The Evolution of Managing Real Storage and zFLASH’s Impact

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The following is the text of an IBM Data Processing Division press release distributed on April 7, 1964.

A new generation of electronic computing equipment was introduced today by International Business Machines Corporation.

IBM Board Chairman Thomas J. Watson Jr. called the event the most important product announcement in the company's history.

The new equipment is known as the IBM System/360.

System/360 core storage memory capacity ranges from 8,000 characters of information to more than 8,000,000. Information storage devices linked to the system can store additional billions of characters of data and make them available for processing at varying speeds, depending on need.

- **Memory power.** A hierarchy of memories within System/360 makes information in core storage available at varying speeds. Small local store memories operate in as little as 200 billionths-of-a-second. Control memories operate in as little as 250 billionths-of-a-second. Powerful main memories -- containing up to 524,000 characters of information -- range from 2.5 millionths-of-a-second down to one millionth-of-a-second.

A key development provides 8,000,000 characters in bulk core storage -- each character available in eight millionths-of-a-second and each at the direct command of a computer programmer. This is over sixty times more directly addressable characters than were previously available in IBM computers. The computer's historic limitations on memory size are overcome by this development.
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Generations of IBM360 -> 370 -> 390

The original 360 family was announced in 1964, and the lower midrange model 40 was the first to ship a year later. The most interesting version was model 67 (first shipped June 1966) which had hardware to support virtual memory. IBM had planned a special operating system for it (TSS/360), which they never managed to get to work well enough to be usable. Within IBM, model 67 was used with a system known as CP-67, which allowed a single 360/67 to simulate multiple machines of various models. This turned out to be very useful for developing operating systems. In the summer of 1970, IBM announced a family of machines with an enhanced instruction set, called System/370. These machines were all designed with virtual hardware similar to 360/67, and eventually all the operating systems were enhanced to take advantage of it in some way.

When System/360 was successful, other companies started making their machines similar to IBM's, but not close enough to actually run the same software. In 1970, however, Gene Amdahl (who had been the chief architect for the 360 family) started a company to build a series of machines that were direct clones of the 360-370 architecture, and later Hitachi followed suit. (The first Amdahl machine was shipped in 1975.)

Big, fast disk drives were one of the strengths of IBM. In 1973, the big mainframe disk drive was model 3330-11: 400 MB for $111,600 or $279/MB. By 1980, you could get the 3380: 2.5GB for $87,500 or $35/MB. DRAM prices were dropping, too: In 1979 the price was cut from $75,000/MB to $50,000/MB.

Through the 1970's and 1980's, the machines got bigger and faster, and multi-processor systems became common, but the basic architecture did not change. Around 1982, addresses were extended from 24 bits to 31 bits (370-XA), and in 1988 extensions were put in to support multiple address spaces (370-ESA). In 1990, the ES/9000 models came out with fiber-optical I/O channels (ESCON), and IBM began using the name System/390.
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History
- Real
- Expanded
- Importance of Page Packs

Today
- Large Page
  - 1M
  - 1M Pageable
  - 2G
  - INCLUDE1MAFC

- zFLASH

Philosophy
- Memory allocation
- DB2 Buffers - Fix or don’t define
- FLASH - What it’s good for (Good move or bad - DB2)
- What’s changing
Note: z/OS 1.13 documentation does not cover INCLUDE1MAFC parameter.
LFAREA (A,B)

\[ 1M = (a, b) \]

Specifies the number of 1 MB pages of online real storage to reserve in the large frame area. Up to eight decimal digits each can be specified for \( a \) and \( b \). The value specified for \( a \) is the target number of pages, and the value specified for \( b \) is the minimum number. The system attempts to meet the request at or as near as possible up to the target number, but at no less than the minimum number. The value specified for \( b \) must be less than or equal to the value specified for \( a \), and can be zero. A specification of \( 1M = (0, 0) \) results in zero 1 MB pages being reserved. Once the LFAREA parameter has been processed, no additional amounts of storage are reserved later in an attempt to reach the target. Both a value and a percentage, such as \( 1M = (a, b\%) \) or \( 1M = (a\%, b) \), cannot be specified.
The V2R1 Exchange is making this APAR known to all members:

APAR OA41968 applies to V2R1 and V1R13:

Added the INCLUDE1MAFC keyword to the operands for LFAREA in IEASYSxx.

Here are some LFAREA examples using INCLUDE1MAFC:

\[
\text{LFAREA}=(64\text{M},\text{INCLUDE1MAFC})
\]
- Note: Using the xM|xG|xT|x% syntax, INCLUDE1MAFC is a positional parameter and must be coded after the xM|xG|xT|x% specification.

\[
\text{LFAREA}=(20\%,\text{INCLUDE1MAFC})
\]
- Note: Using the xM|xG|xT|x% syntax, INCLUDE1MAFC is a positional parameter and must be coded after the xM|xG|xT|x% specification.

\[
\text{LFAREA}=(1\text{M}=64,\text{INCLUDE1MAFC})
\]
- Note: Using the 1M= syntax, INCLUDE1MAFC can be specified anywhere within the parentheses.

\[
\text{LFAREA}=(\text{INCLUDE1MAFC},1\text{M}=20\%,\text{NOPROMPT})
\]
- Note: Using the 1M= syntax, INCLUDE1MAFC can be specified anywhere within the parentheses.
Memory Philosophy

- LPARs should be memory rich, CPU management of memory is costly
- I define specific values for LFAREA allocations
  - RMF Monitor 3 provides great insight
- LFAREA is specified in the IEASYSxx member
  - Requires an IPL
- Remember that frequently used items like DB2 bufferpools will always reside in memory so fixing the frames really has no cost… but there are significant savings
Storage constrained environment without the **INCLUD1MAFC** APAR. The APAR changes the harvesting of unused LFAREA pages to being aggressive when the LFAREA parmlib member has **INCLUD1MAFC** specified.

**Without ** **INCLUD1MAFC** specified**

```
RESPONSE=AEC91
IAR019I 14.31.59 DISPLAY VIRTSTOR 974
   SOURCE = 91
   TOTAL LFAREA = 4096M
   LFAREA AVAILABLE = 3941M
   LFAREA ALLOCATED (1M) = 143M
   LFAREA ALLOCATED (4K) = 12M
   MAX LFAREA ALLOCATED (1M) = 433M
   MAX LFAREA ALLOCATED (4K) = 66M
```
Storage constrained environment with the **INCLUD1MAFC** APAR. The APAR changes the harvesting of unused LFAREA pages to being aggressive when the LFAREA parmlib member has **INCLUD1MAFC** specified.

```
-D VIRTSTOR,LFAREA
IAR019I  14.39.48 DISPLAY VIRTSTOR 618
  SOURCE  =  91
  TOTAL LFAREA  =  4096M , 0G
  LFAREA AVAILABLE  =  19M , 0G
  LFAREA ALLOCATED (1M)  =  1063M
  LFAREA ALLOCATED (4K)  =  3014M
  MAX LFAREA ALLOCATED (1M)  =  1064M
  MAX LFAREA ALLOCATED (4K)  =  3033M
  LFAREA ALLOCATED (PAGEABLE1M)  =  0M
  MAX LFAREA ALLOCATED (PAGEABLE1M)  =  0M
  LFAREA ALLOCATED NUMBER OF 2G PAGES  =  0
  MAX LFAREA ALLOCATED NUMBER OF 2G PAGES  =  0
```
LFAREA at IPL on a z196

LFAREA=(20%,INCLUDE1MAFC) specified in IEASYSxx member

00000290 IAR040I REAL STORAGE AMOUNTS: 160
160 00000290 TOTAL AVAILABLE ONLINE: 30G
160 00000290 LFAREA LIMIT FOR xM, xG, OR xT : 22G
160 00000290 LFAREA LIMIT FOR SUM OF 1M= AND 2G= : 21299M
160 00000290 LFAREA LIMIT FOR 2GB PAGES FOR 2G= : 0 (NOT SUPPORTED)
00000290 IAR048I LFAREA=(20%,INCLUDE1MAFC) WAS PROCESSED WHICH RESULTED IN
4096 1MB PAGES AND 0 2GB PAGES.
00000290 IAR013I 8G STORAGE IS RECONFIGURABLE
LFAREA - 2G page specified on z196

IAR041E  LFAREA=(1M=20%, 2G=2, INCLUDE1MAFC) WAS SPECIFIED BUT 2GB PAGE SUPPORT IS NOT AVAILABLE.
IAR045I  VALID RANGE FOR LFAREA xM, xG, xT IS 0M TO 22G, OR 0% TO 80%. A 163 MINIMUM OF 7% MUST BE SPECIFIED TO RESERVE AT LEAST ONE 1MB PAGE.
IAR045I  VALID RANGE FOR LFAREA 1M= IS 0 TO 21299, OR 0% TO 80%. A 164 MINIMUM OF 1% MUST BE SPECIFIED TO RESERVE AT LEAST ONE 1MB PAGE.
IAR045I  VALID VALUE FOR LFAREA 2G= IS 0, OR 0%. HARDWARE SUPPORT UNAVAILABLE FOR 2GB PAGES.
IAR047I  AT THE FOLLOWING PROMPT, SPECIFY THE COMPLETE LFAREA PARAMETER OR PRESS ENTER FOR ZERO 1MB AND 2GB PAGES.
IEA341A  RESPECIFY LFAREA PARM OR PRESS ENTER
IEE600I  REPLY TO 00 IS: LFAREA=(1M=20%, INCLUDE1MAFC)
IAR048I  LFAREA=(1M=20%, INCLUDE1MAFC) WAS PROCESSED WHICH RESULTED IN 5324 1MB PAGES AND 0 2GB PAGES.
• LFAREA specifications that can not be satisfied - hold up the IPL if NOPROMPT *is not* specified
• If NOPROMPT is specified, the IPL continues… but the LFAREA parameters that could be satisfied are also ignored
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On an EC12

DATA SET LAST UPDATED AT 19:23:17 ON 10/03/2013 (GMT)

IEA940I THE FOLLOWING PAGE DATA SETS ARE IN USE:

PLPA ............  - SYS1.PG91AA.LPA
COMMON ..........  - SYS1.PG91AA.CSA
LOCAL .........  - SYS1.PG91AB.LOCAL1
LOCAL .........  - SYS1.PG91AC.LOCAL1
LOCAL .........  - SYS1.PG91AD.LOCAL1
LOCAL .........  - SYS1.PG91AE.LOCAL1
LOCAL .........  - SYS1.PG91AF.LOCAL1
LOCAL .........  - SYS1.PG91AG.LOCAL1
LOCAL .........  - SYS1.PG91AH.LOCAL1
LOCAL .........  - SYS1.PG91AI.LOCAL1

IEE252I MEMBER IEASVC91 FOUND IN SYS1.PARMLIB.AEPLEX0A

IAR040I REAL STORAGE AMOUNTS: 241

TOTAL AVAILABLE ONLINE: 11G

LFAREA LIMIT FOR xM, xG, OR xT : 6963M
LFAREA LIMIT FOR SUM OF 1M= AND 2G= : 5734M
LFAREA LIMIT FOR 2GB PAGES FOR 2G= : 2

IAR048I LFAREA = (1M=20%, 2G=2, INCLUDE1MAFC) WAS PROCESSED WHICH
RESULTED IN 1433 1MB PAGES AND 2 2GB PAGES.

IAR013I 9G STORAGE IS RECONFIGURABLE

IAR031I USE OF STORAGE-CLASS MEMORY FOR PAGING IS ENABLED - PAGESCM=AL
L, ONLINE=00000000M
Memory Management

CPU should not be traded off for Memory

Large Page allocations should back the DB2 BPs at a minimum

Without zFLASH

- Keep your AFC well stocked (I shoot for 10-15GB backing all address space virtual)
- Watch the SYSTEM UIC - know when it drops (hint sorts)

With zFLASH

- Expand your memory use (DB2 BP’s)
- Keep healthy AFC (2 or more GB - after address spaces are trimmed to only keep WSS frames in storage)
- Active paging should only be a result of the initial trimming, it should not be an ongoing event
FLASH

Flash Memory aka SCM (Storage Class Memory) will be available from 1 to 4 flash features. Each has 1 feature providing 1.4 TB of user storage.

• Goals
  • Paging Relief on Test LPARs
  • Implement 1MB paging for Websphere clocking the Websphere Memory issues

• SOFTWARE
  • z/OS 1.13 - Requires a web deliverable download of support
  • z/OS 2.1 - Support delivered in base

• Parmlib (IEASYSxx)
  • PAGE= (new Option *NONE*) discuss warm start and options
  • PAGESCM=ALL (flash used only for paging… it is the default value - fine for today but hoping)

• HMC - Defining the flash to an LPAR
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- Select the **SYSTEMS MANAGEMENT** tag
- Select the radio button for the CPC desired (Z1W)
- Under **CONFIGURATION** select **MANAGE FLASH**
Select **ADD ALLOCATION** from the scroll down **SELECT ACTION** box.
Use Radio button on *Use existing*
Select LPAR from Pull down box
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FLASH Commands

-D ASM,SCM
IEE207I 19.23.52 DISPLAY ASM 220
STATUS FULL SIZE USED IN-ERROR
IN-USE 27% 67,108,864 18,741,379 0

-D M=SCM(DETAIL)
IEE174I 19.25.57 DISPLAY M 539
STORAGE-CLASS MEMORY STATUS - INCREMENT DETAIL
256G DEFINED
ADDRESS IN USE STATUS
0G 0% ONLINE
16G 0% ONLINE
32G 0% ONLINE
48G 0% ONLINE
64G 0% ONLINE
80G 0% ONLINE
96G 0% ONLINE
112G 89% ONLINE
128G 90% ONLINE
144G 91% ONLINE
160G 92% ONLINE
176G 63% ONLINE
192G 0% ONLINE
208G 0% ONLINE
224G 27% ONLINE
240G 0% ONLINE
ONLINE: 256G OFFLINE-AVAILABLE: 0G PENDING OFFLINE: 0G
28% IN USE
SCM INCREMENT SIZE IS 16G

FLASH Config commands
May be issued to config on and config off Flash in 16GB increments.

I believe in allocating FLASH in larger than required segments.

1.4 TB of FLASH goes a long way. If you need that much order more

Up to 4 - 1.4TB features may be ordered. Max of 2 features per drawer.
RMFIII - Storage Use of Memory Objects - storage constrained system (1 of 2)
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RMFIII - Storage Use of Memory Objects - storage constrained system (2 of 2)

<table>
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<th>Jobname</th>
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<th>Comm</th>
<th>Shr</th>
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<th>Pgable</th>
<th>Total</th>
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RMFIII - Storage Use of Memory Objects - storage $\$RICH\$ system
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RMFIII - Storage Frames - storage constrained system

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RMFIII - Storage Frames - storage $RICH$ system (2 of 2)

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### Post Processor - Paging Activity

#### FRAME AND SLOT COUNTS

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<th>(364 SAMPLES)</th>
<th>TOTAL</th>
<th>AVAILABLE</th>
<th>SQA</th>
<th>LPA</th>
<th>CSA</th>
<th>LSQA</th>
<th>REGIONS+SWA</th>
<th>HV SHARED</th>
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<td>SHARED FRAMES / SLOTS</td>
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### Post Processor - Memory Objects

#### Paging Activity

<table>
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<tr>
<th>z/OS V2R1</th>
<th>SYSTEM ID AE32</th>
<th>START 08/04/2014-09.59.00</th>
<th>INTERVAL 000.59.59</th>
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<tbody>
<tr>
<td>OPT = IEAOP32</td>
<td>LFAREA SIZE = 2306867K</td>
<td>MEMORY OBJECTS AND HIGH VIRTUAL STORAGE FRAMES</td>
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#### Memory Objects

<table>
<thead>
<tr>
<th>OBJECTS</th>
<th>COMMON</th>
<th>SHARED</th>
<th>1 MB</th>
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<tbody>
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<td>MIN</td>
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<td>33</td>
</tr>
<tr>
<td>MAX</td>
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<td>33</td>
</tr>
<tr>
<td>AVG</td>
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<td>26</td>
<td>33</td>
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#### 1 MB Frames

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#### High Shared Frames

<table>
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<th>CENTRAL STORAGE</th>
<th>AUX DASD</th>
<th>AUX SCM</th>
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<tbody>
<tr>
<td>MIN</td>
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#### High Common Frames

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<th>CENTRAL STORAGE</th>
<th>FIXED 4K</th>
<th>AUX DASD</th>
<th>AUX SCM</th>
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</thead>
<tbody>
<tr>
<td>MIN</td>
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<td>3,254</td>
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<td>7,262</td>
</tr>
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<td>MAX</td>
<td>17301504</td>
<td>26,510</td>
<td>3,254</td>
<td>0</td>
<td>7,262</td>
</tr>
<tr>
<td>AVG</td>
<td>17301504</td>
<td>26,506</td>
<td>3,254</td>
<td>0</td>
<td>7,262</td>
</tr>
</tbody>
</table>
The Evolution of Managing Real Storage and zFLASH’s Impact

Post Processor - Page Dataset Activity

```
# P A G E  D A T A  S E T  A C T I V I T Y
#    z/OS V2R1
# SYSTEM ID AE31
# START 08/04/2014-09.59.00
# RPT VERSION V2R1 RMF
# END 08/04/2014-10.59.00
# CYCLE 1.000 SECONDS
# NUMBER OF SAMPLES = 3,600

PAGE  DATASET AND SCM USAGE
-----------------------------------------------
PAGE  %  PAGE  V
SPACE   VOLUME  DEV DEVICE  SLOTS  ---- SLOTS USED ---  BAD  IN  TRANS  NUMBER  PAGES  I
TYPE    SERIAL  NUM  TYPE  ALLOC  MIN  MAX  AVG  SLOTS  USE  TIME  IO  REQ  XFER'D  O  DATA SET NAME
PLPA    PG31B0  9177  33903  89999  11915  11915  11915  0  0.00  0.000  0  0  SYS1.PG31B0.LPA
COMMON  PG31B0  9177  33903  89999  37   37    37  0  0.00  0.000  0  0  SYS1.PG31B0.CSA
LOCAL   PG31B1  9BFB  33909  5850K  19189  19339  19325  0  0.00  0.000  26  196 Y  SYS1.PG31B1.LOCAL1
LOCAL   PG31B2  9B20  33909  5850K  19030  19155  19142  0  0.00  0.000  39  175 Y  SYS1.PG31B2.LOCAL1
LOCAL   PG31B3  9B21  33909  5850K  17967  18133  18120  0  0.00  0.000  37  223 Y  SYS1.PG31B3.LOCAL1
LOCAL   PG31B4  9BFE  33909  5850K  19330  19496  19481  0  0.00  0.000  36  215 Y  SYS1.PG31B4.LOCAL1
LOCAL   PG31B5  9BFF  33909  5850K  18315  18451  18438  0  0.00  0.000  44  204 Y  SYS1.PG31B5.LOCAL1
LOCAL   PG31B6  9D6D  3390A  5850K  17742  17938  17918  0  0.00  0.000  44  244 Y  SYS1.PG31B6.LOCAL1
LOCAL   PG31B7  9F11  3390A  5850K  18497  18737  18714  0  0.00  0.000  47  320 Y  SYS1.PG31B7.LOCAL1
LOCAL   PG31B8  9C02  33909  5850K  19472  19682  19662  0  0.03  0.003  61  309 Y  SYS1.PG31B8.LOCAL1
LOCAL   PG31B9  9C11  33909  5850K  19591  19801  19782  0  0.00  0.000  66  310 Y  SYS1.PG31B9.LOCAL1
LOCAL   PG31BA  9BA6  33909  5850K  19581  19775  19755  0  0.00  0.000  43  251 Y  SYS1.PG31BA.LOCAL1
LOCAL   PG31BB  9BA7  33909  5850K  19103  19373  19345  0  0.03  0.003  70  379 Y  SYS1.PG31BB.LOCAL1
LOCAL   PG31BC  9AA5  33909  5850K  18886  19033  19018  0  0.03  0.005  35  210 Y  SYS1.PG31BC.LOCAL1
SCM     N/A     N/A   N/A  67109K 23306K 23539K 23447K  0  0.86  0.000  78,442 25,291 N/A
```
zFLASH - Other Uses

DBAR

- zFLASH can expand the scope of the storage available on the CBU machine
- Ideal for DBAR tests
- Provides a survival mechanism for an actual disaster event till decision is made to return or upgrade.

Altering the Philosophy of memory allocation

- Increasing the active use of memory

Hardware Failure events
Problem Recovery

In the event of a system check stop – example Book Failure

– Whole system is affected - machine down

– Depending on the type of failure a processor book may become “fenced offline”

– Resources on the fenced book are unavailable
  • Processors, Memory, I/O interconnect (coupling links if present)
  • LPAR activations will likely fail at some point
Fenced Book - Service Message

The Evolution of Managing Real Storage and zFLASH’s Impact
Fenced Book - Checkbox
Fenced Book box
Fenced Book - USER View

Customize Activation Profiles: Z5W : RESETA2 : Fenced

- Z5W
  - RESETA2
    - General
    - Storage
    - Dynamic
    - Options
    - CP/SAP
    - Fenced
    - Partitions
- AE93
- AE94
- AE91
- AE92
- AEVM
- AEV2

Number of available processors for Licensed Internal Code: 12
Number of available processors when a book is fenced: 12
- Determined by the system
- Determined by the user

Processor Assignment

<table>
<thead>
<tr>
<th>Processor Type</th>
<th>LICCC Definition</th>
<th>Value Used when Book is Fenced</th>
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</thead>
<tbody>
<tr>
<td>Central</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>System assist</td>
<td>8</td>
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</tr>
<tr>
<td>Integrated facility for Linux</td>
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<td>1</td>
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<tr>
<td>System z integrated information processors</td>
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<tr>
<td>Total:</td>
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<td>12</td>
</tr>
</tbody>
</table>
Fenced Book - Activation Msg

Activation Profiles - Z5W

Your system storage is currently degraded. The sum of the initial central and expanded storage for the partitions listed below is larger than the amount of storage currently available (32768).

As long your system storage remains degraded, these image profiles will not activate. Would you like to specify smaller initial storage amounts?

AE91

ACTB0231

Yes  No
Fenced Book - Activation Issue

Activation Profiles - Z5W

Your system storage is currently degraded. The sum of the initial central and expanded storage for the partitions listed below is larger than the amount of storage currently available (32768).

As long your system storage remains degraded, these image profiles will not activate. Would you like to specify smaller initial storage amounts?

AE91

ACTB0231

Yes  No
Fenced Book - Storage originally

- Total Installed Storage: 131072 MB (128 GB)
  - Customer Storage: 98304 MB (96 GB)
  - Hardware System Area (HSA): 32768 MB (32 GB)

Customer Storage Details

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Amount</th>
<th>Percent</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Expanded Storage</td>
<td>0 MB</td>
<td>0 %</td>
</tr>
<tr>
<td>Available Storage</td>
<td>86016 MB</td>
<td>88 %</td>
</tr>
</tbody>
</table>
Fenced Book - Storage degraded

- Total Installed Storage: 65536 MB (64 GB)
- Customer Storage: 32768 MB (32 GB)
- Hardware System Area (HSA): 32768 MB (32 GB)

- Central Storage: 0 MB 0%
- Expanded Storage: 0 MB 0%
- Available Storage: 32768 MB 100%

The system storage is degraded. The amount of customer storage available for allocating central storage and expanded storage is temporarily reduced.
The Evolution of Managing Real Storage and zFLASH’s Impact

Fenced Book -

![Customize Activation Profiles: Z5W : RESET2 : AE91 : Storage](image)
Fenced Book - Actions

- POR and come up with a fenced book
- Make Processor adjustments if needed
- Determine LPAR priority list
- Re-adjust available storage for activation of LPARs (don’t forget the RESERVE memory for non-disruptive restoration of temporarily reduced storage allocation)
- zFLASH may make the difference between coming up with a subset of your LPARs and having the full list of LPARs running that tolerate the memory reduction due to zFLASH Paging
Thanks

Session 16180