window and system catalogs, see the following website:

<https://ibm.biz/BdsXGs>

New SQL Performance Monitor parameters

The SQL Performance Monitor Wizard now supports up to 10 user names or group names and generic names in the “Current user or group profile” field.

Also, a new Host variable values field can control how values of the host variables are captured when the monitor is active. The following values are available:

- ▶ The *BASE value has the same behavior as on IBM 7.1 or earlier
- ▶ The *CONDENSED value allows for less impact to the database
- ▶ The *SECURE value prevents host variable values from being visible in the collected data

See Figure 8-48.

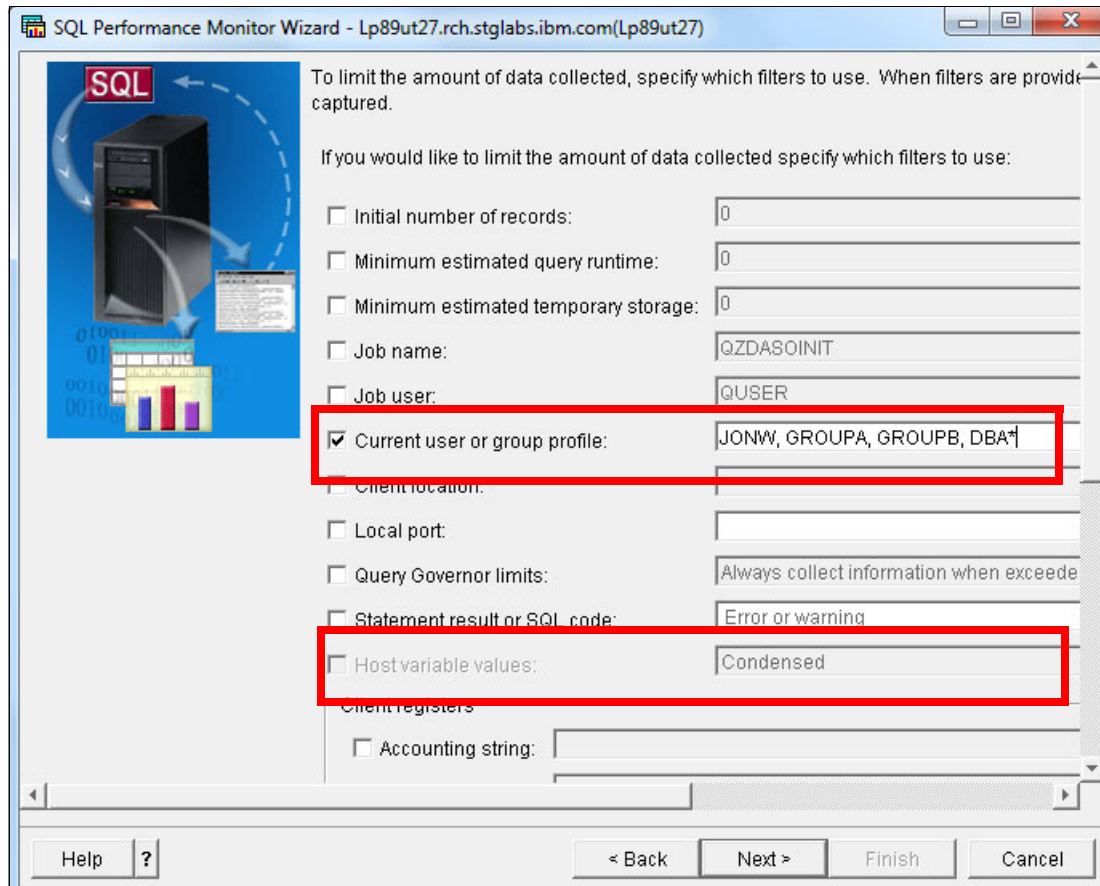


Figure 8-48 SQL Performance Monitor Wizard enhancements

For more information about the Host variables values parameter for SQL Performance Monitors, see the following website:

<https://ibm.biz/BdsXGZ>

New fields in the Table Definition window

Table and partition definition information is extended with “Preferred storage media is solid-state drive” and “Keep in memory” fields, as shown on Figure 8-49 on page 401.

Also, the Show SQL function is enhanced to support these changes.

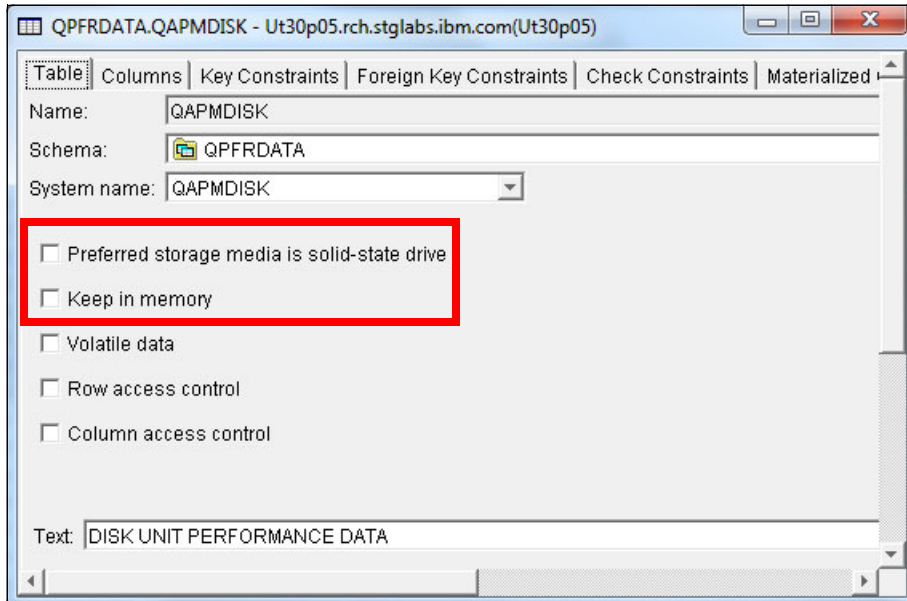


Figure 8-49 New fields in the Table Definition window

Program statements for user-defined table function in Visual Explain

You can use Visual Explain to see detailed program statements for UDTFs. See Figure 8-50.

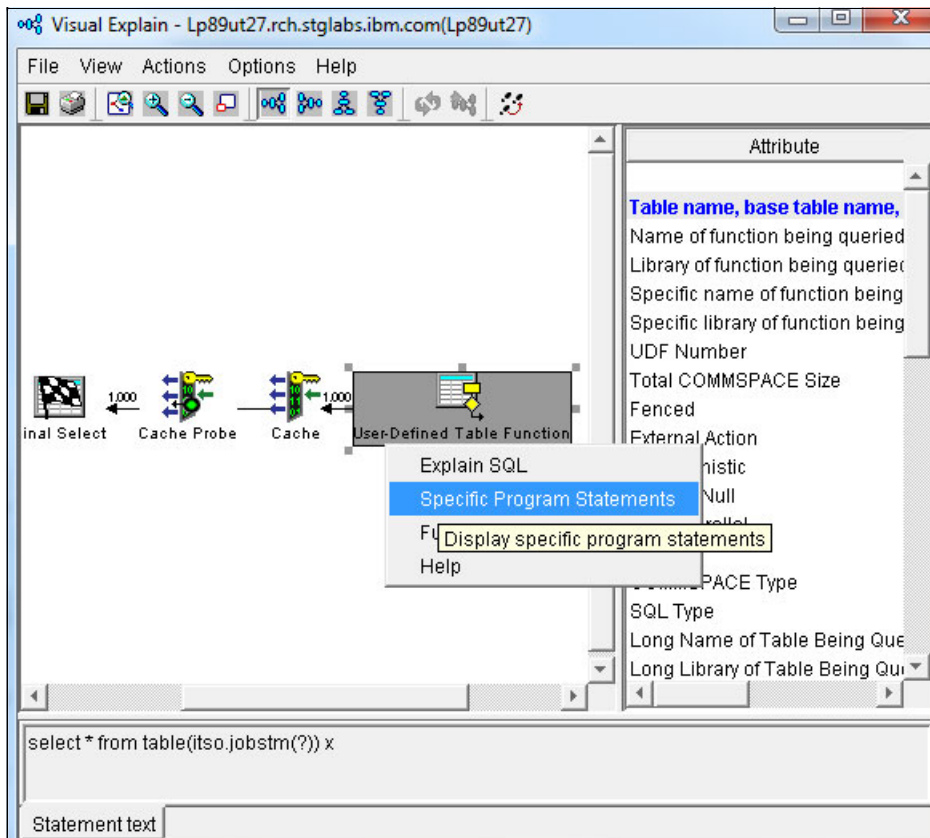


Figure 8-50 Specific program statements for user-defined table functions in Visual Explain

For more information about specific program statements for UDTF in Visual Explain, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Visual%20Explain%20ability%20to%20drill%20into%20a%20UDTF>

Automating SQL plan cache operations

New system procedures are added to automate SQL plan cache snapshots and event monitors importation and removal. Before this change, you had to perform these operations manually from the IBM System i Navigator. Here are the new procedures:

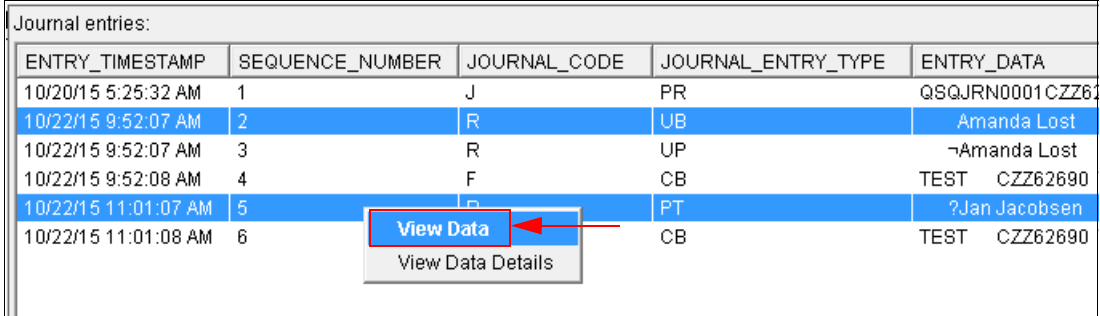
- ▶ QSYS2/IMPORT_PLAN_CACHE()
- ▶ QSYS2/REMOVE_PLAN_CACHE()
- ▶ QSYS2/IMPORT_EVENT_MONITOR()
- ▶ QSYS2/REMOVE_EVENT_MONITOR()

For more information about automating SQL plan cache operations, see the following website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Automated%20DBE%20tasks%20for%20Navigator>

Adding multiple view entries support to the journal viewer

Within a journaled environment, you can now select multiple rows, as shown in Figure 8-51. You can then right-click and select **View Data**. This makes it easier to compare the before and after situation.



Journal entries:

ENTRY_TIMESTAMP	SEQUENCE_NUMBER	JOURNAL_CODE	JOURNAL_ENTRY_TYPE	ENTRY_DATA
10/20/15 5:25:32 AM	1	J	PR	QSQRN0001CZZ6
10/22/15 9:52:07 AM	2	R	UB	Amanda Lost
10/22/15 9:52:07 AM	3	R	UP	~Amanda Lost
10/22/15 9:52:08 AM	4	F	CB	TEST CZZ62690
10/22/15 11:01:07 AM	5		PT	?Jan Jacobsen
10/22/15 11:01:08 AM	6		CB	TEST CZZ62690

A context menu is open over the row with sequence number 5, showing the options "View Data" and "View Data Details".

Figure 8-51 Journal viewer: select multiple entries

When the data is displayed, you also can control whether you want to see the text or hex formatted data for comparison purposes, as shown in Figure 8-52 on page 403.

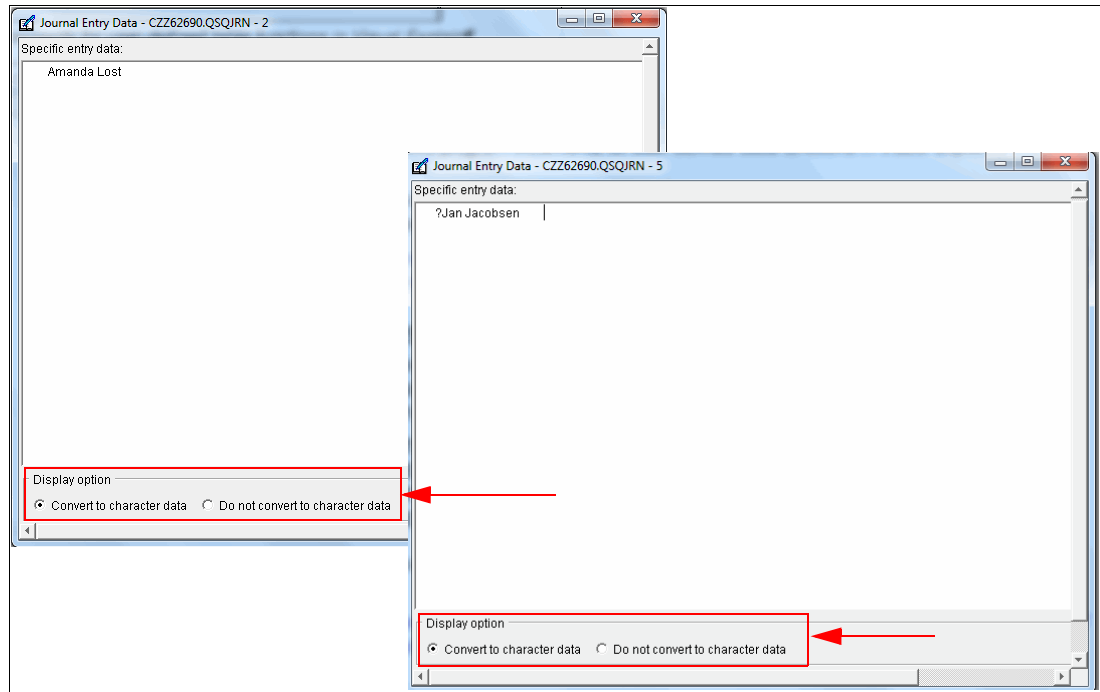


Figure 8-52 Journal entry data viewer

8.7.2 IBM Navigator for i: DB2 related functions

IBM Navigator for i has become a robust tool for IBM i management that an administrator can use to control all areas of the system. IBM Navigator for i is intended to replace IBM System i Navigator tool in the future. Many of the IBM Navigator for i enhancements are not available in other tools. The DB2 engineering functions of the tool are not an exception to this rule. Enhancements that are introduced to IBM System i Navigator are also available for IBM Navigator for i except for Visual Explain UDTF statements.

Many improvements were made to the Database functions, resulting in enhanced usability and performance of the web tool. Key changes include the following changes:

- ▶ Redesigned window for better usability and performance in a web browser:
 - Select Schemas
 - SQL Details for Jobs
 - Show Status (Table Reorganizations, Table Alters, Index Builds, and OmniFind text index builds)
 - Grid Column Chooser
- ▶ Performance changes to improve list retrieval, filtering, and data compression
- ▶ Usability changes to display lists resulting from database actions in a separate tab for easier navigation between lists
- ▶ Usability changes to display selected dialogs as Dojo pop-up menus
- ▶ Quick path access to several database windows

The On Demand Performance Center groups menu options and perspectives that are related to database performance, such as SQL plan cache or Index Advisor. The following changes were made to the On Demand Performance Center:

- ▶ A menu option was added to SQL Plan Cache snapshots and SQL database performance monitors to view overview charts in PDI.

Figure 8-53 shows the new Investigate Performance Data menu option in the SQL Plan Cache Snapshots window. You can use this option to navigate directly to PDI for snapshot analysis.

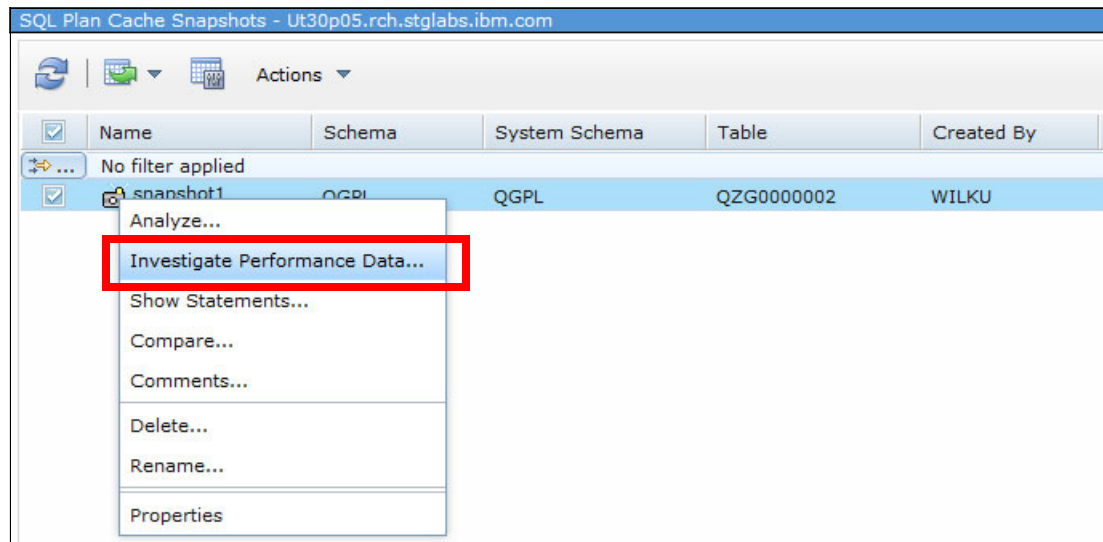


Figure 8-53 Investigate Performance Data menu option

- ▶ A menu option was added to a selected statement in the SQL Plan Cache to see the job history for that statement.

Figure 8-54 shows a new Show Job History menu option for a selected statement in the SQL Plan Cache Statements window. You can view the jobs that run the selected statement.

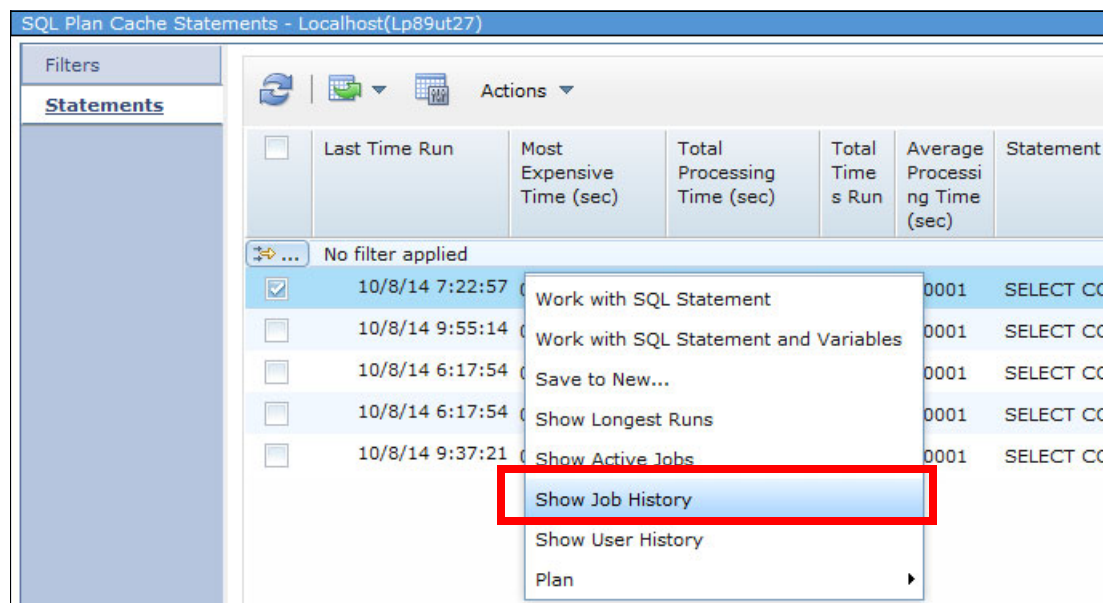


Figure 8-54 New Show Job History menu option in the SQL Plan Cache Statements window

- ▶ Additional filters are now used when you select to show the statements for a row from the Index Advisor and condensed index advice lists. These filters provide a better match of statements that generated the advice in the SQL Plan Cache.
- ▶ The Index Advisor list now includes a column with the times that the index was advised when it depended on other index advice.

Figure 8-55 shows the new Times Advised Dependent on Other Advice column in the Index Advisor view.

	Table for Which Index was Advised	Schema	Keys Advised	Times Advised Dependent on Other Advice
No filter applied				
<input type="checkbox"/>	QASZRAIRD	QUSRSYS	COMPID, FULLPATH	0
<input type="checkbox"/>	QAUGDBPMD2	QUSRSYS	"Free Storage Method", "Memory Handle"	0
<input type="checkbox"/>	QAUGDBPMD2	QUSRSYS	"Memory Handle", "Free Storage Method"	0
<input type="checkbox"/>	QATOVDC1	QUSRSYS	ORDER_NUMBER	0
<input type="checkbox"/>	QATOVDRGRP	QUSRSYS	ORDER_NUMBER	0
<input type="checkbox"/>	QASZRAIRC	QUSRSYS	PRODNAME, COMPNAME, FEATNAME, VE	0
<input type="checkbox"/>	QAPMCCCNAC	QUSRSYS	CCACTTYPE	0
<input type="checkbox"/>	QATOVDCUP	QUSRSYS	CONN_DEF_NAME	0
<input type="checkbox"/>	QAPMCCCNTB	QUSRSYS	CCCLNFMT, CCSTATUS	0

Figure 8-55 New Times Advised Dependent on Other Advice column in the Index Advisor window

- ▶ A filter was added to the Show Statements window filters, which specifies whether the other filters all need to match.

Figure 8-56 shows a new filter option on the Show Statements window filters, which specifies whether the other filters all need to match.

Statements - snapshot1 - Localhost(Ut30p05)

Filters

Filters to apply:

- Statements only need to match one filter to be included
- Minimum runtime for the longest execution of the statement: 0... Seconds
- Statements that ran on or after this date and time: 9/29/14 10:41:26 PM Example: 12:30:00 PM

Figure 8-56 New filter option on the Show Statements Filters window

Database management is extended with the following features:

- ▶ Support for new database features:
 - Row permissions and column masks and the ability to activate these row- and column-level security capabilities on tables.
 - Define multiple event triggers.
 - Define named parameters and default values for parameters in SQL stored procedures and functions.

For more information, see 8.2.1, “QIBM_DB_SECADM function usage” on page 323.

- ▶ Generate SQL now supports several new options:
 - Obfuscate an SQL trigger, function, or procedure.
 - Specify whether to schema qualify objects.
 - Add the **OR REPLACE** clause.
 - Add **KEEP IN MEMORY** clause.

Figure 8-57 shows the new options that are available in the Generate SQL window.

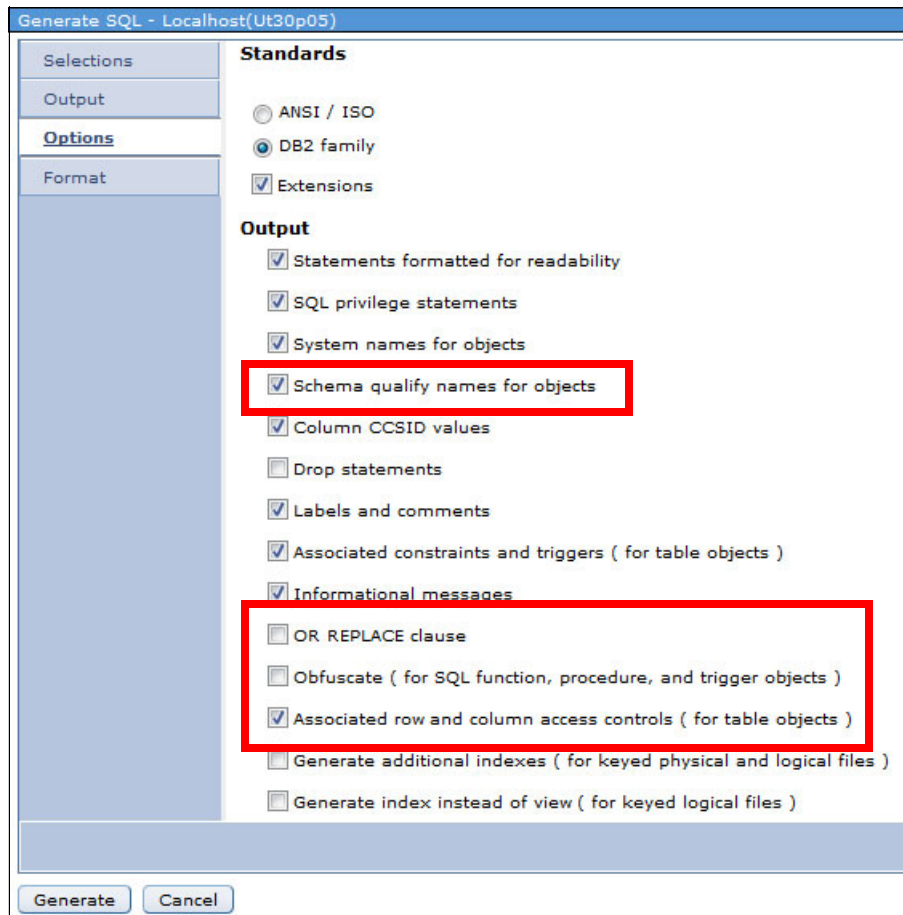


Figure 8-57 New options that are available in the Generate SQL window

- Support was added to view the contents of a table. Figure 8-58 shows the new View Contents menu option in the Tables window, which you can use to browse and filter data within the specified table.

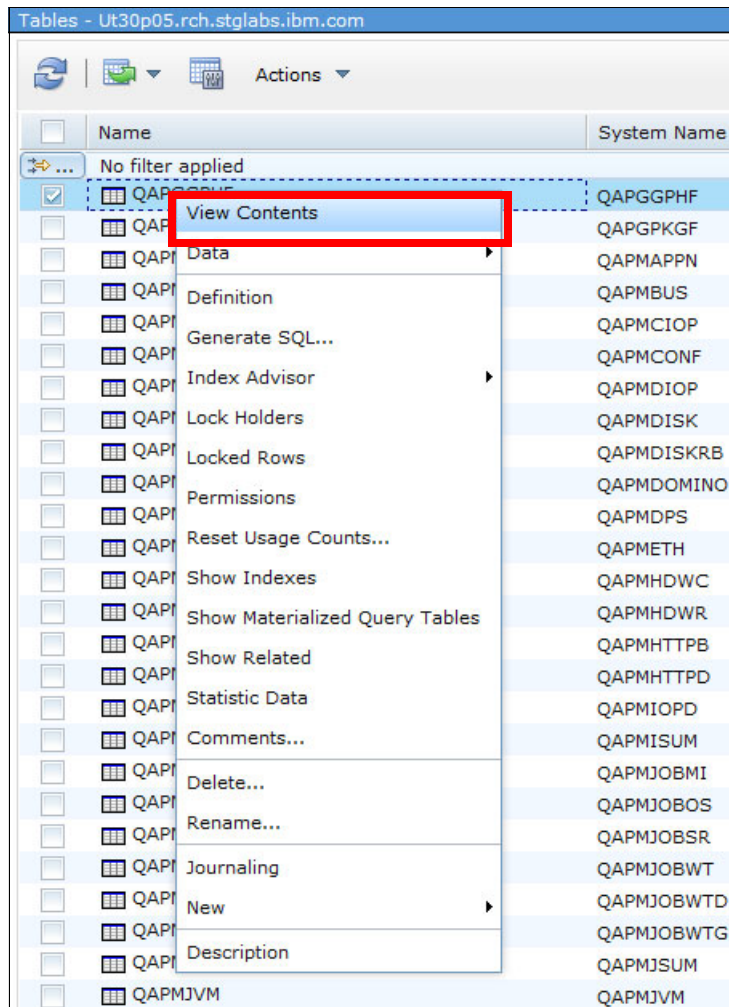


Figure 8-58 New View Contents menu option in the Tables window

- Support for the memory-preference for tables and indexes. For more information, see 8.6.6, “KEEP IN MEMORY for tables and indexes” on page 385.

- ▶ Table Reorganization status is extended with the following information (see Figure 8-59):
 - Record the number where the reorganization started.
 - Amount of storage that is returned because of deleted records.
 - Number of deleted rows during reorganization.

Reorganize ITSOPEX.QAYPETIDX

Status: Complete

- ✓ Preparation phase (100% complete)
- ✓ Reorganization phase
 - ✓ Reorganizing rows (100% complete)
 - ✓ Processing deleted rows - 26991 deleted rows removed
 - ✓ Rebuilding access paths (0 of 3 complete)
 - ITSOPEX.QAYPETIDXL[SES1] Complete
 - ITSOPEX.QAYPETID2L[SES1] Complete
 - ITSOPEX.QAYPETIDX[SES1] Complete

Details:

Detail	Value
Reorganize the table by:	Compressing out deleted rows
Allow reorganization to be suspended:	Yes
Allow users to access the table during reorganization (Online):	No
Allow changes to the table during reorganization:	No
Reorganize starting at:	5000
Amount of storage returned:	0 bytes
Access paths:	Rebuild at the end
Reorganization job:	212186/Quser/Qzdasoinit
Current number of rows:	2497579
Number of deleted rows:	26991
Number of rows to reorganize:	2421571
Parallel degree requested:	*NONE
Parallel degree used:	0
Total Elapsed time:	00:01:30

Figure 8-59 New information in the Table Reorganization status window

For more information about general enhancements of IBM Navigator for i, see 2.1, “IBM Navigator for i” on page 14.

For more information about PDI database-related changes, see 8.6.3, “PDI for DB2” on page 381.

For more information about DB2 for i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/dbmult/rzaf3kickoff.htm

8.7.3 Queued exclusive locks

A new option that is called **PREVENT_ADDITIONAL_CONFLICTING_LOCKS** is now available in the QAQINI file. This new option allows the database engine to give preference to the operation that requires an exclusive lock over the operations to lock the object for reading. This option can be useful in situations where application activity on a database is high and cannot be quiesced. Therefore, obtaining an exclusive non-read lock is hard or even impossible.

Table 8-40 describes the values that are available for the **PREVENT_ADDITIONAL_CONFLICTING_LOCKS** option.

Table 8-40 *PREVENT_ADDITIONAL_CONFLICTING_LOCKS* parameter values

Value	Description
*NO	When a job requests an exclusive lock on an object, do not prevent concurrent jobs from acquiring additional exclusive locks on the object.
*YES	New requests for read locks are queued behind the exclusive lock request and wait until the exclusive lock completes or times out.
*DEFAULT	The same as *NO.

The following SQL operations are affected by this new option as exclusive lock requests:

- ▶ **ALTER TABLE** (add, alter, or drop a column)
- ▶ **CREATE TRIGGER**
- ▶ **LOCK TABLE**
- ▶ **RENAME TABLE**

For more information about DB2 for i SQL statements, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm?lang=en

For more information about the QAQINI file and its options, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/qryopt.htm?lang=en

8.7.4 CREATE TABLE AS SELECT from a remote database

It is now possible to create, on a local system, a table that references one or more tables on a remote server. Along with the **SELECT** statement, you can specify copy options to get attributes, such as the default values or identity column information, which is copied for the new table.

The **WITH DATA** or **WITH NO DATA** clause must be specified to indicate whether to populate the table from the remote system. The remote server connection must be defined as a relational database entry (by running **WRKRDBDIRE**).

Example 8-31 shows how to create a table whose definition reflects a table on a remote server and populates it with the data from the remote server.

Example 8-31 Create a table that reflects a definition on a remote server with data

```
CREATE TABLE EMPLOYEE4 AS
  (SELECT PROJNO, PROJNAME, DEPTNO
   FROM REMOTESYS.TESTSCHEMA.EMPLOYEE
   WHERE DEPTNO = 'D11') WITH DATA
```

For more information about creating tables that reference a remote database, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/sqlp/rbafycrttblrmt.htm?lang=en

8.7.5 Live movement of tables and indexes to SSD

Media preference of SQL tables, SQL views, and SQL indexes (the Preferred storage unit parameter of the **CHGPF** and **CHGLF CL** commands) can now be changed without obtaining an exclusive lock on the file.

This change can be made when shared read (***SHRRD**) or update (***UPDATE**) locks exist on the file being changed.

After the ***SSD** is specified as a preferred storage media, data asynchronously moves to the SSD drives.

8.7.6 Range partitioned tables

Ranged partitioned tables can now be created with partitions out of order, as shown in Example 8-32.

Example 8-32 Create a range partitioned table with partitions out of order

```
CREATE TABLE CORPDB.SALES_TABLE FOR SYSTEM NAME SALES00002 (
  TRANS_DATE TIMESTAMP DEFAULT NULL)
  PARTITION BY RANGE (TRANS_DATE NULLS LAST) (
  PARTITION PART000001
  STARTING ( '2014-01-01-00.00.00.000000' ) INCLUSIVE
  ENDING ( '2014-01-31-23.59.59.999999' ) INCLUSIVE,
  STARTING ( '2014-08-01-00.00.00.000000' ) INCLUSIVE
  ENDING ( '2014-08-31-23.59.59.999999' ) INCLUSIVE,
  STARTING ( '2014-05-01-00.00.00.000000' ) INCLUSIVE
  ENDING ( '2014-05-31-23.59.59.999999' ) INCLUSIVE )
```

As a result, the SALES_TABLE range partitioned table was successfully created.

For range partitioned tables, DB2 for i now recognizes whether an update operation is made to the column that was used for range partitioning. If the update affects partition assignment of the row, the row is automatically moved to the correct partition (database file member).

For more information about partitioned tables, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/dbmult/partitionedtables.htm?lang=en

For more information about DB2 for i SQL statements, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm?lang=en

8.8 DB2 Web Query for i

DB2 Web Query for i V2.1.0, which provides core analytics and Business Intelligence (BI) platform capabilities, including queries, reporting, OLAP, and dashboards, is now supported.

DB2 Web Query for i is available as either a Standard Edition or Express Edition in IBM i 7.2:

- ▶ DB2 Web Query for i Express Edition provides an entry-level software bundle that includes report authoring tools, a Query/400 import function, and analytic reporting options for a small number of users.

With Express Edition, you can generate high-quality reports and OLAP reports for analysts that are interested in understanding trends or finding exceptions in the data to uncover what is driving results.

Also, you can use the spreadsheet pivot table support and integrate ad hoc reporting directly in to Microsoft Excel spreadsheets. DB2 Web Query for i provides an array of mobile capabilities. For example, for those users with mobile devices who must analyze data while on the road, Active Technologies provide analytics for the users disconnected from the server.

- ▶ DB2 Web Query Standard Edition combines all of the functions that are included in Express Edition plus more, providing a robust offering that can support up to thousands of users running reports. With Standard Edition, user licenses are included to support a typical rollout of developers and administrators, report authors, and a virtually unlimited number of runtime users and report consumers.

With Standard Edition, you can build more sophisticated dashboards for executives monitoring key performance indicators (KPIs). You can use Standard Edition to create an enterprise report distribution model with the abilities to schedule report execution and distribution through email or save the reports for later viewing. Optionally, use the data adapter for Microsoft SQL Server that is included in Standard Edition to build reports that include data from any of those databases in your network.

Each edition of DB2 Web Query for i has its own unique ordering Product ID. Express Edition is 5733-WQE, and Standard Edition is 5733-WQS. However, the Product ID that is installed on the system is 5733-WQX. Control of whether you can use Express or Standard Edition is done by enabling the appropriate feature through IBM i License Management.

In addition to the data adapter for Microsoft SQL Server, the JD Edwards adapter is available as a separate option of Standard Edition. You can use this adapter to connect to your JD Edwards environment and view the information that is stored in JD Edwards as a data source for a DB2 Web Query for i environment.

For more information about DB2 Web Query for i, see *IBM DB2 Web Query for i Version 2.1 Implementation Guide*, SG24-8063.

DB2 Web Query for i is an independent product from DB2 for i. Enhancements and updates of DB2 Web Query for i are provided as a separate PTF Group from the DB2 for i PTF Group. In DB2 Web Query for i terminology, the PTF Group is also called a *test fix*. In recent test fixes, the following enhancements were delivered:

- ▶ Using workload group controls
- ▶ DB2 for IBM z/OS support
- ▶ DB2 for Linux, UNIX, and Windows support
- ▶ Single sign-on capability with Kerberos
- ▶ RESTful web services
- ▶ Runtime environment change from Lightweight Infrastructure (LWI) to IBM WebSphere Liberty Profile

For information about the current DB2 Web Query for i PTF Group, see the following website:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/W516d8b60d32c_4fc5_a811_5f3d840bf524/page/PTFs%20and%20n-going%20Service

8.9 OmniFind Text Search Server for DB2 for i

The OmniFind Text Search Server for DB2 for i (5733-OMF V1R3M0) is available for IBM i 7.2 at no charge. This product is used as a text search engine for documents that are stored in DB2 for i, and it also provides extensions that enable searches for IBM i objects, such as spool files in an output queue or stream files in the Integrated File System (IFS).

A text search collection describes one or more sets of system objects that have their associated text data indexed and searched. For example, a collection might contain an object set of all spool files in output queue QUSRSYS/QEZJOBLOG, or an object set for all stream files in the `/home/alice/text_data` directory.

The text search collection that is referred to in this document should not be confused with a DB2 schema (sometimes also referred to as a *collection*) or a Lucene collection (part of the internal structure of a DB2 text search index).

When a text search collection is created, several DB2 objects are created on the system in an SQL schema. The following objects are created in the schema:

- ▶ Catalogs for tracking the collection's configuration
- ▶ Catalogs for tracking the objects that are indexed
- ▶ SQL stored procedures to administer and search the collection
- ▶ A DB2 text search index for indexing the associated text

The administration of the collection is provided with stored procedures, most of which are created in the schema.

In OmniFind Text Search Server for DB2 for i V1R3M0, the following enhancements are included:

- ▶ Extensions to index and search non DB2 data:
 - Adding an object set for a multiple-member source physical file
 - Adding an object set for stream file data
 - Altering a text search collection
 - Removing object set by attribute:
 - Removing object set for spool file data
 - Removing object set for stream file data
 - Removing an object set for a multiple-member source physical file
- ▶ Searching for special characters
- ▶ Removing orphaned indexes
- ▶ Shutting down a server
- ▶ Checking the status and return code for each row in a warning or error state
- ▶ RCAC support:
 - Creating a secured text search index
 - Altering a text search index to secured index

For more information about the enhancements in OmniFind Text Search Server for DB2 for i V1R3M0, see the following resources:

- ▶ IBM i 7.2 IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzash/rzashwhatsnew.htm

- ▶ And see also the developerWorks OmniFind for IBM i website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/OmniFind%20for%20IBM%20i>



Application development

This chapter describes a selection of products from IBM and third-party providers that can be used for developing different types of applications for IBM i or for using IBM i as application or database server. Detailed information about application development and modernization tools can be found in the following IBM Redbooks publications:

- ▶ *Modernizing IBM i Applications from the Database up to the User Interface and Everything in Between*, SG24-8185
- ▶ *Tools and Solutions for Modernizing Your IBM i Applications*, REDP-5095

This chapter describes the following topics:

- ▶ 9.1, “Languages and compilers” on page 416
- ▶ 9.2, “Java on IBM i” on page 434
- ▶ 9.3, “Rational Tools for i” on page 439
- ▶ 9.4, “Portable Applications Solutions Environment” on page 463
- ▶ 9.5, “Ruby on Rails for i” on page 463
- ▶ 9.6, “Zend and PHP on IBM i” on page 463
- ▶ 9.7, “Mobile application development for IBM i” on page 469
- ▶ 9.8, “Open Source for IBM i” on page 470
- ▶ 9.9, “Samba on IBM i” on page 472

For more information about the IBM i 7.2 application enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

9.1 Languages and compilers

IBM i provides many choices of programming languages for creating applications. This section introduces enhancements in IBM i 7.2 for the following programming languages and compilers:

- ▶ 9.1.1, “Command Language” on page 416
- ▶ 9.1.2, “ILE RPG” on page 421
- ▶ 9.1.3, “ILE COBOL” on page 430
- ▶ 9.1.4, “ILE C/C++” on page 432
- ▶ 9.1.5, “System APIs” on page 434

9.1.1 Command Language

This section covers the following Command Language (CL) topics:

- ▶ “New CL retrieve exit programs running after command completion” on page 416
- ▶ “New built-in functions support for both ILE CL and OPM CL” on page 416

New CL retrieve exit programs running after command completion

The IBM i command analyzer support for the `QIBM_QCA_RTV_COMMAND` exit point was enhanced. Before, the registered exit programs were always called just before control was transferred to the command processing program (CPP) that was associated with the command being run. Now, you can register an exit program for the `QIBM_QCA_RTV_COMMAND` exit point and indicate that you want the exit program to be called after control returns from the CPP.

For more information about `QIBM_QCA_RTV_COMMAND`, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/cmdanalyz.htm

New built-in functions support for both ILE CL and OPM CL

Many of the new built-in functions that are similar to RPG built-in functions are available in both ILE CL and OPM CL.

The following new built-in functions are supported for working with character strings:

- ▶ “%CHECK and %CHECKR” on page 417
- ▶ “%SCAN” on page 417
- ▶ “%TRIM, %TRIML, and %TRIMR” on page 418

The following new built-in functions are supported for conversion operations:

- ▶ “%CHAR” on page 418
- ▶ “%DEC” on page 419
- ▶ “%INT” on page 419
- ▶ “%UINT” on page 419
- ▶ “%LOWER” on page 419
- ▶ “%UPPER” on page 420

The following new built-in functions are supported for size operations:

- ▶ “%LEN” on page 420
- ▶ “%SIZE” on page 420

%CHECK and %CHECKR

The check built-in function (**%CHECK**) returns the first position of a base string that contains a character that does not appear in the comparator string. The reverse check built-in function (**%CHECKR**) returns the last position of a base string that contains a character that does not appear in the comparator string. If all of the characters in the base string also appear in the comparator string, the function returns 0.

Here are the formats of the **%CHECK** and **%CHECKR** built-in functions:

- ▶ **%CHECK**(comparator-string base-string [starting-position])
- ▶ **%CHECKR**(comparator-string base-string [starting-position])

Example 9-1 shows an example of retrieving a numeric value from a string by using **%CHECK** and **%CHECKR**. The first **CHGVAR** statement uses the **%CHECK** built-in function to find the leftmost character that is not a dollar sign (\$), an asterisk (*), or a blank. The second **CHGVAR** statement uses the **%CHECKR** built-in function to find the rightmost character that is not a dollar sign, asterisk, or blank. The third **CHGVAR** statement computes the number of characters between the two values. The last **CHGVAR** statement uses the substring (**%SST**) built-in function to convert part of the base string to a decimal CL variable.

Example 9-1 Retrieve a numeric value from a string by using %CHECK and %CHECKR

```
DCL VAR(&PRICE) TYPE(*CHAR) VALUE('$*****5.27*** ')
DCL VAR(&COMP) TYPE(*CHAR) LEN(3) VALUE('$* ')
DCL VAR(&SPOS) TYPE(*UINT) LEN(2)
DCL VAR(&EPOS) TYPE(*UINT) LEN(2)
DCL VAR(&DEC) TYPE(*DEC) LEN(3 2)
DCL VAR(&LEN) TYPE(*UINT) LEN(2)
CHGVAR VAR(&SPOS) VALUE(%CHECK(&COMP &PRICE))
CHGVAR VAR(&EPOS) VALUE(%CHECKR(&COMP &PRICE))
CHGVAR VAR(&LEN) VALUE(&EPOS - &SPOS + 1)
CHGVAR VAR(&DEC) VALUE(%SST(&PRICE &SPOS &LEN))
```

For more information about the check built-in function, see the check built-in function topics in IBM Knowledge Center:

- ▶ **%CHECK** built-in function

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6checkbif.htm

- ▶ **%CHECKR** built-in function

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6checkrbif.htm

%SCAN

The scan built-in function (**%SCAN**) returns the first position of a search argument in the source string, or 0 if it was not found.

Here is the format of the **%SCAN** built-in function:

%SCAN(search-argument source-string [starting-position])

Example 9-2 shows an example of searching for a specific string by using the %SCAN built-in function.

Note: The scan by %SCAN is case-sensitive. Therefore, a scan for 'John' does not return a positive result if &FNAME contains the value 'JOHN'.

Example 9-2 Search for a specific string by using the %SCAN built-in function

```
PGM PARM(&FNAME)
DCL VAR(&FNAME) TYPE(*CHAR) LEN(10)
IF COND(%SCAN('John' &FNAME) *EQ 0) +
  THEN(SNDPGMMSG ('NOT FOUND!'))
```

For more information about the %SCAN built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6scanbif.htm

%TRIM, %TRIML, and %TRIMR

The %TRIM, %TRIML, and %TRIMR built-in functions use one parameter to produce a character string with blanks removed:

- ▶ %TRIM removes any leading and trailing blanks.
- ▶ %TRIML removes any leading blanks.
- ▶ %TRIMR removes any trailing blanks from a given string.

Here are the formats of the %TRIM, %TRIML, and %TRIMR functions:

- ▶ %TRIM(**character-variable-name** [**characters-to-trim**])
- ▶ %TRIML(**character-variable-name** [**characters-to-trim**])
- ▶ %TRIMR(**character-variable-name** [**characters-to-trim**])

Example 9-3 shows an example of trimming blanks by using the %TRIM function.

Example 9-3 Trim blanks by using the %TRIM function

```
DCL VAR(&FIRSTNAME) TYPE(*CHAR) VALUE(' JOHN ')
DCL VAR(&LASTNAME) TYPE(*CHAR) VALUE(' SMITH ')
DCL VAR(&NAME) TYPE(*CHAR) LEN(10)
CHGVAR VAR(&NAME) VALUE(%TRIM(&FIRSTNAME) *BCAT %TRIM(&LASTNAME))
```

For more information about the %TRIM built-in functions, see IBM Knowledge Center:

- ▶ %TRIM

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6trimbif.htm

- ▶ %TRIML

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6trimlbif.htm

- ▶ %TRIMR

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6trimrbif.htm

%CHAR

The %CHAR built-in function converts logical, decimal, integer, or unsigned integer data to the character format.

Here is the format of the %CHAR built-in function:

%CHAR(**convert-argument**)

Note: The **convert-argument** parameter must be a CL variable with a **TYPE** of *LGL, *DEC, *INT, or *UINT.

For more information about the **%CHAR** built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6charbif.htm

%DEC

The **%DEC** built-in function converts character, logical, decimal, integer, or unsigned integer data to the packed decimal format.

Here is the format of the **%DEC** built-in function:

%DEC(convert-argument [total-digits decimal-places])

Note: The **convert-argument** must be a CL variable with a **TYPE** of *CHAR, *LGL, *DEC, *INT, or *UINT.

For more information about the **%DEC** built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6decbif.htm

%INT

The **%INT** built-in function converts character, logical, decimal, or unsigned integer data to the integer format.

Here is the format of the **%INT** built-in function:

%INT(convert-argument)

Note: The **convert-argument** must be a CL variable with a **TYPE** of *CHAR, *LGL, *DEC, or *UINT.

For more information about the **%INT** built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6intbif.htm

%UINT

The **%UINT** built-in function converts character, logical, decimal, or integer data to the unsigned integer format.

Here is the format of the **%UNIT** built-in function:

%UINT(convert-argument) or **%UNS**(convert-argument)

Note: The **convert-argument** must be a CL variable with a **TYPE** of *CHAR, *LGL, *DEC, or *INT.

For more information about the **%UNIT** built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6uintbif.htm

%LOWER

The **%LOWER** built-in function returns a character string that is the same length as the argument that is specified, with each uppercase letter replaced by the corresponding lowercase letter.

Here is the format of the %LOWER built-in function:

```
%LOWER(input-string [CCSID])
```

Note: The **input-string** parameter must be a CL variable with a **TYPE** of *CHAR.

For more information about the %LOWER built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6lowerbif.htm

%UPPER

The %UPPER built-in function returns a character string that is the same length as the argument that is specified, with each lowercase letter replaced by the corresponding uppercase letter.

Here is the format of the %UPPER built-in function:

```
%UPPER(input-string [CCSID])
```

Note: The **input-string** parameter must be a CL variable with a **TYPE** of *CHAR.

For more information about the %UPPER built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6upperbif.htm

%LEN

The %LEN built-in function returns the number of digits or characters of the CL numeric or character variable.

Here is the format of the %LEN built-in function:

```
%LEN(variable-argument)
```

Note: The **variable-argument** parameter must be a CL variable with a **TYPE** of *CHAR, *DEC, *INT, or *UINT.

For more information about the %LEN built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6lenbif.htm

%SIZE

The %SIZE built-in function returns the number of bytes that are occupied by the CL variable.

Here is the format of the %SIZE built-in function:

```
%SIZE(variable-argument)
```

Note: The **variable-argument** must be a CL variable.

For more information about the %SIZE built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rbam6/rbam6sizebif.htm

9.1.2 ILE RPG

This section covers the following ILE RPG topics:

- ▶ “Free-form Control, File, Definition, and Procedure statements”
- ▶ “Fully free-form statements in ILE RPG IV” on page 424
- ▶ “CCSID support for alphanumeric data and external subfields” on page 424
- ▶ “Enhancements that are related to CCSID conversion” on page 424
- ▶ “Implicit conversion for concatenation” on page 425
- ▶ “Control the length that is returned by %SUBDT” on page 425
- ▶ “Increased precision for time stamp data” on page 426
- ▶ “Open Access files” on page 426
- ▶ “New XML-INTO options” on page 426
- ▶ “VALIDATE(*NODATETIME) keyword in Control-Specification” on page 429
- ▶ “Mixed case PCML support in ILE RPG IV” on page 429

Free-form Control, File, Definition, and Procedure statements

In IBM i 7.1 TR7 timed enhancements, ILE RPG had a significant enhancement where Control-Specification (H-Spec), File-Specification (F-Spec), Definition-Specification (D-Spec), and Procedure-Specification (P-Spec) syntax are supported in free-form in addition to Calculation-Specification (C-Spec). IBM i 7.2 also has this capability.

Historically, the progress of free-form RPG started in OS/400 V5R. Free-form in C-Spec by specifying /FREE and /END-FREE was introduced in ILE RPG in OS/400 V5R1. In i5/OS V5R3, embedded SQL was supported in free-form C-Spec. The additional free-form enhancements in IBM i 7.1 TR7 and IBM i 7.2 provide more ease of use and understanding of ILE RPG for existing RPG programmers and new comers to RPG from other programming languages, such as Java, PHP, and Visual Basic.

Figure 9-1 on page 422 through Figure 9-4 on page 423 show some examples of the progress of free-form RPG.

For more information about free-form RPG support on IBM i, see the developerWorks website:

<https://www.ibm.com/developerworks/ibmi/library/i-ibmi-rpg-support/>

Figure 9-1 shows an example of Original Program Model (OPM) RPG in OS/400 V2R3.

```

FCUSTFILEIF E          DISK
FREPOR  0  E          PRINTER
ICUSTDS  E DSCUSTFILE
/COPY GETCURDAT
/COPY INVOICE
C
C          *INLR      READ CUSTFILE          LR
C          DUE DAT    DOWNE*ON
C          IFGT CURDAT
C          EXSR SNOVDU
C          WRITEREPORTFM
C/EXEC SQL INSERT :NAME, :DUE DATE INTO
C+          MYLIB/MYFILE
C/END-EXEC
C
C          ENDF
C          READ CUSTFILE          LR
C          ENDDO
C*
C          SNOVDU     BEGSR
C          CALL 'SNDINVC'
C          PARM          CUSTDS
C          PARM ISOVDU   OVERDU 10
C          ENDSR

```

Figure 9-1 OPM RPG in OS/400 V2R3

Figure 9-2 shows an example of /FREE and /END-FREE in C-Spec of ILE RPG in OS/400 V5R1.

```

H bnddir('ACCRCV') dftactgrp(*no)
Fcustfile  uf  e          disk
Frepor  0  e          printer
D custDs          ds          extname(custfile)
D sendOverdueNotice...
D          pr
/free
  read custfile custDs;
  dow not %eof;
  if dueDate > %date(); // overdue?
    sendOverdueNotice ();
  write reportFmt;
/end-free
C/exec sql insert :name, :duedate into
C+          mylib/myfile
C/end-exec
/free
  endif;
  read custfile custDs;
  enddo;
  *inlr = '1';
/end-free

```

Figure 9-2 /FREE and /END-FREE in C-Spec of ILE RPG in OS/400 V5R1

Figure 9-3 shows an example of support for embedded SQL within /Free and /END-FREE in ILE RPG in i5/OS V5R3.

```

H bnddir('ACCRCV') dftactgrp(*no)
Fcustfile  uf  e          disk
Freport    o  e          printer
D custDs   e  ds          extname(custfile)
D sendOverdueNotice...
D          pr
/free
  read custfile custDs;
  dow not %eof;
    if dueDate > %date(); // overdue?
      sendOverdueNotice ();
      write reportFmt;
      exec sql insert :name, :duedate into
                mylib/myfile;
    endif;
  read custfile custDs;
enddo;
*inlr = '1';
/end-free
P sendOverdueNotice...
P          b
/copy invoices

```

Figure 9-3 Support for embedded SQL within /Free and /END-FREE in ILE RPG in i5/OS V5R3

Figure 9-4 shows an example of support for free-form control, file, definition, and procedure statements in ILE RPG in IBM i 7.2.

```

ctl-opt bnddir('ACCRCV');
dcl-f custfile usage(*update);
dcl-ds custDs likerec(custRec);
dcl-f report printer;

read custfile custDs;
dow not %eof;
  if dueDate > %date(); // overdue?
    sendOverdueNotice ();
    write reportFmt;
    exec sql insert :name, :duedate into
              mylib/myfile;
  endif;
  read custfile custDs;
enddo;
inlr = '1';

dcl-proc sendOverdueNotice;
  /copy invoices
  sendInvoice (custDs : IS_OVERDUE);
end-proc;

```

Figure 9-4 Free-form control, file, definition, and procedure statements in ILE RPG in IBM i 7.2

Fully free-form statements in ILE RPG IV

As part of enhancing the RPG language and make it look and feel like a modern programming language, the restriction for code to be 8 - 80 columns was removed.

To use this new function, you must code ****FREE** at the beginning of column 1 before entering any other RPG statements on the following line. The ****FREE** specification is valid only for a single source, which means that if you use **/COPY** or **/INCLUDE** directives, they should have their own ****FREE** specification on the first line, or they will use the standard column limitations.

For more information about this topic, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/ssfree.htm?lang=en

CCSID support for alphanumeric data and external subfields

In IBM i 7.2, alphanumeric CCSID for the module can be set to many more CCSIDs, including UTF-8 and hexadecimal. Alphanumeric data can be defined with a CCSID.

Supported CCSIDs include the following ones:

- ▶ Single-byte and mixed-byte EBCDIC CCSIDs
- ▶ Single-byte and mixed-byte ASCII CCSIDs
- ▶ UTF-8
- ▶ Hexadecimal

CCSID(*EXACT) can be used for an externally described data structure to indicate that the alphanumeric subfields should have the same CCSID as the fields in the file.

For more information about CCSID, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/dccsid.htm

Enhancements that are related to CCSID conversion

The capability that is related to CCSID conversion is enhanced in the IBM i 7.2 ILE RPG compiler. These enhancements include the following functions:

- ▶ No allowance for implicit or explicit CCSID conversion of hexadecimal data. CCSID conversion is not allowed for implicit or explicit conversion of hexadecimal data that includes the following types of data:
 - Hexadecimal literals.
 - Alphanumeric and graphic data that is defined with **CCSID(*HEX)**.
 - Alphanumeric and graphic data in buffers for externally described files when the **DATA** keyword is in effect for the file and the CCSID of the field in the file is 65535.
 - Alphanumeric and graphic data in externally described data structures that are defined with **CCSID(*EXACT)** when the CCSID of the field in the file is 65535.
- ▶ Open database files without conversion to the job CCSID. Use Control keyword **OPENOPT(*NOCVTDATA)** or File keyword **DATA(*NOCVT)** to specify that a database file will be opened so that alphanumeric and graphic data is not converted to and from the job CCSID for input and output operations.

For more information about the **OPENOPT** and **DATA** keywords, see the IBM Knowledge Center:

– **OPENOPT**

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/hopenop.htm

– **DATA**

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/fkwdata.htm

- ▶ Support for CCSID conversions that cause a loss of data. An exception or a diagnostic message that is related to a CCSID conversion by using the C-Spec keyword **CCSIDCVT(*EXCP : *LIST)**. The meaning of the CCSID keyword can be one of the following items:

- **CCSIDCVT(*EXCP)**: Get an exception if a CCSID conversion loses data because of the source character not having a match in the target character set.

- **CCSIDCVT(*LIST)**: Get a listing of every CCSID conversion in the module, with a diagnostic message indicating whether the conversion has the potential of losing data.

For more information about the **CCSIDCVT** keyword, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/hccsidcv.htm

Implicit conversion for concatenation

You can use the ILE RPG compiler in IBM i 7.2 to perform the implicit conversion between alphanumeric, graphic, and UCS-2 data for concatenation expressions.

For more information about implicit conversion, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/ccsidconv.htm

Control the length that is returned by %SUBDT

You can use an optional third parameter for the **%SUBDT** built-in function to specify the number of digits in the result.

Here is the format of **%SUBDT**:

```
%SUBDT(value : unit { : digits { : decpos } })
```

Example 9-4 shows an example of using the **%SUBDT** built-in function.

Example 9-4 Example of the %SUBDT built-in function

```
date = d'1999-02-17';
time = t'01.23.45';
timestamp = z'1999-02-17-01.23.45.98765';

num = %subdt(date:*YEARS:4);
// num = 1999

num = %subdt(time:*MN);
// num = 23

seconds = %subdt(timestamp:*S:5:3);
// seconds = 45.987
```

For more information about the **%SUBDT** built-in function, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/bbsubdt.htm

Increased precision for time stamp data

Time stamp data can have 0 - 12 fractional seconds, which are added to the DB2 for i SQL functions.

Example 9-5 shows an example of using the **TIMESTAMP** keyword that is used in a free-form definition to indicate that the item has a type of time stamp. The number of fractional seconds can be specified as an optional parameter. If this parameter is not specified, the number of fractional seconds defaults to 6.

*Example 9-5 Example of the **TIMESTAMP** keyword in a free-form definition*

```
DCL-S TS0  TIMESTAMP(0);    // YYYY-MM-DD-hh-mm-ss
DCL-S TS1  TIMESTAMP(1);    // YYYY-MM-DD-hh-mm-ss.f
DCL-S TS6A TIMESTAMP;       // YYYY-MM-DD-hh-mm-ss.ffffff
DCL-S TS6B TIMESTAMP(6);    // YYYY-MM-DD-hh-mm-ss.ffffff
DCL-S TS12 TIMESTAMP(12);   // YYYY-MM-DD-hh-mm-ss.ffffffffffff
```

For more information about increased precision for time stamp data, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/dtimes.htm

Open Access files

An Open Access file was introduced as the core of the IBM Rational® Open Access RPG Edition, which originally was a separate licensed program from the ILE RPG compiler in IBM i 6.1 and 7.1. In 2012, this function was delivered as PTFs and combined into the ILE RPG compiler and run time. In IBM i 7.2, it is also available as a part of the ILE RPG compiler and run time.

An Open Access file is a file that has all its operations handled by a user-written program or procedure, rather than by the operating system. This program or procedure is called an *Open Access Handler* or simply a *handler*. The **HANDLER** keyword specifies the handler.

For more information about Open Access files, see the following websites:

- ▶ IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/openaccessfiles.htm

- ▶ IBM developerWorks:

https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/We13116a562db_467e_bcd4_882013aec57a/page/Rational%20Open%20Access.%20RPG%20Edition

New XML-INTO options

The following additional options of XML-INTO operation code are available in IBM i 7.2:

- ▶ The **ns** option

The **ns** option controls how XML-INTO handles XML names with a namespace when XML-INTO is matching XML names to the names in the path option or the subfield names of a data structure. The following values can be specified as this option:

- keep
- remove
- merge

Example 9-6 shows an example of specifying remove as an ns option.

Example 9-6 Example of specifying remove as an ns option

```
D info          DS          QUALIFIED
D  type         25A    VARYING
D  qty         10I 0
D  price       7P 3

xml-into info %xml('info1.xml'
                : 'doc=file ns=remove');
// info.type = 'Chair'
// info.qty = 3
// info.price = 79.99
```

This example assumes that the info1.xml file contains the content that is shown in Example 9-7.

Example 9-7 Content of the info1.xml file

```
<abc:info xmlns:abc="http://www.abc.xyz">
  <abc:type>Chair</abc:type>
  <abc:qty>3</abc:qty>
  <abc:price>79.99</abc:price>
</abc:info>
```

Example 9-8 shows an example of specifying merge as an ns option.

Example 9-8 Example of specifying merge as an ns option

```
D info          DS          QUALIFIED
D  abc_type     25A    VARYING
D  def_type     25A    VARYING
D  abc_qty     10I 0
D  abc_price   7P 3

xml-into info %xml('info2.xml'
                : 'doc=file ns=merge path=abc_info');
// info.abc_type = 'Chair'
// info.def_type = 'Modern'
// info.abc_qty = 3
// info.abc_price = 79.99
```

This example assumes that the info2.xml file contains the content that is shown in Example 9-9.

Example 9-9 Content of the info2.xml file

```
<abc:info xmlns:abc="http://www.abc.xyz"
          xmlns:def="http://www.def.xyz">
  <abc:type>Chair</abc:type>
  <abc:qty>3</abc:qty>
  <def:type>Modern</def:type>
  <abc:price>79.99</abc:price>
</abc:info>
```

For more information about the ns option, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/nsopt.htm

► The **nsprefix** option

The **nsprefix** option is valid only when **ns=remove** is specified. It allows an RPG program to determine the values of the namespaces that were removed from the XML names.

Example 9-10 shows an example of specifying **ns_** as a **nsprefix** option.

Example 9-10 Example of specifying ns_ as a nsprefix option

```
D info          DS          QUALIFIED
D  type          25A      VARYING DIM(2)
D  ns_type       10A      VARYING DIM(2)
D  qty           10I 0
D  price         7P 3
D  ns_price      10A      VARYING

xml-into info %xml('info3.xml'
                : 'doc=file ns=remove nsprefix=ns_');
// info.type(1) = 'Chair'
// info.ns_type(1) = 'abc'
// info.type(2) = 'Modern'
// info.ns_type(2) = 'def'
// info.qty = 3
// info.price = 79.99
// info.ns_price = 'abc'
```

This example assumes that the `info3.xml` file contains the content that is shown in Example 9-11.

Example 9-11 Content of the info3.xml file

```
<abc:info xmlns:abc="http://www.abc.xyz"
          xmlns:def="http://www.def.xyz">
  <abc:type>Chair</abc:type>
  <abc:qty>3</abc:qty>
  <def:type>Modern</def:type>
  <abc:price>79.99</abc:price>
</abc:info>
```

For more information about the **nsprefix** option, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/nsprefixopt.htm

► The **case** option

The **case** option specifies the way that XML-INTO should interpret the element and attribute names in the XML document when searching for XML names that match the RPG field names and the names in the **path** option. **case=convert** indicates that the names in the XML document are converted to valid RPG names before matching to RPG names.

Example 9-12 shows an example of specifying **convert** as a **case** option.

Example 9-12 Example of specifying convert as a case option

```
D etudiant      ds          qualified
D  age          3p 0
D  nom          25a      varying
D  ecole        50a      varying

D student      ds          likeds(etudiant)
```

```
xml-into etudiant %xml('info4.xml'
                        : 'doc=file case=convert '
                        + 'ccsid=ucs2');
// etudiant.nom = 'Élise'
// etudiant.age = 12
// etudiant.ecole = 'Collège Saint-Merri'
```

This example assumes that the `info4.xml` file contains the content that is shown in Example 9-13.

The `case=convert` option specifies that the names in the XML document are converted by using the *LANGIDSHR translation table for the job before matching to the RPG names in the path and in the list of subfields.

The names `Étudiant`, `Âge`, and `École` are converted to `ETUDIANT`, `AGE`, and `ECOLE`. The XML data itself is not converted, so the subfield `ecole` receives the value 'Collège Saint-Merri' as it appears in the XML document.

Example 9-13 Content of the info4.xml file

```
<Étudiant Nom="Élise" Âge="12">
  <École>Collège Saint-Merri</École>
</Étudiant>
```

For more information about the `case=convert` option, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/caseopt.htm

VALIDATE(*NODATETIME) keyword in Control-Specification

The Control-Specification keyword **VALIDATE(*NODATETIME)** allows the ILE RPG compiler to treat date, time, and time stamp data as character data, without performing the checks for validity.

Important: This keyword might improve the performance of some date, time, and time stamp operations. However, skipping the validation step can lead to serious data corruption problems. You should use this feature only when you are certain that your date, time, and time stamp data is always valid.

For more information about **VALIDATE(*NODATETIME)**, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/hvalidate.htm

Mixed case PCML support in ILE RPG IV

ILE RPG IV was enhanced to support the generation of mixed case Program Call Markup Language (PCML). You can now select which exported procedures have generated PCML. There is a new *DCLCASE parameter for keyword **PGMINFO** of H specification, which forces the RPG compiler to generate in the same case as they are coded in RPG source. Before this enhancement, PCML names were generated in upper case.

Also, usage of the **PGMINFO** keyword with parameters `*YES` or `*NO` can specify which procedures in the module PCML are generated.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzasd/pgminfokw.htm?lang=en

9.1.3 ILE COBOL

This section covers the following enhancements of ILE COBOL in IBM i 7.2:

- ▶ “TIMESTAMP support of 0 - 12 fractional seconds” on page 430
- ▶ “XML PARSE enhancement” on page 430
- ▶ “PCML generation improvement” on page 431
- ▶ “National data enhancements” on page 431
- ▶ “Increased accuracy of NUMVAL and NUMVAL-C built-in functions” on page 431
- ▶ “ARITHMETIC parameter for CRTBNDCBL and CRTCBMOD” on page 431
- ▶ “New PROCESS statement options” on page 432

TIMESTAMP support of 0 - 12 fractional seconds

In IBM i 7.2, the precision of **TIMESTAMP** is increased and can be set 0 - 12. This enhancement applies to ILE COBOLE and ILE RPG and DB2 for i SQL functions. On ILE COBOL, the following intrinsic functions now allow **PICOSECONDS** as a duration when specified for a time stamp item:

- ▶ **ADD-DURATION**
- ▶ **EXTRACT-DATE-TIME**
- ▶ **FIND-DURATION**
- ▶ **SUBTRACT-DURATION**

The **SIZE** keyword is allowed with **FORMAT TIMESTAMP**. The size can be 19, indicating zero fractional seconds, or a value 21 - 32, indicating 1 - 12 fractional seconds.

For more information about **PICOSECONDS** of each function and the **SIZE** keyword of **TIMESTAMP**, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/rzasemain.htm

XML PARSE enhancement

XML PARSE now can parse XML files that are greater than 16 MB if no individual document piece that is passed to the processing procedure is greater than 16 MB. The following new **XML-CODE** values are associated with this change:

- ▶ **XML-CODE 62** indicates that the XML document exceeds 16,000,000 bytes.
- ▶ **XML-CODE 170** indicates that an XML event exceeds 16,000,000 bytes.

For more information about **XML PARSE** and **XML-CODE**, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/rzasemain.htm

PCML generation improvement

In the IBM i 7.2 ILE COBOL compiler, the following improvements are added to the PCML generation function:

- ▶ New **init** keyword for improved OCCURS DEPENDING ON array handling
PCML generation provides improved OCCURS DEPENDING ON array handling with the addition of a new **init** keyword that is set to the maximum size of the array.
- ▶ Automatic data-item naming in generated PCML for filler data items and unnamed items in a data structure
PCML generation provides automatic data-item naming in generated PCML for filler data items and unnamed items in a data structure, helping to enable web services to use generated PCML without first modifying it. The names for these data items are `_filler_1`, `_filler_2`, and so on.

For more information about PCML generation, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/cblpcml.htm

National data enhancements

The IBM i 7.2 ILE COBOL compiler supports the numeric national data type. A numeric literal can be specified for the **VALUE** clause for a numeric national data item. The figurative constant **ZERO/ZEROS/ZEROES** represents one or more national zero digits when used with national data items. When the new **PROCESS** option **NATIONALPICNLIT** is specified, National 'N' literals are supported.

For more information about national data, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/rzasemain.htm

Increased accuracy of NUMVAL and NUMVAL-C built-in functions

The accuracy of numeric intrinsic functions **NUMVAL** and **NUMVAL-C** increases to 31 digits by using compiler option **ARITHMETIC(*EXTEND31)** or **PROCESS** option **EXTEND31**.

ARITHMETIC parameter for CRTBNDCBL and CRTCBLMOD

A new ***EXTEND31FULL** option value is available as a value of the **ARITHMETIC** parameter for the **CRTBNDCBL** and **CRTCBLMOD** CL commands. This new value provides the following features:

- ▶ The accuracy of the following numeric intrinsic functions increases from floating-point accuracy of up to 15 digits to decimal floating-point accuracy of up to 34 digits:
 - **ANNUITY**
 - **MEAN**
 - **MEDIAN**
 - **MIDRANGE**
 - **NUMVAL**
 - **NUMVAL-C**
 - **PRESENT-VALUE**
 - **VARIANCE**
- ▶ The intermediate result of a fixed-point arithmetic expression can be up to 34 digits and numeric literals may have a maximum length of 34 digits.

For more information about the **ARITHMETIC** parameter for the **CRTBNDCL** and **CRTCBLMOD** CL commands, see IBM Knowledge Center:

- ▶ http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/crtbndcbl.htm
- ▶ http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/cl/crtcb1mod.htm

New **PROCESS** statement options

In ILE COBOL in IBM i 7.2, the following options are added to the **PROCESS** statement:

▶ **NOCHGFLTRND** and **ALWCHGFLTRND**

Specifies whether COBOL uses the floating point rounding mode computational attribute that is specified by MI instruction SETCA. You can use SETCA to set the rounding mode of the result of a floating-point calculation to either round or truncate.

▶ **NATIONALPICNLIT**

Enables N" and N' as the opening delimiter for a national literal and enables elementary data items that are defined by using the picture symbol N to have an implied **USAGE NATIONAL** clause.

▶ **EXTEND31FULL**

This option corresponds to the enhancement of the **CRTBNDCL** and **CRTCBLMOD** CL commands. You can use this option to increase the floating-point accuracy of up to 34 digits and the ***EXTEND31FULL** option of **ARITHMETIC** parameter for **CRTBNDCL** and **CRTCBLMOD** CL commands.

For more information about the **PROCESS** statement, see IBM Knowledge Center:

- ▶ http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/proc.htm
- ▶ http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzase/optonly.htm

9.1.4 ILE C/C++

This section covers the following enhancements of ILE C/C++ in IBM i 7.2:

- ▶ New predefined macros
- ▶ “New option of the **LANGLVL** parameter for CL commands” on page 433
- ▶ “Implementing the initial C++0x features” on page 434

New predefined macros

The following predefined macros are available in ILE C/C++ in IBM i 7.2.

ILE C macros

The following ILE C macros are available:

- ▶ **__C99_BOOL** indicates support for the **_Bool** data type.
- ▶ **__C99_DESIGNATED_INITIALIZER** indicates support for the designated initialization.
- ▶ **__C99_DUP_TYPE_QUALIFIER** indicates support for duplicated type qualifiers.
- ▶ **__C99_EMPTY_MACRO_ARGUMENTS** indicates support for empty macro arguments.
- ▶ **__C99_FLEXIBLE_ARRAY_MEMBER** indicates support for flexible array members.
- ▶ **__C99_INLINE** indicates support for the inline function specifier.
- ▶ **__C99_LLONG** indicates support for C99-style long long data types and literals.
- ▶ **__C99_MAX_LINE_NUMBER** indicates that the maximum line number is 2147483647.
- ▶ **__C99_MIXED_DECL_AND_CODE** indicates support for mixed declaration and code.

- ▶ `__C99_NON_CONST_AGGR_INITIALIZER` indicates support for non-constant aggregate initializers.
- ▶ `__C99_NON_LVALUE_ARRAY_SUB` indicates support for non-constant aggregate initializers.
- ▶ `__C99_NON_LVALUE_ARRAY_SUB` indicates support for non-lvalue subscripts for arrays.
- ▶ `__C99_STATIC_ARRAY_SIZE` indicates support for the static keyword in array parameters to functions.
- ▶ `__C99_VAR_LEN_ARRAY` indicates support for variable length arrays.

All of these macros are defined when the **LANGLVL(*EXTENDED)** compiler is in effect.

ILE C++ macros

The following ILE C++ macros are available:

- ▶ `__C99_MAX_LINE_NUMBER` indicates that the maximum line number is 2147483647.
- ▶ `__C99_MIXED_STRING_CONCAT` indicates support for concatenation of wide string and non-wide string literals.
- ▶ `__IBMCPP_AUTO_TYPEDEDUCTION` indicates support for the auto type deduction feature.
- ▶ `__IBMCPP_C99_PREPROCESSOR` indicates support for the C99 preprocessor features that are adopted in the C++0x standard.
- ▶ `__IBMCPP_DECLTYPE` indicates support for the decltype feature.
- ▶ `__IBMCPP_DELEGATING_CTORS` indicates support for the delegating constructors feature.
- ▶ `__IBMCPP_EXTENDED_FRIEND` indicates support for the extended friend declarations feature.
- ▶ `__IBMCPP_EXTERN_TEMPLATE` indicates support for the explicit instantiation declarations feature.
- ▶ `__IBMCPP_INLINE_NAMESPACE` indicates support for the inline namespace definitions feature.
- ▶ `__IBMCPP_STATIC_ASSERT` indicates support for the static assertions feature.

All of these macros are defined when the **LANGLVL(*EXTENDED0X)** compiler is in effect.

New option of the LANGLVL parameter for CL commands

In IBM i 7.2, the new ***EXTENDED0X** option of the **LANGLVL** parameter for CL commands is supported in a way that corresponds to the implement initial C++0x features in this release. C++0x is now called C++11. ***EXTENDED0X** defines the same preprocessor variables as ***EXTENDED** does, and also defines an individual preprocessor variable for each C++11 language feature that is supported in this release. This option causes the compiler to use all the capabilities of ILE C++ and supported C++11 features that are implemented in this version of ILE C++ compiler.

For more information about the **LANGLVL** parameter for CL commands, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzarf/compile_langlvl.htm

Implementing the initial C++0x features

ILE C++ in IBM i 7.2 supports the initial C++0x features, including the following features:

- ▶ C++0x is a new version of the C++ programming language standard.
- ▶ C++0x is ratified and published as ISO/IEC 14882:2011 and now is called C++11.
- ▶ All references to C++0x in this document are equivalent to the ISO/IEC 14882:2011 standard.

Note: IBM continues to develop and implement the features of the new standard. The implementation of the language level is based on IBM's interpretation of the standard. Until IBM's implementation of all the features of the C++0x standard is complete, including the support of a new C++ standard library, the implementation might change from release to release. IBM makes no attempt to maintain compatibility, in source, binary, or listings and other compiler interfaces, with earlier releases of IBM's implementation of the new features of the C++0x standard, and they should not be relied on as a stable programming interface.

9.1.5 System APIs

For a list with detailed information about new APIs in IBM i 7.2, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apifinder/apifinder50.htm

For a list with detailed information about changed APIs in IBM i 7.2, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/apifinder/apifinder60.htm

9.2 Java on IBM i

The section covers the following topics:

- ▶ “IBM Developer Kit for Java”
- ▶ “IBM Toolbox for Java” on page 438

9.2.1 IBM Developer Kit for Java

This section describes the following topics:

- ▶ “IBM Developer Kit for Java Packaging”
- ▶ “Support for multiple Java Development Kits” on page 436
- ▶ “Security Updates for Java on IBM i” on page 438

IBM Developer Kit for Java Packaging

In IBM i 6.1 and IBM i 7.1, IBM Developer Kit for Java was available as the licensed program 5761JV1. In IBM i 7.2, the new product ID 5770JV1 is for IBM Developer Kit for Java. This product covers the same options as 5761JV1, but the following options are not available in IBM i 7.2 5770JV1:

- ▶ Option 8: JDK50, 32-bit
- ▶ Option 9: JDK50, 64-bit
- ▶ Option 13: JDK142, 64-bit

All of the available versions of Java for IBM i 7.2 are called IBM Technology for Java, which is based on the AIX version of the IBM Center for Java Technology Developer Kit. IBM Developer Kit for Java Option 6, Option 7, and Option 10, which are referred as Classic Java, were dropped in IBM i 7.1 and also are not available in IBM i 7.2. If you are still using Classic Java before in IBM i before Version 7.1, you should refer the following considerations and migrate your application to use IBM Technology for Java:

- ▶ When migrating from the Classic Java virtual machine (JVM), which was the 64-bit virtual machine, to the 32-bit version of IBM Technology for Java, consider that there might be limitations when using the 32-bit environment. For example, the amount of addressable memory is much smaller. In 32-bit mode, the Java object heap cannot grow much larger than 3 GB. You also are limited to running approximately 1000 threads. If your application requires more than 1000 threads or a Java object heap larger than 3 GB, use the 64-bit version of IBM Technology for Java. Table 9-1 shows the level of Classic Java and the IBM Technology for Java replacement.

Table 9-1 Classic Java levels and the suggested IBM Technology for Java replacement

Current Classic Java version	Possible options of IBM Technology for Java replacements
Java Developer Kit 1.4 (5761JV1 Option 6)	Java SE 71 32-bit (5770JV1 Option 14) Java SE 71 64-bit (5770JV1 Option 15) Java SE 7 32-bit (5770JV1 Option 14) Java SE 7 64-bit (5770JV1 Option 15) Java SE 6 2.6 32-bit (5770JV1 Option 11) Java SE 6 2.6 64-bit (5770JV1 Option 12) Java SE 6 32-bit (5770JV1 Option 11) Java SE 6 64-bit (5770JV1 Option 12) Java SE 8 32-bit (5770JV1 Option 16) Java SE 8 64-bit (5770JV1 Option 17)
Java Developer Kit 5.0 (5761JV1 Option 7)	Java SE 71 32-bit (5770JV1 Option 14) Java SE 71 64-bit (5770JV1 Option 15) Java SE 7 32-bit (5770JV1 Option 14) Java SE 7 64-bit (5770JV1 Option 15) Java SE 6 2.6 32-bit (5770JV1 Option 11) Java SE 6 2.6 64-bit (5770JV1 Option 12) Java SE 6 32-bit (5770JV1 Option 11) Java SE 6 64-bit (5770JV1 Option 12) Java SE 8 32-bit (5770JV1 Option 16) Java SE 8 64-bit (5770JV1 Option 17)
Java Developer Kit 6 (5761JV1 Option 10)	Java SE 71 32-bit (5770JV1 Option 14) Java SE 71 64-bit (5770JV1 Option 15) Java SE 7 32-bit (5770JV1 Option 14) Java SE 7 64-bit (5770JV1 Option 15) Java SE 6 2.6 32-bit (5770JV1 Option 11) Java SE 6 2.6 64-bit (5770JV1 Option 12) Java SE 6 32-bit (5770JV1 Option 11) Java SE 6 64-bit (5770JV1 Option 12) Java SE 8 32-bit (5770JV1 Option 16) Java SE 8 64-bit (5770JV1 Option 17)

- ▶ Adopted authority for Java programs is not supported by IBM Technology for Java Virtual Machine.

- ▶ IBM Technology for Java virtual machine works on Portable Applications Solutions Environment (PASE). When IBM Technology for Java Virtual Machine or PASE for i native methods encounter problems, they dump diagnostic files into the IFS, and you cannot see messages in the job log. There are several types of these core files, including core*.dmp, javacore*.txt, Snap*.trc, and heapdump*.phd. The files range in size from tens of kilobytes up to hundreds of megabytes. In most cases, more severe problems produce larger files. The larger files can quickly and quietly consume large amounts of IFS space.

Note: Despite the space these files consume, they are useful for debugging purposes. When possible, you should preserve these files until the underlying problem is resolved.

- ▶ If your ILE programs use Java Native Interface (JNI) functions, you must compile these programs with teraspace storage enabled.

Note: As a preferred practice, use Java SE 71 when migrating from Java Developer Kit 1.4 or 5.0.

Support for multiple Java Development Kits

IBM i 7.2 supports multiple versions of the Java Development Kits (JDKs) and the Java Platform, Standard Edition. To install the IBM Technology for Java options on IBM i 7.2, follow the steps that are found in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaha/rzahainstalljdk.htm

Table 9-2 shows the list of supported options of 5770JV1 IBM Technology for Java product and their JAVA_HOME in IBM i 7.2.

Table 9-2 Supported options of 5770JV1 IBM Technology for Java in IBM i 7.2

5770JV1 options	JAVA_HOME
Option 11 IBM Technology for Java 6 32-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk60/32bit
Option 11 IBM Technology for Java 6 2.6 32-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk626/32bit
Option 12 IBM Technology for Java 6 64-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk60/64bit
Option 12 IBM Technology for Java 6 2.6 64-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk626/64bit
Option 14 IBM Technology for Java 7 32-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk70/32bit
Option 14 IBM Technology for Java 71 32-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk71/32bit
Option 15 IBM Technology for Java 7 64-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk70/64bit
Option 15 IBM Technology for Java 71 64-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk71/64bit
Option 16 IBM Technology for Java 8 32-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk80/32bit
Option 17 IBM Technology for Java 8 64-bit	/QopenSys/QIBM/ProdData/JavaVM/jdk80/64bit

JDK 8.0 is available for IBM i 7.1 and 7.2 since April 28, 2015. Here is more information about how to obtain JDK 8.0 for your IBM i OS version:

- ▶ Required group PTF levels for JDK 8.0:
 - IBM i 7.2: SF99716 Level 5 or higher
 - IBM i 7.1: SF99572 Level 20 or higher
- ▶ You can obtain JDK 8.0 32-bit and 64-bit as ISO images from IBM Entitled Software Support (ESS) and then install them by using GO LICPGM Option 11. To access instructions about how to download JDK8.0 on IBM i, see the following documentation:
<http://www.ibm.com/support/docview.wss?uid=nas8N1020692>
- ▶ For more information about PTFs for Java on IBM i, see the IBM i Technology Updates developerWorks wiki:
<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/PTF%20groups%20and%20latest%20SR%2C%20FP>

IBM i also supports using multiple JDKs simultaneously through multiple JVMs. A single JVM runs one specified JDK. The default JDK that is chosen in this multiple-JDK environment depends on which 5770-JV1 options are installed. The following order of precedence determines the default JDK:

1. Option 14 - IBM Technology for Java 7.1 32-bit
2. Option 15 - IBM Technology for Java 7.1 64-bit
3. Option 14 - IBM Technology for Java 7.0 32-bit
4. Option 15 - IBM Technology for Java 7.0 64-bit
5. Option 11 - IBM Technology for Java 6 32-bit
6. Option 12 - IBM Technology for Java 6 64-bit
7. Option 16 - IBM Technology for Java 8.0 32-bit
8. Option 17 - IBM Technology for Java 8.0 64-bit

You can access IBM Technology for Java JDKs by setting the JAVA_HOME environment variable or by specifying a fully qualified path to the Java tool or utilities in the JDK that you want to use.

Example 9-14 shows an example of using IBM Technology for Java 71 64-bit by setting JAVA_HOME. Figure 9-5 shows the result of running `java -version` from PASE by using the settings of Example 9-14.

Example 9-14 Example of setting IBM Technology for Java 71 64-bit to JAVA_HOME

```
ADDENVVAR ENVVAR(JAVA_HOME) VALUE('/QOpenSys/QIBM/ProdData/JavaVM/jdk71/64bit')
```

```
                                /QOpenSys/usr/bin/-sh
$
> java -version
java version "1.7.0"
Java(TM) SE Runtime Environment (build pap6470_27sr1fp1-20140708_01(SR1 FP1))
IBM J9 VM (build 2.7, JRE 1.7.0 OS/400 ppc64-64 Compressed References jvmap64
70_27sr1fp1-20140708_01_cr (JIT enabled, AOT enabled)
J9VM - R27_Java727_SR1_20140707_1408_B205525
JIT - tr.r13.java_20140410_61421.07
GC - R27_Java727_SR1_20140707_1408_B205525_CMPRSS
J9CL - 20140707_205525)
JCL - 20140707_01 based on Oracle 7u65-b16
$
```

Figure 9-5 Result of `java -version` by specifying IBM Technology for Java 7.1 64-bit

For more information about IBM Developer Kit for Java, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaha/whatitis.htm

Security Updates for Java on IBM i

The following developerWorks website provides the current security update information about Java on IBM i security, including Java SR Delivery Schedule for IBM i and Common Vulnerabilities and Exposures (CVE) information:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Java%20on%20IBM%20i%20security%20updates>

9.2.2 IBM Toolbox for Java

To access resources, including data in IBM i from your Java applications, you can use IBM Toolbox for Java. IBM Toolbox for Java provides a set of Java classes, which can be used in Java client/server applications, applets, and servlets that work with data on your IBM i system. Some typical functions of IBM Toolbox for Java are IBM Toolbox for Java JDBC Driver, Program Call and Program Call Markup Language (PCML) functions, and so on. An open source version of IBM Toolbox for Java, which is referred as JTOpen, is also available. JTOpenLite (JTLite) is also available for accessing IBM i resources to mobile applications.

This section covers the following enhancements of IBM Toolbox for Java in IBM i 7.2:

- ▶ “New AS400JDBCTimestamp class” on page 439
- ▶ “JTOpenLite Java classes library” on page 439

New AS400JDBCTimestamp class

In IBM i 7.2, the maximum precision of a time stamp increases from 6 to 12. Corresponding to the DB2 for i SQL functions and ILE programming languages, the IBM Toolbox for Java JDBC driver also is enhanced to retrieve these larger time stamp values. Because the `java.sql.Timestamp` class supports only 9 digits of precision, a new `AS400JDBCTimestamp` class was created to handle those cases where the data from the server includes more than 9 digits of precision.

For more information about the `AS400JDBCTimestamp` class, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahh/javadoc/com/ibm/as400/access/AS400JDBCTimestamp.html

New QueryTimeoutMechanism JDBC connection property

The IBM Toolbox for Java JDBC driver originally implemented the `queryTimeout` feature by using the `QQRYTIMLMT` feature of the database engine. However, this mechanism does not correctly allow for the ending of long running operations.

The `QueryTimeoutMechanism` connection property allows the `queryTimeout` to be implemented by using a database **CANCEL**. The possible values are `qqrylimlmt` and `cancel`. If `qqrylimlmt` is specified, the `QQRYTIMLMT` feature of the database engine is used to limit how long queries can run. If `cancel` is specified, the running SQL statement is canceled after the specified timeout expires.

For more information about the `QueryTimeoutMechanism` connection property, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahh/jdbcproperties.htm

JTOpenLite Java classes library

The `JTOpenLite` package (`com.ibm.jopenlite`) is an alternative to the IBM Toolbox for Java and `JTOpen` that provides a small footprint (about 420 KB). You can use `JTOpenLite` to write Java programs that allow a variety of mobile devices to access directly IBM i data and resources. Although `JTOpenLite` is considered a part of IBM Toolbox for Java, it is not included in the licensed product. The `JTOpenLite` JAR file (`jopenlite.jar`) is included in the open source version of IBM Toolbox for Java, called `JTOpen`. You must separately download and set up `JTOpenLite`, which is contained in `JTOpen`.

For more information about `JTOpenLite`, see *Modernizing IBM i Applications from the Database up to the User Interface and Everything in Between*, SG24-8185.

9.3 Rational Tools for i

This section covers the following Rational Tools for i:

- ▶ 9.3.1, “IBM Rational Developer for i” on page 440
- ▶ 9.3.2, “IBM Rational Application Developer for WebSphere Software” on page 451
- ▶ 9.3.3, “IBM Rational Business Developer” on page 452
- ▶ 9.3.4, “IBM Rational Team Concert for i” on page 456
- ▶ 9.3.5, “IBM Rational Host Access Transformation Services” on page 457
- ▶ 9.3.6, “IBM Rational Application Management Toolset for i” on page 460
- ▶ 9.3.7, “ARCAD Pack for Rational” on page 462

9.3.1 IBM Rational Developer for i

IBM Rational Developer for i (RDi) is an integrated development environment (IDE) that is built on the Eclipse platform. It is the strategic desktop development tool for creating IBM i applications. RDi is installed on a workstation and supports the development of IBM i applications in both host-connected and disconnected modes. RDi can be installed in either Windows, or Linux developer workstations. RDi supports the development of RPG, COBOL, C, C++, SQL, and CL applications, including DDS (for instance display and printer files).

This section covers the following topics:

- ▶ “Rational Developer for i versions” on page 440
- ▶ “Rational Developer for i packaging” on page 440
- ▶ “What is new in the latest versions of RDi” on page 441

Rational Developer for i versions

The earliest version of RDi that supports IBM i 7.2 base enhancements is Version 9.1. The latest version supporting IBM i 7.2 is Version 9.5.

RDi V9.1 was delivered in 2014 for the announcement of IBM i 7.2. To support IBM i 7.2 TR1, Version 9.1.1 was released later in 2014.

Both RDi V9.1 and V9.1.1 are built on Eclipse 4.2.2, and RDI V9.5 is built on Eclipse 4.4.2 and Java 8.

For more information about RDi version evolution, go to the following website:

<http://www.ibm.com/support/docview.wss?uid=swg21681378>

Rational Developer for i packaging

RDi is available in three editions since Version 9.1:

- ▶ RPG and COBOL Tools

This edition is for developing basic compiled language applications that run on IBM i, including C, C++, CL, DDS, and SQL development. The IDE can be connected to IBM i versions 6.1, 7.1, and 7.2.

- ▶ RPG and COBOL + Modernization Tools, Java Edition

This edition contains all the functions of RPG and COBOL Tools and a substantial subset of the IBM Rational Application Developer for WebSphere software. This edition provides a rich Java, web, SOA, and mobile development environment to support extension and modernization of heritage IBM i applications. This edition also includes IBM Worklight Developer Edition to support the development of hybrid mobile applications that use the capabilities of the Worklight run times and connect to systems of record that are implemented in RPG, COBOL, C/C++, SQL, or Java/JEE running on AIX or Linux on Power Systems servers.

For more information about Rational Application Developer, see 9.3.2, “IBM Rational Application Developer for WebSphere Software” on page 451.

For more information about IBM Worklight Developer Edition, see the following developerWorks website:

<http://www.ibm.com/developerworks/mobile/worklight/>

- ▶ RPG and COBOL + Modernization Tools, EGL Edition

This edition contains the complete Rational Business Developer product to support extension and modernization of heritage IBM i applications that use the EGL language in addition to the RPG and COBOL Tools.

For more information about Rational Business Developer, see 9.3.4, “IBM Rational Team Concert for i” on page 456.

What is new in the latest versions of RDi

RDi V9.1 has the following enhancements:

- ▶ “Line-level batch code coverage analysis capability” on page 441
- ▶ “Support of free-form RPG” on page 445
- ▶ “Filter function in the RPG outline view” on page 448

RDi V9.1.1 has the following enhancements:

- ▶ “Interactive Code Coverage support” on page 449
- ▶ “Push-to-client function” on page 450

RDi V9.5 has the following enhancements:

- ▶ Removes the columns 8 - 80 restriction for formatting free-form RPG, as described in “Fully free-form statements in ILE RPG IV” on page 424.
- ▶ Provides for “smart” indentation of free-form RPG with RPG code editor.
- ▶ Includes an embedded 5250 emulator.
- ▶ Delivers dramatic improvement of code coverage analysis performance (observed, but not formally benchmarked, as 20 times faster than the previous version).
- ▶ Provides tools support for Java 8 and Java Enterprise Edition 7 in the Java edition.

For more information about IBM Rational Developer for i, see the following website:

<http://www.ibm.com/software/products/en/dev-ibm-i/>

Also, see IBM Knowledge Center:

<http://www.ibm.com/support/knowledgecenter/SSAE4W/welcome?lang=en>

Line-level batch code coverage analysis capability

Batch code coverage can be started on any program or service program that can be debugged. This capability can be used to determine the effectiveness of automated or manual tests. It can help focus additional testing on code paths that have not been run. It can aid the reduction of the amount of testing that is required by eliminating tests that duplicate which code paths that they exercise.

Figure 9-6 shows starting the Batch Code Coverage capability by right-clicking a program object in RDi. With this capability, the developer can then see, by views, html reports, and editor annotations, exactly which lines of the programs are or are not run by that particular scenario.

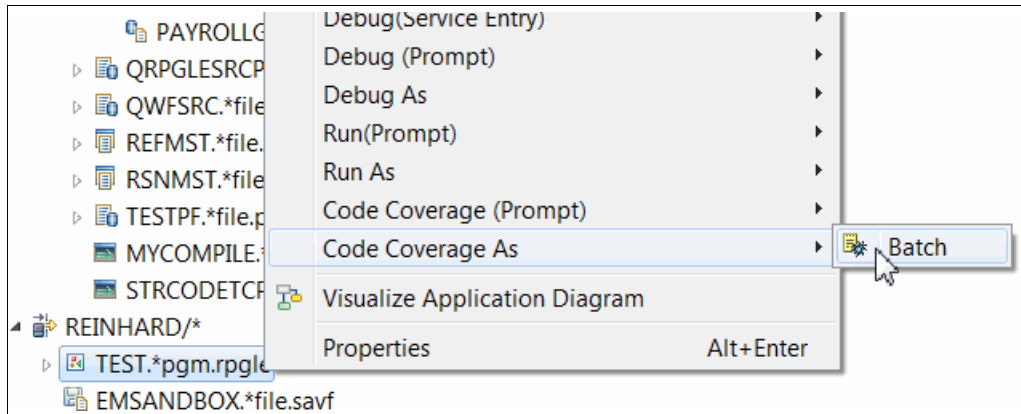


Figure 9-6 Start batch code coverage

Figure 9-7 shows an example of Code Coverage Report as an editor.

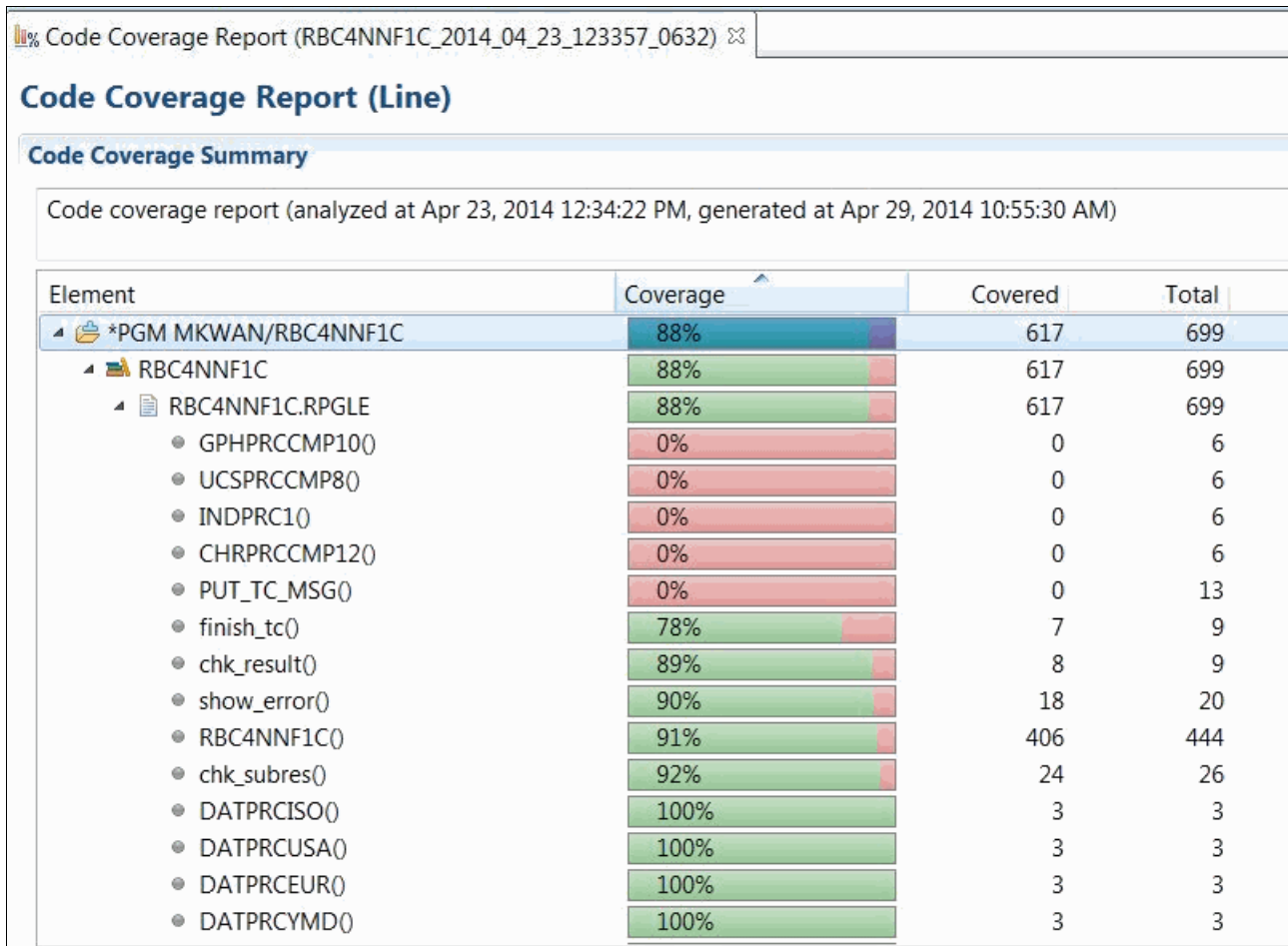


Figure 9-7 Code Coverage Report

The developer can drill down from this report in the editor to determine which lines are covered. The editor opens the related source member with green and red annotations, showing which lines are covered, as shown in Figure 9-8.

```

Line 1490      Column 50      Replace      Browse
.....PName+++++.....B.....Keyword.....Commer
P finish_tc    b                export
D finish_tc    pi
D tc           likeds(tc_t)
/free

// If all variations passed, set the test case status to successful
if tc.succ_v = tc.run;
  RptTest (tc.testname: tc.succ_v: tc.fail_v: SUCCESS);
  return;
endif;

// Otherwise, write a summary line and close the output file
VarFail ('*CLOSE': tc.succ_v);
RptTest (tc.testname: tc.succ_v: tc.fail_v: FAILURE);

close qprint;

/end-free
P finish_tc    e

P put_tc_msg   b                export
D put_tc_msg   pi
D msgPtr       * value options(*string)
D MAX LINE     c                52

```

Figure 9-8 Source member with annotations about which lines are covered

The Code Coverage Report also can be shown as HTML and PDF reports. Figure 9-9 is an example of an HTML report. Those reports are available for those users who are not using RDi such as quality assurance and management.

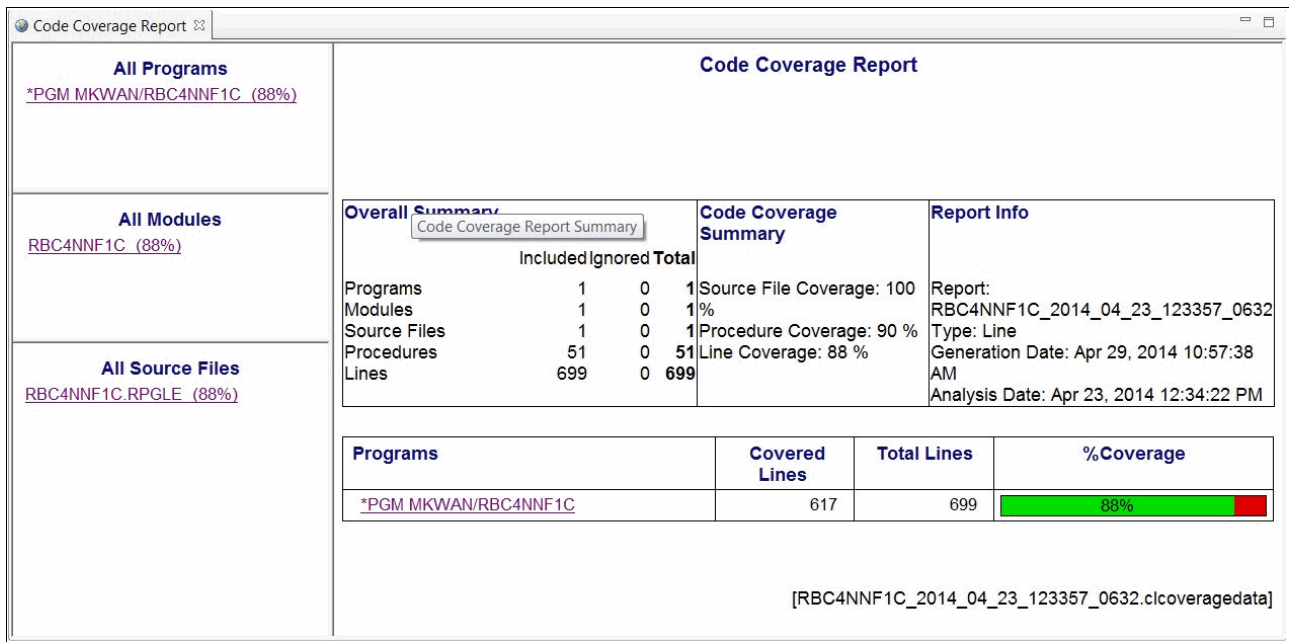


Figure 9-9 Example of a Code Coverage HTML report

For more information about the Code Coverage capability, see the following developerWorks website:

<http://www.ibm.com/developerworks/library/d-code-coverage-tools-rational-developer-i/index.html>

Support of free-form RPG

RDi V9.1 supports and uses the free-form RPG with prompting, syntax checking, program verifiers, source styling logic, live outline views, content assist, hover hints, and other functions.

Wizards such as the D-Specification Wizard, which is shown in Figure 9-10, Procedure Wizard, as shown in Figure 9-11 on page 447, and Java Method Call Wizard, as shown in Figure 9-12 on page 448, can generate free-form definitions into the correct location of mixed free-form and fixed-form RPG sources.

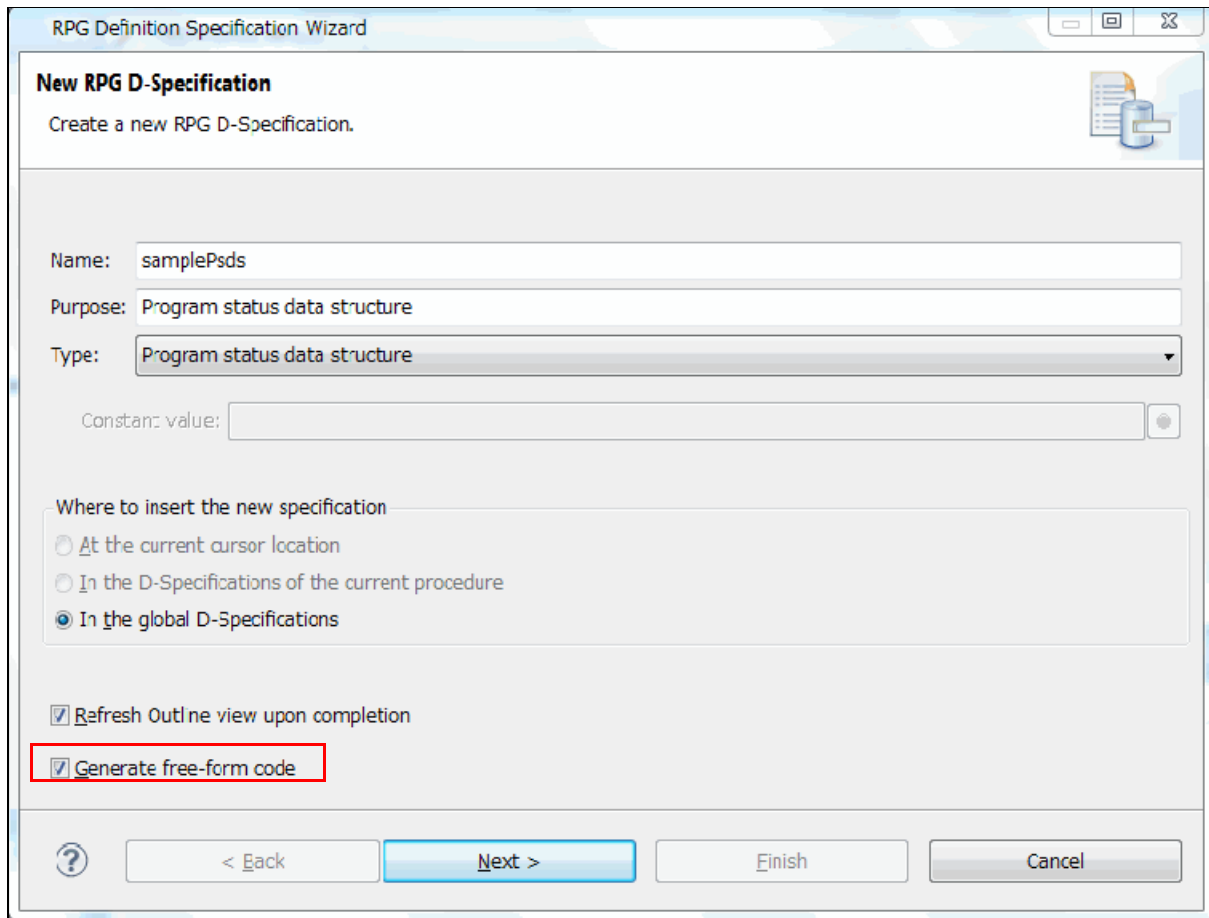


Figure 9-10 D-Specification Wizard

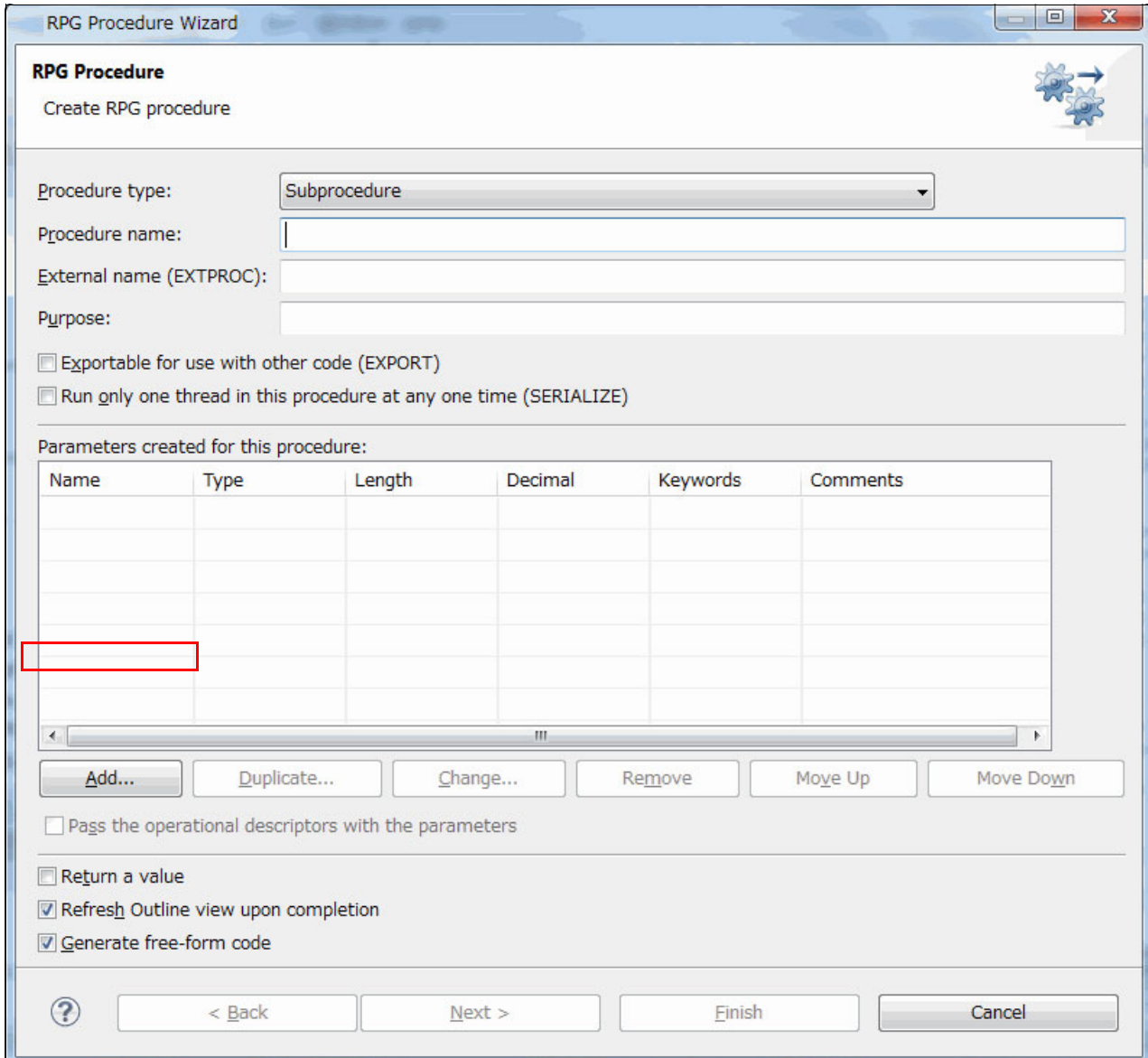


Figure 9-11 Procedure Wizard

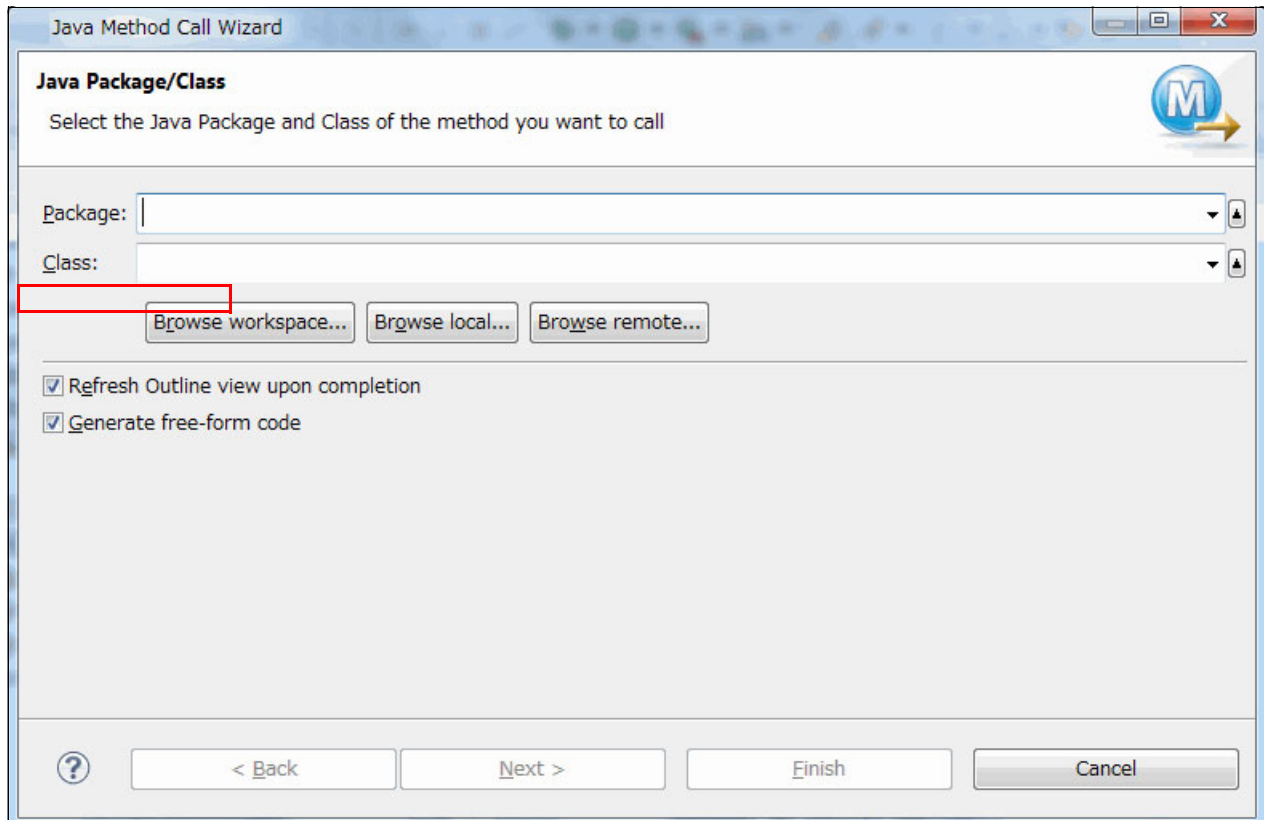


Figure 9-12 Java Method Call Wizard

For more information about free-form RPG support, see the following resources:

- ▶ IBM developerWorks website:
<https://www.ibm.com/developerworks/ibmi/library/i-ibmi-rpg-support/>
- ▶ IBM Knowledge Center:
https://www.ibm.com/support/knowledgecenter/SSAE4W_9.5.0/com.ibm.etools.iseries.rse.doc/topics/teditrpg.html

Filter function in the RPG outline view

The RPG outline can be quickly set to the language elements of interest by specifying a filter. The ability to filter to the variable or procedure of interest and see all the references can be a boon to productivity.

This function provides an optional filter field at the top of the Outline view, as shown in Figure 9-13 on page 449, and sets the view as the developer types. Figure 9-13 on page 449 shows only the definitions containing EMP because EMP is in the filter field of the Outline view.

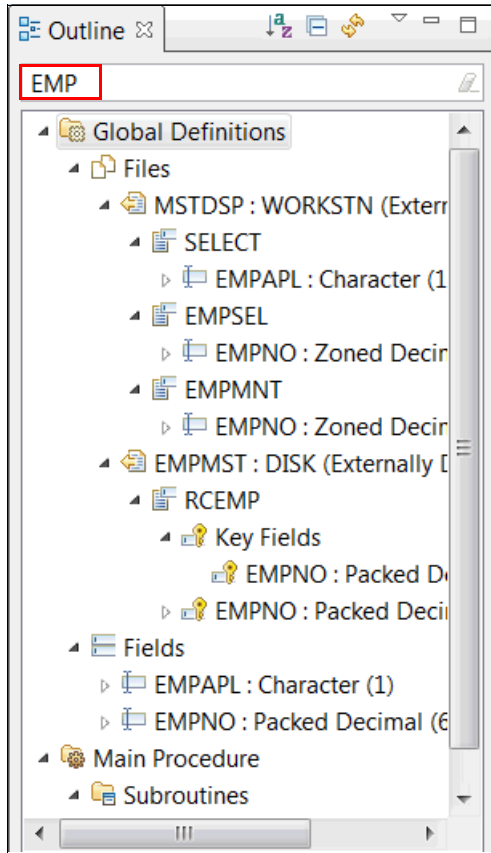


Figure 9-13 Filter field of the Outline view

Interactive Code Coverage support

In RDi V9.1.1, the Interactive Code Coverage analysis capability is supported in addition to the existing batch code coverage analysis, which is described in “Line-level batch code coverage analysis capability” on page 441. With this enhancement, the Code Coverage capability can be adopted by batch processes and interactive processes, such as interactive jobs and web services.

For more information about Interactive Code Coverage support, see the following developerWorks website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%207.2%20-%20TR1%20Enhancements>

Push-to-client function

RD_i V9.1.1 supports the Push-to-client function, which updates all RD_i client workspaces from a central IBM i. You can use this capability to distribute and maintain RD_i across a team of developers. Figure 9-14 shows the concept of the Push-to-client function. By using this function, you can store workspace configurations in a central location and push them to client workstations so that your developers have a consistent workspace environment.

The Push-to-client function can be used to administer consistent work environments or to simply share or back up configurations.

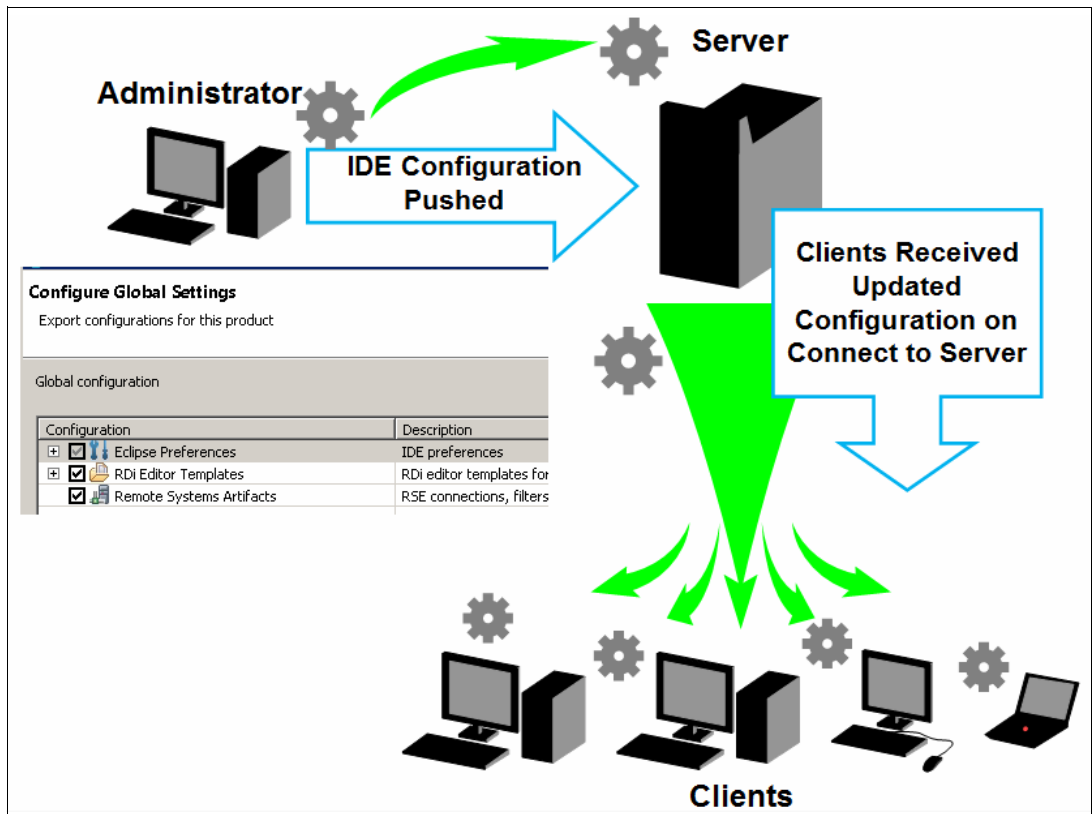


Figure 9-14 Concept of Push-to-client function

The following information and files can be distributed from a central IBM i:

- ▶ Remote System Explorer (RSE) Connections
- ▶ Filters
- ▶ Eclipse Preferences
- ▶ Update templates
 - Free-form RPG
 - Free-form SQL
 - COBOL
 - C/C++
- ▶ Database Connections
- ▶ RSE Compile Actions
- ▶ RSE User Actions

For more information about the Push-to-client function, see the following developerWorks website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%207.2%20-%20TR1%20Enhancements>

9.3.2 IBM Rational Application Developer for WebSphere Software

Rational Application Developer is an Eclipse-based IDE that is used to build Java, Java EE, Web 2.0, mobile, portal, and service-oriented architecture (SOA) applications for distributed platforms and IBM Bluemix®. The purpose of this tool is the development of Java Platform, Enterprise Edition software for multiple platforms running IBM WebSphere Application Server software. IBM i is one of supported platforms. The latest version of Rational Application Developer for WebSphere Software is Version 9.5 running on Eclipse 4.4.2 and Java 8.

There are several advantages to using this software:

- ▶ Accelerates the development and maintenance of web and mobile applications with tools for established and new and emerging programming models and technologies.
- ▶ Speeds the development of services and Java applications with productivity tools that support the current Java EE and SOA programming models.
- ▶ Is optimized for IBM middleware, including the new, lightweight Liberty Profile, the full WebSphere Application Server profile, the IBM WebSphere Portal Server, and IBM Workload Deployer.
- ▶ Includes advanced test and analysis tools to help you achieve higher initial code quality while accelerating application development, deployment, and management.
- ▶ Provides flexible deployment options and rich integration with the Rational Collaborative Application Lifecycle Management solution to help raise productivity and improve quality outcomes at both the team and individual practitioner levels.

IBM Rational Application Developer for WebSphere Software V9.5 provides the following new and enhanced capabilities:

- ▶ Provides tool support for Java 8 and Java Enterprise Edition 7, and the latest version of WebSphere Application Server Liberty, including new support for remote profiling on WebSphere Application Server Liberty and support for portlets on the WebSphere Application Server Liberty profile.
- ▶ Offers integration with the Jasmine framework for JavaScript unit testing.
- ▶ Delivers updated tools for working with IBM Bluemix and new integration with the Cloud Foundry CLI interface, and updated Cordova support.
- ▶ Enables the use of static code analysis results as a criterion for permitting change sets to be delivered to IBM Rational Team Concert™.
- ▶ Provides functional and usability improvements (including streamlined installation) to the included utilities for automating builds, static code analysis, unit testing, and code coverage analysis in Continuous Integration environments. These capabilities are now packaged into a new Code Quality Extension for Continuous Integration component.

For more information, see the IBM Rational Application Developer for WebSphere website:

<http://www.ibm.com/software/products/en/application>

Also, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/SSRTLW_9.5.0/com.ibm.rad.install.doc/to pics/c_install_build_utility_8.html?lang=en

9.3.3 IBM Rational Business Developer

Rational Business Developer (or Rational Developer for i - EGL tools) contains the following features (examples):

- ▶ A complete IDE for EGL development (IBM Rational Business Developer V9.0 functions)
- ▶ Limited Java and web development

Rational Business Developer is an Eclipse-based IDE that simplifies the development of SOA applications by using the Enterprise Generation Language (EGL).

Developers can now deliver web, Web 2.0, and mobile applications and services without having to master Java and SOA programming. They can create, test, and debug EGL applications while generating Java, JavaScript, or COBOL code for deployment. RPG and COBOL developers can migrate to EGL easily because they can use it to create portable applications with modern architectures and user interfaces, without having to learn concepts of object-oriented languages.

Here are the main features of Rational Business Developer (and also EGL tools):

- ▶ EGL transformation
 - Transforms an EGL source into Java, JavaScript, or COBOL code that is optimized for deployment to application hosting environments, including Java EE servers and traditional transactional systems.
 - Streamlines development by using a single, high-level language for complete development of the business application.
 - Generates different languages for a single application, such as JavaScript for an application user interface and Java or COBOL for the application back end.
 - Increases productivity and reduces the technology learning curve to improve business agility and competitiveness.
- ▶ Simplified service creation
 - Simplifies service creation, concealing the technical complexity of SOA. Multiplatform deployment deploys applications and services on many platforms, either as web services or natively.
 - Provides built-in service constructs and a facility for service generation, allowing business-oriented developers to create SOA applications without extensive training.
 - Creates EGL services and automates the generation of web services from EGL services.
 - Supports the development and deployment of services to WebSphere Application Server on multiple platforms.
 - Allows developers to work within the familiar Eclipse-based environment by using existing development skills.
- ▶ Unified Modeling Language (UML) support
 - Supports UML to EGL transformations, allowing complex applications to be modeled graphically.
 - UML supports a model-driven approach that streamlines the creation of Java and Web 2.0 applications and services.
 - UML supports the implementation of EGL services.
 - UML supports full Create, Read, Update, Delete applications without the need for manual coding.

- ▶ Extensible platform
 - Integrates with several IBM products to extend support for IBM i and expand software lifecycle functions.
 - Extends existing IT assets and provides the extensibility, scalability, and productivity features of an Eclipse-based platform.
 - Integrates with IBM Rational Developer for i for SOA Construction and IBM Rational Software Architect.

For more information about EGL, see the following websites:

- ▶ EGL Cafe:

<https://www.ibm.com/developerworks/community/groups/service/html/communityview?communityUuid=3e2b35ae-d3b1-4008-adee-2b31d4be5c92>

- ▶ IBM Knowledge Center:

<http://www.ibm.com/support/knowledgecenter/SSMQ79/welcome?lang=en>

New features in Rational Business Developer V9.1

Here are the new features of Rational Business Developer V9.1:

- ▶ New annotations:
 - `Description=#doc{}`
 - `isDeprecated`
 - `StartTransactionID/RestartTransactionID`
- ▶ New Dojo widget and Dojo Mobile widget enhancements:
 - Addition of `DojoMobileTimePicker` widget
 - `allowEmptyRows` property on `Datagrid` to show/hide empty rows
- ▶ Support for EGL web applications in the IBM CICS® V5.1 Liberty Profile. Includes RUI/Web 2.0 based, JSF based, `JavaWrappers`, and `VAGen` style web transactions.
- ▶ Extension Points/APIs enabling development of custom code for the following features:
 - Support Fixed/Structured Records in RUI handlers
 - Extend the EGL RUI Visual Editor
- ▶ Shell Share capability with other Rational V9.1 IDE products.

New features in Rational Business Developer V9.5

Here is a list of the new features in Rational Business Developer V9.5:

- ▶ Source code analysis with Code Review. With Code Review, you can create configurations of coding rules for EGL source code. You can then run the configurations to check the source code for consistency with the rules.
- ▶ Rich UI enhancements:
 - Rich UI widget projects update

By default, the following Rich UI system projects are in use:

 - For EGL widgets that are not based on Dojo: `com.ibm.egl.rui_4.3.2`
 - For EGL Dojo widgets: `com.ibm.egl.rui.dojo.widgets_2.3.0`
 - For EGL Dojo samples: `com.ibm.egl.rui.dojo.samples_2.3.0`
 - For the local Dojo runtime access: `com.ibm.egl.rui.dojo.runtime.local_1.10.4`

- DojoUploader Widget

DojoUploader widget is a new widget in Rational Business Developer V9.5. You can use it to upload files from the client side to the server.
- maxHeight property for DojoFilteringSelect

maxHeight is a new property for the DojoFilteringSelect widget to specify the max height of its drop-down view.
- Support of XulRunner in 64-bit Windows

Xulrunner for Windows 64-bit is supported as the visual editor render engine in Rational Business Developer V9.5.
- ▶ Mobile enhancements:
 - EGL Cordova library and tools

Rational Business Developer introduces a new EGL Cordova programming model in Version 9.5. You can develop, test, debug, and deploy hybrid mobile applications with this new library and tool set. You can learn how to develop with the EGL Cordova library and look up the EGL Cordova library API.
 - EGL Dojo Mobile widgets

By default, the mobile widgets in use are updated to Version 1.4.0.

More properties, such as `isLongList` and `isFilteredList`, are added to the `DojoMobileList` widget to provide a performance boost when processing long lists or using filters for a list.

More widgets, such as `DojoMobileAccordion`, `DojoMobileAccordionPane`, `DojoMobileContentPane`, `DojoMobileScrollablePane`, and `DojoMobileSimpleDialog`, are added to provide more container and layout capability.
- ▶ Service enhancements:
 - SOAP V1.2 client support in JAX-WS

Rational Business Developer V9.5 supports invoking third-party web services that use SOAP V1.2 bindings. You must switch the service run time to JAX-WS when calling a SOAP V1.2 web service.
 - Unwrapped SOAP Service support

Rational Business Developer V9.5 supports invoking third-party web services that provide document/literal unwrapped style WSDL files. You must make sure that the service run time is JAX-RPC when calling a web service that is described by a document/literal unwrapped style WSDL file.
 - Ant task `egl.generateWSDL`

A new Ant task named `egl.generateWSDL` was introduced to enable generation of the WSDL file from an EGL service file through Ant.
- ▶ New annotation `isRemoved`. The `isRemoved` annotation is a new annotation in Rational Business Developer V9.5. You can use it to logically remove any of your own EGL parts or types such as libraries, services, external types, records, or variables so that usage of these display as an error in the IDE.

- ▶ New EGL generation time options:
 - genXSDFile

The genXSDFile build descriptor option specifies whether an XML schema definition (XSD) side file is created for called programs with passed parameters. This option creates the XSD file, which can be used as input to enable testing with the Rational Virtualization Server.
 - minSubStringLength

The minSubStringLength build descriptor option specifies the smallest length that is allowed for a substring move before an IndexOutOfBoundsException is thrown.
 - ADDITIONALUSERFILES

The ADDITIONALUSERFILES parameter is a new generation symbolic parameter that identifies additional files to be added to the build plan dependency list. This allows additional user files to be processed and uploaded to a host machine during generation of COBOL.
 - CICS channels with J2C connections

You can now use CICS Channels with CICS J2C connections. In your linkage options, set parmForm to CHANNEL and remoteComType to CICSJ2C.
 - New Resource Association Property includeRecordLengthField

The property specifies whether to also write the Record Length field for variable-length sequential records when generating Java from EGL source.
- ▶ New EGL preferences:
 - Delete generated files during project clean

You can select this check box to delete all files (except the properties files) and any resulting empty directories from the EGLGen/JavaSource directory during a project clean.
 - Search EGLARs for details

You can select this check box to obtain function and variable descriptions from EGL editor when content assist is used.
 - Show advanced hover details

You can select this check box to display extensive hover details when using the mouse-over function during an editor session for EGL source when content assist is used.
- ▶ New environment variable: VSECON / Changes to VSE Build Server.

VSE Build Server now uses the environment variable VSECON to locate the VSE Connector Client. This variable should be set to the installation directory of the VSE Connector Client, or a directory containing both VSEConnector.jar and cci.jar. You no longer need to copy these files into the distributed build plug-in directory.
- ▶ Debugger enhancement: EGL Debug Support for the Liberty Profile. The ability to debug EGL services, web transactions, and UI programs when using the Liberty Profile was added.

9.3.4 IBM Rational Team Concert for i

IBM Rational Team Concert, which is part of Rational Collaboration Lifecycle Management (CLM) and Rational Systems and Software Engineering, is a team collaboration tool that is built on the IBM Jazz™ technology platform. Rational Team Concert uses the Change and Configuration Management (CCM) application to provide features that integrate development project tasks, including iteration planning, process definition, change management, defect tracking, source control, build automation, and reporting.

The current version of Rational Team Concert running on IBM i is V6.0.

Rational Team Concert provides the following capabilities:

- ▶ An integrated set of collaborative software delivery tools for IBM i development, including source control, change management, builds, process management, and governance
- ▶ Integration with Rational Developer for i to enable team capabilities for native IBM applications
- ▶ Specialized support for source control, change management, and builds of traditional language artifacts, such as RPG and COBOL
- ▶ Support for multitier software development and application modernization efforts by using RPG, COBOL, PHP, Java, and others
- ▶ Supports the IBM i native library file system and Integrated File System (IFS)
- ▶ IBM i artifact builds, including RPG, COBOL, CL, and Java
- ▶ Build agent, which runs natively on the IBM i operating system (runs IBM i commands and call programs)
- ▶ Native hosting of the IBM Jazz Team Server on IBM i

Rational Team Concert consists of client and server components. To use Rational Team Concert functions for developing IBM i applications, the Rational Team Concert client must be installed on a workstation with Rational Developer for i. Rational Team Concert server components are supported on several platforms, including IBM i, AIX, z/OS, Solaris, Red Hat (RHEL) and SUSE (SLES) Linux distributions, and Windows Server.

Supported operating systems versions and limitations are described in the Jazz Community Site by Rational Team Concert version. For example, the system requirements of Rational Team Concert V6.0 are described at the following website:

<https://jazz.net/wiki/bin/view/Deployment/CLMSystemRequirements60>

What is new in the current version of Rational Team Concert

New functions in each Rational Team Concert version and release are listed at the Jazz Community Site. For example, here is the website for Rational Team Concert V5.0.1, which is the current version of Rational Team Concert as of October 2014:

<https://jazz.net/downloads/jazz-foundation/releases/6.0?p=news>

For more information about Rational Team Concert, see the following website:

<https://jazz.net/products/rational-team-concert/>

You can find more information about Rational Team Concert in IBM Knowledge Center:

https://www.ibm.com/support/knowledgecenter/SSCP65_6.0.0/com.ibm.rational.clm.doc/helpindex_clm.html

Finally, see *Modernizing IBM i Applications from the Database up to the User Interface and Everything in Between*, SG24-8185.

9.3.5 IBM Rational Host Access Transformation Services

Rational Host Access Transformation Services (HATS) is a tool that you can use to transform applications that use text-based 5250 user interfaces into web pages, that is, you can create a web application from an existing 5250 application without touching the source code. Rational HATS can connect to IBM Mainframe 3270 and general UNIX VTY panels, run macros there, gather the data, and present data from multiple systems in one single web page.

Rational HATS general description

The Rational HATS tool is based on the Eclipse environment. The current version, which is Version 9.0, uses Eclipse 4.2.2.

As a prerequisite for performing development activity, Rational HATS needs one of the following Rational products:

- ▶ Rational Developer for i V9.0
- ▶ Rational Business Developer V9.0
- ▶ Rational Application Developer for WebSphere Software V9.0
- ▶ Rational Software Architect for WebSphere Software V9.0
- ▶ Rational Developer for AIX and Linux V9.0

Here are the supported runtime Java application servers:

- ▶ IBM i - Release Overview V7.1 and future modification levels and their fix packs
- ▶ IBM i - Release Overview V6.1 and future modification levels and their fix packs
- ▶ IBM i - Release Overview V5.4 and future modification levels and their fix packs
- ▶ Apache Geronimo 2.2.1 and future modification levels and fix packs
- ▶ Apache Geronimo 2.1.7 and future modification levels and fix packs
- ▶ WebSphere Application Server: Different versions of Express/Base/Network Deployment editions, from Version 7.0 to the latest, which is Version 8.5.5
- ▶ Oracle WebLogic server 12c (12.1.1) and future modification levels and their fix packs

Note: Any of the WebSphere, WebLogic, and Apache Geronimo technologies can run on a different platform from where they are supported (IBM i is not mandatory). These servers then connect by using telnet or secure telnet protocol to the IBM i server where the original 5250 application runs.

Rational HATS V9.0 can create two types of clients:

- ▶ A web-based one running in a web browser
- ▶ A client/server-based client running either in IBM Lotus Notes®, a Lotus Expeditor environment, or in an Eclipse SDK environment

Here are the supported web browsers:

- ▶ Mozilla Firefox
- ▶ Android
- ▶ Google Chrome

- ▶ Apple Safari
- ▶ Apple Safari on iOS
- ▶ Microsoft Internet Explorer
- ▶ Microsoft Internet Explorer mobile browser
- ▶ Konqueror
- ▶ Opera

Rational HATS can also create portlets when it is used with Rational Application Developer for WebSphere Software. It supports different IBM WebSphere Portal Server Editions, from Version 7.0 to Version 8.0.

For detailed system requirements and possible limitations, see the following website:

<http://www.ibm.com/support/docview.wss?uid=swg27011794>

Rational HATS basic functions

Rational HATS transforms traditional text-based interfaces, such as 3270 and 5250 green-screen applications, into web, portlet, rich-client, or mobile device user interfaces. It also extends 3270, 5250, and virtual terminal (VT) applications as standard web services. With Rational HATS, you can easily convert traditional text-based host application panels to GUIs.

Rational HATS is available in the following packages:

- ▶ Rational HATS for Multiplatforms and HATS for Linux on IBM System z®
- ▶ Rational HATS for 5250 Applications on Multiplatforms
- ▶ Rational HATS for 5250 Applications on i5/OS

Note: Rational HATS for Multiplatforms can create applications by using IBM i 5250, IBM Mainframe 3270, and UNIX VT-based panels (VT is only for capturing data, not panels). Rational HATS for 5250 can use only IBM i 5250 panels.

Rational HATS for Multiplatforms and Rational HATS for 5250 Applications on Multiplatforms can use any supported HTTP server on any supported Java application server (see “Rational HATS general description” on page 457). Rational HATS for 5250 Applications on i5/OS can have only a Java application server run time on IBM i.

The Rational HATS product provides both a Rational HATS Toolkit (Windows Eclipse-based plug-in for development of Rational HATS applications) and a Rational HATS run time. The Rational HATS Toolkit can be downloaded for free from the Rational HATS product website, found at:

<http://www.ibm.com/developerworks/downloads/ws/whats/>

Using Rational HATS, you can reuse your existing assets in the following innovative ways:

- ▶ Terminal applications
 - Transforms the user interface of your 3270 and 5250 green-screen applications.
 - Allows tunable default rendering of all non-customized panels of the application.
 - Transforms specific panels by using panel customizations and transformations.
 - Transforms terminal application components, such as function keys and menu items, into intuitive links, buttons, or text with images.

- ▶ Web services
 - Extends 3270, 5250, and VT application core business logic as web services or JavaBeans.
 - Captures panel flows, inputs, and outputs with a wizard-based macro recorder. You can edit what is captured by using the Visual Macro Editor, and create integration objects and web services from the panel flows.
 - Reuses terminal application business logic in new business processes and applications.
- ▶ Customization
 - Provides customizable workflow and application navigation.
 - Rational HATS simplifies panel navigation with macros and panel combinations.
 - Uses global variables to store data, pre-fill drop-down menus or windows, and inputs information for the user.
 - Can transform a text-based user interface with a rich set of GUI widgets, such as drop-down menus, calendars, tables, windows, and radio buttons.
 - Using business logic, Rational HATS augments terminal applications by aggregating terminal application data with other data sources.
- ▶ Rational HATS Toolkit
 - Provides wizard-based visual development, including visual page design and macro editing.
 - Works with a supported Rational IDE environment, such as Rational Application Developer for WebSphere Software, Rational Business Developer, or Rational Developer for i V9.0 + Modernization Tools, EGL Edition.
 - Provides access to standard Eclipse features, such as Java development tools.
 - Features a wizard-based development process for creating Rational HATS applications.
- ▶ Deployments
 - Routes applications to WebSphere Application Server and WebSphere Portal Server, and a number of devices and clients.
 - Creates standard web applications for deployment to WebSphere Application Server.
 - Customizes portlets with the Rational HATS Toolkit for deployment to WebSphere Portal Server.
 - Optimizes web applications for mobile devices running Apple iOS or Microsoft Windows Mobile.
 - Creates a standard Eclipse rich client application for deployment to IBM Lotus Notes, Lotus Expeditor, or Eclipse Rich Client Platform.

For more information about the Rational HATS product, see the following websites:

- ▶ Rational HATS product website:
<http://www.ibm.com/software/products/us/en/rhats>
- ▶ IBM Knowledge Center:
<http://www.ibm.com/support/knowledgecenter/api/redirect/hatshelp/v90/index.jsp>

9.3.6 IBM Rational Application Management Toolset for i

Rational Application Management Toolset for i provides IBM i system administrators and other advanced users with a lightweight set of tools for the common tasks of working with library file system objects and for creating and maintaining Command Language (CL) programs.

Application Management Toolset for i is a subset of the Application Development Toolset (ADTS), which is sold as part of WebSphere Development Studio for i V6.1 or as part of Rational Development Studio for i V7.1. Two of the key components of ADTS are Programming Development Manager (PDM) and Source Entry Utility (SEU).

In Version 7.2, the original product 5761-AMT was migrated to product 5770-AMT.

The new Application Management Toolset for i includes these two components, in modified form, as shown in Figure 9-15.

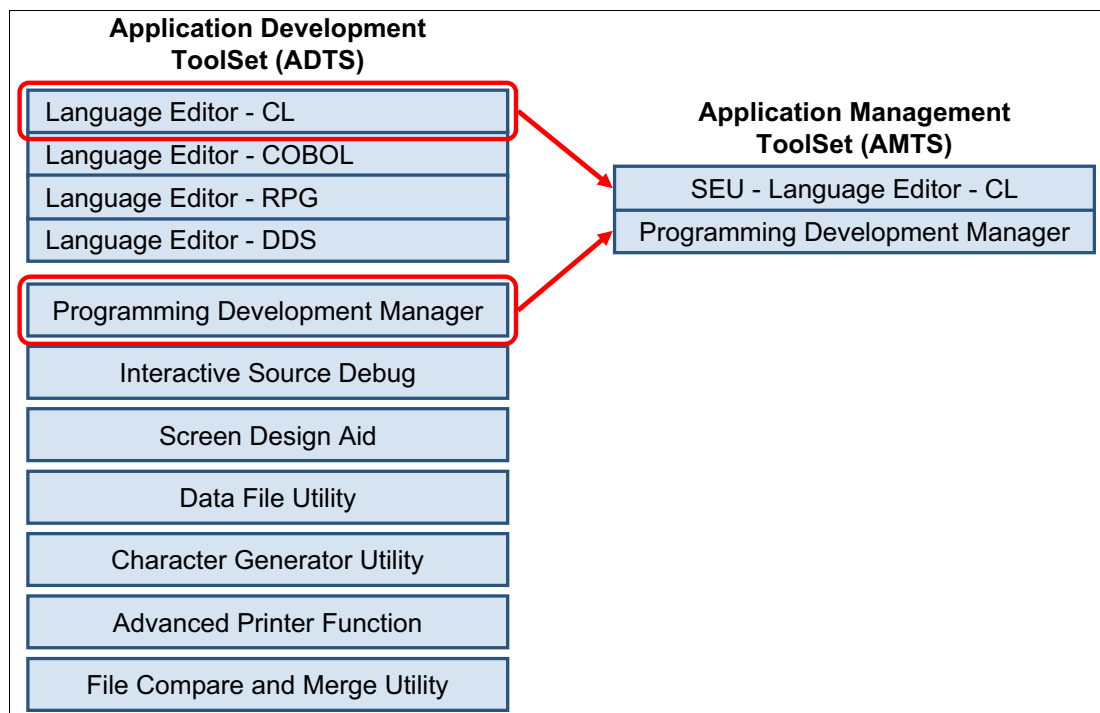


Figure 9-15 Application Management Toolset for i includes modified components of ADTS

The version of SEU that is included in Application Management Toolset for i supports only editing of the CL source. It does not support editing of source members that are written in other languages, such as RPG, COBOL, C, C++, or DDS. Like SEU, this editor provides language-sensitive features, such as syntax checking and prompting for CL source members.

Application Management Toolset for i supports the operating system member types CL, CLLE, CLP, TXT, and CMD in the **EDTCLU** (same as **STRSEU**) CL command.

The version of PDM that is included in Application Management Toolset for i can be used to browse, move, filter, and manipulate objects of any type, but it enables only software development options (such as Edit and Compile) for CL objects.

Application Management Toolset for i supports the following functions from PDM:

- ▶ All the menu functions of **STRPDM** (new CL command **STRAMT**)
- ▶ All the functions of **WRKLIBPDM** (new CL command **WRKLIBAMT**)

- ▶ All the functions of **WRKOBJPDM** (new CL command **WRKOBJAMT**), including **FNDSTRPDM** (new CL command **FNDSTRAMT**), except for the following functions:
 - No option 18 to call DFU.
 - No option 34 to call ISDB.
 - No option 54 to call CMPPFM.
- ▶ All the functions of **WRKMGRPDM** (new CL command **WRKMGRAMT**), including **FNDSTRPDM** (new CL command **FNDSTRAMT**), with the following exceptions:
 - Option 2 (Edit) uses the new command **EDTCLU**, which supports only the CL, CLLE, CLP, TXT, and CMD member types.
 - No option 17 to call SDA.
 - No option 19 to call RLU.
 - No option 54 to call CMPPFM.
 - No option 55 to call MRGSRC.

None of the other components from ADTS are included with Rational Application Management Toolset for i.

Rational Application Management Toolset for i licensing

IBM Rational Application Management Toolset for i V7.2 (5770-AMT) is licensed per processor, for unlimited usage on that processor by any number of persons. The license is priced according to the software tier of the machine on which Rational Application Management Toolset for i is used.

Like WebSphere Development Studio for i and Rational Development Studio for i, ongoing maintenance and support costs for Rational Application Management Toolset for i are included in the IBM i system Software Maintenance agreement (SWMA).

Rational Application Management Toolset for i requirements

Here are the Rational Application Management Toolset for i requirements:

- ▶ Hardware requirements:
 - IBM Rational Application Management Toolset for i V6.1 supports all the hardware models that support IBM i 6.1 and IBM i 7.1.
- ▶ Software requirements:
 - Rational Application Management Toolset for i V6.1 supports IBM i 7.2.

Accessing Rational Application Management Toolset for i

The main menu for Rational Application Management Toolset for i (AMT) (Figure 9-16) can be accessed by running **STRAMT**.

```
Application Management Toolkit (AMT)

Select one of the following:

    1. Work with libraries
    2. Work with objects
    3. Work with members

    9. Work with user-defined options

Selection or command
====>

F3=Exit      F4=Prompt    F9=Retrieve   F10=Command entry
F12=Cancel   F18=Change defaults
```

Figure 9-16 Main menu for Rational Application Management Toolkit for i

9.3.7 ARCAD Pack for Rational

ARCAD Pack for Rational provides modern development enhancements to Rational Team Concert and Rational Developer for i. Designed to complement these Rational products, ARCAD Pack provides a modern collaborative development environment, supporting both agile and traditional methods. ARCAD Pack for Rational uses deep dependency analysis to provide audit, impact analysis, and intelligent build and deployment capabilities, and also allows RPG code to be converted to the latest free-format RPG specifications.

ARCAD Pack for Rational helps IBM i development teams deliver high-quality software faster based on six main components:

► ARCAD-Observer

ARCAD-Observer brings easy-to-use application intelligence for maintaining and transferring knowledge of existing systems. ARCAD-Observer references all dependencies between applications and components down to the field and source line level, whatever language is used. You can use this solution to analyze the information flow across processes, produce data models, perform cross-platform impact analysis, and quickly identify business rules that are contained in the code. The built-in editor displays information as graphics that can be enhanced and included in documentation.

► ARCAD-Builder

ARCAD-Builder automates 100% of the build process for any type of IBM i component. Executable code is re-created without any manual intervention and ensures that there is no regression.

► ARCAD-Deliver

ARCAD-Deliver coordinates deployment of all platform components in a single transfer operation. With this solution, you can manage a deployment process from a central console and deploy any type of files to any number of target servers that run IBM i, AIX, UNIX, Linux, and Windows operating systems.

▶ ARCAD-Audit

ARCAD-Audit provides IBM i code audit and restructuring. ARCAD-Audit identifies the following items:

- Multiple copies of the same code
- Which objects are used in production
- Source without objects
- Objects without source
- A source with a date later than the object
- Unused objects

▶ ARCAD-Converter

You can use ARCAD-Converter, which works as a plug-in of Rational Developer for i, to convert fixed-form RPG sources to free-form RPG sources with the latest compiler specs. This solution supports both on-demand (statement-by- statement) and bulk conversions to accelerate the modernization of RPG code.

▶ CASE and 4GL support

CASE and 4GL support allows CASE/4GL, such as CA 2E (Synon), JD Edwards (JDE), LANSAS, and Adeliathe, to be managed.

For more information about ARCAD Pack for Rational, see *Modernizing IBM i Applications from the Database up to the User Interface and Everything in Between*, SG24-8185, and the following website:

<http://arcadsoftware.com/>

9.4 Portable Applications Solutions Environment

There are two new enhancements for PASE:

- ▶ PASE now supports programs that are compiled for AIX 7.1.
- ▶ A new version of OpenSSL 1.0.1g is included in IBM Portable Utilities for i 7.2 (5733-SC1).

9.5 Ruby on Rails for i

PowerRuby is a freely available and commercially supported port of the Ruby language. It is a web application development framework (Rails) that is written in the Ruby language. This product is available for download from the following website:

<http://powerruby.com/>

9.6 Zend and PHP on IBM i

PHP Hypertext Preprocessor (PHP) is an open source scripting language that is designed for web application development and enables simple scripting.

PHP applications are easily integrated with data in IBM DB2 for i, RPG, COBOL, and other business applications that are running on IBM i.

PHP is used for content management, customer relationship management, database access, e-commerce, forums, blogs, wikis, and other web-based applications.

Zend and IBM worked together to deliver Zend Solutions for IBM i, a complete PHP development and production environment solution for the IBM i platform.

Here are the Zend Solutions for IBM i:

- ▶ Zend Server Basic Edition for IBM i (1-year Basic Support from Zend)
- ▶ Zend Server Professional Edition for IBM i
- ▶ Zend Server Enterprise Edition for IBM i
- ▶ Zend Studio for IBM i (1 year of Basic Support from Zend)
- ▶ Zend DBi

Tip: Use always the distribution that is downloaded from Zend website. It contains the most up-to-date version of Zend Server Community Edition.

Zend Server Version for IBM i version 8 and 8.5 supports IBM i 7.2:

http://files.zend.com/help/Zend-Server/content/system_requirements.htm

For more information about Zend products, go to the Zend website:

<http://www.zend.com/en/solutions/modernize-ibm-i>

Figure 9-17 shows the Zend application development and deployment architecture for IBM i.

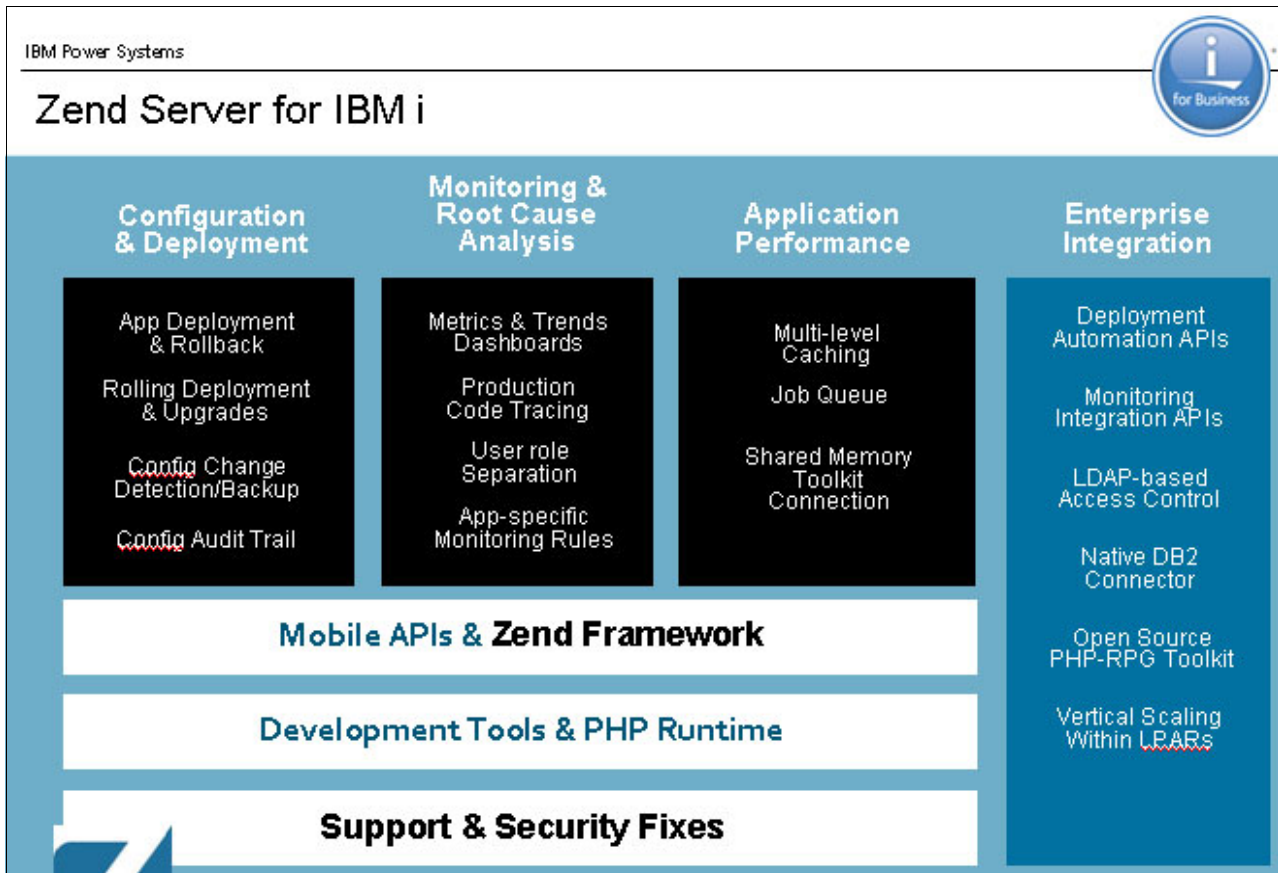


Figure 9-17 Zend PHP application development and deployment architecture for IBM i

The following topics are covered in this section:

- ▶ 9.6.1, “What is new in Zend Server V8 and V8.5” on page 465
- ▶ 9.6.2, “Zend Server Basic Edition for IBM i” on page 466
- ▶ 9.6.3, “Zend Server Professional and Enterprise Edition for IBM i” on page 466
- ▶ 9.6.4, “Zend Studio for IBM i” on page 466
- ▶ 9.6.5, “Zend DBi and PHP database support” on page 468

9.6.1 What is new in Zend Server V8 and V8.5

Zend Server V8 contains the following new functions:

- ▶ Delivers in-context insight into your PHP applications
- ▶ Provides extra specific details for applications such as Magento, Drupal, and Wordpress, and frameworks such as Zend Framework, Symfony, and Laravel
- ▶ Enables debugging of mobile and web services requests originating from a browser, mobile, or device-to-device communications
- ▶ Provides URL insight on your slowest and worst-performing pages
- ▶ Other new features and enhancements include:
 - PHP 5.5 and 5.6 support
 - Apigility included in Zend Server Support SLA
 - A new SDK library for all Zend Server APIs and command-line tools

Zend Server V8.5 contains the following new functions:

- ▶ The Gallery of community-driven add-ons aggregates and organizes all Z-Ray extensions and Zend Server plug-ins in an easy-to-use interface. This release introduces new plug-ins for Joomla, Doctrine2, Redis, OPcache, MariaDB, and LoS Modules, in addition to plug-ins for WordPress, Drupal, Magento, Zend Framework, Apigility, Laravel, and Symfony.
- ▶ Enhanced Job Queue with support for multiple-queues management. You can schedule jobs based on time, priority, and even dependencies. You can defer jobs or run periodically and run in parallel. The management GUI tracks the execution of jobs, their status, execution time, and output. Unlike cron jobs, Job Queue allows asynchronous execution, deferred jobs, and more. Multiple-queues management facilitates the creation and management of groups of jobs that are functionally or logically related.
- ▶ The Live Support function makes it easier to troubleshoot problems with live users in real time, addressing issues that are not otherwise visible or reproducible. A specific user’s session can be Z-Ray enabled, tracked, and analyzed without exposing any sensitive information. The combination of these two features allows developers to get deep insights into a specific user’s requests without affecting the overall server performance and without disclosing sensitive information.
- ▶ Redesigned UI for a superior user experience. Includes a new menu structure, and a more modern look and feel.
- ▶ A built-in understanding of application request routing logic aggregates monitoring events, and displays improved results for URLs listed within URL Insight.

- ▶ Enhanced Xdebug support. You can now easily select your preferred debugger and configure specific connection settings per debugger (Xdebug and Zend Debugger).
- ▶ Other new features and enhancements include:
 - Notifications about the environment are displayed directly in Z-Ray.
 - Improved performance and lower memory consumption.
 - Increased granularity control of the data that is collected by Z-Ray.
 - New plug-ins display with multiple panels now consolidated under one top-level panel.
 - New capability to perform server-side actions from Z-Ray.
 - New added support for application independent plug-ins, such as Amazon EC2.
 - New support for Microsoft Azure.

9.6.2 Zend Server Basic Edition for IBM i

Zend Server Basic Edition is a fully tested and enhanced version of open source PHP. It provides the PHP run time and is packaged to make the software installation easier and faster by using the instant PHP setup. It is enhanced to take advantage of IBM i specific resources and capabilities.

Zend Server Basic Edition for IBM i is a lightweight version of Zend Server, and replaces Zend Community Edition. This edition has a minimal feature set for running your PHP applications.

9.6.3 Zend Server Professional and Enterprise Edition for IBM i

Zend Server Professional and Enterprise Edition is a robust PHP production environment that helps ensure that applications that are written in PHP run smoothly at all time. It is designed for IT personnel and businesses that require commercial-grade web applications in highly reliable production environments.

Zend Server replaces the Zend platform. It offers all the features that are provided in Zend Server Basic Edition for IBM i.

The following website shows a comparison between the features that are offered in Zend Server Basic Edition for IBM i and Zend Server Professional and Enterprise for IBM i:

<http://www.zend.com/en/products/server/editions-ibm-i-production-new>

9.6.4 Zend Studio for IBM i

Zend Studio for IBM i is an industry-leading Eclipse-based PHP integrated development environment (IDE) for professional developers. It includes all the development components that are necessary for the full PHP application lifecycle and simplifies complex projects. It supports development for mobile devices and for using PHP REST XML Web Services.

Zend Studio for IBM i V12.5 includes the following features and enhancements:

- ▶ The new version includes a whole new way to set up remote debugging. If you have multiple servers that are configured locally, in the cloud, or remotely on an intranet, you can configure the debugger separately for each particular server and define the connection settings through the server creation and edit wizard.
- ▶ There is support for PHPUnit 4 for effective integration testing and simplified unit tests to make sure that your code is stable and functioning correctly.
- ▶ There is support for the latest version of Apigility so you can build, test, and debug your APIs more efficiently.
- ▶ There is content assist for Magento and Doctrine, Angular JS Explorer View, Markdown Editor, and GitHubMylyn Integration that allows you to use a GitHub repository to store and retrieve Mylyn tasks. Additional improvements include upgraded installation packages with built-in JRE so you do not have to preinstall it, the font size plug-in, and many performance and quality improvements.
- ▶ You can develop client-side applications with AngularJS, which is the open source web application framework from Google. Zend Studio takes full advantage of the framework client-side model-view-controller (MVC) architecture.
- ▶ You can create hybrid mobile applications with the integrated Ionic framework. Ionic offers a library of mobile-optimized HTML, CSS, and JS components, gestures, and tools for building highly interactive apps.
- ▶ You can code mobile applications all in HTML/CSS/JS from within Studio with Cordova. Apache Cordova is a set of device APIs that allow a mobile application developer to access native device functions from JavaScript.
- ▶ You can get full support for PHP 5.6. Zend Studio takes full advantage of the new PHP features, such as constant scalar expressions, variadic functions, phpdbg, large file uploads, gost-crypto hash algorithm, and more.
- ▶ You can discover hidden bugs and performance issues by using your browser and then open a debugging or profiling session directly from Z-Ray to fix the uncovered issues by using Zend Studio. Leverage Z-Ray Live! to get information about your application performance from mobile devices and address them with Studio. With Z-Ray Live!, you can debug mobile and web services API calls with Z-Ray Live! You have all the advantages of Z-Ray for debugging requests originating from native mobile clients and other non-browser sources.
- ▶ Manage easily all your frameworks, libraries, assets, and utilities with the integrated Bower framework. Bower works by fetching and installing packages from all over, taking care of hunting, finding, downloading, and saving the items that you are looking for. It provides hooks to facilitate using packages in your tools and workflow. Bower is optimized for the front end. It uses a flat dependency tree, requiring only one version for each package, reducing page load to a minimum.
- ▶ Zend Studio lets you deploy your PHP application on any server. In addition, you can take full advantage of the cloud with the Amazon AWS Zend certified PHP stack offering, which is an instantly available, consistent PHP environment that provides a cloud-based Zend Server. Zend Studio also works with other leading cloud platforms, such as IBM Bluemix and SoftLayer®, Red Hat OpenShift, and Microsoft Azure. You can easily deploy your PHP applications on these public or private platforms by using the built-in cloud deployment integration function.

- ▶ You can extend PHP code to access IBM i resources. The newly integrated Toolkit is designed to work either statelessly or statefully. Its stateful abilities enable developers to call RPG/COBOL/CL programs and APIs while retaining cursors, library lists, the QTEMP library, and more, to enable reuse of existing programs for web applications.
- ▶ Zend Studio is built on top of the Eclipse 4 Luna platform and benefits from many new enhancements that are included in the new platform.

Zend Studio for IBM i V13 includes the following features and enhancements:

- ▶ Zend Studio ships with the most complete PHP 7 support to date. It supports the newest scripting concepts in PHP 7, such as Return Type Declarations, Anonymous Classes, the Spaceship Operator, Group Use Declarations, Scalar Type Hints, and more.
- ▶ Zend Studio includes support for PHP 7 Express. The new built-in migration tool assistant makes the transition to PHP 7 easier and faster. This new tool scans existing projects for compatibility issues such as - removed and deprecated usages, or new reserved words in PHP 7. It points developers to the exact line of code where the issue is and suggests quick fixes.
- ▶ Zend Studio includes new Docker tools that support the management of Docker Images and Containers. It integrates with existing PHP tools, which allows running, testing, and debugging PHP applications on Docker Containers with a PHP stack.
- ▶ Zend Studio supports EGit 4.0 tools. One of the highlights in this new version is the support for the Git Flow branching model, which is used among PHP developers.
- ▶ This new version of Zend Studio is based on the latest version of Eclipse Mars 4.5.1. Developers already using Eclipse as a development platform will welcome the addition of a dedicated Zend Studio 13 plug-in that can be installed directly from within their development environment.
- ▶ A new debugging workflow design makes debugging easier. Zend Studio automatically detects the installed debugger for local and remote servers and helps configure the client IPs for debugging. Redundant client IPs are detected and removed while invalid or inaccessible IPs are reported. When adding a PHP server, Zend Studio automatically provides the “best match” client IP. Also, Zend Debugger tunneling configuration can now be set up in debugger client settings for a PHP server.

For more information about the enhancement of Zend Studio for IBM i, see the following Zend website:

<http://www.zend.com/en/solutions/modernize-ibm-i>

9.6.5 Zend DBi and PHP database support

The Zend DBi product provides MySQL implementation for IBM i. DB2 Storage Engine enables MySQL data storage in DB2.

Zend DBi is supported only for IBM i. 6.1 and 7.1.

Zend DBi supports open source-based applications. An application uses MySQL data commands against Zend DBi or a MySQL database, the storage engine translates the commands, and then passes the data to DB2 for i. With this solution, there is only one database to manage, back up, and protect.

Figure 9-18 on page 469 shows an overview of Zend DBi and MySQL using the DB2 Storage engine.

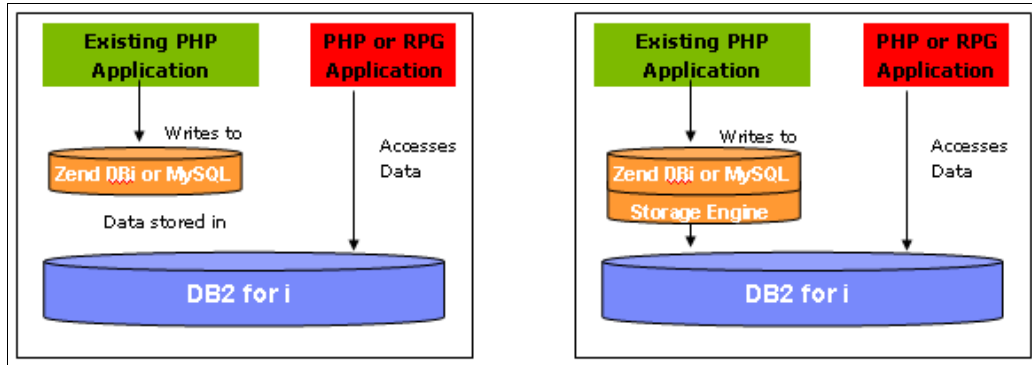


Figure 9-18 Zend DBi and MySQL using a DB2 Storage engine

PHP now supports the following database connectivity:

- ▶ Local DB support for MySQL and DB2
- ▶ Remote DB support for MySQL and Oracle

For more information about Zend products for IBM i, see the following websites:

- ▶ Zend and IBM i:
<http://www.ibm.com/systems/power/software/i/php/index.html>
- ▶ Zend Studio:
<http://www.zend.com/en/products/studio/>
- ▶ Zend DBi:
<http://www.zend.com/en/solutions/modernize-ibm-i>

9.7 Mobile application development for IBM i

Mobile support is described in several chapters and sections in this book. If we speak about mobile support, we speak either about system management or mobile support in application development tools that enables the development of mobile applications in connection with IBM i. The following products now support mobile access application development:

- ▶ RPG Open Access
- ▶ XML Services
- ▶ JTOpen Lite
- ▶ PHP - Zend Server for IBM i and Zend Studio
- ▶ IBM Connections™ 5.0
- ▶ IBM Notes Traveler 9.0.1
- ▶ IBM Mobile Database
- ▶ DB2 WebQuery
- ▶ Rational HATS

IBM i Mobile Access enables IBM i users to access IBM i resources from web-enabled mobile devices in a mobile-friendly view by using a mobile web browser. For more information about this topic, see 2.2.4, “IBM i Mobile Access” on page 152.

9.8 Open Source for IBM i

Open Source for IBM i (5773OPS) is new license program option. It provides many of the open source technologies for IBM i. The world of open source continues to rapidly evolve and change. Recently, there were many Open Source Technologies added to IBM i. This section explains the enhancements of Open Source for IBM i.

The following topics are covered in this section:

- ▶ 9.8.1, “Node.js” on page 470
- ▶ 9.8.2, “Python” on page 471
- ▶ 9.8.3, “GNU Compiler Collection” on page 472

You can obtain new Licensed Program 5770OPS as ISO images from the IBM Entitled Software Support (ESS) website. The 5770OPS package is titled F_MLTI_NLV_110_IBM_i_Open_Source_Solutions. You can download it from the 5770SS1 section.

The ESS website is at:

<https://www.ibm.com/servers/eserver/ess/index.wss>

9.8.1 Node.js

Node.js is an open source project based on Google Chrome V8 Engine. It provides a platform for server-side JavaScript and networking applications. Node.js applications are written in JavaScript, but run without browsers. The event-driven, non-blocking I/O model makes it lightweight and efficient to use. It also provides several built-in modules to simplify programming, especially for networking applications. There are many third-party modules that can be easily installed with the built-in npm (node packaged modules) tool to extend Node.js.

Figure 9-19 shows an overview of Node.js converting JavaScript code into machine code.

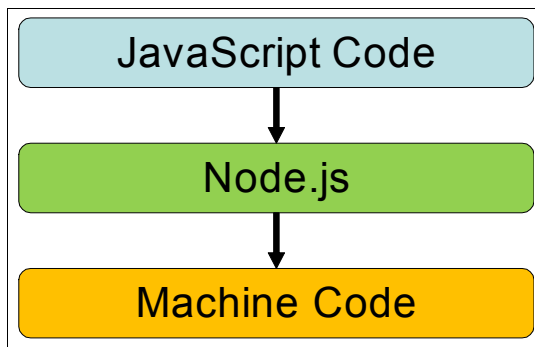


Figure 9-19 Node.js engine converts the JavaScript into machine code

Node.js is now delivered as Open Source for IBM i (5773OPS) Option1. This new offering includes the following functions:

- ▶ DB2 for i access library
- ▶ Node.js toolkit for IBM i

Licensed program prerequisites

To install Node.js on IBM i V7.2, the following licensed programs are required:

- ▶ 5770SS1 Option 33, Portable Application Solutions Environment
- ▶ 5733SC1 Option 1, OpenSSH, OpenSSL, zlib
- ▶ 5770DG1 *BASE, IBM HTTP Server for
- ▶ 5733OPS Option 1, Node.js run time for IBM i

PTF prerequisites

To install Node.js on IBM i V7.2, the following PTFs are required:

- ▶ SI55606 for 5733SC1
- ▶ SI55747, SI55763 for 5733OPS
- ▶ SF99713 level 6: HTTP Server Group PTF

Note: Upgrade to the latest HTTP Server PTF Group level because all updates for 5733OPS are provided in the HTTP Server Group PTF.

For more information about installing and managing Node.js, see IBM developerWorks:

- ▶ <https://www.ibm.com/developerworks/ibmi/library/i-native-js-app-ibmi-with-nodejs/>
- ▶ <http://www.ibm.com/support/docview.wss?uid=na8N1020583>

DB2 for i access library

The DB2 for i access library is a JavaScript API for DB2 database manipulation on IBM i. It provides JavaScript interfaces that correspond to the DB2 for i SQL call-level interface (CLI). DB2 for i access library is shipped with Node.js for IBM. The DB2 for i access library is in the following directory:

```
/QOpenSys/QIBM/ProdData/Node/os400/db2i/
```

For more information about using the DB2 for i access library, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/DB2%20for%20i%20access%20APIs>

Node.js Toolkit for IBM i

The Node.js Toolkit for IBM i API set is based on XMLSERVICE to easily access IBM i native objects, such as PTF information, data queues, and programs. Node.js Toolkit for IBM i is shipped with Node.js for IBM i. Node.js Toolkit for IBM i is in the following directory:

```
/QOpenSys/QIBM/ProdData/Node/os400/os400/
```

For more information about using the Node.js Toolkit for IBM i, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Toolkit%20for%20i%20APIs>

9.8.2 Python

Python is now being delivered and packaged for IBM i. It is available as the Open Source for IBM i (5773OPS) Option 2. Python is a high-level programming language. It is easily extensible through the use of third-party packages and often allows powerful functions to be written with few lines of code. Python caters to multiple programming styles (object-oriented, procedural, and so on) and the code tends to be readable and maintainable.

This Python offering contains the Python 3.4.2 run time, which installs to the following directory:

/QOpenSys/QIBM/ProdData/OPS/Python3.4

Licensed program prerequisites

To install Python on IBM i V7.2, the following licensed programs are required:

- ▶ 5770SS1 Option 33, Portable Application Solutions Environment
- ▶ 5733SC1 Option 1, OpenSSH, OpenSSL, zlib
- ▶ 5733OPS Option 2, Python run time for IBM i

PTF prerequisites

To install Python on IBM i V7.2, the following PTFs are required:

- ▶ SI57008 for 5733OPS (or its latest superseding PTF)
- ▶ Latest PTFs for 5733SC1
- ▶ SI57253 for using DB2 for i connector add-ons (or its latest superseding PTF)
- ▶ SI57254 for using Toolkit for IBM i add-ons (or its latest superseding PTF)
- ▶ SI57255 for using fastCGI gateway add-ons (or its latest superseding PTF)
- ▶ SI57256 for using lightweight web framework add-ons (or its latest superseding PTF)

For more information about installing and managing Python, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Python>

9.8.3 GNU Compiler Collection

The GNU Compiler Collection (GCC) and Open Source development toolkit is now delivered as The Open Source for IBM i (5773-OPS) Option3. GCC compiler is a part of the Free Software Foundation's GNU Project. The GCC compiler supports many languages, such as C, C++, and Java. Open source software is designed to be compiled by the GCC compiler; the software does not always compile successfully under the XLC compiler. By using the GCC compiler, you can get open source software to run on an IBM POWER® chip more easily.

9.9 Samba on IBM i

The open source Samba package is now available for IBM i. File serving, something that has been on IBM i for a long time, is provided with IBM i NetServer. IBM i NetServer has many great features when it comes to file serving, although in some instances performance has been an issue. Samba is a server that uses TCP/IP on IBM i to interact with Windows clients or servers as through it is a Windows file and print server. Samba is not intended to be a full replacement for file serving on IBM i, but rather give customers an additional option. For example, Samba does not support Kerberos, automatic CCSID conversions, or integration with IBM i auditing exit programs. For those features, IBM i NetServer is the preferred choice. But, if you require just basic file serving with performance, then Samba might be the preferred way for you.

PTF prerequisites

To install Samba on IBM i V7.2, you must install the SI52624 for 5770SS1 PRF (Cumulative PTF C4101720 contains this fix).

Installing this PTF places the Samba 3.6 package and installer archive file (samba.zip) into the IFS directory. The package can then be extracted to the current directory for installation by running it. To install Samba package on IBM i, run the following command from a PASE command prompt:

```
jar xvf /QIBM/ProdData/OS/Samba.zip
```

For more information about installing and managing Samba on IBM i, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/SAMBA%20on%20IBM%20i>



IBM i server functions

This chapter describes enhancements to the following IBM i server functions:

- ▶ 10.1, “IBM HTTP Server for i” on page 476
- ▶ 10.2, “IBM i Integrated Web Application and Web Services Server” on page 480
- ▶ 10.3, “IBM WebSphere Application Server” on page 484
- ▶ 10.4, “IBM Social Collaboration products” on page 487
- ▶ 10.5, “IBM Printing” on page 487

For more information about the IBM i 7.2 enhancements, see the IBM i Technology Updates developerWorks wiki:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20i%20Technology%20Updates>

10.1 IBM HTTP Server for i

IBM HTTP Server for i (5770-DG1) provides the facility of web serving in IBM i. The implementation of this HTTP server is based on open source server code that is provided by the Apache Software Foundation. This section explains the enhancements of IBM HTTP Server for i in IBM i 7.2.

10.1.1 Licensed program requirements

Here are the licensed program requirements for using IBM HTTP Server for i in IBM i 7.2:

- ▶ Extended Base Directory Support (5770-SS1 Option 3)
- ▶ Host Servers (5770-SS1 Option 12)
- ▶ Qshell (5770-SS1 Option 30)
- ▶ IBM Portable Application Solutions Environment for i (5770-SS1 Option 33)
- ▶ IBM TCP/IP Connectivity Utilities for i (5770-TC1)
- ▶ IBM Developer Kit for Java (5770-JV1 Option 11)

10.1.2 Upgraded to Apache 2.4.12

The IBM HTTP Server Power by Apache is updated to Apache level 2.4.12, which includes many new features, such as support for WebSocket. The Web Admin GUI is enhanced to include a wizard for configuring SSL for Liberty-based servers, such as the IBM i Integrated Application Server.

What is new in Apache 2.4.12

Apache 2.4.12 contains the following new functions:

- ▶ Support for WebSocket.
- ▶ Perl Compatible Regular Expressions (PCRE) regular expression is supported in the configuration file.
- ▶ A new module `mod_proxy_wstunnel` enables support for the tunneling of web socket connections to a back-end web sockets server.
- ▶ A new module `mod_proxy_html` enables an output filter to rewrite HTML links in a proxy situation to ensure that the links work for users outside the proxy.
- ▶ A new module `mod_macro` enables the specify macro in HTTP configurations.
- ▶ Server Name Indication (SNI) implementation is optimized and enhancement.
- ▶ HTTP Server prestart CGI support for IASP.
- ▶ Enhancements for serviceability, displaying CGI job information, and thread IDs in log.

For more information about the update to IBM HTTP Server for i, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/News%20of%20Web%20Integration%20on%20IBM%20i>

What is WebSocket

WebSocket is developed as part of the HTML5 initiative JavaScript interface. It defines a full-duplex, single-socket connection over the web between a browser and server. The WebSocket standard simplifies much of the complexity around bidirectional web communication and connection management. The WebSocket protocol is an independent TCP-based protocol. Its only relationship to HTTP is that its handshake is interpreted by HTTP servers as an Upgrade request. WebSocket makes more interaction between a browser and a website possible, facilitating live content and the creation of real-time applications.

Figure 10-1 shows the WebSocket architecture.

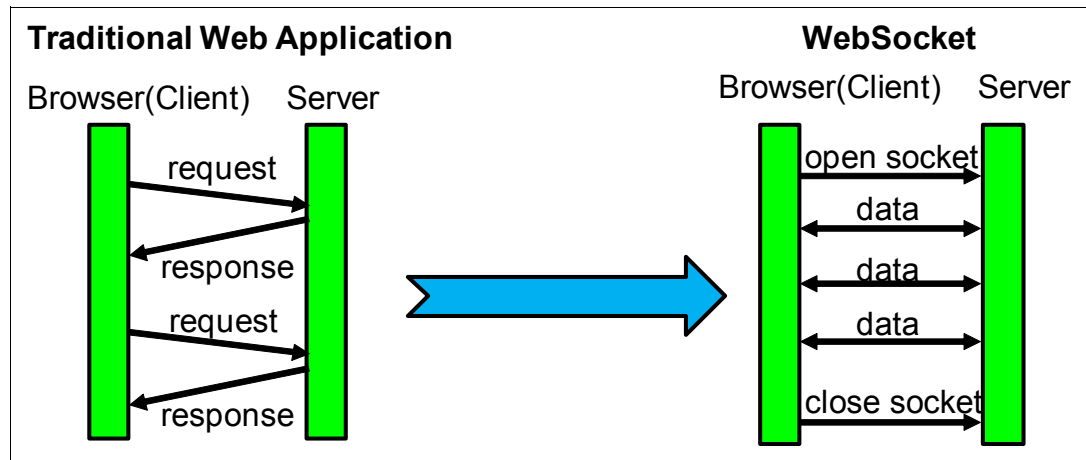


Figure 10-1 Compare WebSocket and a traditional web application

For more information and examples about WebSocket, see the following website:

<http://www.websocket.org/>

IBM HTTP Server for i in IBM 7.2 is upgraded from Apache 2.2 (as in IBM i 7.1) to Apache 2.4. Compared to Apache 2.2, this upgrade delivers significant core enhancements, new features and modules, and configuration and access control changes. All current Apache 2.4 security vulnerability issues are also fixed in IBM i 7.2.

Because IBM i 7.2 provides Apache 2.4, users are required to consider their web applications before moving from an earlier release of IBM i to IBM i 7.2. For more information about the HTTP server changes in IBM i 7.2, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaie/rzaiewhatsnew.htm

Configuration-related changes

There are some configuration-related changes in IBM i 7.2 that come with Apache 2.4. This section explains those changes that might require users to change their configuration so that they can continue to use IBM HTTP Server for i on IBM i 7.2.

Load balancing implementations moved to mod_proxy sub modules

All load balancing implementations have moved to individual, self-contained `mod_proxy` submodules, such as `mod_lbmethod_byrequests`, `mod_lbmethod_bybusyness`, and `mod_lbmethod_bytraffic`. Its default value is `byrequest`. Users might need to load one of these load balancing implementation methods that correspond to the configuration that is used.

DefaultType no longer has any effect

The `DefaultType` directive no longer has any effect other than to emit a warning if it is used with any value other than `none`. For unknown file extensions, which are not declared in `/QIBM/UserData/HTTPD/conf/mime.types` (for example, the `.mbr` files in QSYS file system), HTTP server does not add a `DefaultType (text/plain)` in the response anymore. To display these files correctly, users are now required to assign media types in IBM i 7.2, for example, `"AddType text/html .mbr`.

Options directive default value is changed

The default value of `Options` directive was changed from `All` to `FollowSymLinks`. Users must adjust their configuration because of this default value change.

Module `mod_disk_cache` is renamed

Module `mod_disk_cache` is renamed to `mod_cache_disk`. Users must replace `LoadModule disk_cache_module /QSYS.LIB/QHTTPSVR.LIB/QZSRCORE.SRVPGM` with `LoadModule cache_disk_module /QSYS.LIB/QHTTPSVR.LIB/QZSRCORE.SRVPGM`.

For more information about `mod_cache_disk`, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaie/rzaiemod_disk_cache.htm

CacheEnable directive is changed

The second parameter to `CacheEnable` in `mod_cache` matches forward proxy content only if it begins with the correct protocol. In IBM i 7.1 and earlier versions, a parameter of `'/'` matched all content. Specifying `<protocol>://` for the second parameter caches forward proxy content only from the default port of that protocol.

In IBM i 7.2, `CacheEnable disk http://` now caches HTTP forward proxy content only from port 80. Use `CacheEnable disk http://*` instead to cache HTTP forward proxy content from all ports.

FileETag default value is changed

The `FileETag` default value in Apache 2.4 is changed to `MTimeSize`, without `INode`, which exists in Apache 2.2.

Changes to `mod_dav_fs`

The format of `DavLockDB` in `mod_dav_fs` is changed for systems with inodes. The old `DavLockDB` file must be deleted on upgrade to Apache 2.4.

The `mod_deflate` option skips the compression process

`mod_deflate` can skip the compression process if it knows that the size of the increase that is added by the compression is larger than the data to be compressed.

KeepAlive value is changed

In previous releases, a `KeepAlive` value other than `Off` or `0` was treated as `On`. In Apache 2.4, `KeepAlive` accepts a value of only `On` or `Off`.

The `mod_log_config` option matches the whole cookie name

In previous releases, `${cookie}C` in `mod_log_config` matches any string. However, in Apache 2.4, `${cookie}C` matches whole cookie names.

Syntax changes in mod_filter

The FilterProvider syntax in mod_filter is changed and now uses a Boolean expression to determine whether a filter is applied.

Changes to mod_include

mod_include has undergone the following changes:

- ▶ The #if expr element now uses the new expression parser. The old syntax can be restored with the new directive SSILegacyExprParser.
- ▶ An SSI* configuration directive in directory scope no longer causes all other per-directory SSI* directives to be reset to their default values.

The mod_autoindex option extracts titles and descriptions

mod_autoindex can extract titles and display a description for .html files, which were previously ignored.

For more information about changes in IBM i 7.2 regarding Apache 2.4, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaq9/rzaq9.pdf

For more information about the new Apache 2.4 modules compared to Apache 2.2, see the Apache website developer website:

http://httpd.apache.org/docs/2.4/developer/new_api_2_4.html

For more information about IBM HTTP Server for i, see the IBM HTTP Server developerWorks website:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/IBM%20HTTP%20Server%20Upgrading%20to%20Apache%202.4>

10.1.3 IBM Web Administration for i for managing a WebSphere Application Server installation

WebSphere Application Server V8.0 and later must be installed by using IBM Installation Manager. As this tool does not have a GUI on the IBM i, IBM Web Administration for i in IBM i 7.2 (Web Admin) provides an easy-to-use GUI for managing the installation of WebSphere Application Server.

From Web Admin in IBM i 7.2, users can easily install and uninstall programs, update fix packs, apply interim fixes, and so on, by using simple wizards.

For more information about installing and managing a WebSphere Application Server installation by using IBM Web Administration for i, see the IBM developerWorks website:

http://www.ibm.com/developerworks/ibmi/library/i-webSphere_application_server_installation/

For more information about IBM HTTP Server for i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaie/rzaiemain.htm

For more information about electronic business and web serving in IBM i 7.2 by using IBM HTTP Server for i, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgebus.htm

10.2 IBM i Integrated Web Application and Web Services Server

The new IBM WebSphere Application Server Liberty Profile based IBM i Integrated Web Application Server (IAS) and IBM i Integrated Web Services Server (IWS) are introduced in IBM i 7.2. By using the IBM WebSphere Application Server Liberty Profile, benefits such as the following ones are provided to IBM i Integrated Web Application Server and IBM i Integrated Web Services Server environments:

- ▶ Ability to ensure PCI Compliance by being able to obtain and apply patches against security vulnerabilities, which are delivered as security updates for WebSphere web containers
- ▶ Easy to adopt new technologies, such as new Java virtual machines and a Web Services runtime engine
- ▶ Use common development tools, such as Rational Application Developer, for developing applications that run on IAS

10.2.1 IBM i Integrated Web Application Server

Both IBM Lightweight Infrastructure (LWI) based IAS and IBM WebSphere Application Server Liberty Profile based IAS work on IBM i 7.2. The version of LWI-based IAS is 8.1, and the version of Liberty Profile based IAS is 8.5.

Important: LWI-based IAS V8.1 is used for existing IAS instance purposes only, so you cannot create instances of LWI-based IAS on IBM i 7.2. Instead, you can create Liberty Profile based IAS V8.5 instances, and you are encouraged to use Liberty Profile based IAS V8.5 instead of LWI-based IAS V8.1. IBM provided IAS-based applications, such as DB2 Web Query for i (5733-WQX), IBM Application Runtime Expert for i (5733-ARE), and Web Admin, are already moved to Liberty Profile based IAS.

Now you can obtain Liberty Profile based IAS V8.5.5 by applying the following HTTP Server Group PTF levels:

- ▶ IBM i 7.2: SF99713 level 9 or higher
- ▶ IBM i 7.1: SF99368 level 35 or higher
- ▶ IBM i 6.1: SF99115 level 45 or higher

Figure 10-2 on page 481 shows the Create Application Server wizard in IBM Web Administration for i in IBM i 7.1 with TR8 timed HTTP Group PTFs.

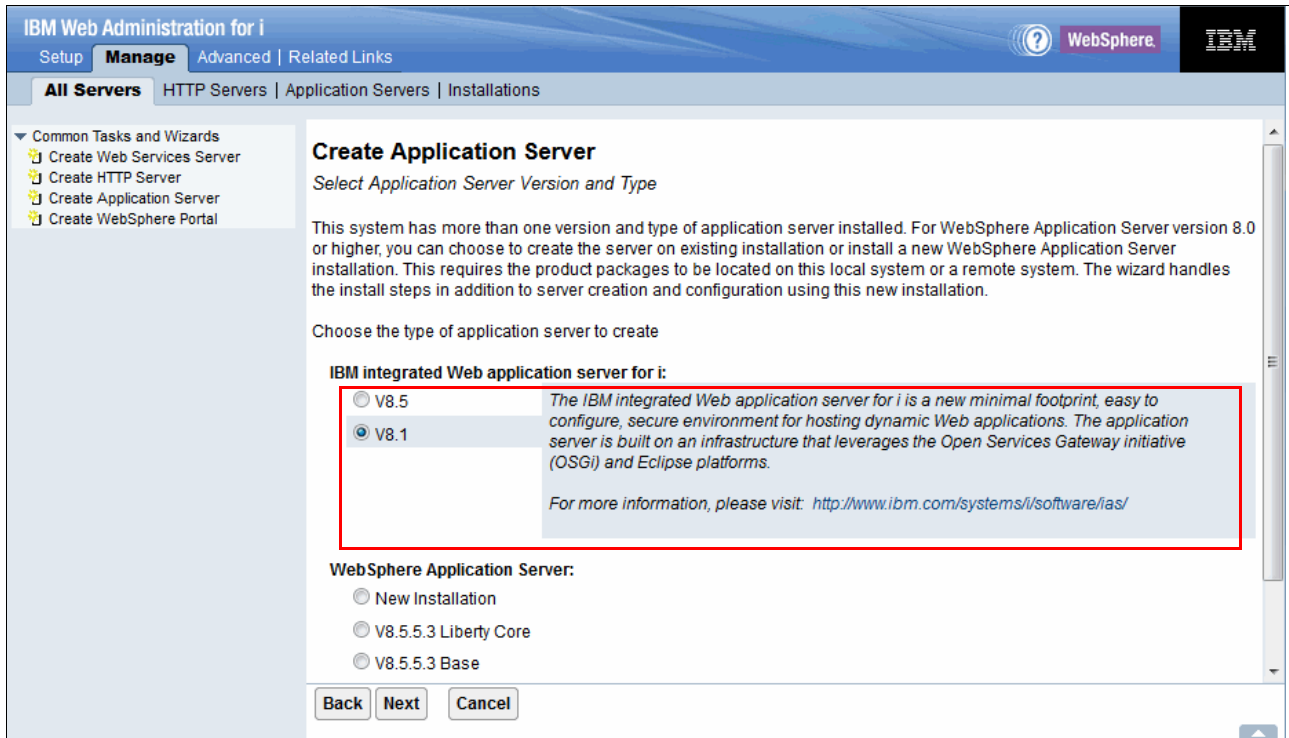


Figure 10-2 Create Application Server wizard in IBM Web Administration for i in IBM i 7.1

In this wizard, you can choose the version of IAS, both V8.1 and V8.5. In IBM i 7.2, you can create an IAS V8.5 instance only, as shown in Figure 10-3.

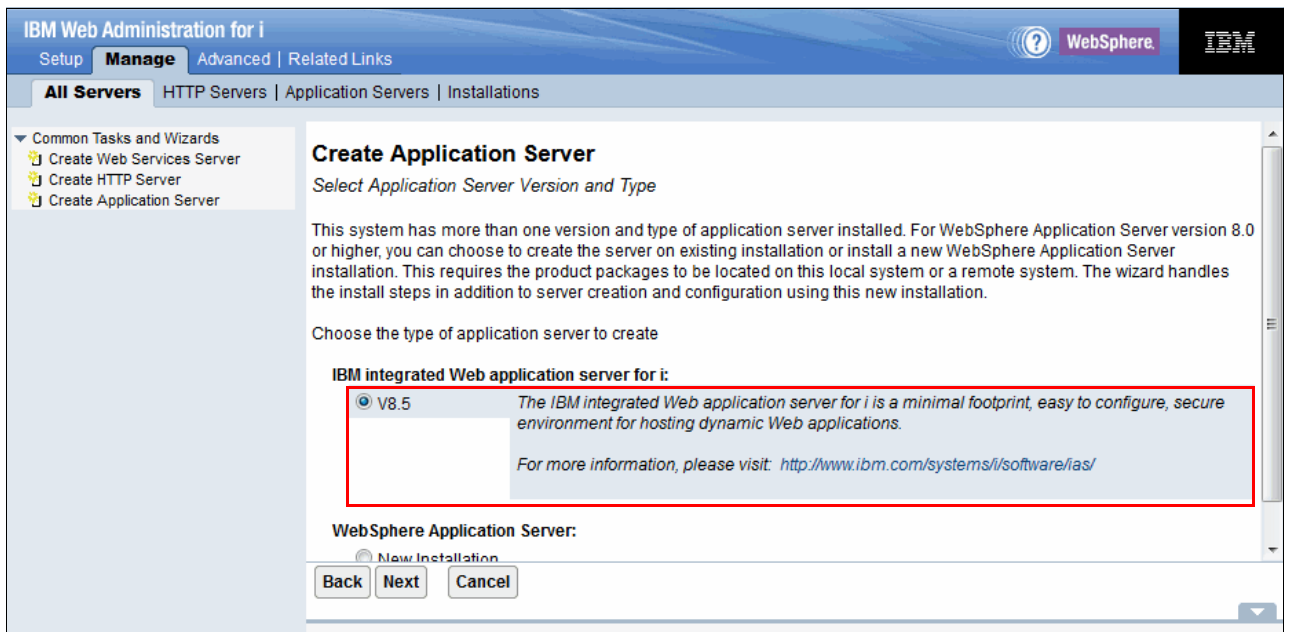


Figure 10-3 Create Application Server wizard in IBM Web Administration for i in IBM i 7.2

If you have any IAS V7.1 instances and are upgrading your IBM i to 7.2, these instances automatically are upgraded to V8.1 instances, which is LWI-based IAS, during the upgrade to IBM i 7.2.

Note: You can continue to use IAS V8.1 instances and deploy your application on those instances, but it is a preferred practice to migrate your applications to IAS V8.5 Liberty Profile based instances because the LWI-based run time will be removed in a future release. There is no automatic upgrade from IAS V8.1 to V8.5 because the run times are based on different technologies.

Note: In August 2015, support for IAS V7.1 was withdrawn. IAS V7.1 continues to run on IBM i V7.2 and previous releases, but if you encounter any problems, you cannot get any support for IAS V7.1.

For more information about IBM i Integrated Web Application Server, see IBM developerWorks:

<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/Web%20Integration%20on%20i>

10.2.2 IBM i Integrated Web Services Server

IBM WebSphere Application Server Liberty Profile based IBM i Integrated Web Services Server (IWS) is introduced in IBM i 7.2 at Version 2.6. Because IWS V2.6 is powered by Java API for RESTful Web Services (JAX-RS), IWS V2.6 supports REST services. Figure 10-4 shows a concept of IWS V2.6 REST services. IWS V2.6 is running on IAS V8.5 and sends JSON REST packets to web service requesters.

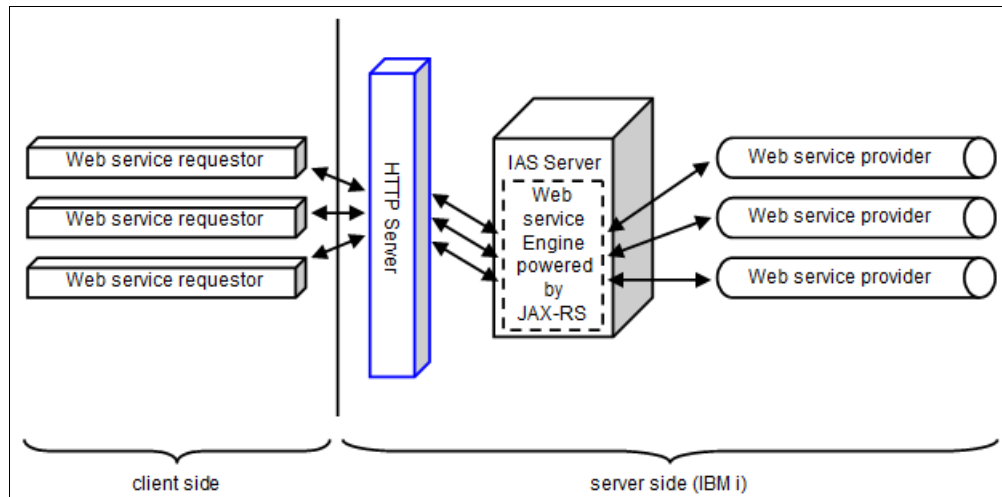


Figure 10-4 Concept of IWS V2.6 powered by Liberty Profile and JAX-RS

IWS V1.5 is also available in IBM i 7.2, which is an LWI-based web services server. If you have any existing IWS instances that are running with Version 1.3, you must upgrade those instances to IWS V1.5 by using the upgrade wizard that is part of the IBM Web Administration for i GUI. The wizard is shown in the navigation bar if the server is eligible to be upgraded.

Note: After upgrading to IWS V1.5, you can continue to use those IWS instances in IBM i 7.2, but it is a preferred practice to migrate to IWS V2.6 because the LWI-based runtime and web services will be removed in a future release.

In addition to REST support, the IWS V2.6 scripting is updated in the following ways:

- ▶ The `restoreWebServices.sh` script is enhanced to enable the migration of web services that are on an IWS server V1.5 to an IWS server that is based on Liberty. Users do not have to go through the process of reinstalling the web services manually to a new IWS server.

Note: When you move from IWS V1.5 to the newest version of IWS, Web Services Description Language (WSDL) includes the following changes:

- ▶ The schema namespace is different; only one SOAP version can be specified.
 - ▶ The URL endpoint is different.
- ▶ You can use new Qshell scripts (`saveWebServicesServer.sh` and `restoreWebServicesServer.sh`) to save IWS servers and restore the servers on another Power Systems server running IBM i. This restoration includes the deployed web services. It ensures that the corresponding back-end ILE programs are on the new system.

For more information about Integrated Web Services Server for IBM i, see the following website:

<http://www.ibm.com/systems/power/software/i/iws/index.html>

For more information about the enhancements of IWS, see the developerWorks website:

<https://ibm.biz/BdsRJ5>

Integrated web services server for IBM i updates

In July 2015, a number of enhancements about IWS servers were released. The following updates were provided:

- ▶ Support for nested output arrays
- ▶ Enabling improved processing of large output character fields
- ▶ Preserving case sensitivity of identifiers
- ▶ Preserving field ordering
- ▶ Enabling of RESTful services to return user-defined media types
- ▶ Allowing for new transport metadata values to be passed to a web service
- ▶ Installing a web service script that is updated for SOAP services
- ▶ Allowing Java based web services

PTF prerequisites

To get the IWS servers updates, you must apply the following HTTP Server Group PTFs:

- ▶ IBM i 7.2: SF99713 level 9 or higher
- ▶ IBM i 7.1: SF99368 level 35 or higher
- ▶ IBM i 6.1: SF99115 level 45 or higher

Note: The above updates apply to IWS V2.6 or later, except for the install web service enhancement, which applies to all version of IWS servers. In addition, you cannot get the REST updates in IBM i V6.1 because IBM i V6.1 does not support REST services.

For more information about IWS servers updates, see IBM developerWorks:

<http://www.ibm.com/developerworks/ibmi/library/i-integrated-web-services-server/index.html>

For more information about REST service with IWS, see IBM developerWorks:

<https://www.ibm.com/developerworks/ibmi/library/i-rest-web-services-server1/>

10.3 IBM WebSphere Application Server

WebSphere Application Server is the leading open standards-based application foundation, offering accelerated delivery of innovative applications and unmatched operational efficiency, reliability, administration, security, and control on IBM i. This section covers the following topics:

- ▶ “Supported WebSphere Application Server versions on IBM i 7.2”
- ▶ “WebSphere Application Server Liberty Core packaging” on page 485
- ▶ “WebSphere Application Server Liberty Profile” on page 486
- ▶ “Installation of WebSphere Application Server to IBM i” on page 486
- ▶ “Upgrading to IBM i 7.2” on page 486

10.3.1 Supported WebSphere Application Server versions on IBM i 7.2

On IBM i 7.2, the following package options of WebSphere Application Server are supported:

- ▶ IBM WebSphere Application Server Express V8.0/V8.5
- ▶ IBM WebSphere Application Server Base V8.0/V8.5
- ▶ IBM WebSphere Application Server Network Deployment V8.0/V8.5
- ▶ IBM WebSphere Application Server for Developers V8.0/V8.5
- ▶ IBM WebSphere Application Server Liberty Core V8.5.5

Note: WebSphere Application Server V6.1 and V7.0 are not supported on IBM i 7.2. If you have these WebSphere Application Server environments on IBM i, you also must migrate your WebSphere Application Server to the appropriate versions when upgrading to IBM i 7.2.

Figure 10-5 on page 485 shows a high-level view of the packaging options of WebSphere Application Server for IBM i.

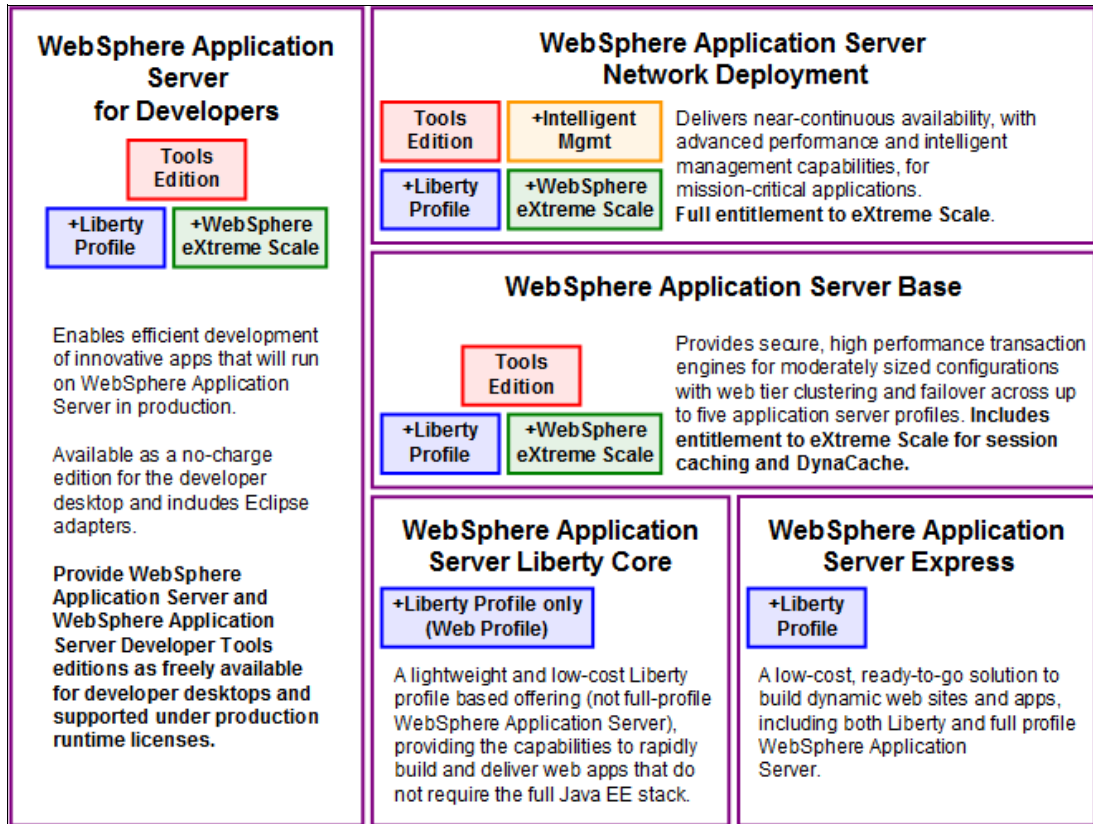


Figure 10-5 WebSphere Application Server for IBM i packaging options

The minimum maintenance level of each package option of WebSphere Application Server V8.0 that is supported on IBM i 7.2 is Version 8.0.0.7; for WebSphere Application Server V8.5, it is Version 8.5.5.2.

For more information about the supported versions of WebSphere Application Server, see the IBM Support website:

<http://www.ibm.com/support/docview.wss?rs=180&uid=swg27006921#8.0>

IBM WebSphere Application Server Express for i is delivered as the part of IBM Web Enablement for i (5770-WE2). IBM Web Enablement for i product on IBM i 7.2 includes the following versions of IBM WebSphere Application Server Express so that you can choose the version of IBM WebSphere Application Server Express to install on your IBM i platform:

- ▶ IBM WebSphere Application Server Express for i V8.0
- ▶ IBM WebSphere Application Server Express for i V8.5

10.3.2 WebSphere Application Server Liberty Core packaging

In WebSphere Application Server V8.5.5, WebSphere Application Server Liberty Core is newly introduced as a stand-alone package option for delivering WebSphere Application Server Liberty Profile and it is also available for IBM i. WebSphere Application Server Liberty Core does not include the wider range of features that is found in the Liberty profile that is shipped with the other WebSphere Application Server package options.

For more information about WebSphere Application Server Liberty Core, see IBM Knowledge Center:

https://www.ibm.com/support/knowledgecenter/SSD28V_8.5.5/com.ibm.websphere.wlp.core.doc/ae/cwlp_core_welcome.html

10.3.3 WebSphere Application Server Liberty Profile

You can use WebSphere Application Server Liberty Profile to build and deliver rapidly web applications that do not need the full Java EE stack. Liberty Profile is delivered within each package option for Version 8.5 or later. Since Version 8.5.5, Liberty Profile is also available as a stand-alone offering known as WebSphere Application Server Liberty Core.

This profile is intended for use as a development or production environment for running web applications that do not require a full Java EE stack. The Liberty profile provides enterprise qualities of service, including security and transaction integrity.

Because a Liberty Profile server is lightweight, it can be packaged easily with applications in a compressed file. This package can be stored, distributed to colleagues, and used to deploy the application to a different location or to another system. It can even be embedded in the product distribution. The Liberty profile configuration operates from a set of built-in configuration defaults. You can specify only the required changes for your environment by using a simple XML format.

For more information about WebSphere Application Server Liberty Profile in WebSphere Application Server V8.5.5, see *WebSphere Application Server V8.5.5 Technical Overview*, REDP-4855.

In IBM i 7.2 TR1 timed enhancements, IBM i Integrated Application Server, and Integrated Web Services Server use WebSphere Application Server Liberty Profile. For more information about the enhancements of IBM i Integrated Application Server, see 10.2, “IBM i Integrated Web Application and Web Services Server” on page 480.

10.3.4 Installation of WebSphere Application Server to IBM i

In IBM i 7.2, the Web Admin user interface can be used to install WebSphere Application Server package options to IBM i. IBM Installation Manager is required to install WebSphere Application Server package options. The new user interface of Installer for WebSphere Application Server in Web Administration for i also includes installing IBM Installation Manager to IBM i.

For more information about the installation of WebSphere Application Server to IBM i, see 10.1.3, “IBM Web Administration for i for managing a WebSphere Application Server installation” on page 479.

10.3.5 Upgrading to IBM i 7.2

If you are using Application Server V7.0 and upgrading to Version 7.2, you must migrate to the WebSphere Application Server V8.0.0.8 or V8.5.5.2 products. Because migration does not require Application Server V7.0 to be operational, migration can occur before you upgrade to Version 7.2.

For more information about migrating your existing WebSphere Application Server environments, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzaq9/rzaq9.pdf

10.4 IBM Social Collaboration products

IBM 7.2 supports the following social collaboration products (formerly under the IBM Lotus brand):

- ▶ IBM Domino® V9.0.1.
- ▶ IBM Notes Traveler V9.0.1.
- ▶ IBM Sametime® V9.0. Sametime V9.0 requires hotfix HF1 to support IBM i 7.2.
- ▶ IBM Enterprise Integrator 9.0.1.

Actual compatibility of IBM Social Collaboration products can be found in the following document:

http://www.ibm.com/systems/resources/systems_power_ibmi_lotus_releasesupport.pdf

Note: There is a larger set of IBM Lotus product versions that support IBM i 7.1, but not IBM i 7.2. If such products are needed in the future, additional checks must be done if a version that is compatible with IBM 7.2 is released.

10.5 IBM Printing

This section covers the IBM i printing enhancements in IBM i 7.2. The following topics are covered in this section:

- ▶ 10.5.1, “CPYSPLF CL command now supports the PDF format” on page 487
- ▶ 10.5.2, “Controlling the method of sending spooled files from list panels” on page 488
- ▶ 10.5.3, “Changes to TrueType and OpenType fonts” on page 488
- ▶ 10.5.4, “New bar code types for the printer DDS BARCODE keyword” on page 488
- ▶ 10.5.5, “Color image support” on page 489
- ▶ 10.5.6, “Color management support added to Print Services Facility for IBM i” on page 489
- ▶ 10.5.7, “Host print transform now supports color images” on page 490
- ▶ 10.5.8, “AFP color and grayscale solutions” on page 490

10.5.1 CPYSPLF CL command now supports the PDF format

The **CPYSPL CL** command can copy a spool file to IFS in PDF format. The new option ***PDF** for parameter **WSCST** was added for this purpose. Example 10-1 shows an example of this command.

*Example 10-1 Example of the CPYSPLF CL command with the *PDF option*

```
CPYSPLF FILE(QPRINT)
        TOFILE(*TOSTMF)
        JOB(000172/QSECOFR/DSP01)
        SPLNBR(1)
        TOSTMF('/home/qprint.pdf')
        WSCST(*PDF)
```

10.5.2 Controlling the method of sending spooled files from list panels

By using an environment variable, you can control whether spooled files are sent by using the **SNDNETSPLF (SNADS)** or **SNDTCPSPLF (TCP/IP)** CL command from the **WRKSPLF**, **WRKOUTQ**, and **WRKJOB OPTION(*SPLF)** panels.

The default method of sending spooled files from the **WRKSPLF**, **WRKOUTQ**, and **WRKJOB OPTION(*SPLF)** panels by specifying "1=Send" uses the **SNDNETSPLF** CL command. If you prefer to use the **SNDTCPSPLF** CL command to send spooled files from these panels, you can do that by using the environment variable **QIBM_SNDSPLF_OPT**.

To change the default command for your job to be **SNDTCPSPLF**, run the following command:

```
ADDENVVAR ENVVAR(QIBM_SNDSPLF_OPT)VALUE(TCP)LEVEL(*JOB)
```

To change the default command for the system to **SNDTCPSPLF**, run the following command:

```
ADDENVVAR ENVVAR(QIBM_SNDSPLF_OPT)VALUE(TCP)LEVEL(*SYS)
```

The environment variable name and its value must be uppercase. If the environment variable is not found or not set to TCP, the system defaults to the **SNDNETSPLF** CL command from the spooled file list panels.

10.5.3 Changes to TrueType and OpenType fonts

The TrueType fonts are delivered as option 43 in the IBM i operating system product 5770-SS1. They are provided as stream files in the TrueType (OpenType) format.

TrueType and OpenType fonts are expected to be found in one of two Integrated File System directories:

- ▶ /QIBM/ProdData/OS400/Fonts/TTFonts for IBM supplied fonts
- ▶ /QIBM/UserData/OS400/Fonts/TTFonts for user fonts

It is possible to specify additional directories for user fonts by using the environment variable **QIBM_FONT_RESOURCES_PATH**. One or more directories, which are separated by a colon, can be specified.

When searching for fonts, the system looks to see whether there are any paths set in the environment variable **QIBM_FONT_RESOURCES_PATH**. If so, those paths are searched first. Then, the UserData path is searched, followed by the ProdData path.

The detailed table of fonts that are provided can be found in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzalu/rzalucontruetype.htm

10.5.4 New bar code types for the printer DDS BARCODE keyword

The **BARCODE DDS** keyword now supports these new types of bar codes:

- ▶ QR Code
- ▶ Code 93
- ▶ USPS Intelligent Mail
- ▶ Royal Mail Red Tag
- ▶ GS1 Databar

Some modifiers to formerly supported bar codes were added to the following bar codes:

- ▶ UCC/EAN 128 (or GS1-128)
- ▶ USPS intelligent Mail Container
- ▶ GS1 ITF-14

The UCC/EAN 128 (or GS1-128) bar code can be selected by specifying the CODE128 bar-code-ID and a bar code modifier of 03 or 04.

The USPS Intelligent Mail Container bar code can be selected by specifying the CODE128 bar-code-ID and a bar code modifier of 05.

The GS1 ITF-14 bar code (Interleaved 2 of 5 with bearer bars) can be selected by specifying the INTERL2OF5 bar-code-ID and a bar code modifier or 03 or 04.

Also, Databar and Intelligent Mail bar codes can be rendered by Host Print Transform and Transform Services (5770-TS1) as a PDF.

The detailed definition of the BARCODE DDS keyword can be found in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzakd/rzakdmstptbarco.htm

10.5.5 Color image support

IBM 7.2 supports color printing. The following sections describe these enhancements in brief. Color image support is a complicated area that includes IBM products such as Print Services Facility™ for IBM i and IBM Infoprint Server for i, and Ricoh products. For more information about this topic, see the following resources:

- ▶ IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgprint.htm

- ▶ The RICOH website, found at:

<http://www.ricoh.com>

The AFP Consortium (AFPC) was founded in 2004 and renamed to the AFP Color Consortium. Its members are companies that develop and improve the AFP Color Management Architecture (ACMA). The consortium's present scope is the complete Advanced Function Presentation (AFP) architecture.

For more information about the AFPC, see the following website:

<http://afpcinc.org>

10.5.6 Color management support added to Print Services Facility for IBM i

Print Services Facility for IBM i were enhanced to support the AFP Color Management Architecture (CMOCA). A mechanism to print color consistently on different printers by different manufacturers was added. Color profiles for input and output are used to adjust colors automatically at high speed. You must have the AFP Resource Installer Tool to generate a Resource Access Table (RAT).

10.5.7 Host print transform now supports color images

The AFP-to-ASCII transform supports color images when you print to a color printer that supports the PCL language (for example, PCL5C). The supported images are JPG, GIF, and TIFF. The images can be referenced by the **AFPRSC DDS** keyword. Stream files can be used to reference the resources.

For more information, see IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzakd/printthis.htm

Information about the Workstation Customization Object tag **PRTDTASTRM** can be found in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzalu/prtdtastrm.htm

10.5.8 AFP color and grayscale solutions

It is now possible to include color images or specify colors for AFP objects in your spooled files and send them to an AFP color printer. The color images and objects print in color, which is based on the default settings in your print server and printer.

You can perform this task with or without explicit color management. You can use color management to print color images in exact colors, calibrate devices such as scanners and printers. Color management solutions are supported by RICOH products. For more information about these products, go to the following website:

<http://www.rioh.com>

For color and grayscale printing, you can use the AFP Color Management Object Content Architecture (CMOCA). You can include the AFP CMOCA resources in your spool file, or you can manage and store it centrally so that you can leverage the full advantages of CMOCA and improve the speed of print processing.

Your graphical objects can have different formats, such as AFPC JPEG Subset, EPS, GIF, IOCA, PDF, PNG, and TIFF.

For uploading data objects, use the AFP Resource Installer. For more information about this product, see the following website:

<http://rpp.rioh-usa.com/products/software/color-manage/afp-resource-installer>

Related publications

The publications that are listed in this section are considered suitable for a more detailed description of the topics that are covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Some publications that are referenced in this list might be available in softcopy only.

- ▶ *Accessing IBM i Health Indicators Using Performance Data Investigator*, REDP-5150
- ▶ *Creating IBM i Client Partitions Using Virtual Partition Manager*, REDP-4806
- ▶ *IBM DB2 Web Query for i Version 2.1 Implementation Guide*, SG24-8063
- ▶ *IBM i 7.1 Technical Overview with Technology Refresh Updates*, SG24-7858
- ▶ *IBM Power Systems E870 and E880 Technical Overview and Introduction*, REDP-5137
- ▶ *IBM Power Systems S814 and S824 Technical Overview and Introduction*, REDP-5097
- ▶ *IBM Power Systems SR-IOV: Technical Overview and Introduction*, REDP-5065
- ▶ *IBM PowerVM Virtualization Introduction and Configuration*, SG24-7940
- ▶ *IBM PowerVP: Introduction and Technical Overview*, REDP-5112
- ▶ *IBM System Storage SAN Volume Controller and Storwize V7000 Replication Family Services*, SG24-7574
- ▶ *Modernizing IBM i Applications from the Database up to the User Interface and Everything in Between*, SG24-8185
- ▶ *PowerHA SystemMirror for IBM i Cookbook*, SG24-7994
- ▶ *Row and Column Access Support in IBM DB2 for i*, REDP-5110
- ▶ *Tools and Solutions for Modernizing Your IBM i Applications*, REDP-5095
- ▶ *Uncovering Application Runtime Expert - IBM i 7.1*, REDP-4805

You can search for, view, download, or order these documents and other Redbooks, Redpapers, web docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as further information sources:

- ▶ *Connecting to IBM i - IBM i Access Client Solutions*
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajr/rzajroconoverview.htm
- ▶ *Connecting to IBM i - IBM i Access for Web*
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzamm/rzammaccessweb.htm
- ▶ DB2 for i SQL reference in IBM Knowledge Center
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm
- ▶ *How to use the Batch Model performance tool*
<https://www.ibm.com/developerworks/ibmi/library/i-how-to-use-the-batch-model-performance-tool/>
- ▶ IBM developerWorks
<http://www.ibm.com/developerworks/ibmi/>
- ▶ IBM i 7.2 IBM Knowledge Center
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/ic-homepage.htm
- ▶ *IBM i iSCSI Solution Guide*
<http://www.ibm.com/systems/power/software/i/integratedserver/guide/iscsi.html>
- ▶ *IBM i Memo to Users Version 7.2*
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzahg/rzahgmtu.htm
- ▶ *IBM i Version 7.2 Database DB2 for i SQL Reference*
http://www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm
- ▶ IBM Power Virtualization Center Standard 1.2.1 documentation
http://www.ibm.com/support/knowledgecenter/SSXK2N_1.2.1/com.ibm.powervc.standard.help.doc/kc_welcome-standard-supermap.html?locale=en&ro=kcUI
- ▶ *IBM i Access Client Solutions: Customization and deployment made easy*
<https://www.ibm.com/developerworks/ibmi/library/i-ibmi-access-client-solutions-customization-trs/>

Online resources

These websites are also relevant as further information sources:

- ▶ Cloud on Power Systems
<http://www.ibm.com/systems/power/solutions/cloud/resources.html>
- ▶ Customer Notices and information for IBM i 7.2
<http://www.ibm.com/systems/support/planning/notices72.html>
- ▶ Dates for support of various IBM i releases
<http://www.ibm.com/systems/support/i/planning/upgrade/suptschedule.html>

- ▶ DB2 for i blog
<http://db2fori.blogspot.com/>
- ▶ Free-form RPG support on IBM i
<https://www.ibm.com/developerworks/ibmi/library/i-ibmi-rpg-support/>
- ▶ IBM Backup, Recovery, and Media Services (BRMS) for i developerWorks wiki
<https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20Backup%20Recovery%20and%20Media%20Services%20%28BRMS%29%20for%20i>
- ▶ IBM Cloud Manager with OpenStack for Power Systems
<http://www.ibm.com/systems/power/solutions/cloud/smartcloudentry/>
- ▶ IBM Cloud Manager with OpenStack wiki
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