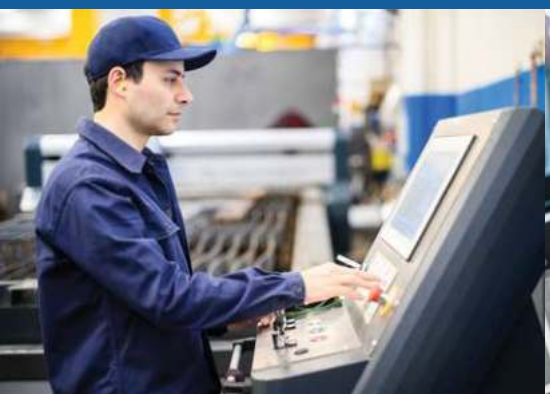
Stratus | ztC Endurance

Evolutionary Fault Tolerance

A new approach to availability in x86 architectures



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Executive Summary

This white paper discusses the evolutionary fault tolerance delivered by the availability architecture of the Stratus ztC Endurance™ computing platform. The paper provides a high-level overview of the redundant, fault tolerant platform and its availability architecture, underscoring ztC Endurance's unique design. Combined with Stratus' proven, award-winning service and support, ztC Endurance provides our partners and customers the highest possible levels of uptime, availability, and reliability for mission-critical applications and data.

The Stratus ztC Endurance availability architecture is based on a number of factors and was carefully designed to provide the optimal combination of protection, performance, intelligence, modularity, flexibility, and serviceability for a modern next-generation mission-critical computing system. ztC Endurance utilizes redundant modular hardware, advanced health monitoring and predictive diagnostics, and automatic self-healing and failover capabilities. Additionally, the platform proactively identifies and isolates faults, facilitating system services and repairs through simple online replacements. This identify, isolate, and service availability architecture provides maximum uptime and availability for workloads and ensures that critical applications will continue to run with no downtime or data loss, even if a hardware failure should occur.

The Stratus ztC Endurance Platform

Stratus ztC Endurance is an innovative new family of fault-tolerant computing platforms that enable intelligent predictive failover and 99.99999% compute platform availability. This family of platforms evolves from Stratus' proven combination of built-in fault tolerance, proactive health monitoring, and unmatched serviceability. The ztC Endurance platform, together with its Automated Uptime Layer with Smart Exchange™, delivers the predictable, protected performance needed by today and tomorrow's data center and edge environments by leveraging Intel RAS capabilities, embedded hardware and software security, and increased manageability and serviceability via a modular architecture.

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The Stratus ztC Endurance platform is available in three distinct models:

- **ztC Endurance 3100** - The entry-level ztC Endurance model is designed to provide affordable performance for critical applications in remote offices, branch offices, or shop floor locations. It is a reliable, fault-tolerant system with a single-socket processor architecture that is roughly suitable for 12 medium-sized virtual machines or applications. This model will offer a single-processor architecture with 1 x 12-core Hyper-Threaded Intel® Xeon® Silver processor (providing 24 threads, or vCPUs) and will include either 64 GB, 128 GB, or 256 GB of memory.
- **ztC Endurance 5100** - The mid-range ztC Endurance model offers a versatile compute platform for rapidly growing or evolving application requirements in regional offices, remote plants, or regional data centers. The mid-range ztC Endurance model is a reliable, fault-tolerant system that is roughly suitable for 24 medium-sized virtual machines or applications. This model will offer a dual-processor architecture with 2 x 12-core Hyper-Threaded Intel Xeon Silver processors (providing 48 threads, or vCPUs) and will include either 128 GB, 256 GB, or 512 GB of memory. The mid-range ztC Endurance system will provide a balance of application performance and value to meet the demands of mission-critical applications in traditional data centers as well as at the edge.
- **ztC Endurance 7100** - The high-performance ztC Endurance model provides the highest level of performance for data-intensive / transaction-intensive applications of larger remote plants or corporate data centers and for compute-intensive applications such as AI and ML. This ztC Endurance model offers a dual-processor architecture with 2 x 24-core

Hyper-Threaded Intel Xeon Gold processors (providing 96 threads, or vCPUs) and will include either 256 GB, 512 GB, or 1024 GB of memory. The high-end model will be roughly suitable for 40+ medium-sized virtual machines or applications.

> This family of fault tolerant platforms is another advance by Stratus in providing simple, protected, and autonomous computing.

Simple

Stratus computing platforms are designed to be simple to use, to install, and to maintain. For rapid time-to-value and simple management, including non-technical staff, Stratus computing solutions are easy to install, deploy, and manage across applications and infrastructure with zero-touch operation. Stratus computing platforms support both bare metal and virtualized architectures to provide quick application deployment, to offer flexibility, to maximize computing resources, and to lower the total cost of ownership of the system.

Easy To Use: The Stratus ztC Endurance platform has been designed for simplicity and ease of use for both IT and OT personnel. Features such as automatic deployment scripts, a simple user interface, industry-standard interfaces for remote monitoring and management, support for standard off-the-shelf operating systems and hypervisors, automatic local and remote notification capabilities, and hot-swappable plug-and-play components ensure that a ztC Endurance system is easy to deploy, easy to configure, easy to operate, easy to monitor, and easy to service.

Modular / Serviceable: The Stratus ztC Endurance system design builds upon the redundant, hot-swappable Customer Replaceable Units (CRUs) offered in previous Stratus computing platforms, but expands that concept into an even more modular, more serviceable design.

A single ztC Endurance system chassis includes eight CRU modules:

- 2 x Compute Modules
- 2 x Storage Modules
- 2 x I/O Modules
- 2 x Power Supply Units (PSUs)

Each of these eight CRUs can be independently hot-replaced (i.e., a failed CRU can be hot-removed as indicated by the CRU's "safe-to-pull" LED and a replacement CRU can be hot-inserted) to restore a ztC Endurance system to a healthy, fully redundant configuration in the event of a hardware failure. This allows for ease of service whereby replacement parts can be dispatched to a site and hot-installed in the system, restoring the system to full health while it is running and with no impact to operations, applications, and data. This also allows for highly granular serviceability whereby only the failed CRU is removed and replaced. This means that any one subsystem (compute, storage, I/O, or power) can be independently serviced without affecting the other subsystems.

Protected

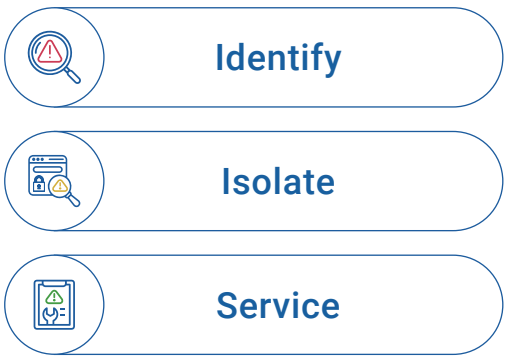
Stratus computing solutions are designed to protect operations, applications, and data. Stratus solutions are redundant, fault-tolerant, and reduce operational, financial, and reputational risk by ensuring "always on" availability, zero downtime, and zero data loss. The ztC Endurance platform is a redundant, fault-tolerant, hardened, secure system with no single points of failure, ensuring continued operation with no loss of in-flight data if a hardware failure should occur.

Redundant Architecture: A core concept of the ztC Endurance architecture is its fully redundant hardware design, including, for example, mainboards, processors, memory, disk drives, network interfaces, and power supplies. To achieve this redundancy, a ztC Endurance system includes 8 CRU modules, as described above, including a pair of identical compute modules, a pair of identical storage modules, a pair of identical I/O modules, and a pair of identical Power Supply Units. Each pair of CRU modules provides redundancy for a ztC Endurance subsystem, so that one CRU in each pair can fail without causing a system outage.

Redundancy for the compute modules is provided via an active / standby availability architecture. The active compute module handles all processing while the standby compute module stays ready to be promoted to active status via an automatic compute failover process, called Smart Exchange™ described below, should the active compute module begin to fail.

Redundancy for the storage modules, I/O modules, and PSUs is provided via an active / active availability architecture whereby both storage modules, both I/O modules, and both PSUs are active and operational in a healthy ztC Endurance system. This active / active redundancy allows the associated subsystem (storage, I/O, or power) to continue operation in a seamless, bumpless fashion (i.e., with no system outage, no downtime, and no failover process required) if one of the redundant modules in that subsystem should fail. This redundancy also allows a failed module to be serviced (removed/replaced) while the healthy active module continues operation without any disruption to the operation of the overall system or to the applications.

Fault-Tolerant Approach: If the Automated Uptime Layer with Smart Exchange™ identifies a hardware failure or predicts a potential hardware failure, the Stratus ztC Endurance platform will utilize its redundant hardware and built-in failover capabilities to automatically take action to avoid a system outage.



The ztC Endurance platform utilizes an "Identify -> Isolate -> Service" approach whereby any internal components that are identified as failed or likely to fail are automatically removed from operation without impacting the compute workload.

Despite the failure (or potential failure) of a component, the applications will continue to run, and the data will continue to be accessible. The failed component can then be serviced via online CRU replacement while the server is running with no interruption to the business operations.

The ztC Endurance platform automatically provides this fault-tolerant protection in an application-transparent fashion. This means that the system's hardware redundancy and fault-tolerant capabilities are abstracted from an operating system / hypervisor, virtual machine, or application, allowing the ztC Endurance to run standard operating systems / hypervisors and the same applications that would run on a typical commodity server — with no special setup, custom configuration, or code modifications required. This automatically protects the operating system / hypervisor, virtual machines, applications, and data from outages and downtime, and requires no additional work.

> SMART Zefr™ memory reduces the memory-related Defective Parts Per Million (DPPM) metric from an industry-standard level of 3,000 DPPM down to 200 DPPM.

Hardened Hardware and Software: The ztC Endurance solution makes use of hardened hardware components where possible. One example of this is the utilization of SMART Zefr memory. Zefr stands for Zero Failure Rate. All memory modules utilized in ztC Endurance systems will undergo a Zefr screening process. The process involves extended-runtime testing of each memory module on a server-class motherboard at elevated operational temperature with high-speed data exchange driven by demanding test scripts. This screening process filters out potentially weak memory modules and reduces the memory-related Defective Parts Per Million (DPPM) metric from an industry-standard level of 3,000 DPPM down to 200 DPPM. This dramatically increases the reliability of the memory modules and further increases the overall reliability and availability of the ztC Endurance platform.

Additionally, Stratus develops and deploys hardened device drivers to support the robust redundancy and fault-tolerance of the ztC Endurance storage and I/O subsystems. These hardened device drivers allow a ztC Endurance platform to continue running and automatically self-heal in the event of a firmware lockup, a driver-related error condition, or a surprise removal or insertion of a storage or I/O hardware component. Competing solutions do not typically include hardened device drivers and cannot typically recover or continue running if a similar error condition should occur.

Secure Operation: Ensuring the security of our computing platforms is of utmost important to Stratus. Cybersecurity has become increasingly important in the modern computing world due to an increasing reliance on technology, a growing need for interconnectivity and networking between distributed sites, the adoption of remote access technologies, the emergence of IoT, and the convergence of IT and OT. These trends are exposing previously isolated systems to new and existing vulnerabilities and are creating difficulties in securing computing architectures using traditional methods and tools.

Stratus reduces risk by delivering platforms with multi-layered defense-in-depth approaches to minimize viable attack vectors. Stratus focuses on both process security and product security to ensure maximum security.

For more information on Stratus process security and on the security of the Stratus ztC Endurance platform, please download the Stratus Product Security Whitepaper.

Autonomous

Stratus zero-touch computing platforms require zero human intervention for identification and isolation of faults and minimal human intervention for system support, service, maintenance, and repair. Stratus platforms offer “call home” features for remote issue notifications and 24x7x365 support to further minimize any chance of unplanned downtime for equipment and applications. Stratus also supports remote management and monitoring to provide for flexibility in system management and maintenance activities.

Self-Monitoring: The Stratus ztC Endurance platform actively monitors hundreds of internal data points from multiple data sources and continuously analyzes those data points to identify failures or to predict failures before they occur. If a hardware component fails or is about to fail, ztC Endurance will automatically identify the issue via these health monitoring capabilities.

Once a system issue has been identified, ztC Endurance provides both local and remote notifications to ensure that issue resolution can immediately begin. A ztC Endurance system can locally alert the user of a system issue using industry-standard methods and protocols such as e-mail alerts, SNMP, and REST APIs. ztC Endurance can also “call home” to notify Stratus support of an issue via secure, encrypted communication channels.

Self-Healing: As described above, the Stratus ztC Endurance platform will automatically take action – with no user intervention required – to ensure continued operation of the system if a component should fail or if a component is predicted to fail. To achieve this, the system utilizes built-in health monitoring and predictive analysis capabilities and will leverage hardware redundancy and online failover functionality to continue operating through component failures with zero downtime or data loss.

If a component or module has failed, ztC Endurance will run diagnostics on the failed component or module after it has been taken out of service. The management subsystem will use algorithms to determine whether the error condition was persistent or transient. In the case of a persistent error or a frequent transient error, the component or module would be left out of service and would need to be replaced.

But in the case of an infrequent transient error, the failed component or module may be reset and returned to service to self-heal the system.

Additionally, ztC Endurance's self-healing capabilities assist the operator if replacement of a module is ever required. No additional operator action or intervention is required beyond physically plugging the replacement module into the ztC Endurance system chassis. There is no need for a keyboard, mouse, or monitor or for any operator actions (such as performing diagnostics, restoring device configurations, flashing firmware, synchronizing data, running scripts, balancing loads, etc.) that are typically associated with component replacement. The ztC Endurance management subsystem will automatically detect the replacement module and will automatically perform any actions required to return the component to service and to return the system to full health. This self-healing capability ensures that simple module replacements can be done by OT staff without requiring support from IT.

Remote Monitoring and Management: The Stratus ztC Endurance management subsystem provides several web-based user interfaces for remote monitoring and management. These web-based user interfaces include a BMC UI (used for system health monitoring, console access, and power control), a management subsystem UI (used for system health monitoring and system management), and an OS/hypervisor UI (used for system management and for configuration of virtual machines, applications, etc.).

Additionally, ztC Endurance provides built-in support for remote monitoring by Stratus. This provides automatic notification of any system issue to Stratus Support via secure internet-based connectivity with no additional implementation required.

Remote Service and Support: The Stratus ztC Endurance platform provides a cloud-based capability for remote access that can enable Stratus Support to connect remotely for diagnostics, troubleshooting, and service. This can be done through secure internet-based connectivity, only if explicitly permitted by the user.

Additionally, Stratus Managed Services provides a wide range of additional remote service and support features, including server management, health monitoring, database administration, reporting, and additional services.

Interoperability: In modern data center and Edge Computing environments, interoperability – the ability of different computerized systems to connect and communicate with one another freely and easily using standard, coordinated methods with minimal restriction and without requiring custom implementation effort and specialized support – has become increasingly important. The Stratus ztC Endurance platform provides broad support for industry-standard protocols, such as SNMP, SMTP, and REST APIs, that can be utilized by standard off-the-shelf system management platforms to enable centralized remote monitoring and management.

The Stratus Availability Architecture

The Stratus ztC Endurance platform's availability architecture was specifically designed to leverage the increased reliability and intelligence of modern compute hardware components to deliver the highest possible levels of server availability and performance.

The ztC Endurance platform ensures the highest possible availability by utilizing internal health monitoring, component diagnostics, predictive failure analysis, redundancy, and automatic failover capabilities. At the same time, the ztC Endurance system provides maximum compute performance by utilizing the advanced features and full functionality of modern hardware components, such as the fourth generation Intel® Xeon® processors, while shielding the system from spurious alarms, false data divergences, and unnecessary hardware recovery / resync cycles resulting from common, transient, correctable errors.

The overall uptime percentage of a ztC Endurance system is 7 nines (or 99.99999%). This uptime percentage model equates to an expected average system downtime of less than 3.15 seconds per year. The availability of ztC Endurance is significantly higher than the expected availability of a typical High Availability (HA) cluster system with an uptime percentage of 99.95%, or an expected average downtime of 4 hours and 23 minutes per year.

It is also greater than the expected availability of a conventional standalone server with an uptime percentage of 99%, or an expected average downtime of 87 hours and 40 minutes per year.

> The overall uptime percentage of a ztC Endurance system is 7 nines (or 99.99999%). This equates to an expected average system downtime of less than 3.15 seconds per year.

ztC Endurance provides an active / standby availability architecture from a compute (i.e., motherboard, processors, and memory) perspective with fully redundant active / active storage (i.e. disk drives), I/O (i.e. network interfaces and PCIe peripherals), and power.

Stratus Automated Uptime Layer with Smart Exchange

The Stratus ztC Endurance platform includes Stratus-provided firmware and software known as the Automated Uptime Layer with Smart Exchange (AUL - Smart Exchange) to support the system's availability features. Unique in the industry, AUL - Smart Exchange provides reliability and fault-tolerance features for motherboards, processors, memory, busses, storage devices, and I/O devices. AUL - Smart Exchange also simplifies monitoring and management of the system and enables local monitoring and remote service / support.

Service and Support

The redundancy, fault tolerance, and availability architecture of the Stratus ztC Endurance platform ensure that a workload will continue operation with no significant downtime, outage, or interruption in the event of a hardware failure. Ensuring continued operation despite a hardware failure is an essential benefit. It is also critical to identify that an issue has occurred and to resolve the issue quickly, returning the system to fully healthy, redundant, fault tolerant mode as soon as possible.

As such, Stratus Customer Support plays a significant role in achieving the highest possible levels of uptime and availability for a ztC Endurance system. In addition to providing proactive monitoring and next-day replacement parts in the event of a hardware failure, Stratus Customer Support makes other value add services available, including 24x7x365 technical support for all Stratus-provided hardware and software, system software upgrades and patches, root cause failure analysis services, emergency onsite response, vendor collaboration for OEM components, and full support for the operating system / hypervisor.

For additional details on the Stratus ztC Endurance, the Stratus Availability Architecture, or Stratus Customer Support, please contact us to schedule a meeting with a Stratus expert, or reach out to your local representative. You can also visit www.stratus.com to learn more.

About Stratus

For leaders digitally transforming their operations in order to drive predictable, peak performance with minimal risk, Stratus ensures the continuous availability of business-critical applications by delivering zero-touch computing platforms that are simple to deploy and maintain, protected from interruptions and threats, and autonomous. For over 40 years, we have provided reliable and redundant zero-touch computing, enabling global Fortune 500 companies and small-to-medium sized businesses to securely and remotely turn data into actionable intelligence at the Edge, cloud and data center – driving uptime and efficiency. For more information, please visit www.stratus.com or follow on Twitter @StratusAlwaysOn and LinkedIn @StratusTechnologies.