Accelerate Banking Automation While Reducing Risk and Cost
Oracle Optimized Solution for Oracle FLEXCUBE

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## Table of Contents

Executive Overview .................................................. 1
Introduction .......................................................... 1
Oracle Optimized Solution for Oracle FLEXCUBE ....... 2
  Oracle FLEXCUBE .................................................. 2
  Oracle’s SPARC T5 Servers ..................................... 2
Solution Benefits .................................................... 2
Solution Architecture Overview ............................... 3
Solution Validation .................................................. 4
  Account, Customer, and Branch Volumes .................. 4
  Batch Workload Descriptions .................................. 4
  Online Transaction Workload Description ............... 5
Performance Testing Results ....................................... 5
  Batch Testing Results ............................................ 5
  Online Testing Results ......................................... 6
  Fault Injection Testing ......................................... 6
Addressing Security Concerns using Oracle Optimized Solutions .... 7
Conclusion .......................................................... 7
  For More Information ........................................... 8
Executive Overview

Oracle’s tagline—Hardware and Software, Engineered to Work Together—is a promise of dramatic improvements in cost reduction, risk reduction, productivity, and security of application and business systems. Of course, Oracle FLEXCUBE Release 12, along with industry-leading middleware and database software technologies, operates on a wide variety of non-Oracle hardware platforms. But it is Oracle’s investment in deep application-to-disk integration, end-to-end testing with fault injection, and documented best practices for running Oracle software on Oracle hardware that help customers most effectively manage the ever-increasing pressure to consistently deliver more with less cost and risk.

Introduction

Financial institutions face increasing pressure to consistently deliver secure anywhere-anytime, always-on banking with a competitive customer experience. But they also must streamline operations for both customer-facing online processing and back-office end-of-day and end-of-financial-period processing. Moreover, they must contain costs while meeting a growing demand for a variety of financial services. As such, it is critical to their success that a banking solution be able to handle large transaction volumes over millions of accounts in a predictable way.

By combining Oracle FLEXCUBE Release 12 with Oracle’s SPARC T5 servers running Oracle Solaris, financial institutions can deploy competitive banking solutions on a highly available, highly efficient, and secure platform. To validate the performance, scalability, and availability of these solutions, Oracle engineering conducted fault injection testing and online throughput benchmarks, along with end-of-day and end-of-period batch benchmarks, on a system supporting more than 10 million customers with 10 million accounts. This document reviews the results and key findings.
Oracle Optimized Solution for Oracle FLEXCUBE

Oracle Optimized Solution for Oracle FLEXCUBE is a secure, high-efficiency, highly scalable, multimillion customer account “bank-in-a-box” that delivers Oracle-defined high availability out of the box. This solution features Oracle FLEXCUBE Release 12; Oracle’s SPARC T5 servers running Oracle Solaris 11 and built-in, no-cost virtualization; Oracle ZFS Storage Appliance; and Oracle’s networking technology. The entire solution, application to disk, can be supported end to end by Oracle.

Oracle FLEXCUBE

Oracle FLEXCUBE Release 12 addresses the needs of financial institutions with its customer-centric core banking, online banking, and wealth management solutions. It enables a consistent and personalized customer experience through a combination of enhanced self-service options and assisted support across channels. It helps empower knowledge workers with a wide range of functionality, built-in intelligence, a 360-degree view of the customer, and an enhanced interactions framework. Oracle FLEXCUBE also offers a new open development environment, allowing its user community to create its own user interface, business logic, and integration.

For the set of test results described in this paper, Oracle FLEXCUBE Release 12.0.1 was used for universal banking product configurations.

Oracle’s SPARC T5 Servers

Oracle’s SPARC T5 servers are based on Oracle’s SPARC T5 microprocessor. Since their introduction, these servers have set nearly two dozen world records and are the best platforms for enterprise computing at any scale. SPARC T5 servers, in combination with Oracle Solaris, have demonstrated in recent benchmarks that they are the fastest single servers in the world for running Oracle Database, Java, and Oracle’s middleware. More important, these advantages are not only in performance, but also in competitive price-performance.

Oracle FLEXCUBE deployments usually rely heavily on Oracle Database and Java, and they usually run on Oracle WebLogic application servers. Because of these and other factors, Oracle’s SPARC T5-2 servers—running Oracle FLEXCUBE Release 12 with Oracle Database 11g Release 2 on Oracle Solaris 11—achieved audited world-record results, processing 25 million accounts in 56 minutes for end-of-day and 150 minutes for end-of-month workloads. In addition to these record-breaking results, the system also achieved a new world record result by processing 10.14 million accounts in 28 minutes for end-of-day workload on a single server.

Oracle Optimized Solution for Oracle FLEXCUBE is based on Oracle’s SPARC T5-2 servers, which are compact 3U servers. These SPARC T5 servers offer significant advantages over Oracle’s previous-generation SPARC T4 servers: they typically achieve at least two times better on key server performance and price-performance metrics. Additionally, these servers run Oracle Solaris 11, with guaranteed binary compatibility and support for legacy applications. Finally, Oracle VM Server for SPARC and Oracle Solaris Zones are built-in, no-cost virtualization technologies that come with every SPARC T5 server.

Solution Benefits

Although Oracle Optimized Solution for Oracle FLEXCUBE is targeted for banks with up to three million accounts when it is initially deployed, all testing was done at a scale factor over three times greater than that. As such, workload testing account scale factor was 10 million customer accounts including batch-of-day accruals, end-of-period liquidation, and ATM and branch online transaction processing, in addition to the load applied under all fault injection testing.
Based on the tested solution configuration above, the following four solution benefits were demonstrated.

» Saved money with deployment platform efficiency that allows the solution to do much more with less.
  » All deployment platform servers, operating systems, virtualization, storage, and solution interconnect have a current acquisition list price of approximately 1/3 million US dollars and a net (street) price that is even lower.
  » The cost of infrastructure acquisition is 2.4 times lower than an IBM Power Systems configuration sized to handle the same workload. This result is based on a list price to list price comparison for all hardware infrastructure acquisition costs including operating system, virtualization, database, and middleware licensing.

» Increased productivity.
  » More than 3.3 million ATM and branch online transactions per hour were measured with sub-second response times.
  » Approximately two hours elapsed time to calculate interest and liquidate 10 million accounts for end-of-period/month (EOP/EOM) batch processing.
  » End-of-day (EOD) standard batch workload processed in under an hour.

» Reduced deployment risk.
  » The complete, pretested, validated, and documented solution with available architecture paper and implementation guide reduces risk during deployment.
  » This solution deploys 4.5 times faster than conventional solution approaches based on duration of deployment steps.

» Reduced operational risk with a secure, highly available and fault injection-tested solution.
  » The no-single-point-of-failure architecture provides a high-availability solution out of the box.
  » Compute, network, and storage isolation security strategies are optimized for performance and scalability
  » Fault injection impact characterization shows solution recovery to full load throughput in seconds to minutes depending on fault.

**Solution Architecture Overview**

This solution is built around two SPARC T5-2 servers that are in turn securely partitioned into two logical domains (Ldoms), each using Oracle VM Server for SPARC virtualization technology (see Figure 1). These four domains create redundant node instances for both database and application servers. Two database nodes in an Oracle Real Application Clusters (Oracle RAC) configuration and two application server nodes, each with its own node manager instance, and two managed servers running Oracle FLEXCUBE instances eliminate any single point of failure in the solution.

Direct NFS Client, a feature of Oracle Database 11g, is used to access all database files on NFS shares provided by an Oracle ZFS Storage ZS3-2 active-passive cluster. Connectivity across all these components is implemented with redundant Oracle Switch ES1-24 switches utilizing 10 Gigabit Ethernet connectivity and separate secure VLANs for application access, database storage, and Oracle RAC private interconnects.

The Oracle FLEXCUBE Release 12 application instances were run on Oracle WebLogic Server 10.3.6, each running on Oracle Solaris 11. For the database tier, both Oracle Database 11.2.0.3 nodes were run on Oracle Solaris 11.
Solution Validation

Oracle Optimized Solution for Oracle FLEXCUBE was assessed for performance using three separate use cases and their associated benchmarks and workloads.

» End-of-day batch job completion time that includes daily accrual processing
» End-of-period/end-of-month (EOM) batch job measuring completion time that includes interest and liquidation
» Online transactional workload using virtual users while measuring transactions per second (TPS) and response times

These benchmarks had the goal of simulating the work volume typical of a 10-million account financial institution. And though the workloads were run for a universal banking scenario that did not include loan processing or end-of-period report generation, the scalability findings are believed to be applicable to other types of financial services with the proper scale factors applied.

Account, Customer, and Branch Volumes

For all three benchmarked use cases, a 10-million customer base bank model with 10 million accounts—including savings accounts, current accounts, and term deposit accounts—was created across 400 branches, as shown in Table 1 below. Approximately 1 million accounts are zero balance accounts.

<table>
<thead>
<tr>
<th>TABLE 1: ACCOUNT VOLUMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of Number Term Deposit Accounts</td>
</tr>
<tr>
<td>Total of Number Savings Accounts</td>
</tr>
<tr>
<td>Total of Number Current Accounts</td>
</tr>
<tr>
<td>Total Accounts</td>
</tr>
</tbody>
</table>

Batch Workload Descriptions

The goal of the two batch workloads was to simulate and measure the performance and scalability of daily and monthly batch processing typical for Oracle FLEXCUBE Release 12 in a universal banking scenario. Workload test data for these batch runs was based on what is typical of a real bank. Batch workload test data included data for customers, accounts, and transactions.
End-of-Day Batch Runs. End-of-day batch runs included end-of-day accrual for savings and term deposit accounts, interest capitalization for saving accounts, and interest payout for term deposit accounts.

End-of-Period/Capitalization Batch Runs (End of Month). End-of-month batch runs included periodic (monthly in this use case) customer account accruals and liquidation. For each account, interest is calculated for accrual and liquidated for credit during this batch run. The interest is calculated according to the interest calculation rule and mapped to the products within each customer account.

Online Transaction Workload Description

For the online testing, workload generators simulating 200 concurrent virtual users were used to apply a transactional banking workload mix consisting of a variety of queries along with deposits, withdrawals, and transfer transactions, as shown in Table 2.

<table>
<thead>
<tr>
<th>Transaction Name</th>
<th>Transaction Type</th>
<th>Transaction Mix %</th>
<th>Virtual Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1401 – Cash Deposit</td>
<td>Financial</td>
<td>10%</td>
<td>20</td>
</tr>
<tr>
<td>1001 – Cash Withdrawal</td>
<td>Financial</td>
<td>10%</td>
<td>20</td>
</tr>
<tr>
<td>1006 – AC to AC Transfer</td>
<td>Financial</td>
<td>10%</td>
<td>24</td>
</tr>
<tr>
<td>STDCUSAC – Account Query</td>
<td>Nonfinancial</td>
<td>12%</td>
<td>24</td>
</tr>
<tr>
<td>STDCIF – Customer Query</td>
<td>Nonfinancial</td>
<td>12%</td>
<td>24</td>
</tr>
<tr>
<td>DEDQUERY – RT Query</td>
<td>Nonfinancial</td>
<td>12%</td>
<td>24</td>
</tr>
<tr>
<td>STDCUSBL – Account Balance Query</td>
<td>Nonfinancial</td>
<td>12%</td>
<td>24</td>
</tr>
<tr>
<td>ATM Balance Enquiry</td>
<td>Nonfinancial</td>
<td>12%</td>
<td>24</td>
</tr>
<tr>
<td>ATM Cash Withdrawal</td>
<td>Financial</td>
<td>10%</td>
<td>20</td>
</tr>
</tbody>
</table>

The representative transaction mix for online transactions was set up based on the real-time experience of a bank. Each of the transactions shown in Table 2 had a corresponding script for posting the transaction to the application server. For the purpose of scripting, data required for various fields within the transaction was provided using a data pool to ensure that the posting of transactions was distributed uniformly across customers and accounts. The scripted transactions invoked the validation events and the posting of transactions, and then they concluded with the final confirmation of the transaction. The transactions per second (TPS) measured correspond to this end-to-end transaction sequence.

For financial transactions, account posting was done through a scheduled batch (semi-online), and the TPS, the average CPU utilization, the memory utilization, and the disk I/O of the database and application server were monitored.

Performance Testing Results

Oracle Optimized Solution for Oracle FLEXCUBE easily exceeded the performance targets; and in all three use cases, performance was limited by CPU throughput in the database tier.

Batch Testing Results

For 10 million accounts over 10 million customers, end-of-day processing completed in 39 minutes and end-of-month processing completed in 136 minutes. Batch job builds and layout optimizations are part of the Oracle FLEXCUBE application and are dependent upon execution in the application tier. However, the execution of the batch jobs themselves is solely within the database tier.
Online Testing Results

For 10 million accounts with 200 virtual users, the system processed 923 transactions per second with a 98th percentile response time of 343 milliseconds. This is more than 55,000 transactions per minute or 3.3 million transactions per hour. The system was principally CPU bound in the database tier. The CPU utilization was more than two times higher in the 56-core database tier cluster than in the 8-core application tier cluster. This is about 16 times more CPU utilization in the database tier versus the application tier on a processor-for-processor basis in this solution.

Fault Injection Testing

All fault injection testing was done under full OLTP load as described above, with approximately 900 transactions per second. A summary of the reduction in system performance and associated duration for each of the nine key faults tested is listed in Table 3 below.

The OLTP traffic stopped in only three cases of fault injection testing (the first three entries in Table 3). Of these, the longest total stoppage was approximately two minutes for an abrupt loss of an entire Oracle RAC database server node. Even loss of the storage controller and associated takeover by the passive controller stopped traffic for only approximately 16 seconds. In most cases, these faults only slow available throughput by a range of 2 to 50 percent.

<table>
<thead>
<tr>
<th>Fault Injection Testing Scenario</th>
<th>Time to Return to 100% OLTP Throughput After Fault</th>
<th>Average % Loss of OLTP Throughput During Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrupt database server node loss (power off)</td>
<td>20 minutes</td>
<td>50%</td>
</tr>
<tr>
<td>Abrupt database Oracle RAC node halt (kill PMON)</td>
<td>20 minutes</td>
<td>50%</td>
</tr>
<tr>
<td>Abrupt storage controller loss (power off)</td>
<td>4 minutes</td>
<td>50%</td>
</tr>
<tr>
<td>Graceful database Oracle RAC node drop</td>
<td>20 minutes</td>
<td>33%</td>
</tr>
<tr>
<td>Abrupt application server node loss</td>
<td>16 minutes</td>
<td>8%</td>
</tr>
<tr>
<td>Abrupt managed server and node server halt</td>
<td>15 minutes</td>
<td>6%</td>
</tr>
<tr>
<td>Graceful managed server shutdown</td>
<td>6 minutes</td>
<td>5%</td>
</tr>
<tr>
<td>Abrupt managed server halt (kill process)</td>
<td>4 minutes</td>
<td>6%</td>
</tr>
<tr>
<td>Network switch loss (power off)</td>
<td>4 minutes</td>
<td>2%</td>
</tr>
</tbody>
</table>

For more detailed information on fault injection testing results, contact an Oracle sales representative.
Addressing Security Concerns using Oracle Optimized Solutions

Security must be a priority starting with the architecture definition and the design phases of a solution, rather than an afterthought during or after implementation. Many security flaws can be remediated by following pretested and evaluated implementation documentation that provides workarounds and recommendations. Leveraging existing security guides and their recommendations, consistent with local site deployment policies and regulations, is one of the best ways to ensure secure deployments.

Table 4 below lists resources containing key security recommendations for Oracle Optimized Solution for Oracle FLEXCUBE.

**TABLE 4: FLEXCUBE SOLUTION STACK SECURITY GUIDELINES**

<table>
<thead>
<tr>
<th>Stack Layer</th>
<th>Security Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Server/JAVA</td>
<td>iase.disa.mil/stigs/Documents/u_oracle_weblogic_server_12c_v1r1_stig.zip</td>
</tr>
<tr>
<td>Database</td>
<td>iase.disa.mil/stigs/Documents/U_Oracle_Database_11-2G_V1R2_STIG.zip</td>
</tr>
<tr>
<td>Operating System</td>
<td>iase.disa.mil/stigs/Documents/U_Solaris_11_SPARC_V1R2_STIG.zip</td>
</tr>
<tr>
<td>Networking</td>
<td>docs.oracle.com/cd/E39109_01/html/E39117/index.html</td>
</tr>
</tbody>
</table>

Conclusion

With Oracle Optimized Solution for Oracle FLEXCUBE, customers can realize substantial benefits over a do-it-yourself approach from a collection of vendors.

By combining Oracle FLEXCUBE Release 12 with Oracle’s SPARC T5 servers running Oracle Solaris 11, along with Oracle ZFS Storage Appliance and Oracle’s networking technology, financial institutions can deploy competitive banking solutions on a highly available, efficient, and secure platform that is supported by a single vendor. The efficiency, performance, and availability of this solution were validated in the lab for both customer-facing online processing and back-office end-of-day and end-of-financial-period processing. Performance was demonstrated to meet peak transactional and batch volumes typical of a 10-million customer bank with 10 million accounts—all while still providing significant spare CPU capacity. These test results also demonstrated the solution’s ability to handle large transaction volumes over millions of accounts in a predictable way. These unique technologies and abilities ensure that financial institutions gain the following three key benefits.

» **Cost Savings.** The efficiency of SPARC T5, Oracle Solaris, and SPARC virtualization technologies are all used to help maximize investments in Oracle infrastructure licenses. Additionally, the use of efficient application-engineered Oracle ZFS Storage ZS3-2 and Oracle Switch ES1-24 (a low-cost, enterprise-class data center switch) reduces the total hardware acquisition cost dramatically. As such, a large account base can be processed so quickly with the smallest of Oracle’s SPARC T5 rack servers that financial institutions can expect to achieve some of the most competitive acquisition costs for their banking automation solution and its infrastructure.

» **Reduced Risk.** Given that performance was tested on a high-availability configuration using a number of clustering technologies along with rock-solid Oracle Solaris and reliability, availability, and serviceability (RAS)-rich SPARC T5 servers, operational risk is demonstrated to be significantly reduced using this no-single-point-of-
failure architecture. Moreover, the predictable performance demonstrated in these tests, along with the implicit sizing provided, can significantly reduce security and deployment risk.

**Increased Productivity.** Targeted at an initial deployment scale factor of up to three million customer accounts, but tested at a scale factor over three times greater—10 million customer accounts—Oracle Optimized Solution for Oracle FLEXCUBE delivers outstanding batch and OLTP results on a platform that produces world-record performance. With significant headroom to scale up, users are assured of an excellent banking experience while back office users are given smooth-running and rapid banking automation.

For More Information

To discover more about how Oracle Optimized Solution for Oracle FLEXCUBE can help financial institutions do more with less cost and risk, including details on the actual solution architecture, contact an Oracle sales representative or visit oracle.com/optimizedsolutions.