



# IBM Power Systems: Designing and Implementing Serviceability

IBM Power™ Platform  
Reliability, Availability and Serviceability (RAS)

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## Overview: Designing for Serviceability

The IBM POWER6™ Serviceability strategy evolves from, and improves upon, the service architecture deployed on System p™ and System i™ POWER5™ processor-based systems. The service team has enhanced base service capabilities and continues to implement a strategy that incorporates best-of-breed service characteristics from IBM's diverse System x™, System i™, System p, and high-end System z™ offerings.

At IBM, the Serviceability Team strives to provide the most efficient service environment possible by designing a system package that incorporates:

- *Easy access* to service components
- *On demand* service education
- *An automated/guided repair strategy* using common service interfaces for a converged service approach across multiple IBM server platforms

By delivering upon these goals, POWER6 processor-based systems enable faster and more accurate repair while reducing the possibility of human error.

The notion of client control of the service environment extends to firmware maintenance on all POWER6 processor-based systems. When taken together, these factors can deliver increased value to the end user. This strategy contributes to higher systems availability with reduced maintenance costs.

This white paper provides an overview of the progressive steps of error detection, analysis, reporting, and repairing found in a POWER6 processor-based system.

## Detecting

The first and most crucial component of a solid serviceability strategy is the ability to accurately and effectively detect errors when they occur. While not all errors are a guaranteed threat to system availability, those that go undetected are dangerous because the system does not have the opportunity to evaluate and act if necessary. POWER6 processor-based systems are specifically designed with this in mind, employing System z server-inspired error

detection mechanisms that extend from processor cores and memory to power supplies and hard drives.

### *Error Checkers*

POWER6 processor-based systems contain specialized hardware detection circuitry, utilized to detect erroneous hardware operations. Error checking hardware ranges from parity error detection coupled with processor instruction retry and bus retry, to ECC correction on caches and system buses. All IBM hardware error checkers have distinct attributes:

- *Continually monitoring* system operations to detect potential calculation errors.
- *Attempt to isolate* physical faults based on run-time detection of each unique failure.
- *Ability to initiate a wide variety of recovery mechanisms* designed to correct the problem. POWER6 processor-based systems include extensive hardware and firmware recovery logic.

### *Fault Isolation Registers and Who's On First? Logic*

Error checker signals are captured and stored in hardware Fault Isolation Registers (FIRs). Associated circuitry, called "Who's on First?" logic, is used to limit the domain of an error to the first checker that encounters the error. In this way, run-time error diagnostics can be deterministic such that for every check station, the unique error domain for that checker is defined and documented. Ultimately, the error domain becomes the FRU call, and manual interpretation of the data is not normally required.

### *First Failure Data Capture (FFDC)*

First Failure Data Capture (FFDC) is an error isolation technique that ensures that when a fault is detected in a system through error checkers or other types of detection methods, the root cause of the fault will be captured without the need to recreate the problem or run any sort of extended tracing or diagnostics program.

For the vast majority of faults, a good FFDC design

means that the root cause will be detected automatically without service intervention. Pertinent error data related to the fault is captured and saved for analysis. In hardware, FFDC data is collected from the fault isolation registers and “Who’s On First?” logic. In Firmware, this data consists of return codes, function calls, etc.

FFDC “check stations” are carefully positioned within the server logic and data paths to ensure that potential errors can be quickly identified and accurately tracked to an individual Field Replaceable Unit (FRU).

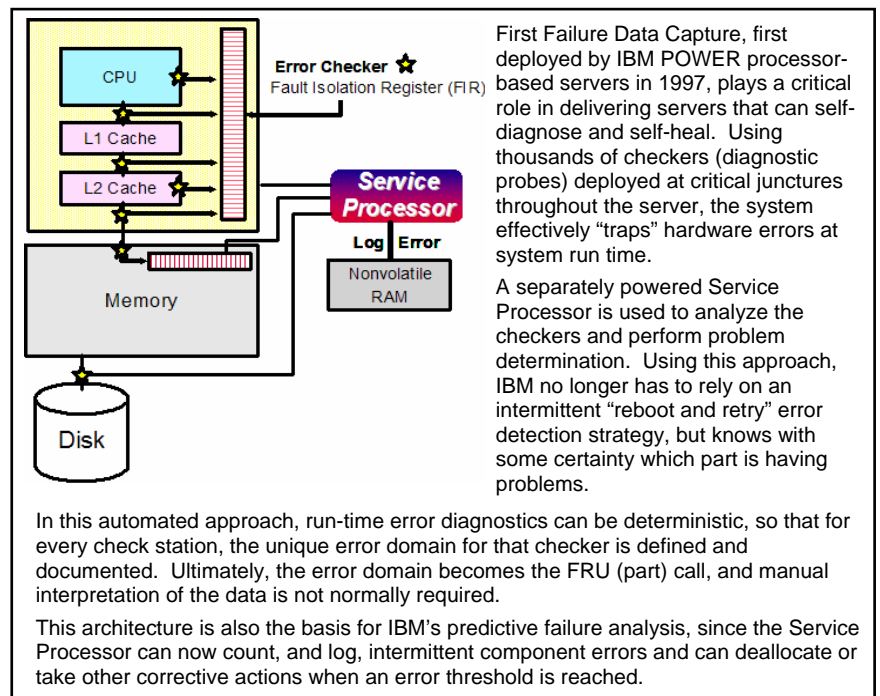
This proactive diagnostic strategy is a significant improvement over less accurate “reboot and diagnose” service approaches.

Using projections based on IBM internal tracking information it is possible to predict that high impact outages would occur two to three times more frequently without FFDC. In fact, without some type of pervasive method for problem diagnosis, even simple problems that behave intermittently can be a cause for serious and prolonged outages.

### *Fault Isolation*

POWER6 processor-based systems include a sophisticated Service Processor that interprets error data captured by the FFDC checkers – saved in the fault isolation registers and “Who’s On First?” logic or other firmware related data capture methods – in order to determine the root cause of the error event.

Root cause analysis may indicate that the event is recoverable, meaning that a service action point or need for repair has not been reached. Alternatively, it could indicate that a service action point has been reached, where the event exceeded a pre-determined threshold or was unrecoverable. Based upon the isolation analysis, recoverable error threshold counts may be incremented. If the event is recoverable, then no specific service action may be necessary.



First Failure Data Capture, first deployed by IBM POWER processor-based servers in 1997, plays a critical role in delivering servers that can self-diagnose and self-heal. Using thousands of checkers (diagnostic probes) deployed at critical junctures throughout the server, the system effectively “traps” hardware errors at system run time.

A separately powered Service Processor is used to analyze the checkers and perform problem determination. Using this approach, IBM no longer has to rely on an intermittent “reboot and retry” error detection strategy, but knows with some certainty which part is having problems.

If the event is deemed to be a Serviceable Event, additional required information will be collected to service the fault. For unrecoverable errors or for recoverable events that meet or exceed their service threshold – meaning a service action point has been reached – a request for service will be initiated through an error logging component.

### **Diagnosing**

Using the extensive network of advanced and complementary error detection logic built directly into POWER6 hardware, firmware, and operating systems, IBM Systems are able to perform considerable self diagnosis.

### *Boot-Time*

When an IBM POWER6 processor-based system powers up, the Service Processor initializes system hardware. Boot-time diagnostic testing uses a multi-tier approach for system validation, starting with managed low-level diagnostics supplemented with system firmware initialization and configuration of I/O hardware, followed by OS-initiated software test routines. Boot-time diagnostic routines include:

- *Built-in-Self-Tests* (BISTs) for both logic components and arrays, which deal with the internal integrity of components. Having the Service Processor assist in performing these tests enables the system to perform fault determination and isolation whether system processors are operational or not. Boot-time BISTs may also find faults not otherwise detectable by processor-based Power-on-Self-Test (POST) or diagnostics.
- *Wire-Tests* discover and precisely identify connection faults between components such as processors, memory, or I/O hub chips.
- *Initialization of components* such as ECC memory, typically by writing patterns of data and letting the server store valid ECC for each location, can help isolate errors.

In order to minimize boot time, the system will determine which of the diagnostics are required to be executed in order to ensure correct operation based on the way the system was powered off or on the boot-time selection menu.

### *Runtime*

All POWER6 processor-based systems include the ability to monitor critical system components during run-time, and to take corrective actions when recoverable faults occur. IBM's hardware error check architecture provides the ability to report non-critical errors in an "out-of-band" communications path to the Service Processor without affecting system performance.

A significant part of IBM's runtime diagnostic capabilities originate with the POWER6 Service Processor. Extensive diagnostic and fault analysis routines have been developed and improved over many generations of POWER processor-based servers, and enable quick and accurate predefined responses to both actual and potential system problems.

The Service Processor correlates and processes runtime error information, using logic derived from IBM's engineering expertise to count recoverable errors ("Thresholding") and predict when corrective

actions must be automatically initiated by the system. These actions can include:

- *Requests* for a part to be replaced.
- *Dynamic (on-line) invocation* of built-in redundancy for automatic replacement of a failing part.
- *Dynamic deallocation* of failing components so that system availability is maintained.

### *Device Drivers*

In certain cases diagnostics are best performed by operating system-specific drivers, most notably I/O devices that are owned directly by a partition. In these cases, the OS device driver will often work in conjunction with I/O device microcode to isolate and/or recover from problems. Potential problems are reported to an OS device driver, which logs the error. I/O devices may also include specific exercisers that can be invoked by the diagnostic facilities for problem recreation if required by service procedures.

### **Reporting**

Following diagnosis, POWER6 processor-based systems report the error through a number of mechanisms. This ensures that appropriate entities are aware that the system may be operating in an error state. However, a crucial piece of a solid reporting strategy is ensuring that a single error communicated through multiple error paths is correctly aggregated, so that later notifications are not inadvertently (and confusingly) duplicated.

### *Error Logging and Analysis*

Once the root cause of an error has been identified by a fault isolation component, an error log entry is created with some basic data such as:

- *An error code* uniquely describing the error event
- *The location* of the failing component
- *The part number* of the component to be replaced, including pertinent data like engineering and manufacturing levels
- *Return codes*

- Resource identifiers
- FFDC data

Data containing information on the effect that the repair will have on the system is also included. Error log routines in the operating system can then utilize this information and decide to call home, notify only, or continue without an alert.

### Remote Support

The Remote Management and Control (RMC) application is delivered as part of the base operating system, including the operating system running on the HMC. RMC provides a secure transport mechanism across the LAN interface between the Operating System and the HMC and is used by the Operating System diagnostic application for transmitting error information. It performs a number of other functions as well, but these are not used for the service infrastructure.

### Service Focal Point

A critical requirement in a partitioned environment is to ensure that no error is lost before being reported for service, and that an error should only be reported once, regardless of how many partitions experience the potential effect of the error. Service Focal Point (SFP) is an application that runs on the Hardware Management Console (HMC) and is responsible for aggregating duplicate error reports, among other things.

When a local or globally reported service request is

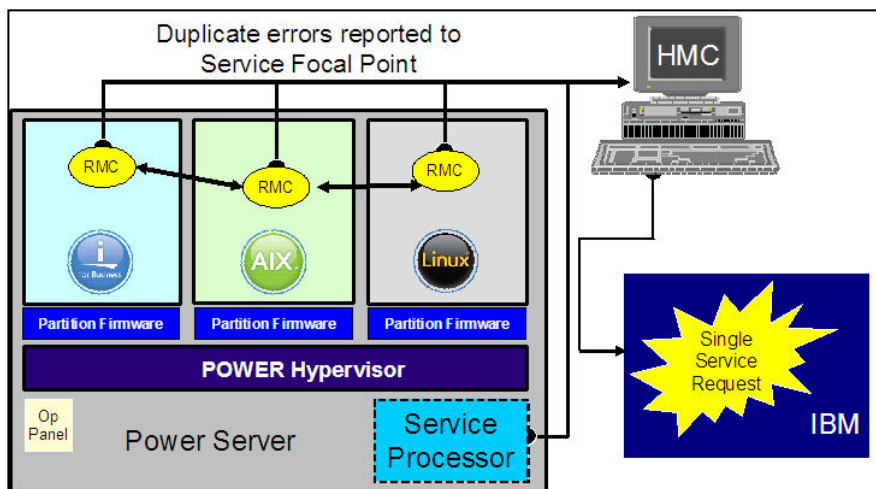
made to the operating system, the OS diagnostic subsystem uses the Remote Management and Control Subsystem (RMC) to relay error information to Service Focal Point, running on the HMC. For global events (platform unrecoverable errors, for example) the POWER6 Service Processor will also forward error notification of these events to the HMC, providing a redundant error-reporting path in case of errors in the RMC network.

Service Focal Point logs the first occurrence of each failure type, and then filters and maintains a history of duplicate reports from other partitions or the Service Processor. It then looks across all active service event requests, analyzes the failure to ascertain the root cause and, if enabled, initiates a call home for service. This methodology insures that all platform errors will be reported through at least one functional path, ultimately resulting in a single notification for a single problem.

### Extended Error Data (EED)

Extended error data (EED) is additional data that is collected either automatically at the time of a failure or manually at a later time. The data collected is dependent on the invocation method but includes information like firmware levels, OS levels, additional fault isolation register values, recoverable error threshold register values, system status, and any other pertinent data.

The data is formatted and prepared for transmission back to IBM to assist the service support organization with preparing a service action plan for the server or for additional analysis.



### System Dump Handling

In some circumstances, an error may require a dump to be automatically or manually created. In this event, it will be offloaded to the HMC upon reboot. Specific HMC information is included as part of the information that can optionally be sent to IBM support for analysis. If additional information relating to the dump is required, or if it becomes

necessary to view the dump remotely, the HMC dump record will notify IBM's support center upon which HMC the dump is located.

## **Notifying**

Once a POWER6 processor-based system has detected, diagnosed, and reported an error to an appropriate aggregation point, it then takes steps to notify the customer and/or IBM. Depending upon the assessed severity of the error and support agreement, this could range from a simple notification to having field service personnel automatically dispatched to the data center with correct replacement part in hand.

### *Client Notify*

When an event is important enough to report but not necessarily indicative of a need for a repair action or call home to IBM, it is classified as "Client Notify." Events that do not require a part swap or a service representative but may be of use to an administrator are part of this category. They may be symptoms of an expected systemic change, such as a network reconfiguration or failover testing of redundant power/cooling systems. Examples include:

- *Network events* like loss of contact over LAN
- *Environmental events* such as ambient temperature warnings
- *Events that appear to be an error* from the view of the component detecting the error, but are not necessarily events that require parts or a repair action without further examination by the client

Client Notify events are serviceable events by definition because they indicate that something has happened which requires client awareness in the event they want to take further action. These can always be reported back to IBM at the client's discretion.

### *Call Home*

Call Home is the ability of a correctly-configured POWER6 processor-based system to initiate an

automatic or manual call from a client location to IBM support structure with error data, server status, or other service-related information. Call home invokes the service organization in order for the appropriate service action to begin, automatically opening a problem report and in some cases dispatching field support as well.

Automated calling provides faster and potentially more accurate transmittal of error information. While configuring call home is optional, clients are strongly encouraged to configure this feature in order to obtain the full value of IBM service enhancements.

### *Vital Product Data (VPD) and Inventory Management*

POWER6 processor-based systems store vital product data (VPD) internally, which keeps a record of how much memory is installed, how many processors are installed, manufacturing level of the parts, etc. These records provide valuable information that can be used by remote support and service representatives, enabling them to provide assistance in keeping the firmware and software on the server up-to-date.

### *IBM Problem Management Database*

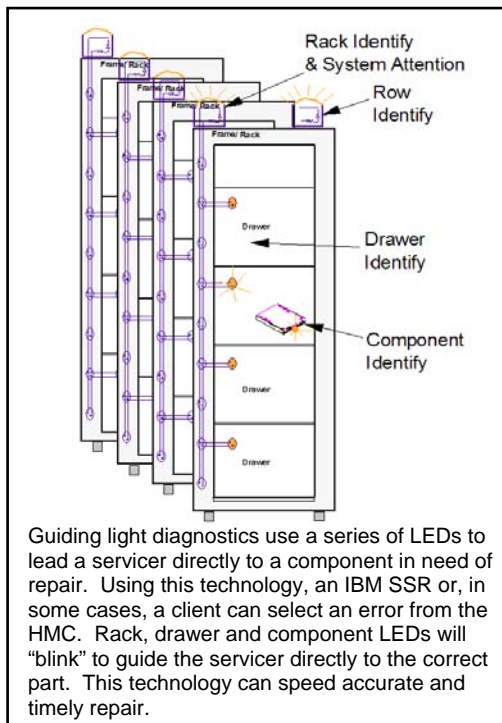
At the IBM support center, historical problem data is entered into the IBM Service and Support Problem Management database. All of the information related to the error along with any service actions taken by the servicer are recorded for problem management by the support and development organizations. The problem is then tracked and monitored until the system fault is repaired.

## **Locating and Servicing**

The final component of a comprehensive design for serviceability is the ability to effectively locate and replace parts requiring service. POWER6 processor-based systems utilize a combination of visual cues and guided maintenance procedures to ensure that the identified part is replaced correctly, every time.

## Guiding Light LEDs

Guiding Light is a system that uses a constellation of LEDs, allowing a servicer to quickly and easily identify the location of system components. Similar in concept to the Lightpath diagnostics used in the System x server family, Guiding Light is expanded to encompass the service complexities associated with high-end systems. Given that some client configurations are very complex, Guiding Light is capable of handling multiple error conditions simultaneously.



In the Guiding Light LED implementation, when a fault condition is detected on a POWER6 processor-based system, an amber System Attention LED will be illuminated. Upon arrival, a service provider engages "Identify" mode by selecting a specific problem. The Guiding Light system then pinpoints the exact part by flashing the amber identity LED associated with the part to be replaced.

Datacenters can be complex places, and Guiding Light is designed to do more than identify visible components. When a component might be hidden from view, Guiding Light can flash a sequence of LEDs that extend to the frame exterior, clearly "guiding" the servicer to the correct rack, system,

enclosure, drawer, and component.

## The Operator Panel

The Operator Panel on a POWER6 processor-based system is a four row by 16 element LCD display used to present boot progress codes, indicating advancement through the system power-on and initialization processes. The Operator Panel is also used to display error and location codes when an error occurs that prevents the system from booting. It includes several buttons allowing a Service Support Representative (SSR) or client to change various boot-time options and a variety of other limited service functions.

## Concurrent Maintenance

POWER6 processor-based systems are designed with the understanding that certain components have higher intrinsic failure rates than others. The movement of fans, power supplies, and physical storage devices naturally make them more susceptible to wear down or burnout, while other devices such as I/O adapters may begin to wear from repeated plugging or unplugging. For this reason, these devices are specifically designed to be concurrently maintainable, when properly configured.

In other cases, a customer may be in the process of moving or redesigning a datacenter, or planning a major upgrade. At times like these, flexibility is crucial. It is with this in mind that POWER6 processor-based systems are designed for redundant and/or concurrently maintainable power, fans, physical storage, and I/O towers.

## Blind-swap PCI Adapters

"Blind-swap" PCI adapters, first introduced in selected IBM pSeries® and iSeries™ servers in 2001, represent significant service and ease-of-use enhancements in I/O subsystem design while maintaining high PCI adapter density.

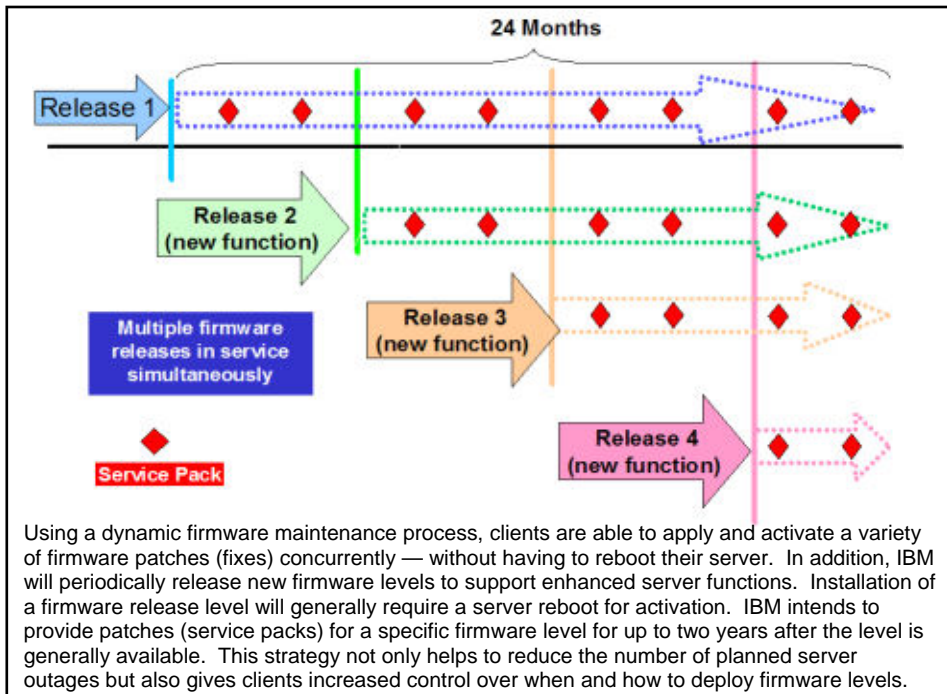
"Standard" PCI designs supporting "hot-add" and "hot-replace" require top access so that adapters can be slid into the PCI I/O slots vertically. "Blind-swap" allows PCI adapters to be concurrently replaced

without having to put the I/O drawer into a service position. Since first delivered, minor carrier design adjustments have improved an already well-thought out service design.

### Firmware Updates

Firmware updates for POWER6 processor-based systems are released in a cumulative sequential fix format, packaged as an RPM for concurrent application and activation. Administrators can install and activate many firmware patches without cycling power or rebooting the server.

current patch level. Because changes to some server functions (for example, changing initialization values for chip controls) cannot occur during system operation, a patch in this area will require a system reboot for activation. Under normal operating conditions, IBM intends to provide patches for an individual firmware release level for up to two years after first making the release code generally available. After this period, clients should plan to update in order to stay on a supported firmware release.



Activation of new firmware functions (as opposed to patches) will require installation of a new firmware release Level.<sup>2</sup> This process is disruptive to server operations in that it requires a scheduled outage and full server reboot. In addition to concurrent and disruptive firmware updates, IBM will also offer concurrent patches that include functions which do not activate until a subsequent server reboot. A server with these patches will operate normally, with additional concurrent fixes installed and activated after the next scheduled outage.

Additional capability is being added to the POWER6 firmware to be able to view the status of a system power

The new firmware image is loaded on the HMC using any of the following methods:

- *IBM-distributed media* such as a CD-ROM
- *A Problem Fix distribution* from the IBM Service and Support repository
- *Download* from the IBM Web site.<sup>1</sup>
- *FTP* from another server

IBM will support multiple firmware releases in the field, so under expected circumstances a server can operate on an existing firmware release, using concurrent firmware fixes to stay up-to-date with the

control network background firmware update. This subsystem will update as necessary as migrated nodes or I/O drawers are added to the configuration. The new firmware will not only provide an interface to be able to view the progress of the update, but also control starting and stopping of the background update to times which may be more convenient.

### Repair and Verify

Repair and Verify (R&V) is a system developed by IBM to walk a servicer step-by-step through the process of repairing a system and verifying that the

<sup>1</sup> <http://www.software.ibm.com/webapp/set2/firmware>

<sup>2</sup> Requires HMC V4 R5.0 or later and FW 01SF230-120-120 or later.

problem has been repaired. The steps are customized in the appropriate sequence for the particular repair for the specific system being repaired. Repair scenarios covered by R&V include:

- *Replacing* a defective FRU
- *Reattaching* a loose or disconnected component
- *Correcting* a configuration error
- *Removing/replacing* an incompatible FRU
- *Updating* firmware, device drivers, operating systems, middleware components, and IBM applications

R&V procedures are designed to be used both by servicers who are familiar with the task at hand and those who are not. Education On Demand content is placed in the procedure at the appropriate places. Throughout the R&V procedure, repair history is collected and provided to the Service and Support Problem Management Database for storage with the Serviceable Event, to ensure that the guided maintenance procedures are operating correctly.

### *System Support Site*

System Support Site is an electronic information repository that provides on-line training and educational material; allowing service qualification for the various Power Systems offerings.

For POWER6 processor-based servers, service documentation detailing service procedures for faults not handled by the automated Repair and Verify guided component will be available through the System Support Site portal. Clients can subscribe to System Support Site to receive notification of updates to service related documentation as they become available. The latest version of the documentation is accessible through the Internet; however, a CD-ROM based version is also available.

### **IBM Power Systems – Designed for Serviceability**

The IBM RAS Engineering team has planned and is delivering a roadmap of continuous service enhancements in POWER6 processor-based systems. The service plan embraces a strategy that shares “best-of-breed” service capabilities developed in IBM Systems product families such as the System x and System z servers. The Service Team continues to work directly with the server design and packaging engineering teams, ensuring that their designs supported efficient problem determination and service. Because IBM develops hardware, firmware, and operating systems in close coordination, POWER6 processor-based systems are well-suited to provide unique value through an ever-evolving Serviceability roadmap.



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