Exadata Technical Overview

Last updated – March 19, 2014
Exadata Database Machine

- The ultimate platform for all database workloads
  - OLTP, Warehousing, Database as a Service

- Most advanced hardware
  - Fully scale-out servers and intelligent storage with unified InfiniBand connectivity and PCI flash

- Most advanced software
  - Database optimized compute, storage, and networking algorithms dramatically improve performance and cost

- Standardized, optimized, hardened end-to-end
1000s of Deployments at Leading Companies
Half are Warehouses, Half are OLTP or Mixed Workloads

- Petabyte Warehouses
- Online Financial Trading
- E-Commerce Sites
- Consolidation of 100s of Databases
Exadata for Packaged Applications
Exadata Architecture

Complete | Optimized | Standardized | Hardened Database Platform

- **Standard Database Servers**
  - 8x 2-socket servers ➞ **192 cores**, 2TB DRAM
  - 2x 8-socket servers ➞ **160 cores**, 4TB DRAM

- **Unified Ultra-Fast Network**
  - 40 Gb InfiniBand internal connectivity ➞ **all ports active**
  - 10 Gb or 1 Gb Ethernet data center connectivity

- **Scale-out Intelligent Storage Servers**
  - 14x 2-socket servers ➞ **168 cores in storage**
  - 168 SAS disk drives ➞ **672 TB HC** or **200 TB HP**
  - 56 Flash PCI cards ➞ **44 TB Flash + compression**
Pre-built and Optimized Out-of-the-Box

Performance Achievement

100%

Performance Achievement

Assemble dozens of components

Measure, diagnose, tune and reconfigure

Multi-vendor finger pointing

Test & debug failure modes

Time (Days)

Time (Months)

Custom Configuration

100%

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Exadata Engineered System Transformation

Less Risk, Better Results

- Hundreds of engineer years spent optimizing and hardening the system end-to-end
  - Frees I/T talent to focus on business needs

- Standard platform improves support experience

- Runs all existing Oracle Database workloads

- Building block of the Oracle Cloud
Exadata Hardware
Exadata X4 Compared with X3
Much More Performance and Capacity – Same Price

X4 Storage

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2X Larger Physical Flash Memory</td>
<td>44 TB of Flash Memory</td>
</tr>
<tr>
<td>Up to 4X Larger Logical Flash Memory</td>
<td>88 TB using Flash Cache Compression</td>
</tr>
<tr>
<td>77% More Flash IOs/sec on X4-2</td>
<td>2.66M Reads, 1.96M Writes from SQL</td>
</tr>
<tr>
<td>33% Larger High Capacity Disks</td>
<td>672 TB using 4TB Disks</td>
</tr>
<tr>
<td>2X Larger High Performance Disks</td>
<td>200 TB using 1.2 TB Disks</td>
</tr>
</tbody>
</table>

X4-2 Compute

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% More Database Cores</td>
<td>192 Cores using 12-Core Xeon® CPUs</td>
</tr>
<tr>
<td>2X Larger DB Server Local Storage</td>
<td>2.4 TB per server using 600GB Disks</td>
</tr>
<tr>
<td>2X Faster InfiniBand</td>
<td>InfiniBand PCI-3 Card. All Ports Active</td>
</tr>
</tbody>
</table>

Per DB Machine Full Rack
# X4-2 Database Server

New 12-core “IvyBridge” CPUs, Faster InfiniBand Card, Larger Disks

<table>
<thead>
<tr>
<th>Processors</th>
<th>2 Twelve-Core Intel® Xeon® E5-2697 v2 Processors (2.7GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>256 GB (16 x 16GB) – Expandable to 512GB (16 X 32GB) via memory kits</td>
</tr>
<tr>
<td>Local Disks</td>
<td>4 x 600GB 10K RPM SAS Disks (Hot-Swappable)</td>
</tr>
<tr>
<td>Disk Controller</td>
<td>Disk Controller HBA with 512MB Cache – Battery Online Replaceable</td>
</tr>
<tr>
<td>Network</td>
<td>2 x InfiniBand 4X QDR (40Gb/s) Ports (PCIe 3.0) – Both Ports Active</td>
</tr>
<tr>
<td></td>
<td>4 x 1GbE/10GbE Base-T Ethernet Ports</td>
</tr>
<tr>
<td></td>
<td>2 x 10GbE Ethernet SFP+ Ports (1 Dual-port 10GbE PCIe 2.0 network card based on the Intel 82599 10GbE Controller technology)</td>
</tr>
<tr>
<td>Remote Management</td>
<td>1 Ethernet port (ILOM)</td>
</tr>
<tr>
<td>Power Supplies</td>
<td>Redundant Hot-Swappable power supplies and fans</td>
</tr>
</tbody>
</table>
# X4-2 Storage Server

6-core IvyBridge CPUs, Larger disks, Larger Flash Cards, Flash Compression

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processors</td>
<td>2 Six-Core Intel® Xeon® E5-2630 v2 Processors (2.6 GHz) - Faster clock</td>
</tr>
<tr>
<td>Memory</td>
<td>96 GB (4 x 8GB + 4 x 16GB) - More memory needed to manage larger flash</td>
</tr>
<tr>
<td>Disks</td>
<td>12 x 1.2 TB 10K RPM High Performance SAS (hot-swap) – 2.5” disk size OR 12 x 4 TB 7.2K RPM High Capacity SAS (hot-swap) – 3.5” disk size</td>
</tr>
<tr>
<td>Flash</td>
<td>4 x 800 GB Sun Flash Accelerator F80 PCIe Cards – Hardware Compression</td>
</tr>
<tr>
<td>Disk Controller</td>
<td>Disk Controller HBA with 512MB Cache - Battery Online Replaceable</td>
</tr>
<tr>
<td>Network</td>
<td>2 InfiniBand 4X QDR (40Gb/s) Ports (PCle 3.0) – Both Ports Active Embedded Gigabit Ethernet Ports for management connectivity</td>
</tr>
<tr>
<td>Remote Management</td>
<td>1 Ethernet port (ILOM)</td>
</tr>
<tr>
<td>Power Supplies</td>
<td>Redundant Hot-Swappabe power supplies and fans</td>
</tr>
</tbody>
</table>
# X3-8 Database Server

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processors</td>
<td>8 x Ten-Core Intel® Xeon® E7-8870 Processors (2.40 GHz)</td>
</tr>
<tr>
<td>Memory</td>
<td>2 TB (128 x16 GB)</td>
</tr>
<tr>
<td>Local Disks</td>
<td>8 x 300GB 10K RPM SAS Disks (Hot-Swappable)</td>
</tr>
<tr>
<td>Disk Controller</td>
<td>Disk Controller HBA with 512MB Battery Backed Cache</td>
</tr>
<tr>
<td>Network</td>
<td>8 x InfiniBand 4X QDR (40Gb/s) Ports (4 Dual-port PCE 2.0 Express Modules)</td>
</tr>
<tr>
<td></td>
<td>Two Network Express Modules (NEM), providing a total of</td>
</tr>
<tr>
<td></td>
<td>• 8 x 1GbE Ethernet Ports</td>
</tr>
<tr>
<td></td>
<td>• 8 x 10 GbE Ethernet SFP+ Ports (via 4 Fabric Express Modules (FEM) based Intel 82599 10GbE Controller technology)</td>
</tr>
<tr>
<td>Remote Management</td>
<td>1 Ethernet port (ILOM)</td>
</tr>
<tr>
<td>Power Supplies</td>
<td>Redundant Hot-Swappable power supplies and fans</td>
</tr>
</tbody>
</table>
Exadata Database Machine X4-2 Full Rack
Pre-Configured for Extreme Performance

• 8 Xeon-based Dual-processor Database Servers
  – 192 cores (24 per server)
  – 2 TB memory expandable to 4 TB (256 GB per server expandable to 512 GB)
  – 10 Gig E-connectivity to Data Center
    • 40 x 10Gb E-ports (5 per server)
• 44.8 TB High Speed Flash
• 14 Exadata Storage Servers X4-2
  – All with High Performance 12 x 1.2 TB SAS disks
  OR
  – All with High Capacity 12 x 4 TB SAS disks
• 2 Sun Datacenter InfiniBand Switch 36
  – 36-port Managed QDR (40Gb/s) switch
• 1 “Admin” Ethernet switch
• Redundant Power Distributions Units (PDUs)

Available in Smaller Configurations
Exadata Database Machine X3-8 Full Rack
Larger Database Servers with X4-2 Storage Servers

• 2 Xeon-based Eight-processor Database Servers
  – 160 CPU cores (80 per server)
  – 4 TB memory (2TB per server)
  – 10 GigE connectivity to Data Center
    • 16 x 10Gb E-ports (8 per server)
• 44.8 TB High Speed Flash
• 14 Exadata Storage Servers X4-2
  – All with High Performance 12 x 1.2 TB SAS disks
    OR
  – All with High Capacity 12 x 4 TB SAS disks
• 2 Sun Datacenter InfiniBand Switch 36
  – 36-port Managed QDR (40Gb/s) switch
• 1 “Admin” Ethernet switch
• Redundant Power Distributions Units (PDUs)

Add more racks for additional scalability
Exadata Storage Expansion X4-2 Full Rack

For additional storage – backups, historical data, unstructured data

- 18 Exadata Storage Servers X4-2
  - All with High Performance 12 x 1.2 TB SAS disks
  - OR
  - All with High Capacity 12 x 4 TB SAS disks

- 57.6 TB High Speed Flash

- 2 Sun Datacenter InfiniBand Switch 36
  - 36-port Managed QDR (40Gb/s) switch

- 1 “Admin” Ethernet switch

- Redundant Power Distributions Units (PDUs)

Add storage capacity to Database Machine online
Scalable from Eighth-Rack to Multi-Rack

Field Upgradeable - Supports Multiple Generations of Hardware
Seamless Upgrades and Expansions

Upgrade Example

- **X2-2**: Initial Quarter Rack deployed in 2011
- **X3-2**: Qtr to Half Upgrade in 2013
- **X4-2**: Half to Full Upgrade in 2014

- A single Database Machine can have servers from different generations
- Databases and Clusters can span across multiple hardware generations
- New software runs on older hardware
Operating System Updates in 11.2.3.3.0

- Oracle Linux distribution updated to 5.9
  - Including all recent security updates

- Linux kernel updated to UEK2 kernel (2.6.39-400)
  - Same kernel on database servers (2-socket and 8-socket) and the storage servers

- Oracle Solaris updated to S11 Update 1 SRU 9
## X4-2 Database Machine IO Performance from SQL

<table>
<thead>
<tr>
<th>Flash Cache</th>
<th>X4-2 Full Rack</th>
<th>X4-2 Half Rack</th>
<th>X4-2 Quarter</th>
<th>X4-2 Eighth</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQL Bandwidth(^1,^3)</td>
<td>High Cap Disk</td>
<td>100 GB/s</td>
<td>50 GB/s</td>
<td>21.5 GB/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>100 GB/s</td>
<td>50 GB/s</td>
<td>21.5 GB/s</td>
</tr>
<tr>
<td>Flash SQL IOPS(^2,^3)</td>
<td>8K Reads</td>
<td>2,660,000</td>
<td>1,330,000</td>
<td>570,000</td>
</tr>
<tr>
<td></td>
<td>8K Writes</td>
<td>1,960,000</td>
<td>980,000</td>
<td>420,000</td>
</tr>
<tr>
<td>Disk SQL Bandwidth(^1,^3)</td>
<td>High Cap Disk</td>
<td>20 GB/s</td>
<td>10 GB/s</td>
<td>4.5 G/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>24 GB/s</td>
<td>12 GB/s</td>
<td>5.2 GB/s</td>
</tr>
<tr>
<td>Disk SQL IOPS</td>
<td>High Cap Disk</td>
<td>32,000</td>
<td>16,000</td>
<td>7,000</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>50,000</td>
<td>25,000</td>
<td>10,800</td>
</tr>
<tr>
<td>Data Load Rate(^4)</td>
<td>20 TB/hr</td>
<td>10 TB/hr</td>
<td>5 TB/hr</td>
<td>2.5 TB/hr</td>
</tr>
</tbody>
</table>

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1. Bandwidth is peak physical scan bandwidth achieved running SQL, assuming no compression. Effective data bandwidth will be much higher when compression is factored in.

2. IOPS – Based on read IO requests of size 8K running SQL, typically with sub-millisecond latencies. Note that the IO size greatly effects flash IOPS. Others quote IOPS based on smaller IOs that are not relevant for databases and measure IOs using low level tools instead of SQL.

3. Actual Performance varies by application.

4. Load rates are typically limited by database server CPU, not IO. Rates vary based on load method, indexes, data types, compression, and partitioning.
Note on Compression and Measurements

- Note that all capacity and performance numbers are shown without including the benefits of compression
  - Compression rates very greatly by application and compression type
  - Therefore it is inaccurate to quote a single number for all users
  - Capacity and performance will greatly improve over the quoted numbers when compression benefits are factored in

- When comparing Exadata capacity and performance to other vendors note:
  - Many vendors (especially flash array vendors) quote capacity and performance assuming some rate of compression
  - Many vendors quote flash IOs per second running low level IO utilities and using very small blocks. These are several times higher than can be achieved using SQL.
  - All Exadata measurements are from SQL workloads using standard 8K block sizes
## X3-8 Database Machine IO Performance from SQL

<table>
<thead>
<tr>
<th></th>
<th>X3-8 Full Rack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flash Cache SQL Bandwidth</strong>&lt;sup&gt;1,3&lt;/sup&gt;</td>
<td>High Cap Disk  100 GB/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk 100 GB/s</td>
</tr>
<tr>
<td><strong>Flash SQL IOPS</strong>&lt;sup&gt;2,3&lt;/sup&gt;</td>
<td>8K Reads 1,500,000</td>
</tr>
<tr>
<td></td>
<td>8K Writes 1,000,000</td>
</tr>
<tr>
<td><strong>Disk SQL Bandwidth</strong>&lt;sup&gt;1,3&lt;/sup&gt;</td>
<td>High Cap Disk 20 GB/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk 24 GB/s</td>
</tr>
<tr>
<td><strong>Disk SQL IOPS</strong></td>
<td>High Cap Disk 32,000</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk 50,000</td>
</tr>
<tr>
<td><strong>Data Load Rate</strong>&lt;sup&gt;4&lt;/sup&gt;</td>
<td>16TB/hr</td>
</tr>
</tbody>
</table>

1 - Bandwidth is peak physical scan bandwidth achieved running SQL, assuming no compression. Effective data bandwidth will be much higher when compression is factored in.

2 - IOPS – Based on read IO requests of size 8K running SQL, typically with sub-millisecond latencies. Note that the IO size greatly effects flash IOPS. Others quote IOPS based on smaller IOs that are not relevant for databases and measure IOs using low level tools instead of SQL. Exadata Flash read IOPS are so high they are typically limited by database server CPU, not IO.

3 - Actual Performance varies by application.

4 - Load rates are typically limited by database server CPU, not IO. Rates vary based on load method, indexes, data types, compression, and partitioning.
## X4-2 Storage Expansion IO Performance from SQL

<table>
<thead>
<tr>
<th></th>
<th>X4-2 Full Rack</th>
<th>X4-2 Half Rack</th>
<th>X4-2 Quarter</th>
<th>X4-2 Single Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flash Cache SQL Bandwidth</strong>&lt;sup&gt;1,3&lt;/sup&gt;</td>
<td>High Cap Disk</td>
<td>130 GB/s</td>
<td>65 GB/s</td>
<td>29 GB/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>130 GB/s</td>
<td>65 GB/s</td>
<td>29 GB/s</td>
</tr>
<tr>
<td><strong>Flash SQL IOPS</strong>&lt;sup&gt;2,3&lt;/sup&gt;</td>
<td>8K Reads</td>
<td>3,420,000</td>
<td>1,710,000</td>
<td>760,000</td>
</tr>
<tr>
<td></td>
<td>8K Writes</td>
<td>2,520,000</td>
<td>1,260,000</td>
<td>560,000</td>
</tr>
<tr>
<td><strong>Disk SQL Bandwidth</strong>&lt;sup&gt;1,3&lt;/sup&gt;</td>
<td>High Cap Disk</td>
<td>26 GB/s</td>
<td>13 GB/s</td>
<td>6 GB/s</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>30 GB/s</td>
<td>15 GB/s</td>
<td>7 GB/s</td>
</tr>
<tr>
<td><strong>Disk SQL IOPS</strong></td>
<td>High Cap Disk</td>
<td>42,000</td>
<td>21,000</td>
<td>9,500</td>
</tr>
<tr>
<td></td>
<td>High Perf Disk</td>
<td>64,000</td>
<td>32,000</td>
<td>14,400</td>
</tr>
</tbody>
</table>

1 - Bandwidth is peak physical scan bandwidth achieved running SQL, assuming no compression. Effective data bandwidth will be much higher when compression is factored in.

2 - IOPS – Based on read IO requests of size 8K running SQL, typically with sub-millisecond latencies. Note that the IO size greatly effects flash IOPS. Others quote IOPS based on smaller IOs that are not relevant for databases and measure IOs using low level tools instead of SQL. Exadata Flash read IOPS are so high they are typically limited by database server CPU, not IO. This is especially true for expansion racks.

3 - Actual Performance varies by application.
# Database Machine Capacity (Uncompressed)

<table>
<thead>
<tr>
<th></th>
<th>X3-8 or X4-2 Full</th>
<th>X4-2 Half</th>
<th>X4-2 Quarter</th>
<th>X4-2 Eighth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw Flash Capacity(^1,4)</strong></td>
<td>44.8 TB</td>
<td>22.4 TB</td>
<td>9.6 TB</td>
<td>4.8 TB</td>
</tr>
<tr>
<td><strong>Effective Flash Capacity Due to Caching(^4)</strong></td>
<td>440 TB</td>
<td>220 TB</td>
<td>96TB</td>
<td>48TB</td>
</tr>
<tr>
<td><strong>Raw Disk Capacity(^1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>672 TB</td>
<td>336 TB</td>
<td>144 TB</td>
<td>72 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>200 TB</td>
<td>100 TB</td>
<td>43.2 TB</td>
<td>21.6 TB</td>
</tr>
<tr>
<td><strong>Usable Mirrored Capacity(^2,3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>300 TB</td>
<td>150 TB</td>
<td>63 TB</td>
<td>30 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>90 TB</td>
<td>45 TB</td>
<td>19 TB</td>
<td>9 TB</td>
</tr>
<tr>
<td><strong>Usable Triple Mirrored Capacity(^2,3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>200 TB</td>
<td>100 TB</td>
<td>43 TB</td>
<td>21.5 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>60 TB</td>
<td>30 TB</td>
<td>13 TB</td>
<td>6.3 TB</td>
</tr>
</tbody>
</table>

1 - Raw Disk Capacity defined using standard disk drive terminology of 1 TB = 1000 * 1000 * 1000 * 1000 bytes.
2 - Capacity calculated using normal space terminology of 1 TB = 1024 * 1024 * 1024 * 1024 bytes.
3 - Actual space available for a database after mirroring (ASM normal or high redundancy). For the ASM normal redundancy case, assume one disk (Quarter and Half) or two disks (Full Rack) of free space to automatically remirror after disk failures.
4 – Effective Flash Capacity is larger than the physical flash capacity and takes into account the high flash hit ratios due to Exadata’s intelligent flash caching algorithms, and the size of the underlying disk storage. It is the size of data files that often can be stored in Exadata and be accessed at the speed of flash memory.
Effective Flash Capacity for Typical Database Workloads

- Exadata flash cache delivers flash performance for data sets that are much bigger than the size of flash – often 10x bigger
  - 440 TB of effective flash on full rack
- Exadata Flash Cache automatically moves frequently accessed data into flash
  - With a very fine granularity and in real-time
  - Flash cache does not need to hold mirror copies
- Typical flash cache hit rates in 95% - 99% range when caching 10x as much disk space
- HCC and OLTP compression further increase effective flash capacity when measured in terms of user data in flash
## Storage Expansion Capacity (Uncompressed)

<table>
<thead>
<tr>
<th></th>
<th>X4-2 Full</th>
<th>X4-2 Half</th>
<th>X4-2 Quarter</th>
<th>X4-2 Single Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw Flash Capacity</strong>¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57.6 TB</td>
<td>28.8 TB</td>
<td>12.8 TB</td>
<td>3.2 TB</td>
<td></td>
</tr>
<tr>
<td><strong>Effective Flash Capacity Due to Caching</strong>⁴</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>570 TB</td>
<td>280 TB</td>
<td>128 TB</td>
<td>32 TB</td>
<td></td>
</tr>
<tr>
<td><strong>Raw Disk Capacity</strong>¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>864 TB</td>
<td>432 TB</td>
<td>192 TB</td>
<td>48 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>258 TB</td>
<td>129 TB</td>
<td>57 TB</td>
<td>14.4 TB</td>
</tr>
<tr>
<td><strong>Usable Mirrored Capacity</strong>²,³</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>387 TB</td>
<td>194 TB</td>
<td>85 TB</td>
<td>20 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>116 TB</td>
<td>58 TB</td>
<td>25 TB</td>
<td>6 TB</td>
</tr>
<tr>
<td><strong>Usable Triple Mirrored Capacity</strong>²,³</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cap Disk</td>
<td>260 TB</td>
<td>130 TB</td>
<td>58 TB</td>
<td>14.5 TB</td>
</tr>
<tr>
<td>High Perf Disk</td>
<td>78 TB</td>
<td>39 TB</td>
<td>17 TB</td>
<td>4.25 TB</td>
</tr>
</tbody>
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2 - Capacity calculated using normal space terminology of 1 TB = 1024 * 1024 * 1024 * 1024 bytes.
3 - Actual space available for a database after mirroring (ASM normal or high redundancy). For the ASM normal redundancy case, assume one disk (Quarter and Half) or two disks (Full Rack) of free space to automatically remirror after disk failures.
4 – Effective Flash Capacity is larger than the physical flash capacity and takes into account the high flash hit ratios due to Exadata’s intelligent flash caching algorithms, and the size of the underlying disk storage. It is the size of data files that often can be stored in Exadata and be accessed at the speed of flash memory.
## Exadata Database Machine Hardware Summary

<table>
<thead>
<tr>
<th></th>
<th>X3-8 Full</th>
<th>X4-2 Full</th>
<th>X4-2 Half</th>
<th>X4-2 Quarter</th>
<th>X4-2 Eighth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Servers</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Database Grid Cores</td>
<td>160</td>
<td>192</td>
<td>96</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td>Database Grid Memory (GB)</td>
<td>4096</td>
<td>2048</td>
<td>1024</td>
<td>512 (max 1024)</td>
<td>512 (max 1024)</td>
</tr>
<tr>
<td>InfiniBand switches</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ethernet switch</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Exadata Storage Servers</td>
<td>14</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Storage Grid CPU Cores</td>
<td>168</td>
<td>168</td>
<td>84</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td>Raw Flash Capacity</td>
<td>44.8 TB</td>
<td>44.8 TB</td>
<td>22.4 TB</td>
<td>9.6 TB</td>
<td>4.8 TB</td>
</tr>
<tr>
<td>Raw Storage Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>200 TB</td>
<td>200 TB</td>
<td>100 TB</td>
<td>43.2 TB</td>
<td>21.6 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>672 TB</td>
<td>672 TB</td>
<td>336 TB</td>
<td>144 TB</td>
<td>72 TB</td>
</tr>
<tr>
<td>Usable mirrored capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>90 TB</td>
<td>90 TB</td>
<td>45 TB</td>
<td>19 TB</td>
<td>9 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>300 TB</td>
<td>300 TB</td>
<td>150 TB</td>
<td>63 TB</td>
<td>30 TB</td>
</tr>
<tr>
<td>Usable Triple mirrored capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>60 TB</td>
<td>60 TB</td>
<td>30 TB</td>
<td>13 TB</td>
<td>6.3 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>200 TB</td>
<td>200 TB</td>
<td>100 TB</td>
<td>43 TB</td>
<td>21.5 TB</td>
</tr>
</tbody>
</table>
## Exadata Storage Expansion Rack Summary

<table>
<thead>
<tr>
<th></th>
<th>X4-2 Full</th>
<th>X4-2 Half</th>
<th>X4-2 Quarter</th>
<th>Single Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>InfiniBand switches</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Ethernet switch</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Exadata Storage Servers</td>
<td>18</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Storage Grid CPU Cores</td>
<td>216</td>
<td>108</td>
<td>48</td>
<td>12</td>
</tr>
<tr>
<td>Raw Flash Capacity</td>
<td>57.6 TB</td>
<td>28.8 TB</td>
<td>12.8 TB</td>
<td>3.2 TB</td>
</tr>
<tr>
<td>Raw Storage Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>258 TB</td>
<td>129 TB</td>
<td>57 TB</td>
<td>14.4 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>864 TB</td>
<td>432 TB</td>
<td>192 TB</td>
<td>48 TB</td>
</tr>
<tr>
<td>Usable mirrored capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>116 TB</td>
<td>58 TB</td>
<td>25 TB</td>
<td>6 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>387 TB</td>
<td>194 TB</td>
<td>85 TB</td>
<td>20 TB</td>
</tr>
<tr>
<td>Usable Triple mirrored capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Perf</td>
<td>78 TB</td>
<td>39 TB</td>
<td>17 TB</td>
<td>4.25 TB</td>
</tr>
<tr>
<td>High Cap</td>
<td>260 TB</td>
<td>130 TB</td>
<td>58 TB</td>
<td>14.5 TB</td>
</tr>
</tbody>
</table>
## Hardware Generational Advances

<table>
<thead>
<tr>
<th>Year</th>
<th>Storage (TB)</th>
<th>Flash (TB)</th>
<th>CPU (Cores)</th>
<th>Memory (GB)</th>
<th>Connectivity (Gb/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>168</td>
<td>0</td>
<td>64</td>
<td>256</td>
<td>8</td>
</tr>
<tr>
<td>V2</td>
<td>336</td>
<td>5.3</td>
<td>64</td>
<td>576</td>
<td>24</td>
</tr>
<tr>
<td>X2</td>
<td>504</td>
<td>5.3</td>
<td>96</td>
<td>1152</td>
<td>184</td>
</tr>
<tr>
<td>X3</td>
<td>504</td>
<td>22.4</td>
<td>128</td>
<td>2048</td>
<td>400</td>
</tr>
<tr>
<td>X4</td>
<td>672</td>
<td>44.8</td>
<td>192</td>
<td>4096</td>
<td>400</td>
</tr>
</tbody>
</table>

- **V1**: 2008
- **V2**: 2009
- **X2**: 2010
- **X3**: 2012
- **X4**: 2013
Exadata Innovations
Unique Software Optimizes Database Processing

- **Query offload in storage**
  - Data intensive query operations offloaded to storage CPUs
  - 100 GB/sec SQL data throughput
  - Storage Index data skipping

- **Database storage compression**
  - Hybrid Columnar for 10x DB size reduction and faster analytics

- **Database optimized PCI Flash**
  - Smart caching of database data
  - 2.66 Million Database IOs/sec
  - Smart Flash log speeds transactions

- **Database optimized QoS**
  - End-to-end prioritization from application to DB and storage

- **Database optimized availability**
  - Fastest recovery of failed database, server, storage or switch
  - Fastest backup. Incremental offload
  - Exachk top-to-bottom validation of hardware, software, settings

- **Database optimized messaging**
  - SQL optimized InfiniBand protocol for high throughput low latency SQL
Innovation Continues: Recent Enhancements

- **Query offload** in storage
  - Offload searches on LOBs (12c)
  - Offload joins for non-parallel queries (11.2.0.4)

- **Database optimized compression**
  - Hybrid Columnar enhanced for OLTP
  - and for Spatial and Text data (12c)

- **Database optimized PCI Flash**
  - Ultra high speed flash compression (X3 & X4) at multi-million IOs/sec
  - Automatic caching for table scans
  - Faster file initialization

- **Database optimized QoS**
  - Prioritization of CPU and IO by multitenant pluggable database (12c)

- **Database optimized availability**
  - Prioritize recovery of critical DB files (11.2.0.4)

- **Database optimized messaging**
  - End-to-End prioritization of critical database messages (11.2.0.4), including log writes and RAC
Exadata Intelligent Storage Grid

- **Data Intensive processing runs in Exadata Storage Grid**
  - Filter rows and columns as data streams from disks (168 Intel Cores)

- Example: How much product X sold last quarter
  - Exadata Storage Reads 10TB from disk
  - Exadata Storage Filters rows by Product & Date
  - Sends 100GB of matching data to DB Servers

- Scale-out storage parallelizes execution and removes bottlenecks
Simple Query Example

Oracle DB Grid

What were my sales yesterday?

Optimizer Chooses Partitions & Indexes to Access

Select sum (sales) where Date='24-Sept'

• 10 TB scanned
• 1 GB returned to servers

Exadata Storage Grid

• Scan compressed blocks in partitions / indexes
• Retrieve sales amounts for Sept 24
Exadata Intelligent Storage

- Exadata storage servers also run more complex operations in storage
  - Join filtering
  - Incremental backup filtering
  - I/O prioritization
  - Storage Indexing
  - Database level security
  - Offloaded scans on encrypted data
  - Data Mining Model Scoring

- 10x reduction in data sent to DB servers is common
Exadata is Smart Storage

- **Database Servers**
  - Perform complex database processing such as joins, aggregation, etc.

- **Exadata Storage Servers**
  - Storage Server is smart storage, not a DB node
  - Search tables and indexes filtering out data that is not relevant to a query
  - Cells serve data to multiple databases enabling **OLTP and consolidation**
  - Simplicity, and robustness of storage appliance
Exadata Storage Index
Transparent I/O Elimination with No Overhead

- Exadata Storage Indexes maintain summary information about table data in memory
  - Store MIN and MAX values of columns
  - Typically one index entry for every MB of disk
- Eliminates disk I/Os if MIN and MAX can never match “where” clause of a query
- Completely automatic and transparent

<table>
<thead>
<tr>
<th>Table</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>A B C D</td>
<td>A B C D</td>
</tr>
<tr>
<td>1</td>
<td>Min B = 1</td>
</tr>
<tr>
<td>3</td>
<td>Max B = 5</td>
</tr>
<tr>
<td>5</td>
<td>Min B = 3</td>
</tr>
<tr>
<td>5</td>
<td>Max B = 8</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Select * from Table where B<2 - Only first set of rows can match
Storage Index with Partitions Example

<table>
<thead>
<tr>
<th>Order#</th>
<th>Order_Date</th>
<th>Ship_Date</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2007</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2008</td>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2009</td>
<td>2009</td>
<td></td>
</tr>
</tbody>
</table>

- Queries on Ship_Date do not benefit from Order_Date partitioning
  - However Ship_date and Order# are highly correlated with Order_Date
  - e.g. Ship dates are usually near Order_Dates and are never less
- Storage index provides partition pruning like performance for queries on Ship_Date and Order#
  - Takes advantage of ordering created by partitioning or sorted loading
Storage Index with Joins Example

Select count(*) from fact, dim
where fact.m=dim.m and dim.name='Camry'

Dimension

<table>
<thead>
<tr>
<th>Name</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accord</td>
<td>1</td>
</tr>
<tr>
<td>Camry</td>
<td>3</td>
</tr>
<tr>
<td>Civic</td>
<td>5</td>
</tr>
<tr>
<td>Prius</td>
<td>8</td>
</tr>
</tbody>
</table>

Bloom filter constructed with min/max for M

Perform IO and apply bloom filter

Skip IO Due to Storage Index
Exadata Hybrid Columnar Compression
Highest Capacity, Lowest Cost

• Data is organized and compressed by column
  • Dramatically better compression

• Speed Optimized **Query Mode** for Data Warehousing
  • **10X compression typical**
  • **Runs faster because of Exadata offload!**

• Space Optimized **Archival Mode** for infrequently accessed data
  • **15X to 50X compression typical**

**Faster and Simpler**
Backup, DR, Caching, Reorg, Clone

Benefits Multiply
Compression Ratio of Real-World Data

Query Compression Ratio (Avg = 13x)

- Compression Ratio varies by customer and table
- Trials were run on largest table at 10 ultra large companies
  - Average revenue > $60 BB
- Average Query Compression ratio was 13x
  - On top of Oracle’s already highly efficient format
Exadata Smart Flash Cache

- Caches Read and Write I/Os in PCI flash
- Transparently accelerates read and write intensive workloads
  - Up to 2.66 million 8K read IOPS from SQL
  - Up to 1.96 million 8K write IOPS from SQL
- Persistent write cache speeds database recovery
- Exadata Flash Cache is much more effective than flash tiering architectures used by others
  - Caches current hot data, not yesterday’s
  - Caches data in granules 8x to 16x smaller than tiering
    - Greatly improves the effectiveness of flash
Exadata Flash Cache Compression

- Exadata uses compression to expand smart flash cache
  - Data automatically compressed as it is written to flash cache
  - Automatically decompressed when it is read out of flash cache
  - Up to 2X more data fits in smart flash cache, so flash hit rates will improve and performance will improve for large data sets

- Flash cache compress/decompress implemented in hardware
  - Performance is same as uncompressed – millions of I/Os per second
    - ZERO performance overhead
  - Supported on X3 or X4 storage servers (requires F40 or F80 cards)

- Note – Flash cache compression does not change DB format, so does not improve backups, buffer cache, network, scan rates, etc.
Exadata Flash Cache Compression

- As always, compression benefits vary based on data

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Typical Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncompressed Tables</td>
<td>1.3X to 4X</td>
</tr>
<tr>
<td>OLTP Compressed Tables</td>
<td>1.2X to 2X</td>
</tr>
<tr>
<td>Indexes</td>
<td>1.3X to 4X</td>
</tr>
<tr>
<td>Oracle E-biz uncompressed DB</td>
<td>3x to 5x</td>
</tr>
<tr>
<td>HCC Compressed Tables or Compressed LOBs</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

- X4 with flash cache compression stores up to 80TB of data in flash
  - Up to 4X more than X3 (depending on compressibility of data)

Many OLTP Databases will see 2x Flash Increase
Flash Cache Compression Commands

- Trivial to implement, no management
- Enable using simple cell command:
  - On X4 machines: alter cell flashCompression=TRUE
  - On X3 machines also run:
    - alter cell FlashCacheCompX3Support=TRUE
- Amount of data cached in Exadata Smart Flash Cache grows and shrinks dynamically and automatically based on data compressibility
- Monitor Flash Cache Compression using cell metric FC_BY_USED
  - Reported flash cache size will increase to up to double physical flash size
Exadata Smart Flash Table Caching

- Smarter flash caching for large table scans
  - Exadata software understands database table and partition scans and automatically caches them when it makes sense
  - Avoids thrashing flash cache when tables are too big or scanned infrequently or scanned by maintenance jobs
  - If scanned table is larger than flash, then subset of table is cached
  - No need to manually “KEEP” tables that are only scanned
Exadata Smart Flash Log
Accelerate Transaction Response Times Using Flash

- Choppy Response
- High Outliers

Smart Flash Log
- 3x faster response
- Much lower outliers

- Uses Flash for Database Logs in a clever way
  - Flash is fast but has slow outliers
- Smart Flash Log feature transparently uses Flash as a parallel write cache to disk controller cache
  - Whichever write completes first wins (disk or flash)
- Better response time and more throughput
- Uses almost no flash capacity (0.1% of capacity)
Exadata Flash Performance Scales Linearly

Storage Array Architecture Limits Flash Performance

- Exadata scales using
  - True Scale-Out
  - InfiniBand
  - Smart Storage

Query Throughput
Gigabytes per Second

Storage Array
Exadata

4 to 13

100
Extreme Performance and Low Cost

- **Extreme Performance dramatically lowers cost**
  - Workloads that require huge traditional systems run on small Exadatas
  - Hardware needed for an application is often reduced 10x

- **Exadata also delivers Extreme Capacity**
  - Huge disk footprint for large or less active data
    - 672 TB of disk per rack for historical data, low activity data, images, documents, backups, etc.
  - Columnar compression expands disk and memory capacity 10x
  - Blend of tiers gives highest performance at lowest cost
    - Placing all data in DRAM would cost $20M just for chips
Business Benefits of X4 Database Machine

- Sub-millisecond latency
  - Interactive OLTP with millions of users

- Sub-second analytics
  - Real-time decision making, instant reports

- 10x faster parallel jobs
  - Quarter close, payroll, supply planning, field inventory, pricing, route planning, sub-ledger accounting
Exadata Network Resource Management

- Exadata Network Resource Management uniquely prioritizes critical database messages through the entire fabric
  - From database to InfiniBand card through InfiniBand switches to storage
  - Latency sensitive messages prioritized over batch, reporting, and backup messages
  - Log file writes have highest priority to ensure low latency transactions
- Combines with Exadata CPU and IO Resource management to ensure safe consolidation of workloads and databases
- Completely automatic & transparent

![Graph showing performance comparison with and without Network Resource Management](chart.png)

**Without Network RM, OLTP performance drops when a network intensive workload is**

**Network Resource Management maintains steady performance**

DB Version 11.2.0.4 or 12c, Switch 2.1.3-4
**Exadata I/O Resource Management**

**Mixed Workloads and Multi-Database Environment**

- Ensure different databases are allocated the correct relative amount of I/O bandwidth
  - Database A: 33% I/O resources
  - Database B: 67% I/O resources
- Ensure different users and tasks within a database are allocated the correct relative amount of I/O bandwidth
  - Database A:
    - Reporting: 60% of I/O resources
    - ETL: 40% of I/O resources
  - Database B:
    - Interactive: 30% of I/O resources
    - Batch: 70% of I/O resources
Secure Database Machine
Complete Security Portfolio

Near-Zero Overhead for fully encrypted database!
- Application transparent
- Decryption in hardware, not software (5x faster)

PREVENTIVE
- Encryption
- Redaction and Masking
- Privileged User Controls

DETECTIVE
- Activity Monitoring
- Database Firewall
- Auditing and Reporting

ADMINISTRATIVE
- Privilege Analysis
- Sensitive Data Discovery
- Configuration Management

Legal
HR
Finance
Comprehensive Database as a Service Platform

- **Scale-Out Platform optimized for** Database
  - Scale to any size

- **Deploy 100s of databases**
  - Using separate databases or 12c multitenant databases

- **Supports complex & varying mix of workloads**
  - No Performance Bottlenecks
  - Performance Isolation – CPU, I/O, Network
No Performance Bottlenecks for Consolidation

- Best way to ensure performance is to avoid bottlenecks
- Exadata has unique extreme performance for complex workloads that mix OLTP, DW, batch, reporting
  - Millions of I/Os per second, 100 GB/sec of throughput
  - Sub-millisecond response times
  - Highest bandwidth network
- Unique software optimizations that eliminate bottlenecks
  - e.g. Storage Offload, Smart Flash logging
Unique Performance Isolation for Consolidation

- Database Resource Manager provides CPU resource management for normal and pluggable databases
  - Both CPU prioritization and limits on CPU usage
- Exadata uniquely provides I/O resource management by pluggable database, job, user, service, etc.
- Exadata uniquely provides database aware network resource management
  - Prioritizes critical DB messages through entire fabric
Exadata Storage Server Software

12.1.1.1.0

Available on all systems except V1
Exadata Storage Server 12.1.1.1.0

- Supports Database 12c Smart Scan offload
- Supports IORM for Database 12c pluggable database

Cell-to-cell Data Transfer
- With Database 12c, offload data movement for ASM operations like resynchronization, resilver, and rebalance
- Cells transfer data directly to destination cell without going through the database server
Support for Multiple DB versions on Exadata

- Exadata Systems can run a mix of 11.2 and 12.1 databases
- Different offload server process for each DB version
  - Matches DB libraries
- Offload server startup/shutdown/restarts automatic
- Offload server communicates only to cellsrv
Exadata Management
Exadata Storage Management & Administration

- Enterprise Manager
  - Manage & administer Database and ASM
  - Monitor the Exadata Database Machine Hardware

- Auto Service Request (ASR)
  - File SRs automatically for common hardware faults

- Comprehensive CLI
  - Local Exadata Storage cell management
  - Distributed shell utility to execute CLI across multiple cells

- Embedded Integrated Lights Out Manager (ILOM)
  - Remote management and administration of hardware
Enterprise Manager 12c
Integrated H/W + S/W management for Exadata

- **Hardware view**
  - Schematic of cells, compute nodes and switches
  - Hardware components alerts

- **Software/system view**
  - Performance, availability, usage by databases, services, clusters
  - Software alerts db, cluster, ASM
  - Topology view of DB systems/clusters

- **Configuration view**
  - Version summary of all components along with patch recommendations
Automated Service Request (ASR)

Comprehensive Fault Coverage
- CPU
- Disk controllers
- Disks
- Flash Cards
- Flash modules
- InfiniBand
- Cards
- Memory
- System Board
- Power supplies
- Fans

Fault occurs

Product's auto-diagnosis facility sends SNMP trap to ASR Manager

Service Request created

SR routed to Support Engineer

Fault telemetry securely transmitted to Oracle

SR creation email notification to customer

FRU replaced by Field Engineer

Oracle Field Engineer

Oracle Support Services

Customer Data Center
Platinum Support for Exadata

- **24/7 support**
- **Specialized Engineered Systems Support Team**
- **2-hour onsite response** to hardware issues\(^1\)
- **New Updates and Upgrades for** Database, Server, Storage, and OS software
- **My Oracle Support** proactive support portal
- **"Phone home"** automated service requests (ASR)

**ORACLE PLATINUM SERVICES**

- Better support for the complete Oracle stack
  - Includes higher support levels for Database software
- **Proactive remote monitoring for faults**
- **Industry leading service level response times:**
  - 5 Minute Fault Notification
  - 15 Minute Restoration or Escalation to Development
  - 30 Minute Joint Debugging with Development
- **Oracle Engineers perform quarterly patching and updates**

Available for [certified configurations](#) on Exadata

\(^1\) Covered system must be within an Oracle two-hour service area to receive two-hour response as a standard service.
Exadata Maximum Availability Architecture

Comprehensive protection from failures
Server – Storage – Network – Site – Corruptions

Active Disaster Recovery: Real-time standby open for query offload
Correction from human errors: database, table, row, transaction
Online indexing and table redefinition
Online patching and upgrades
Exadata Comparisons and Customer Use Cases
PayPal: Real-Time OLTP

**Benefits**

- Faster Applications: 10x Faster Overall
- Reduced Risk Exposure: 99.99% Analysis
- Maximum Availability: 99.99%
- Increased Payment Volume: 200% Increase

**“We chose Oracle Exadata to help keep us nimble by delivering a response time of less than 100ms over petabytes of data.”**
- Sehmuz Bayhan, CTO PayPal

**Objectives**

- Analyze 100% of payments for risk in < 100 milliseconds
- 99.999% uptime
- 2x increase in transaction volume

**Solution**

- 3 Pods, each with two X2-8’s plus two X2 Storage Expansion Racks, and Active Data Guard to identical standby configuration

<table>
<thead>
<tr>
<th>2x Exadata X2-8</th>
<th>2x Exadata X2-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x Storage Expansion</td>
<td>2x Storage Expansion</td>
</tr>
<tr>
<td>Production (Primary Data Center)</td>
<td>Standby (DR Data Center)</td>
</tr>
</tbody>
</table>

- 24 Exadata Systems in total, across 3 “pods”
- 120 TB database
  \[X \times 3 = 360 \text{ TB total}\]
- 300,000+ executions per second
- 40 ms (avg) response times (99.99%)
### VocaLink: OLTP Performance

#### Objectives
- Enable real-time enquiries against transaction data
- Process 20 million financial transactions/day
- Sub-second response time
- Zero data loss DR protection

#### Solution
- Two Quarter-rack Exadata V2 systems - Oracle Maximum Availability Architecture

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Fast and Scalable Performance</th>
<th>Zero Unplanned Downtime</th>
<th>More Capacity</th>
<th>Zero Data Loss DR Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Our critical electronic payments service has been live on Exadata since early 2011 with 100% uptime. The service reliably processes the transfer of billions of Euros per week and achieves subsecond response times for online enquiries.&quot; - Martin McGeough, Database Technical Architect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\leq 540$ ms response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 million transactions/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Pre-Exadata
- 4 ProdServers, 2 SANs

#### Exadata V2
- Quarter Rack

- **2011**
- **Active Data Guard**
- **Synchronous Zero Data Loss**

- Electronic Payment System
- Mixed workload, high volume OLTP and batch processing

- Performance boost with no application change using Exadata Smart Flash Cache and Smart Scan

- Zero RPO, 15 minute RTO
- Auto block repair
- Standby-first maintenance

**Exadata test system**

**Benefits**
- Zero Unplanned Downtime
- Fast and Scalable Performance
- Zero Data Loss DR Protection
- More Capacity

**Electronic Payment System**
- Mixed workload, high volume OLTP and batch processing

**OLTP and batch processing**

**2011**

**Active Data Guard**
- Synchronous Zero Data Loss

**Exadata V2**
- Quarter Rack

**Zero RPO, 15 minute RTO**
- Auto block repair
- Standby-first maintenance
## U.S. Customs and Border Protection

### Objectives
- Real-time processing and monitoring of all cargo and every passenger crossing the US border
- Shrink data center costs

### Solution
- 2010: Implement V2, X2-2
- 2011: Add X2-2, X2-8
- 2012: Add X2-8, Exalogic

### Benefits

<table>
<thead>
<tr>
<th>Faster Applications</th>
<th>Storage Savings</th>
<th>Maximum Availability</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>10X speedup</td>
<td>1 Petabyte</td>
<td>99.95%</td>
<td>75% Cost Reduction</td>
</tr>
<tr>
<td>32 billion queries/day</td>
<td>Replaced $$ SAN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Exadata

- **Exadata V2 Primary/Standby**
- **Exadata X2-2 Primary/Standby**
- **Exadata X2-8 Primary/Standby**

### Oracle Exadata Quote

"Oracle Exadata has changed our strategic IT focus from building systems to developing and supporting services."

- Ken Ritchhart, Deputy Assistant Commissioner

### Exadata Systems

- Automated Targeting Systems
- Automated Export Systems
- Passenger & Cargo Systems
- Enterprise Data Warehouse

---

---
Oracle Beehive: Collaboration

Objectives
- Company-wide collaboration for > 100K users
- CPU/ storage growth 3+ years
- Improved response times
- Guarantee uptime

Solution
- 2009: Move Beehive storage to Exadata V1 storage
- 2011: Migrate to Exadata X2-2

Benefits
- Faster Response: 5x – 60x
- 100% Uptime
- Capacity for Growth

"Beehive is our largest application in-house. It is Oracle’s largest backend database."
- Campbell Webb, Vice-President IT, Oracle

Exadata V1 Storage Servers
- 96 V1 storage servers
- Post-Sun acquisition, CPU and disk oversubscribed

Exadata X2-2 Production
- Austin (Texas) Data Center
- 9 full-rack X2-2
- 2.3 Petabytes raw disk
- 48 TB flash
- > 5,000 peak TPS

Data Guard

Exadata X2-2 Standby
- Utah Data Center
- 9 full-rack X2-2
- Triple mirroring
- Disk backups/flashback enabled
- 100% uptime since go-live

"Beehive is our largest application in-house. It is Oracle’s largest backend database."
- Campbell Webb, Vice-President IT, Oracle
## Turkcell: DW and DB Consolidation

### Objectives
- Speed up BI
- Lean, green data center
- Prepare for big data growth

### Solution
- **2010**: Replace 11 racks with 1 full-rack Exadata V2 for DW
- **2011**: Add 2 full-rack Exadata X2-2s for DB consolidation

---

### Benefits

<table>
<thead>
<tr>
<th>Faster Reports</th>
<th>Storage Savings</th>
<th>Reduced Admin</th>
<th>Data Center Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10X</strong></td>
<td><strong>900 TB</strong></td>
<td><strong>20%</strong></td>
<td><strong>80% Less Power</strong></td>
</tr>
<tr>
<td>27 min to 3 min (avg for 50k rpts)</td>
<td>1,000 TB to 100 TB</td>
<td></td>
<td><strong>30 m² Less Space</strong></td>
</tr>
</tbody>
</table>

“In a word, Oracle Exadata is fantastic. Almost no report takes more than 10 minutes to run, versus hours before. It sounds unreal, but it’s real.”
- Power User, Finance Department, Turkcell

---

### Pre-Exadata Data Warehouse
- Hitachi USP-V 5 Racks
- 250 TB Raw Data

### Exadata V2 Data Warehouse
- EMC DMX-4 5 Racks
- 25 TB Compressed

### 2 Exadata X2-2 Prod
- 2010
  - 2 Prod Databases
  - 600 TB Raw / 60 TB Compressed
  - 16-node RAC Cluster
- 2011
  - 4 Prod, 2 Test Databases
  - 400 TB Raw / 40 TB Compressed
  - 2 RAC Clusters

---

### Data Center Cost Savings
- 80% Less Power
- 30 m² Less Space

---

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SK Telecom: Revenue Assurance DW

Benefits

“Oracle Exadata Database Machine has overwhelmingly superior performance, with average data processing rates 8 to 20 times greater than other SK Telecom in-house systems.”

- Jin-hyung Lee, Manager, Network Engineering Department, SK Telecom

<table>
<thead>
<tr>
<th>Extreme Capacity</th>
<th>Storage Savings</th>
<th>Capture Lost Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>18+ TB/day</td>
<td>1620 TB</td>
<td>$ Millions</td>
</tr>
<tr>
<td>1800 TB to 180 TB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Business Objectives

- Ensure billing accuracy
- Enhance customer service
- Predict data traffic trends

Solution

- 2009: Create new DW on Exadata
- 2010: Move to full-rack Exadata V2
- 2011: Add full-rack Exadata X2-2
- 2012: Clustered 3 full racks

Exadata V1
Data Warehouse
(2009)

- Billing Analysis System

Exadata V2
Data Warehouse

- Billing Analysis System
- Usage & Roaming Inquiries

Exadata V2+ two X2-2
Data Warehouse

- Raw Data 1800 TB
- Compressed to 180 TB
- DB size: 350 TB with indices
- 24-node RAC, 42 Exadata Cells

Exadata X2-2
Qtr Rack (2010)

- Spam Filtering

Capture Lost Revenue

1800 TB to 180 TB

Oracle Exadata Database Machine has overwhelmingly superior performance, with average data processing rates 8 to 20 times greater than other SK Telecom in-house systems.”

- Jin-hyung Lee, Manager, Network Engineering Department, SK Telecom
## Organic Food Retailer: OLTP Consolidation

### Objectives
- Consolidate all OLTP databases to simplify and standardize management and reduce costs
- One vendor to call for support

### Solution
- 2011: Consolidate 14 servers onto two Qtr-rack Exadata X2-2

### Benefits

<table>
<thead>
<tr>
<th>Faster Applications</th>
<th>Uniform HA/DR</th>
<th>Simplified Support</th>
<th>Data Center Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 20X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

```
“One number for me to call; no more forwarding phone calls and email between vendors when we are digging into an issue.”
- DBA Team Leader
```

### Pre-Exadata
- 14 Legacy Servers
- 3 O/S Versions
- 18 Oracle Databases
- 5 Oracle DB Versions
- 12 Application Teams

### Exadata X2-2 DB Consolidation
- PeopleSoft HR
  - Ordering
  - Timekeeping
- Decision Support
- Many other applications

### Exadata X2-2 Dev/Test

---

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P&G: DW and Mixed Workload

Objectives
- Improve stability and supportability
- Lower costs
- Boost performance

Solution
- 2010: Implement 1st DW on V2
- 2011: Move 2nd DW to X2-2, Move OLTP/Analytics to X2-2
- 2012: Move 3rd DW to X2-8

Benefits

*Performance with Exadata is much better, and getting an out-of-the-box solution dramatically reduced the time and money to build and maintain our DW platform.*
- Brian Beckman, DW Platform Manager, Procter & Gamble

<table>
<thead>
<tr>
<th>Faster Applications</th>
<th>Storage Savings</th>
<th>Simplified Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 30X</td>
<td>3x – 10x</td>
<td>Compression</td>
</tr>
</tbody>
</table>

Exadata V2 Data Warehouse
- Trade/Mkt/POS Data
- Prod
- Non-Prod

Exadata X2-2 Data Warehouse
- Shipments Data
- Prod
- DR
- Dev
- UAT

Exadata X2-8 Data Warehouse
- Fin’l/Planning Data
- Prod
- Non-Prod

Exadata X2-2 OLTP/Analytics
- Trade Fund Management
- Prod
- Non-Prod
## Objectives
- Reduce cost and complexity
- Deploy Oracle E-Business Suite quickly
- Dramatically improve performance and availability

## Solution
- X2-2 for production E-Bus Suite
- X2-2 for Standby DR and test/QA
- Database Appliance for testing

## Benefits
- **Faster Applications**
  - 5X+ Speedup
- **Reduced TCO**
  - 50%
- **Maximum Availability**
  - 99.95%
- **Data Center Cost Savings**
  - Reduced TCO 50%

## Benefits Quote
“Oracle Exadata has enabled us to deliver exceptional service to our business users while reducing the cost involved. Exadata has been a big win for our business and for IT.”
- Saul Hernandez, CIO

## Pre-Exadata (Hosted)
- IBM x86 Servers
- 3 O/S Versions

## Exadata X2-2 DB Consolidation
- Production
- E-Business Suite

## Oracle Database Appliance Dev/Test
- Disaster Protection
- Test and QA

---

### Pre-Exadata

- IBM x86 Servers
- 3 O/S Versions

### Exadata X2-2 DB Consolidation

- Production
- E-Business Suite

### Oracle Database Appliance Dev/Test

- Disaster Protection
- Test and QA

---

**Oracle Exadata has enabled us to deliver exceptional service to our business users while reducing the cost involved. Exadata has been a big win for our business and for IT.”**
- Saul Hernandez, CIO

---

**Oracle Exadata has enabled us to deliver exceptional service to our business users while reducing the cost involved. Exadata has been a big win for our business and for IT.”**
- Saul Hernandez, CIO
Garmin: OLTP Consolidation

### Objectives
- Support 400% growth in customer facing applications
- Eliminate bottlenecks in Manufacturing and Planning
- Consolidate to reduce costs

### Solution
- 2012: Consolidate 12 servers onto two Half-rack Exadata V2
- 2012: Add two Half-rack X2-2 systems, two Qtr-rack storage expansion

### Benefits

<table>
<thead>
<tr>
<th>Faster Month End Reports</th>
<th>99.95% Uptime</th>
<th>4x Growth</th>
<th>Data Center Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 11X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Consolidation on Exadata reduced costs and eliminated critical performance bottlenecks in our Manufacturing and Planning systems”
- Ed Link, Vice-President IT, Garmin

- 4x Growth
- Faster Month End Reports
- 99.95% Uptime
- Data Center Cost Savings

### Exadata V2 DB Consolidation
- EBS, ASCP, Hyperion DB Consolidation
- Data Guard
- High-Capacity Exadata Storage Servers

- Exadata V2 Dev/Test/Local Standby
- Data Guard
- Archived Data

- Exadata X2-2 Dev/Test/Local Standby
- Data Guard
- Archived Data

- Pre-Exadata 12 Prod Servers
- Oracle E-Business Suite
- Advanced Supply-Chain Planning
- Hyperion Reporting
- Garmin Connect custom app

- Exadata X2-2 Garmin Connect
- Half-rack Exadata
- Qtr-rack Storage Expansion
Lion: SAP on Exadata and Consolidation

**Benefits**

“Exadata has always high performance. Data Compression is also wonderful result. It is best consolidation database platform. Also, thanks to careful planning and verification, it was smooth without any major problems as a project.”

- Masatoshi Utsunomiya, Director, Integration system department, Lion

**Business Objectives**

- Reduce TCO
- Improve Operation and Maintenance Cost
  - Standardize the environment

**Solution**

2010: Project start Exadata V2 Quarter Rack
2012: Software Upgrade X2-2 SAP DB Consolidation

- **Mainframe Migration**
  - Sales/Logistics, Master Data Cost Mgmt, Sales Analytics
  - Migrated Aug 2012

- **SAP Database Migration**
  - SAP FI (from Linux)
  - Consolidate 3 systems
  - Compress 1400 GB to 700 GB
  - Migrated May 2012

- **Teradata DWH Migration**
  - Compress 320GB to 60GB
  - Migrated Mar 2013

- **Operation Cost Savings**
  - SAP FI: 2x
  - Teradata: Over 5x
  - Avg. up to 20x

- **Storage Savings**
  - Max. up to 100x

- **Faster Application**
  - Max. up to 100x

- **Oracle Exadata Quarter Rack**
- DWH used HCC, SAP used Advanced Compression
- Delete useless index of Teradata
### Business Objectives

- Eliminate server proliferation
- Provide consistent service levels
- Free up redundant administrators
- Standardize roles and permissions

### Solution

- Consolidate 40 DB servers onto 2 Exadata X2-2 Half-Racks
- Create a standard Schema-as-a-Service with 150+ schemas in 8 databases, serving all departments

### Server Consolidation

- 40 servers → 2 Exadata
- 235 databases → 29

### Reduced Administration

- 5 DBAs → 3

### Standardized Configurations

- Security, Backup, HA/DR

---

“We consolidated dozens of database servers onto Exadata and freed up many of our admins for more strategic tasks. Standardizing our database services and configurations has yielded benefits across many dimensions.”

- Andy Wattenhofer, Database Administration Manager, University of Minnesota

---

![Exadata X2-2 Half-Rack Diagram](https://example.com/exadata_diagram.png)
CBA: DBaaS

**Business Objectives**
- Cost Savings
- Rapid Provisioning
- Extreme Standardization

**Solution**
- Exadata for
  - Rapid, reliable deployments
  - Standardized environments

---

**Benefits**

<table>
<thead>
<tr>
<th>OPEX</th>
<th>ROI</th>
<th>Rapid Provisioning</th>
<th>Simplified Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>50~60% reduction</td>
<td>150% in 5 years</td>
<td>Months to Minutes</td>
<td>Two Oracle Homes</td>
</tr>
</tbody>
</table>

"As the business seeks more services on demand, we needed to provide that resilient platform and Exadata provides us a consolidated platform for database services that can meet all those needs”
- Nicolas Tan, Head, Infrastructure and Platform Services

---

"Rapid, reliable deployments
Standardized environments"
## Major Semiconductor Company: Manufacturing Data Warehouse

### Business Objectives

- Improve yield management by correlating data across fabs
- Reliability, availability, scalability
- Reduce support costs and improve serviceability
- Lower data center costs

### Solution

- **2013:** 2 x X3-8 Full Rack; X3-2 Half Rack; 2 x ZFS Storage

### Benefits

<table>
<thead>
<tr>
<th>Faster Applications</th>
<th>Data Center Cost Savings</th>
<th>Storage Savings</th>
<th>Reduced Admin Serviceability</th>
</tr>
</thead>
</table>
| • 10-15 x Faster Data Load  
• 5-50x Faster Queries | 5x Less Hardware  
80% Less Power | ~ 9 x Data Compression | 40% Savings  
Single Patch Platinum Services |

**“Exadata transformed production data analysis. Exadata improved performance better than 5x and reduced costs by more that 50.”**

### Pre-Exadata Data Warehouse (2012)

- 63 HP DL 580
- 7 identical DWs (1 per fab)  
- 63 servers, 14 storage racks

### Exadata X3-8 Data Warehouse

- 2013
- ZFS 7420 Backup Appliance  
- 7 production DBs

### Exadata X3-8 Active Data Guard

- ZFS 7420 Backup Appliance  
- DR and additional reporting  
- Stdby 1st patches & rolling upgrades

### Exadata X3-2 Half Rack Dev/Test

- Oracle Platinum Services

**EMC DMX-4  
14 Racks**

**WAN @1,300 miles**
Deutsche Bank: Financial DW

**Business Objectives**

- Disclosure
- RWA (Basel I / II)
- EC / EL / GVA
- Daily Derivatives
- Many more

**Solution**

- Establish real-time credit risk, regulatory law, and internal management reporting to optimize credit risk analysis, as the ability to perform daily analyses of risk ratios is increasingly important

---

**Benefits**

- Extreme Usage: 1000s of users
- Storage Savings: 75%
- Started to add Big Data

“With the implementation of Oracle Exadata Database Machine, data processing performance improved significantly, and the bank acquired the ability to analyze increasing data volume in much shorter cycles. In addition, compressing the data volume by 75% reduced electrical usage and costs.”

- Marcus Prätzas, Head FDW, Deutsche Bank

---

**Oracle Database Exadata ODM**

**Data Layer**

ODM 2.8 (PRD-1) DR Sync by Database ODM 2.8 (PRD-2) ODM 2.8 (UAT) ODM 2.0 (UAT/DEV)
Loblaw: JDA on Exadata

**Benefits**

- “Exadata is fast. We achieved 6x performance improvements over our existing platform in our forecasting and replenishment batch run, enabling our store level forecasting to complete consistently within SLA and scaling up seamlessly to full volume without performance degradation”.  
  - David Markwell, VP of IT, Technology Services Management

<table>
<thead>
<tr>
<th>Faster Applications</th>
<th>Operation Cost Savings</th>
<th>Simplified Support</th>
<th>Data Center Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5X - 6X</td>
<td>Reduced Admin by 40%</td>
<td>1 Week Deployment</td>
<td>80% Less Power 30 m² Less Space</td>
</tr>
</tbody>
</table>

**Objectives**

- Eliminate Bottlenecks in Supply Chain Planning
- Reduce the long running batch window
- Reduce support time and cost

**Solution: 2013**

- 2013: Migrated from IBM-P7 to X2-8 for production.
- X2-2+ for DR (using Active Data Guard.) and Dev/Test

**Pre-Exadata**

- IBM P7
- Hitachi USP V w/ SSDs

**Exadata X2-8 Production**

- JDA (Supply Chain Planning)
- Performance boost with no application change using Exadata Smart Flash Cache and Smart Scan

**Exadata X2-2+X3-2 Disaster Recovery**

- ½ rack: X2-2 ¼ rack upgraded with X3-2 ¼ rack

**Exadata X2-2+ X3-2 Dev/Test**

- ½ rack: X2-2 ¼ rack upgraded with X3-2 ¼ rack

**Turning 2nd Day Delivery into Next Day Delivery**
Starwood: DW and Mixed Workload

**Business Objectives**
- Improve application response time
- More current reports
- More responsive marketing

**Solution**
- 2011: X2-2 full rack for prod and DR
- 2013: full Storage Expansion Rack; 2 x ZFS Backup Appliance

**Benefits**

<table>
<thead>
<tr>
<th>Faster Reports</th>
<th>Faster ETL</th>
<th>Simplified Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>14X</td>
<td>16 hours to 3</td>
<td>Single Vendor &gt; 25% cost reduction</td>
</tr>
</tbody>
</table>

“14x performance improvements enable our field managers to take proactive actions not possible before. Reporting with ‘real time’ data is rapidly becoming the expectation at Starwood.”
Gordon Light, Sr. Dir., Datawarehouse, Starwood

---

**Pre-Exadata (2011)**
- 2 servers @128 cpu each
- DR: RMAN to disk, NetBackup to tape
- 45 TB on 2 frames
- DB 10.2
- HA: RAC; DR SRDF

**Exadata X2-2 Full Rack Production Dev/Test**
- Apps: Loyalty program; marketing & revenue analytics
- DB 11.2

**Exadata X2-2 Full Rack Disaster Recovery**
- Offsite reporting
- RMAN to ZFS; ZFS-ZFS

**Faster Reports**
- 14X

**Faster ETL**
- 16 hours to 3

**Simplified Support**
- Single Vendor
- > 25% cost reduction

**Storage Expansion**
- 2011
- Storage Expansion
- 2013
- Remote Backup
- WAN @ 2,700 miles

---

**2011**
- WAN @ 2,700 miles
- Faster Reports
- 14X

**2013**
- Faster ETL
- 16 hours to 3
- Simplified Support
- Single Vendor
- > 25% cost reduction

---

**2011**
- WAN @ 2,700 miles
- Faster Reports
- 14X

**2013**
- Faster ETL
- 16 hours to 3
- Simplified Support
- Single Vendor
- > 25% cost reduction
WestJet: Siebel on Exadata

Business Objectives
- Consolidate DBs
- Consistency of performance
- Availability, especially during rolling upgrades
- Time to market
- Lower data center costs

Solution
- 2013: 3 x X2-2s ¼ Rack

Benefits
- Faster Response: 19x – 260x
- Data Center Cost Savings: 18 servers → 2 Exadata
- Reduced Admin Serviceability: 70% Savings Single Patch Platinum Services
- Zero Unplanned Downtime

"WestJet consolidated 16 databases while delivering exceptional and consistent performance to our online ticketing, customer rewards and loyalty programs. Performance is at least 19 times faster. “ -Kris Trzesicki, DBA, WestJet

Pre-Exadata (2012)
- HP Unix (2) + 23+ x64 servers
- DB 11g R1

Exadata X2-2 DB Consolidation
- Siebel, OBIEE, Booking & Notification, + other
- DB 11gR2
- Consolidated 16 DBs
- 1/2 rack: ¼ staging and ¼ prod’n

Exadata X2-2 Active Data Guard
- DR: ¼ rack

Dev/Test
- HP EVA Storage
- HP Unix
- EVA Storage
- Exadata X2-2
- Oracle Platinum Services
- Faster Response
- Reduced Admin Serviceability
- Zero Unplanned Downtime

Reduced Admin Serviceability
- 70% Savings Single Patch Platinum Services
- Single Patch
- Zero Unplanned Downtime

Faster Response
- 19x – 260x
- 18 servers → 2 Exadata

Oracle Platinum Services
- HP EVA Storage
- HP Unix
- Exadata X2-2
- Faster Response
- Reduced Admin Serviceability
- Zero Unplanned Downtime

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## Benefits

"Oracle Exadata enabled us to support more users with much better response time while at the same time improving uptime for our core banking OLTP system."

- Serdar Mutlu, Manager, Database Systems

## Objectives

- Meet OLTP SLAs (99.95% availability, disk response time under 3ms, 25,000 users, 3,000 TPS)
- Zero Data Loss HA configuration
- Reduce overnight batch window from 8 hours to 3 hours
- Stability and availability with mixed workloads

## Solution

- 2013 Q2: 2 x Half Racks, and 1 x Quarter Rack X3-2 for production
- 2013 Q3: 1 x Eighth Rack for test and development

### Smaller Batch Window

- 60% less time

### Consolidation of Databases

- 40% fewer Admin tasks

### System Utilization

- 70% to 30%

### Zero Data Loss HA Protection

<table>
<thead>
<tr>
<th>Exadata X3-2 Half Rack</th>
<th>Exadata X3-2 Quarter Rack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asynchronous Active Data Guard</strong></td>
<td><strong>Synchronous Active Data Guard</strong></td>
</tr>
<tr>
<td><strong>Finart Core Banking DB</strong></td>
<td><strong>Finart ADG</strong></td>
</tr>
<tr>
<td>- 1,500 Branches</td>
<td>- Archive DBs, 8x compression with HCC</td>
</tr>
<tr>
<td>- 5,000 ATMs</td>
<td>- DWH Summary</td>
</tr>
<tr>
<td>- Internet Banking</td>
<td>- Document Management</td>
</tr>
</tbody>
</table>

<table>
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<td><strong>Asynchronous Active Data Guard</strong></td>
</tr>
<tr>
<td><strong>Test</strong></td>
</tr>
<tr>
<td><strong>Development</strong></td>
</tr>
</tbody>
</table>
Softbank Replaces 36 Teradata Racks

3 Exadata racks
150% more data capacity

12:1 advantage

36 total racks
Twice the operational cost of Exadata

- Billions of CDRs processed in 7 hours (from 25 with Teradata)
- Power, cooling, space savings
- Maintenance charges slashed
- Up to 8x faster

Twice the operational cost of Exadata
Exadata X4 vs. Traditional Storage Arrays

Largest Storage Array

52 GB/sec

1 Rack Exadata

100 GB/sec
Exadata Flash Performance Scales Linearly

Largest Storage Array

52 GB/sec

800 GB/sec

8 Rack Exadata
Exadata Database Machine

- The ultimate platform for all database workloads
  - OLTP, Warehousing, Database as a Service

- Most advanced hardware
  - Fully scale-out servers and intelligent storage with unified InfiniBand connectivity and PCI flash

- Most advanced software
  - Database optimized compute, storage, and networking algorithms dramatically improve performance and cost

- Standardized, optimized, hardened end-to-end