White Paper

SGI® Adaptive Data Warehouse Solution: Building a High-End Oracle Data Warehouse Using Industry-Standard Technologies

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Executive Summary

Making effective use of enterprise data can result in a positive impact on business results. With increasing frequency, key decision makers are taking advantage of data warehouses to gain powerful business insights. As the value of data warehouses rises, IT departments face requirements to create infrastructure to support larger data set sizes and increasingly complex queries.

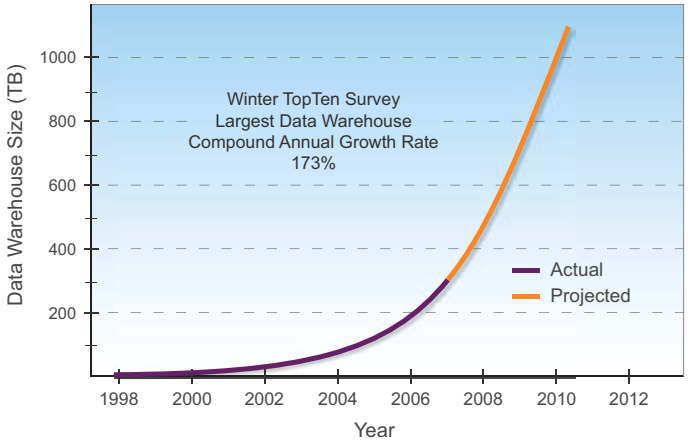
SGI is collaborating with Oracle to address the need for large-scale, powerful data warehouse solutions. Years of experience delivering industry standard-based solutions that scale to support petabytes of data and harness the power of thousands of processors make SGI uniquely capable of building effective infrastructure for large-scale enterprise data warehouses. Through participation in the Oracle Optimized Warehouse Initiative, SGI has created a set of data warehouse configurations based on Oracle best practices. These SGI Adaptive Data Warehouse Solution Families support from 5 TB to 320 TB of data with optimal performance.

SGI Adaptive Data Warehouse Solutions offer organizations exceptional scalability and flexibility. High-performance SGI server and storage products help maximize scalability and simplify incremental expansion. Within the architecture, advanced elements, including InfiniBand, NUMAlink™, and global shared memory technology, work to effectively address scalability challenges. Furthermore, a building block approach to SGI Adaptive Data Warehouse capacity expansion simplifies the process of adapting to new business requirements and helps reduce costs by avoiding or eliminating the need for forklift upgrades.

1.0 Demand for Effective Data Warehousing Solutions

Across the enterprise, activities from product design to inventory tracking and business transactions, continuously generate electronic data. In addition, a wealth of information is also acquired from partners and third-party data providers. Companies are beginning to recognize the strategic advantages that are gained from utilizing data warehouses to correlate, mine, and analyze these records. Providing the right information in a timely manner to key decision makers can lead to worthwhile results, such as improved revenue, greater customer satisfaction, and better business performance management.

With volumes of existing information and many more data points flowing in each day, capitalizing on this valuable resource can provide a challenge. As shown in Figure 1, data warehouse growth is escalating each year. In addition, users are requesting access to more types of data and completing increasingly complex queries in an attempt to gain a better insight into business operations. In the absence of a powerful infrastructure, organizations can begin to experience problems, such as the inability to access or manage needed data, difficulty handling concurrent mixed workloads and larger user communities, poor ad-hoc or concurrent query performance, and failure to complete certain queries that answer important business questions.



Data Source: Winter TopTen Survey, Winter Corporation, Waltham, MA © 2006, 2007

Figure 1. Anticipated data warehouse growth pattern

1.1 Data Warehouse Architectural Challenges

Many organizations are finding the need for large-scale data warehouses that can manipulate massive amounts of data very rapidly. The fundamental challenge for a data warehouse architecture is to achieve balanced and scalable performance throughout the entire data path, from disk drives to processors. A solid data warehouse architecture offers consistent bandwidth throughout and avoids the introduction of potential bottlenecks. When constructing a large-scale data warehouse, common architectural pitfalls include the following:

- High latency or inadequate data paths between nodes in a scale-out architecture
- Insufficient bandwidth between processors and storage devices
- Servers with limited I/O connectivity
- High capacity disk drives mounted in storage devices that lack the bandwidth to provide rapid data transfer
- Use of low cost desktop drive technologies rather than enterprise duty cycle devices

1.2 Scaling Processing and Storage Capacity

Scalable data warehouse performance is achieved by architecting a balanced solution that can be readily expanded across all performance elements in a simple and consistent manner. A scale-out or scale-up approach to processing capacity can be utilized. In order to provide consistent performance and true scalability, solutions that implement a scale-out architecture must mitigate the latency and bandwidth challenges of internode communications. Scale-up architectures must provide components with exceptional physical expansion capabilities and the flexibility to bias a configuration toward I/O capacity without adding unreasonable costs.

Storage architecture requirements for a large-scale data warehouse differ from the needs of many other enterprise applications. Traditional enterprise workloads are often focused on transactional events, involving thousands of users executing various applications and driving hundreds of thousands of very small I/O operations per second (IOPS). In contrast, large-scale data warehouse systems generally utilize a small set of applications with a user community in the hundreds. While large-scale data warehouses drive relatively few I/O operations, each read operation tends to be exceedingly large in size.

In a data warehousing scenario, enterprise storage arrays with advanced features designed for transactional workloads add little value and generally increase the cost of the implementation unnecessarily. An effective data warehouse solution must prioritize data throughput over the number of IOPS. Data warehouses also require scalable storage arrays that offer high-performance drives without sacrificing capacity or reliability.

The performance of modest size data warehouses degrades minimally without proper bandwidth and data expansion capabilities. However, as data volumes and workload complexity increase, issues that were only nuisances can become insurmountable for a large-scale data set size. For example, a poorly balanced small-scale system that degrades query performance from seconds to minutes may have a negligible impact on operations. However, as the data volume grows, the response time can deteriorate further and generate results in hours versus minutes. With the right data warehouse architecture, performance, capacity, and cost can all scale in proportion.

1.3 SGI Providing Solutions for Demanding Workloads

As the demands of data warehouse systems continue to escalate — requiring the processing of larger data sets and more complex queries — solutions must approach performance and scalability levels once exclusive to High Performance Computing environments. With a solid history of helping organizations conquer some of the most demanding computational problems and sizeable data sets, SGI platforms are uniquely suited to bring industry-leading scalability and response times to data warehousing solutions.

Cost-effective SGI solutions can manage larger data sets and move data faster than other leading systems. Combining high-performance Intel® processors, industry-standard Linux® environments, the SGI NUMAlink technology, and massively scalable global shared memory capabilities, SGI® Altix® platforms provide the power, flexibility, and high reliability needed by large-scale data warehouse solutions. SGI® InfiniteStorage systems are scalable, high-performance devices built specifically for data-intensive environments. As a result, solutions that utilize SGI Altix servers and SGI InfiniteStorage systems can scale to support more than 1,000 processor cores and multiple petabytes of data.

2.0 The SGI Adaptive Data Warehouse Solution

SGI Adaptive Data Warehouse solutions combine SGI large-scale platform expertise with Oracle's core competencies as the world's leading database vendor to deliver standards-based systems designed to address even the largest data warehousing challenges. Utilizing SGI Altix platforms, SGI InfiniteStorage, and Oracle technology, the SGI Adaptive Data Warehouse solutions offer dramatic scalability and exceptional processing power. Furthermore, the architecture of SGI Adaptive Data Warehouse solutions supports flexible and affordable growth paths to help organizations readily adapt to changing business demands.

2.1 Solution Families

In order to accommodate various initial capacity requirements and future growth projections, SGI offers three families of data warehouse architectures. These families offer complete flexibility to construct a solution to best match application requirements. In addition, specific reference configurations offered within each family can help organizations get started quickly. Midrange, Large, and Ultra Large SGI Adaptive Data Warehouse solutions support storage capacities from 5 TB to over 320 TB (Figure 2).

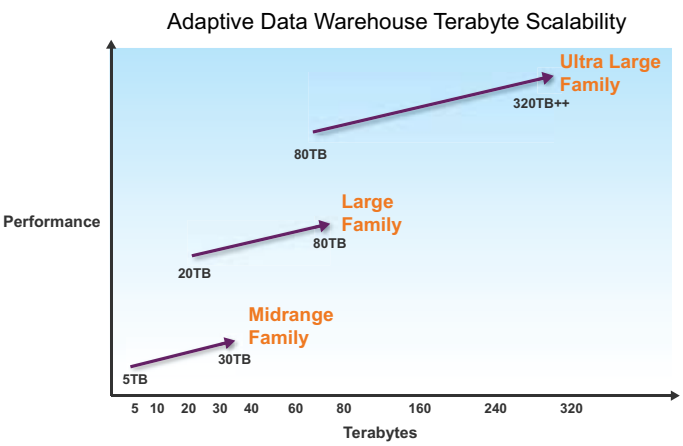


Figure 2. SGI Adaptive Data Warehouse Families

- The Midrange Family utilizes SGI® Altix® XE250 servers, SGI® InfiniteStorage 220 systems, and an InfiniBand node interconnect switch to support scalability up to 30 TB of user data. The affordable Midrange SGI Adaptive Data Warehouse Family is suitable for environments with moderate initial capacity requirements and modest growth plans.
- The Large Family incorporates SGI® Altix® 450 servers and SGI InfiniteStorage 220 systems to scale to support as much as 80 TB of user data. With the Large SGI Adaptive Data Warehouse Family, architects can create powerful solutions that offer substantial expansion capabilities.
- The Ultra Large Family scales to 320 TB and beyond, and is based on SGI® Altix® 4700 servers and SGI® InfiniteStorage 4600 systems. The Ultra Large SGI Adaptive Data Warehouse Family supports massive processing and data storage requirements. Solutions based on the Ultra Large Family can expand to meet the needs of the world's most sizeable data warehousing projects.

Workload characteristics and the size of the data repository often change during the lifecycle of a data warehouse solution. These extremely adaptable solutions from SGI utilize a building block approach to simplify the process of meeting new enterprise demands. SGI Adaptive Data Warehouse building blocks consist of servers, storage systems, and interconnect components, and define the scaling increment for each family — 10 TB (Midrange Family), 20 TB (Large Family), and 80 TB (Ultra Large Family). Solutions within each family are easily customized, and transitioning from one product family to another is as simple as upgrading servers and expanding the existing storage infrastructure.

2.2 Oracle Optimized Warehouse Initiative

Oracle created the Oracle Optimized Warehouse Initiative (OWI) to help ensure that Oracle customers can easily obtain balanced Oracle configurations that deliver the best possible performance, and are simple to deploy and easy to upgrade. Within the OWI program, SGI collaborates with Oracle to create reference configurations and validate the performance capabilities of SGI Adaptive Data Warehouse solutions. Reference configurations within each SGI solution family are based on Oracle best practices and offer exceptional, scalable performance.

To simplify deployment and future expansion of reference configurations, the OWI program emphasizes the building block approach to system scaling — as adopted by SGI Adaptive Data Warehouse solutions.Taking advantage of this modularity, performance scales as storage capacity expands. In fact, SGI offers some of the most scalable and highest performing reference configurations available today.

2.3 Industry Standards-Based Solutions

The use of proprietary technology in computing platforms often increases costs and limits the longevity, flexibility, and usefulness of a solution. SGI Adaptive Data Warehouse solutions are built on SGI Altix servers incorporating the latest Intel® processors and other components to deliver uncompromised performance at low cost. Running the Linux operating system, the solution further enhances flexibility and leverages existing enterprise UNIX® and Linux expertise. Extensive use of industry standards throughout SGI Adaptive Data Warehouse solutions helps organizations protect technology investments, reduce costs, and simplify solution integration.

2.4 Redundancy for Availability

As an important tool in making business-critical decisions, many organizations require around the clock access to enterprise data warehouses. The major elements and architecture of SGI Adaptive Data Warehouse solutions work together to help maximize system availability. Built with reliable components, SGI Altix servers and SGI InfiniteStorage systems help create a solid foundation. To minimize single points of failure, the Midrange, Large, and Ultra Large SGI Adaptive Data Warehouse Families leverage Oracle Real Application Cluster technology to spread workloads over a cluster of server nodes. Oracle Real Application Cluster technology also helps minimize downtime due to maintenance activities by supporting the addition and removal of each cluster node without impacting continuous application processing.

3.0 SGI Adaptive Data Warehouse Architectures

SGI Adaptive Data Warehouse solutions are uniquely capable of handling the most demanding data warehouse projects. Architectural elements such as InfiniBand, NUMAlink technology, and global shared memory work to maximize bandwidth, improving performance for ad-hoc and complex queries. In fact, internal testing shows that an SGI solution can deliver up to five times better query response time than similarly configured solutions from other vendors.

As business needs grow and change, SGI Adaptive Data Warehouse solutions are architected to easily and affordably transform to support new workloads, demands, and application characteristics. The scalability of SGI Adaptive Data Warehouse solutions offer enterprises the ability to establish an initial configuration that meets current needs, and expand the architecture to support hundreds of terabytes of data. Furthermore, these architectures facilitate the independent scaling of processor, memory, and I/O capacity, helping to reduce the cost of incremental upgrades.

3.1 Midrange SGI Adaptive Data Warehouse Family

Configurations within the Midrange SGI Adaptive Data Warehouse Family are built to maximize scalability and minimize cost. SGI Altix XE250 servers with cost-effective Intel® Xeon® processors are connected by InfiniBand technology in a scale-out architecture. For data storage, the Midrange SGI Adaptive Data Warehouse Family utilizes low cost SGI InfiniteStorage 220 arrays equipped with high-performance 15K RPM enterprise duty cycle Serial Attached SCSI (SAS) drives. In addition, the solution employs a large number of controllers to effect high bandwidth. As a result, the Midrange SGI Adaptive Data Warehouse Family achieves extremely high performance at a modest cost. An initial configuration is depicted in Figure 3.

Utilizing the building block approach, a Midrange SGI Adaptive Data Warehouse scales to six times the initial configuration. A building block for the 10 TB Midrange SGI Adaptive Data Warehouse Family includes the following components:

- Six SGI Altix XE250 servers
- Ten SGI InfiniteStorage 220 arrays
- 440 x 146 GB 15K SAS disk drives
- Four Fibre Channel switches
- Two InfiniBand switches
- Two Gigabit Ethernet switches

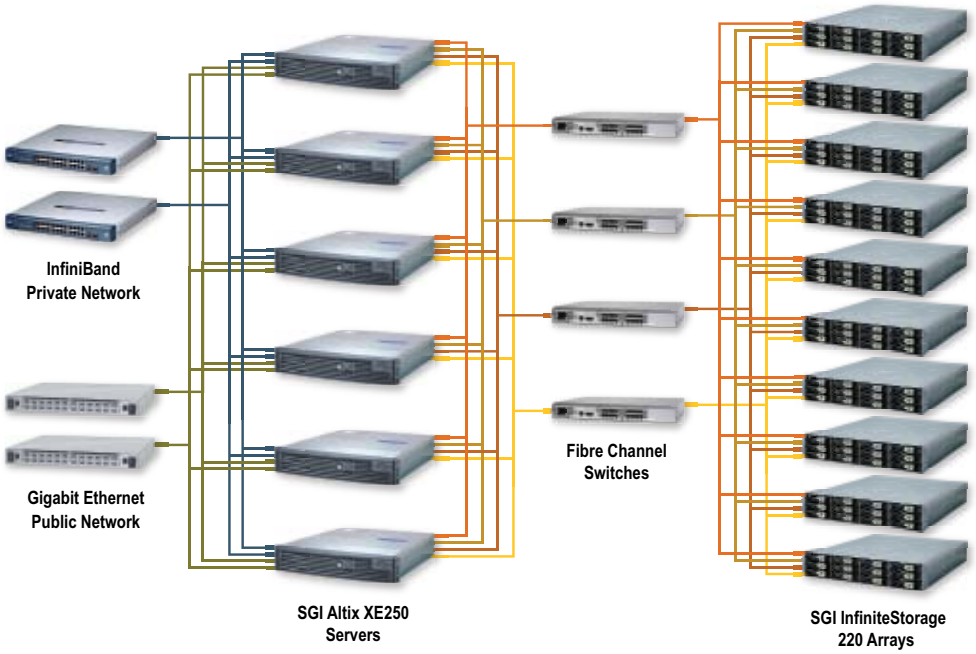


Figure 3. Midrange SGI Adaptive Data Warehouse Solution Architecture

InfiniBand Technology

The Midrange SGI Adaptive Data Warehouse Family addresses the latency and bandwidth limitations present in other scale-out solutions by leveraging InfiniBand technology. Each InfiniBand interconnect provides up to 2.5 GB per second data transfer or 30 to 50 percent better performance than Gigabit Ethernet with the Reliable Datagram Sockets (RDS) protocol[1]. In fact, the 10 TB Midrange SGI Adaptive Data Warehouse reference configuration can achieve up to 50 percent higher bandwidth than the IBM p570 Oracle OWI configuration of equivalent capacity[2]. By maximizing bandwidth between nodes, the Midrange SGI Adaptive Data Warehouse Family offers improved performance on queries that scan large tables.

3.2 Large SGI Adaptive Data Warehouse Family

The Large SGI Adaptive Data Warehouse solution offers support for substantial processing power and data capacity expansion. Within this family, SGI Altix 450 servers with purpose-built CPU, memory, and I/O blades combine in a shared memory architecture to create a powerful solution without the high cost of most large-scale servers. For data storage up to 100 TB, the Large SGI Adaptive Data Warehouse Family takes advantage of low cost SGI InfiniteStorage 220 arrays. For configurations larger than 100 TB, the architecture employs high-performance, scalable SGI InfiniteStorage 4600 arrays that can support substantial throughput and capacity requirements.

Building blocks for the Large SGI Adaptive Data Warehouse Family help scale the solution as much as four times the capacity of the original configuration. The initial configuration and each subsequent building block of the 30 TB Large SGI Adaptive Data Warehouse Family includes the following components (Figure 4):

- Four Altix 450 servers
- 27 SGI InfiniteStorage 220 arrays
- 1296 x 146 GB 15K SAS disk drives
- Four Fibre Channel switches
- Two Gigabit Ethernet switches
- Two 10 Gigabit Ethernet switches

3.3 Ultra Large SGI Adaptive Data Warehouse Family

Featuring starting configurations that exceed the maximum capacity of many other solutions, the Ultra Large SGI Adaptive Data Warehouse Family is an ideal choice for organizations with growing data repositories. To support massive data expansion, the Ultra Large Family storage architecture utilizes SGI InfiniteStorage 4600 arrays with exceptionally high controller bandwidth to drive very large numbers of high-performance 15K RPM Fibre Channel drives.

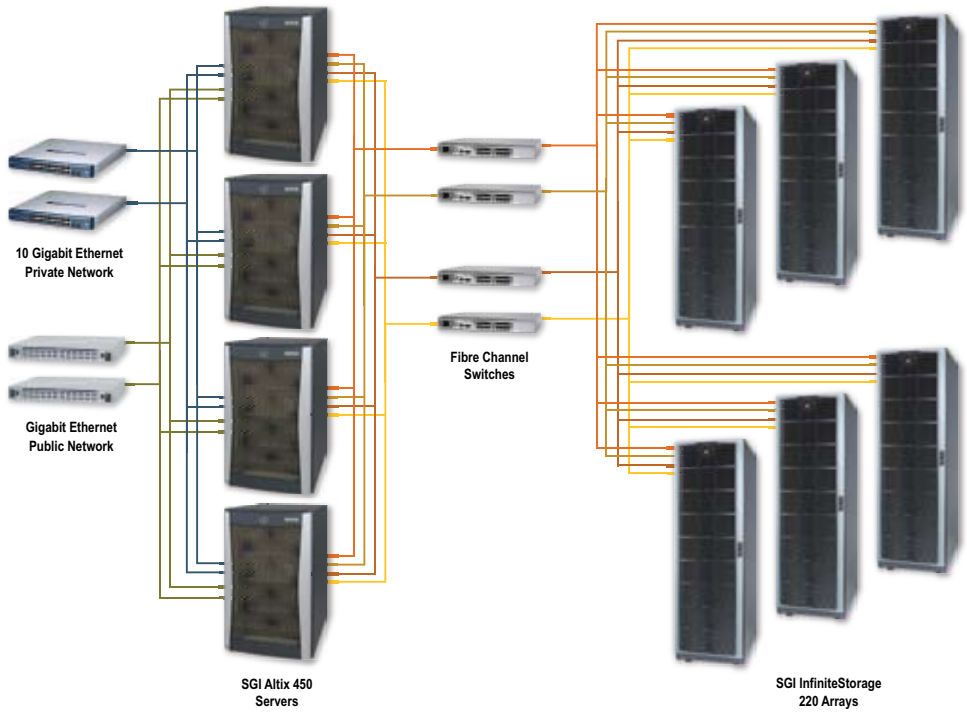


Figure 4. Large SGI Adaptive Data Warehouse Solution Architecture

1. For more information, please see http://www.pr-inside.com/voltaire-infiniband-accelerates-oracle-r-r296154.htm

2. Based on SGI measured I/O rates of 4 GB/s using Orion benchmark as compared to 2.66 GB/s for IBM: http://www.oracle.com/solutions/business_intelligence/docs/oowforibm-datasheet.pdf

SGI Altix 4700 servers in an advanced shared memory architecture help this solution move beyond the limits of server clusters and large-scale symmetric multiprocessing (SMP) approaches to scalability. In fact, the Ultra Large SGI Adaptive Data Warehouse Family can scale to support as many as 1,024 processor cores and 24 TB of global shared memory in a single Linux system image.

As depicted in Figure 5, an initial configuration and building block for the 80 TB Ultra Large SGI Adaptive Data Warehouse Family includes the following components:

- Two Altix 4700 servers
- Seven SGI InfiniteStorage 4600 arrays
- 1,682 x 300 GB 15K Fibre Channel disk drives
- Four Fibre Channel switches
- Two Gigabit Ethernet switches
- Two 10 Gigabit Ethernet switches

3.4 Key Architectural Features

The simple integration of large numbers of processors and disk arrays does not always lead to true scalability. Large and Ultra Large SGI Adaptive Data Warehouse solutions utilize advanced technology to build an effective and flexible solution. Global Shared Memory and NUMAlink technology play a significant role in the scalability and adaptability of the Large and Ultra Large SGI Adaptive Data Warehouse configurations.

Global Shared Memory

Speeding data transfer between nodes is key to improving the performance and scalability of a large-scale data warehouse solution. By utilizing global shared memory, all system processors within the Large and Ultra Large SGI Adaptive Data Warehouse solutions can directly access memory, regardless of memory location. Processor issued load instructions can read any address in the entire global shared memory space of local and remote nodes. In fact, the system interconnect within the Large and Ultra Large SGI Adaptive Data Warehouse solutions is capable of efficiently distributing the processor address space across hundreds or even thousands of nodes.

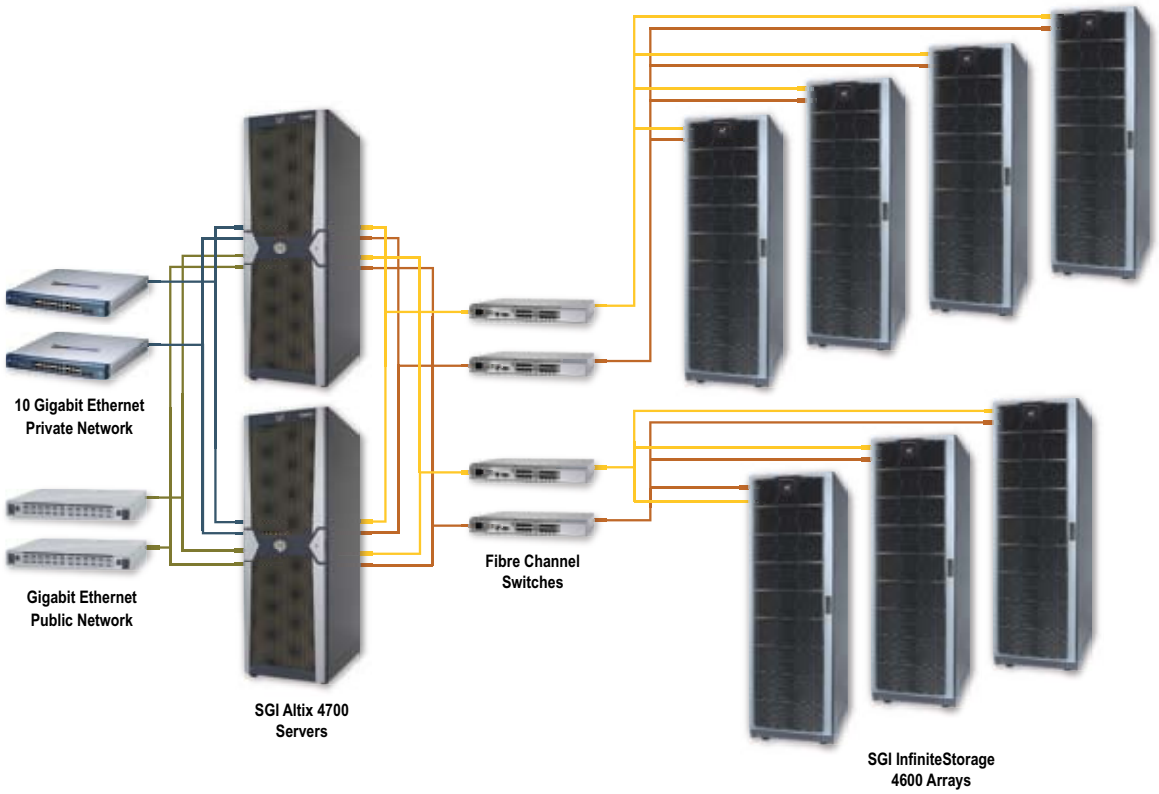


Figure 5. Ultra Large SGI Adaptive Data Warehouse Architecture

NUMAlink Technology

Most SMP architectures provide a fixed number of I/O slots and require the purchase of expensive system boards for simple incremental upgrades. The SGI NUMAlink architecture helps to ensure that cost and performance scale proportionately. By taking advantage of NUMAlink technology, SGI Altix server configurations are extremely flexible — processors, memory, and I/O can scale independently. The addition of each I/O blade contributes 3.2 GB per second of bandwidth, actually scaling performance as blades are added. With this advanced level of flexibility, SGI Adaptive Data Warehouse solutions can be built to prioritize I/O bandwidth and capacity.

4.0 High-Performance, Scalable SGI Altix Platforms and SGI InfiniteStorage Systems

Designed with large memory subsystems and fast I/O and memory access channels, SGI platforms let applications load more data in main memory, complete transactions faster, and scale to greater capacity levels. In addition, reliable SGI InfiniteStorage systems support the large-scale capacity demands of modern data warehousing deployments at economical prices.

4.1 SGI Altix Servers

Solutions that utilize SGI Altix servers can provide exceptional performance and throughput, and offer substantial headroom for future application growth. The SGI Altix XE250 server is a powerful, compact system that is ideal for scale-out architectures and incremental expansion strategies. Leveraging the strength and versatility of dual- and quad-core Intel® Xeon® processors, SGI Altix XE250 servers provide organizations with a fast, reliable platform at an exceptional price point. The innovative board design of SGI Altix XE250 servers maximizes compute density, helping to reduce datacenter floor space and energy expenses.

SGI Altix 4700 and 450 servers combine the power of Intel® Itanium® processors with the unique SGI NUMAflex architecture. With NUMAflex, enterprises can cost-effectively mix and match a variety of compact blades — including interchangeable compute, memory, I/O, and special purpose blades — to create a data warehousing solution that best matches application requirements.

In order to speed throughput, the architecture of SGI Altix 4700 and 450 servers support 8.6 GB per second bandwidth per processor socket and 3.2 GB per second bandwidth per I/O blade. In addition, SGI NUMAflex® global shared memory pushes SGI Altix servers past the scalability limitations of other environments with support for up to 24 TB of global shared memory. This large-scale memory architecture can accelerate performance by increasing the potential for executing database transactions entirely in memory.

4.2 SGI InfiniteStorage RAID Products

Storage solutions play a critical role in the scalability and performance of a data warehouse solution. SGI offers a wide range of storage systems, from advanced storage area network solutions to fully-integrated storage appliances. Versatile SGI InfiniteStorage systems deliver scalable capacity and connectivity while reducing the complexity of Storage Area Network (SAN) management.

With the ability to support as much as 168 TB of storage in a single cabinet, SGI InfiniteStorage systems help enterprises efficiently respond to the rapidly growing volumes of enterprise data. In addition, the business continuance features of SGI InfiniteStorage systems support organizational efforts to keep data warehousing systems accessible during operational maintenance and even unanticipated system faults.

The SGI InfiniteStorage 4600 array provides exceptional performance, scalability, and availability features. With economical expansion to more than 100 TB, SGI InfiniteStorage 4600 systems easily accommodate growing capacity requirements. Ideal for both transaction-oriented and bandwidth-intensive environments, the system delivers uncompromising performance. Each Fibre Channel host provides up to 4 gigabits per second bandwidth and up to 16 host ports per array. To help ensure that critical data remains accessible, SGI InfiniteStorage 4600 systems are built with highly reliable components and include features such as fully redundant I/O paths, automated failover functionality, hot-swappable components, and online administration capabilities.

The SGI InfiniteStorage 220 system offers enterprises cost-effective configurations for low initial capacity requirements and easily expands to support up to 24 TB of total storage. By incorporating an appliance-like design, the SGI InfiniteStorage 220 system simplifies initial deployment and on-going management, and helps organizations to reduce administration burden and improve operational efficiencies. An intuitive GUI helps administrators automate and streamline configuration tasks, such as capacity scaling and RAID group expansion.

5.0 SGI Professional Services

The right expertise can streamline the process of deploying new enterprise solutions and help organizations to avoid common pitfalls. SGI Professional Services engagements deliver a wealth of knowledge and expertise to business intelligence and data warehousing projects. During SGI Professional Services engagements, seasoned experts work to optimize the customization of the reference architecture, ease deployment of

the solution, and speed project completion. The following optional services can prove valuable to enterprises in the process of building effective data warehousing solutions.

SGI Adaptive Data Warehouse Architectural Assessment

Thorough and proper evaluation of project requirements is essential to achieving success. During an architectural assessment, SGI Professional Services experts utilize proven processes to assess project requirements and gather information about specific needs and challenges. At the end of the discovery process, SGI professionals deliver a system configuration and solution architecture recommendation.

SGI Adaptive Data Warehouse Proof of Concept Service

SGI can develop an Adaptive Data Warehouse Proof of Concept environment to demonstrate applicable performance and functionality. The results of this POC include a report which provides agreed upon deliverables. Please contact your SGI sales representative or SGI Channel Partner for further information.

SGI Adaptive Data Warehouse Installation Service

During the SGI Adaptive Data Warehouse Installation Service, SGI Professional Services engineers create an installation plan and work jointly with organizations to finalize a success criteria checklist. Installation and configuration of the solution is performed by SGI staff at SGI facilities, and pre-configured equipment is shipped to the customer location. SGI staff subsequently deploy the solution within the customer network and finalize solution documents. SGI Professional Services teams work hard to help ensure that solutions are well understood by key players in the enterprise. Toward this effort, SGI experts create a deployment guide for use by database administrators to help facilitate future maintenance of the solution. At the end of the project, the SGI Professional Services team provides a technical architecture document that reflects the details of the actual implementation.

SGI Customer Education Programs

Taking advantage of SGI customer education programs can help organizations maximize investments in SGI Adaptive Data Warehouse solutions. SGI offers a broad range of courses that provide system, database, and network administrators, technicians, and software developers valuable knowledge and experience. Courses are offered for every level of expertise and include introductory and in-depth courses on deployment, management, and administration of SGI Altix systems, SGI InfiniteStorage arrays, Storage Area Networks, the Linux operating environment, and Oracle Real Application Cluster technology.

6.0 Summary

SGI products and expertise can help organizations effectively tackle and meet the stringent demands of large-scale data warehousing solutions. Highly reliable, flexible servers and storage systems from SGI provide power and availability to the solution. Proven SGI Adaptive Data Warehouse configurations and SGI Professional Services offerings help enterprises deploy effective data warehousing solutions on-time and within budget. By taking advantage of the scalability of SGI Adaptive Data Warehouse solutions, enterprises can analyze more data in less time and make better business decisions faster.

6.1 For More Information

For additional information on SGI Adaptive Data Warehouse Solutions, please contact your local SGI representative or consult the Web references listed in Table 1.

Table 1. Web references

Web URL	Description
http://sgi.com/industries/enterprise	SGI Enterprise Solutions
http://sgi.com/products/servers/altix	SGI Altix Family
http://sgi.com/products/storage	SGI InfiniteStorage Family
http://sgi.com/products/services	SGI Services
http://intel.com/products/server/processors/	Intel Server Processors
http://oracle.com/ solutions/business_intelligence/optimized-warehouse-initiative.html	Oracle Optimized Warehouse Initiative

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