System z Flash Express
Introduction, Setup, Management, Configuration, Uses, and Benefits

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Agenda

• z/OS Customer Value Proposition
• System z Flash Express and z/OS
• Flash Performance Results
• z/OS Flash Roadmap
• Under the Covers – Implementation Highlights
Flash Express is a PCIe IO adapter with NAND Flash SSDs (Solid State Drives)

Flash Express is accessed using the Extended Asynchronous Data Mover
  – Optimized software path for Flash Access based on prior learning with z expanded store

Flash Express provides continuous availability
  – RAID 10 to cover adapter failure
  – Concurrent Firmware update to cover service

Flash Express is fully virtualized
  – A single adapter pair can provide Flash to 60 partitions on a CEC
  – Adapter RAS (call home, recovery, etc.) done at system level, not in OS.
  – Transparent migration to new adapter technology
IBM Flash Express – Smarter Availability for Smarter Systems

• Flash Express is an innovative solution designed to help you compete effectively in today’s marketplace
  – Automatically improve availability for key workloads at critical processing times
  – Drive availability and performance for workloads that cannot tolerate paging spikes or inconsistent performance
  – Slash latency for critical application processing such as diagnostics collection

• Extends IBM’s expertise in memory management introducing a new tier of memory using Flash Express

• Provides a secured, resilient and immediately usable solution

• Planned Flash Express and pageable large page exploiters:
  - z/OS V1.13 Language Environment
  - IMS 12 Common Queue Server
  - DB2 10 *
  - Java SDK601 SR4, and Java SDK7 SR3 and by extension:
  - WAS Liberty Profile v8.5

*DB2 date to be determined. Support for V10 with APARs is planned.
**Traditional WAS support is planned for a future date

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Flash Express Strengthens Availability

• Innovation to drive availability to exceptional levels
  – Extends IBM’s expertise in memory management introducing a new tier of memory using Flash Express
  – Is an industry unique application of Flash to improve availability
  – Takes the next step in advanced memory management

• Flash Express can improve availability and reduce latency
  – Improves availability during transition periods and spikes
  – Helps accelerate start of day processing - batch to online
  – Enables faster snapshots of diagnostics (e.g. SVC dump, standalone dump)
  – With pageable large pages can improve performance of DB2 and Java
  – Ideal for applications with random read access and high read/write ratios

• Helps customers deliver vigorous service levels
  – Designed to help provide exceptional availability and fast response time
  – Delivered in tandem with pageable large pages for superior performance

• Minimal configuration- no special skills needed
  – Usable immediately; no special training required
  – Easy to set up and dynamically configurable
Representative Use Cases - Flash Express

Flash Express can reduce latency delays from paging to bring system availability to new heights and improve overall service levels.

Application related errors will require collection of diagnostics. These diagnostics can be collected faster with Flash Express, reducing paging related delays that can impact your overall availability.

Having your working data resident in Flash can help accelerate start of day processing, and improve service for many industries at the busiest time of their work day- a time when they cannot afford disruptions.

DB2® and Java™ in memory buffer pools work to store and process application data. DB2 and Java can benefit from 1MB pageable large pages with Flash Express, improving overall performance.
Flash Express – What is it?

FLASH Express
► Flash Express is a PCIe IO adapter with NAND Flash SSDs
► Physically comprised of internal storage on Flash SSDs
► Used to deliver a new tier of memory-storage class memory
► Uses PCIe I/O drawer

► Sized to accommodate all LPAR paging
  ▪ Each **card pair** provides 1.4 TB usable storage (2.8 TB total)
  ▪ Maximum 4 card pairs (4 X1.4=5.6 TB)

► Immediately usable
  ▪ Simplifies capacity planning
  ▪ No intelligent data placement needed
  ▪ Full virtualization across partitions

► Robust design
  ▪ Delivered as a RAID10 mirrored pair
  ▪ Designed for long life
  ▪ Designed for concurrent firmware upgrade

► Secured
  ▪ Flash Express adapter is protected with 128-bit AES encryption.
  ▪ Key Management provided based on a Smart Card
  ▪ Secure Cryptographic Erase meets audit requirements

Access Time
► CPU nanos
► Flash microseconds
► Disk -milleseconds

Flash memory (SCM) blurs the distinction between memory and storage characteristics.

All statements regarding IBM’s future directions and intent are subject to change or withdrawal without notice and represent goals and objectives only.
Companies competing for the highest quality of service in today’s market must deliver outstanding availability and performance.

Changes in workload processing can impact service levels at critical processing times.

**Flash Express is an innovative solution designed to help you improve availability and performance to compete effectively in today’s market**

- Automatically improves availability for key workloads at critical processing times.
- Drives availability and performance for workloads that cannot tolerate paging spikes or inconsistent performance.
- Slashes latency for critical application processing such as start of day processing and also collection of diagnostics (SVC dumps, standalone dumps).
- Delivered as a new adapter card in the PCIe I/O drawer.

**Benefits**

- Improves availability and performance helping companies achieve highest service levels.
- Delivers a secured, resilient and immediately usable solution.
- Automatic, requires minimal setup, no special training needed.
System z Flash and z/OS
Introduction to zFlash

Initial Setup
  – Customer Service Representative (CSR) Portion
    • Install Smart Cards in Support Elements (SE)
    • Install zFlash cards if necessary
    • Create Pair
  – Customer Portion
    • No IOCDS changes
    • Allocate zFlash memory to partition(s)
    • Configure z/OS to use zFlash

Management
  – Management of zFlash Allocations
  – zFlash PCHID details
  – View Partition to PCHID map
  – View Flash Allocations for a specific Partition
  – View Flash (details)
  – System Activity Display (SAD) / Monitors Dashboard
  – Console Events
  – Security Logs
  – Status (Service Personnel Only)
  – Configure On/Off (Service Personnel Only)
  – Service On/Off (Service Personnel Only)

Terminating Flash
  – Change all instances of z/OS to no longer use zFlash
  – Disband all zFlash pairs
  – Remove SE Smart Cards and destroy (optional)
Install Smart Cards in Support Elements (CSR responsibility)

- Cards will be installed by the CSR
  - During machine installation if zFlash shipped with the machine
  - Before installing the first zFlash adapters (if the machine was not shipped with zFlash)
More on Smart Cards

- The data on the zFlash cards is encrypted. This is done to prevent access to the data if a zFlash card is removed from the system, such as for a repair action or thru some malicious action (i.e. theft).

- The Smart Cards are an essential part of managing the encryption keys.

- The blank Smart Card is the same one used by the TKE device.

- The Primary SE will create an authentication key using the smart card and store it on the SE. The Alternate SE will uses the smart card in it to store the key sent from the primary.

- The smart card, the SE hardware, the CEC, and the generated Key are tightly coupled in order to prevent access to the data on the zFlash card in any place other than the CEC it was formatted for.

- If for some reason the smart card fails on the primary an automatic switch to the alternate will happen and a service call will occur to have the smart card or the SE serviced. There are procedures to ensure the repaired SE or Smart Card is properly updated with the encryption keys.

- The keys will not be preserved during migrations/upgrades. So, persistence of data on the zFlash adapters is thus not guaranteed. The zFlash adapters are therefore good for things like paging storage but should not be used for situations where persistence is required.

- Bottom line: The Smart Cards must be installed so that the SE is prepared to store and handle the encryption keys used to protect the data on the zFlash adapters.
Install zFlash cards if necessary (CSR responsibility)

- Installed in pairs in Seneca cages, one per I/O domain
- Pairs are cabled together with 2 SAS cables
Install zFlash cards if necessary (CSR responsibility)

- Once installed, the cards are visible on the Support Element's User Interface as a PCHID
Create pair(s) of zFlash adapters (CSR Responsibility)

- A “create pair” operation must be performed that allows the paired adapters to initialize themselves into a pair and format the storage.

- Done via a new SE task, **Flash Status and Controls**

- Service Personnel only

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GUSRDA6: Flash Status and Controls

<table>
<thead>
<tr>
<th>Select</th>
<th>PCHID</th>
<th>Cage-Card Slot</th>
<th>Serial Number</th>
<th>Adapter State</th>
<th>Array-config State</th>
<th>Serial of Partner</th>
<th>Port A State</th>
<th>Port B State</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑</td>
<td>0300</td>
<td>Z01B-LG01-J.00</td>
<td>04001001</td>
<td>Online</td>
<td>Not formatted</td>
<td>0400100E</td>
<td>0000, Operational</td>
<td>0000, Operational</td>
</tr>
<tr>
<td>☑</td>
<td>032C</td>
<td>Z01B-LG14-J.00</td>
<td>0400100E</td>
<td>Online</td>
<td>Not formatted</td>
<td>04001001</td>
<td>0000, Operational</td>
<td>0000, Operational</td>
</tr>
<tr>
<td>☑</td>
<td>0350</td>
<td>Z01B-LG25-J.00</td>
<td>04001019</td>
<td>Online</td>
<td>Not formatted</td>
<td>04001021</td>
<td>0000, Operational</td>
<td>0000, Operational</td>
</tr>
<tr>
<td>☑</td>
<td>036C</td>
<td>Z01B-LG33-J.00</td>
<td>04001021</td>
<td>Online</td>
<td>Not formatted</td>
<td>04001019</td>
<td>0000, Operational</td>
<td>0000, Operational</td>
</tr>
</tbody>
</table>
Create Pair

- Select **Create Pair** to create and format a pair
- Use the Refresh button to monitor the progress of the formatting.
- It takes a while (15 to 20 minutes) to complete the pairing/formatting operation.
Allocate zFlash Memory to partition(s)

Manage Flash Allocation SE and HMC task

- Available on both the HMC and SE.
- Displays current summary Flash information for the system.
- Displays current Flash information by partition.
- Use to Add, Change or Remove allocations to a partition.
Manage Flash Allocation Task's Actions
Manage Flash Allocation - Add zFlash Allocation

- Allocation can be done for a partition defined in any IOCDS or a partition not currently defined.
- May be done after initial zFlash setup as necessary (such as when a new partition is defined).
- Example of picking an existing partition:
Example of typing in a new partition name:
Allocating Flash to a partition

- The initial and maximum amount of Flash Memory available to a particular logical partition is specified at the SE or HMC via a new Flash Memory Allocation panel.
- Can dynamically change maximum amount of Flash Memory available to a logical partition.
- Additional Flash Memory (up to the maximum allowed) can be configured online to a logical partition dynamically at the SE or HMC.
  - For z/OS this can also be done via an operator command.
- Can dynamically configure Flash Memory offline to a logical partition at the SE or HMC.
  - For z/OS this can also be done via an operator command.
- Predefined subchannels, no IOCDS.

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**Allocating z FLASH**

- **Summary**
  - Allocated: 976 GB
  - Available: 1872 GB
  - Uninitialized: 0 GB
  - Unavailable: 0 GB
  - Total: 2848 GB
- **Partitions**
  - Select: --- Select Action ---
  - Partition Name: R70
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 48
    - Maximum (GB): 2848
  - Partition Name: R71
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 128
    - Maximum (GB): 2848
  - Partition Name: R72
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 48
    - Maximum (GB): 2848
  - Partition Name: R73
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 32
    - Maximum (GB): 2848
  - Partition Name: R74
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 80
    - Maximum (GB): 2848
  - Partition Name: R75
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 80
    - Maximum (GB): 2848
  - Partition Name: R76
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 64
    - Maximum (GB): 2848
  - Partition Name: R77
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 64
    - Maximum (GB): 80
  - Partition Name: R7B
    - Status: Inactive
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 128
    - Maximum (GB): 128
  - Partition Name: R7F
    - Status: Active
    - IOCDS: A0,A1,A2,A3
    - Allocated (GB): 32
    - Maximum (GB): 64

---

For z/OS this can also be done via an operator command.
z FLASH Virtualization

- Full virtualization of physical Flash PCIe cards across partitions, software sees an Abstracted Flash Storage Space...
  - Allows each logical partition to be configured with its own SCM address space
  - Allocate Flash to partitions by amount, not card size
  - Ability to change underlying technology while preserving API

▶ No Hardware Specifics in Software.
  - Error Isolation, Transparent mirroring, Centralized diagnostics, etc.
  - Hardware Logging, FRU Call, Recovery: Independent of software

- Data transfer between Main Memory and Storage Class Memory is via EADMF (4KB or 1MB blocks)
FLASH for z/OS Paging Value

Flash Memory is a faster paging device as compared to HDD

- The value is NOT in replacing memory with Flash but replacing disk with Flash
- Flash is suitable for workloads that can tolerate paging and will not benefit workloads that cannot afford to page
- The z/OS design for Flash Memory does not completely remove the virtual storage constraints created by a paging spike in the system. (Some scalability relief is expected due to faster paging I/O with Flash Memory.)
A z/OS Flash Configuration

AUX STORAGE

FLASH

- OFFLINE SCM ADDRESS INCREMENT
- OFFLINE SCM ADDRESS INCREMENT

Main Memory

CONFIG SCM, OFFLINE

Data

LP1

Firmware Management of Adapter

Allocated SCM Pool

Free (Not Initialized)

Free (Initialized)

SCM Increment

SCM Increment

SCM Increment

IOP/HSA

zNext

LP2

Configure SCM CHSC

Deconfigure SCM CHSC

Main Memory

CONFIG SCM, ONLINE

Data

AUX STORAGE

FLASH

- ONLINE SCM ADDRESS INCREMENT

Data

Local Data

PLPA

VIO

Data

PLPA

VIO

Data

Local Data
Typical Customer Configurations for FLASH

• Flash card pair memory size is 1.4TB
  – Min: 1 Card Pair
  – Max: 4 Card Pairs

• Typical customer configuration is 6 to 8 LPARs per CEC and 40GB - 80GB for paging configuration dataset size

• Even with 10 LPARs per CEC, each LPAR has 140 GB of Flash Memory available for its paging datasets, more than double the current typical customer configuration.
  – All paging data can easily reside on Flash
  – Data will preferably go to Flash and only go to disk (if any) when Flash is full
  – No intelligent placement of data on internal Flash needed
Flash vs Disk Placement Criteria

Main Memory

Evict Page

- Check Data Characteristics (i.e., must reside on flash or must reside on disk)
- If data can reside on either: check space availability
  - Flash full
- If space available on both check response time statistics
  - Flash is faster

FLASH

Paging Dataset
HDDs or SSDs
## Flash vs Disk Placement Criteria

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Page Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLPA</td>
<td>At IPL/NIP time PLPA pages will be placed both on Flash and disk.</td>
</tr>
<tr>
<td>VIO</td>
<td>VIO data will always be placed on disk (First to VIO accepting datasets with any spillover flowing to non-vio datasets)</td>
</tr>
<tr>
<td>Pageable Large Pages</td>
<td>If contiguous Flash space is available, pageable large page will be written to Flash. If Flash is not available in the system configuration pageable large pages will be backed with 4k page frames.</td>
</tr>
<tr>
<td>All other data</td>
<td>If available space exists on both Flash and disk then make a selection based on response time.</td>
</tr>
</tbody>
</table>
z/OS FLASH Use Cases

Paging

• z/OS paging subsystem will work with mix of internal Flash and External Disk
  – Self Tuning based on measured performance
  – Improved Paging Performance, Simplified Configuration

• Begin Paging 1 MB Large Pages only on Flash
  – Exploit Flash’s random IO read rate to get CPU performance by enabling additional use of Large Pages. Currently large pages are not pagable.

• Begin Speculative Page-In of 4K Pages, 1MB Pages only on Flash
  – Exploit Flash’s random IO read rate to get Improved Resilience over Disruptions.
  – Market Open, Workload Failover
Flash Memory Usage and Invocation

- New PAGESCM= keyword in IEASYSxx defines the amount of flash to be reserved for paging
  - Value may be specified in units of M, G, or T
  - NONE indicates do not use flash for paging
  - ALL (default) indicates all flash defined to the partition is available for paging
Flash Memory Usage and Invocation (cont)...

- New messages issued during IPL indicate the status of SCM
  - IAR031I USE OF STORAGE-CLASS MEMORY FOR PAGING IS ENABLED - PAGESCM=ALL, ONLINE=00065536M
  
  OR

  - IAR032I USE OF STORAGE-CLASS MEMORY FOR PAGING IS NOT ENABLED - PAGESCM=NONE
Flash Memory Usage and Invocation (cont)…

- The D ASM and D M commands are enhanced to display flash-related information/status
  - D ASM lists SCM status along with paging data set status
  - D ASM, SCM displays summary of SCM usage
  - D M=SCM display SCM online/offline and increment information
  - D M=SCM(DETAIL) displays detailed increment-level information
### Display ASM Command

**d asm**

<table>
<thead>
<tr>
<th>Type</th>
<th>Status</th>
<th>Dataset Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLPA</td>
<td>100% FULL</td>
<td>SYS1.PLPA.PAGCOM</td>
</tr>
<tr>
<td>COMMON</td>
<td>61% OK</td>
<td>SYS1.COMMON.PAGCOM</td>
</tr>
<tr>
<td>LOCAL</td>
<td>0% OK</td>
<td>SYS1.LOCAL.PAGEP2</td>
</tr>
<tr>
<td>LOCAL</td>
<td>0% OK</td>
<td>SYS1.LOCAL.PAGEP3</td>
</tr>
<tr>
<td>LOCAL</td>
<td>0% OK</td>
<td>SYS1.LOCAL.PAGEP4</td>
</tr>
<tr>
<td>SCM</td>
<td>11% OK</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**d asm,scm**

<table>
<thead>
<tr>
<th>Status</th>
<th>Size</th>
<th>Used</th>
<th>In-Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN-USE</td>
<td>16,777,216</td>
<td>2,096,144</td>
<td>0</td>
</tr>
</tbody>
</table>
Flash Related Commands

**D M=SCM**
IEE174I 17.57.26 DISPLAY M 230
STORAGE-CLASS MEMORY STATUS
80G DEFINED
ONLINE
0G-64G
16G OFFLINE-AVAILABLE
14% IN USE
SCM INCREMENT SIZE IS 16G

**D M=SCM(DETAIL)**
IEE174I 17.57.30 DISPLAY M 232
STORAGE-CLASS MEMORY STATUS - INCREMENT DETAIL
80G DEFINED
ADDRESS IN USE STATUS
  0G  55% ONLINE
  16G  0% ONLINE
  32G  0% ONLINE
  48G  0% ONLINE
ONLINE: 64G  OFFLINE-AVAILABLE: 16G  PENDING OFFLINE: 0G
14% IN USE
SCM INCREMENT SIZE IS 16G

**CF SCM(16G),ONLINE**
IEE195I SCM LOCATIONS 64G TO 80G ONLINE
IEE712I CONFIG  PROCESSING COMPLETE
Flash Memory Usage and Invocation (cont)…

· The CONFIG ONLINE command is enhanced to allow bringing additional SCM online
  - CF SCM(*amount*),ONLINE
    - CF SCM(16G),online
      - IEE195I SCM LOCATIONS 64G TO 80G ONLINE
      - IEE712I CONFIG PROCESSING COMPLETE

· The CONFIG OFFLINE command is enhanced to allow...
  - CF SCM(*amount*),OFFLINE
  - CF SCM(*start_range*-end_range*),OFFLINE
  - Requires APAR OA40968
Flash Memory Usage and Invocation (cont)…
Flash Memory Usage and Invocation (cont)…
RMF Updates

- RMF Monitor II Page Data Set Activity Report includes SCM activity (RMF II → Resource → PGSP):

```
RMF - PGSP Page Data Set Activity

CPU= 1     UIC= 65K PR=   0         System= 4381 Total

S VOLUME DEV  DEV      %SLOTS   PAGE   I/O REQ AVG PAGES   10:21:00
T SERIAL NUM  TYPE     IN USE TRAN TIME  RATE    PER I/O V   DATA SET NAME

P PAGCOM 02E6 33903     100.0 ------ ------- 0.000    SYS1.PLPA.PAGCOM
C PAGCOM 02E6 33903     63.04 ------- ------- 16.500    SYS1.COMMON.PAGCOM
L PAGEP2 098E 33903      0.00 ------- ------- 0.000 Y   SYS1.LOCAL.PAGEP2
S N/A    N/A N/A        8.58 ------ ------- 10.939    N/A
```
RMF Updates (cont)

- RMF Monitor III STORF Report includes SCM usage in 'Aux Slots' count (RMF III → Resource → STORF):

  RMF V2R1   Storage Frames
  Line 2

<table>
<thead>
<tr>
<th>Service</th>
<th>-- Frame Occup.--</th>
<th>-- Active Frames --</th>
<th>AUX</th>
<th>PGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jobname</td>
<td>C Class</td>
<td>Cr TOTAL</td>
<td>ACTV</td>
<td>IDLE</td>
</tr>
<tr>
<td>J273</td>
<td>S SYSSTC</td>
<td>8332</td>
<td>8332</td>
<td>0</td>
</tr>
<tr>
<td>OMVS</td>
<td>S SYSTEM</td>
<td>6560</td>
<td>6560</td>
<td>0</td>
</tr>
<tr>
<td>HZSPROC</td>
<td>S SYSSTC</td>
<td>3996</td>
<td>3996</td>
<td>0</td>
</tr>
<tr>
<td>XCFAS</td>
<td>S SYSTEM</td>
<td>3637</td>
<td>3637</td>
<td>0</td>
</tr>
<tr>
<td>PGOOUT30L</td>
<td>S SYSSTC</td>
<td>3551</td>
<td>0</td>
<td>3551</td>
</tr>
</tbody>
</table>

Samples: 100   System: 4381   Date: 05/09/13   Time: 10.48.20   Range: 100
## zFlash SVC Dump - RMF Page Data Set Report Example

- **RMF Page Data Set report: average over 6 minutes**

### PAGE DATA SET ACTIVITY

<table>
<thead>
<tr>
<th>System</th>
<th>Date</th>
<th>Interval</th>
<th>Time</th>
<th>Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>z/OS V1R13</td>
<td>10/09/2012</td>
<td>05.59.585</td>
<td>14.30.28</td>
<td>0.050 SECONDS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Samples</th>
<th>Page Data Set and SCM Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,190</td>
<td>------------------------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Page</th>
<th>Type</th>
<th>Serial</th>
<th>Num</th>
<th>Volume</th>
<th>Dev</th>
<th>Device</th>
<th>SLOTS Used</th>
<th>Bad</th>
<th>In</th>
<th>Trans</th>
<th>Number</th>
<th>Pages</th>
<th>I</th>
<th>O</th>
<th>DATA SET NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLPA</td>
<td>PLPA</td>
<td>41PAG0</td>
<td>5473</td>
<td>33903</td>
<td>98999</td>
<td>14655</td>
<td>14655</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Y</td>
<td>SYS1.P41.PLPA</td>
</tr>
<tr>
<td>COMMON</td>
<td>COMMON</td>
<td>41PAG0</td>
<td>5473</td>
<td>33903</td>
<td>89999</td>
<td>61</td>
<td>61</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>32</td>
<td>0</td>
<td></td>
<td>SYS1.P41.COMMON</td>
</tr>
<tr>
<td>LOCAL</td>
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<td>33903</td>
<td>410399</td>
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<td>0</td>
<td>0</td>
<td>Y</td>
<td>SYS1.P41.LOCAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCM</th>
<th>Type</th>
<th>Serial</th>
<th>Volume</th>
<th>Dev</th>
<th>Device</th>
<th>SLOTS Used</th>
<th>Bad</th>
<th>In</th>
<th>Trans</th>
<th>Number</th>
<th>Pages</th>
<th>I</th>
<th>XFER'D</th>
<th>DATA SET NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>SCM</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>33554K</td>
<td>6030K</td>
<td>6108K</td>
<td>6061K</td>
<td>0</td>
<td>4.24</td>
<td>0.000</td>
<td>721516</td>
<td>17.19M</td>
</tr>
</tbody>
</table>
SVC Dump Statistics

• VERBX IEAVTSFS

• Shows total dump capture time, system/task non-dispatch time, page operations required to dump requested address space (real-to-real copies, page-ins, etc)
<table>
<thead>
<tr>
<th>Description</th>
<th>Date/Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dump start</td>
<td>10/09/2012 14:30:29.867495</td>
</tr>
<tr>
<td>Dump end</td>
<td>10/09/2012 14:30:44.224584</td>
</tr>
<tr>
<td><strong>Total dump capture time</strong></td>
<td><strong>00:00:14.357089</strong></td>
</tr>
<tr>
<td>System nondispatchability start</td>
<td>10/09/2012 14:30:29.870030</td>
</tr>
<tr>
<td>System set nondispatchable</td>
<td>10/09/2012 14:30:29.870048</td>
</tr>
<tr>
<td>Time to become nondispatchable</td>
<td>00:00:00.000017</td>
</tr>
</tbody>
</table>
SVC Dump Statistics (cont)

Asid 0071:

- Local storage start: 10/09/2012 14:30:30.424083
- Local storage end: 10/09/2012 14:30:43.011936
- Local storage capture time: 00:00:12.587853
- Tasks reset dispatchable: 10/09/2012 14:30:43.011944
- Tasks were nondispatchable: 00:00:12.587861

- Defers for frame availability: 0
- Pages requiring input I/O: 170196
- Source page copied to target: 16987
- Source frames re-assigned: 566614
- Source AUX slot IDs re-assigned: 15749
Manage Flash Allocation - Change zFlash Allocation

- Allocated can only be changed for inactive partitions (APIVM2) or undefined partitions (NEWPARTN)
- Changing Allocated results in loss of data
- Changing allocations for an inactive partition:
Manage Flash Allocation - Change zFlash Allocation

- Changing allocations for an active partition (notice only the maximum can be altered):
Manage Flash Allocation - Remove zFlash Allocation

- Remove Allocation can only be performed for an inactive partition
- All data will be lost
- A warning message will be issued and confirmation required before the Remove Allocation is done
Manage Flash Allocation - View Partition to PCHID Map

- Shows information for all PCHIDs
- SE and HMC

![View Partition to PCHID Map - P00MNXXK4](image)

<table>
<thead>
<tr>
<th>Partition Name</th>
<th>Status</th>
<th>Adapter A PCHID</th>
<th>Adapter B PCHID</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP01</td>
<td>Inactive</td>
<td>0300</td>
<td>032C</td>
</tr>
<tr>
<td>LP02</td>
<td>Active</td>
<td>0300</td>
<td>032C</td>
</tr>
<tr>
<td>NEWPARTN</td>
<td></td>
<td>0300</td>
<td>032C</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>3</strong></td>
<td></td>
</tr>
</tbody>
</table>
zFlash PCHID Details

- Display information for one PCHID
- SE only
View Flash Allocations Task

- Display information for one partition
- SE only
View Flash

- For the selected PCHID, shows you some physical and allocation details
- SE Only
System Activity Display (SAD) / Monitors Dashboard

- Zflash is not supported by System Activity Display (SAD)
- It is supported by Monitors Dashboard. Refer to the new “Adapters” table in the lower right.
Console Events

- Event logs will be generated when a flash allocation is added, changed or removed:

![Console Events](image-url)
Security Logs

- Appropriate security logs will be generated for zFlash-related actions.

- Examples:

<table>
<thead>
<tr>
<th>Select</th>
<th>Date</th>
<th>Time</th>
<th>Security Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4/29/12</td>
<td>19:03:40.320</td>
<td>*A Flash Memory Allocation was changed for logical partition CF01.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>19:02:59.460</td>
<td>*A Flash Memory Allocation was added for logical partition CF01.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:55:33.020</td>
<td>*A Flash Memory Allocation was removed for logical partition LP02.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:57:16.500</td>
<td>A concurrent resource change has resulted in a change to the processor speed.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:57:16.500</td>
<td>*Power-on reset was successful.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:41:58.720</td>
<td>A1 was made the active input/output configuration data set (IOCDS).</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:41:58.680</td>
<td>Changed write protect of input/output configuration data set (IOCDS) STARTER in A1 to ON.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:41:58.680</td>
<td>Changed write protect of input/output configuration data set (IOCDS) STARTER in A1 to OFF.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:41:19.250</td>
<td>User pedebug has logged on from the console to session id 2. The user's maximum role is &quot;Product Engineering Tasks&quot;.</td>
</tr>
<tr>
<td></td>
<td>4/29/12</td>
<td>18:38:47.610</td>
<td>Power-on was performed.</td>
</tr>
</tbody>
</table>

* - Denotes additional data for an event. Click "Details..." to display.
Flash Status and Controls States (Service Personnel Only)

- **Adapter States:**
  - Not Installed
  - Online
  - Online in progress
  - Offline
  - Offline check stopped
  - Offline in progress
  - Online check stopped
  - Service
  - Configuration error

- **Array States:**
  - Not formatted
  - Format in progress #\% complete
  - Unformat in progress
  - Formatted
  - Configuration error
  - Rebuild in progress #\% complete
  - Exposed
  - Unformat required

- **Port States:**
  - Unknown
  - Operational
  - Service
  - Dangling
  - Check stopped
  - Configuration error
  - Entering service mode
  - Exiting service mode
  - Repair in progress
  - Not installed
Configure the zFlash Adapter On/Off (Service Personnel Only)

Configure the adapter online or offline.
Adapter Service Mode (Service Personnel Only)

Enter adapter service mode or exit adapter service mode, they are both disabled right now because the adapter status is Online.
Port Service Mode (Service Personnel Only)

- Enter Port A service mode or exit Port A service mode, the exit is disabled currently because the port is currently in operational state.

- Port B Service behaves the same way.
Flash Express Performance Results

- All performance information was determined in a controlled environment.
- Actual results may vary.
- Performance information is provided “AS IS” and no warranties or guarantees are expressed or implied by IBM.
Flash Express Performance Test Setup

• z/OS Tests were designed to demonstrate flash performance under paging workloads that are typically encountered in a z/OS enterprise environment
  – SSD performance is not only about the number of IOPS but about steady performance over time and consistent latency
  - Preconditioned SSDs with random-write IO engage the device’s wear leveling, error handling, and flash management algorithms
• Comparison DASD Characteristics used current device configurations
  • DS8800 model 2107-951
  • 60 GB cache, cache hit rates of 95-100% were observed during the tests
  • DASD was not shared with any other systems and did not have any I/O traffic other than the paging traffic used for these tests
  • Configured 16 local page datasets spread across 8 LCUs
Flash Express Performance Benefits

Test Results

- **FLASH paging benefits**
  - Improved availability through faster paging at critical times
    - Faster workload transitions (e.g.; morning startup)
      - *meaning less time to reach peak transaction rates*
    - Faster SVC dumps (reduced **non-dispatchable** time)
      - *meaning higher availability – more transactions can be run*

- **Pageable Large Page benefit**
  - Java realizes performance benefits from use of large 1MB pageable pages
    - Large pages benefits for JIT Code Cache, 31 bit Java applications
    - No authorization needed to access fixed large pages
    - Approximately 5-8% CPU improvement from PLP
Workload Configuration Block Diagram
Building block – A WAS instance accessing CICS and DB2

Each WAS instance has a WAS Control Region and 3 WAS Servant Regions. Each WAS Control Region has a 0.5GB heap plus a JIT Code cache. Each WAS Servant Region has a 2GB heap plus a JIT Code Cache.

Test Configuration
- WAS 7 (3 servants each with two GB heap) + 1 control region (.5 GB Heap)
- CICS V4.2, DB210 on a zEC12
- Storage: DS8800 2107-951 with 60GB cache, very fast device
- Tests simulated morning transition time typical of trading or call center work
- SVC dump measurements were taken for an 18 GB dump.

WAS Control Region (0.5GB heap)

<table>
<thead>
<tr>
<th>WAS Servant Region (2GB heap)</th>
<th>WAS Servant Region (2GB heap)</th>
<th>WAS Servant Region (2GB heap)</th>
</tr>
</thead>
</table>

CICS transactions

DB2

2-book zEC12
I. Morning Transition
Transition from night batch to OLTP

WAS workload to CICS and DB2 represents OLTP work which is then stopped.
Simulated overnight work consumes real storage pushing other pages out.

~21GB is pushed out to Auxiliary storage.
Morning Transition - Transition from night batch to OLTP

The “Night Work” is then stopped and OLTP work is started (WAS 1 and WAS 2). Measure the time needed to bring the OLTP work to full speed.

~14GB is paged back in from Auxiliary storage
Morning Transition - Results

- During morning transition, workloads using Flash Express reached peak throughput in under 1/4th the time.

Paging to DASD required about 44 seconds for the workload to reach steady state.

Paging to Flash required only 10 seconds for the workload to reach steady state.
### Morning Transition - Results Apparent in First 45 Seconds

<table>
<thead>
<tr>
<th>Transaction completion &amp; response time</th>
<th>DASD</th>
<th>Flash</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Transactions within first 45 seconds</td>
<td>251</td>
<td>343</td>
<td><strong>37% increase</strong></td>
</tr>
<tr>
<td>Average response time within first 45 seconds</td>
<td>0.62</td>
<td>0.06</td>
<td><strong>90% reduction</strong></td>
</tr>
</tbody>
</table>

Units in seconds

- Paging to Flash Express during morning transition showed up to a 10 times faster response time and up to a 37% increase in throughput within the first 45 seconds

(1) Test was for the first 45 seconds of morning transition time
II. SVC Dump
SVC dump with pages out

Three of four WAS instances were active. One WAS instance was stopped and most pages were paged out.
Capture an SVC dump of WAS instance 3 and 4, and DB2. Measure the capture time for the SVC dump.
SVC Dump - Results

- Flash Express SVC dump elapsed time was up to 25% shorter

<table>
<thead>
<tr>
<th>SVC Dump Metrics</th>
<th>DASD</th>
<th>Flash</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC Dump size (in bytes):</td>
<td>18GB</td>
<td>18GB</td>
</tr>
<tr>
<td>% of pages from Aux storage:</td>
<td>50%</td>
<td>53%</td>
</tr>
<tr>
<td>DUMP Elapsed time:</td>
<td>189</td>
<td>143</td>
</tr>
<tr>
<td>Max address space non-dispatchable seconds</td>
<td>58.89</td>
<td>13.74</td>
</tr>
<tr>
<td>System non-dispatchable seconds</td>
<td>1.34</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Let’s graph these results....
SVC Dump - Results

- In SVC dump test, steady state performance was achieved up to 4 times faster *

14 sec.

Steady state Flash

60 sec.

Steady state DASD

Focus on first 90 seconds.

* Transaction steady state was reached in 14 seconds with Flash Express, vs. 60 seconds DASD
zFlash SVC Dump – Page-in Rate

- Peak page-in rate with Dasd: 75,000 pages per sec
- Peak page-in rate with SCM: 260,000 pages per sec
zFlash SVC Dump – CPU Usage

- CPU peaks correspond to peaks in page-in rates
- Several peaks when using DASD while one peak when using SCM
### zFlash SVC Dump - RMF Page Data Set Report Example

- **RMF Page Data Set report:** average over 6 minutes

---

#### PAGE DATA SET ACTIVITY

<table>
<thead>
<tr>
<th>z/OS V1R13</th>
<th>SYSTEM ID P41</th>
<th>DATE 10/09/2012</th>
<th>INTERVAL 05.59.585</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPT VERSION V1R13 RMF</td>
<td>TIME 14.30.28</td>
<td>CYCLE 0.050 SECONDS</td>
<td></td>
</tr>
</tbody>
</table>

**NUMBER OF SAMPLES = 7,190**

**PAGE DATA SET AND SCM USAGE**

<table>
<thead>
<tr>
<th>SPACE</th>
<th>VOLUME</th>
<th>DEV</th>
<th>DEVICE</th>
<th>SLOTS</th>
<th>---- SLOTS USED ---</th>
<th>BAD</th>
<th>IN</th>
<th>TRANS</th>
<th>NUMBER</th>
<th>PAGES</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>SERIAL</td>
<td>NUM</td>
<td>TYPE</td>
<td>ALLOC</td>
<td>MIN</td>
<td>MAX</td>
<td>AVG</td>
<td>SLOTS</td>
<td>USE</td>
<td>TIME</td>
<td>IO REQ</td>
</tr>
<tr>
<td>PLPA</td>
<td>41PAG0</td>
<td>5473</td>
<td>33903</td>
<td>98999</td>
<td>14655</td>
<td>14655</td>
<td>14655</td>
<td>0</td>
<td>0.00</td>
<td>0.000</td>
<td>0</td>
</tr>
<tr>
<td>COMMON</td>
<td>41PAG0</td>
<td>5473</td>
<td>33903</td>
<td>89999</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>0</td>
<td>0.00</td>
<td>0.000</td>
<td>2</td>
</tr>
<tr>
<td>LOCAL</td>
<td>41PAG0</td>
<td>5473</td>
<td>33903</td>
<td>410399</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.000</td>
<td>0</td>
</tr>
</tbody>
</table>

| SCM | N/A | N/A | N/A | 33554K | 6030K | 6108K | 6061K | 0 | 4.24 | 0.000 | 721516 | 17.19M | N/A |

---

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Stand-Alone Dump

- Improvements in Stand-Alone Dump time when dumping data that are paged out
- Overall 37 second reduction in dump time due to faster page-in of data from aux when using Flash representing approximately a 19% reduction in total dump time for an 36 GB dump

<table>
<thead>
<tr>
<th>Tests</th>
<th>Total dump time In minutes</th>
<th>Paging I/O wait time In seconds</th>
<th>Batch read rate MB/sec</th>
<th>Total GB dumped</th>
<th>GB of data from aux</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASD Page data sets (DS8800)</td>
<td>00:03:12.92</td>
<td>00:00:41.30</td>
<td>438.06</td>
<td>36.2</td>
<td>17.7</td>
</tr>
<tr>
<td>Flash for paging</td>
<td>00:02:35.03</td>
<td>00:00:10.38</td>
<td>1612.30</td>
<td>36.3</td>
<td>16.3</td>
</tr>
</tbody>
</table>
Benefits of large pages:
- Better performance by decreasing the number of TLB misses that an application incurs
- Less time spent converting virtual addresses into physical addresses
- Less real storage used to maintain DAT structures

Fixed large pages vs pageable large pages:
- Fixed large pages are backed at allocation. Pageable large pages are backed when referenced.
- Use of fixed large pages for unauthorized users is controlled by a RACF profile (IARRSM.LRPAGES). No RACF authorization to use pageable large pages.
- Fixed large pages stay as 1 MB pages while pageable large pages may be demoted to 4K pages in certain situations.

Performance:
- Java: performance with pageable 1MB large pages is equivalent to 1MB fixed large pages for java heap: up to 8% ITR impact
- IMS using pageable large pages: up to 1% system ITR improvement.
- DB2 using pageable large pages: up to 3% system ITR improvement.
Pageable 1MB Frames – Example from IBM Brokerage Workload

All of buffer pools are backed by real storage – DB2 10
- zEC12 16 CPs, 5000-6000 tps (simple to complex transactions)
  - 120GB real storage with 70GB LFAREA configured for 1MB measurements
- 1MB Pageable frames are 2% better than 4KB pageable frames for this workload
  - 70GB buffer pools are used, 8-10 sync I/O per transaction
- 1MB frames with PageFixed is the best performer in general

Total DB2 CPU Time per Transaction
z/OS Java SDK 7: 16-Way Performance Shows up to 60% Improvement
64-bit Java Multi-threaded Benchmark on 16-Way

Aggregate 60% improvement from zEC12 and Java7SR3

■ zEC12 offers a ~45% improvement over z196 running the Java Multi-Threaded Benchmark
■ Java7SR3 offers an additional ~13% improvement (-Xaggressive + Flash Express pageable 1Meg large pages)
## WAS benchmark: z/OS Performance for Pageable Large Pages

The WAS Day Trader benchmarks showed up to an 8% performance improvement using Flash Express.

<table>
<thead>
<tr>
<th>Java 7 SR3</th>
<th>JIT</th>
<th>Java Heap</th>
<th>Multi Threaded</th>
<th>WAS Day Trader 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 bit</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>64 bit</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64 bit</td>
<td></td>
<td>yes</td>
<td></td>
<td>4%</td>
</tr>
</tbody>
</table>

* WAS Day Trader 64-bit Java 7 SR3 with JIT code cache & Java Heap

**DETAILS**
- **64-bit Java heap** (1M fixed large pages (FLPs) or 1M Pageable (PLPs)) versus 4k pages
  - Java heap 1M PLPs improve performance by about
    - 4% for Multi-Threaded workload
    - 5% for WAS Day Trader 2.0
  - 64-bit Java 7 SR3 with JIT code cache 1M PLPs vs without Flash
    - 3% improvement for traditional WAS Day Trader 2.0*
    - 1% improvement for Java Multi-Threaded workload
  - 31-bit Java 7 SR3 with JIT code cache and Java heap 1M PLPs vs without Flash
    - 4% improvement for Java Multi-Threaded workload

* Note: This test used 64-bit Java 7 SR3 with JIT code cache & Java Heap leveraging Flash and pageable large pages.

Also, tests used WAS Day Trader app that supports PLP; earlier version of 31-bit Java did not allocate 1M large pages.
Performance Summary for Flash Express(1)

WORKLOAD TRANSITION

- During morning transition, workloads using Flash Express reached peak throughput in under 1/4th the time
- Paging to Flash Express during morning transition showed up to a 10 times faster response time and up to a 37% increase in throughput within the first 45 seconds

WAS JAVA PERFORMANCE BENCHMARKS

- The WAS Day Trader benchmarks showed up to an 8% performance improvement using Flash Express.(2)
  * This test used 64-bit Java 7 SR3 with JIT code cache & Java Heap leveraging Flash and pageable large pages.

Improved Availability During Diagnostics

- In SVC dumps, availability was up to 4 times higher for workloads and up to twice as high for systems*
- In SVC dump tests, steady state performance was achieved up to 4 times faster *
- Flash Express SVC dump elapsed time was up to 25% shorter
  * Transaction steady state was reached in 14 seconds with Flash Express, vs. 60 seconds DASD.

DB2

- Up to 28% improvement in DB2™ throughput due to faster CPU and leveraging Flash Express with Pageable Large Pages (PLP)*
- Workloads leveraging Flash Express with PLP can see up to a 8%** price performance improvement over the z196.

* PLP for DB2 helps DB2 to achieve “additional” up to 3% additional performance on top of zEC12 CPU expected throughput improvements of 25%.
** based on average 5% discount for zEC12 workloads under the AWLC pricing plus up to 3% more performance per MSU with Flash Express.

(1) All tests are comparing the use of Flash Express as compared to using DASD (DS8800)
(2) System non dispatchability and address space non dispatchability time were dramatically reduced enabling work to be processed that would otherwise have been stopped
z/OS Flash Roadmap
Flash Express Exploitation

*Flash support in z/OS sets the stage for further use*

- **Flash Express announced**
- **z/OS support**
- **4Q12**
  - IBM zEnterprise® EC12 (zEC12) 9/19
  - z/OS support for zEC12
- **1Q13**
  - z/OS V1.13, enabling PTF
  - z/OS RSM Enablement Offering
    - Flash Dynamic Reconfiguration
    - Optional PLPA & Common dataset definition

- **z/OS V1.13 Flash Web Deliverable December 14th 2012**
- **Linux® on System z (native)**

- **Planned Flash Express and pageable large page exploiters:**
  - DB2 for z/OS
  - Java SDK7
  - WAS Liberty Profile v8.5
  - IMS™ 12
  - z/OS V1.13 Language Environment®
  - Other (CICS®)

*Expect continued middleware exploitation for 1MB pageable large pages*
Flash Express Implementation

✓ System Overview
✓ Redundant Physical Structures
✓ Data Protection Mechanisms
✓ Data and Key Encryption
✓ Non-Disruptive Service Techniques
Redundant Physical Structures

LPAR 1….n
- SSCH
- ORB
- AOB
- AIDAWs
- Data
- Data

SAP 1….n
- Firmware Management of Adapter
  - Subchannel
  - Device control
  - EADMF control

Support Element

System Bus

Multiple Processors

PCIe Switch

Storage Class Memory
- LPAR1 Increments
- RAID Controller
- Firmware

Flash Express Cards

PCIe IO Drawer

Flash Express Cards

PCIe Switch

Storage Class Memory
- RAID Controller
- Firmware
- LPAR1 Increments
Redundant Physical Structures

Redundant SE's for configuration and key service
Redundant Physical Structures

LPAR 1….n
SSCH
ORB
AOB
AIDAWs
Data

SAP 1….n
Firmware Management of
Subchannel
Device control

I/O Drawer Connections

OS

I/O Hub
PCIe Switch

PCIe

Data Transfer

Storage Class Memory

Flash Express Cards

PCIe IO Drawer

RAID Controller

Firmware

LPAR1 Increments

RAID Controller

Firmware

LPAR1 Increments

PCIe

PCIe
Redundant Physical Structures

Self-Mirrored Adapters w/ dual mirror cables
Comm links (SAS, PCIe) provide embedded protection & recovery

CEC-based hardware address protection on communication from adapter

ECC on internal system memory

RAID10: Protection and performance
- RAID0 = Striping
- RAID1 = Mirroring
- RAID10 = Striped mirrored data

CRC and block seq. number stored on SSD

Additional CRC around block transfer
Data and Key Encryption

✓ On SSD, data is protected with inline encryption (hidden encryptKey)

✓ Access to SSD is via authentication key (authKey) served from SE

During Flash install, in smart card on SE:
- Create authKey (aka PIN)
- Wrap authKey in an encrypted file
- wrapKey stored in smart card
- Wrapped key file stored on SE

SE → CEC-FW authkey service:
- asymmetric protocol – pub/private
- IOP sends public key to SE
- In smart card, Key file unwrapped then encrypted with CEC pubKey
- Encrypted authKey sent to CEC
- CEC 'unwraps' authKey using its privKey

✓ AuthKey used during SSD format and subsequent power cycles
Non-disruptive Service Strategy

- Firmware updates
  - Adapter
  - SSD
  - Expanders
  - CEC-FW
- Adapter replacement
- Cable replacement
- Recoveries
  - CEC
  - Adapter
  - SSD
IBM Flash materials

**Redbooks**
SG24- 8049 - IBM zEnterprise System Connectivity Handbook (GRS ESCON / FICON CTCs, and FLASH Express, etc.)

SG24-5444 - IBM zEnterprise EC12 Technical Introduction (FLASH Express, and IBM zAware, etc.)

SG24- 8050 - IBM zEnterprise EC12 Technical Guide (FLASH Express, and IBM zAware, etc.)

**Flash Express White Paper**

**Flash Blogs**
Reference Documentation

- Available from “Books” group of Classic Style UI and the Welcome page of the Tree Style UI (& IBM Resource Link: Library->zEC12->Publications)
  - IBM SB10-7030: Application Programming Interfaces
  - IBM SC28-2605: Capacity on Demand User’s Guide
  - IBM SB10-7154: Common Information Model (CIM) Management Interfaces
  - IBM SB10-7156: PR/SM Planning Guide
  - IBM SA22-1088: System Overview
  - IBM SC27-2623 Advanced Workload Analysis Reporter (IBM zAware) Guide

- Available from IBM Resource Link: Library->zEC12->Technical Notes
  - System z Hardware Management Console Security
  - System z Hardware Management Console Broadband Remote Support Facility
  - System z Activation Profile Update and Processor Rules
System z Social Media Channels

- **Top Facebook pages related to System z:**
  - IBM System z
  - IBM Academic Initiative System z
  - IBM Master the Mainframe Contest
  - IBM Destination z
  - Millennial Mainframer
  - IBM Smarter Computing

- **Top LinkedIn groups related to System z:**
  - System z Advocates
  - SAP on System z
  - IBM Mainframe- Unofficial Group
  - IBM System z Events
  - Mainframe Experts Network
  - System z Linux
  - Enterprise Systems
  - Mainframe Security Gurus

- **Twitter profiles related to System z:**
  - IBM System z
  - IBM System z Events
  - IBM DB2 on System z
  - Millennial Mainframer
  - Destination z
  - IBM Smarter Computing

- **YouTube accounts related to System z:**
  - IBM System z
  - Destination z
  - IBM Smarter Computing

- **Top System z blogs to check out:**
  - Mainframe Insights
  - Smarter Computing
  - Millennial Mainframer
  - Mainframe & Hybrid Computing
  - The Mainframe Blog
  - Mainframe Watch Belgium
  - Mainframe Update
  - Enterprise Systems Media Blog
  - Dancing Dinosaur
  - DB2 for z/OS
  - IBM Destination z
  - DB2utor
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Backup Material
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Reference Documentation

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zFlash Setup, Management, and Configuration

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