Troubleshooting Memory on IBM System x® and BladeCenter® Servers

Using Intel Xeon 5500 Series Processors

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Executive Overview

The purpose of this paper is to describe the best practices for problem determination of DIMMs and recovery procedures on the following IBM System x® and BladeCenter® servers:

- IBM iDataPlex™ dx360 M2
- IBM BladeCenter HS22
- IBM System x3400 M2
- IBM System x3500 M2
- IBM System x3550 M2
- IBM System x3650 M2

These servers have processors with integrated memory controllers instead of memory controllers that are separate components on the system board. They also incorporate the new Unified Extensible Firmware Interface (UEFI), which replaces BIOS, and an integrated management module (IMM), which replaces the baseboard management controller and Remote Supervisor Adapter II. These changes require new and different memory problem-determination procedures.

By proactively investigating and properly resolving DIMM problems, you can increase system reliability, reduce downtime, and prevent unnecessary replacement of DIMMs.

Introduction

By understanding System x and BladeCenter memory features and health alerts, you can reduce unplanned downtime and costs associated with the unnecessary replacement of functioning DIMMs.

IBM System x and BladeCenter servers include multiple memory reliability, availability, and serviceability (RAS) technologies and redundancy modes that enable the servers to maintain stable operation despite multiple memory failures. The following memory RAS technologies can be configured on System x and BladeCenter servers;

- Single DIMM fault isolation
- Data ECC protection
- Address parity error detection
- Mirroring redundancy memory mode
- Chipkill technology
- IBM memory Predictive Failure Analysis (PFA) alert algorithm

Note: IBM DIMMs pass a comprehensive qualification process that ensures that you receive only the most dependable DIMMs.

Memory Tips

- Genuine IBM DIMMs are required for warranted, reliable, and high-performance operation.
- Replace a DIMM only if it has been specifically identified as defective by light path diagnostics, the system-event log, or other diagnostic tool. Note that other DIMMs in the same channel might be offline but not defective.
- Make sure that DIMMs are enabled after you perform a service action (for more information, see “Using the Setup Utility to Enable a DIMM Connector”).
- In some configurations, one defective DIMM can disable several DIMMs in a channel. **Note:** If a replacement DIMM is not available, remove failed DIMM and re-populate channel per channel population rules.
- If an installed DIMM is not reflected in the total memory count and the Setup utility shows that the DIMM connector is empty, reseat the DIMM.
- Before you replace a DIMM, check for IBM System x Server Firmware updates that pertain to memory or DIMM issues.

Indications of Memory Failure

Possible memory failures are identified by one or more of the following indicators:

- The light path diagnostics MEM LED is lit (in some servers). See Figure 1.
- An error LED on a DIMM connector is lit, indicating that the DIMM connector is disabled.
- Memory errors are logged in the system-event log, indicating the connector number of the failed DIMM.
- A hardware inventory through the IMM, operating system, or Dynamic System Analysis (DSA) shows that a DIMM is installed but has a capacity of zero, indicating that an installed DIMM is not contributing to the total available system memory, because it is either disabled or redundant because of memory mirroring or memory sparing.
- In the Setup utility, when you select **System Settings → Memory → Planar DIMM Details**, one or more DIMMs are shown as disabled.

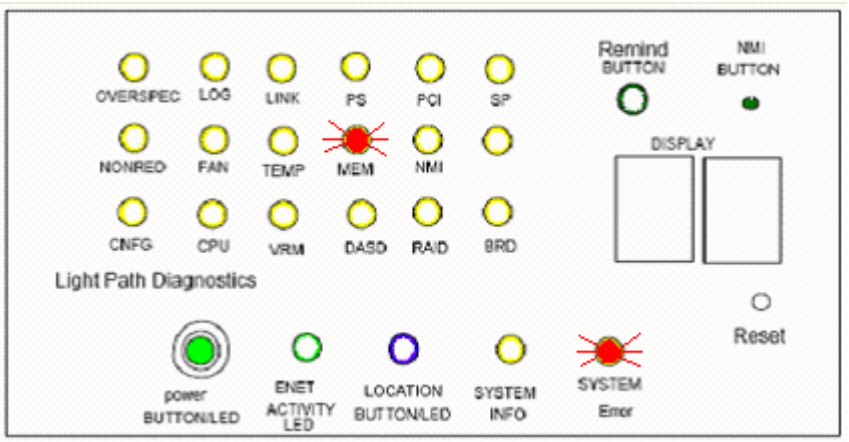


Figure 1: Light path diagnostics panel with the lit MEM and system-error LEDs

Single DIMM Isolation

IBM System x servers and blade servers that use the Intel® Xeon 5500 series processor can isolate DIMM failures to a specific failed DIMM. Earlier technology could isolate a failure only to a pair of DIMMs. A single memory-error LED is lit next to the DIMM connector that contains the failed DIMM.

Because of memory channel electrical loading and signal requirements, a failed DIMM in some configurations might temporarily inhibit the operation of other DIMMs in the same channel. By replacing the failed DIMM, you can restore the operation of the other DIMMs in the same channel. Do not replace a DIMM that is merely disabled or not initialized; replace a DIMM only if it is identified by memory- failure events on a specific DIMM connector or by a lit DIMM error LED.

Recovery Tip: If a replacement DIMM is not available, remove the defective DIMM and move the other DIMMs as necessary to achieve the correct DIMM population sequence. When the replacement DIMM is available, install it in the next available DIMM connector, following the correct DIMM population sequence.

DDR3 Memory Configuration and Population

Note: Always consult your server's User Guide for model specific model information.

DIMM Population Rules

- Only Populate DIMMs when the associated CPU is installed.
- Populate in a 'fill-farthest' approach (see below)
- DIMMs with the highest load should be populated in the DIMM connector farthest from the CPU working back toward the CPU within each channel. (ie. Populate Quad-Rank DIMMs ahead of Single or Dual-Rank., and Dual-Rank before Single-Rank)
- Maximum of two Quad-Rank DIMMs per Channel
- Mixing of ECC and non-ECC DIMMs will result in no ECC protection.
- Mixing of RDIMMs and UDIMMs is not supported (*UDIMMs only supported on specific server models)
- The Third Memory Channel is not used for Mirroring Mode (Holds spare DIMMs when in sparing mode)
- Some server models require DIMM filler to be installed in empty DIMM connectors to maintain proper airflow and cooling

DIMM Population Guidelines (Follow for best balance of capacity & bandwidth)

- Memory operational speed is determined by the processor model, DIMM type, DIMM speed, type of ranking, and DIMM configurations across the channels.
  - If memory speeds are mixed, the system will run at the lowest speed.
- DIMMs should be the same type and balanced in number across all channels and configured the same for both processors
- The number of DIMMs installed on each CPU should not differ more than one DIMM.
- The total number of DIMMs installed in each channel should also be within one DIMM
  - For example, if channel 0 has three DIMMs installed (channel 0 is fully populated), the other active channels should each have at least two DIMMs (note that in mirroring mode only two channels per CPU are active)

'Fill-farthest' means that the DIMM connector farthest from the CPU within each channel needs to be populated first. Additionally DIMMs should be equally balanced between channels and processors whenever possible.

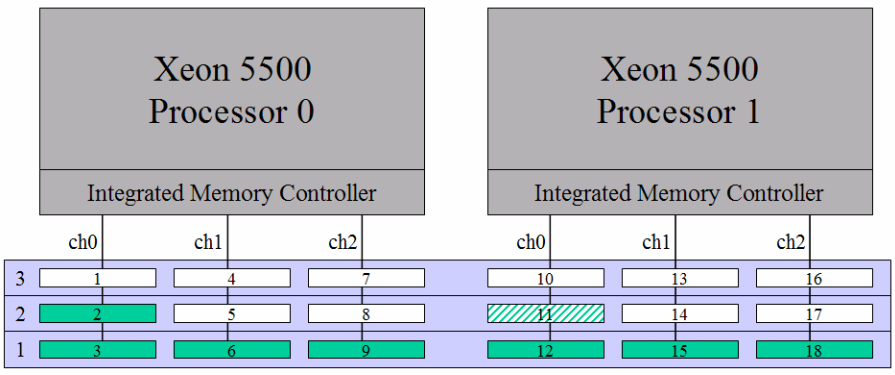


Figure 2: Example of a properly balanced population sequence (numbers within DIMM slots are physical slot numbers, ch0 is "Channel 0", and number along side the rows of DIMMs corresponds to the DIMM population sequence within each channel.)

In figure 2, Seven DIMMs have been populated, the next DIMM connector that should be populated is connector #11 (indicated by stripe-fill). This approach ensures that the number of DIMMs per Channel is optimized. As DIMMs are added to the same channel (in figure 2, notice that connectors 2 & 3 are both populated in channel 0), memory bandwidth decreases.

Note: DIMM Connectors on empty processor sockets are not usable, DIMMs populated in those positions will not initialize or show up in hardware inventory.

Note: For specific performance optimization guidelines with respect to DIMM population and memory configuration, please refer to the "**Optimizing the Performance of IBM System x and BladeCenter Servers using Intel Xeon 5500 Series Processors**" IBM whitepaper.

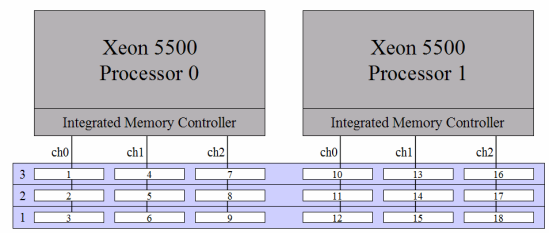


Figure 3: 18 DIMM Layout

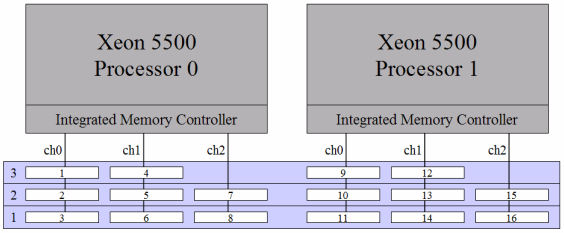


Figure 4: 16 DIMM Layout

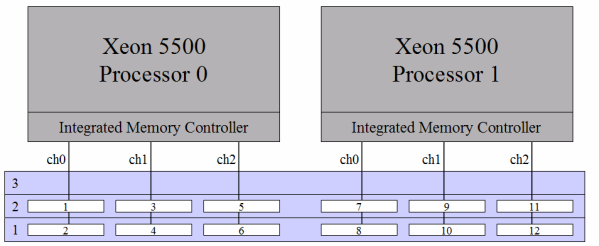


Figure 5: 12 DIMM Layout

Collateral Effects of DIMM Failures and Incorrect DIMM Population

Single DIMM fault isolation is a key feature of IBM servers based on the Xeon 5500 series processor. Unlike previous x86 memory architectures, in which memory faults are isolated only to the DIMM pair, these servers can isolate a problem to a single failing DIMM.

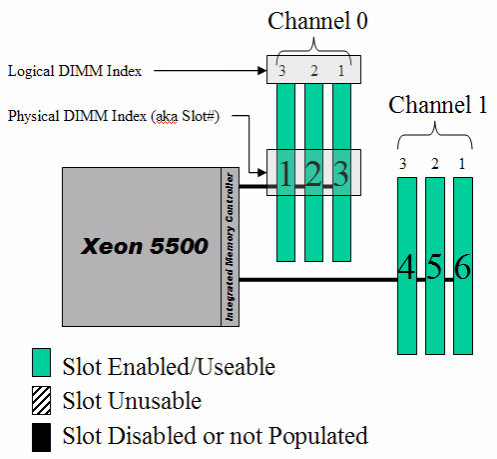
DIMMs are installed in channels. The channels are electrically isolated from each other. Population problems and faults within one channel do not affect other channels, except in configurations in which global configuration rules apply, including mixed populations of UDIMM (selected models) and RDIMMs, and RAS modes (such as Mirroring).

A DIMM connector can be disabled or made unusable if either of the following conditions occurs:

- A disabled DIMM in the channel affects population or initialization rules. For more information, see "How DIMM Disablement or Non-presence Affects Other DIMMs in the Same Channel."
- A defective DIMM negatively affects signal quality on the channel. This can apply to any configuration scenario.

A DIMM that is installed in a disabled or unusable DIMM connector will not be initialized and does not contribute to total system memory. However, FRU information for a DIMM that is installed in a disabled or unusable DIMM connector is reported in SMBIOS Type 17 Memory Information and other DIMM VPD inventories (DIMM capacity is shown as zero).

IBM servers using the Xeon 5500 series processor support up to three DIMMs per channel. The channels generally function in the same manner.



DIMM numbering has two schemes: physical and logical. Physical DIMM numbering starts from the DIMM that is closest to the first processor. Logical DIMM numbering groups the DIMM connectors into channels and then numbers the DIMMs within each channel by position. For example, in a tri-channel (three DIMMs per channel) server, physical DIMM connector 3 is CPU 0, Channel 0, DIMM 1 in logical terms.
Note: The diagram here applies to tri-channel servers such as System x 34xx, 35xx, and 36xx servers. The same logic applies to servers such as the BladeCenter HS22 which have two DIMM connectors per channel.

How DIMM Disablement or Non-presence Affects Other DIMMs in the Same Channel

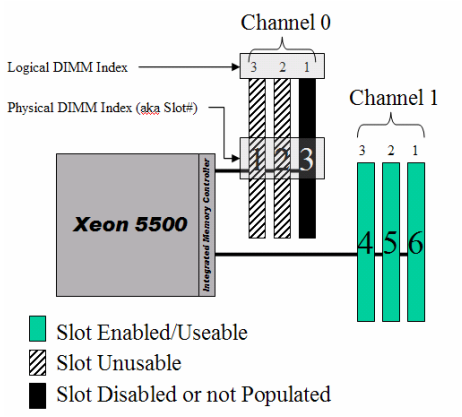
In the physical numbering scheme, DIMM connectors are populated within a memory channel starting with the DIMM connector that is farthest from the processor. In the logical numbering scheme, DIMM connector 1 is populated first, followed by connector 2 and connector 3.

In channel 0, logical connector 1 corresponds to physical connector 3, logical connector 2 corresponds to physical connector 2, and logical connector 3 corresponds to physical connector 1. For the population sequence guidelines for your server, see the *Problem Determination and Service Guide* on the IBM *Documentation* CD for your server. The guidelines incorporate channel and processor balancing rules to optimize performance.

From a memory-channel configuration perspective, a disabled DIMM connector is, at best, the same as a non-populated or empty DIMM connector and at worse will render the affected channel unusable.

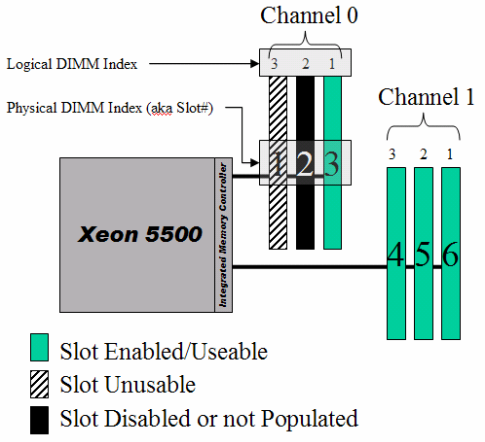
As a rule, when a DIMM connector in a given channel is disabled, the logical DIMM connectors (within that channel) that are numerically higher are unusable. Additionally, if the failed DIMM is causing channel signal quality issues the logical DIMM connectors (within that channel) numerically lower may be unable to properly train and initialize (ie. DIMM connector is Unusable). Unusable DIMM connectors are not disabled, however they will cause DIMMs to show 'zero' capacity in hardware inventories such as SMBIOS.

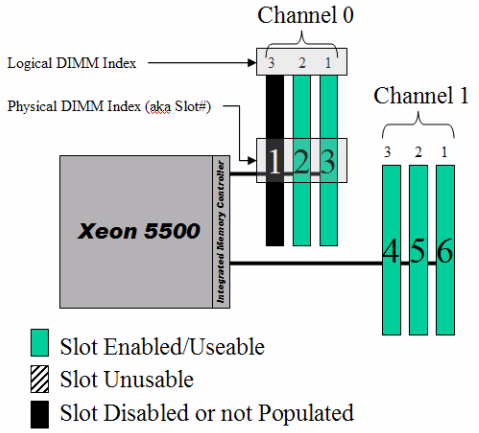
The examples below will attempt to clarify the externalities of DIMM failure & disablement within an arbitrary channel.



Example 1 – DIMM connector 3 disabled: If the first DIMM connector in a channel (physical connector 3 in the diagram) is disabled (because of a POST memory test failure or runtime double-bit error) or is not populated, the remaining two DIMM connectors (physical connectors 1 and 2) in the channel are inactive or unusable.

Example 2 – DIMM connector 2 disabled: If the second DIMM connector in a channel is disabled (because of a POST memory test failure or runtime double-bit error) or is not populated, physical connector 1 is disabled or unusable. The first DIMM connector in the channel (physical connector 3 in the diagram) is populated and enabled.





Example 3 – DIMM connector 1 disabled: If the third DIMM connector in a channel (physical connector 1 in the diagram) is disabled (because of a POST memory test failure or runtime double-bit error) or is not populated, only that connector is disabled or unusable. The first and second DIMM connectors in the channel (physical connectors 2 and 3) are still populated and enabled.

Types of Runtime Memory Failures

Memory failures fall broadly into the following categories, based on impact to the operation of the server.

Excessive correctable memory failures (Predictive Failure Analysis alert):

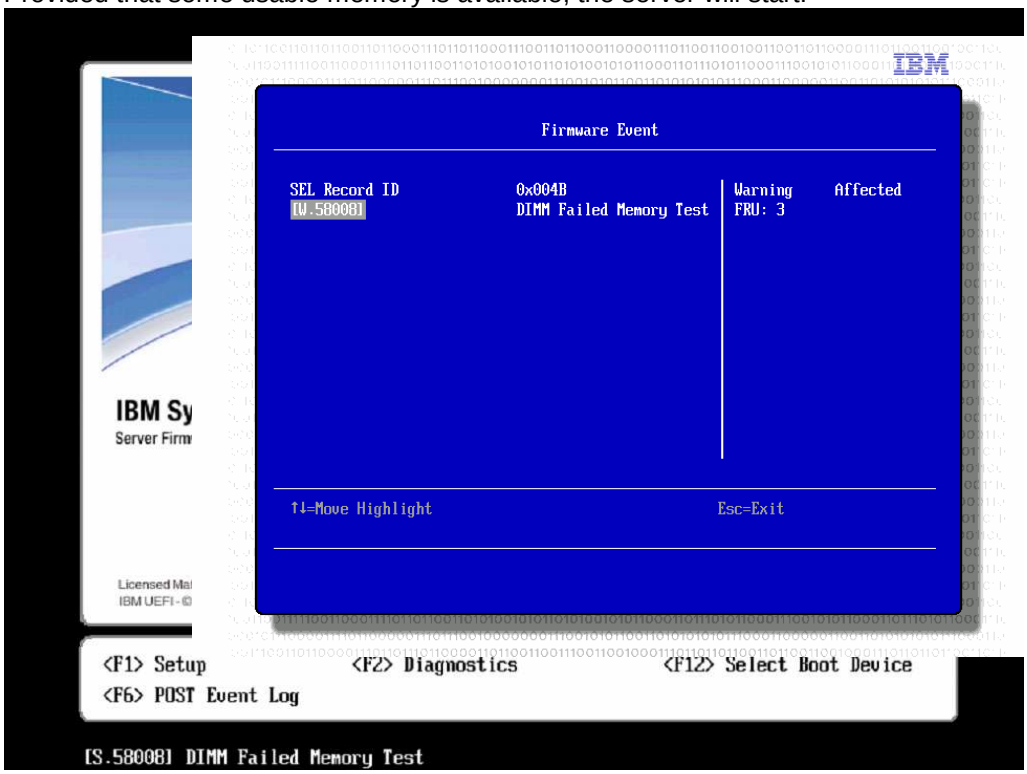
- **Operational impact:** The server continues to operate, with possible degradation in performance (for example, a DIMM with a defective or open data line).
- **Indications at the time of the failure:**
  - The system-error LED, MEM LED (in a server with a light path diagnostics panel), and the affected DIMM connector error LED are lit.
  - A Correctable ECC Error Rate Exceeded platform event is logged in the system-event log.
- **Possible root cause:**
  - Likely: Failure of the DIMM
  - Less likely: Spurious noise caused by power rail regulation or some other physical anomaly
- **Suggested corrective action:**
  - Check the IBM support site for IBM System x Server Firmware updates and RETAIN tips that pertain to memory Predictive Failure Analysis alerts.
  - Replace the DIMM at the next maintenance opportunity, because the DIMM might be failing and might result in unscheduled downtime.
  - Follow the memory problem determination procedures to isolate a potentially failing part.

Uncorrectable Memory Failure

- **Operational impact:** The server restarts, with the affected DIMM disabled. The server can immediately return to production with the remaining memory. Replace the DIMM at the next maintenance opportunity, or immediately, if the remaining memory is insufficient for production.
- **Indications at the time of the failure:**
  - The system-error LED, MEM LED (in a server with a light path diagnostics panel), and the affected DIMM connector error LED are lit.
  - An Uncorrectable ECC Error platform event is logged in the system-event log.
- **Possible root causes:**
  - Uncorrectable memory ECC error (data line)
  - DIMM address parity error
  - Damaged DIMM connector
  - Damaged processor or socket
- **Suggested corrective action:**
  - Replace the DIMM at the next maintenance opportunity.
  - If the DIMM in connector 3 failed as in Example 1, you can move the DIMM from connector 1 to connector 3 to enable the server to run with the remaining two good DIMMs instead of losing the use of the entire channel.
  - If the problem remains, follow the memory problem determination procedures to isolate a potentially failing part.

Types of POST Memory Initialization Errors

The IBM System x Server Firmware initializes, configures, and tests system memory. Provided that some usable memory is available, the server will start.



Screenshot of 'SplashScreen' w/ Memory Test Failure Message & F6 Post Event Viewer

Memory test failure (see above figure):

- **Operational impact:** The DIMM connector that contains a DIMM that failed a memory test is disabled, and server will continue to start if other DIMMS are installed and pass the memory test.
- **Indications at the time of the failure:**
  - The system-error LED, MEM LED, and CFG LED (in a server with a light path diagnostics panel) are lit.
  - A Memory Device Configuration Error platform event is logged in the system-event log.
- **Possible root causes:**
  - Defective DIMM, ECC errors
  - Damaged DIMM connector
  - Damaged processor or socket
- **Suggested corrective action:** Replace the defective DIMM as indicated by the logs, the DIMM Planar Details form in the Setup utility, and light path diagnostics. Follow the memory problem determination procedures to isolate a potentially failing part.

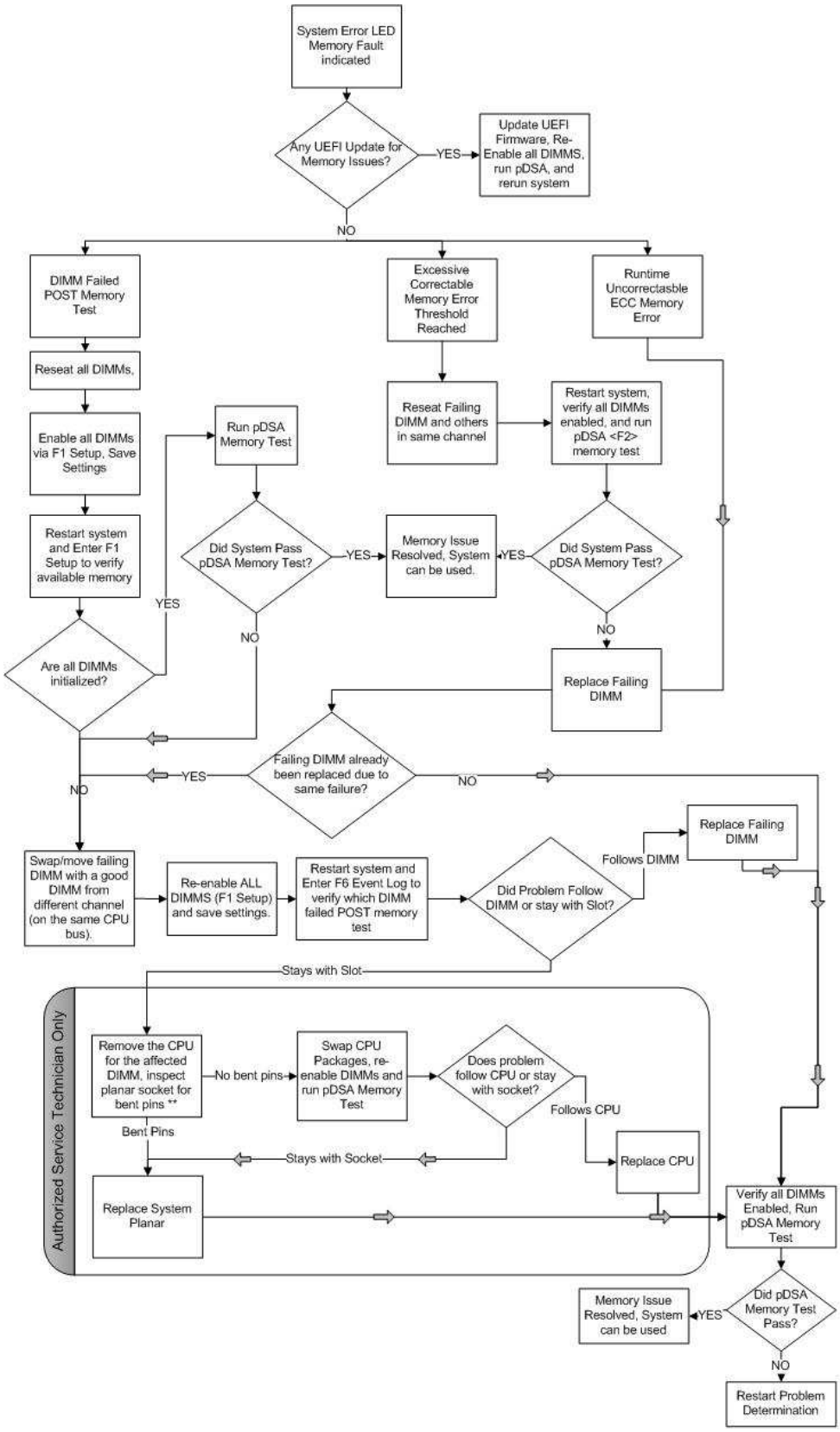
Memory configuration (population) error:

- **Operational impact:** One or more DIMMs are not initialized and are not shown in the total count of installed memory.
- **Indications at the time of the failure:**
  - The system-error LED, MEM LED, and CFG LED (in a server with a light path diagnostics panel) are lit.
  - A Memory Device Configuration Error platform event in is logged in the system-event log.
- **Possible root causes:**
  - The DIMM connectors are incorrectly populated.
  - Another disabled DIMM in the same channel is causing the indicated DIMM to be unusable or incorrectly located in its present connector. When a DIMM connector is disabled, the logical connectors that are numerically greater are made inactive or unusable. The problem might also be caused by a failed DIMM that is affecting channel signal quality.
- **Suggested corrective action:** Populate the DIMM connectors according to the DIMM population sequence that is described in the *Problem Determination and Service Guide* on the IBM *Documentation* CD for the server. Follow the memory problem determination procedures to isolate a potentially failing part.

No memory detected or available:

- **Operational impact:** The server cannot detect any DIMMs that are available to be initialized. The server does not start.
- **Indications at the time of the failure:**
  - The system-error LED, MEM LED, and CFG LED (in a server with a light path diagnostics panel) are lit.
  - A No Memory Detected platform event is logged in the system-event log.
- **Possible root causes:**
  - The DIMM connectors are incorrectly populated.
  - All installed DIMMs are disabled.
  - The processor is defective.
  - The system board is defective.
- **Suggested corrective action:** Install one DIMM at a time in the correct population sequence and run POST. Follow the memory problem determination procedures to isolate a potentially failing part.

Memory Problem Determination Flow Chart



Action Steps by POST Error Codes

Event code	Description	Action
0050001	DIMM disabled	If the DIMM was disabled because of a memory fault, follow the procedure for that event. If no memory fault is recorded in the logs and no DIMM connector error LEDs are lit, you can re-enable the DIMM through the Setup utility or the Advanced Settings Utility (ASU).
0051003	Uncorrectable DIMM error	1. Check for an IBM System x Server Firmware update that addresses memory issues. 2. Replace the DIMM. 3. (Trained service technician only) If the same DIMM connector experiences a subsequent uncorrectable error, reverse the positions of the processors. 4. (Trained service technician only) If the problem is related to the processor, replace the processor. 5. (Trained service technician only) If the problem is not related to the processor, replace the system board
0051006	DIMM mismatch detected	Make sure that the DIMMs are installed in the correct population sequence, according to the *Problem Determination and Service Guide* for the server.
0051009	No memory detected	1. Make sure that one or more DIMMs are installed in the server. 2. Reseat all DIMMs. 3. Install DIMMs in the correct population sequence, according to the *Problem Determination and Service Guide* for the server 4. (Trained service technician only) Replace the processor. 5. (Trained service technician only) Replace the system board.
005100A	No usable memory detected	1. Make sure that one or more DIMMs are installed in the server. 2. Reseat all DIMMs. 3. Install DIMMs in the correct population sequence, according to the *Problem Determination and Service Guide* for the server 4. Clear CMOS memory to ensure that all DIMM connectors are enabled. Note that all firmware settings will revert to the defaults.

0058001	PFA threshold exceeded	1. Check for an IBM System x Server Firmware update that addresses memory issues. 2. Reseat all DIMMs in the affected channel and restart the server. 3. With all DIMMs enabled, boot the server to DSA Preboot (press F2 at the splash screen) and run the full memory test 4. If the server fails the memory test, replace the affected DIMM. 5. (Trained service technician only) If the same DIMM connector experiences a subsequent uncorrectable error, reverse the positions of the processors. 6. (Trained service technician only) If the problem is related to the processor, replace the processor. 7. (Trained service technician only) If the problem is not related to the processor, replace the system board.
0058007	Unsupported DIMM population	1. Reseat the DIMMs ensuring the DIMM connectors are populated according to the guidelines in the *Problem Determination and Service Guide* for the server.
0058008	DIMM failed memory test	1. Check for an IBM System x Server Firmware update that addresses memory issues. 2. Reseat the DIMMs and restart the server. 3. Reverse the DIMMs between the channels (on the same CPU bus). If the problem is related to a DIMM, replace the failing DIMM. 4. (Trained service technician only) Install the failed DIMM on the second CPU bus, if available, to verify that the problem is not the processor or the DIMM connector. 5. (Trained service technician only) Replace the system board.
00580A1	Unsupported DIMM population for mirroring mode	1. If a DIMM connector error LED is lit, resolve the failure. 2. Make sure that the DIMM connectors correctly populated for mirroring mode, according to the *Problem Determination and Service Guide* for the server
00580A4	DIMM population changed	Information only. Memory has been added, moved, or changed.

00580A5	Mirror failover detected	Information only. Memory redundancy has been lost. Check the system-event log for uncorrected DIMM failures.

Replacing a DIMM

If problem determination indicates that a DIMM must be replaced, complete the following steps:

1. Replace the failed DIMM, according to the *Problem Determination and Service Guide* for the server.
2. Restart the server.
3. When the prompt <F1> Setup is displayed, press F1.
4. Select **System Settings → Memory** and confirm that the correct amount of memory is shown. If less memory is shown than expected, select **System Settings → Memory → Planar DIMM Details**, re-enable any disabled DIMMs, save the settings, and exit from the Setup utility. Then, restart the server and verify that the correct amount of memory is shown in the Setup utility.

Interfaces and Tools for Enabling Disabled DIMM Connectors

You can use the following tools to view a disabled DIMM connector and re-enable it after you replace the DIMM in the connector or if the DIMM connector was inadvertently disabled because of a failure on the same channel.

Setup utility:
To view the status of a DIMM connector or re-enable it, complete the following steps:

1. Restart the server.
2. When the prompt <F1> Setup is displayed, press F1.
3. Select **System Settings → Memory**. The Global Memory Configuration Settings are displayed.
4. Select **{Planar, Card [*n*]} DIMM Details** to view the status of a DIMM connector or enable it.

Advanced Settings Utility (ASU): See the ASU documentation.

In more extreme cases, it might be more practical to clear disabled DIMM connectors by clearing the server configuration by using the ASU or by completing the following steps:

1. Disconnect the server from power and remove the server battery. Wait at least 10 seconds before you reinstall the battery.
2. While the server is off and connected to power, apply the CMOS/RTC clear jumper or switch (for details, see the *Problem Determination and Service Guide* for the server) for at least 10 seconds before you restore the jumper or switch to the default position.

Tools That Report DIMM Status and Inventory

You can use the following tools to view the status of the memory subsystem and DIMM connectors:

- Setup utility (to view the status of a DIMM connector and enable or disable it)
- Advanced Settings Utility (ASU)
- SMBIOS viewer (status and inventory)
- IMM Web interface (status and inventory)
- DSA Preboot hardware inventory (status and inventory)
- IBM Systems Director

Using the Setup Utility to View DIMM Status

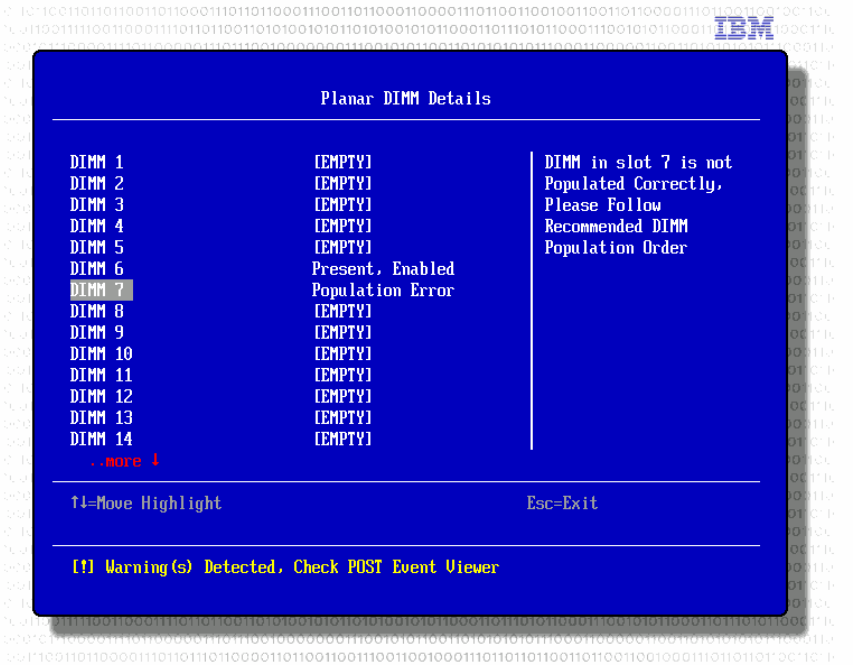
To start the Setup utility and view the status of the DIMMs, complete the following steps:

1. Restart the server.
2. When the prompt <F1> Setup is displayed, press F1.
3. Select **System Settings → Memory**.
4. Use one of the following procedures:
    - If the DIMM connectors are on the system board, select **Planar DIMM Details**.
    - If the DIMM connectors are on a memory expansion card, select **Card *n* DIMM Details**.

The information that is displayed shows the status of each DIMM connector. As of the date of this document, the follow statuses are valid:

- **[EMPTY]:** The DIMM is not physically present, or it has defective Serial Presence Detect (SPD).
- **Present, Enabled:** The DIMM is physically present and properly initialized. Note that redundant DIMMs that are in Present, Enabled status do not contribute memory capacity to the total available memory count.
- **Present, Ready:** The DIMM is physically present but was disabled on the previous boot and therefore is not yet initialized.
- **Population Error:** The DIMM is physically present but is not usable because of an error in the population sequence. For example, the third channel is populated in a mirroring configuration, or the second DIMM connector was populated before the first DIMM connector in a channel.
- **Disabled:** The DIMM is physically present but has been disabled because of an initialization failure, POST memory test failure, or runtime failure.

When you select a DIMM with the cursor, the right pane displays additional status and capacity information.



Screenshot of 'F1' Setup Utility showing the status of DIMM connectors

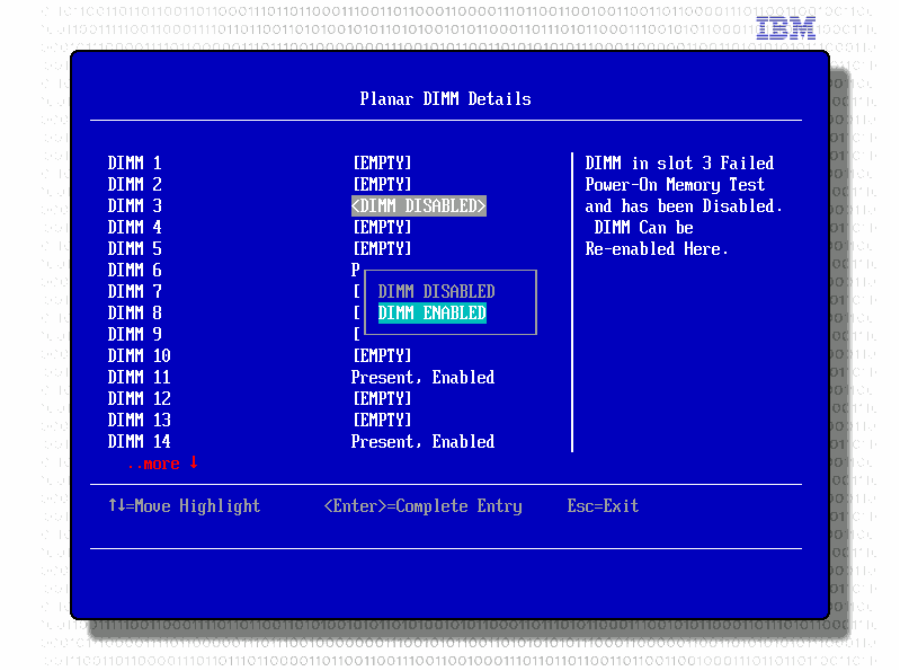
Using the Setup Utility to Enable a DIMM Connector

You can enable, but not disable, a DIMM connector by using the Setup utility.

To start the Setup utility and enable a DIMM connector, complete the following steps:

1. Restart the server.
2. When the prompt <F1> Setup is displayed, press F1.
3. Select **System Settings → Memory**.
4. Use one of the following procedures:
   - If the DIMM connectors are on the system board, select **Planar DIMM Details**.
   - If the DIMM connectors are on a memory expansion card, select **Card *n* DIMM Details**.
5. Select the DIMM connector that you want to enable, and select **DIMM ENABLED**.
6. Save the settings and exit from the Setup utility.

The DIMM connector is enabled when the server is restarted. If the DIMM connector is still disabled when the server is restarted, a Memory Test Failed event is logged, indicating that the DIMM was not replaced or the replacement DIMM is defective.



Screenshot of 'F1' Setup Utility on step#5

Using the Advanced Settings Utility to Enable a DIMM Connector

To enable a DIMM connector through the Advanced Settings Utility, use the following command:

asu set UEFI.MemorySlotDisableControl.*dimmnumber* enable

where *dimmnumber* is the DIMM connector number (1-based).

For more information, see the Advanced Settings Utility documentation

Electrostatic Discharge (ESD) Precautions

Modern electronics are far more susceptible to damage from ESD than older equipment. ESD fields smaller than you can feel and can permanently damage semiconductors. Some damage can take years to show as a failure. To prevent damage to your Memory DIMMs, observe the following precautions during Memory DIMMs unpacking and installation:

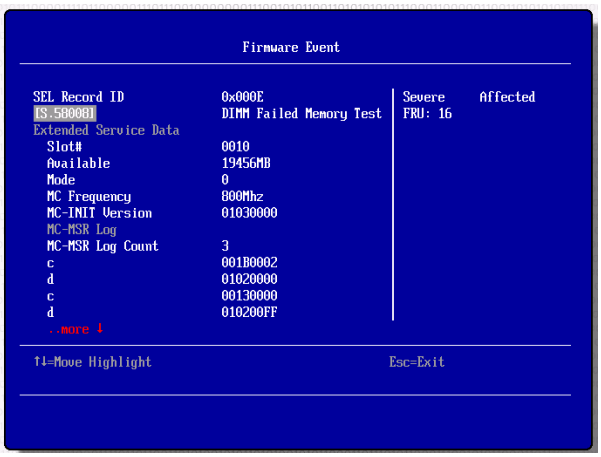
- Stand on a static-free mat.
- Wear a static strap to ensure that any accumulated electrostatic charge is discharged from your body to ground.
- Handle Memory DIMMs by their edges, do not touch the gold plated side of the DIMM.
- **Keep uninstalled Memory DIMMs in protective antistatic bags.**

Extended Service Data Records for Memory Events

Extended service data records are primarily intended to support IBM L2 and L3 support investigations but occasionally may be helpful to advanced users. Extended service data records uniquely define each class of event (for example, memory, PCI, or CRTM).

Although extended service data might be useful in diagnosing unusual problems, it is usually not necessary to isolate and correct errors according to the "POST error codes" table in the *Problem Determination and Service Guide* for the server.

Memory extended service data records are of two types: preboot errors and runtime errors.



Preboot errors include the POST Memory Test, SPD, Training and other memory initialization failures. Preboot memory extended service records contain the following information:

- Available memory capacity
- RAS mode
- Memory frequency
- Memory initialization code level
- Count of memory Initialization entries
- Memory initialization log (C = event code, D= event data)

Runtime errors include uncorrectable memory errors and correctable threshold Predictive Failure Analysis (PFA) alerts. Runtime error extended service records contain the following information:

- Correctable error count history (up to a 24-hour cycle)
- MC8 machine check registers (for IBM support to decode, if necessary)
- Memory configuration at the time of the failure

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For More Information

IBM System x and xSeries Servers	**ibm.com**/systems/x
IBM Rack Configurator	**ibm.com**/pc/us/eserver/xseries/library/configtools.html
IBM Configuration and Options Guide	**ibm.com**/servers/eserver/xseries/cog

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Maximum internal hard disk and memory capacities may require the replacement of any standard hard drives and/or memory and the population of all hard disk bays and memory slots with the largest currently supported drives available. When referring to variable speed CD-ROMs, CD-Rs, CD-RWs and DVDs, actual playback speed will vary and is often less than the maximum possible.

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