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x86 SERVERS

Oracle Server X6-2L System Architecture

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Introduction

Oracle Server X6-2L, Oracle's latest two-socket server, is the newest addition to Oracle's family of x86 servers that are purpose-built to be best for running Oracle software. This 2U server is optimized for customers requiring a robust and reliable platform for running single-node instances of Oracle Database or as a storage server with Oracle Solaris and ZFS along with large amounts of direct-attached storage.

Product Overview

Oracle Server X6-2L supports up to two Intel® Xeon® E5-2600 v4 processors, and each has up to 22 cores and up to 55 MB L3 cache. With 24 DDR4-2400 dual inline memory module (DIMM) slots, the server provides up to 1.5 TB of main memory. Memory bandwidth increases to 2400 MT/sec per channel compared to 2133 MT/sec in the previous generation.

In addition, Oracle Server X6-2L has six PCI Express (PCIe) Gen3 slots (2x 16-lane, 4x 8-lane slots), four 10GBase-T ports, and six USB ports. Oracle server X6-2L has four different disk cages providing four different disk cage options that are factory configured to a specific configuration.

1. 8 x 2.5-inch + optional DVD, with up to 9.6 TB of storage
2. 24 x 2.5-inch + 2 x 2.5-inch (rear), with up to 31.2 TB of storage
3. All-flash configuration with up to 28.8 TB of NVM Express (NVMe) solid-state drives (SSDs)
4. 12 x 3.5-inch + 2 x 2.5-inch (rear), with up to 98.4 TB of storage

Configurations 1, 2, and 3 support NVMe SSDs. Up to four NVMe SSDs, each with 3.2 TB of flash capacity are supported in configurations 1 and 2, while configuration 3 supports up to nine NVMe SSDs. Configuration 4 can be optionally configured with up to four 3.2 TB Oracle Flash Accelerator F320 PCIe Cards. An optional DVD drive is supported in configuration 1 to allow local access for operating system installation.

Designed to Meet Today's Security Challenges

According to the Department of Homeland Security, imported software and electronics are often shipped in to the United States with malware, spyware, and security-compromising components that are purposely embedded by unknown foreign parties. There has been concern about supply-chain security, because computers and IT equipment pass through several suppliers before the final product is deployed. A federal report released on the supply chain between the United States and foreign nations speculated the possibility that somewhere along the line, someone could compromise a component and design a "back door entry" capability that could enable cyberattacks.

Greg Schaffer, acting deputy undersecretary of the DHS National Protection and Programs Directorate, testified before the House Oversight and Government Reform Committee. Rep. Jason Chaffetz (R-Utah) said, "These pieces are embedded in software and hardware, and people don't know that. It's very difficult to detect. Are you aware of any software or hardware components that have been embedded with security risks?" Schaffer replied, "I am aware of instances where that has happened." See http://www.eweek.com/c/a/Mobile-and-Wireless/DHS-Claims-Foreign-Suppliers-Have-Embedded-Malware-in-USElectronics-832422 for details.

One example of such a cyberattack has been christened "BIOS Plot." An NSA analyst discovered that a nation state had the intention to destroy computers—via the BIOS—used by US financial institutions.

Debora Plunkett, Director of Cyber Defense for the NSA discusses BIOS Plot: “Think about the impact of that across the entire globe. It could literally take down the US economy…Don't be fooled. There are absolutely nation states who have the capability and the intentions to do just that.” See http://www.cbsnews.com/news/nsa-speaks-out-on-snowden-spying for details.

As recently as December 2015, a security breach was discovered at a major US computer networking equipment manufacturer. US officials worried that hackers working for a foreign government have been able to spy on the encrypted communications of the US government and private companies for years. It is believed that attackers embedded a “back door” into the source code of the communication protocols of the equipment. See http://www.cnn.com/2015/12/18/politics/juniper-networks-us-government-security-hack/ for details.

These types of attacks are just a few examples of how hackers are becoming more and more sophisticated at attacking multiple layers in the IT stack. It is no longer good enough just to secure applications and the network perimeter of a data center; the enterprise must apply security in depth across hardware, firmware, and software.

Oracle’s Approach to Security

Oracle’s philosophy on security in depth is based on the philosophy that “security needs to be built in, not bolted on.” Oracle has a company-wide initiative to incorporate security features across all of its products, starting with the design and manufacturing of its servers, through the operating systems layers, and extending into the database, middleware, and application layers. The Global Product Security group is chartered with the goal of setting, auditing, and enforcing security policies across all Oracle products. It also performs periodic security audits and ensures compliance with the latest threat profiles. This organization also publishes regular security alerts to users of Oracle products. An example alert can be found at:

http://www.oracle.com/technetwork/topics/security/alert-cve-2016-0603-2874360.html

Securing the Foundation—100 Percent In-House Design and Manufacture

The entire x86 server product line is designed 100 percent in-house. No third parties ever touch the motherboard design, ensuring that no components are added to create a “back door entry” into Oracle servers. Additionally Oracle applies strict control over the entire supply chain with all of its servers being manufactured in the United States, thus maximizing supply chain security. This is unique to Oracle.

The firmware installed in Oracle’s x86 servers, such as the BIOS and system management stack, are developed and owned by Oracle with no source code ever released to third parties. The Oracle Integrated Lights Out Manager (Oracle ILOM) system management stack is FIPS 140-2 compliant, ensuring the latest cryptography ciphers are supported. Oracle ILOM also includes other security-related features, such as fine-grained access control and logging, that enable IT administrators to control and monitor access to the infrastructure. Oracle has incorporated technologies into Oracle ILOM that ensure that illegal firmware updates are prevented.

In addition Oracle ILOM makes sure that newly unpacked and connected Oracle x86 servers are secure “out of the box,” because only secure protocols such as HTTPS, SNMP, and IPMI are allowed, while untrustworthy connections are rejected. The Oracle ILOM service processor is ubiquitous across all of Oracle’s engineered systems, storage appliances, SPARC servers, and x86 servers—ensuring that common security, reliability, and manageability features are applied across all platforms.

All of these features are embedded within the servers themselves and there are no additional licensing fees to be paid for them.

Best for Oracle Software

Oracle Server X6-2L systems are ideal x86 platforms for running Oracle software. Only Oracle provides customers with an optimized hardware and software stack that comes complete with choice of OS, virtualization software, and cloud management tools—all at no extra charge. Oracle's optimized hardware and software stack has enabled a 10x performance gain in its engineered systems and has delivered world-record benchmark results. Oracle's comprehensive, open standards–based x86 systems provide the best platform on which to run Oracle software with enhanced reliability for data center environments.

In today's connected world, vast amounts of unstructured data flow into an enterprise, creating an immediate business need to extract query-able structured datagrams from this slew of information. Online transaction processing (OLTP) is a technology that historically has been used for traditional enterprise applications such as enterprise resource planning (ERP) and human capital management (HCM). Now OLTP is itself in a unique position to accelerate business intelligence and analytics. As such, this places greater demands on the database, I/O, and main memory requirements in data centers. Oracle Database is designed to take advantage of hardware features such as high-core-count central processing units (CPUs), non-uniform memory access (NUMA) memory architectures, and tiered storage of data that enhance system performance.

Benefits include increased transaction throughput and improved application response times, which reduce the overall cost per transaction.

Oracle Solaris and ZFS Acceleration with Flash

As companies look for ways to correct the imbalance between system processing needs and storage system throughput capabilities, it is essential to find an approach that maximizes IOPS. With hard disk drive performance affected by seek, rotation, and transfer times, the latency created when transferring data to and from drives results in I/O bottlenecks. Flash can be placed in a new storage tier to assist hard disk drives by holding frequently accessed data. By utilizing flash to handle CPU I/O, and hard disk drives to store massive data sets, a hybrid storage pool gives organizations significant performance gains without sacrificing capacity.

Oracle Solaris ZFS is an enterprise-class, general-purpose file system that provides virtually unlimited file system scalability and increased data integrity to large-scale solutions. By automatically allocating space from pooled storage when needed, Oracle Solaris ZFS simplifies storage management and gives organizations the flexibility to optimize data for performance. Oracle Solaris ZFS can utilize flash in many different ways to accelerate performance of applications that can benefit from a large amount of direct-attached storage. Some of the flash-specific optimizations in Oracle Solaris and ZFS are in the areas of adaptive replacement cache to accelerate reads and the ZFS intent log to accelerate writes.

Oracle Server X6-2L supports flash in two configurations that also have large amounts of disk capacity. The 24-disk cage configuration is the ideal choice for implementing a storage server solution that needs to combine high spindle density with flash, while the 12-disk cage configuration is the ideal choice for implementing a storage server solution that needs to combine vast amounts (96 TB) of storage with flash, using Oracle Solaris and ZFS. These configurations offer a wide range of choices for the disk drive and flash subsystems, ranging from hard disk drives (HDDs), conventional SSDs, and NVMe SSDs/PCIe cards, allowing users to configure tiered storage that is optimized for spindle density and flash-to-disk ratios. In addition, the compute power of Oracle Server X6-2L is used by Oracle Solaris ZFS to execute algorithms related to block allocations, compression, intelligent prefetch, monitoring RAID functionality, and the overall health of the storage subsystem.

Oracle Server X6-2L and NVM Express

Oracle Server X6-2L incorporates flash technology called NVM Express (NVMe) that provides a high-bandwidth, low-latency PCIe interface to large amounts of flash within the system. Oracle Database—with its Database Smart Flash Cache feature—and Oracle Solaris ZFS are specifically engineered to take advantage of this low-latency, high-bandwidth interface to flash in Oracle Server X6-2L. Oracle Solaris and Oracle Linux are coengineered with Oracle Server X6-2L to function in enterprise-class workloads by enabling hot-pluggable capabilities (with the SSD form factor). Traditional SSDs with a SAS/SATA interface are a popular method of adding flash to a server, and these take advantage of legacy storage controller and disk cage infrastructures. NVMe is an entirely new end-to-end design that eliminates the performance bottlenecks of using conventional storage interfaces.

Oracle-Unique NVMe Design

Figure 1 illustrates a block diagram of a traditional SAS-3 SSD connected to a server. The server PCIe root complex is connected to a PCIe/SAS controller that translates the PCIe protocol to the SAS protocol to allow the server to read from and write to the SAS-3 SSD. Because NVMe SSDs already use the PCIe protocol, there is no need for the PCIe-to-SAS controller translation, as shown in Figure 2.

Oracle's NVMe drives have a much lower latency and higher bandwidth than standard SAS-3 drives due to the fact that each drive connects directly to four lanes of PCIe Gen3 with an aggregate bandwidth of 32 Gb/sec (or 64 Gb/s) as opposed to 12 Gb/sec for a traditional SAS-3 SSD.

Oracle Server X6-2L with the 8 x 2.5-inch disk cage and the 24 x 2.5-inch disk cage can be configured with up to four NVMe small-form-factor (SFF) SSDs that provide up to 12.8 TB of flash storage. The Oracle Server X6-2L all-flash configuration (shown in Figure 3) supports up to 28.8 TB of flash that is ideally suited for applications that can benefit from very high IOPS (over 4.5 million IOPS) with all nine SSDs populated. For the 12 x 3.5-inch disk cage, up to 98.4TB of HDD storage and up to 12.8TB of flash storage can be configured.

Because flash technologies are temperature sensitive, most high-performance flash drives will throttle down their I/O speeds as temperatures rise in order to protect the flash from damage. Oracle's NVMe SSDs, on the other hand, include multiple temperature sensors that are monitored by the server's Oracle ILOM service processor (SP) to ensure the drive maintains optimum operating temperature. Oracle ILOM modulates the fan speed to ensure sufficient cooling for maximum system performance at all times. The benefits of this are that the server consistently operates at maximum performance across its full operating temperature range independent of the system configuration.

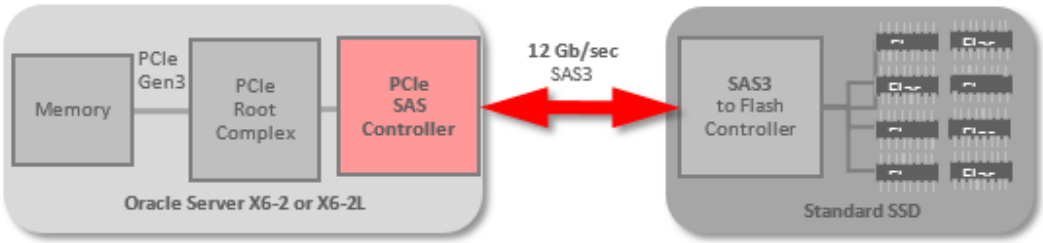

Figure 1. Traditional SAS-3 solid state drive architecture

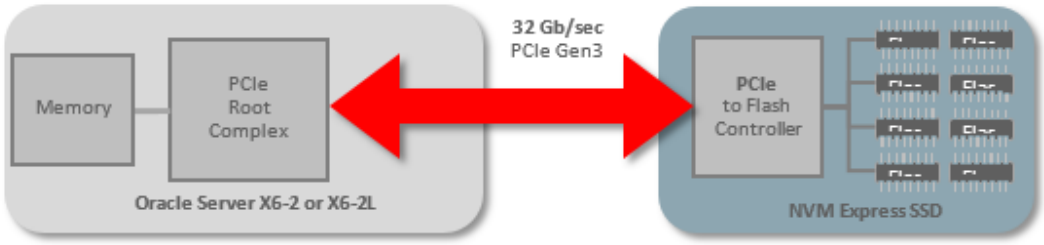

Figure 2. Oracle's NVMe SSD architecture

Figure 3. Oracle Flash Accelerator F320 PCIe Card architecture

Extreme Flexibility and Reliability

Oracle Server X6-2L chassis is designed with flexibility in mind. It offers four disk cage options: an 8 x 2.5-inch disk cage configuration; a 12 x 3.5-inch disk cage (plus 2x 2.5-inch SFF in rear) configuration, a 24 x 2.5-inch disk cage (plus 2x 2.5-inch SFF in rear) configuration, and an all-flash configuration. These options provide ultimate flexibility in disk choice to accommodate maximum redundancy and speed optimizations.

Oracle Server X6-2L with the 8 x 2.5-inch disk cage configuration provides extreme I/O density with six PCIe 3.0 slots (two 16-lane and four 8-lane slots) offering 128 GB/sec of I/O bandwidth in a 2U form factor. The increased free airflow in the 2U chassis with larger fans (compared to a 1U server) combined with Oracle Advanced System Cooling features of Oracle Server X6-2L improves the power efficiency of the cooling subsystem. The incremental power savings and maximum system uptime make this server ideally suited for environments in which power and cooling delivery to the rack is constrained.

Oracle Server X6-2L with the 12 x 3.5-inch disk cage configuration has a maximum capacity of 98.4 TB of direct-attached storage along with an optional 12.8 TB flash implemented with Oracle Flash Accelerator F320 PCIe Card, providing the flexibility to be used as a storage server. The compute power of Oracle Server X6-2L can be used to extend storage density for applications that require a combination of compute power and storage capacity at the same time, such as video compression and transcoding.

Because Oracle Server X6-2L provides a 24-disk configuration, the reliability of the system can be enhanced by configuring some of the disks for redundancy to ensure a backup of critical data is maintained in direct-attached storage. For example, a database can be mirrored on redundant disks using RAID to ensure that no data is lost in the event of a faulty disk.

Oracle Server X6-2L incorporates Oracle ILOM and diagnostics tools to monitor the health of the system, evaluate potential faults, determine the root cause of actual faults and offline faulty components while keeping the system up and running. Service requests to replace faulty components are automatically sent to the field service engineers, further improving system uptime. The 24-drive option allows a mix of magnetic, solid state, and NVMe drives to meet divergent system requirements of spindle density and traditional SSD-based storage, as well as the high-bandwidth tiered flash needs of enterprise applications. (NVMe SSDs are available only in the 2.5-inch disk cage configurations.)

Oracle's engineered systems—such as the Oracle Exadata, Oracle Big Data Appliance, and Oracle Zero Data Loss Recovery Appliance engineering systems, Oracle's flagship hardware products—use Oracle's x86 servers as building blocks. The coengineering performed by Oracle's hardware and software teams when developing these engineered systems ensures that maximum performance and reliability are incorporated into the Oracle Server X6-2L design. As a result, both hardware and software work together in harmony.

Combining Oracle ILOM capabilities (runtime fault diagnosis and self-recovery) with the extensive reliability testing and built-in redundancy makes Oracle Server X6-2L the most reliable two-socket server in the market for running Oracle Database in single-node configurations in remote or branch offices.

Innovative Reliability, Availability, and Serviceability

Reliability, availability, and serviceability (RAS) are extremely important to customers who demand maximum system uptime when running business-critical applications. If a fault occurs in a server, revenue can be lost.

Oracle Server X6-2L is designed completely in house from the ground up and is engineered to be easily serviceable while maximizing reliability. In particular, the chassis design has special features that improve performance while also improving reliability and serviceability. Oracle engineers designed a rigorous testing process for all components of the server such as memory DIMMs, hard disk drives, power supplies, and so on. These quality assurance tests are supplementary to those conducted by the component suppliers. All components of the system have to pass these tests prior to release of the product to market.

Hardware Designed for Advanced RAS

Oracle Server X6-2L is designed for maximum uptime with enterprise-grade availability features. All disks are hot swappable and support RAID 0, 1, 5, 6, 10, 50, and 60. The RAID controller has a 1 GB write-back cache design and uses an energy storage module to save data in flash upon a server power failure. This energy storage module resides in a location in the server that guarantees data protection of the write-back cache for all operating conditions of the server. The power supplies and fans are also redundant and hot swappable, ensuring that a failure to any single component does not affect the running system. With two power supplies, the server offers N+N power redundancy.

The chassis and motherboard are designed to eliminate as many cables as possible; for example, the power supplies mate directly to connectors on the motherboard, eliminating a power distribution cable and a single point of failure. The fans also mount directly to the motherboard, eliminating cables, and hence improving reliability. All disks are front accessible and hot swappable, including the NVMe SFF drives.

Fault Management and Diagnostics

With higher levels of integration among various subsystems in the server, it is becoming more complex to diagnose faults down to the component level. A key element of serviceability that is taken into consideration in Oracle Server X6-2L is automatic fault diagnosis with accurate identification of faulty components. This results in significant reductions in time and effort for debugging problems and waiting on service personnel to replace faulty components.

Oracle Server X6-2L includes built-in fault management and diagnostic tools that increase system availability and enable faster service response times that increase server uptime. Oracle Server X6-2L includes Oracle ILOM, which performs advanced health monitoring of the server operating environment (power and cooling), CPUs, and memory subsystems. This advanced diagnosis engine is resident in the embedded service processor firmware and constantly monitors the state of these subsystems without interfering with the functionality of the host. Automatic notifications are generated in the event of problems. Building on the fault management infrastructure, Oracle ILOM has the ability to raise automatic service requests (ASRs). This feature enables service requests to be generated automatically with important fields prepopulated for use by Oracle service personnel. The elimination of human intervention in the service request generation process improves the accuracy of problem notification to Oracle.

On a typical server, the host operating system and the service processor have mutually exclusive (although sometimes partially overlapping) subsystems that they manage. The host operating system has ownership of the CPU, memory, and I/O subsystems while the service processor presides over the fans, power supplies, DIMMs, and other miscellaneous chassis components. For these reasons, data center managers are often forced to monitor the health of the host operating system and the service processor as if they are separate entities.

Oracle Server X6-2L overcomes the above limitations by enabling a bidirectional communication path between Oracle ILOM and Oracle Solaris or Oracle Linux. This path facilitates the exchange of critical health information between the host and the service processor. Having a dedicated interconnect between the host OS and Oracle ILOM allows a holistic and single view of all problems in a system. Data center managers and administrators can depend on this operating system and hardware integration for complete system diagnosis, eliminating the need to connect to multiple management entities.

Oracle Solaris and Oracle Linux include a set of diagnosis engines that process raw error events from the hardware and provide an automated and intelligent method for problem diagnosis and fault isolation. These engines are part of the overall Fault Management Architecture feature of Oracle Solaris and Oracle Linux and include a set of agents that respond to fault events, such as off-lining a faulty CPU thread or retiring a memory page on a DIMM. These advanced, self-healing features help reduce unplanned downtime by isolating a problem at runtime and keeping applications running.

Running Oracle Linux or Oracle Solaris on Oracle Server X6-2L ensures maximum system availability by providing early warnings of potential failures, fault visibility, and dynamic off-lining of faulty hardware. All of these functions are available at no additional cost.

TABLE 1: BENEFITS OF ORACLE SOLARIS AND ORACLE LINUX ON ORACLE SERVER X6-2L

	Oracle x86 Server with Oracle Solaris or Oracle Linux	Non-Oracle x86 Server with Third-Party OS
Diagnosis of correctable and uncorrectable CPU and memory errors on Intel Xeon processor–based servers	✓	✓
Single view of all hardware problems on the server	✓	✗
Identification of faulty components using the same name that is printed on the chassis or motherboard	✓	✗
Fault indicator (LED) turned on for component and server that has a problem	✓	✗
Automatically generated service request for host diagnosed problems	✓	✗
Validated and quality tested for each new hardware model	✓	✗

Oracle's x86 Servers, Oracle Linux, and Oracle Software—Engineered to Work Together

Oracle invests heavily in engineering and quality assurance for its Linux operating system. While many customers choose Oracle Linux to support their mission-critical applications, Oracle Linux is also the principle development platform for Oracle's own database, middleware, and application software, utilizing more than 175,000 Oracle Linux installations deployed on both physical and virtual servers.

Oracle Linux receives more than 128,000 hours of database and application testing each day, which makes Oracle software more reliable. Even before formal evaluation occurs, Oracle Linux is the base platform on which developers prove functionality, quality, and software viability. In addition, Oracle Linux includes Oracle's Unbreakable Enterprise Kernel, which is specifically optimized for the best performance of Oracle software. Oracle engineers extensively test the Unbreakable Enterprise Kernel across Oracle's database, middleware, and application tiers on Oracle's x86 servers and engineered systems to ensure optimum functionality. This extensive testing ensures that the combination of Oracle Server X6-2L with Oracle Linux provides an extremely reliable, robust, and high-performance server for database and enterprise applications.

As part of Oracle's philosophy of layering security, Oracle Linux is the only Linux distribution today to support Oracle Ksplice. This is a ground-breaking technology that allows data center managers to apply security patches to the operating system kernel without incurring downtime. This aids IT administrators in staying up to date with the latest security-related patch releases.

Single-Pane-of-Glass Management

Oracle Enterprise Manager 12*c* is a suite of systems management tools that provides a single-pane-of-glass management solution for the entire Oracle stack. This enables organizations to manage their Oracle Server X6-2L servers from the hardware layer all the way up to the database and applications running on them.

Oracle Enterprise Manager Ops Center 12*c*, part of the Oracle Enterprise Manager family, is an enterprise management tool that allows IT staff members to manage all aspects of their servers. In addition to providing detailed hardware monitoring and reporting for hardware problems, Oracle Enterprise Manager Ops Center can provision a bare-metal system with an operating system and also configure virtualization.

Oracle Enterprise Manager Cloud Control, a feature of Oracle Enterprise Manager 12*c*, can be used to implement a private cloud on Oracle Server X6-2L. Oracle Enterprise Manager Cloud Control provides a complete cloud lifecycle management solution enabling users to quickly set up, manage, and support enterprise clouds and traditional Oracle IT environments from applications to disk.

Conclusion

Because business success often depends closely on enterprise applications, IT departments strive to provide a secure software and hardware infrastructure—one that delivers responsive performance, scalable capacity, and secure “always-on” availability. Oracle Server X6-2L is designed to simplify field installation, reduce cabling, minimize power consumption, maximize system uptime, and improve storage density, making it an ideal choice for system deployment.

Oracle Server X6-2L is the ideal 2U platform for single-node databases and enterprise storage solutions. Supporting the standard and enterprise editions of Oracle Database, this server delivers best-in-class database reliability in single-node configurations. Optimized for compute, memory, I/O, and storage density simultaneously, Oracle Server X6-2L delivers extreme storage capacity at lower cost when combined with Oracle Solaris and ZFS file system compression.

The key features incorporated in Oracle Server X6-2L—such as the high-bandwidth, low-latency NVMe flash drives; SAS-3 SSDs; and DDR4 memory—significantly improve the performance over the previous generation. Combining these features with built-in, proactive fault detection and advanced diagnostics ensures Oracle Server X6-2L provides extreme reliability for enterprise workloads.

Oracle's x86 systems serve as a key building block for Oracle's engineered systems, such as Oracle Exadata, which have achieved a 10x performance gain through integration and optimization. These optimizations have been incorporated into the design of Oracle Server X6-2L, further improving its performance and reliability—making it an ideal choice for enterprises that value the quality, system availability, and server efficiency that result in reduced total cost of ownership.

More information about Oracle Server X6-2L can be found at http://www.oracle.com/goto/X6-2L or an Oracle representative can be reached at +1.800.ORACLE1.

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Integrated Cloud Applications & Platform Services

Oracle Server X6-2L System Architecture
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