Oracle Database Performance on Intel Linux Servers

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10:45am Caspian
Steve Shaw

- Database Technology Manager for Intel EMEA: 10 years with Intel

- Previously with Oracle: Over 15 years of Oracle on Intel from Sequent on the Pentium Pro 180MHz onwards

- Co-author of Pro Oracle Database 10g/11g RAC on Linux

- Author of Hammerora Open Source Load Testing software available on Sourceforge

- Special Focus on RISC to Linux Migration

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Server Performance Agenda

- The Basics ‘Out of the box’ Configuration (80/20 rule)
- Server Performance and Configuration:
  - CPU,
  - Memory
  - I/O
- High Availability & Performance
- Putting it all Together: Load Testing
- MySQL and Oracle
The Basics : BIOS Settings

- Always check for appropriate BIOS settings:
- Look out for:
  - CPU features
  - Memory
  - Power Management
- Example:
  - Sub-Optimal default power settings for Oracle
- If uncertain then make sure you test your BIOS settings
The Basics : Linux Configuration

- Linux for Oracle
- Server : Red Hat/Oracle Enterprise Linux
- OEL
  - Easy to Acquire
  - Easy to Install and Configure for Oracle
  - No Ambiguity over Licensing or Distribution

- SUSE popular with customers in EMEA
- My Dev Platform : SuSE Enterprise Linux Desktop

- Why?
  - Compatible notebook/mobile features
  - Oracle and MySQL installs and configures ‘out of the box’
Linux Install and Configure Options

• Aims
  – Easy to Install and Configure for Oracle

• Linux Installation
  – CD/DVD
  – Network, Hard-Drive, other media
  – Unattended PXE Boot

• Configure with the Oracle Validated RPM
  – Requires a Yum Repository
  – ULN (Unbreakable Linux Network)
  – Oracle Public Yum Server
  – Your own Yum Server

• Example Install and Configure for Performance
1. Make a bootable USB Drive

```
[root@londonmgr1 media]# df -h
Filesystem  Size  Used  Avail   Use%  Mounted on
/dev/hda2   72G   44G   25G   65%   /
/dev/hda1   190M  46M   135M  26%   /boot
none         252M    0   252M   0%   /dev/shm
/dev/hdc    622M  622M    0   100%  /media/cdrom
/dev/sdb1   964M  159M   805M  17%   /media/usbdisk
```

```
[root@londonmgr1 ~]# umount /media/usbdisk/

[root@londonmgr1 images]# ls
boot.iso  minstg2.img  README  TRANS.TBL
diskboot.img  pxeboot  stage2.img  xen
```

```
[root@londonmgr1 images]# dd if=diskboot.img of=/dev/sdb
24576+0 records in
24576+0 records out
12582912 bytes (13 MB) copied, 3.02538 seconds, 4.2 MB/s
```
2. Server and Yum Repository

[root@ftp1 OEL5U4-x86-64]# ls
Enterprise-R5-U4-Server-x86_64-disc1.iso  mkdvdiso.sh
Enterprise-R5-U4-Server-x86_64-disc2.iso  V17795-01.zip
Enterprise-R5-U4-Server-x86_64-disc3.iso  V17796-01.zip
Enterprise-R5-U4-Server-x86_64-disc4.iso  V17797-01.zip
Enterprise-R5-U4-Server-x86_64-disc5.iso  V17798-01.zip
Enterprise-R5-U4-Server-x86_64-disc6.iso  V17799-01.zip
Enterprise-R5-U4-Server-x86_64-dvd.iso    V17800-01.zip

[root@ftp1 OEL5U4-x86-64]# mkdir -p /var/ftp/pub/el5_4_x86_64

[root@ftp1 OEL5U4-x86-64]# mount -o loop Enterprise-R5-U4-Server-x86_64-dvd.iso
/var/ftp/pub/el5_4_x86_64

/etc/vsftpd/vsftpd.conf
anonymous_enable=YES
anon_root=/var/ftp

[root@ftp1 ~]# service vsftpd start
Starting vsftpd for vsftpd: [ OK ]
3. Minimal Options

• Boot from USB, FTP Media, minimal options

Base System for Minimal Install

This group includes a minimal set of packages. Useful for creating small router/firewall boxes, for example.

108 of 132 optional packages selected

Optional packages

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4. New Install to Yum Repository

- Options:
  - ULN (Unbreakable Linux Network)
  - Oracle Public Yum Server
  - Your own Yum Server (...the install server)
  - Configure `/etc/yum.conf` on the new server to your repository

/etc/yum.conf and add the following section to the end of the file.

```
[Server]
name=Server
baseurl=ftp://ftp1.example.com/pub/el5_4_x86_64/Server/
gpgcheck=0
enabled=1
```
5. Configure

[root@london1 etc]# yum install oracle-validated

Loaded plugins: security
Setting up Install Process
Resolving Dependencies

... Is this ok [y/N]: y

... Installed:
  oracle-validated.x86_64 0:1.0.0-18.el5

Dependency Installed:
  compat-db.x86_64 0:4.2.52-5.1
  compat-gcc-34.x86_64 0:3.4.6-4
  compat-gcc-34-c++.x86_64 0:3.4.6-4
  elfutils-libelf-devel.x86_64 0:0.137-3.el5
  elfutils-libelf-devel-static.x86_64 0:0.137-3.el5
  gcc.x86_64 0:4.1.2-46.el5
  gcc-c++.x86_64 0:4.1.2-46.el5
  gdb.x86_64 0:6.8-37.el5
  glibc-devel.i386 0:2.5-42
  glibc-devel.x86_64 0:2.5-42
  glibc-headers.x86_64 0:2.5-42
  kernel-headers.x86_64 0:2.6.18-164.el5
  libXp.i386 0:1.0.0-8.1.el5
  libaio-devel.x86_64 0:0.3.106-3.2
  libgomp.x86_64 0:4.4.0-6.el5
  libstdc++-devel.x86_64 0:4.1.2-46.el5
  sysstat.x86_64 0:7.0.2-3.el5
  unixODBC.x86_64 0:2.2.11-7.1
  unixODBC-devel.x86_64 0:2.2.11-7.1

Complete!

• Packages and dependencies, oracle user and groups, kernel parameters, security settings ...

Done!
Server Performance and Configuration

1. CPU

- Intel® Xeon® Processor 5500 Series
  - Up to 4GB per slot, up to 9 slots per processor, 144GB max
  - Available in single or dual-socket configurations

2. Memory

- DDR3 800/1066
  - Up to 4GB per slot, up to 9 slots per processor, 144GB max

3. I/O and Disk

- Intel® 5520 I/O Hub
- Intel® I/O Controller Hub ICH10R
  - PCI Express Gen2 (multiple configurations possible)
  - 6 Serial ATA Port
  - USB 2.0 (up to 13 ports)

- Dual GbE
- Intel® Ethernet Controller
- PXH
- PXH-V

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Moore’s Law

Moores Law:
Innovations in technology allows a doubling of the number of transistors on a microchip every two years

“The implementation of high-k metal materials marks the biggest change in transistor technology since ... the late 1960s.”

– Gordon Moore

Silicon Advances Deliver:

• More transistors for new features and capabilities
• Higher performance
• Lower power consumption (switching and leakage)
• Smaller footprint
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Hyper-Threading

- **Multiple Cores**
  - Fully duplicated processing cores
  - Appears as 2 (or more) physical processors to the operating system
  - Executes threads independently with own computing resources
  - Provides a way to scale performance and minimizing power consumption and heat dissipation

- **SMT Simultaneous Multi-Threading**
  - Run 2 threads at the same time per core

- **Take advantage of 4-wide execution engine**
  - Keep it fed with multiple threads
  - Hide latency of a single thread

- **Most power efficient** performance feature
  - Very low die area cost
  - Can provide significant performance benefit depending on application

Note: Each box represents a processor execution unit
SMT on Linux CPU Mappings

- Processor Topology
- In /proc/cpuinfo
- You see 16 CPUs: 0-15

- Processor Topology Tool identifies which thread is which Linux CPU (and a lot more)

eg Socket 0, Core 0, Thread 1 is Linux CPU 8

<table>
<thead>
<tr>
<th>Socket 0</th>
<th>OScpu#</th>
<th>0 8</th>
<th>1 9</th>
<th>2 10</th>
<th>3 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>c0_t0  c0_t1</td>
<td>c1_t0 c1_t1</td>
<td>c2_t0 c2_t1</td>
<td>c3_t0 c3_t1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Socket 1</th>
<th>OScpu#</th>
<th>4 12</th>
<th>5 13</th>
<th>6 14</th>
<th>7 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>c0_t0  c0_t1</td>
<td>c1_t0 c1_t1</td>
<td>c2_t0 c2_t1</td>
<td>c3_t0 c3_t1</td>
<td></td>
</tr>
</tbody>
</table>
SMT Performance Comparison

Typical Oracle OLTP Performance Profile

Nehalem Architecture with SMT Enabled

Nehalem Architecture with SMT Disabled

Baseline Previous Generation

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CPUSPEED FREQUENCY SCALING

[root@london1 ~]# cat /proc/cpuinfo
processor : 0
vendor_id : GenuineIntel
cpu family : 6
model : 26
model name : Intel(R) Xeon(R) CPU X5570 @ 2.93GHz
stepping : 5
cpu MHz : 2933.570
cache size : 8192 KB
...

[root@london1 ~]# service cpuspeed stop
Disabling ondemand cpu frequency scaling:[  OK  ]

[root@london1 ~]# cat /proc/cpuinfo | grep -i MHz
cpu MHz : 2927.000
cpu MHz : 2927.000

[root@london1 ~]# service cpuspeed start
Enabling ondemand cpu frequency scaling:[  OK  ]

[root@london1 ~]# cat /proc/cpuinfo | grep -i MHz
cpu MHz : 1596.000
cpu MHz : 1596.000

Dynamic Values in /proc/cpuinfo

Independent frequencies in response to demand
Scheduling Priorities

![System Monitor](image)

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Oracle CPU Workload Example

Top 5 Timed Events
~~~~~~~~~~~~~~~~~~
Event Waits Time (s) Time (ms) Avg %Total Call Time Wait Class
----------------------------------- ----------- ----------- ----------- -----------
latch: cache buffers chains 114,324 218,927 2154 72.1 Concurren
CPU time 25,442 9.1
latch free 1,998 1,342 577 0.2 Other

SQL> select * from (select name, addr, spin_gets, gets, misses, sleeps from v$latch_Children where name = 'cache buffers chains' order by gets desc) where rownum < 5;
NAME
---------------------------
ADDR SPIN_GETS GETS MISSES SLEEPS
-------------------------------
cache buffers chains
00000003E1A0A3F8 838682200 1136069722 839855996 4227

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Oracle and Memory

Connected to:
Oracle Database 10g Express Edition Release

SQL> show sga;

Total System Global Area 805306368 bytes
Fixed Size 1289996 bytes
Variable Size 197132532 bytes
Database Buffers 603979776 bytes
Redo Buffers 2904064 bytes
SQL>

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Virtual & Physical Memory

• Each Process sees contiguous virtual memory
• MMU (Memory Management Unit) on CPU translates virtual to physical memory
• The TLB (Translation Lookaside Buffer) Caches most recent translations

[root@london1 ~]# cat /proc/cpuinfo
processor : 0
vendor_id : GenuineIntel
cpu family : 6
model : 26
model name : Intel(R) Xeon(R) CPU X5570 @ 2.93GHz
...
address sizes : 40 bits physical, 48 bits virtual

• 40/44 bit physical 1TB/16TB memory
• MAXPHYADDR for x86-64 is 52 bits = 4 petabytes
From Virtual to Physical

• If address translation is not in the TLB there is a Page Table Walk

4 level hierarchy of Page Translation

• **CR3**
  - The base physical address of the PML4 is stored in the CR3 Register.

1. **PML4**
  - The page map level 4 (PML4) — An entry in a PML4 table contains the physical address of the base of a page directory pointer table

2. **PDP**
  - A set of page directory pointer tables — An entry in a page directory pointer table contains the physical address of the base of a page directory table.

3. **PDE**
  - Sets of page directories — An entry in a page directory table contains the physical address of the base of a page table.

4. **PTE**
  - Sets of page tables — An entry in a page table contains the physical address of a page frame

• **Offset**
  - Based on the real physical address, PAGE_SHIFT into the page frame
48-bit Virtual Addressing

- Each linear address entry is 8 bytes (64 bits)
- 48 bits = PML4 + PDP + PDE + PTE + page offset
- 16 high-order linear address bits currently reserved
  - Bits 48 to 63 are currently the same as bit 47
- Page Size defined by offset
  - eg in Linux #define PAGE_SHIFT 12
  - 2 to the power of 12 = 4KB Page
  - eg a Linear Address in x86-64

<table>
<thead>
<tr>
<th>bit 47</th>
<th>bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>39</td>
</tr>
<tr>
<td>PML4</td>
<td>Directory_Ptr</td>
</tr>
</tbody>
</table>

- Each process requires 8 bytes per 4KB page
- Up to 256TB of linear address space
Addressing Example

• Example 6GB SGA and 1000 dedicated user processes
• Memory is shared but each process needs to build page tables for the SGA
• Example Workings

(6 gigabytes) divided by (4 kilobyte pages) = 1,572,864
4KB pages for the SGA

1,572,864 pages multiplied by 8 bytes for each linear address = 12 megabytes per process

12 GB Page Tables to address 6GB SGA

NOTE: PRE_PAGE_SGA will build entries on creation
**Huge Pages**

1. Don’t Oversize the SGA and use Huge Pages
2. Huge Pages changes the address offset (usually 2 to the 21th on x86-64 = 2MB)
3. `vm.nr_hugepages` kernel parameter

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>39</td>
<td>38</td>
<td>30</td>
<td>29</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>PML4</td>
<td>Directory Ptr</td>
<td>Directory</td>
<td>Offset</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...  

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HugePages Total</td>
<td>0</td>
<td>HugePages_Total</td>
<td>7500</td>
</tr>
<tr>
<td>HugePages_Free</td>
<td>0</td>
<td>HugePages_Free</td>
<td>299</td>
</tr>
<tr>
<td>Hugepagesize</td>
<td>2048kB</td>
<td>HugePages_Rsvd</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hugepagesize</td>
<td>2048 kB</td>
</tr>
</tbody>
</table>
Physical Memory: Previous Architecture

Front-Side Bus Evolution

- CPU
- Memory
- MCH
- ICH

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QuickPath Interconnect
Non-Uniform Memory Access (NUMA)

- FSB architecture
  - All memory in one location
- Starting with Nehalem
  - Memory located in multiple places
- Latency to memory dependent on location
- Local memory
  - Highest BW
  - Lowest latency
- Remote Memory
  - Higher latency

Ensure software is NUMA-optimized for best performance
Oracle Database and NUMA

Subject: Oracle NUMA usage recommendation
Doc ID: 759565.1 Type: ALERT Modified Date: 19-JUN-2009 Status: PUBLISHED

Disabling or enabling NUMA can change application performance. It is strongly recommended to evaluate the performance after disabling or before enabling NUMA in a test environment. Operating system and/or hardware configuration may need to be tuned or reconfigured when disabling Oracle NUMA support.

Consult your hardware vendor for more information or recommendation

select a.ksppinm "Parameter", b.ksppstvl "Session Value", c.ksppstvl "Instance Value" from x$ksppi a, x$ksppcv b, x$ksppsv c where a.indx = b.indx AND a.indx = c.indx AND ksppinm like '%NUMA%';

... _enable_NUMA_support TRUE
In Alert.log
NUMA system found and support enabled (4 domains - 16,16,16,16)
NUMA Disabled

NUMA is enabled by default if enabled at the BIOS but can be turned off with a kernel option:

```
kernel /vmlinuz-2.6.18-128.el5 ro root=/dev/VolGroup00/LogVol00 numa=off
```

dmesg | grep -i numa

Command line: ro root=/dev/VolGroup00/LogVol00 numa=off

NUMA turned off

NUMA OFF: Only one memory node configured

```
[root@nehalem1 ~]# numactl --hardware
available: 1 nodes (0-0)
node 0 size: 18149 MB
node 0 free: 2685 MB
node distances:
node 0
```

```
[root@london1 ~]# ipcs -m

------- Shared Memory Segments -------
key        shmid  owner   perms  bytes     nattch
0x6422c258  32768  oracle  660     4096      0
0x10455eac  98305  oracle  600  15034482688 31
```
When NUMA is enabled

```
$ dmesg | grep -i numa
```

**NUMA: Using 31 for the hash shift**

**NUMA ON:** Two memory nodes configured

```
$ numactl --hardware
```

available: 2 nodes (0-1)
node 0 size: 9059 MB
deferred: 778 MB
node 1 size: 9090 MB
node 1 free: 1306 MB

node distances:
node 0 1
0: 10 21
1: 21 10

```
$ ipcs -m
```

<table>
<thead>
<tr>
<th>key</th>
<th>shmid</th>
<th>owner</th>
<th>perms</th>
<th>bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xa3c20e68</td>
<td>32768</td>
<td>oracle</td>
<td>660</td>
<td>4096</td>
</tr>
<tr>
<td>0x00000000</td>
<td>884737</td>
<td>oracle</td>
<td>660</td>
<td>1140850688</td>
</tr>
<tr>
<td>0x00000000</td>
<td>917506</td>
<td>oracle</td>
<td>660</td>
<td>5905580032</td>
</tr>
<tr>
<td>0x00000000</td>
<td>950275</td>
<td>oracle</td>
<td>660</td>
<td>5905580032</td>
</tr>
<tr>
<td>0xfb0938e4</td>
<td>983044</td>
<td>oracle</td>
<td>660</td>
<td>2097152</td>
</tr>
</tbody>
</table>

Linux sees memory as node 0 and
node 1

Distances convey latency
Linux and Oracle must manage
the memory

2MB allocations
NUMA statistics and monitoring

/sys/devices/system/node

```
[root@london1 node0]# more meminfo
Node 0 MemTotal:  9276828 kB
Node 0 MemFree:  1465256 kB
Node 0 MemUsed:  7811572 kB
Node 0 Active:  2114000 kB
Node 0 Inactive:  77752 kB
Node 0 HighTotal:  0 kB
Node 0 HighFree:  0 kB
Node 0 LowTotal:  9276828 kB
Node 0 LowFree:  1465256 kB
Node 0 Dirty:  28 kB
Node 0 Writeback:  0 kB
Node 0 FilePages:  170280 kB
Node 0 Mapped:  38620 kB
Node 0 AnonPages:  199608 kB
Node 0 PageTables:  13304 kB
Node 0 PerfEvent:  0 kB
Node 0 NFS_Unstable:  0 kB
Node 0 Bounce:  0 kB
Node 0 Slab:  15732 kB
Node 0 HugePages_Total:  3588
Node 0 HugePages_Free:  847
```

```
[oracle@london1 ~]$ numastat

<table>
<thead>
<tr>
<th></th>
<th>node0</th>
<th>node1</th>
</tr>
</thead>
<tbody>
<tr>
<td>numa_hit</td>
<td>394822</td>
<td>873142</td>
</tr>
<tr>
<td>numa_miss</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>numa_foreign</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>interleave_hit</td>
<td>11826</td>
<td>11605</td>
</tr>
<tr>
<td>local_node</td>
<td>386530</td>
<td>854775</td>
</tr>
<tr>
<td>other_node</td>
<td>8292</td>
<td>18367</td>
</tr>
</tbody>
</table>
```

```
[root@london1 ~]# numactl --show

policy: default
preferred node: current
physcpubind: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
cpubind: 0 1
nodebind: 0 1
membind: 0 1
```
Memory Bandwidth Considerations

Stream Bandwidth for Xeon X5570 processor

Stream Bandwidth – Mbytes/Sec (Triad)

<table>
<thead>
<tr>
<th>Bandwidth Capacity Per Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>32GB/s 48GB</td>
</tr>
<tr>
<td>25.5GB/s 96GB</td>
</tr>
<tr>
<td>19.2GB/s 144GB</td>
</tr>
</tbody>
</table>

Higher is better

Source: Intel internal measurement – March 2009

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/resources/limits.htm Copyright © 2009, Intel Corporation. * Other names and brands may be claimed as the property of others.
#dmidecode

**Motherboard**
Handle 0x0003, DMI type 2, 16 bytes
Base Board Information
Manufacturer: Intel
Product Name: **S5000PAL0**

**Processor**
Processor Information
Version: **Intel(R) Xeon(R) CPU X5355**

**Memory**
Handle 0x0034, DMI type 17, 27 bytes
Memory Device
Data Width: 64 bits
Size: **2048 MB**
Form Factor: DIMM
Set: 1
Locator: ONBOARD **DIMM_A1**
Bank Locator: Not Specified
Type: **DDR2**
Type Detail: Synchronous
Speed: **667 MHz** (1.5 ns)

**What this tells us:**
Motherboard
4 Memory Channels (S5000PAL0) 8 Slots

**CPU**
Intel Clovertown CPUs
1333Mhz (Dual Independent FSB)
Bandwidth 10666 MB/s per FSB
21 GB/s Maximum FSB Bandwidth

**Memory**
Memory DDR2 667 = PC2-5300
4 Memory Channels at 5.3GB/s each
Memory Bandwidth of 21 GB/s from all 4 channels
16GB memory in total
DMIDECODE Example 2

#dmidecode
Motherboard
Handle 0x0002, DMI type 2, 15 bytes.
Base Board Information
Manufacturer: Supermicro
Product Name: X8DTN

Processor
Processor Information
Version: Intel(R) Xeon(R) CPU X5570

Memory
Array Handle: 0x0029
Data Width: 64 bits
Size: 1024 MB
Form Factor: DIMM
Set: 1
Locator: A1_DIMM0
Bank Locator: A1_Node0_Channel0_Dimm0
Type: <OUT OF SPEC>
Type Detail: Synchronous
Speed: 800 MHz (1.2 ns)

• What this tells us:
Motherboard
6 Memory Channels (X8DTN), 18 slots
Node0/Node1, Channel0/1/2, DIMM0/1/2

CPU
Intel Nehalem CPUs
3.2GHz QPI (Quickpath Interconnect)
Bandwidth 25.6 GB/s socket to socket
Up to 32GB/s Memory Bandwidth per CPU

Memory
Memory DDR3 800 = PC4-6400
6 Memory Channels at 6.4GB/s each
Memory Bandwidth of 38.4GB/s from all 6 channels
19.2GB/s per processor
18GB memory in total
Disk and I/O

Oracle OLTP

I/O Impact on Performance

- Identical Servers with CPU and Memory
- Identical OS and Oracle Database
- Identical Application and Workload
- Different Storage Subsystems

Amdahl’s Rule of Thumb

1 byte of memory and 1 byte per second of I/O are required for each instruction per second supported by a computer
## OLTP Redo I/O Dependency

<table>
<thead>
<tr>
<th>Event</th>
<th>Waits</th>
<th>Time(s)</th>
<th>Avg wait (ms)</th>
<th>% DB time</th>
<th>Wait Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>log file sync</td>
<td>894,491</td>
<td>5,490</td>
<td>6</td>
<td>61.33</td>
<td>Commit</td>
</tr>
<tr>
<td>DB CPU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>db file sequential read</td>
<td></td>
<td>82,013</td>
<td>728</td>
<td>9</td>
<td>User I/O</td>
</tr>
<tr>
<td>enq: TX - row lock contention</td>
<td>17,977</td>
<td>116</td>
<td>6</td>
<td>1.29</td>
<td>Application</td>
</tr>
<tr>
<td>latch: In memory undo latch</td>
<td>44,552</td>
<td>79</td>
<td>2</td>
<td>0.88</td>
<td>Concurrency</td>
</tr>
</tbody>
</table>

Subject: WAITEVENT: "log file sync" Reference Note
Doc ID: 34592.1 Type: REFERENCE
Modified Date: 14-JUL-2009 Status: PUBLISHED
* Tune LGWR to get good throughput to disk. eg: Do not put redo logs on RAID 5*
## OLTP Redo CPU Dependency

### Per Second

<table>
<thead>
<tr>
<th>Event</th>
<th>Waits</th>
<th>Time(s)</th>
<th>Avg wait (ms)</th>
<th>% DB time</th>
<th>Wait Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>log file sync</td>
<td>1,795,089</td>
<td>5,909</td>
<td>3</td>
<td>50.38</td>
<td>Commit</td>
</tr>
<tr>
<td>DB CPU</td>
<td>2,789</td>
<td></td>
<td></td>
<td>23.78</td>
<td></td>
</tr>
<tr>
<td>db file sequential read</td>
<td>162,468</td>
<td>2,703</td>
<td>17</td>
<td>23.05</td>
<td>User I/O</td>
</tr>
<tr>
<td>enq: TX - row lock contention</td>
<td>23,311</td>
<td>205</td>
<td>9</td>
<td>1.74</td>
<td>Application</td>
</tr>
<tr>
<td>log file switch completion</td>
<td>1,429</td>
<td>52</td>
<td>37</td>
<td>0.44</td>
<td>Configuration</td>
</tr>
</tbody>
</table>

- Identical Storage Subsystems
- Identical Memory
- Identical OS and Oracle Database
- CPU Upgrade (LGWR also requires CPU)

*Upgrading the CPU enabled more than 2X throughput increase for redo*
I/O Configuration

• ASM Default Storage Choice on Linux
• Raw Devices not supported by OUI for Oracle 11.2
• Raw may still bring benefits for intensive redo and large redo log files
  – Udev Rules to changes permissions and persistence
    KERNEL="sdd[1-9]", OWNER="oracle" GROUP="dba", MODE="0660"

[root@london1 rules.d]# udevcontrol reload_rules
[root@london1 rules.d]# start_udev
Starting udev:

[root@london1 rules.d]# ls -l /dev/sdd1
brw-r----- 1 oracle dba 8, 49 Jul 29 17:20 /dev/sdd1

SQL> alter database add logfile group 1 '/dev/sdd1' ........
Hard Disk and CPU Performance

175X CPU vs 1.3X HDD Scaling

Normalized CPU Performance
Normalized Media Access Time for 20K Read

SSD Potential

Measured HDD performance scaling = 1.3X since 1/96

Measured CPU performance scaling = 175x

Source: Intel measurements
Hard Disks and SSDs Compared

1 Rack of 120 HDDs
- 36,000 IOPS
- 12 GB/sec sustained BW
- 1452 Watts
- 8.8 TB

Per HDD:
- R/W 150 MB/sec
- 320 IOPS (Read)
- 120 IOPS (Write)
- 12.1 W (active)

1 Rack of 120 SSDs
- 4,200,000 IOPS
- 36 GB/sec sustained BW
- 288 Watts
- 3.8 TB

Per SSD:
- Read 250 MB/sec
- Write 170 MB/sec
- 35,000 IOPS (Read)
- 4000 IOPS (Write)
- 2.4 W (active)
SAN vs SSDs OLTP Performance

Oracle 11g OLTP Performance

8 disk SSD

15 disk SAN

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Linux
High Availability

• Oracle VM Cluster

  • The Server Pool
  • The cluster, servers grouped to provide services

  • Oracle VM Manager
  • Management Console, central point of cluster management and repository

  • Oracle VM Agent
  • Reports status and manages virtual Servers

  • Public & Private Networks
  • Public Network for external access private network(s) for internal communication eg migration and data
Oracle VM High Availability

**Startup**
- Virtual Machines load balanced starts on least loaded node
- Start Single Instance Database

**Failure**
- Server hardware or software failure, node removed from cluster
- Client loses connection

**Restart and Recovery**
- VM restarts on available node
- Redo Recovery on Database
- Client reconnects with same connection (appears identical)

**Server Available**
- Oracle VM Server Started

**Live Migrates to original node***
- No downtime
- Intel® VT FlexMigration enables migration across different generations of Intel CPUs

*See Metalink 464754.1 Certified Software on Oracle VM

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Virtual vs Native Performance

Virtualisation performance is proportional to native performance

Native Performance Drives Virtualized Performance

Overhead approx 16% for database applications
Putting it Together: Load Testing

- Holistic approach to performance
- Test Configurations
- Compare Systems
- Performance Profiles as opposed to single data points
- Independent
- Backed by Performance Data

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Hammerora

• Search on Google for “Oracle Load Test” and hit “I’m Feeling Lucky”...
• Over 30,000 downloads to date over 90 countries
• Multithreaded Database and Web Testing
• Trace File Replay
• Includes Database tests based on TPC-C and TPC-H specifications
• Pre-compiled for Linux x86-64, Linux x86,

• Free, Open Source, developed on Linux, community based
• Compare and contrast Oracle and MySQL Database performance on different hardware platforms
• Validate the benefits of migration
Load Test Overview

- Write or modify a test script
- View the output from virtual users
- Observe transactions and queries
- Define and observe
  Autopilot One key press for a full sequence of tests
- Interactive Console for host commands and error reports

Transaction Counter

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OLTP Schema Creation

- Select benchmark from menu
- Select Schema options
- Define Schema options
- Create the Schema
- Load Completing
- Confirm

- Creating

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OLTP Workload

• Virtual Users
  • Create Virtual Users
  • Run the test

• TPC-C Driver Script
OLTP AWR Workload

- Takes AWR reports and reports transactional throughput
- Timed Tests, first user takes snapshots
Performance Profile Example

Performance Profiles

Scalability

Performance

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### AWR, CPU, Memory, I/O Analysis

<table>
<thead>
<tr>
<th>DB Name</th>
<th>DB Id</th>
<th>Instance</th>
<th>Inst num</th>
<th>Startup Time</th>
<th>Release</th>
<th>RAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIN01</td>
<td>13823227</td>
<td>LINDB</td>
<td>1</td>
<td>10-May-10 13:05</td>
<td>11.2.0.1.0</td>
<td>NO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Host Name</th>
<th>Platform</th>
<th>CPUs</th>
<th>Cores</th>
<th>Sockets</th>
<th>Memory (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINSERVE</td>
<td>Linux x86 64-bit</td>
<td>64</td>
<td>32</td>
<td>4</td>
<td>125.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Begin</th>
<th>End</th>
<th>Std Block Size:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer Cache:</td>
<td>102,400M</td>
<td>102,400M</td>
</tr>
<tr>
<td>Shared Pool Size:</td>
<td>6,144M</td>
<td>6,144M</td>
</tr>
</tbody>
</table>
# Load Profile: Performance

<table>
<thead>
<tr>
<th></th>
<th>Per Second</th>
<th>Per Transaction</th>
<th>Per Exec</th>
<th>Per Call</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB Time(s):</td>
<td>63.8</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>DB CPU(s):</td>
<td>46.6</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Redo size:</td>
<td>119,429,174.4</td>
<td>5,164.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical reads:</td>
<td>2,353,169.4</td>
<td>101.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block changes:</td>
<td>733,744.7</td>
<td>31.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical reads:</td>
<td>66.4</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical writes:</td>
<td>0.3</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User calls:</td>
<td>35,454.1</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parses:</td>
<td>27,603.2</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard parses:</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/A MB processed:</td>
<td>1.9</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logons:</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Executes:</td>
<td>477,348.2</td>
<td>20.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rollbacks:</td>
<td>39.3</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transactions:</td>
<td>23,124.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.2GB per minute redo

Transactions per second
## Top 5 Timed Events: CPU

<table>
<thead>
<tr>
<th>Event</th>
<th>Waits</th>
<th>Time(s)</th>
<th>Avg wait (ms)</th>
<th>% DB time</th>
<th>Wait Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB CPU</td>
<td>14,000</td>
<td></td>
<td>73.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>latch: cache buffers chains</td>
<td>667,452</td>
<td>2,815</td>
<td>4</td>
<td>14.68</td>
<td>Concurrency</td>
</tr>
<tr>
<td>log file sync</td>
<td>4,731,309</td>
<td>1,662</td>
<td>0</td>
<td>8.67</td>
<td>Commit</td>
</tr>
<tr>
<td>eqn: TX - row lock contention</td>
<td>54,287</td>
<td>119</td>
<td>2</td>
<td>0.62</td>
<td>Application</td>
</tr>
<tr>
<td>cursor: mutex S</td>
<td>644,823</td>
<td>99</td>
<td>0</td>
<td>0.51</td>
<td>Concurrency</td>
</tr>
</tbody>
</table>

*Valid use of CPU usage*

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### Time Model : CPU

<table>
<thead>
<tr>
<th>Statistic Name</th>
<th>Time (s)</th>
<th>% of DB Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>sql execute elapsed time</td>
<td>16,842.93</td>
<td>87.85</td>
</tr>
<tr>
<td>DB CPU</td>
<td>13,999.71</td>
<td>73.02</td>
</tr>
<tr>
<td>PL/SQL execution elapsed time</td>
<td>1,838.49</td>
<td>9.59</td>
</tr>
<tr>
<td>parse time elapsed</td>
<td>118.03</td>
<td>0.62</td>
</tr>
<tr>
<td>repeated bind elapsed time</td>
<td>2.98</td>
<td>0.02</td>
</tr>
<tr>
<td>hard parse elapsed time</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>sequence load elapsed time</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>hard parse (sharing criteria) elapsed time</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>DB time</td>
<td>19,171.59</td>
<td></td>
</tr>
<tr>
<td>background elapsed time</td>
<td>295.13</td>
<td></td>
</tr>
<tr>
<td>background cpu time</td>
<td>205.16</td>
<td></td>
</tr>
</tbody>
</table>

All time SQL or PL/SQL
### SQL Ordered by: CPU

<table>
<thead>
<tr>
<th>CPU Time (s)</th>
<th>Executions</th>
<th>%Total</th>
<th>Elapsed Time (s)</th>
<th>%CPU</th>
<th>%IO</th>
<th>SQL Id</th>
<th>SQL Module</th>
<th>SQL Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,327.02</td>
<td>2,312,990</td>
<td>59.48</td>
<td>11,484.98</td>
<td>72.50</td>
<td>0.00</td>
<td>16dhat4ta7</td>
<td>wish8.5@nehep1 (TNS V1-V3)</td>
<td>begin neword(:no_w_id, :no_max...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>xs9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,132.19</td>
<td>2,314,058</td>
<td>15.23</td>
<td>2,382.07</td>
<td>89.51</td>
<td>1.07</td>
<td>aw9ttz9acx</td>
<td>wish8.5@nehep1 (TNS V1-V3)</td>
<td>BEGIN payment(:p_w_id, :p_d_id...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bc3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,898.75</td>
<td>231,669</td>
<td>13.56</td>
<td>343</td>
<td>87.35</td>
<td>0.01</td>
<td>d4ujh5yqt1f</td>
<td>wish8.5@nehep1 (TNS V1-V3)</td>
<td>BEGIN delivery(:d_w_id, :d_o_c...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ph</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CPU Time vs Elapsed Time**
## Buffer Pool Sizing: Memory

<table>
<thead>
<tr>
<th>P</th>
<th>Size for Est (M)</th>
<th>Size Factor</th>
<th>Buffers (thousands)</th>
<th>Est Phys Read Factor</th>
<th>Est Phys Read (thousands)</th>
<th>Est Phys Read Time</th>
<th>Est %DBtime for Rds</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>10,240</td>
<td>0.10</td>
<td>1,263</td>
<td>2.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>20,480</td>
<td>0.20</td>
<td>2,525</td>
<td>1.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>30,720</td>
<td>0.30</td>
<td>3,788</td>
<td>1.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>40,960</td>
<td>0.40</td>
<td>5,050</td>
<td>1.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>51,200</td>
<td>0.50</td>
<td>6,313</td>
<td>1.05</td>
<td>5,451</td>
<td>1</td>
<td>3.00</td>
</tr>
<tr>
<td>D</td>
<td>61,440</td>
<td>0.60</td>
<td>7,575</td>
<td>1.00</td>
<td>4,946</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>71,680</td>
<td>0.70</td>
<td>8,838</td>
<td>0.95</td>
<td>4,893</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>81,920</td>
<td>0.80</td>
<td>10,101</td>
<td>0.95</td>
<td>4,850</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>92,160</td>
<td>0.90</td>
<td>11,363</td>
<td>1.01</td>
<td>4,816</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>102,400</td>
<td>1.00</td>
<td>12,626</td>
<td>1.00</td>
<td>4,783</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>112,640</td>
<td>1.10</td>
<td>13,888</td>
<td>1.00</td>
<td>4,765</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>122,880</td>
<td>1.20</td>
<td>15,151</td>
<td>0.99</td>
<td>4,757</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>133,120</td>
<td>1.30</td>
<td>16,414</td>
<td>0.99</td>
<td>4,754</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>143,360</td>
<td>1.40</td>
<td>17,676</td>
<td>0.99</td>
<td>4,754</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>153,600</td>
<td>1.50</td>
<td>18,939</td>
<td>0.99</td>
<td>4,754</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>163,840</td>
<td>1.60</td>
<td>20,201</td>
<td>0.99</td>
<td>4,753</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>174,080</td>
<td>1.70</td>
<td>21,464</td>
<td>0.99</td>
<td>4,753</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>184,320</td>
<td>1.80</td>
<td>22,726</td>
<td>0.99</td>
<td>4,753</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>194,560</td>
<td>1.90</td>
<td>23,989</td>
<td>0.99</td>
<td>4,753</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>204,800</td>
<td>2.00</td>
<td>25,252</td>
<td>0.99</td>
<td>4,753</td>
<td>1</td>
<td>2.00</td>
</tr>
</tbody>
</table>

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## IOStat: I/O

<table>
<thead>
<tr>
<th>Filetype Name</th>
<th>Reads:</th>
<th>Reqs per sec</th>
<th>Data per sec</th>
<th>Writes:</th>
<th>Reqs per sec</th>
<th>Data per sec</th>
<th>Small Read</th>
<th>Large Read</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log File</td>
<td>0M</td>
<td>0.00</td>
<td>0M</td>
<td>35.8G</td>
<td>18166.32</td>
<td>121.944</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data File</td>
<td>156M</td>
<td>62.48</td>
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<td>18166.83</td>
<td>121.954</td>
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<td>0.94</td>
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35GB of redo in 5 minutes

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Redo & I/O

- Redo Performance is the key I/O dependency
  - SSDs
  - SAN

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<th>Writes: Data</th>
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- IOPs as opposed to bandwidth is key advantage
- Ensure all Checkpoints are equal in all tests
- Checkpoints at this level of redo will need considerable I/O write capacity to Datafiles
MySQL and Oracle

- Customers evaluating complementary RISC Migration approach
- Where does MySQL fit in the migrated architecture?
- We run same performance tests as Oracle
- Storage engines most interest for next generation databases on SSDs and BI
Conclusion

1. EVALUATION
2. ASSESSMENT
3. PERFORMANCE
4. DATA MIGRATION METHOD
5. BUSINESS CONTINUITY
6. ARCHITECTURE & DESIGN
7. PORTING, TESTING & ACCEPTANCE
8. PRODUCTION MIGRATION
9. SWITCHOVER & SUPPORT
10. CASE STUDY

Methodology Optimization

New Technologies

RISC MIGRATION R&D

RISC Migration Project

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