IBM i Storage Options:
Internal vs. External Storage

- MRMUG May, 2014
IBM i can use external storage
  • Direct attached
  • Native attached
  • Using VIO Server
  • In combination and with internal storage

All disk presented appear and are configured and utilized the same as internal disk
  • A disk is a disk

With external disk, protection is provided by the Storage device
  • Don’t turn on RAID or mirroring in OS/400 for external disk
IBM Power® Systems storage for IBM i

Historically

<table>
<thead>
<tr>
<th>High End</th>
<th>Mid Range</th>
<th>Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>SAN attached</td>
<td></td>
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</tbody>
</table>

POWER6 and beyond

<table>
<thead>
<tr>
<th>High End</th>
<th>Mid Range</th>
<th>Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>SAN attached</td>
<td>Virtualized</td>
</tr>
<tr>
<td></td>
<td>SAN, Virtual, and Integrated can combine HDDs and SSDs</td>
<td></td>
</tr>
</tbody>
</table>
DAS & SAN - Two Good Options

- Both options are strategic
- Both options have their strengths
- Can use both options on the same server

**DAS**
Direct Attached Storage
("internal")

- Fastest (lower latency)
- Typically lower cost hardware/software
- Often simpler config

**SAN**
Storage Area Network
("external")

- Fast
- Multi-server sharing
- Advanced functions/values
  - Flash Copy, Metro/Global Mirror, Live Partition Mobility, Easy Tier
IBM i heritage is internal disk
Disk/database performance is very important

PROS:
• Fastest - low latency
• Lower cost
• Simple setup but with versatility
  • All setup done at the IBM i level (DST)
  • Mirroring
  • RAID 5 and 6
  • Multiple auxiliary storage pools (ASP)
  • Independent ASP (iASP)
  • iASP used for mobility and HA/DR
  • Solid performance
  • Historically faster than external disk
  • Simple troubleshooting and fix
  • Easy to add / remove
• Add/remove disk concurrently (natively using IBM i OS V7R1)
• Can be used to support IBM i hosted partitions
  • Not the best performance for hosted partitions (hosted in IFS of the hosting IBM i partition)

CONS:
• Configuring the disk subsystem for best performance can result in more “trapped” capacity than is required
• Server upgrade/replacement sometimes time consuming
  • Complete restore of system required in some situations
    • When older disk no longer supported in newer enclosures
• Replication is done via software, or OS/LIC level
  • always done from host to host
External disk is gaining ground
Disk/database performance is still very important

PROS:
• Very fast now
  • Can be *ridiculously* fast with FlashSystems
    • but so can internal SSDs
• Very versatile
  • High Availability
    • Maintenance and Backup
  • Disaster Recovery
  • Consolidation
  • Virtualization
  • Centralized Storage Management
• Replication can be done at the storage level
• Easier server upgrade/replacement
  • No need to restore the system
• Most supported devices can now be attached without VIOS
• Use fewer cards slots to connect multiple logical partitions (using VIOS)
  • Saves adapter and expansion unit expenses (when performance allows)
• Change physical disk concurrently (using SVC)

CONS:
• Higher cost (generally)
  • Initial purchase
  • Maintenance
• Adds complexity
  • Planning
  • Setup
  • Changes
• Additional expertise required for design, installation and management
Some Definitions

**Native Attached** – No need to virtualize adapters or LUNs via VIOS

**Direct Attached** – External disk device is attached directly to the fibre channel adapter without a switch
• This requires that each logical partition attaching to the storage owns a fibre channel card and attached directly an available fibre channel port on the storage device
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
2-port 16 Gb Fibre Channel (HBA)

- Runs at 16Gb, 8Gb or 4Gb
- For POWER7+ 710/720/730/740/750/760
  - SOD for 770/780 (‘C’ and ‘D’ models)

- Compared to the #5735 2-port 8Gb FC
- Price* #5735 = $3499    #EN0A = $4500

- Only 30% more price = 100% more bandwidth**

- Even if not using 16Gb switches / devices today, for just a little more, buy and use an adapter which can adapt to your future configurations

* Prices shown are IBM USA suggested list prices as of Feb 2013 on a Power 720 and are subject to change without notice; Reseller prices may vary.
** Running at 8Gb provides half the potential bandwidth compared to running at 16 Gb. Running at 4Gb provides ¼ the potential bandwidth.
2-port 16 Gb Fibre Channel Adapter

- 16 Gb per port bandwidth
  - 2X the bandwidth of the 2-port 8Gb Fibre Channel adapter
  - Same bandwidth of 4-port 8Gb Fibre Channel adapter

- Each port runs at 16Gb, 8Gb or 4Gb (fastest available connection)

- For PCIe Gen2 slots in POWER7+ 710/720/730/740/750/760
  - SOD for 770/780 (‘C’ and ‘D’ models)
  - For Power 795 see #EN23 2-port 16Gb FC GX++ Adapter

- NPIV support through VIOS

- AIX, IBM i, Linux, VIOS support
  - AIX Version 7.1 with TL 7100-02 and Service Pack 2, or later
  - AIX Version 6.1 with TL 6100-08 and Service Pack 2, or later
  - AIX Version 6.1 with TL 6100-07 and Service Pack 7, or later (Planned availability March 29, 2013)
  - IBM i 6.1 -- VIOS required. Both VSCSI and NPIV protocols supported.
  - IBM i 7.1 -- VIOS required. Both VSCSI and NPIV protocols supported.
  - SUSE Linux Enterprise 11 Service Pack 2, or later
  - Red Hat Executive Linux – see SOD
  - VIOS requires VIOS 2.2.2.2, or later
### IBM i POWER External Storage Support Matrix

The most current version of this document can be located at one of the following URLs:


<table>
<thead>
<tr>
<th>Last updated August 6, 2013</th>
<th>Rack / Tower Systems</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Server model</td>
<td>IBM i version</td>
</tr>
<tr>
<td>Storage Family</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>POWER5</td>
<td>POWER6</td>
</tr>
<tr>
<td>V3500</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>V3700</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>V7000</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>SVC</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>Flash Systems</td>
<td>☒</td>
<td>☑</td>
</tr>
</tbody>
</table>

**Notes**

- IBM i 6.1 or later is a prerequisite for VIOS vSCSI, VIOS NPIV, and POWER7 systems.
- Native attach means the fibre channel IOA is allocated to the IBM i LPAR.
- NPIV support requires IBM i 7.1 TR6 or later
- NATIVE support requires
  - POWER7 or POWER7+ servers
  - IBM i 7.1 TR6 plus PTFs MF56600, MF56753, MF56854 or their supersedes
  - and 6.4.1.4 or later SVC/V3700/V7000 firmware.
- DIRECT attach available for POWER7 systems when utilizing PCIe 4Gb fibre channel adapters (feature 5774 or 5276).
- There is no support without SVC or Storwize and SVC/Storwize firmware level 6.4.1.5 or higher is required. See support documentation at the URLs listed on the notes page.
# IBM i POWER External Storage Support Matrix

<table>
<thead>
<tr>
<th>Storage Family</th>
<th>IBM i POWER6</th>
<th>IBM i POWER7</th>
<th>IBM i 6.1</th>
<th>IBM i 7.1</th>
<th>Direct Attach</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS3000</td>
<td></td>
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<td></td>
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<tr>
<td>DS3200</td>
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<td>✓</td>
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<td>DS3200 only supports SAS connection and is not supported on rack/tower servers.</td>
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<tr>
<td>DS3400</td>
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<td>✓</td>
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<tr>
<td>DS3500</td>
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<td>✓</td>
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<td></td>
<td>DS3500 must utilize fibre channel connection for rack/tower servers.</td>
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<tr>
<td>DS3700</td>
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<td>DS4100</td>
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<td>✓</td>
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<td>DS4200 supports IBM i 7.1 TR2 and server firmware xx730 or later. Native channel requires Smart Fibre Channel adapters - NOT supported with IBM-based Fibre Channel adapters.</td>
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<tr>
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<tr>
<td>DS5000</td>
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<td>DS5100</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>NPIV support requires IBM i 7.1 TR2 and server firmware xx730 or later. Native channel requires Smart Fibre Channel adapters - NOT supported with IBM-based Fibre Channel adapters.</td>
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<tr>
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<td>DS6000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DS6400</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Support for POWER or IBM i 7.1 must be made utilizing SCORE System RPO process. Direct attach to may be requested using this process as well.</td>
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<tr>
<td>DS6500</td>
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<td>DS8000</td>
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</tr>
</tbody>
</table>
| DS8400         | ✓            | ✓            | ✓         | ✓         | ✓             | Direct attach available for both POWER6 and POWER7 systems when utilizing:
- PCIe 4Gb fibre channel adapters (features 5749, 5774 or 5726)
- PCIe 8Gb fibre channel adapters (features 5735 or 5723) |
| DS8500         | ✓            | ✓            | ✓         | ✓         | ✓             | Direct attach available for both POWER6 and POWER7 systems when utilizing:
- PCIe 4Gb fibre channel adapters (features 5749, 5774 or 5726)
- PCIe 8Gb fibre channel adapters (features 5735 or 5723) |
| DS8600         | ✓            | ✓            | ✓         | ✓         | ✓             | Direct attach available for both POWER6 and POWER7 systems when utilizing:
- PCIe 4Gb fibre channel adapters (features 5749, 5774 or 5726)
- PCIe 8Gb fibre channel adapters (features 5735 or 5723) |

**Storwize**

<table>
<thead>
<tr>
<th>Storwize</th>
<th>IBM i POWER6</th>
<th>IBM i POWER7</th>
<th>IBM i 6.1</th>
<th>IBM i 7.1</th>
<th>Direct Attach</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>V3000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| V3500    | ✓            | ✓            | ✓         | ✓         |               | V3500 supports IBM i 7.1 TR6 or later. NATIVE support requires:
- POWER7 or POWER7+ servers
- IBM i 7.1 TR6 plus PTFs M56426, M56576, M56584 or their superseded
- 6.4.1.4 or later SVC/CV/3700Q/7000 firmware. |
| V5000    | ✓            | ✓            | ✓         | ✓         |               |       |
| V7000    | ✓            | ✓            | ✓         | ✓         |               | V7000 supports IBM i 7.1 TR6 plus PTFs M56426, M56576, M56584 or their superseded
- 6.4.1.4 or later SVC/CV/3700Q/7000 firmware. |

**SVC**

<table>
<thead>
<tr>
<th>SVC</th>
<th>IBM i POWER6</th>
<th>IBM i POWER7</th>
<th>IBM i 6.1</th>
<th>IBM i 7.1</th>
<th>Direct Attach</th>
<th>Notes</th>
</tr>
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</tbody>
</table>

**Flash Systems**

Flash Systems require either SVC or Storwize. SVC/Storwize firmware level 6.4.1.5 or higher is required. See support documentation at the URLs listed on the next page for additional information. VIOS VSCSI virtualization without SVC or Storwize is not supported. Also see SVC/ Storwize information on this page.

**XIV**

<table>
<thead>
<tr>
<th>XIV</th>
<th>IBM i POWER6</th>
<th>IBM i POWER7</th>
<th>IBM i 6.1</th>
<th>IBM i 7.1</th>
<th>Direct Attach</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

**N Series**

<table>
<thead>
<tr>
<th>N Series</th>
<th>IBM i POWER6</th>
<th>IBM i POWER7</th>
<th>IBM i 6.1</th>
<th>IBM i 7.1</th>
<th>Direct Attach</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>N Series is only supported for iFS via NFS mount and can only be used as file server. No load source or boot support. No IBM iDB2 support.</td>
</tr>
</tbody>
</table>
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
Virtual storage (virtual SCSI) for partitions on traditional servers

- **IBM i hosting**
  - Disk storage resources owned by an IBM i partition, used by secondary partitions (AIX®, IBM i, Linux, and/or Windows)
  - Integrated or SAN attached storage
  - HMC required
  - Can mix virtual and direct I/O in client partitions

- **Virtual I/O Server (VIOS) hosting**
  - Disk storage resources owned by VIOS partition, used by secondary partitions (AIX, IBM i, Linux)
  - Integrated or SAN attached storage
  - Virtual SCSI or virtual fibre channel (NPIV)
  - HMC usually required
  - Can mix virtual and direct I/O in client partitions
IBM i 6.1 partition can host
IBM i 7.1 and 6.1 partitions
AIX 5.2, 5.3, 6.1, 7.1
SLES and Red Hat Linux partitions
iSCSI attached System x and BladeCenter

IBM i 7.1 partition can host
IBM i 7.1 and 6.1 partitions
AIX 5.2, 5.3, 6.1, 7.1
SLES and Red Hat Linux partitions
iSCSI attached System x and BladeCenter

PowerVM VIOS can host
IBM i 7.1 and 6.1 partitions
AIX and Linux partitions
VIOS supports advanced virtualization technologies
including Active Memory Sharing and NPIV

Storage Virtualization can reduce costs while
improving IT infrastructure flexibility
Virtualizing storage with IBM i or VIOS

- Single IBM i or VIOS host provides access to SAN or internal storage
  - AIX, IBM i, or Linux client partitions
  - Protect data via RAID-5, RAID-6, or RAID-10

- **Redundant** IBM i or VIOS hosts provide access to SAN or internal storage
  - AIX, IBM i, and Linux client partitions
  - Client LPAR protects data via mirroring
  - Two sets of disk and adapters

- **Redundant** VIOS hosts provide multiple paths to attached SAN storage with MPIO
  - AIX, IBM i, and Linux client partitions
  - One set of disk
Virtualizing Direct Attach Storage for IBM i

- Virtualization DAS (integrated drives) can be a good thing, but do it with common sense. Some scenarios don’t fit as well as others.
- Note latest levels of software highly, highly recommended for IBM i + VIOS + (#5913/#ESA3 SAS Adapter) configurations.

<table>
<thead>
<tr>
<th>IBM i</th>
<th>IBM i + IBM i + #5913 SAS</th>
<th>IBM i + IBM i + #5805 SAS</th>
<th>IBM i + VIOS + #5913 SAS + HDD</th>
<th>IBM i + VIOS + #5913 SAS + SSD</th>
<th>IBM i + VIOS + FC SAN</th>
<th>AIX + IBM i + #5913 SAS</th>
<th>AIX + VIOS + #5913 SAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>#5913 SAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Native is highest performance

======Performance is good======

Performance depends on workload. See tech doc

See tech doc for more information
- IBMers: http://w3.ibm.com/support/cчасdoc/tчасmastr.nsf/WebIndex/TD105929
- Business Partners: http://www-03.ibm.com/partnerworld/partnerinfo/src/at часmastr.nsf/WebIndex/TD105929

Above performance comments are rules of thumb and assume configurations appropriately configured. There are many variables and your results may vary.

*Not really recommended unless Model 770 or above
N_Port ID Virtualization (NPIV)

- N_Port ID Virtualization (NPIV) provides direct Fibre Channel connections from client partitions to SAN resources, simplifying SAN management
  - Physical fibre channel adapter (IOA) is owned by VIOS partition
  - Supported with PowerVM Express, Standard, and Enterprise Edition
  - Supports AIX 5.3, AIX 6.1, IBM i 6.1, IBM i 7.1, and Linux
  - POWER6 or POWER7 systems with an 8Gb PCIe fibre channel adapter or 10Gb Fibre Channel over Ethernet (FCoE) adapter

IBM i requires:
- LIC 6.1.1 or LIC 7.1
- DS8000 storage subsystem
  and/or
- Supported tape/tape library devices
VIOS Support for Virtual Tape

- Virtual tape support enables IBM i and AIX partitions to directly backup to PowerVM VIOS attached tape drive saving hardware costs and management time

- **Simplifies backup and restore processing with BladeCenter implementations**
  - IBM i partitions on BladeCenter Power blades
  - Supports IBM i save/restore commands & BRMS
  - Best solution for BladeCenter S implementations

- **Simplifies migration to blades from tower/rack servers**
  - LTO-4 drive can read backup tapes from LTO-2, 3, 4 drives

- **Can also be used with VIOS and IBM i or AIX on POWER6 and POWER7 processor-based servers**

- **Supports IBM Systems Storage SAS LTO-4 Drive**
  - TS2240 for BladeCenter and Power Servers
    - Connected via Non-RAID SAS Switch or the SAS RAID Controller Module
  - 7214 Model 1U2 with FC#1404, and FC#5720 DVD/Tape SAS External Storage Unit with FC#5746 for Power servers
I/O Virtualization on POWER

IO Bus Virtualization with Dedicated Adapters

IO Adapter Virtualization with VIO Server

Increasing Adapter BW & LPAR Density per Slot
IBM i + vSCSI (Classic)

- Assign storage to the physical HBA in the VIOS
- Hostconnect is created as an open storage or AIX hosttype,
- Requires 512 byte per sector LUNs to be assigned to the hostconnect
- Cannot Migrate existing direct connect LUNs
- Many Storage options supported
- Storage is assigned to the VIOS partition
- Within the VIOS you map physical tape or optical or file backed virtual optical to the vhost corresponding to the client partition
- No tape library support with vscsi adapters. Must use VFC adapters.
IBM i + NPIV (Virtual Fiber Channel)

- Hypervisor assigns 2 unique WWPNs to each Virtual fiber.
- Hostconnect is created as an IBM i host type.
- Requires 520 byte per sector LUNs to be assigned to the IBM i hostconnect on DS8K.
- Can Migrate existing direct connect LUNS.
- DS8100, DS8300, DS8700, DS8800, DS5100 and DS5300 supported.

Note: an NPIV (N_port) capable switch is required to connect the VIOS to the DS8000 to use virtual fiber.
NPIV Concepts

- Multiple VFC server adapters may map to the same physical adapter port.
- Each VFC server adapter connects to one VFC client adapter; each VFC client adapter gets a unique WWPN.
- Client WWPN stays the same regardless of physical port it is connected to.
- Support for dynamically changing the physical port to virtual port mapping.
- Clients can discover and manage physical devices on the SAN.
- VIOS can’t access or emulate storage, just provides clients access to the SAN.
- Support for concurrent microcode download to the physical FC adapter.
NPIV Configuration - Server Adapter Mappings

Modify Virtual Fibre Channel Partition Assignment - za6be-9406-675-SN107074C

A selected row in the table indicates that the physical port is assigned to the logical partition. Select additional partitions to assign to the port or deselect partitions that are currently assigned to the port.

Available connections:

<table>
<thead>
<tr>
<th>Select</th>
<th>Partition Name</th>
<th>Partition State</th>
<th>World Wide Port Names</th>
<th>Current Assignment</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>za6bp10</td>
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<td>c0507600024d0120</td>
<td>fcs4</td>
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<td>Running</td>
<td>c0507600024d00d1</td>
<td>fcs4</td>
</tr>
<tr>
<td></td>
<td>za6bp16</td>
<td>Not Activated</td>
<td>c0507600024d00d3</td>
<td>fcs4</td>
</tr>
<tr>
<td></td>
<td>za6bp17</td>
<td>Not Activated</td>
<td>c0507600024d00d4</td>
<td>fcs4</td>
</tr>
<tr>
<td></td>
<td>za6bp18</td>
<td>Not Activated</td>
<td>c0507600024d00d5</td>
<td>fcs3</td>
</tr>
<tr>
<td></td>
<td>za6bp19</td>
<td>Not Activated</td>
<td>c0507600024d00d6</td>
<td>fcs3</td>
</tr>
<tr>
<td></td>
<td>za6bp20</td>
<td>Not Activated</td>
<td>c0507600024d00d7</td>
<td>fcs3</td>
</tr>
<tr>
<td></td>
<td>za6bp21</td>
<td>Running</td>
<td>c0507600024d00d8</td>
<td>fcs3</td>
</tr>
<tr>
<td></td>
<td>za6bp22</td>
<td>Running</td>
<td>c0507600024d00d9</td>
<td>fcs3</td>
</tr>
<tr>
<td></td>
<td>za6bp23</td>
<td>Running</td>
<td>c0507600024d00d0</td>
<td>fcs4</td>
</tr>
</tbody>
</table>

One of more of the connections are currently assigned to a running partition. While some connections can be modified safely while a partition is running, it is generally safer to modify connections when a partition is shutdown. If you would like to proceed anyway, select the checkbox below, and select OK.

- [ ] Force connection removal from running partitions.

OK  Cancel  Help
NPIV Configuration - Limitations

• Single client adapter per physical port per partition
  – Intended to avoid single point of failure
  – Documentation only – not enforced
• Maximum of 64 active client connections per physical port
  – It is possible to map more than 64 clients to a single adapter port
  – May be less due to other VIOS resource constraints
• 32K unique WWPN pairs per system platform
  – Removing adapter does not reclaim WWPNs
    • Can be manually reclaimed through CLI (mksyscfg, chhwres…)
    • “virtual_fc_adapters” attribute
  – If exhausted, need to purchase activation code for more
• Device Limitations
  – Maximum of 128 visible target ports
    • Not all visible target ports will necessarily be active
    • Redundant paths to a single DS8000 node
    • Device level port configuration
    • Inactive target ports still require client adapter resources
  – Maximum of 64 target devices
    – Any combination of disk and tape
    – Tape libraries and tape drives are counted separately
Step 1: configure virtual and physical FC adapters
- Best Practice to make VIOS redundant or separate individual VIOS partitions where a single hardware failure would not take down both VIOS partitions.

Step 2: configure SAN fabric and storage
- Zone Luns to the virtual WWPNs.
- Each DASD sees a path through 2 VIOS partitions.

Notes:
- Support up to 8 paths per LUN
- Not all paths have to go through separate VIOS partitions.
- New multi-path algorithm in 7.1 TR2
LPAR Suspend/Resume – Customer Value

• Resource balancing for long-running batch jobs
  – e.g. suspend lower priority and/or long running workloads to free resources.

• Planned CEC outages for maintenance/upgrades
  – Suspend/resume may be used in place of or in conjunction with partition mobility.
  – Suspend/resume may require less time and effort than manual database shutdown and restart, for example.

Requirements:

• All I/O is virtualized
• HMC version 7 releases 7.3
• FW: Ax730 Xxx
• IBM i 7.1 TR2
• VIOS 2.2.1.0 FP24 SP2
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
## Protecting data on disk

<table>
<thead>
<tr>
<th>Disk protection choice</th>
<th>Level of protection</th>
<th>Relative performance&lt;sup&gt;1&lt;/sup&gt;</th>
<th>What is protected</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAID-5 with protected write cache</td>
<td>Basic</td>
<td>Standard</td>
<td>Single disk unit failure within a parity set.</td>
</tr>
<tr>
<td>RAID-6 with protected write cache</td>
<td>Basic +</td>
<td>Slight degradation</td>
<td>Multiple disk unit failures within a parity set. Protection from IOA write cache failure.</td>
</tr>
<tr>
<td>RAID-x with protected write cache and hot spare</td>
<td>Better</td>
<td>No effect</td>
<td>Same protection as RAID choice, plus reduced risk of write cache data loss. Plus reduced window of multiple drive failure risk. Outage occurs with disk IOA failure.</td>
</tr>
<tr>
<td>RAID-x with dual controllers</td>
<td>Basic + (R5) or Better + (R6)</td>
<td>Standard to improved when active-active utilized</td>
<td>Potentially multiple hardware components including loop, tower, IOA, and disk are protected.</td>
</tr>
<tr>
<td>SAN attached storage with multipath</td>
<td>Better to Best</td>
<td>Standard to improved</td>
<td>Redundancy within storage subsystem minimizes outage and data loss due to multiple component failure in subsystem. Multipath minimizes outage due to IOA or path failure.</td>
</tr>
<tr>
<td>IBM i disk mirroring or RAID-10</td>
<td>Not quite best</td>
<td>Improved</td>
<td>Potentially multiple hardware components including loop, tower, IOA, and disk with no outage required during component failure.</td>
</tr>
<tr>
<td>IBM i disk mirroring with dual controllers</td>
<td>Best</td>
<td>Improved</td>
<td>Multiple hardware components protected. No mirror resync when adapter fails.</td>
</tr>
</tbody>
</table>

<sup>1</sup>Assumes the same quantity of physical disk units. R/W ratio of 50/50 to 30/70.
What level of risk are you willing to take?

Typical scenario without hot spare if a disk drive fails.

**Disk fails**
- System alerts operator
- If authorized, system calls IBM
- Operator calls IBM
- IBM calls back
- IBM brings replacement disk
- IBM installs disk
- Rebuild disk

**RAID-5** – Time system exposed (at risk) if a 2nd drive in same array were to fail

**RAID-6** – Time parity set “degraded”, not at risk unless a 2nd drive in same array were to fail

**RAID hot spare provides additional “insurance”**

**Exposure time potentially eliminated with RAID hot spare**

**Disk fails**
- System alerts operator
- If authorized, system calls IBM
- Operator calls IBM
- IBM calls back
- IBM brings replacement disk
- IBM installs disk
- Rebuild disk
Dual controllers for RAID5 or RAID6 protection

Typical single controller RAID

- CEC
- I/O Loop
- Controller with auxiliary write cache
- RAID set

Disk unit failure protected by RAID-5 or RAID-6. Additional data loss protection with auxiliary write cache

Dual controller with RAID

- CEC
- I/O Loop
- Controller
- RAID sets

Dual controllers can provide redundant I/O paths, redundant I/O adapter and cache, and redundant RAID. Reduces single points of failure and increases uptime.
Dual controllers for mirrored protection

Typical mirrored implementation

Dual controller mirrored implementation
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
IBM i resiliency and replication solutions

Software replication
- iCluster and vendor logical replication software
- Domino clusters

Operating system delivered resiliency
- PowerHA Switchable IASPs and devices
- PowerHA Geographic Mirroring replication
- Admin Domain (security and config data)

Native attached external storage resiliency
- Toolkit DS8000 LUN Level Switching
- PowerHA and Toolkit IASP copy services
- Full system copy (cloning)

Virtualized (VIOS) external storage resiliency
- Storage attached to VIOS and SVC
- Basic - full system copy (cloning)
- PowerHA Geographic Mirroring and iCluster

DS = Storage such as DS6000 or DS8000
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
“it depends …”

Performance information and recommendations in this presentation is based on measurements, analysis, and projections in a controlled environment for specific performance workloads.

Your results will vary significantly and are dependent on the application and configuration.

This information is provided along with general recommendations for you to better understand system and disk subsystem performance.

Information is provided AS IS without warranty of any kind.
1.2 / 1.1 TB 10K RPM Disk Drive

33% larger capacity SAS disk drive than previously available

Same price as 900/856 GB disk drive
  = 33% price performance improvement per GB

- Great for applications with larger capacity needs which don’t require faster 15k rpm performance
- Save footprint space, save energy, potentially reduce number of SAS adapters

Based on IBM USA suggested list prices as of Oct 2013. Subject to change without notice; Reseller prices may vary.
Enhanced Leadership Support for SSDs

- **IBM i 5.4 and 6.1 Storage Manager** can maximize the impact of high performing SSDs
  - New trace and balance commands can move hot data to SSDs
  - High priority object types are automatically placed on SSD drives
  - DB2 Objects have new parameter and can be placed on SSD drives
- **IBM i advanced support for SSDs** supports
  - SSDs installed in I/O drawers
  - SSDs installed in SANs*
  - SSDs installed behind VIOS*

- **New SSD Analyzer Tool**
  - Designed to help determine if SSDs can help improve application performance
  - Runs on customer’s IBM i 5.4 or 6.1 system
  - Up to 40% increase in throughput implementing IBM invented skip-read-write technology

Power eMLC SSD Performance versus 15k rpm HDD
Drive to Drive comparisons

<table>
<thead>
<tr>
<th>HDD</th>
<th>SSD</th>
<th>SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>177GB</td>
<td>387GB</td>
<td>177GB</td>
</tr>
</tbody>
</table>

SSD offers up to 66x – 250x more I/O Operations Per Second (IOPS)

1X | 125X | 250X

New eMLC SSD nearly 2X WRITE throughput (MB/s) than HDD

HDD is 12X – 41X slower (latency) than SSD (milliseconds)

1X | 1X | 1.8X

1.25X | 1X | 41X

Drive-to-drive compares ignore any caching by SAS controller
Comparing on performance (not capacity):

Depending on the workload, the HDD stack may be much higher on the left.

This shows a fairly conservative HDD vs SSD performance comparison.
SSD Savings with 6-Packs and 4-Packs

Save 20%  PLUS
convenient to order & easy to understand / explain

Order with a new server order

For Ultra SSD I/O Drawer:

A 2.3 TB six-pack = up to 140,000 IOPS for 20% less than buying single features

For EXP24S Drawer or system unit or 12X drawer:

A 1.5 TB four-pack = up to 90,000 IOPS for 20% less than buying single features

Prices shown are IBM USA suggested list prices and are subject to change without notice; reseller prices may vary. Packs consists of six or four SSD drives. An SSD drawer or SAS controller is not included in the pack. Maintenance after warranty is not discounted. IOPS are read-only using a typical workload used to measure I/O workload, not necessarily typical server I/O usage. IOPS achievable will vary with the configuration.
SSD Six-Packs  (#ESR2/ESR4)

For Ultra SSD Drawer:

- A 2.3TB six-pack = up to 140,000 IOPS for 20% less than buying six single features
- Assuming Power 740, list price savings = $7,320 for one 6-pack
- Package is SSD only. EXP30 Ultra SSD Drawer ordered in addition to six-packs

- For EXP30 Ultra SSD I/O Drawer
  - #EDR1 or #5888
- Must order with a new server, no MES orders.
- Max quantity = 5X available Ultra SSD Drawers which can hold them

- #ESR2 (AIX, Linux, VIOS) (= 6 X #ES02)
- #ESR4 (IBM i) (= 6 X #ES04)

Prices shown are IBM USA suggested list prices and are subject to change without notice; reseller prices may vary. Packs consists of six or four SSD drives. An SSD drawer or SAS controller is not included in the pack. Maintenance after warranty is not discounted. IOPS are read-only using a typical workload used to measure I/O workload, not necessarily typical server I/O usage. IOPs achievable will vary with the configuration.
New Third-generation eMLC SSD

• Refreshing Solid State Drives (SSDs) with faster technology
• Adding 775 GB capacity – 2X larger than current size drives

**387 GB**
- SFF (2.5-inch) SAS drive
- Up to 2X more IOPs than previous
- Up to 40% better latency than previous
- Same price as current 387GB SSD
- Supported on POWER7/POWER7+ models 710-795 and 7R1-7R4

**775 GB**
- SFF (2.5-inch) SAS drive
- Up to 2X more IOPs than previous
- Up to 40% better latency than previous
- ~15% lower price per GB than 387 GB SSD. Plus footprint savings benefit
- Supported on POWER7/POWER7+ models 710-795 and 7R1-7R4

IBM USA suggested list prices as of Oct 2013 and are subject to change without notice; Reseller prices may vary.
New Third-generation eMLC SSD

387 GB
- SFF (2.5-inch)
- Up to 2X more IOPs than previous
- Up to 40% better latency than previous
- Same price as current 387GB SSD

775 GB
- New capacity point
- SFF (2.5-inch)
- Up to 2X more IOPs than previous
- Up to 40% better latency than previous
- ~15% lower price per GB than 387 GB SSD. Plus footprint savings benefit

Generation-3 387GB equals same price/GB, more performance

Generation-3 775 GB equals better price/GB, more performance, Plus footprint savings

IBM USA suggested list prices as of Oct 2013 and are subject to change without notice; Reseller prices may vary.
### Power eMLC SSD Performance by Generation

<table>
<thead>
<tr>
<th>2.5-inch (SFF)</th>
<th>IO OPERATIONS PER SECOND (IOPS)</th>
<th>Throughput (MB/s)</th>
<th>Latency - Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SSD</td>
<td>Random Read</td>
<td>Random Write</td>
</tr>
<tr>
<td>Gen 1</td>
<td>177GB</td>
<td>15 k</td>
<td>4 k</td>
</tr>
<tr>
<td>Gen 2</td>
<td>387GB</td>
<td>39 k</td>
<td>22 k</td>
</tr>
<tr>
<td>Gen 3</td>
<td>387GB 775GB</td>
<td>80 k</td>
<td>49 k</td>
</tr>
</tbody>
</table>

**For grins …**

15k rpm HDD

<table>
<thead>
<tr>
<th>Throughput (MB/s)</th>
<th>Latency - Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~175 MB</td>
<td>8.3 – 2.5 ms</td>
</tr>
</tbody>
</table>

Note these are single drive specific measurements reflecting sustained drive workloads (not burst). The values assume 528 byte sectors running RAID-0 with no protection. Hypothetically if measured with unsupported 512 byte sectors, values would be higher. The values are highly workload dependent. Factors such as read/write mix, random/non-random data, drive cache hits/misses, data compressibility in the drive controller, large/small block, type of RAID or mirroring protection, etc will change these values. The choice of which SAS controller/adapter is running the drive can also impact these values.. These values produced by a server with plenty of processor, memory and controller resources to push this much I/O into the SSD. Most client system applications don’t push SSD nearly this hard. Latency measurements using OLTP1 60/40 random 4k transfers.
SSD Four-Packs 3rd Generation (#ESRE/ESRF/ESRG/ESRH)

- A 1.5TB four-pack = up to 200,000 IOPS for 10% less than buying four single features
- Assuming Power 740, list price savings = $1,435 for one 4-pack
- Package is SSD only. SAS bay enclosure or SAS adapters ordered in addition to four-packs

- Must order with a new server, no MES orders.
- Max quantity = 1
  - Qty ESRE + ESRF + ESRG + ESRH = 1
  - Can not combine with ESRA+B+C+D
- For CEC or for #5802/5803
  - #ESRE (AIX, Linux, VIOS) (= 4 x #ES10)
  - #ESRF (IBM i) (= 4 x #ES11)
- For #5887 EXP24S I/O Drawer
  - #ESRG (AIX, Linux, VIOS) (= 4 x #ES19)
  - #ESRH (IBM i) (= 4 x #ES1A)
- Can be ordered with “singles” features

Prices shown are IBM USA suggested list prices as of Oct 2013 and are subject to change without notice; reseller prices may vary. Packs consists four SSD drives. An SSD drawer or SAS controller is not included in the pack. Maintenance after warranty is not discounted. IOPS are read-only using a typical workload used to measure I/O workload, not necessarily typical server I/O usage. IOPs achievable will vary with the configuration.
Re-engineered PCIe2 1.8GB RAID SAS Adapter → feature # ESA3

~20% more energy efficient – lower power draw, less cooling

Same performance as #5913 PCIe2 1.8GB RAID SAS Adapter

$600/$786 lower price per pair adapters than existing #5913 Adapter

Supported on POWER7+ 720, 740, 770, 780. SOD for more models

$600 for Power 720/740 IBM USA suggested list prices as of Oct 2013. $786 for Power 770/780 IBM USA suggested list price as of Oct 2013. Subject to change without notice; Reseller prices may vary.
1.8 GB Cache PCIe SAS Adapter - #ESA3 or #5913

- Premier SAS PCIe adapter – IBM technology designed for SSD
- Paired, full-high, single-slot adapters
- PCIe Gen2 adapter – 6Gbps
- Up to 4GB/s transfer
- 1.8GB write cache
- No batteries to maintain!!
  - Built in flash protection
- Supports SAS HDD and/or SSD
  - All expected protection options
  - RAID, mirroring, etc
  - RAID array sizes from 3 - 32

Paired adapters for redundancy and performance
Introducing PCIe Gen3 SAS Adapter Technology

Comparing large cache SAS Adapters

PCIe SAS – PCIe Gen 3
1Q 2014
Designed for newest SSD
800k-ish IOPS *
Up to 96 HDD
Up to 48 SSD

PCIe SAS – PCIe Gen 2
4Q 2011
1st SAS adapter designed for SSD
300-400k IOPS
Up to 72 HDD
Up to 24 SSD

* restricted by PCIe Gen1 slot

PCI-X SAS
2Q 2009
Est 70-80k IOPS
Up to 48-60 HDD ....
Also can do some SSD

SAS adapter technology – designed by IBM
Power Systems with Power Systems reliability, ruggedness, integrity, performance,
The Most Powerful SAS RAID Adapters EVER

First PCIe Gen3 adapters introduced by Power Systems
Most powerful SAS adapters ever created by Power Systems *

- Supports 2X more SSD devices than Gen2 SAS adapter
- Up to 10X more performance than Gen1 SAS Adapter
- 2X more performance than Gen2 SAS adapter

#EJ0L effectively has 6X more write cache

Better prices than predecessor Gen2 SAS adapters

* IBM Development team not aware of a more powerful SAS adapter in the world
Effectively 6X more cache than PCIe2 SAS adapter
- 12 GB for PCIe3
- 1.8 GB for PCIe2 #5913/ESA3

- Effectively 12 GB
  - Physically 3 GB cache
    - Physical 3GB is 66% larger than the previous physical 1.8GB
  - Adapter uses compression to provide 12 GB cache
    - Data’s compressibility will cause this to vary, but for typical workloads about 4X typical compression yields 12GB effectively
PCIe Gen3 SAS OS Support

For #EJ0J, #EJ0L, & EJ0X

- **OS**
  - AIX V7.1 with the 7100-03 Technology Level and Service Pack 1 or later
  - AIX V6.1 with the 6100-09 Technology Level and Service Pack 1 or later
  - IBM i 6.1 with machine code 6.1.1 or later
  - IBM i 7.1 or later
  - Red Hat Enterprise Linux 6.4 for POWER, or later
  - SUSE Linux Enterprise Server 11 Service Pack 3, or later
  - VIOS 2.2.3.1 or later
Things to be considered when choosing storage

- Cost
- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Availability needs
- Performance needs
SSDs compared to HDDs

- 36 HDDs, 1.5G write cache
- 48 HDDs, 1.5G write cache
- 4 SSDs, 1.5G write cache
- 8 SSDs, 1.5G write cache
- 4 SSDs, 2x 380MB write cache
- 8 SSDs, 2x 380MB write cache
- 8 SSDs, 2x PCIe adapter
- 8 SSDs, 2x PCIe adapter, mirrored
SSDs compared to HDDs – US$s per IOP

Operations per Second vs. US$ per IOP

- 8 SSDs, 1.5G write cache
- 4 SSDs, 1.5G write cache
- 36 HDDs, 1.5G write cache
- 48 HDDs, 1.5G write cache
PCle SSD virtualized to IBM i – application performance view

57CD 2x with 8 SSDs mirrored by IBM i

Response Time (seconds)

TPM

- i 7.1 native
- Dual VIO hosting i 6.1.1 - JBoD (each VIO 1/2-CPU, 2G memory)
- Dual VIO hosting i 6.1.1 - R0 (each VIO 1/2-CPU, 2G memory)
- Dual VIO hosting i 6.1.1 - R0 (each VIO 1CPU, 2G memory)
PCle SSD virtualized to IBM i – drive performance view

57CD 2x with 8 SSDs mirrored by IBM i

- 7.1 native
- Dual VIO hosting i 6.1.1 - JBoD (each VIO 1/2-CPU, 2G memory)
- Dual VIO hosting i 6.1.1 - R0 (each VIO 1/2-CPU, 2G memory)
- Dual VIO hosting i 6.1.1 - R0 (each VIO 1CPU, 2G memory)
Consistent DS8000 Performance Focus for POWER IBM i

Key enhancements of the re-architected data/command paths

- **Smart-IOA** - no IOP in the command path
  - Leverage today’s faster, more powerful IOA technology

- **Tagged Command Queuing**
  - Multiple ops to each LUN-connection (more multi-threading)

- **Header Strip/Merge Improvements**
  - Moved function into IOA reducing traffic on HSL/12X and PCI X bus, reducing latency

**Example* DS8300 Application**

- 8 IOP-IOA pairs replaced by 2 Smart-IOAs (16 > 2)
- Smart IOA and 6.1 - 7.1 performance wins

* Performance measurement for other configurations or workloads may have different results.

- POWER5, POWER6, POWER7
- IBM i 6.1 and 7.1
DS8800 results for OLTP-like application

- HDD baseline configuration:
  - 144 15K rpm 146G

- SSD configuration
  - 96 15K rpm 146G drives
  - 16 SSDs
  - 4 DA pairs

![Graph showing DS8800 Baseline vs Easy Tier comparison]
IBM i and DS8000 Performance Monitoring Integration

Performance monitoring integration and ease of use

• Focus on end-to-end performance monitoring and investigation for an IBM i and DS8000 environment

• IBM i 7.1 adds a new category to IBM i Collection Services
  – *EXTSTG – new collection performance metrics from DS8000
    • Requires DS8000 R4 or later firmware
  – Data can be presented in graphs using iDoctor today
    • Performance Data Investigator (PDI), in a future release (next update semi-annual function update)
Storage considerations review

- Platform for attachment
  - Server
  - Operating system
- Virtual or direct
- Availability needs
- Performance needs
- Cost per IO/s not GBs
- Protection schema
  - RAID-1 / RAID-10
  - RAID-5
  - RAID-6
- Physical planning
  - Space
  - Cabling
  - Power
  - Heat/cooling
  - Floor loading

Focus on two choices
The End, Thank You!
How does cost compare?

Very roughly

The equivalent capacity/performance for:

* V7000 vs. internal 2.8TB and 6TB = 3x more

V3700 vs. internal 2.8TB and 6 TB = 1.5x more

Costs get closer with more capacity

*Note: Available capacity. Using compression with V7000 the total capacity can be reduced (up to 70% - 90%)