



Reliability, Availability, and Serviceability for the Always-on Enterprise

The Enhanced RAS Capabilities of Intel® Processor-based
Server Platforms Simplify 24x7 Business Solutions

Infrastructure uptime is increasingly critical in today's real-time, always-on business environment. Intel® processor-based platforms provide the robust foundation needed for success. They meet the highest quality standards and support a wide array of sophisticated reliability, availability, and serviceability (RAS) features. From dual-processor systems to mainframe-class platforms, they help businesses address their high-availability requirements on a flexible architecture that helps drive down total costs.

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Executive Summary

The pace of business is accelerating around the globe, as leading companies in compute intensive industries, such as financial trading¹, manufacturing² and retail,³ move toward a real-time business model in which transactions and information sharing are near-instantaneous.⁴ This transition is putting increasing demands on the performance, capacity, availability, and agility of underlying IT infrastructure. As process timelines are compressed from weeks or days, to hours, minutes or even seconds, the cost of downtime skyrockets. From supplier and customer transactions, to employee communications and financial reporting, business-critical functions must be up and running at all times.

For years, Intel has been continually improving the quality and reliability of its platforms, and today's systems are well suited to this growing challenge. Advanced reliability, availability, and serviceability (RAS) features are integrated into all of Intel's server product lines, along with security enhancements that help guard against digital attacks. These capabilities are backed by one of the world's most extensive programs for testing and validating platform performance across diverse hardware and software environments. From initial design to final delivery, quality and reliability are built into every Intel server product.

As a result, businesses can count on Intel processor-based platforms to perform reliably in complex, real-world environments; to provide seamless support for enterprise-class security solutions; and to heal themselves in response to a wide variety of errors that can bring down less protected platforms. Server vendors add to these advantages with a broad array of platform-level RAS options that help businesses address their complete range of availability requirements on a consistent and affordable architecture. From redundant and hot-plug subsystems targeting specific RAS requirements, to complete, mainframe-class platforms designed for 99.999% and higher availability, businesses have the affordable resources they need to keep pace with the rising requirements of the real-time enterprise—so they can stay competitive in today's rapidly changing business environment.

¹ According to Information Week (Wall Street & Technology, April 7, 2005), the passage of Reg NMS by the U.S. Securities and Exchange Commission is "ushering in a new and improved trade-through rule that will make best price and fast quotations a requirement for U.S. equities trading." This is just one key example of a broad trend that continues to transform the financial sector. To stay competitive in this real-time marketplace, financial organizations need consolidated information that is current, accurate and actionable. To find out how a market leader is addressing this need, read the Intel case study about Raymond James Financial's business intelligence solution (http://www.intel.com/business/casestudies/raymond_james.pdf).

² For manufacturers, real-time business means reduced inventories, responsive supply chains and faster time-to-market. To find out how a leading IT company has accelerated its processes while saving millions in internal IT costs, read the Intel case study about Fujitsu Siemens Computers (http://www.intel.com/business/casestudies/fujitsu_siemens.pdf); to learn how another industry leader is accelerating complex design processes to increase its competitiveness, read the Intel case study about Toyota Motorsport (<http://www.intel.com/business/casestudies/toyota.pdf>).

³ The combination of mobile computing and real-time inventory management via RFID technology is on the verge of transforming the retail industry. To find out how a global leader is responding to this opportunity, see the Intel case study about Procter and Gamble (http://www.intel.com/business/casestudies/procter_gamble.pdf).

⁴ This move toward real-time business is a broad phenomenon: "Results from a poll taken at Gartner's December 2004 Data Center Conference reveal the strategic importance of real-time infrastructures. Sixty-seven percent of clients polled consider RTIs to be an imperative." (Source: *Two-Thirds of Conference Attendees See RTI As an Imperative*, Donna Scott, Gartner Research, April 18, 2005.)

The Growing Need for High Availability

Almost every aspect of today's business environment has come to rely on the uninterrupted availability of platforms, applications, and data. From customer relationship management and enterprise resource planning, to employee communication and collaboration, a failed application or system can be costly and disruptive.

The impact of downtime continues to grow as companies move toward a real-time business model supported by Services Oriented Infrastructure. Based on Web Services technologies, this approach allows them to integrate their data and applications more completely, and adapt them more easily. Transactions are processed in real time, instead of waiting for large batch runs at the end of the day. Collaboration and agility are improved, not only within the enterprise, but across multi-vendor supply chains.

This real-time computing strategy gives businesses and their partners better visibility into their markets and operations, so they can respond more quickly to new opportunities, changing customer demands, and unexpected supply challenges. It can also help them address today's increasingly stringent regulatory requirements. Yet as companies become more connected and response times compress, the cost of downtime continues to increase.

The TCO Challenge

Achieving high service availability to meet growing needs requires a combination of people, processes, and technology, including:⁵

- Highly reliable platforms
- Extensive hardware and software testing
- Rigorous change management
- Redundant architectures
- Highly trained staff
- Well-established emergency procedures

With a sufficient investment, virtually any level of availability can be achieved. Yet costs can be prohibitive, especially as IT organizations strive to increase availability guarantees from 3-nines (99.9% uptime), to 4-nines (99.99%), to 5-nines (99.999%) and up.

Three high-level strategies are crucial to contain total cost of ownership (TCO), while addressing increasing availability requirements (Figure 1):

1. Standardize Your Infrastructure and Operations —

Enterprise standards are essential to optimize the business value of IT, while reducing total cost and risk. Industry-standard solutions magnify these benefits. They are more flexible and affordable than proprietary solutions, and are now capable of supporting the most demanding, business-critical environments (see the sidebar on page 4, *The Critical Importance of Standards-based Solutions*).

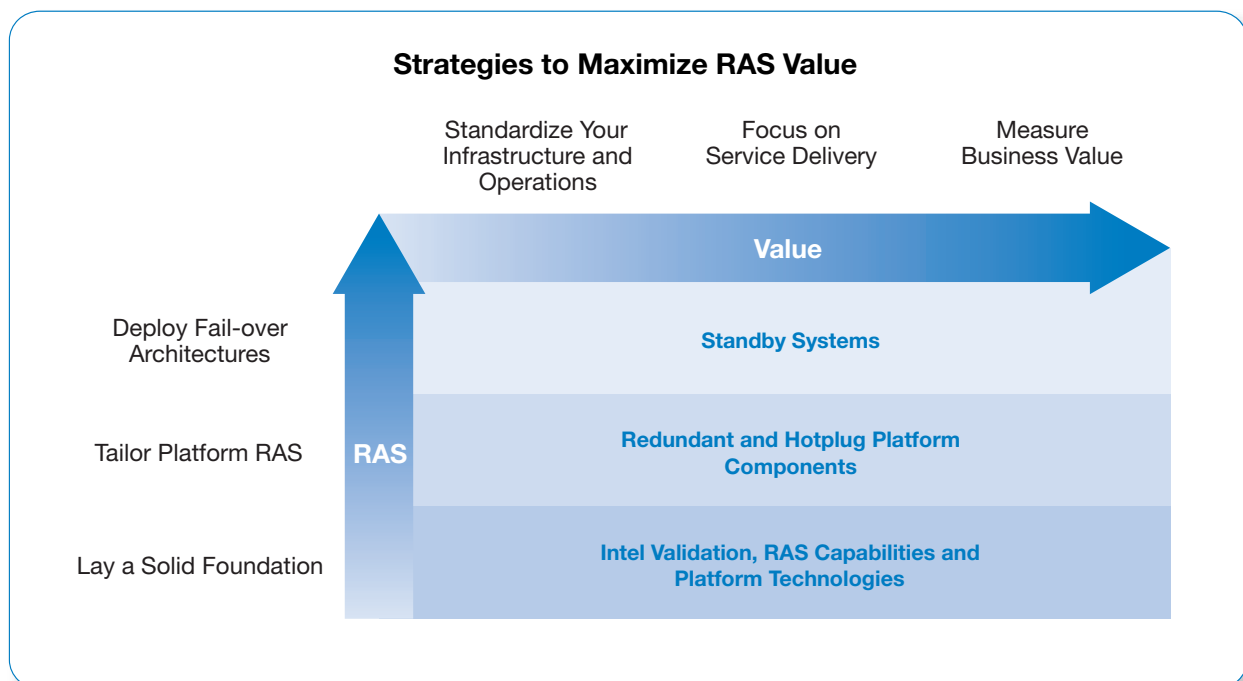


Figure 1. By combining IT best practices with the flexibility and affordability of Intel architecture, businesses can optimize the value of their RAS investments across their entire infrastructure.

⁵ For more information on planning and implementing high-availability solutions, see *High-availability: A Perspective*, by Jane Wright and Ann Katan, Gartner Research, November 24, 2004.

The Critical Importance of Standards-based Solutions

"Extraordinary resources are needed for application projects that introduce new nonstandard technology."

— *The Cost of Implementing Nonstandard Technologies*, Chip Gliedman with Adam Brown, Forrester Research, Inc., November 22, 2004.

A recent report by Forrester Research corroborates what many IT organizations already know from painful experience: one-of-a-kind solutions and nonstandard technologies can dramatically increase design, deployment, and support costs. They require specialized expertise and nonstandard processes that can lead to inefficiency, lower quality, and reduced availability.

By delivering broad choice on a consistent, standards-based architecture, Intel® processor-based platforms offer an alternative to proprietary solutions. They give IT organizations the flexibility to address diverse availability requirements cost-effectively, while using familiar technologies and skill-sets that can be scaled across virtually all business needs.

2. Focus on Service Delivery⁶—The business value of an application depends on the ability of end-users to access and use the application, as well as any broader service it might support. That service may depend on multiple applications, servers, networks, etc., and these relationships must be considered in assessing availability requirements.

3. Measure the Business Value of High Availability—This allows standard ROI metrics to be established, so decision-makers can align high-availability investments with the actual business value they deliver.⁷

Affordable Availability with Intel® Architecture

"It makes great sense for us to run inexpensive, standard servers in a high-availability scenario.... Their failure rate is basically zero."

— Todd Stewart, Group Director of Computing Operations, Siebel Systems, referring to Siebel's Intel processor-based server solutions⁸

In the past, the highest levels of availability were only supportable on high-end, proprietary systems. However, Intel has driven advanced RAS features into industry-standard components and platforms, and backs these technologies with an extraordinary level of validation testing across diverse hardware and software environments. As a result, high platform reliability is no longer cost-prohibitive (see the sidebar on page 7, *Affordable Availability in Action*). From small business and departmental servers, to enterprise-critical databases, the high reliability and flexibility of Intel architecture can help IT organizations:

- Increase uptime and reduce support costs for new deployments.
- Establish a consistent, standards-based foundation for implementing appropriate levels of availability throughout the IT environment.
- Provide more flexible and affordable support for high-availability solutions and strategies, such as blade frames, virtual partitioning, and automated server provisioning.

Intel Validation: The Foundation for Highly Reliable Platforms

In real-world IT implementations, platform reliability means more than just high uptime for deployed systems. It also means broad compatibility with today's complex hardware and software environments, so IT organizations can deploy solutions quickly, and with a high level of confidence. To address this need, Intel has established one of the world's most extensive environments for testing and validating server components and platforms. Out of all of Intel's investments, the amount devoted to validation testing is second only to Intel's investment in component and platform design. For an average platform, Intel devotes approximately 600 quarters of engineering-hours and roughly a half million hours of validation runtime, all within a 12-15 month product lifecycle (from prototype to production).

⁶ A recent Gartner report corroborates this recommendation: "The majority of respondents measure availability by components, rather than by the users who are affected. By contrast, Gartner recommends measuring from the perspective of the users." (Source: *Data Center Conference Poll Results Offer IT Operations Insights*, by Patricia Adams, April 28, 2005.)

⁷ According to Gartner, "Organizations that have not done any kind of analysis significantly underestimate the potential impact of lost revenue, and even those that have done analysis are producing only conservative estimates with the potential for significantly higher impacts than the organization has considered." Source: *User Survey: High-availability and Mission-critical Services, North America, 2005*, by Bob Igou and Ron Silliman, Gartner Research, April 7, 2005.

⁸ Siebel Systems is the world's leading supplier of Customer Relationship Management (CRM) solutions. For more information about the company, and their Intel architecture-based deployment, see the Intel case study at: <http://www.intel.com/business/casestudies/siebel.pdf>

Testing covers all platform components, 18-20 different operating systems (including multiple versions of Microsoft Windows* and Linux*), and a wide variety of third-party hardware and software components. It also covers a broad portfolio of applications. Since Intel architecture currently accounts for approximately 87% of all servers sold worldwide,⁹ these efforts are supplemented by extensive third-party vendor testing. Intel also works directly with leading hardware and software developers, sharing product roadmaps, design specifications, and test data.

The result of this extensive preproduction validation is an exceptional level of product quality, reliability, and compatibility. Millions of customers are using Intel processor-based platforms to run billions of lines of code in support of business-critical processes. They count on these systems every day to “just work” in their unique hardware, software, and network environments. Intel’s ongoing investments in rigorous validation testing are instrumental in providing that confidence.

Advanced RAS Features: Taking Reliability to the Next Level

Even the most extensive validation testing and scrupulous IT

management cannot remove a common source of platform downtime and data corruption: soft errors. Soft errors occur when an alpha particle or cosmic radiation strikes a component, causing a transistor to change its state. Though much less common than soft errors, hard errors—such as a failed memory bit, line, or device—can be equally catastrophic. To deliver reliable performance, platforms must be able to detect both types of errors and respond accordingly.

Intel does much to address these issues during the design process, using circuit design methods, design tools, and simulation to identify and address potential hard and soft errors. Intel also integrates extensive RAS technologies into its components and platforms (see Table 1 and Appendix B for details). These technologies continuously monitor critical functions. They can detect a wide range of hard and soft errors, and automatically correct or work around many of them. As shown in the table, three Intel processor-based platform families support progressively more sophisticated RAS technologies. Altogether, these platforms address the full range of business performance and availability requirements.

Table 1. Advanced RAS Features Comparison¹—Intel integrates extensive RAS technologies into its components and platforms. This helps to improve overall platform reliability, and makes it easier for IT organizations to support increasing availability requirements. (See Appendix B for an explanation of RAS technologies.)

RAS Capability	Intel® Itanium® 2 Processor-based Systems	Typical Mainframe	Intel® Xeon™ Processor MP-based Systems	Typical RISC	Intel® Xeon™ Processor-based Systems	Other X86 Compatible Systems
Recover from data bus error	✓	✓	✓	✓		
Cache ECC coverage	✓	✓	✓	✓	✓ [§]	✓
Internal logic soft error checking	2005	✓				
Lockstep support	✓ (2005, processor level)		✓ (selected vendors) [‡]			
Bad data containment	✓	✓		✓ (selected vendors)		
Cache reliability (Pellston)	2005	✓		✓ (selected vendors)		
Memory single device error correct	✓	✓	✓	✓	✓	✓
Memory retry on double-bit error detect	✓	✓	✓	✓	✓	
Memory spares	✓	✓	✓	✓	✓	
Hardware Partitioning	✓ node	✓ core	✓ node	✓ node		
Electrically isolated partitions	✓ node	✓	✓ node	✓ node (selected vendors)		

¹ All time-frames, dates, and products are subject to change without further notification.

[‡] Lockstep is supported by selected vendors via enabled chipsets and platforms.

[§] A combination of parity and write capabilities provides protection comparable to ECC coverage.

⁹ Source: IDC Server Tracker, Q4 2004.

High Availability in a Consolidated Environment

With today's software virtualization solutions, IT organizations are consolidating as many as 20 or even 30 applications on a single Intel processor-based server. This can dramatically improve utilization, reduce operating costs, and improve infrastructure agility. The high reliability of Intel processor-based platforms is especially valuable in these consolidated environments, since a platform failure could impact dozens of applications.

In most cases, IT organizations should consider high availability platform configurations when consolidating applications. They should also take advantage of virtual fail-over partitions to tailor availability based on specific application requirements. For many applications, it may be sufficient to configure a fail-over partition on the same platform as the primary application. For more demanding solutions, fail-over partitions should be hosted on separate platforms.

For more information, see the Intel white paper, *Enhanced Virtualization on Intel Architecture-based Servers*, available at: http://www.intel.com/business/bss/products/server/virtualization_wp.pdf

Machine Check Architecture: Enabling Business-critical Solutions

To enable even higher levels of reliability and availability, platforms must not only detect and correct errors but must also have the ability to log them and alert IT staff. With this functionality, IT can monitor system health more easily, and can respond more quickly and accurately when a problem occurs. Intel-based platforms offer two levels of support.

- **Machine Check Architecture**—Intel® Xeon™ processors and Intel Xeon processors MP have dedicated registers for error reporting and logging. This enables IT and management systems to detect error trends. It also makes it easier to diagnose problems and determine root causes.
- **Advanced Machine Check Architecture**—Intel® Itanium® 2 processors have a far more robust Machine Check Architecture that was designed specifically to enable mainframe-class availability for enterprise environments. This architecture includes well-defined interfaces for error handling at the hardware, firmware, and OS levels (Figure 2). It enables firmware and OS involvement in correcting and recovering from complex errors. It also greatly reduces the likelihood of a hung server, since it can automatically reset the system in response to an otherwise fatal error. In combination with the advanced RAS capabilities of Intel Itanium 2-based solutions, this architecture supports a level of availability that was previously only possible with high-end proprietary platforms.

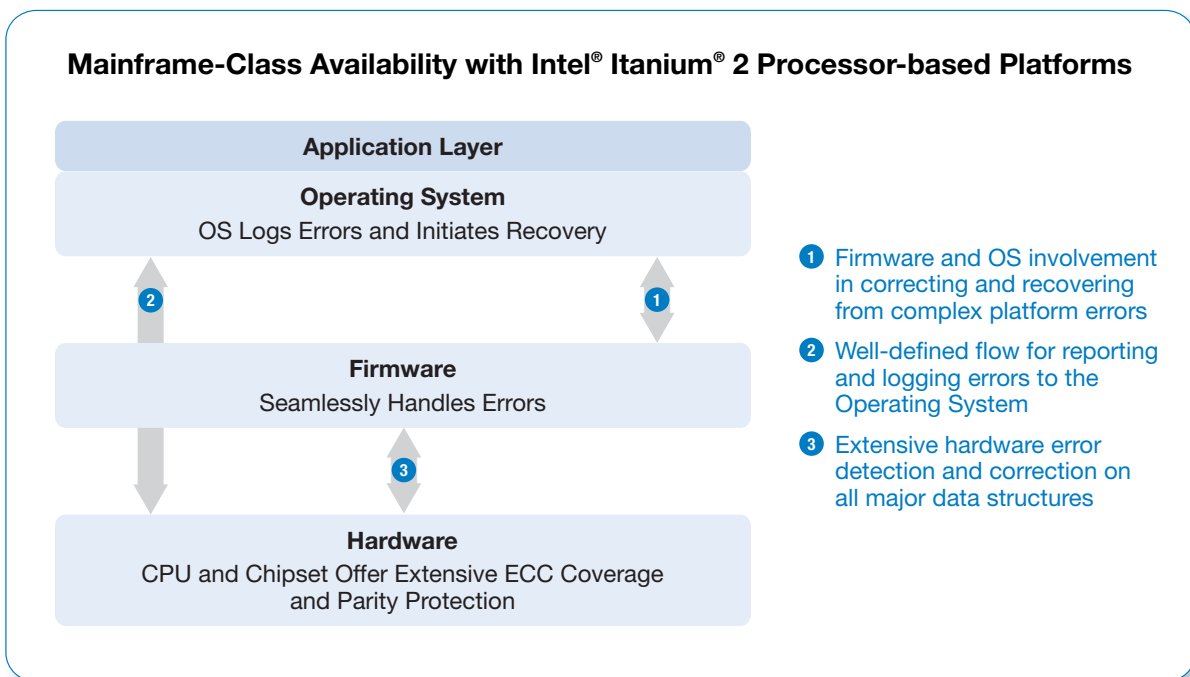


Figure 2. The advanced Machine Check Architecture of Intel® Itanium® 2 processor-based platforms supports mainframe-class availability for enterprise-critical applications. As a standards-based framework, it will help drive increasing levels of availability in future platform generations.

Advanced Machine Check Architecture not only supports mainframe-class availability today, but also provides a very robust, standards-based foundation that makes it easier for component, platform, firmware, and OS developers to cooperate in enhancing future availability solutions. Reliability will continue to improve on all Intel processor-based server platforms, and will evolve most rapidly on Intel Itanium 2 processor-based systems.

Beyond Hardware: Advanced Tools for Affordable RAS

The platform features discussed above are largely transparent to IT organizations; they simply help to improve intrinsic platform reliability. Intel also integrates extensive instrumentation into its components, which enables sophisticated platform management using standards-based applications and frameworks. In addition, Intel is working on a number of RAS-related technologies that will directly influence the way IT organizations support high availability.

- **Intel® Virtualization Technology** (formerly known as Intel Vanderpool technology) will help to improve the value of today's software-only virtualization solutions by making them more secure, reliable, and supportable. This can be expected to drive increasing consolidation across all Intel® processor-based servers. It will not only increase the business value of highly reliable platforms, but will also increase IT flexibility for delivering desired service levels cost-effectively (see the sidebar on page 6, *High Availability in a Consolidated Environment*).
- **Intel® Active Management Technology** will provide IT organizations with new, cross-platform capabilities for remote troubleshooting, recovery, and inventory management. Available even if the OS fails or platform power is unavailable, these capabilities will complement the RAS capabilities of Intel processor-based platforms, helping IT organizations accelerate time to repair for failed systems.¹⁰
- **New Security Features** in both server and client platforms provide enhanced support for enterprise-class security solutions. Examples include the Intel Execute Disable Bit, which enhances protection from certain classes of digital attack; and LaGrande technology, which will help to enable a new generation of security-hardened clients to improve perimeter protection for the enterprise network.

Affordable Availability in Action

Businesses are taking advantage of the increasing robustness of Intel® processor-based platforms to support mission-critical applications very cost-effectively. One example is Intel itself, which now supports its employee e-mail solution on non-clustered, 2-way Intel® Xeon™ processor-based systems (approximately 2,500 users per server).

Through a combination of reliable platforms, efficient management tools, and operational best practices, Intel IT has been meeting its goal of 99.98% availability for more than a year, and is moving toward 100% availability in 2005—even as e-mail volumes continue to increase. Based on the success of this deployment, Intel IT makes the following recommendations:

- Use appropriate monitoring tools (in this case, Microsoft Operations Manager*) to track hardware, OS, and application health, and to head off potential problems.
- Take advantage of remote management tools for faster maintenance and troubleshooting.
- Establish efficient procedures for security patching (viruses, worms, etc., can be a major cause for unplanned downtime).

For more information about implementing affordable availability solutions in real-world environments, see the Intel white paper, *Optimizing Enterprise IT*, available at: <http://www.intel.com/business/bss/infrastructure/managing/optimizing.pdf>

¹⁰ For more information, see the Intel white paper, *Intel Active Management Technology*, available at: http://www.intel.com/business/bss/products/client/active_mgmt.pdf

Flexible RAS Options on a Consistent Architecture

Intel is focused on delivering comprehensive platform solutions, and works both internally and with a broad array of third-party vendors to design and deliver optimized configurations that address the full range of real-world requirements. This helps to provide IT organizations with great flexibility for addressing specific service level requirements, while maintaining a consistent architecture that enables common tools and skill sets to be employed across virtually all solutions. Intel is also moving toward a unified platform architecture for Intel Xeon and Intel Itanium 2 processor-based systems, which will greatly extend these benefits going forward.

Current examples of platform-level RAS capabilities on Intel processor-based systems include:

High-RAS Subsystems

- **RAID (Redundant Array of Independent Disks)**
Storage—In conjunction with Intel I/O processors, these subsystems enable fast, high-availability storage at affordable costs. Both RAID 5 and RAID 6 solutions are supported. RAID 5 provides full data redundancy. RAID 6 adds extra protection to guard against the kind of double-error scenarios that become a significant concern in very large storage arrays.
- **Redundant and Hot-plug Components**—Systems are available with redundant and hot-plug power supplies, fans, I/O cards, etc. Many vendors offer systems that can be configured for full redundancy and accelerated serviceability in business-critical environments.
- **PCI Express**—In addition to providing next-generation I/O performance and scalability, PCI Express delivers a datacenter-class RAS architecture that includes enhanced hot-plug support and integrated error detection, correction and reporting.

High-RAS Platforms and Tools

- **Blade Frames**—Enterprise blade frames are available with no single point of failure and greatly simplified cabling schemes. These “datacenters-in-a-box” are highly tested and validated. They support very cost-effective, high-availability solutions, while also helping to reduce complexity and total costs.

- **Server Virtualization**—Leading software solutions support logical partitions, and provide very flexible resource allocation and fail-over capabilities in dense computing environments.¹¹ Platforms with hard partitions are also available. Hard partitions offer greater isolation than logical partitions. They protect applications in each partition not only from software failures, but also from hardware failures in other partitions.
- **Error Logging and Advanced Manageability Features**—Platform vendors provide the tools that allow IT technicians to interface with Intel’s Machine Check Architecture. In many cases, these tools are designed to plug into leading enterprise management frameworks, enabling a high level of cross-platform support.

Tailoring RAS to Business Needs

The following guidelines can be useful for selecting the most appropriate platforms for optimizing performance, scalability, and RAS in typical business environments (Figure 3).

General Business Solutions

“Our availability is pretty close to 100 percent. If we have a problem with a box—which is almost never because of the hardware—we have redundancy within each cluster at each datacenter, and we have active mirrored datacenters.”

— Paul Nielson, Senior Vice President, Technology Services, Monster, discussing the use of Intel Xeon processor-based servers in his company’s datacenter

Application Types:

- *Front-end enterprise applications (e.g., application servers, workgroups, e-commerce, portals, firewall/security)*
- *Primary business applications in small-business environments*

Recommended Platform:

Intel® Xeon™ processor-based systems

Proven reliability and compatibility are key reasons these dual-processor systems are the most widely deployed platforms in the world. In the enterprise datacenter, they are typically used for front-end applications in clustered or load-balanced configurations, which can provide very high availability and scalability at relatively low cost. They are also ideal as primary business platforms in many departmental and small-business environments.

¹¹ For more information, see the Intel white paper, *Enhanced Virtualization on Intel Architecture-based Servers*, available at: http://www.intel.com/business/bss/products/server/virtualization_wp.pdf

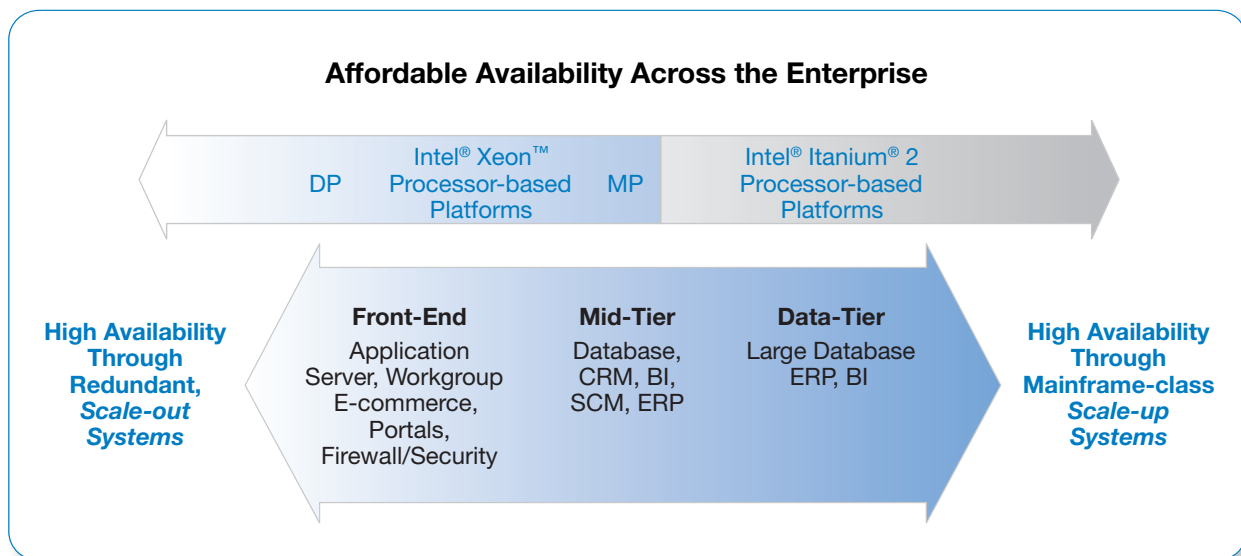


Figure 3. The flexibility of Intel processor-based solutions enables IT organizations to address end-to-end performance, scalability, and RAS requirements on a consistent, affordable, standards-based architecture.

Higher Availability for Demanding Environments

“Our uptime has been off the charts. The Intel® Xeon™ processor-based MP systems deliver less than an hour of unanticipated downtime per year, and we save more by not having to stock spare parts or pay for support.”¹²

— Todd Stewart, Group Director of Computing Operations, Siebel Systems

Application Types:

- Mid-tier enterprise applications, application consolidation, and small- to medium-size enterprise databases (e.g., Customer Relationship Management (CRM), Business Intelligence (BI), Supply Chain Management (SCM), and Enterprise Resource Management (ERP))
- Primary business solutions in medium-size organizations

Recommended Platform:

Intel® Xeon™ processor MP-based systems

These larger platforms (4-way to 32-way and higher) are designed for the more intense workloads and higher availability requirements of mid-tier enterprise applications, small- to medium-size database solutions, and consolidated server environments. They are also appropriate for running primary business applications in mid-size companies. Their additional RAS features provide greater reliability and data protection, and a System Management Bus enhances communications with third-party management systems. Vendors also tend to offer advanced platform RAS options, and fully redundant configurations are available for business-critical environments.

Mainframe-class Availability for Enterprise-critical Solutions

“If you’re doing large-scale computing applications that will impact your business, if you need to support large numbers of users and massive data sets, if you need outstanding reliability—you need to be looking at the Itanium 2 processor.”¹³

— Tim Eitel, Chief Information Officer, Raymond James Financial

Application Types:

- Large enterprise database solutions
- Enterprise ERP and BI applications

Recommended Platform:

Intel® Itanium® 2 processor-based systems

Ranging in size from 2-way to 512-way, Intel Itanium 2 processor-based platforms are designed for business-critical data-tier applications and the most demanding enterprise transactional systems. They have been designed from the ground up for mainframe-class availability; have the most sophisticated RAS features of any Intel architecture-based platforms; and are used by a number of vendors to deliver business-critical platforms for enterprise customers (see *Appendix A: Enterprise-critical Solutions on Intel Architecture*).

¹² Siebel Systems is the world’s leading supplier of Customer Relationship Management (CRM) solutions. For more information about the company, and their Intel architecture-based deployment, see the Intel case study at: <http://www.intel.com/business/casestudies/siebel.pdf>

¹³ Raymond James Financial is one of the largest financial services companies in the U.S. For more information about the company and their Itanium 2-based solution, see the Intel case study at http://www.intel.com/business/casestudies/raymond_james.pdf

Conclusion

The cost of server downtime continues to increase. By offering exceptional reliability and RAS features on industry-standard platforms, Intel architecture helps IT organizations deploy a more robust infrastructure, while keeping their costs down and their options open. Three platform families provide the infrastructure flexibility needed to meet specific availability requirements in virtually any business environment.

- Intel® Xeon™ processor-based platforms (2-way) deliver high reliability and compatibility for general-purpose business applications and front-end enterprise solutions.
- Intel® Xeon™ processor MP-based platforms provide even higher availability for mid-tier enterprise transactional applications and small- to medium-size enterprise databases.
- Intel® Itanium® 2 processor-based platforms support mainframe-class availability for the most demanding, enterprise-critical solutions.

Intel continues to expand its test and validation environment, and to develop and integrate new RAS features. With this ongoing innovation, businesses can continue to depend on Intel architecture for platforms of the highest quality, as well as RAS capabilities that rival or exceed those of proprietary architectures. As they work to address the increasing demands of real-time business solutions, they can take advantage of the power, flexibility, and affordability of industry-standard platforms, so they get leading value from their IT investments.

Appendix A: Enterprise-critical Solutions on Intel Architecture

High-end server manufacturers and software developers are taking advantage of the advanced RAS capabilities of Intel processor-based platforms to deliver cost-effective solutions designed for the most demanding enterprise environments. These fault-tolerant options are available on a variety of operating systems, including Linux*, HP-UX* and Microsoft Windows*. In a report on Microsoft Windows Server 2003*, Datacenter Edition, for example, Gartner cites “a proven track record of 99.99% and higher availability.”^a These solutions are changing the economics of high-end computing, by extending the benefits of standards-based solutions into the highest reaches of the enterprise datacenter.

The following Web sites offer information about specific vendor offerings for fault-tolerant solutions:

- **Bull (NovaScale*)**: <http://www.bull.com/novascale/>
- **Dell**: http://www1.us.dell.com/content/topics/global.aspx/services/en/dps_ha_infra?c=us&cs=555&l=en&s=biz
- **Egenera (Bladeframe*)**: http://www.egenera.com/prod_spec_home.php
- **Fujitsu (PRIMEQUEST*)**: <http://www.fujitsu.com/global/services/computing/server/primequest/>
- **Fujitsu Siemens (Primergy*)**: http://www.fujitsu-siemens.com/products/mission_critical/index.html
- **Hitachi (HA8500 Series*)**: <http://www.hitachi.co.jp/Prod/comp/OSD/pc/ha8500/prod/highlight/itanium.html> (HA8500 Web page—Japanese); <http://www.hitachi.com/> (Corporate home page—English)
- **HP (Integrity*)**: <http://www.hp.com/products1/servers/integrity/>
- **HP (NonStop Advanced Architecture*)**: <http://h20223.www2.hp.com/NonStopComputing/cache/77119-0-0-121.html>
- **IBM (x-Series*)**: <http://www-1.ibm.com/servers/eserver/xseries/>
- **Marathon Technologies (Zero Failover Software*)**: <http://www.marathontechnologies.com/>
- **Microsoft (Windows Server 2003*, Datacenter Edition)**: <http://www.microsoft.com/windowsserver2003/evaluation/overview/datacenter.msp>
- **NEC**: http://www.nec-online.com/Product/P_Range.asp?id=393
- **SGI**: <http://www.sgi.com/products/servers/altix/>
- **Stratus Technologies, Inc. (ftServer W Series*)**: <http://www.stratus.com/>
- **Unisys (ES7000*)**: http://www.unisys.com/products/es7000_servers/availability/index.htm

^a *Microsoft Windows Server 2003, Datacenter Edition Operating System*, by Mary I. Hubley and MaryAnn Richardson, Gartner Research, Inc., March 10, 2005.

* Other names and brands may be claimed as the property of others. Information regarding third-party products is provided solely for educational purposes. Intel is not responsible for the performance or support of third-party products and does not make any representations or warranties whatsoever regarding quality, reliability, functionality, or compatibility of these devices or products.

Appendix B: Glossary of RAS Technologies^a

Intel® Itanium® 2 Processor	Intel® Xeon™ Processor MP	Intel Xeon Processor	RAS Technology
Datacenter Enabling Technologies			
✓ ^b	2006	2006	Intel® Virtualization Technology: Will provide hardware support for virtualization, which will enable today's software-only solutions to be more robust, secure, and supportable.
Future	Future	2006	Intel Active Management Technology: Will provide cross-platform capabilities for remote troubleshooting, recovery, and inventory management.
Platform Error Handling and Containment			
✓+	✓	✓	<ul style="list-style-type: none"> ✓ Machine Check Architecture (MCA): Provides integrated capabilities for logging, reporting, and handling errors. ✓+ Advanced Machine Check Architecture: Provides more advanced error-handling capabilities, with well-defined interfaces at the hardware, firmware, and OS levels.
✓+	✓+	✓	<p>Data Bus Error Checking and Repair:</p> <ul style="list-style-type: none"> ✓ System supports parity or Cyclic Redundancy Checking (CRC) on the data bus to detect errors. ✓+ System supports Error Correction Code (ECC) and has the ability to retry the transaction. It can both detect and correct errors without downtime.
✓	✓	✓	Cache ECC Coverage: Cache arrays are protected with ECC, so a soft error in a memory cell can be detected and corrected. Without this capability, the program would have to be terminated, and the whole system would most likely have to be reset.
✓ ^b			Internal Logic Soft Error Checking: Parity checking is used on large arrays to detect soft errors and prevent applications from using corrupted data.
✓ (processor level) ^b	✓ ^c		Lockstep Support: The same program can be run on two processors using the same data. Outputs are checked every clock cycle to assure data has not been corrupted.
✓			Bad Data Containment: The system can tag a memory location that contains corrupted data (this is sometimes called "data poisoning"). The impact of the corrupted data is limited to the program using it at the time, and the bad data is eliminated when the program is finished or when it overwrites the location. This capability greatly reduces the need to reset a system if data is corrupted.
✓ ^b			Cache Reliability (Pellston): Goes beyond ECC to further enhance the reliability of processor cache memory.
✓	✓	✓	Memory Single Device Error Correction (SDEC): Enables the system to correct all memory errors if a single DRAM device fails. ^d
✓	✓	✓	Memory Retry on Double-bit Error Detect: ECC can detect double-bit errors, but can only correct single-bit errors. In the event of a double-bit error, this enables the memory controller to retry the memory read, which may correct the error.
✓	✓	✓	Memory Spares: Allows a failed memory device to be transparently replaced by a spare device. This improves performance, by eliminating the performance loss caused by ECC correction. It also improves reliability, since it can correct multiple soft errors in a memory device (ECC can only correct single errors).
✓+	✓+	✓	<p>Partitioning: A large computing system can be divided into multiple smaller partitions. The partitions have dedicated resources (which can often be shifted among them), can run different operating systems, and are isolated from software or resource faults in other partitions. Partitioning reduces overall cost of ownership, since the partitions are managed as a single system.</p> <ul style="list-style-type: none"> ✓ All Intel processor-based server platforms support logical partitioning using 3rd party software virtualization solutions (see Intel® Virtualization Technology, above). ✓+ Hardware partitioning is supported by several platform vendors.
✓	✓		Electrically isolated partitions: Electrical isolation prevents hardware faults in one partition from affecting another. This enables multiple applications to be run on a single system, while maintaining a level of isolation comparable to running them on physically separate systems. It is also necessary to allow resources (such as a new processor board or memory board) to be added to a partition while other partitions continue running.

^a All time-frames, dates, and products are subject to change without further notification.

^b Available in platforms based on the next-generation Intel Itanium 2 processor (code-named Montecito), which are planned for the 2005 time-frame.

^c Lockstep is supported by selected vendors via enabled chipsets and platforms.

^d Called "chipkill" by IBM.



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