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Sun Oracle Database Machine

Extreme Performance for Data Warehousing

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Executive Overview

Data warehouses are managing more and more information while business users expect consistently fast query response times. But, getting the right balance of servers, storage, networking and intelligent software to meet these critical business needs can be a challenge.

Meeting these growing demands for more information in a timely manner requires an alternative approach ... an approach that accelerates deployments without compromising scalability, reliability, and security. Many appliances in use today are 'one trick ponies'; orphans of the data center with proprietary software and hardware that require separate, costly skills to properly manage.

But yesterday's appliance hype is already evolving into a trend towards pre-configured solutions that offer a greater portfolio of business functionality, based on industry standard hardware and intelligent, robust software. This trend will also be reflected in the data center; appliance-like solutions will fit right in alongside existing IT infrastructures, able to utilize existing resources and skill sets.

This solution is already available from Oracle. The Sun Oracle Database Machine delivers extreme performance for large-scale data warehouse workloads, for operational data warehousing workloads and for On-Line Transaction Processing (OLTP) workloads, all on a pre-configured system, based on the market leading Oracle database and industry standard server, storage and networking components from Sun. Database Machine is a fast, reliable, secure solution that can easily scale to meet the all of the requirements of the most demanding organizations.

Introduction

The paper introduces you to a new Oracle product family, the Oracle Exadata family, and explains in detail how these products will address the scalability issues related to ever growing data volumes.

One member of the Exadata family, the Sun Oracle Database Machine, is a high bandwidth pre-configured hardware and software solution delivering extreme scalability for data warehousing. The other member of the family, the Sun Oracle Exadata Storage Server is used in the Database Machine as the smart storage solution designed to handle database storage. When used to augment a current system, these smart storage servers vastly speed up the current query performance.

By introducing the Sun Oracle Database Machine and the Sun Oracle Exadata Storage Server, Oracle has brought an industry leading data warehouse solution and Oracle's commitment to customers, to a problem domain that was formerly catered to by small niche vendors.

Exploding Data Volumes

Perhaps the most significant trend in data warehousing over the past few years has been the spectacular growth in data volumes. Whether you are a school district, a financial institution or a manufacturing organization, you are storing more and more data. Independent studies, like the Winter Survey¹ - conducted by a well-known independent consultancy in the world of large-scale data warehousing – confirm this trend.

There are many reasons for these explosive data growth rates. While this paper is not focusing on these reasons, it is important to understand them. More and more parts of an organization are on-line today. Enterprise Resource Planning (ERP), Customer Resource Management (CRM) and other on-line optimizations produce more and more data that is very relevant to an organization.

On top of that, new regulatory requirements introduce stricter rules around data retention, typically requiring more data to be kept on-line for longer periods of time. Compliance with various regulatory demands increases the data stored and therefore increases the need to procure more on-line storage capabilities.

Rather than just seeing these two trends as a cost center, the most advanced organizations in the world try to turn these resulting large data sets into a competitive advantage. Data Warehouses are traditionally the place where this competitive advantage comes from. Instead of storing the data in OLTP archives, a data warehouse allows analysis of these vast amounts of data by business users.

Unfortunately, for many organizations, the current hardware and storage solutions do not allow them to get all the benefits from their data. While they want to analyze a lot of data and ask many questions on a myriad of topics, bottlenecks in their hardware typically will not allow them to ask all they want.

Analyzing Large Data Volumes

To look at bit closer at the impact of data volumes upon what information you can ask for we go back to basics. A business question gets translated into a SQL query that is run on a database. In a simplified world, to deliver the answer to that SQL statement the database software goes to the

¹ Winter TopTen Survey, Winter Corporation, Waltham MA, 2008

storage software and reads data from disk. Once the data is read the database processes the raw data and generates an answer.

This whole process is not necessarily on the analyst's mind, but the speed of reading from disk, moving the data to the database processors and then calculating the result determines the amount of time it takes to answer a question.

To make this a little bit more tangible we will use an example – simplified – to show what could happen. If the system has an example quantity of 50TB of data, and a complex query needs to go through roughly 20% of that data, a traditional disk based block-storage solution will be able to service up this data in about an hour. That means an analyst can only ask a paltry 8 questions a day!

Why is this important? First of all, learning the answer to a business question typically triggers additional questions (Why were my sales down last quarter? What specific products contributed to this sales decline? Should we run promotions for these products?), and to be even remotely productive and focused you do not want to wait an hour for a result. Secondly, some questions require instant answers. If a store is running out of stock on ice cream on a hot day, you need to start restocking right away, not only after an hour.

Now imagine you could sift through the same 20% of data in a fraction of the time. Lets say the system can do it in 30 seconds or less. That translates into more than a hundred questions an hour. At this speed all data is truly available to add value in any business process in the organization.

This additional value is however dependent on the hardware infrastructure your organization has in place.

The Importance of Infrastructure

So, does your system and infrastructure support this desire to use all your data? Can your systems support hundreds of questions from hundreds of people at the same time? To answer that question, look at the following criteria and then weigh your infrastructure against these criteria.

Scalability – Can your infrastructure not just store the required data, but also *scale* out to service the business with information at the required *performance*, both today and next year? Can you scale out in terms of users and can your infrastructure handle the needs for these users even if they are working *concurrently* on these systems?

Agility – Can your system deal with changing requirements, with *mixed workloads* that include loading data while querying, and returning the right answers? Can you easily switch to *real-time data loading* for some of your data and support operational needs in your business?

Enterprise Readiness – Does your infrastructure provide the functionality to always keep your business running? Is the infrastructure delivering the *security* you need, in terms of who can see what data, but also in terms of disaster recovery, and preventing fraudulent manipulation of data?

Is your system running when you need it, and does the infrastructure deliver *maximum availability* to run your business 24*7?

If you look critically at your systems and they are constraining rather than enabling your business, you must take action.

Software and Hardware Requirements

When looking at the scalability, agility and readiness criteria more closely, it is clear that these criteria are implying both software and hardware functionality.

Can you secure your data at data point level, even from your DBA? Can you run mixed workloads or real-time updates on the database system without corrupting data or without interfering with daily business activities? These questions can all be distilled down to whether or not your software is smart enough to handle your business' needs.

Questions like “Does my storage solution allow me to actually store all my data and then allow me to read it fast enough for the database to process?” or “Can I move data fast enough over my Storage Area Network to allow end users to ask many questions an hour?” relate directly to your hardware. Is your hardware brawny enough to handle the required data volumes?

As with our three infrastructure criteria, smart – or brainy – software and brawny hardware should not be separated in diagnosing infrastructure constraints. For example, the storage system should be able to read data back fast, but not at the expense of the security of payroll or other sensitive data.

If you see bottlenecks in your current system, make sure to place requirements on both the software and hardware. Neither one of them by themselves can solve all bottlenecks.

Common Bottlenecks

Bottlenecks exist in both software and hardware. Simply stated, either your software is not brainy enough, or – an unfortunately more typical case in Oracle implementations – the hardware is not brawny enough.

Oracle, as the market-leading database for both OLTP and Data Warehouse applications, delivers all the smarts you need and then some. Be sure to use these smarts in your systems: ensure data security with Virtual Private Databases, achieve scalability with Real Application Clusters, Partitioning and Compression, and leverage the expertise of your database administrators by standardizing on Oracle for any type of application.

Balanced Systems

A system is balanced when the storage sub-system is capable of reading, writing and moving – through the entire storage fabric – enough data to the database servers to have the CPUs

adequately loaded. In other words, neither the IO capacity across the network, nor the bandwidth within the storage subsystem, or the CPUs should be a constraint to the system.

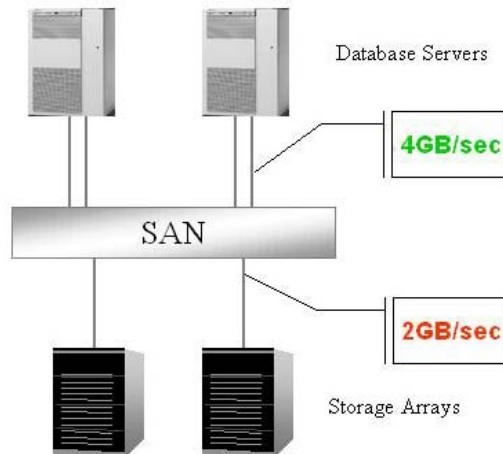


Figure 1. Balance between database and storage bandwidth?

Consider the simplified example as shown in Figure 1. The storage subsystem can deliver a maximum a throughput of 2GB/sec, where as the upper half of the system can consume or deliver 4GB/sec of data throughput. If we now assume that the database servers have sufficient CPU capacity and other resources to handle the 4GB input, they will run at maximum half their capacity. Hence the system is capped at a maximum throughput of 2GB/sec.

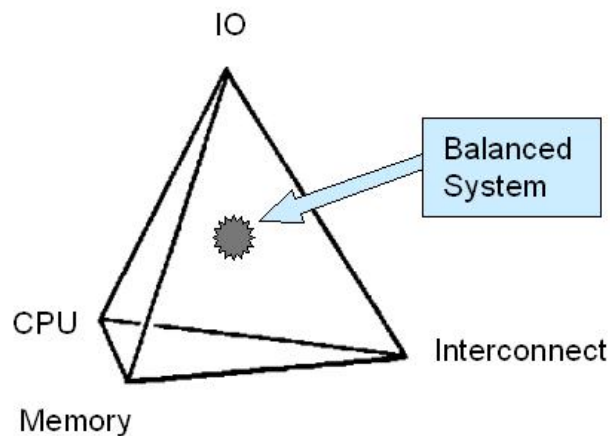


Figure 2. A balanced system

When balancing a system it is crucial to balance between I/O capacity, CPU capacity, the memory available and interconnect capacity. This balance is show in Figure 2.

Balancing the system in Figure 1 will allow the storage arrays to deliver the full 4GB to the compute side and utilize the available CPU capabilities. When all components are balanced, the system doubles its overall performance.

The Data Warehouse Appliance

Vendors large and small have been looking at the data warehouse market as a growth opportunity. The importance of the data warehouse, the growth of the user communities and the growth of data volumes all make data warehousing an important focus area.

Yesterday's hype in data warehousing is the data warehouse appliance. Many small vendors have created a solution to supposedly solve the problems introduced by the increased data volumes.

A Partial Solution to the Problem

Most, if not all, of these new, small vendors are using proprietary hardware platforms using massive hardware to deal with the data growth. The way to market an appliance is by benchmarking a single query as proof of their superiority over the current data warehouse system. Often claims of 100 times faster are then produced, which sounds impressive to the casual listener. However it is not actually that useful to run such a "benchmark".

First of all, this style of benchmarks is not comparing apples to apples. Often a system running on old hardware (three generations out of date for example) is compared with the latest and greatest hardware. The gains touted are purely a matter of running newer hardware with faster CPUs and faster disks. The actual system in place would run much faster if upgraded to that same hardware.

Second, the response times on the incumbent system are almost always measured with full user and query loads, while the appliance benchmark is run with an artificially small load – typically consisting of a single query. Again, the comparison is not an actual real-world benchmark but a comparison stacked in favor of the original system.

Third, most of the current appliances are really one-trick ponies. The trick is to use massive hardware resources to solve a problem with brute force. Long-running data warehouse queries will benefit from this approach, hence the benchmark results. The real problems come into play when the appliance has to ensure that the data is secure, or when a mixed workload has to be run. Now, all of a sudden the appliance starts to run into problems. Because most data warehouse appliances do not handle concurrent reads and writes well an application may be reading incomplete data. The reading of incomplete data delivers incorrect results to the end user. Another problem is user concurrency. As more and more users come on-line, contention for resources starts to become an issue, quickly reducing the real-world performance of the appliances to a level close to the existing system's performance.

What is needed for these workloads is a full solution consisting of smart database software on top of massively scalable hardware. The solution is not just a lot of hardware.

Ease of Deployment

Another angle often claimed as an advantage for an appliance is the ease of deployment. As a customer you purchase a completely configured hardware and software solution, you wheel it into the data center and you start working on it. While this is probably true for most of the appliances to some extent and while this sounds very appealing, what comes next is not so pretty.

Your system administrators and the DBAs will have to deal with very different hardware, different database software and maybe even a different operating system than the ones they use for all your other systems. This means non-standard procedures, specialist resources and a lot of training for the data center staff.

All of a sudden the appliance concept creates an isolated silo of technology and knowledge, rather than a solution that fits within the current data center standards, processes and existing knowledge.

Prohibitive Cost of Upgrading

While it may be easy to deploy an appliance in your data center initially, once it is time to upgrade – due to that ever present data growth – you may get stuck with a painfully large invoice. Why? Most appliances do not come with perpetual licenses, yet most require a forklift upgrade – they cannot be expanded incrementally – so an appliance that has reached its maximum storage capacity must be replaced by a whole new machine. This means that you will need to buy new software licenses for the new machine. So you do not just end up buying new hardware, you also re-purchase the software you already and paid for.

How Viable is The Company

Data warehouse appliance vendors have been popping up like mushrooms. A lot of these vendors are very small with few real customers. Research and Development, support capabilities and overall viability are in a different league from market leaders like Oracle. In today's economy, having invested a multi-million dollar sum in one of these orphans of the data center runs the serious risk of seeing your critical system running on un-supported hardware and software.

Addressing data Growth with Oracle

Oracle Database is probably the smartest database software on the market today, covering requirements from OLTP systems, the largest data warehouses in the world and anything in between.

With a well-balanced and up-to-date hardware architecture in place, Oracle scales to incredible volumes of data. Customers, TPC benchmarks and the Richard Winter Survey prove this time and time again. With 30 years of continuous R&D, Oracle is the clear database and data warehouse market leader today.

Oracle does realize that these never-before-seen data volumes do start to place a strain on the hardware. These very big systems should not become more complex, rather Oracle would like to see them become simple to deploy. In fact, it should be as simple as the smallest systems today.

To be able to do that, and make any system simple to implement on site, the typical appliance model has some distinct advantages over a fully customizable setup. Most notably, the hardware is exactly dictated to achieve a pre-calibrated performance level. On top of that, a single hardware solution shipped with the software allows a lot of the complexity to be taken out of the customer's hands, reducing the implementation risk.

Sun Oracle Database Machine

The Sun Oracle Database Machine is that pre-configured hardware and software solution specifically created for extreme performance database solutions. It comes with the Oracle brains, but also with smart storage from Oracle, the Sun Oracle Exadata Storage Servers. All of this is fully configured using industry standard hardware components and pre-installed on Oracle Enterprise Linux. The system comes pre-wired in a rack for easy deployment in the data center. For linear scalability simply hook multiple racks together.

Leadership Through Innovation – Sun Oracle Exadata Storage Server

Apart from the Oracle database, which is installed on the database servers in the rack, the secret to the extreme performance of the Database Machine comes from the smart storage servers. These Exadata Storage Servers are specifically designed to handle data requests from an Oracle database.

When your SQL question is delivered to Oracle, the database is smart enough to off-load some of the processing to the storage server. Instead of pumping back terabytes of data, which are then processed by the database, Exadata Storage Servers only return the required rows and columns – not entire data blocks – to answer the question. By using these Exadata Smart Scans, the system dramatically reduces the data volumes moving around the system. The reduced data flow in turn reduces the overall time required for running the query and providing you with the

right answer. Several other new features are delivered with Exadata Storage Server software. Exadata Hybrid Columnar Compression delivers 10x compression rates in Query Mode or up to 50x compression rates in Archive Mode. These compression rates allow for large volumes of data to be scanned very efficiently. To ensure only the right data is scanned Exadata Storage Indexes provide a fast way of eliminating rows from the scan processes. A Storage Index works like a negative index, indicating to the Storage Server software, which rows do not fall within the query predicate range. By eliminating these rows, the number of rows to be scanned is further eliminated. These features together create a very compelling storage solution.

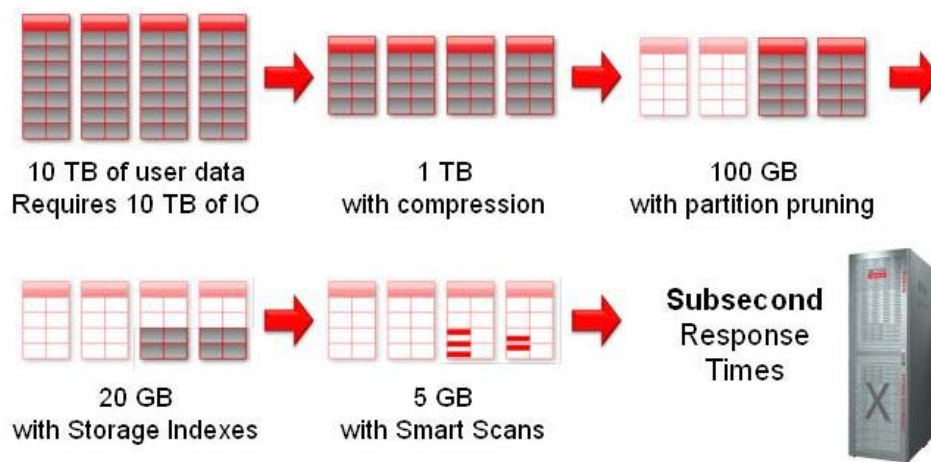


Figure 3. Creating sub-second response times with Exadata

Exadata smart scans, Hybrid Columnar Compression and Storage Indexes are extremely important aspects of the performance puzzle, but with a low-bandwidth connection to the database, a lot of these gains are lost again. To prevent that problem, Oracle delivers InfiniBand connectivity between the Exadata Storage Servers and the database servers. InfiniBand is a relatively new technology that provides a much higher bandwidth than the more traditional Ethernet. On top of that Oracle added more connections than traditionally are added between the storage and database servers.

In short, Exadata Storage Servers waste no time reading and moving unnecessary data, and they move the required data through bigger and more pipes. That is how you achieve extreme performance.

Easy to Deploy

Would you not like to buy your data warehouse based on speed and capacity? I require speed X and capacity Y therefore I need model ABC. That is exactly what the Database Machine brings to the table.

It is a pre-configured system with Oracle Database 11g Release 2 on it, the appropriate number of Exadata Storage Servers and the correct InfiniBand switches to deliver a given throughput with a given amount of user data. And if this one rack is not enough, simply plug a second one or third one right next to it into the wall and connect them together.

Once the Database Machine is switched on, you have the full breadth of Oracle innovation at your fingertips. Partitioning, advanced compression, Virtual Private Databases and all the rest of Oracle features are right there.

As Oracle is also the leading OLTP database, mixed workloads are no problem at all. Whether you load data while querying or you have special no-query periods for loading, Oracle provides the correct data to your business users. Whether you ask short and small questions or lengthy and complex ones, both, as well as both combined, will run equally well.

Transparent to the Organization

As the Database Machine is based on industry standard hardware, Linux and Oracle, the Database Machine is transparent to most data centers and applications. The system is both very easy to deploy and can be managed as any other Oracle system in the data center.

As a Database Machine is an Oracle system, the change to a Database Machine, or for that matter to Exadata Storage Servers is completely transparent to any application. OLTP or data warehouse applications will see a dramatic speed-up, but require no other changes. It's almost like a plug and play way to go fast.

Current Solutions

The innovative technology coming with Exadata Storage Servers and the proven capabilities of Oracle Database 11g deliver an unprecedented powerhouse for data warehousing to the market.

Oracle's Scalability

Oracle software runs some of the largest data warehouse systems in the world. The typical data warehouse appliance claims the same scalability and performance as Oracle, but most appliances and other specialty vendors struggle with heavy user concurrency. Add more active users to the appliances and the query performance degrades rapidly. Oracle, with its OLTP prowess easily deals with thousands of users on large data warehouse data volumes.

Oracle's Agility

On top of the proven scalability and performance Oracle has the unique capabilities of running mixed workloads better than almost any other platform. Combining the strengths in OLTP with its data warehousing features, Oracle offers a unique platform for active data warehousing. Dealing with real time updates to the data warehouse falls in the same category. Oracle always shows a read-consistent view of the data and ensures that even while trickling in data, your answers are always accurate and your performance does not suffer.

Oracle's Enterprise Readiness

Oracle is a leader in data security with very advanced security capabilities. Features like data masking in Enterprise Manager, Virtual Private Databases and Database Vault protect your data in many ways. No other vendor in the market delivers such wide-ranging security. The combination of that functionality with Oracle's Maximum Availability Architecture (MAA) allows Oracle to truly be mission-critical. Features like Active Data Guard give Oracle a large advantage in enterprise readiness.

Vendor Comparison

When comparing these unique capabilities of Oracle Database 11g and the Sun Oracle Database Machine with some of the vendors in the data warehouse market we see a distinct segmentation. The so-called general-purpose database offerings from Oracle and others deliver a much more universal value proposition. Appliances like Netezza really are one-dimensional offerings and even in that claimed specialty fall short of the market leaders.

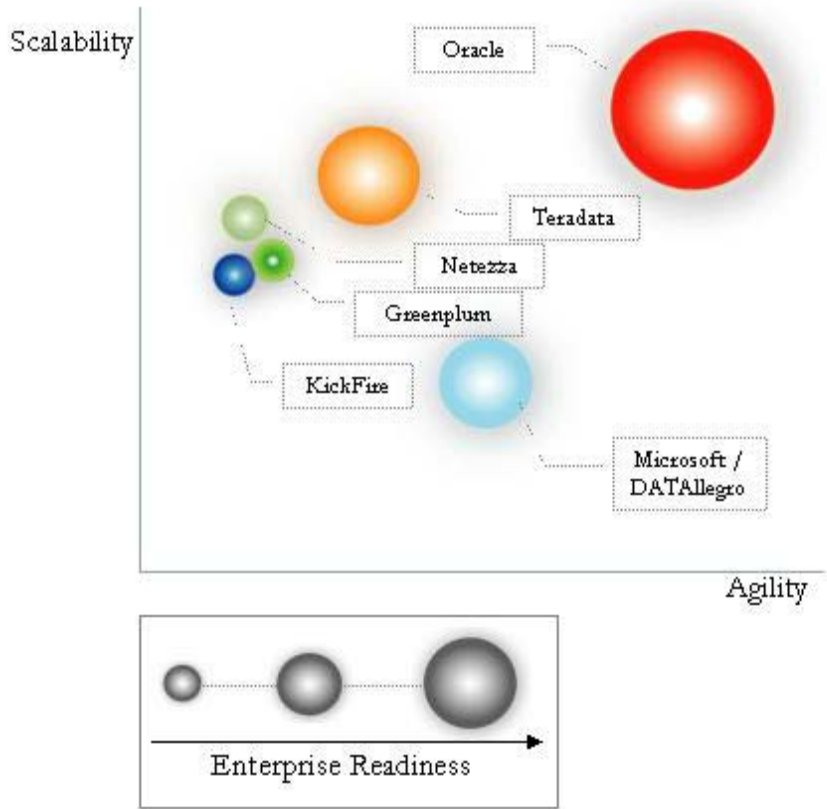


Figure 4. Solution comparison, many vendors, one leader

Figure 4 shows why Oracle is the clear industry leader. It is the only vendor whose offering covers every data warehouse angle from scalability to agility to enterprise readiness.

Summary and Conclusion

The data warehouse world is clearly evolving with niche vendors trying to tout generic solutions with niche products. The trends toward more data and more questions to be asked are undeniable. As a company you have to evolve your IT infrastructure to cater to these new demands.

Oracle goes beyond the hype of data warehouse appliances and brings its thirty years of RDBMS experience to the Sun Oracle Database Machine, a pre-configured solution for extreme performance warehouse queries. With innovations like Oracle Exadata and its revolutionary features, Oracle once again takes a major step in changing the landscape of database technologies.

The future is to run full-featured, robust and secure databases on industry standard hardware platforms delivering extreme performance for OLTP, data warehousing and everything in between packaged as an easy to deploy solution. That future is here now, it is called Sun Oracle Database Machine.



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