Performance and Scalability Benchmark: Oracle Communications Billing and Revenue Management on Sun SPARC Enterprise T5220 and M8000 servers running the Solaris 10 OS

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Leading Performance and Scalability of Oracle Communications Billing and Revenue Management Application and Oracle 10gR2 on Sun SPARC Enterprise T5220 and M8000 running Solaris 10 OS

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EXECUTIVE OVERVIEW

Oracle Communications Billing and Revenue Management (BRM) on Sun SPARC Enterprise servers running Solaris 10 provides a high-performance, scalable, and secure solution for enterprises using Oracle 10g and Oracle 10g Real Application Cluster (RAC). This highly scalable solution helps service providers accelerate the launch of new services; enable monetization of services for any customer type, network, service, business model or geography. This paper discusses the advantages of using Solaris Containers, Zettabyte File System (ZFS), Solaris Clusters, and Dynamic System Domains to build a scalable and highly cost-effective solution with a single instance of Oracle Database and multi-schema Oracle RAC on Sun SPARC Enterprise servers running Solaris 10.

Oracle Communications BRM has been designed and developed with parallelism in mind that enables several operations to utilize hardware strands concurrently, and is perfectly suited to take advantage of Sun's CoolThreads server based on UltraSPARC T2 processor which provides up to eight cores with each core supporting eight threads. This architecture allows to split the rating and loading in many threads resulting in high throughput. The rating pipeline can be configured with 9 or 10 pipelines to use the power of 64 hardware threads. The billing part can also be parallelized based on configurable parameter. Sun SPARC Enterprise servers handle large memory supported by Solaris very efficiently. For rating rate, as millions of subscriber accounts were added, all the threads on the pipeline process spread on the UltraSPARC T2 processor had good access to the large memory allocated in the system. The eco-friendly CoolThreads server is the industry’s first massively threaded system on a chip, with a single-processor die hosting up to 64 threads per processor delivering excellent throughput with dramatic space and power efficiency.

Sun and Oracle have worked a number of years to optimize Oracle Database on Sun SPARC Enterprise System running Solaris. Oracle 10g and Oracle 10g RAC are well proven to take advantage of the high I/O bandwidth and response time needed to achieve high throughput on the Sun SPARC Enterprise M8000 server, which also brings mainframe-class RAS to the open-systems market at lower cost.
and Sun StorageTek 6540 Enterprise class arrays. The Sun SPARC Enterprise M8000 features up to 16 high-performance dual core SPARC64 VI processors and up to 512 GB memory. It also supports 16 dynamic domains, which enables each domain to operate as a separate system. The combination of dynamic domains with Oracle RAC, Solaris Cluster, and Sun StorageTek QFS file systems allows for great horizontal scalability and provides high throughput and fast response time and is a perfect solution for high-performance, data-intensive applications.

The benchmark results from the latest performance and scalability tests for Oracle Communications BRM release 7.3.1 using Oracle 10gR2 and Oracle 10g RAC on Sun SPARC Enterprise T5220 and M8000 servers running free and open Solaris 10 OS shows record throughput and linear scaling from 5 million to 20 million subscribers with a peak rating of 14,828 CDR/second.

INTRODUCTION

The Oracle Communications BRM application suite is a Tier 1, convergent billing framework that is architected for leading service providers. The BRM solution is a fully convergent prepaid and postpaid solution and employs an architecture that allows convergent modules to co-exist and offer integrated services.

Over the years and over subsequent releases, the Oracle Communications BRM application suite has grown into a robust convergent billing solution that is architecturally stable, offers predictable performance, scales horizontally, is available in many configurations and operating systems, and can be customized for specific needs. As a result, there is a continuous need to perform benchmark and scalability analysis to ensure the application suite meets the needs of key workloads.

This white paper describes the performance and scalability results of Oracle Communications BRM 7.3.1 from the recent benchmark conducted at Sun Solutions Center in, Paris, France. The Oracle Communications BRM benchmark was done on Sun SPARC Enterprise T5220 and M8000 servers running Solaris 10. The benchmark originally comprised GSM price plans that were representative of customer cases for telephone, SMS, fax, data, and WAP. The activity was later simplified for the benchmark, and only the two major CDR type, telephone and SMS, were simulated. The presence of fax, data, and WAP would increase the memory usage of the pipeline.

The benchmark involved tests with a single database with 5M subscriber accounts and a multi-schema system using Oracle RAC with 20M subscriber accounts. The benchmark aimed at validating customer requests for performance of Oracle Communications BRM on Sun’s latest servers. The results demonstrate that the performance of Oracle Communications BRM 7.3.1 on Sun SPARC Enterprise servers exceeds customer expectations, provides excellent throughput and price performance to support 20M subscribers in an 8RU space in an application tier, and scales with multi-schema configurations using Oracle RAC and Solaris Cluster. This enables the Oracle Communications BRM 7.3.1 solution on Sun to handle and
manage service providers’ current and future growth with high performance using
less space and energy.

The Oracle Communications BRM benchmark kit, which is a good representation
of customer workload, was suggested by the BRM team and was executed jointly by
Oracle Communications consulting, Oracle Communications Engineering

ARCHITECTURE OVERVIEW
Oracle Communications Billing and Revenue Management

The Oracle Communications BRM architecture is a horizontally scalable
architecture designed to support subscriber and usage data growth. The architecture
uses distributed processing to balance and distribute workload and to provide
optimal performance results, including processed transactions per second (TPS).

Figure 1 provides the multitier definition of the BRM architecture – Application or
the Client tier, BRM server or the Business Process tier, and Data management or
the Database tier.

The business process tier is structured to offer both session-based (real time, on-
line) charging and non-session-based (batch, off-line) charging. Components in the
business process tier are loosely coupled and can be distributed across hardware to
achieve horizontal scalability.

The database tier is structured to offer scalable growth through Oracle RAC and
schema structuring. New schemas can be added to support subscriber growth
within the database tier.
Sun UltraSPARC T2 CoolThreads Server

The UltraSPARC T2 processor provides up to eight cores with each core supporting eight threads. This translates into the industry’s first massively threaded “System on a Chip,” with a single processor die hosting up to 64 threads per processor, on-chip Level-1 and Level-2 caches, per-core floating point capabilities, per-core cryptographic acceleration, as well as 10 GB Ethernet and PCI Express interfaces.

The Sun SPARC Enterprise T5220 servers are designed to leverage the considerable resources of the UltraSPARC T2 processor in the form of cost-effective general-purpose platforms, which is ideal for infrastructure applications as well as enterprise-class applications like Oracle BRM and Oracle Database.

Sun SPARC64 VI-Based Servers

The Sun SPARC Enterprise M8000 system delivers mission-critical services or enterprise-level consolidation with high single-system performance and extreme scalability without the high cost of a mainframe. The Sun SPARC Enterprise M8000 system features up to 16 high-performance, dual-core SPARC64 VI processors and up to 512 GB memory, with faster I/O and increased I/O connectivity. It is an ideal consolidation platform with up to 16 dynamic domains and thousands of Solaris Containers per system.

For the performance test, the system was partitioned into four dynamic domains of four CPUs, each with 64 GB of RAM, and Oracle 10g RAC was used in a four-node cluster. Each node supported very high modification throughput of 1000 TPS. The RAC database allowed the global load on the database to be distributed over four nodes. The scalability provided by four CPU nodes allows handling of 5M accounts per node.

Solaris Operating System

The world’s leading enterprise operating system that is open and free – Solaris 10, can span the entire enterprise from the Web tier to billing, to the most demanding applications, all while delivering performance, stability and security. The Solaris 10 OS supports Dynamic Tracing (DTrace), ZFS, cryptographic infrastructures, IP filter and User and Process Rights Management, and Predictive Self Healing, further enhancing system reliability.

The Solaris Cluster is a high-availability cluster software product for Solaris OS. It is used to improve the availability of applications services such as databases, commerce Web sites, and other applications. It allows very rapid reaction on events and reconfiguration of the cluster, if needed. The shared disks are under survey at the driver level. The Solaris Cluster uses SCSI reservation on quorum devices to validate the start of the cluster and assure data coherency. The Solaris Cluster presents an aggregation of all network links used to interconnect between the
nodes, and it uses the aggregation for performance and availability. This provides good and scalable interconnect for the RAC database.

Sun’s clustering software and Sun’s StorageTek QFS file system allow for seamless file system administration for the DBA. This is a perfect combination for high-performance with very good response time and high number of I/O orders per second. The best known transaction rate seen on the RAC-database can be achieved when the data files are on the QFS file system.

Because BRM is very modification intensive and drives a high transaction rate, it took best advantage of the Solaris Cluster and QFS combination.

The Solaris ZFS is a 128-bit general-purpose file system that spans from the desktop to the data center, where space is shared dynamically between multiple file systems from a single storage pool. Physical storage can be added to or removed from storage pools dynamically, without interrupting services. This capability provides new levels of flexibility, availability, and performance. ZFS was used on the single-instance database test (up to 5M accounts). It was used on a LUN that was constructed by the disk array administration interface. ZFS largely helped to aggregate writes and reads for indexing and Undo operation. This allowed to achieve throughput with fewer disks because the solicitation was simplest to handle. ZFS was used for administration ease and performance (due to a quite large cache) on the application server. Two physical disks were striped to hold the local file activity. The application writes temporary files, modified data is written to it, and any metadata referencing it are similarly read. Nearly all the reads were found in the ZFS cache, and the local disk was able to sustain the load.

**Sun StorageTek Storage**

Sun offers many options for storage, from low-cost arrays that extend built-in storage capacity to solutions that deliver high spindle density and optimal price/performance. The modular design of the Sun StorageTek 6540 can easily adapt to change without disrupting existing applications. The Sun StorageTek 6540 array also offers unparalleled flexibility with the ability to mix and match SATA and Fibre channel drives to meet tiered storage needs and growing backup and archiving requirements. The high I/O bandwidth and high performance of the Sun StorageTek 6540 array combined with the high-performance Sun SPARC Enterprise M8000 proved to be an ideal combination for deploying an Oracle database to support a large number of subscribers. The I/O reached 16,000 I/O operations per second with more Writes (11,000) than Reads (5,000). The response time on the redo log files was very good and was always acknowledged by the disk array cache.

**PERFORMANCE AND BENCHMARKING SETUP**

**System Setup**

This section describes the system architecture and configurations implemented for the performance test.
1. Oracle Communications BRM 7.3.1 and Oracle 10gR2 in a single-database mode supporting 5M subscribers on one Sun SPARC Enterprise T5220 server and one M8000 server, both running Solaris 10.

2. Oracle Communications BRM 7.3.1 and Oracle 10g RAC in a multi-schema database mode supporting 20M subscribers on four Sun SPARC Enterprise T5220 servers and one M8000 server, all running Solaris 10.

**BRM Software Release**

- Oracle Communications BRM 7.3.1 for Solaris with the following components:
  - Portal_Base (build: 10-29-2007 14:13:26)
  - WirelessSuite (build: 10-29-2007 14:2:30)
  - AccountSynchTool (build: 10-29-2007 13:14:10)
  - RatedEventLoader (build: 10-29-2007 14:33:37)
  - MultiDBMgr (build: 10-29-2007 14:0:21)
  - Pipeline (build: 10-29-2007 15:50:15)

**Oracle RDBMS and RAC Software Release**

- Oracle Database 10g Enterprise Edition release 10.2.0.3.0 — 64-bit production, with the Partitioning, RAC, OLAP, and Data Mining options
- The RAC stack and the Oracle database used the same release

**Application Server for 5M Subscribers**

One Sun SPARC Enterprise T5220 server

- One 1.2 GHz UltraSPARC T2 CPU with eight cores
- 32 GB RAM

**Database Server for 5M Subscribers**

One Sun SPARC Enterprise M8000 server dynamic domain

- Four 2.4 GHz SPARC64 VI CPUs with two cores per CPU
- 64 GB RAM

**Application Server for 20M Subscribers**

Four Sun SPARC Enterprise T5220 servers
- One 1.4 GHz UltraSPARC T2 CPU with eight cores
- 64 GB RAM

**Database Server for 20M Subscribers**

The Oracle RDBMS was installed in RAC mode on four dynamic domains of M8000 server

One Sun SPARC Enterprise M8000 server

- Sixteen 2.4 GHz SPARC64 VI CPUs with two cores per CPU
- 256 GB RAM

**Solaris 10 Operating System Release**

Solaris 10 (8/07 s10s_u4wos_12b SPARC with Generic_127111 at level 02, 06, or 09)

**Solaris Cluster and QFS Software Release**

Solaris Cluster release 3.2 (Solaris Cluster 3.2 for Solaris 10 SPARC, SUNWscu: 3.2.0,REV=2006.12.05.22.58)

- QFS for the shared file system on Solaris Cluster, release 4.6.5 (REV=5.10.2007.03.12)

**System Architecture for 5M subscribers**

![System Architecture Diagram](image)

*Figure 2 – BRM System Architecture Layout for 5 million Subscribers*

The 5M subscriber accounts are represented in a single database instance and are connected to the business process tier.
System Architecture for 20M subscribers

The 20M subscriber accounts are split by groups of 5M over four schemas. Each schema is handled by one instance of the RAC database. The RAC database is installed on Solaris Cluster framework and shared QFS file systems. Each Sun SPARC Enterprise T5220 server used as a BRM application server is logically linked to one of the four active schemas.

Plan Types

The GSM Offer used in this performance benchmark is a standard performance configuration used within Oracle Communications Engineering Performance. Three price plans described below were used in both phases of the tests.

The benchmark originally comprised GSM price plans that were representative of customer cases for telephone, SMS, fax, data, and WAP. The activity was later simplified for the benchmark, and only the two major CDR types, telephone and SMS, were simulated. The presence of fax, data, and WAP would increase the memory usage of the pipeline.
CPU Utilization for 5M subscribers

Figure 4 presents the CPU consumption on the Sun SPARC Enterprise T5220 server running the BRM application and on the Sun SPARC Enterprise M8000 domain for the database server. The successive phases of the CPU consumption co-relate with the phases on the application server: pre-rating, rating, and loading. The last phase, the loading, drives a small consumption on the application server and a large one on the database server.

The activity on the database server is very irregular, and the variation is clearly directed by the phases of the loading on the Sun SPARC Enterprise T5220 server.

Figure 4 illustrates that, as the configuration parameters were set for maximum throughput, CPU consumption frequently hits 100% on the BRM application server and sometimes on the database server.

The BRM application server allocates tens of GB of memory for its activity. This requires large physical memory in the application server.
I/O throughput for 5M subscribers

The BRM application loading phase generates high writing throughput on the database server. Figure 5 illustrates that the number of operations hit a volume of 80 MB/s. The choice of the database layout and ZFS for Undo, Tablespace and Index operations were important to achieve these results. The low response time observed on the Redo log file system was also needed. The read flow was about one fifth of the write flow due to large memory usage as cache in the database. The Sun SPARC Enterprise M8000 server domain needs as large a memory for the SGA cache as for the ZFS cache.

CPU Utilization for 20M subscribers
Figure 6 presents the average CPU consumption of the four Sun SPARC Enterprise T5220 servers used as BRM application servers and the average CPU consumption of the four Sun SPARC Enterprise M8000 server domains used in a RAC database server. The load on the application server is lower than on the previous test because the tuning is the same but the servers have a higher-frequency CPU. Each of the four chains of application server, RAC database instance on one domain, has a very similar behavior in test over 5M subscriber accounts.

I/O throughput for 20M subscribers

Figure 7 shows the sum of the writing flow on the four BRM application servers on the Sun SPARC Enterprise T5220 servers and on the four domains of the Sun SPARC Enterprise M8000 server that drives the RAC database. The BRM application server used ZFS on a stripe over two internal disks for the exchange filesystem between the application phases. Nearly all the reads came from the ZFS cache.

The loading phase generates a high writing throughput that is aggregated by the four domains on the two storage arrays. The global writes in volume, measured by number of operations per second (up to 300 MB/s), is very high on the storage arrays from the four domains of the RAC cluster. The choice of the database layout and of the QFS shared file system for all the database file system was very important to achieve the results. The low response time observed on the Redo log file system was also needed. The read flow starts from nearly nothing because all data was held in the four SGAs and grows to nearly half of the writes during the run up.

Large memory on all the servers and efficient storage are required to achieve high CDR/s throughput with the BRM application.
Results

Throughput results

Results for 5M subscriber accounts:

<table>
<thead>
<tr>
<th>Default Schema</th>
<th>Rating CDR/s</th>
<th>Loading CDR/s</th>
<th>Rating and Loading Million CDR / h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3,676</td>
<td>2,947</td>
<td>9.8</td>
</tr>
</tbody>
</table>

Results for 20M subscriber accounts:

<table>
<thead>
<tr>
<th>Schema 1</th>
<th>Rating CDR/s</th>
<th>Loading CDR/s</th>
<th>Rating and Loading Million CDR / h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Schema 2</td>
<td>3,694</td>
<td>2,968</td>
<td>9.8</td>
</tr>
<tr>
<td>Schema 3</td>
<td>3,711</td>
<td>2,938</td>
<td>9.7</td>
</tr>
<tr>
<td>Schema 4</td>
<td>3,711</td>
<td>2,978</td>
<td>9.8</td>
</tr>
<tr>
<td>Schema 5</td>
<td>3,712</td>
<td>2,770</td>
<td>9.2</td>
</tr>
<tr>
<td>Global</td>
<td>14,828</td>
<td>11,654</td>
<td>38.5</td>
</tr>
</tbody>
</table>

Note: Schema 1 was used for reference data used by all other schemas and contains no active subscriber account so no CDR was sent on this schema. Each of the schemas 2 to 5 contains 5 million subscriber accounts.

SUMMARY

Oracle Communications BRM on Sun SPARC Enterprise Server — Oracle Communications BRM 7.3.1 and Oracle 10g RAC scales to 20 million subscribers with a peak rating of 14,828 CDR/s on Sun's SPARC Enterprise T5220 and M8000 servers running free and open Solaris 10.

High Throughput — The Sun SPARC Enterprise T5220/M8000 servers running Solaris 10 linked to two StorageTek 6540 (112 disks) achieved a record of 14,828 CDR/s peak rating and sustained rating and loading of 53 million CDR in 1 hour for 20M subscribers using Oracle Communications BRM 7.3.1 and Oracle 10g RAC.

High Memory Bandwidth — The Sun SPARC Enterprise T5220/M8000 servers were running with 64 GB of memory. The BRM application servers running on each Sun SPARC Enterprise T5220 server required tens of GB of memory. On the database server, around 30 GB were allocated to the SGA to limit the reads. On both servers, the high memory allocations and bandwidth were necessary to achieve the performance results.
Scalability — Sun SPARC Enterprise T5220 and M8000 servers running Solaris 10 OS prove to be the best combination for applications that require high I/O throughput and large memory and provide excellent scalability for deploying Oracle Communications BRM 7.3.1 in a cost-efficient data center. The scalability proved to be linear as shown in test by achieving 3,600 CDR/s for 5 million subscribers with one Sun SPARC Enterprise T5220 server and 14,828 CDR/s for 20 million subscribers with four Sun SPARC Enterprise T5220 servers.

Energy Efficiency — A single Sun SPARC Enterprise T5220 server supports 5M subscribers in a 2RU form factor while consuming an estimated 400 watts with a peak rating of 3,600 CDR/s using Oracle Communications BRM 7.3.1 and Oracle 10gR2.

Efficient File System — Solaris ZFS on the application server eased the administration and performance of managing large number of disk volumes needed to distribute I/O evenly.