

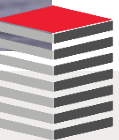
Oracle Database Performance Tuning: The Not SQL Option

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: damorgan11g
twitter: @meta7solutions



Unsafe Harbor

- This room is an unsafe harbor
- You can rely on the information in this presentation to help you protect your data, your databases, your organization, and your career
- No one from Oracle has previewed this presentation
- No one from Oracle knows what I'm going to say
- No one from Oracle has supplied any of my materials
- Everything I will present is existing, proven, functionality





Sign In/Register Help Country ▾ Communities ▾ I am a... ▾ I want to... ▾

Products Solutions **Downloads** Store Support Training Partners About OTN

Oracle Technology Network

Welcome to the world's largest community of developers, admins, and architects using industry-standard technologies in combination with Oracle products.

[Join today or learn more ▶](#)



What's New  Oracle Code: Free event series for developers is coming to your town. [Register now!](#)

 [Java Developers](#)
[What's New ▾](#)

 [Database Admins and Developers](#)
[What's New ▾](#)

 [System Admins and Developers](#)
[What's New ▾](#)

 [Solution Architects](#)
[What's New ▾](#)

Essential Links

Recently Articles

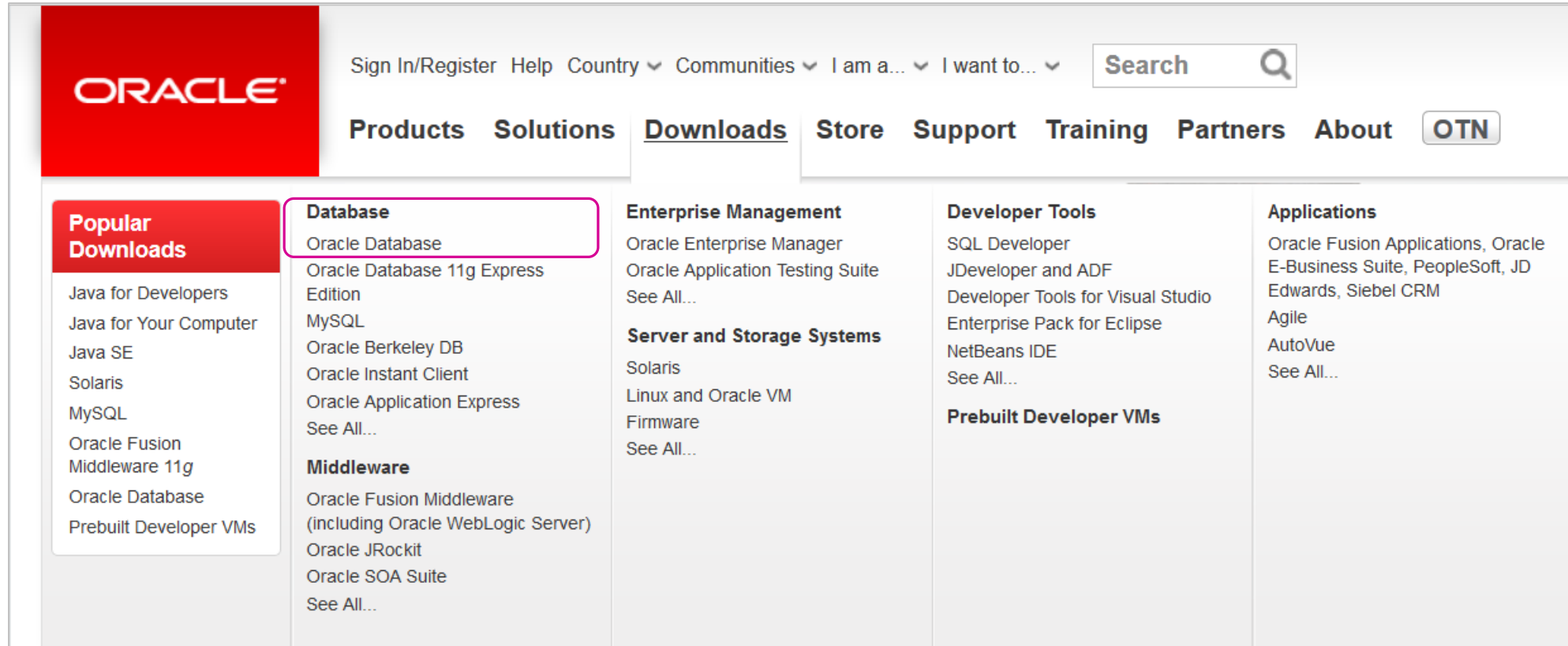
Stay Connected:   

[#OTNDBDev](#)

<http://otn.oracle.com>



Get Database 12.2 Today (2:3)



The screenshot shows the Oracle OTN (Oracle Technology Network) website. The top navigation bar includes the Oracle logo, links for Sign In/Register, Help, Country, Communities, I am a..., and I want to..., a search bar, and a list of main categories: Products, Solutions, Downloads (highlighted), Store, Support, Training, Partners, About, and OTN. Below the navigation bar, the Downloads section is displayed with five columns: Popular Downloads, Database (highlighted with a red box), Enterprise Management, Developer Tools, and Applications. The Database column lists Oracle Database, Oracle Database 11g Express Edition, MySQL, Oracle Berkeley DB, Oracle Instant Client, Oracle Application Express, and See All... The Enterprise Management column lists Oracle Enterprise Manager, Oracle Application Testing Suite, and See All... The Developer Tools column lists SQL Developer, JDeveloper and ADF, Developer Tools for Visual Studio, Enterprise Pack for Eclipse, NetBeans IDE, and See All... The Applications column lists Oracle Fusion Applications, Oracle E-Business Suite, PeopleSoft, JD Edwards, Siebel CRM, Agile, AutoVue, and See All... The Popular Downloads column lists Java for Developers, Java for Your Computer, Java SE, Solaris, MySQL, Oracle Fusion Middleware 11g, Oracle Database, and Prebuilt Developer VMs.

ORACLE

Sign In/Register Help Country ▾ Communities ▾ I am a... ▾ I want to... ▾ Search 🔍

Products Solutions Downloads Store Support Training Partners About OTN

Popular Downloads

- Java for Developers
- Java for Your Computer
- Java SE
- Solaris
- MySQL
- Oracle Fusion Middleware 11g
- Oracle Database
- Prebuilt Developer VMs

Database

- Oracle Database
- Oracle Database 11g Express Edition
- MySQL
- Oracle Berkeley DB
- Oracle Instant Client
- Oracle Application Express
- See All...

Middleware

- Oracle Fusion Middleware (including Oracle WebLogic Server)
- Oracle JRockit
- Oracle SOA Suite
- See All...

Enterprise Management

- Oracle Enterprise Manager
- Oracle Application Testing Suite
- See All...

Server and Storage Systems

- Solaris
- Linux and Oracle VM
- Firmware
- See All...

Developer Tools

- SQL Developer
- JDeveloper and ADF
- Developer Tools for Visual Studio
- Enterprise Pack for Eclipse
- NetBeans IDE
- See All...

Prebuilt Developer VMs

Applications

- Oracle Fusion Applications, Oracle E-Business Suite, PeopleSoft, JD Edwards, Siebel CRM
- Agile
- AutoVue
- See All...

<http://otn.oracle.com>





Sign In/Register Help Country ▾ Communities ▾ I am a... ▾ I want to... ▾

Products Solutions Downloads Store Support Training Partners About **OTN**

Oracle Technology Network > Database > Database 12c > Downloads

Database 12c
Database In-Memory
Multitenant
Options
Application Development
Big Data Appliance
Cloud Database Services
Private Database Cloud
Data Warehousing & Big Data
Database Appliance
Exadata Database Machine
High Availability
Manageability
Migrations
Security
Unstructured Data
Upgrades

Overview Downloads Documentation Learn More Community

Oracle Database Software Downloads

You must accept the [OTN License Agreement](#) to download this software.
☐ Accept License Agreement | ☐ Decline License Agreement

Oracle Database 12c Release 2

(12.2.0.1.0) - Standard Edition 2 and Enterprise Edition

Linux x86-64	File 1 (3.2 GB)	See All
Oracle Solaris (SPARC systems, 64-bit)	File 1 (3.1 GB)	See All
Oracle Solaris (x86 systems, 64-bit)	File 1 (2.8 GB)	See All



Critical Capabilities for
Operational Database
Management Systems

[Read Gartner's
Report >](#)



Join Oracle
at COLLABORATE 17

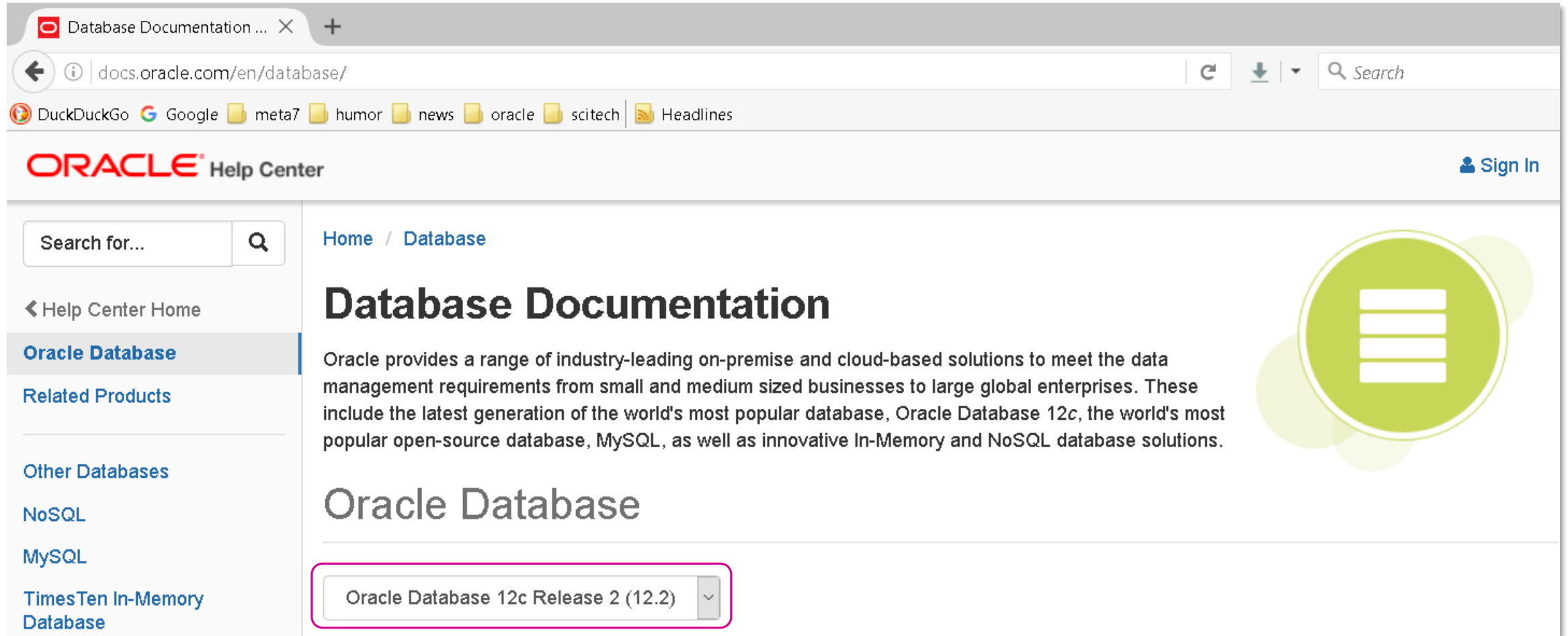
April 2-6, 2017
Mandalay Bay Resort & Casino
Las Vegas, NV

[Register Now](#)

<http://otn.oracle.com>



Get 12.2 Docs Today



The screenshot shows a web browser window with the URL `docs.oracle.com/en/database/`. The page is titled "Database Documentation" and features a sidebar with navigation links: "Help Center Home", "Oracle Database" (highlighted), "Related Products", "Other Databases", "NoSQL", "MySQL", and "TimesTen In-Memory Database". The main content area includes a search bar, a breadcrumb "Home / Database", and a large heading "Database Documentation". Below this, a paragraph describes Oracle's database solutions. A green circular icon with a list symbol is on the right. At the bottom, a dropdown menu is highlighted with a red box, showing "Oracle Database 12c Release 2 (12.2)".

Database Documentation ... X +

docs.oracle.com/en/database/

DuckDuckGo Google meta7 humor news oracle scitech Headlines

ORACLE Help Center [Sign In](#)

Search for... Q

◀ Help Center Home

Oracle Database

[Related Products](#)

[Other Databases](#)

[NoSQL](#)

[MySQL](#)

[TimesTen In-Memory Database](#)

[Home](#) / [Database](#)

Database Documentation

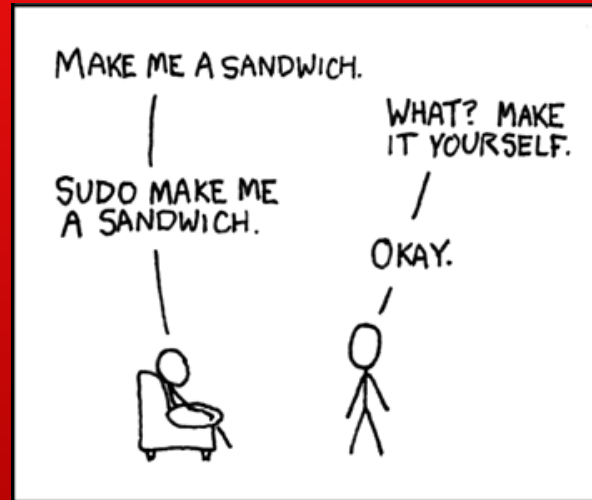
Oracle provides a range of industry-leading on-premise and cloud-based solutions to meet the data management requirements from small and medium sized businesses to large global enterprises. These include the latest generation of the world's most popular database, Oracle Database 12c, the world's most popular open-source database, MySQL, as well as innovative In-Memory and NoSQL database solutions.

Oracle Database

Oracle Database 12c Release 2 (12.2)

`http://docs.oracle.com/en/database`





Introduction



Daniel Morgan



🏆 Oracle ACE Director Alumni

■ Oracle Educator

🏛️ Curriculum author and primary program instructor at University of Washington

🏰 Consultant: Harvard University

■ University Guest Lecturers

- APAC: University of Canterbury (NZ)
- EMEA: University of Oslo (Norway)
- Latin America: Universidad Latina de Panama and Technologico de Costa Rica

■ IT Professional

- First computer: IBM 360/40 in 1969: Fortran IV
- Oracle Database since 1988-9
- Beta Tester 10g, 11g, 12c, GoldenGate, TimesTen
- The Morgan behind www.morganslibrary.org
- Member Oracle Data Integration Solutions Partner Advisory Council
- Co-Founder International GoldenGate Oracle Users Group
- Vice President Twin Cities Oracle Users Group

■ Principal Adviser: Forsythe **Meta7**



System/370-145 system console

email: dmorgan@forsythe.com
Twitter: [@damorgan12c](https://twitter.com/damorgan12c)



My Websites: Morgan's Library



Morgan's Library

[www](#) [library](#)

International Oracle Events 2015-2016 Calendar

FebMarAprMayJunJulAugSepOctNovDecJan

The Library

The library is a spam-free on-line resource with code demos for DBAs and Developers. If you would like to see new Oracle database functionality added to the library ... just email us. Oracle 12.1.0.2.0 has been released and new features will be showing up for many weeks. The first updates have already been made.

[Home](#)
Resources
[Library](#)
[How Can I?](#)
[Code Samples](#)
[Presentations](#)
[Links](#)
[Book Reviews](#)
[Downloads](#)
[User Groups](#)
[Blog](#)
[Humor](#)

General
[Contact](#)
[About](#)
[Services](#)
[Legal Notice & Terms of Use](#)
[Privacy Statement](#)

Presentations Map


MadDog Morgan


Training Events and Travels

- [IOUG, Chicago, Illinois - Mar 10](#)
- [UTOUG, Salt Lake City, Utah - Mar 11-12](#)
- [OUGN, Oslo, Norway - Mar 12-14](#)
- [Collaborate, Las Vegas, Nevada - Apr 12-16](#)
- [NYOUG, New York, NY - May 19](#)
- [GLOC, Cleveland, Ohio - May 19-20](#)

Next Event: 27 January, Redwood Shores, CA

Oracle Events

Click on the map to find an event near you

Morgan

aboard USA-71

ORACLE
ACE Director

Library News

- [Morgan's Blog](#)
- [Join the Western Washington OUG](#)
- [Morgan's Oracle Podcast](#)
- [US Govt. Mil. STIGs \(Security Checklists\)](#)
- [Bryn Llewellyn's PL/SQL White Paper](#)
- [Bryn Llewellyn's Editioning White Paper](#)
- [Explain Plan White Paper](#)



ACE News

 Would you like to become an Oracle ACE? 

Learn more about becoming an ACE



- [ACE Directory](#)
- [ACE Google Map](#)
- [ACE Program](#)
- [Stanley's Blog](#)

Congratulations to our newest
ACE Director Jim Czuprynski



Travel Log: 2010 - Lima Peru



Travel Log: 2013 - Beijing China



Travel Log: 2014 - Galapagos Islands Ecuador



What Meta7 Brings To The Party

- The "Oracle Only" division of Forsythe
- A team of highly skilled professionals with
 - Extensive experience across multiple industries
 - Deep specialization in core Oracle technologies
 - Hardware
 - Licensing
 - Professional Services
 - 0% off-shore: All work performed by US residents
 - \$1M+ investment in the Oracle Cloud
- Reliable on-time and on-budget delivery
- Second largest security integrator in North America
- Corporate headquarters in Chicago, Illinois
- New, State-of-the-Art Technology Evaluation Center
- Flexible financial support



Zero Downtime Migration

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: [damorgan11g](#)
twitter: [@meta7solutions](#)



Safeguarding Databases From Cyber Threats

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: damorgan11g
twitter: @meta7solutions



Scaling VLDBs

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: [damorgan11g](https://www.skype.com/en/contacts/damorgan11g)
twitter: [@meta7solutions](https://twitter.com/meta7solutions)



Database Performance



Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: damorgan11g
twitter: @meta7solutions



Fire Fighting

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: [damorgan11g](https://www.skype.com/user/damorgan11g)
twitter: [@meta7solutions](https://twitter.com/meta7solutions)



Cloud Migration



Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: damorgan11g
twitter: @meta7solutions



Content Density Warning



Take Notes ... Ask Questions



Mythology versus Methodology



The #1 Database Performance Tuning Mythology

Instance Efficiency Percentages (Target 100%)

Buffer Nowait %:	99.80	Redo NoWait %:	100.00
Buffer Hit %:	97.34	In-memory Sort %:	99.99
Library Hit %:	99.97	Soft Parse %:	98.79
Execute to Parse %:	99.29	Latch Hit %:	99.57
Parse CPU to Parse Elapsed %:	0.00	% Non-Parse CPU:	96.60

This was from the worst performing Oracle Database I've seen since 2006



The #1 Database Performance Tuning Methodology

Guessing



BAAG Comrades

7-Sep-08	Mohammad Illiyaz http://	BAAG Member	Because i also want to BATTLE AGAINST ANY GUESSES
22-Sep-08	Ken Jordan http://	BAAG Member	Seeking THE truth!
27-Sep-08	Martin Berger http://berx.at	BAAG Member	I travel on a sea of wild guesses, with some islands of educated guesses. Knowledge is the stars which help me traveling on these seas. I need more light!
22-Nov-08	Daniel Morgan http://www.morganslibrary.org	BAAG Member	Too often a conclusion is simply the place where someone became tired of thinking: Then the "answer" becomes a guess, a prejudice, or a retreat to mythology. I prefer the application of synapses.
11-Feb-09	Fairlie Rego http://www.el-caro.blogspot.com	BAAG Member	becoz I have had enuff
3-Mar-09	Olivier NOEL http://	BAAG Member	Help me in my daily struggle against Oracle
16-Mar-09	Michael Erwin http://www.oracle.com/consulting/technology/grid-computing.html	BAAG Member	I like sharing what I know as actual fact vs. guessing as well.
18-Mar-09	Randolf Geist http://oracle-randolf.blogspot.com/	BAAG Member	I guess (!) it's time to join.
1-Apr-09	Kevin Fries http://	BAAG Member	I guess it cannot make things worse, I've tried everything else and the Magic 8-Ball broke.
13-Apr-09	Henrik Harsfort http://	BAAG Member	to guess is to not know.
24-Apr-09	Paul Clare http://	BAAG Member	Creative problem solving is evolving into an art form.



BAAG Membership



Christian Antognini
Karl Arao
Mark Bobak
Ronald Bradford
Wolfgang Breitling
Doug Burns
Andrew Clarke
Randolf Geist
Alex Gorbachev
Marco Gralike
Frits Hoogland
John Hurley
Anjo Kolk
David Kurtz
Jonathan Lewis
Robyn Sands
Jared Still
Jeremiah Wilton



BAAG Party - Battle Against Any Guess

Home of the BAAG Party

[Blog](#) [About BAAG](#) [BAAG Comrades](#) [Join BAAG](#)

search blog archives

#BAAG on Twitter

Recent Posts

- [The Statspack for PostgreSQL — Meet Pgstatspack](#)
- [SQL Server Performance Diagnostic — Still Guessing?](#)
- [Welcome ASH Masters!](#)
- [BAAG Members page change](#)
- [Avoiding Guesswork in Complex Environments](#)

Recent Comments

- [Alex Gorbachev](#) on [Avoiding Guesswork in Complex Environments](#)
- [Graham Oakes](#) on [Avoiding Guesswork in Complex](#)

About BAAG

Battle Against Any Guess

BAAG - what is it all about? The main idea is to eliminate guesswork from our decision making process — once and for all. It's not Oracle specific even though the roots lie in the area of Oracle database administration. So keep reading even if you don't know anything about Oracle or computers. Before we go any further I should say that the title was inspired by another fine BAA... site — [BAARF](#). Just to avoid any guesses. 😊

After some mental fermentation the [birth](#) of BAAG had been finally triggered by an Oracle-L [thread](#) started as [10gR2 performance sux](#). Title of the post was a direct consequence of pure guess and, worse yet, uneducated guess. It's also interesting to see how the thread [developed](#) - guesswork. [Another problem](#) in the same thread was followed up by the same troubleshooting style. Perhaps, the author, inspired by previous responses, also hoped to find the magic solution from of Oracle-L powered (and often educated) guesses.

Database performance tuning is one of the most noticeable areas where guesswork is still flourishing. There were quite a few methodological techniques born recently, such as [YAPP](#) and [Method R](#), and older guess-based methods such as [Tuning by BCHR](#) are going away. Nevertheless, people's mentality is very difficult to change and we keep relying on guesswork hoping to solve the issue faster. Hope-powered guess is the evil.

Performance tuning is just one example. Imagine that your Oracle database crashes with ORA-600 and guesswork starts powered my your experience. Depending how good your memory and experience are you might want to ask in an Oracle forum something like "My database x.x.x.x crashed with ORA-600. Anyone seen it?" It's fishing for a

MySQL

- [Baron Schwartz](#)
- [Peter Zaitsev](#)
- [Pythian Blog \(MySQL\)](#)

Oracle

- [Anjo Kolik](#)
- [ASH Masters](#)
- [Cary Millsap](#)
- [Daniel Fink](#)
- [James Morie](#)
- [Jonathan Lewis](#)
- [Mogens Nergaard](#)
- [Niall Litchfield](#)
- [Pythian Blog \(Oracle\)](#)
- [Tanel Poder](#)
- [Tom Kyte](#)

PostgreSQL

- [Statspack](#)



Clearly

- No surprise ... I do not endorse guessing
- Possibly a big surprise ... I think most AWR reports are worthless
- I don't think the solutions to every performance issue is an Exadata
- And I am not attracted to all the tools with pretty GUIs
- So let us take a deep dive into performance tuning and address the root cause of the majority of issues I see in my work
- I will focus on what fixes all statements ... not just one statement
- We all know that 30+ years of doing it the way we have been ...
 - DBMS_SUPPORT introduced with version 7.2
 - DBMS_TRACE introduced with version 8.1.5
 - DBMS_MONITOR introduced with version 10.1
 - 10053 and 10046 traces with TKPROF... has not eliminated performance issues

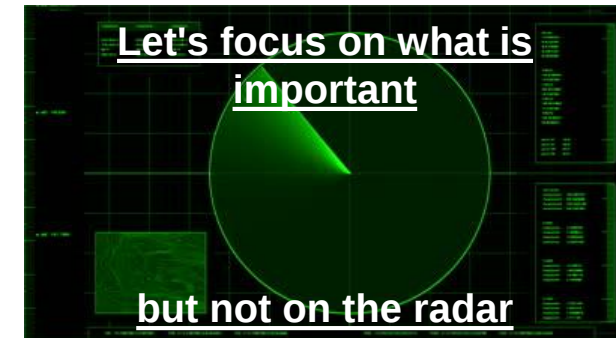


What Affects Performance (1:2)

- Hardware
 - Servers Resources
 - CPU
 - Memory
 - Bus Bandwidth and Latency
 - Storage Subsystems
 - Networks
- Software
 - Operating System Configuration
 - Virtual Machines
 - Drivers
- Database
 - Memory Allocation
 - Optimizer Configuration
 - SQL Quality

- Application

- Web Servers
- Application Servers
- Middleware Caching
- Application Code Quality



What Affects Performance (2:2)

- Everything affects performance
- What I want to focus on today is not those things that affect a single SQL statement
- I want to focus on those things that affect all SQL statements
- The overwhelming majority of database environments where I am brought in, where my team is brought in, have the following characteristics
 - The wrong servers purchased
 - Storage poorly configured
 - Networks poorly configured
 - Database installed using OUI
 - SQL originating in applications where the DBA can't fix it or written by internal developers that think the database is a byte bucket



Servers



Hardware

- Servers and Operating Systems
 - Blade Servers
 - I/O Cards
 - NUMA Architecture
 - HugePages
 - Swapiness
- Virtual Machines
- Storage
 - Controllers
 - Read-Write Caches
 - LUN Size and Layout
- Networks
 - TCP/IP
 - UDP



NUMA Memory Allocation

- Non-Uniform Memory Access

- A memory design used in multiprocessing, where the memory access time depends on the memory location relative to the processor
- A processor can access its own local memory faster than non-local memory
- The benefits of NUMA are limited to particular workloads, notably on servers where the data are often associated strongly with certain tasks or users

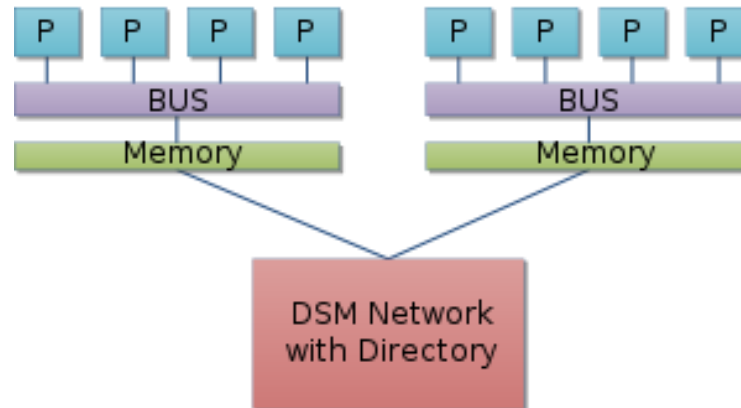


Diagram Source: Wikipedia



Detect NUMA Usage

```
[root@hc1pl-oda01 etc]# numactl --hardware
```

```
available: 1 nodes (0)
```

```
node 0 size: 262086 MB
```

```
node 0 free: 113558 MB
```

```
node distances:
```

```
node    0
```

```
  0:   10
```

```
[root@hc1pl-oda01 etc]# numactl --show
```

```
policy: default
```

```
preferred node: current
```

```
physcpubind: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41  
42 43 44 45 46 47
```

```
cpubind: 0
```

```
nodebind: 0
```

```
membind: 0
```

NUMA Not Configured on an ODA

```
[dmorgan@lخورapln5 ~]$ numactl --hardware
```

```
available: 2 nodes (0-1)
```

```
node 0 size: 48457 MB
```

```
node 0 free: 269 MB
```

```
node 1 size: 48480 MB
```

```
node 1 free: 47 MB
```

```
node distances:
```

```
node    0    1
```

```
  0:   10   20
```

```
  1:   20   10
```

```
[dmorgan@lخورapln5 ~]$ numactl --show
```

```
policy: default
```

```
preferred node: current
```

```
physcpubind: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
```

```
cpubind: 0 1
```

```
nodebind: 0 1
```

```
membind: 0 1
```

NUMA Configured



Is Your Database NUMA Aware?

```
SQL> SELECT a.ksppinm PNAME, c.ksppstvl PVAL, a.ksppdesc PDESC
2  FROM x$ksppi a, x$ksppcv b, x$ksppsv c
3  WHERE a.indx = b.indx
4  AND a.indx = c.indx
5  AND LOWER(a.ksppinm) LIKE '%numa%'
6* ORDER BY 1;
```

PNAME	PVAL	PDESC
-----	-----	-----

_NUMA_instance_mapping	Not specified	Set of nodes that this instance should run on
_NUMA_pool_size	Not specified	aggregate size in bytes of NUMA pool
_db_block_numa	1	Number of NUMA nodes
_enable_NUMA_interleave	TRUE	Enable NUMA interleave mode
_enable_NUMA_optimization	FALSE	Enable NUMA specific optimizations
<u>enable_NUMA_support</u>	<u>FALSE</u>	<u>Enable NUMA support and optimizations</u>
_numa_buffer_cache_stats	0	Configure NUMA buffer cache stats
_numa_shift_enabled	TRUE	Enable NUMA shift
_numa_shift_value	0	user defined value for numa nodes shift
_numa_trace_level	0	numa trace event
_px_numa_stealing_enabled	TRUE	enable/disable PQ granule stealing across NUMA nodes
_px_numa_support_enabled	FALSE	enable/disable PQ NUMA support
_rm_numa_sched_enable	FALSE	Is Resource Manager (RM) related NUMA scheduled
policy enabled		
_rm_numa_simulation_cpus	0	number of cpus for each pg for numa simulation in
resource mgr		
_rm_numa_simulation_pgs	0	number of PGs for numa simulation in resource manager



Enable Database NUMA Support

```
conn / as sysdba

ALTER SYSTEM SET "_enable_NUMA_support" = TRUE
COMMENT='NUMA Support Enabled 15-Mar-2015'
CONTAINER=ALL
SCOPE=SPFILE
SID='*';
```

- **COMMENT**
 - Commenting changes provides change management good practices
- **CONTAINER**
 - New 12c syntax directing a change to alter all containers or the current container
- **SCOPE**
 - MEMORY, SPFILE or BOTH
- **SID**
 - The asterisk indicates that we want the change to take place on all cluster nodes



HugePages

- Also known as "Large Memory Pages" or just "Large Pages"
- Each page table entry represents a “virtual to physical” translation of a process’s memory
- Can be as large as 64 KB in size per entry
- Can be huge for large memory systems
 - See PageTables in /proc/meminfo
 - As large as 1.5 GB
- The entire SGA must fit inside the HugePages
 - If it does not fit ... then none of it will use the HugePage memory
 - You will essentially have walled your database off from using a large portion of the server's memory



Swappiness

- Swapping (aka Paging)
- In a sense the operating system's version of the Oracle Temp tablespace
- Specifies a bias value for the kernel to swap out memory pages used by processes in the cgroup rather than reclaim pages from the page cache
- A value smaller than the default value of 60 reduces the kernel's preference for swapping out memory pages
- A value greater than 60 increases the preference for swapping out
- A value greater than 100 allows the system to swap out pages that fall within the address space of the cgroup's tasks

Value	Strategy
vm.swappiness=0	The kernel will swap only to avoid an out of memory condition
vm.swappiness=60	The default value
vm.swappiness=100	The kernel will swap aggressively

- In older versions of the ODA swappiness was set at 100 (a bad idea) and with the X5-2 has been set at 0 (an almost equally bad idea)



Unstable database Computing System



Tuesday Email



[Redacted]@example.com>

Tue 2015-11-10 10:42

Inbox

Mark as unread

To: Daniel A. Morgan;

• You replied on 2015-11-10 19:41.

Dear Daniel,

We met during Twin Cities Oracle User Group event and discussed a little bit issues for Oracle RAC on Cisco UCS in VMWare environment.

We moved most of our data center RACs to the VMWare on Cisco blades. After that, we started experiencing different kind of issues with Oracle RAC.

Based on log files we can see that when Oracle crashes, the cluster ware reports that there is no heartbeat between nodes or disks ping is taking too long.

Network administrators and Sysadmins do not see anything on HW or VMWare level.

In addition, performance is much worse when one we had one on physical HW despite the fact that we have flash disks, Pure Storage arrays, and they are never busy.

Currently, there is a serious discussion going on inside our company on whether we need to go back to HW from VMWare environment.

Unless VMware is not for Oracle RAC, our guess is that we do not have enough knowledge/expertise on how to Configure VMWare for Oracle RAC right.

So, having that, is that something you or your company can help with? I mean, if we keep Oracle RAC running on VMWare, we'd like to get a consultation or a contractor with a rich background in supporting/architecting production Oracle RAC on VMWare.

Hope to hear from you soon.



Let's Talk About Blades

- Stability is critical to Oracle DBAs the organizations that employ them
- If you have stability issues you can waste staggering amounts of time proving the issue isn't the database
- I have worked extensively with Cisco UCS
 - ~10 databases stand-alone 11gR2
 - ~75 RAC Active-Active and Active-Passive Failover Clusters
- The questions that need to be asked are
 - What is the value of failover for a cluster?
 - What is the value of functioning network diagnostics?
 - What is the value of stability?



VLANs and the Cluster Interconnect (1:2)

- It is essentially impossible to do what is recommended in Oracle Support's "best practices" guidelines for RAC with blades: any blades from any vendor

RAC: Frequently Asked Questions (Doc ID 220970.1)

Cluster interconnect network separation can be satisfied either by using standalone, dedicated switches, which provide the highest degree of network isolation, or Virtual Local Area Networks defined on the Ethernet switch, which provide broadcast domain isolation between IP networks. VLANs are fully supported for Oracle Clusterware interconnect deployments.

Partitioning the Ethernet switch with VLANs allows for:

- Sharing the same switch for private and public communication.
- Sharing the same switch for the private communication of more than one cluster.
- Sharing the same switch for private communication and shared storage access.

The following best practices should be followed:

The Cluster Interconnect VLAN must be on a non-routed IP subnet.

All Cluster Interconnect networks must be configured with non-routed IPs. The server-server communication should be single hop through the switch via the interconnect VLAN. There is no VLAN-VLAN communication.

Oracle recommends maintaining a 1:1 mapping of subnet to VLAN.

The most common VLAN deployments maintain a 1:1 mapping of subnet to VLAN. **It is strongly recommended to avoid multi-subnet mapping to a single VLAN. Best practice recommends a single access VLAN port configured on the switch for the cluster interconnect VLAN.** The server side network interface should have access to a single VLAN.



VLANs and the Cluster Interconnect (2:2)

- It is extremely difficult to troubleshoot interconnect issues with UCS as the tools for separating public, storage, and fusion interconnect packets do not exist

Troubleshooting gc block lost and Poor Network Performance in a RAC Environment (Doc ID 563566.1)

6. Interconnect LAN non-dedicated

Description: **Shared public IP traffic and/or shared NAS IP traffic, configured on the interconnect LAN will result in degraded application performance, network congestion and, in extreme cases, global cache block loss.**

Action: The interconnect/clusterware traffic should be on a dedicated LAN defined by a non-routed subnet. Interconnect traffic should be isolated to the adjacent switch(es), e.g. interconnect traffic should not extend beyond the access layer switch(es) to which the links are attached. **The interconnect traffic should not be shared with public or NAS traffic.** If Virtual LANs (VLANs) are used, the interconnect should be on a single, dedicated VLAN mapped to a dedicated, non-routed subnet, which is isolated from public or NAS traffic.



My Personal Experience

- Blade servers, of which Cisco UCS is but one example, do not have sufficient independent network cards to avoid the networking becoming a single point of failure
- It is good when the public interface has a "keep alive" enabled but this is a fatal flaw for the cluster interconnect as fail-over will be delayed
- When different types of packets, public, storage, and interconnect are mixed low-level diagnostics are difficult ... if not impossible
- When different types of packets, public, storage, and interconnect are mixed the latency of one is the latency of all
- Traffic from any one blade can impact all blades



UCS Blade Server Conclusions

- Blade servers may be a good solution for application and web servers
- They may even be acceptable for stand-alone databases
- Blade servers are unsuitable when
 - High availability is the goal
 - RAC the technology for achieving it
 - Performance is critically important
 - You don't want to stay at work at night, on weekends, and holidays troubleshooting repeated unexplained failures
- **Unstable** database **Computing System**



Network



- Not all HBA cards are the same
- NIC cards vary widely in capabilities and performance
 - TCP Segmentation Offloading (TSO)
 - Kernel Optimization of the TCP/IP stack

```
--enable TCP kernel auto-tuning
/proc/sys/net/ipv4/tcp_moderate_rcvbuf (1=on)

-- tune TCP max memory: tune to 2xBDP (Bandwidth x Delay Product)
-- For example, with 40 Mbits/sec bandwidth, 25 msec delay,
-- BDP = (40 x 1000 / 8 Kbytes/sec) x (0.025 sec) ~ 128 Kbytes
/proc/sys/net/ipv4/tcp_rmem and tcp_wmem 4096 87380 174760

-- tune the socket buffer sizes by setting to 2xBDP
/proc/sys/net/core/rmem_max and wmem_max

-- ensure that TCP Performance features are enabled
/proc/sys/net/ipv4/tcp_sack
/proc/sys/net/ipv4/tcp_window_scaling
/proc/sys/net/ipv4/tcp_timestamps

-- additionally be sure NIC cards have TCP off-loading capability
```



■ Optimize Data Guard

```
--sqlnet.ora
NAMES.DIRECTORY_PATH= (TNSNAMES, EZCONNECT)
DEFAULT_SDU_SIZE=32767

-- listener.ora
DGLOGSHIPB =
  (DESCRIPTION =
    (SDU = 32767)
    (SEND_BUF_SIZE=9375000)
    (RECV_BUF_SIZE=9375000)
    (ADDRESS_LIST =
      (ADDRESS = (PROTOCOL = TCP) (HOST =
10.0.7.2) (PORT = 1526))
    )
    (CONNECT_DATA =
      (SERVICE_NAME = prodb)
    )
  )
```

more examples: www.morganslibrary.org/reference/data_guard.html



- Optimize for RAC
 - Read the Oracle installation documents with very careful attention to the advice given for kernel parameters
 - Disable TCP/IP Keep-Alive for transparent failover
 - If on Linux and you don't know what rmem and wmem are ... read the docs
 - If on Solaris and you don't know what rsize and wsize are ... read the docs



Virtual Machines

- Leave sufficient cpu resources for the bare-metal operating system to perform I/O and manage network traffic
- Disable interrupt coalescing
- Disable chipset power management
- Read the docs http://www.vmware.com/pdf/Perf_Best_Practices_vSphere5.0.pdf
- VMs on NUMA machines should be configured to enhance memory allocation
 - This example is from vSphere where 0 and 1 are the processor sockets

```
numa.nodeAffinity=0,1
```



Port Exhaustion



In The Beginning (1:4)

- Customer Reports are stuck in the queue

Hi Ops

Report Jobs are getting stuck in Waiting in Queue. Also, having performance issues with Admin side

Thanks,
J

Step to Recreate

1. Log into Website
2. Navigate to Reports
3. Search for Account Data
4. Run the report for morgand
5. Notice that the report is stuck in Waiting in Queue



In The Beginning (2:4)

- The website generated an HTTP403 error

As a partner we got communication that the previously assigned sandboxes will be brought down.

Instead -as a partner- we got a them demo environment assigned (Tenant ID: PARTNER0001 which we have integrated with a customer database instance (xxxdemo ace4morgan)).

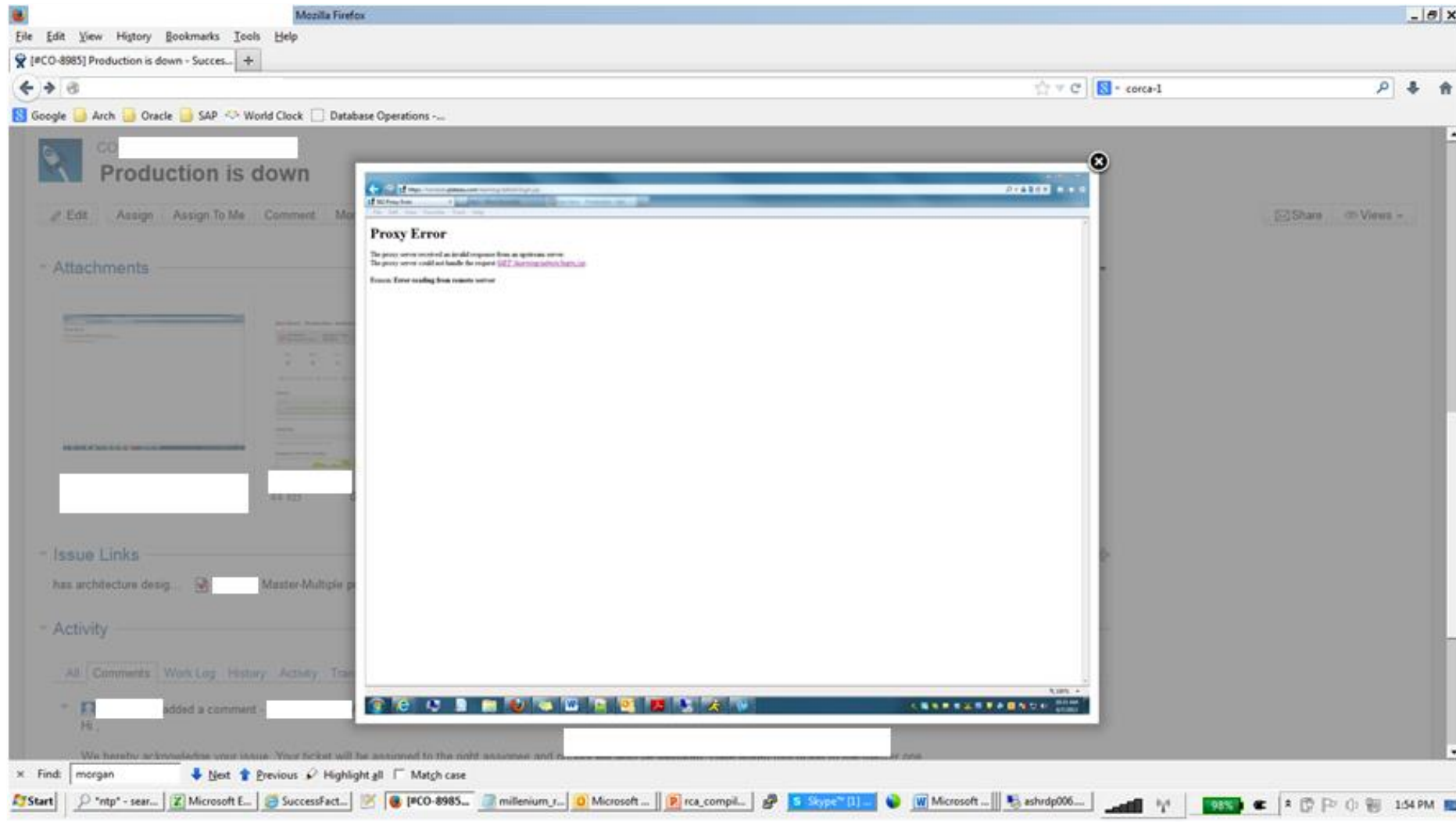
Everything was working fine (including integration).

Today I tried to access the instance via the partner and via the direct url (<https://partner0001.demo.xxx.com/admin/nativelogin.jsp>) but in both case an error is displayed on the screen (see attachment).

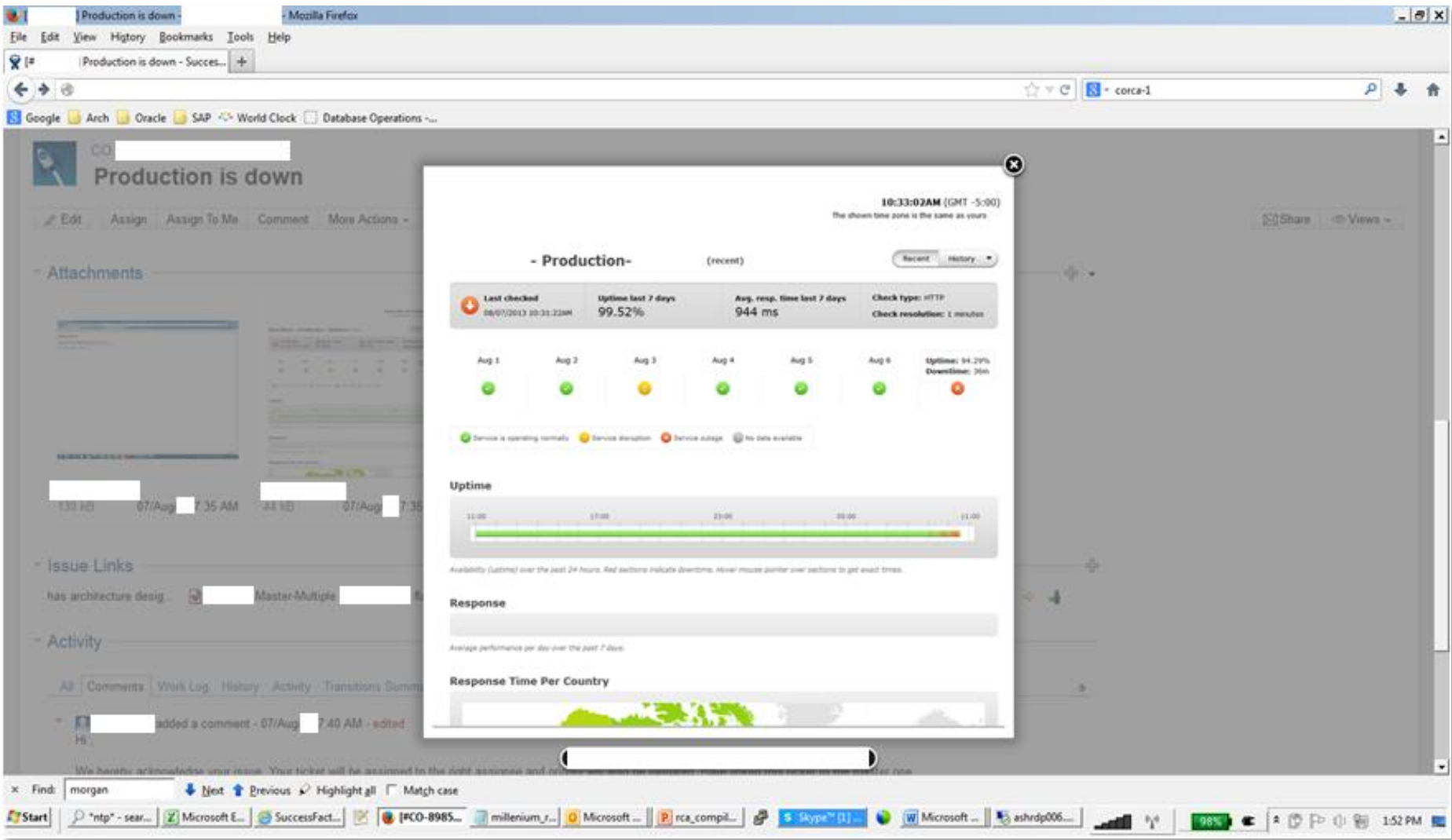
We need this be fixed as soon as possible!
(major customer demo session on Friday!)



In The Beginning (3:4)



In The Beginning (4:4)



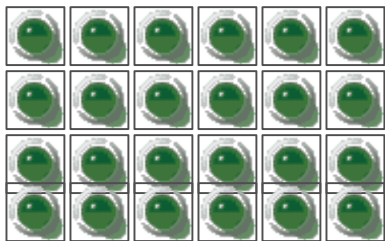
How Does An Application Server Connect to RAC?

- Do you connect to the SCAN IP by name or number?
- If a name ... a DNS server resolves the name to an IP
- To avoid single points of failure you should have two or more DNS servers with a load balancer, or two, in front of them
- The SCAN IP points to a VIP which may again need to be resolved from a name to a physical IP address
- The VIP may again point to a name which must be resolved to a physical IP address
- Most servers cache DNS entries to improve speed
 - Do you know if yours do?



Triaging a Connection Problem

- Try to connect to the cluster?
 - From where?
 - With what tool?
 - To the SCAN, VIP, or physical IP?
- Ping the IP addresses
- Run Trace Route on the IP addresses
- Read the listener log
- Read the database alert log
- Call the network admins who will tell you



everything looks good ...
the network is just Ok ...
the network is always Ok
the network will always be Ok



NAME

resolv.conf- resolver configuration file

SYNOPSIS

`/etc/resolv.conf`

DESCRIPTION

The `resolver` is a set of routines that provide access to the Internet Domain Name System. See [resolver\(3RESOLV\)](#). `resolv.conf` is a configuration file that contains the information that is read by the `resolver` routines the first time they are invoked by a process. The file is designed to be human readable and contains a list of keywords with values that provide various types of `resolver` information.

The `resolv.conf` file contains the following configuration directives:

`nameserver`

Specifies the Internet address in dot-notation format of a name server that the resolver is to query. Up to `MAXNS` name servers may be listed, one per keyword. See `<resolv.h>`. If there are multiple servers, the resolver library queries them in the order listed. If no name server entries are present, the resolver library queries the name server on the local machine. The resolver library follows the algorithm to try a name server until the query times out. It then tries the the name servers that follow, until each query times out. It repeats all the name servers until a maximum number of retries are made.

`domain`

Specifies the local domain name. Most queries for names within this domain can use short names relative to the local domain. If no domain entry is present, the domain is determined from [sysinfo\(2\)](#) or from [gethostname\(3C\)](#). (Everything after the first '.' is presumed to be the domain name.) If the host name does not contain a domain part, the root domain is assumed. You can use the `LOCALDOMAIN` environment variable to override the domain name.



search

The search list for host name lookup. The search list is normally determined from the local domain name. By default, it contains only the local domain name. You can change the default behavior by listing the desired domain search path following the search keyword, with spaces or tabs separating the names. Most `resolver` queries will be attempted using each component of the search path in turn until a match is found. This process may be slow and will generate a lot of network traffic if the servers for the listed domains are not local. Queries will time out if no server is available for one of the domains.

The search list is currently limited to six domains and a total of 256 characters.

sortlist *addresslist*

Allows addresses returned by the `libresolv`-internal `gethostbyname()` to be sorted. A `sortlist` is specified by IP address netmask pairs. The netmask is optional and defaults to the natural netmask of the net. The IP address and optional network pairs are separated by slashes. Up to 10 pairs may be specified. For example:

```
sortlist 130.155.160.0/255.255.240.0 130.155.0.0
```



options

Allows certain internal resolver variables to be modified. The syntax is

```
options option ...
```

where option is one of the following:

debug

Sets `RES_DEBUG` in the `_res.options` field.

ndots: *n*

Sets a threshold floor for the number of dots which must appear in a name given to `res_query()` before an initial absolute (as-is) query is performed. See **resolver(3RESOLV)**. The default value for *n* is 1, which means that if there are any dots in a name, the name is tried first as an absolute name before any search list elements are appended to it.

timeout: *n*

retrans: *n*

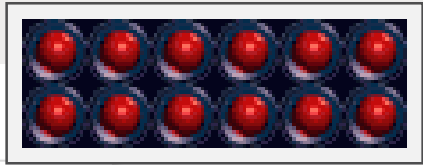
Sets the amount of time the resolver will wait for a response from a remote name server before retrying the query by means of a different name server. Measured in seconds, the default is `RES_TIMEOUT`. See `<resolv.h>`. The `timeout` and `retrans` values are the starting point for an exponential back off procedure where the `timeout` is doubled for every retransmit attempt.

attempts: *n*

retry: *n*

Sets the number of times the resolver will send a query to its name servers before giving up and returning an error to the calling application. The default is `RES_DFLRETRY`. See `<resolv.h>`.





On August 7th, we experienced a 2 hour outage that impacted more than 150 customers. In researching this outage it was noticed that DNS caching had been disabled on the Oracle Database Servers. Also, in going through the logs on the F5 Local Traffic Manager (LTM), it was noticed that there were 39,696 port exhaustion errors on port 53 going to the three DNS servers, starting at approximately 4am and ending slightly after 3pm. There were also an additional 625,665 port exhaustion error messages that were dropped in the logs, bringing the total to 665,361 port exhaustion error messages.

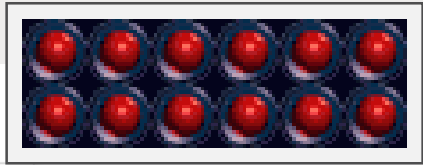
Further research discovered that there was a misconfiguration in the resolv.conf file on the servers in the data center. The resolv.conf file on these servers looked like this:

```
search morgan.priv
nameserver 10.24.244.200 (VIP pointing to servers listed below)
nameserver 10.24.244.21 (Bind server 01)
nameserver 10.24.244.25 (Bind server 02)
nameserver 10.24.244.29 (Bind server 03)
```

This results in the first DNS query going to the VIP for hostname and reverse IP resolution, and then to the three DNS servers. However, the 3 DNS servers which were supposed to be the alternative option to the VIP are also pointing to the same VIP. This basically sets up an infinite loop until the DNS queries time out.

The recommended resolution was to remove the VIP and have the servers query the DNS servers directly.





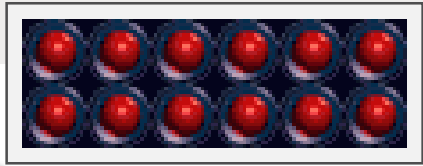
These graphs give an overview of what was happening throughout August 7th on the servers. I noticed that there is a sudden drop in connections right around 10:40am; and returning at around 10:45 am.

If you look at the files I've sent out previously, there is actually less evidence of port exhaustion between 10:22 and 10:42; with increasing levels of port exhaustion as connections and activity increases after about 12:07pm.

Additionally, I went back over the last few days and looked for port exhaustion for the DNS servers on port 53 and found the following:

Jul 29	-	16	port exhaustion errors
Jul 30	-	7	port exhaustion errors
Jul 31	-	8	port exhaustion errors
Aug 1	-	6	port exhaustion errors
Aug 2	-	38,711	port exhaustion errors
Aug 3	-	26,023	port exhaustion errors
Aug 4	-	22,614	port exhaustion errors
Aug 5	-	20	port exhaustion errors
Aug 6	-	11,282	port exhaustion errors





Additionally, I did some calculations on the additional port exhaustion log messages that were dropped – these were the throttling error that I mentioned previously.

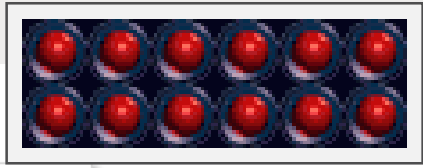
On the 7th of August there were an additional 625,665 port exhaustion error messages that were dropped. On August 3rd, there were an additional 99,199 port exhaustion error messages that were dropped.

And on August 2nd, there were an additional 204,315 port exhaustion error messages that were dropped.

These numbers are in addition to the numbers of port exhaustion errors previously reported.



Resolution: The System Admin POV



Every unix box at the LAX data center has this resolv.conf file:

```
search morgan.priv
nameserver 10.24.244.200 (VIP pointing to both AD01 and AD02 windows servers)
nameserver 10.24.244.21 (Bind server 01)
nameserver 10.24.244.25 (Bind server 02)
nameserver 10.24.244.29 (Bind server 03)
```

The idea behind this design is to firstly query the VIP (for hostname resolution) and then, the 3 bind servers which are slave DNS servers of the AD DNS servers described above.

Now, I've found that the BIND servers (unix) which are supposed to be the alternative option to the VIP, have the same /etc/resolv.conf file and therefore are also pointing to the VIP on the first place. As you can imagine this basically ends up in an infinite loop until the load balancer get finally some relief or the DNS queries timeout.

Refer to the attachment "Morgan current arch" to see the workflow.

The fix should be easy and basically would consist of removing the VIP from the /etc/resolv.conf from the Bind servers and have them pointing to each AD server (bind01 -> AD01, bind02 -> AD02, etc).

The ultimate solution would be to remove the VIP from all the /etc/resolv.conf files and query the BIND servers (Helen has been asking for this for months) and although we have done that in the DEN environment, apparently that hasn't been done on the LAX side yet.



Port Exhaustion Conclusions

- As a DBA you MUST understand how DNS is configured for every one of your databases
- As a DBA you MUST understand resolv.conf and monitor it for content and changes
- As a DBA you MUST educate DNS and System Admins about how to connect to a RAC cluster or a standby
- As a DBA, when troubleshooting connection issues, you MUST log in from an application server to identify what is actually going on ... you can't just FTP to the box



Storage



Storage Hardware

- Storage
 - Spinning Disk
 - Solid State Devices
 - Controllers
 - SAN Switches

Device	Type	IOPS	Interface	Notes
7,200 rpm SATA drives	HDD	~75-100 IOPS ^[2]	SATA 3 Gbit/s	
10,000 rpm SATA drives	HDD	~125-150 IOPS ^[2]	SATA 3 Gbit/s	
10,000 rpm SAS drives	HDD	~140 IOPS ^[2]	SAS	
15,000 rpm SAS drives	HDD	~175-210 IOPS ^[2]	SAS	

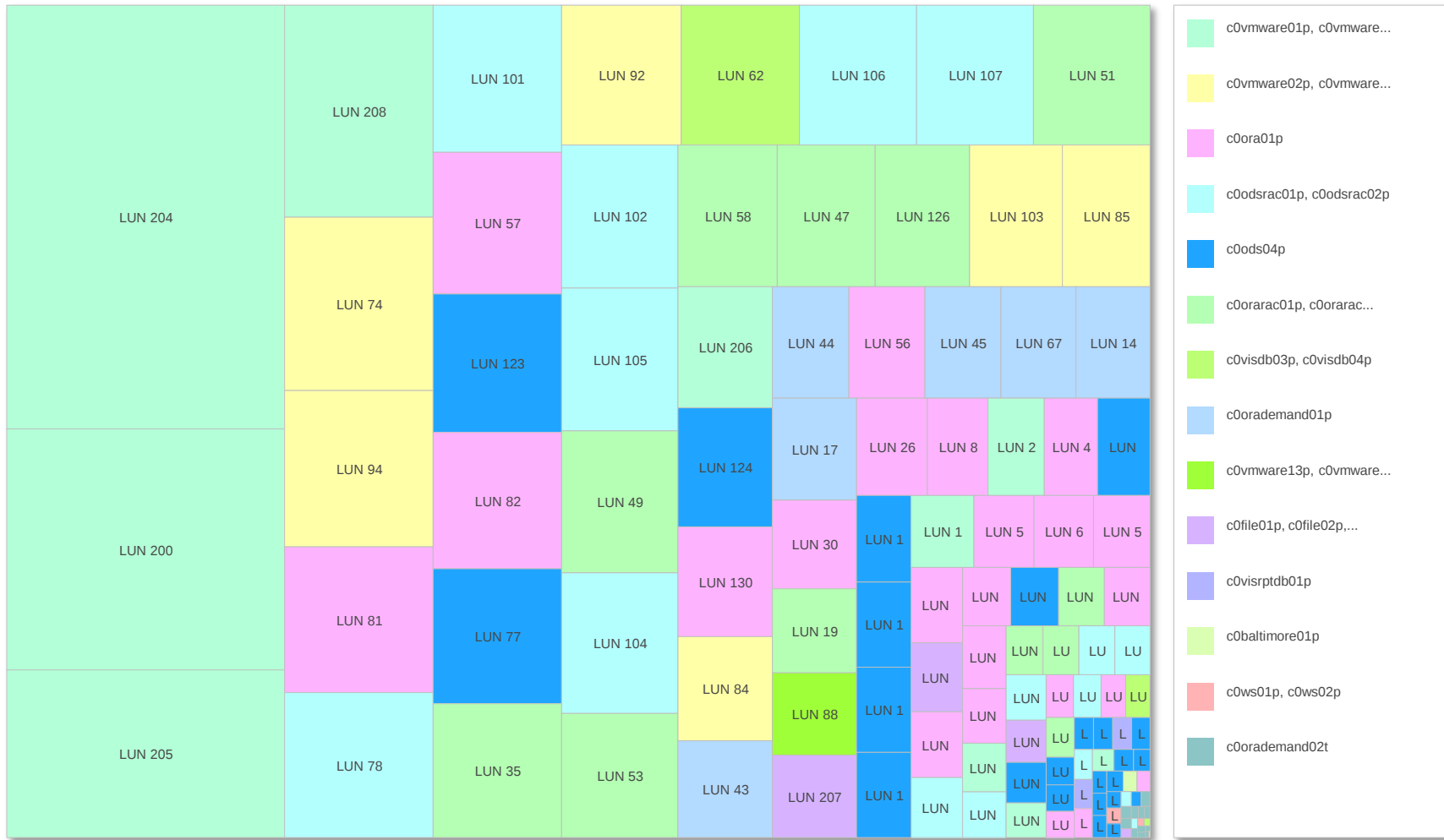
Kaminario K2	Flash/DRAM /Hybrid SSD	Up to 1,200,000 IOPS SPC-1 IOPS with the K2-D (DRAM) ^{[41][42]}	FC	
NetApp FAS6240 cluster	Flash/Disk	1,261,145 SPECsfs2008 nfsv3 IOPs using 1,440 15K disks, across 60 shelves, with virtual storage tiering. ^[43]	NFS, CIFS, FC, FCoE, iSCSI	SPECsfs2008 is the latest version of the Standard Performance Evaluation Corporation benchmark suite measuring file server throughput and response time, providing a standardized method for comparing performance across different vendor platforms. http://www.spec.org/sfs2008/
Fusion-io ioDrive2	SSD	Up to 9,608,000 IOPS ^[44]	PCIe	Only via demonstration so far.



Storage Heat Map



Storage Layout



Solving the Storage Issue

- Do not use shared storage
- Do not use shared storage networks
- Do not use RAID 5
- **Stripe And Mirror Everything**

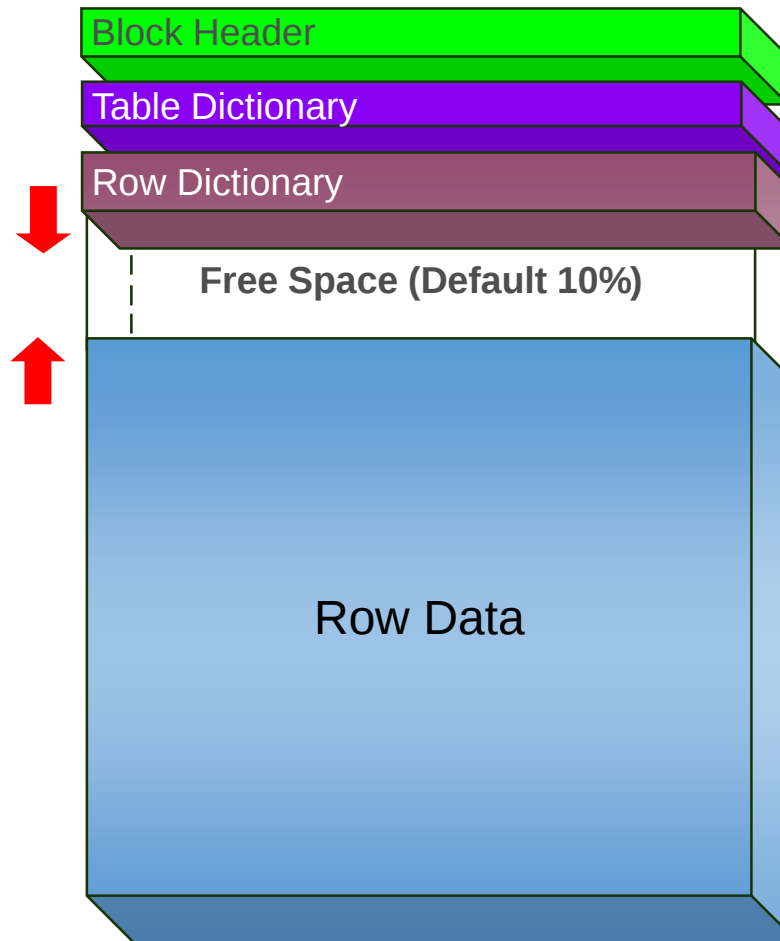


In-Object Space Wastage (1:6)

- By default the Oracle Database wastes 10% of all the storage you allocate to it

```
SQL> SELECT owner, pct_free, count(*)
2  FROM dba_tables
3  WHERE pct_free IS NOT NULL
3  GROUP BY owner, pct_free
4* ORDER BY 1,2;
```

OWNER	PCT_FREE	COUNT (*)
-----	-----	-----
APEX_040200	0	2
APEX_040200	10	450
CTXSYS	0	16
CTXSYS	10	37
DBSNMP	0	1
DBSNMP	10	19
DVSYS	10	34
GSMADMIN_INTERNAL	0	5
GSMADMIN_INTERNAL	10	14
LBACSYS	10	22
MDSYS	10	130
ORDDATA	10	90
SYS	0	90
SYS	1	15
SYS	10	1105
SYSTEM	0	1
SYSTEM	10	131
WMSYS	0	16
WMSYS	10	24
XDB	10	28
XDB	99	1



-  General Block Information (Block add, Segment type) 85 ~ 100 bytes
-  Table info in Cluster
-  Row info in Block (2 byte per row)
-  Used when a row is inserted or updated (pctfree, pctused)
-  Table or Index Data



In-Object Space Wastage (2:6)

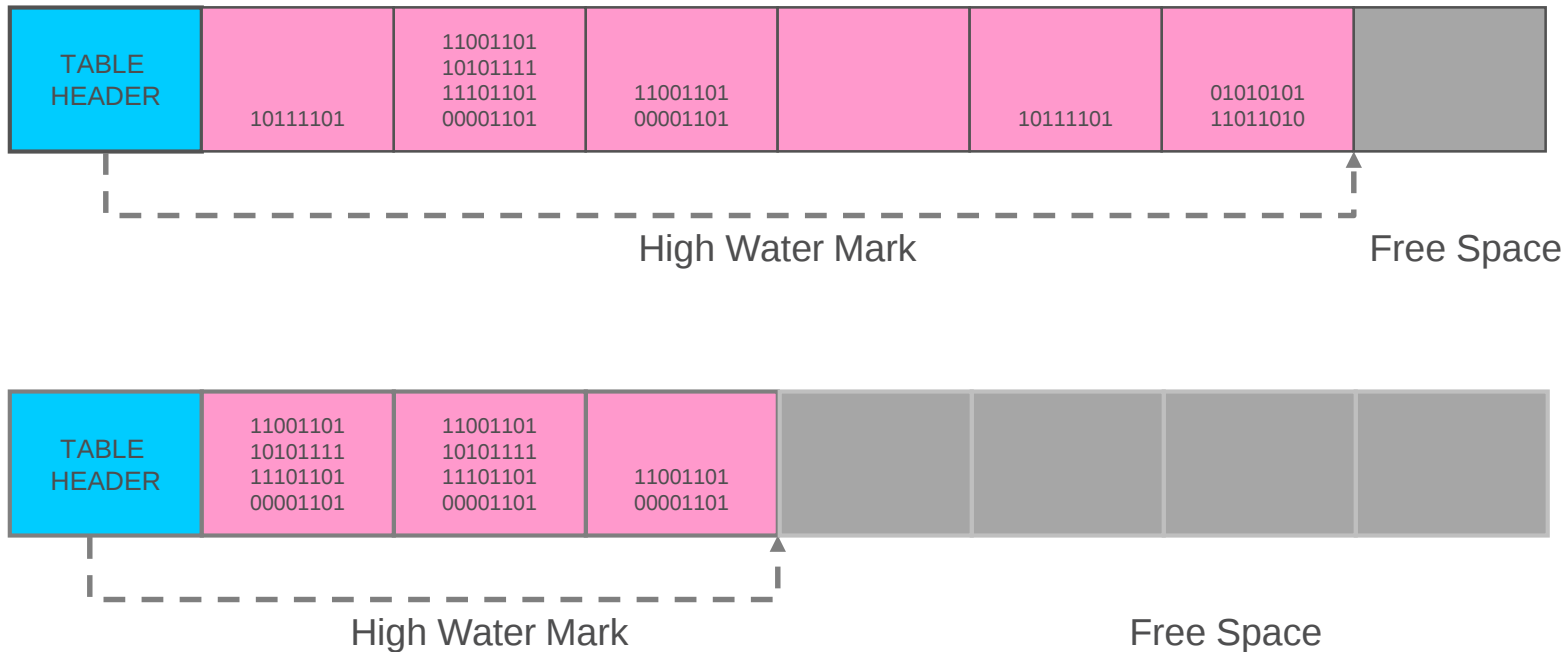
- Within file systems space may not be allocated efficiently to data files
- Within data files space may not be allocated efficiently to segments
- Within segment extents space may not be allocated efficiently too
- In the preceding example, assuming 10% free space and 90 rows per block
 - Reading 89 rows requires reading 8K
 - Reading 91 rows requires reading 16K
 - Without the pctfree loss reading 91-100 rows would still require only 8K of I/O
 - With the free space at 10% reading 200 rows requires reading 3 x 8K
 - With the free space at 0% reading 200 rows saves 1/3 of the I/O
- Know your systems well enough to know if you can eliminate the pct free value



In-Object Space Wastage (3:6)

- Online segments can be shrunk using a variety of technologies
 - DBMS_REDEFINITION
 - DBMS_SPACE
 - DDL

```
SQL> ALTER TABLE servers ENABLE ROW MOVEMENT;  
SQL> ALTER TABLE servers SHRINK SPACE CASCADE;
```



Basic Compression: Heap Tables

- Works by removing duplicate values at the block level
- Sets PCT_FREE to zero

```
SQL> SELECT table_name, pct_free  
2 FROM user_tables
```

TABLE_NAME	PCT_FREE
CAL_MONTH_SALES_MV	10
CHANNELS	10
COSTS	
COUNTRIES	10
CUSTOMERS	10
DIMENSION_EXCEPTIONS	10
DR\$SUP_TEXT_IDX\$I	10
DR\$SUP_TEXT_IDX\$K	0
DR\$SUP_TEXT_IDX\$N	0
DR\$SUP_TEXT_IDX\$R	10
FWEEK_PSCAT_SALES_MV	10
PRODUCTS	10
PROMOTIONS	10
SALES	
SALES_AUDIT	10
SALES_HISTORY	10
SALES_TRANSACTIONS_EXT	0
SH_TEST	0
SUPPLEMENTARY_DEMOGRAPHICS	10
TIMES	10

```
SQL> CREATE TABLE sh_test AS  
2 SELECT /*+ APPEND */ * FROM sales;
```

Table created.

```
SQL> SELECT blocks FROM user_segments WHERE segment_name = 'SH_TEST';
```

```
BLOCKS  
-----  
4608
```

```
SQL> drop table sh_test purge;
```

Table dropped.

```
SQL> CREATE TABLE sh_test COMPRESS AS  
2 SELECT /*+ APPEND */ * FROM sales;
```

Table created.

```
SQL> SELECT blocks FROM user_segments WHERE segment_name = 'SH_TEST';
```

```
BLOCKS  
-----  
1536
```

```
SQL> SELECT 1536/4608 FROM dual;
```

```
1536/4608  
-----  
.333333333
```



Heap Table Compression Benchmark: NONE

```
SQL> CREATE TABLE sh_test AS SELECT /*+ APPEND */ * FROM sales;
```

Table created.

```
SQL> select blocks, pct_free from dba_tables where table_name = 'SH_TEST';
```

BLOCKS	PCT_FREE
4513	10

```
SQL> explain plan for select min(time_id) from sh_test;
```

Explained.

```
SQL> select * from table(dbms_xplan.display);
```

PLAN_TABLE_OUTPUT

Plan hash value: 1514323645

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	8	1229 (1)	00:00:01
1	SORT AGGREGATE		1	8		
2	TABLE ACCESS FULL	SH_TEST	918K	7178K	1229 (1)	00:00:01



Heap Table Compression Benchmark: BASIC

```
SQL> CREATE TABLE sh_test COMPRESS AS SELECT /*+ APPEND */ * FROM sales;

Table created.

SQL> select blocks, pct_free from dba_tables where table_name = 'SH_TEST';

      BLOCKS      PCT_FREE
-----
      1511           0

SQL> explain plan for select min(time_id) from sh_test;

Explained.

SQL> select * from table(dbms_xplan.display);

PLAN_TABLE_OUTPUT
-----
Plan hash value: 1514323645

-----
| Id | Operation              | Name      | Rows  | Bytes | Cost (%CPU) | Time      |
-----
|  0 | SELECT STATEMENT        |           |      1 |      8 |    416  (2) | 00:00:01 |
|  1 |   SORT AGGREGATE        |           |      1 |      8 |           |           |
|  2 |    TABLE ACCESS FULL   | SH_TEST   |    918K | 7178K |    416  (2) | 00:00:01 |
-----
```



Heap Table Compression Benchmark: ADVANCED

```
SQL> CREATE TABLE sh_test COMPRESS FOR OLTP AS SELECT /*+ APPEND */ * FROM sales;
```

Table created.

```
SQL> select blocks from dba_tables where table_name = 'SH_TEST';
```

BLOCKS
1676

```
SQL> select blocks from dba_segments where segment_name = 'SH_TEST';
```

BLOCKS
1792



Heap Table Compression Benchmark: ADVANCED

```
SQL> CREATE TABLE sh_test COMPRESS FOR OLTP AS SELECT /*+ APPEND */ * FROM sales;
```

Table created.

```
SQL> select blocks from dba_tables where table_name = 'SH_TEST';
```

BLOCKS	PCT_FREE
1676	10

```
SQL> CREATE TABLE sh_test ROW STORE COMPRESS ADVANCED AS SELECT /*+ APPEND */ * FROM sales;
```

```
SQL> select blocks, pct_free from dba_tables where table_name = 'SH_TEST';
```

BLOCKS	PCT_FREE
1676	10

```
SQL> explain plan for select min(time_id) from sh_test;
```

Explained.

```
SQL> select * from table(dbms_xplan.display);
```

PLAN_TABLE_OUTPUT

Plan hash value: 1514323645

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	8	461 (2)	00:00:01
1	SORT AGGREGATE		1	8		
2	TABLE ACCESS FULL	SH_TEST	918K	7178K	461 (2)	00:00:01



Heap Table Compression Benchmark: Comparison

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time				

2	TABLE ACCESS FULL	SH_TEST	918K	7178K	1229 (1)	00:00:01	none			
2	TABLE ACCESS FULL	SH_TEST	918K	7178K	416 (2)	00:00:01	basic			
2	TABLE ACCESS FULL	SH_TEST	918K	7178K	461 (2)	00:00:01	advanced			



Basic Compression: B*Tree Indexes

- To compress the leading columns in an index by remove duplicate values
 - Space saving 34.4%

```
SQL> CREATE INDEX ix_sales_bic ON sales(prod_id, time_id, amount_sold);

Index created.

SQL> SELECT blocks FROM user_segments WHERE segment_name = 'IX_SALES_BIC';

      BLOCKS
-----
       4096

SQL> drop index ix_sales_bic;

Index dropped.

SQL> CREATE INDEX ix_sales_bic ON sales(prod_id, time_id, amount_sold) COMPRESS 2;

Index created.

SQL> SELECT blocks FROM user_segments WHERE segment_name = 'IX_SALES_BIC';

      BLOCKS
-----
       2688
```



Advanced Compression: B*Tree Indexes

- New feature in Database 12cR1
 - Specify COMPRESS ADVANCED LOW to enable advanced index compression. Advanced index compression improves compression ratios significantly while still providing efficient access to indexes. Therefore, advanced index compression works well on all supported indexes, including those indexes that are not good candidates for prefix compression.
 - Space saving 20%

```
SQL> CREATE INDEX index ix_sales_amnt_sold ON sales(amount_sold);

Index created.

SQL> SELECT blocks FROM user_segments WHERE segment_name = 'IX_SALES_AMNT_SOLD';

      BLOCKS
-----
       2560

SQL> drop index ix_sales_amnt_sold;

Index dropped.

SQL> CREATE INDEX ix_sales_amnt_sold ON sales(amount_sold) COMPRESS ADVANCED LOW;

Index created.

SQL> SELECT blocks FROM user_segments WHERE segment_name = 'IX_SALES_AMNT_SOLD';

      BLOCKS
-----
       2048
```



DBMS_COMPRESSION Built-in Package

- Supports advanced compression features new as of 11gR2 and the Oracle-Sun Exadata Server
- Stored procedures include
 - DUMP_COMPRESSION_MAP
 - GET_COMPRESSION_RATIO
 - GET_COMPRESSION_TYPE
 - INCREMENTAL_COMPRESS

```
SQL> DECLARE
  2  blkcnt_cmp    PLS_INTEGER;
  3  blkcnt_uncmp  PLS_INTEGER;
  4  row_comp      PLS_INTEGER;
  5  row_uncmp     PLS_INTEGER;
  6  cmp_ratio     NUMBER;
  7  comptype      VARCHAR2(30);
  8  BEGIN
  9      dbms_compression.get_compression_ratio('SYSTEM', 'SYS',
'SOURCE$', NULL, dbms_compression.comp_advanced, blkcnt_cmp,
blkcnt_uncmp, row_comp, row_uncmp, cmp_ratio, comptype);
 10      dbms_output.put_line('Block Count Compressed:      ' || TO_CHAR(blkcnt_cmp));
 11      dbms_output.put_line('Block Count UnCompressed:  ' || TO_CHAR(blkcnt_uncmp));
 12      dbms_output.put_line('Row Count Compressed:      ' || TO_CHAR(row_comp));
 13      dbms_output.put_line('Row Count UnCompressed:  ' || TO_CHAR(row_uncmp));
 14      dbms_output.put_line('Block Count Compressed:  ' || TO_CHAR(cmp_ratio));
 15      dbms_output.put_line('Compression Type:      ' || comptype);
 16* END;
 17 /
Block Count Compressed:      1749
Block Count UnCompressed: 1894
Row Count Compressed:      58
Row Count UnCompressed: 53
Block Count Compressed:      1
Compression Type:      "Compress Advanced"

PL/SQL procedure successfully completed.
```



- DBMS_SPACE Built-In Package
 - Fully documented and supported
 - FREE_BLOCKS
 - SPACE_USAGE
 - UNUSED_SPACE
 - VERIFY_SHRINK_CANDIDATE
 - VERIFY_SHRINK_CANDIDATE_TBF



In-Object Space Wastage (5:6)

- No wastage

```
SQL> DECLARE
 2  uf    NUMBER;
 3  ub    NUMBER;
 4  f1    NUMBER;
 5  f1b   NUMBER;
 6  f2    NUMBER;
 7  f2b   NUMBER;
 8  f3    NUMBER;
 9  f3b   NUMBER;
10  f4    NUMBER;
11  f4b   NUMBER;
12  fbl   NUMBER;
13  fby   NUMBER;
14  BEGIN
15      dbms_space.space_usage('UWCLASS','SERVERS', 'TABLE', uf, ub, f1, f1b, f2, f2b, f3, f3b, f4, f4b, fbl, fby);
16
17      dbms_output.put_line('unformatted blocks:  ' || TO_CHAR(uf));
18      dbms_output.put_line('unformatted bytes:   ' || TO_CHAR(ub));
19      dbms_output.put_line('blocks 0-25% free:    ' || TO_CHAR(f1));
20      dbms_output.put_line('bytes 0-25% free:   ' || TO_CHAR(f1b));
21      dbms_output.put_line('blocks 25-50% free: ' || TO_CHAR(f2));
22      dbms_output.put_line('bytes 25-50% free:  ' || TO_CHAR(f2b));
23      dbms_output.put_line('blocks 50-75% free: ' || TO_CHAR(f3));
24      dbms_output.put_line('bytes 50-75% free:  ' || TO_CHAR(f3b));
25      dbms_output.put_line('blocks 75-100% free: ' || TO_CHAR(f4));
26      dbms_output.put_line('bytes 75-100% free:  ' || TO_CHAR(f4b));
27      dbms_output.put_line('full blocks:        ' || TO_CHAR(fbl));
28      dbms_output.put_line('full bytes:         ' || TO_CHAR(fby));
29  END;
30  /
unformatted blocks: 0
unformatted bytes: 0
blocks 0-25% free: 0
bytes 0-25% free: 0
blocks 25-50% free: 0
bytes 25-50% free: 0
blocks 50-75% free: 0
bytes 50-75% free: 0
blocks 75-100% free: 0
bytes 75-100% free: 0
full blocks: 2
full bytes: 16384
```



In-Object Space Wastage (6:6)

■ Minor wastage

```
SQL> DECLARE
 2  uf    NUMBER;
 3  ub    NUMBER;
 4  f1    NUMBER;
 5  f1b   NUMBER;
 6  f2    NUMBER;
 7  f2b   NUMBER;
 8  f3    NUMBER;
 9  f3b   NUMBER;
10  f4    NUMBER;
11  f4b   NUMBER;
12  fbl   NUMBER;
13  fby   NUMBER;
14  BEGIN
15      dbms_space.space_usage('XDB','X$QN40ORNNWS4T9IVANV2GK293AFHS', 'TABLE', uf, ub, f1, f1b, f2, f2b, f3, f3b, f4, f4b, fbl, fby);
16
17      dbms_output.put_line('unformatted blocks:  ' || TO_CHAR(uf));
18      dbms_output.put_line('unformatted bytes:   ' || TO_CHAR(ub));
19      dbms_output.put_line('blocks 0-25% free:   ' || TO_CHAR(f1));
20      dbms_output.put_line('bytes 0-25% free:   ' || TO_CHAR(f1b));
21      dbms_output.put_line('blocks 25-50% free: ' || TO_CHAR(f2));
22      dbms_output.put_line('bytes 25-50% free:  ' || TO_CHAR(f2b));
23      dbms_output.put_line('blocks 50-75% free: ' || TO_CHAR(f3));
24      dbms_output.put_line('bytes 50-75% free:  ' || TO_CHAR(f3b));
25      dbms_output.put_line('blocks 75-100% free: ' || TO_CHAR(f4));
26      dbms_output.put_line('bytes 75-100% free:  ' || TO_CHAR(f4b));
27      dbms_output.put_line('full blocks:        ' || TO_CHAR(fbl));
28      dbms_output.put_line('full bytes:         ' || TO_CHAR(fby));
29  END;
30  /
unformatted blocks: 0
unformatted bytes: 0
blocks 0-25% free: 0
bytes 0-25% free: 0
blocks 25-50% free: 0
bytes 25-50% free: 0
blocks 50-75% free: 1
bytes 50-75% free: 8192
blocks 75-100% free: 2
bytes 75-100% free: 16384
full blocks: 2
full bytes: 16384
```



Other Storage Optimizations

- Oracle's default tablespace settings waste disk and create unnecessary I/O in the vast majority of databases
- Default smallfile tablespaces should not be used in environments where the number of datafiles, in a tablespace, increases over time
- Default table creations are almost always inefficient
 - Heap tables are the default choice not necessarily the best choice
- Oracle optimizes data dictionary performance by clustering tables ... do you?
- New in 12c ... Attribute clustering specifies how to cluster data in close physical proximity based on column contents which improves compression, indexes, and zone maps

```
CREATE TABLE cluster_t (  
  rid          NUMBER,  
  lname        VARCHAR2(25) ,  
  state_prov   VARCHAR2(2))  
CLUSTERING BY LINEAR ORDER (state_prov) WITH MATERIALIZED ZONEMAP;
```



One Issue with Attribute Clustering

- Oops!

```
SQL> drop table cluster_t purge;
```

Table dropped.

```
SQL> CREATE TABLE cluster_t (  
  2  rid          NUMBER,  
  3  lname        VARCHAR2(25),  
  4  state_prov   VARCHAR2(2))  
  5  CLUSTERING BY LINEAR ORDER (state_prov) WITH MATERIALIZED ZONEMAP;
```

```
CREATE TABLE cluster_t (  
*  
ERROR at line 1:  
ORA-01031: insufficient privileges
```

```
SQL> desc cluster_t
```

Name	Null?	Type
-----	-----	-----
RID		NUMBER
LNAME		VARCHAR2(25)
STATE_PROV		VARCHAR2(2)

- Opening an SR



SQL



I'm Not Afraid To Show You Mine





[illegible]

[illegible]



```
when trunc(datetime_ins, 'mi') > trunc(sysdate)+7/24 then MSC end) summarised_late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+7/24 then MSC end) summarised_online_count, sum(entries) num_of_sumrows from NORTEL_PSCORE.VLR6_DY where datetime = trunc(sysdate)-1 )sumt union all SELECT 'NORTEL_PSCORE.GSCGMM' AS TABLENAME, sunday, CASE WHEN percent(summarised_online_count, (online_count-late_count), 2) > 100 THEN 100 ELSE percent(summarised_online_count, (online_count-late_count), 2) END percent_of_cutoff, case when 100-percent(summarised_online_count, (online_count-late_count), 2) < 0 then 0 else 100-percent(summarised_online_count, (online_count-late_count), 2) end percent_of_cutoff_not_summed, percent(summarised_online_count, online_count+late_count, 2)percentage_of_total_by5am, percent(summarised_online_count+summarised_late_count, online_count+late_count, 2) current_percentage, online_count+late_count current_raw_elements, summarised_online_count+summarised_late_count current_summary_elements, summarised_online_count-summarised_late_count SUM_ELEMENTS_AT5AM, late_count late_raw_elements, online_count-late_count available_at_cutoff, percent(num_of_sumrows, num_of_rows, 2) accuracy from ( select count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+3/24 then SGSN end) late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+3/24 then SGSN end) online_count, count (*) num_of_rows from NORTEL_PSCORE.GSCGMM where datetime between trunc(sysdate)-1 and trunc(sysdate)-1/24/60 )rawt, ( select max(datetime)sunday, count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+7/24 then SGSN end) summarised_late_count, sum(entries) num_of_sumrows from NORTEL_PSCORE.GSCGMM_DY where datetime = trunc(sysdate)-1 )sumt union all SELECT 'NORTEL_PSCORE.GSCSM_ACT' AS TABLENAME, sunday, CASE WHEN percent(summarised_online_count, (online_count-late_count), 2) > 100 THEN 100 ELSE percent(summarised_online_count, (online_count-late_count), 2) END percent_of_cutoff, case when 100-percent(summarised_online_count, (online_count-late_count), 2) < 0 then 0 else 100-percent(summarised_online_count, (online_count-late_count), 2) end percent_of_cutoff_not_summed, percent(summarised_online_count, online_count+late_count, 2)percentage_of_total_by5am, percent(summarised_online_count+summarised_late_count, online_count+late_count, 2) current_percentage, online_count+late_count current_raw_elements, summarised_online_count+summarised_late_count current_summary_elements, summarised_online_count-summarised_late_count SUM_ELEMENTS_AT5AM, late_count late_raw_elements, online_count-late_count available_at_cutoff, percent(num_of_sumrows, num_of_rows, 2) accuracy from ( select count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+3/24 then SGSN end) late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+3/24 then SGSN end) online_count, count (*) num_of_rows from NORTEL_PSCORE.GSCSM_ACT where datetime between trunc(sysdate)-1 and trunc(sysdate)-1/24/60 )rawt, ( select max(datetime)sunday, count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+7/24 then SGSN end) summarised_late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+7/24 then SGSN end) summarised_online_count, sum(entries) num_of_sumrows from NORTEL_PSCORE.GSCSM_ACT_DY where datetime = trunc(sysdate)-1 )sumt union all SELECT 'NORTEL_PSCORE.GSCSM' AS TABLENAME, sunday, CASE WHEN percent(summarised_online_count, (online_count-late_count), 2) > 100 THEN 100 ELSE percent(summarised_online_count, (online_count-late_count), 2) END percent_of_cutoff, case when 100-percent(summarised_online_count, (online_count-late_count), 2) < 0 then 0 else 100-percent(summarised_online_count, (online_count-late_count), 2) end percent_of_cutoff_not_summed, percent(summarised_online_count, online_count+late_count, 2)percentage_of_total_by5am, percent(summarised_online_count+summarised_late_count, online_count+late_count, 2) current_percentage, online_count+late_count current_raw_elements, summarised_online_count+summarised_late_count current_summary_elements, summarised_online_count-summarised_late_count SUM_ELEMENTS_AT5AM, late_count late_raw_elements, online_count-late_count available_at_cutoff, percent(num_of_sumrows, num_of_rows, 2) accuracy from ( select count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+3/24 then SGSN end) late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+3/24 then SGSN end) online_count, count (*) num_of_rows from NORTEL_PSCORE.GSCSM where datetime between trunc(sysdate)-1 and trunc(sysdate)-1/24/60 )rawt, ( select max(datetime)sunday, count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+7/24 then SGSN end) summarised_late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+7/24 then SGSN end) summarised_online_count, sum(entries) num_of_sumrows from NORTEL_PSCORE.GSCSM_DY where datetime = trunc(sysdate)-1 )sumt union all SELECT 'NORTEL_PSCORE.GSDSTATS' AS TABLENAME, sunday, CASE WHEN percent(summarised_online_count, (online_count-late_count), 2) > 100 THEN 100 ELSE percent(summarised_online_count, (online_count-late_count), 2) END percent_of_cutoff, case when 100-percent(summarised_online_count, (online_count-late_count), 2) < 0 then 0 else 100-percent(summarised_online_count, (online_count-late_count), 2) end percent_of_cutoff_not_summed, percent(summarised_online_count, online_count+late_count, 2)percentage_of_total_by5am, percent(summarised_online_count+summarised_late_count, online_count+late_count, 2) current_percentage, online_count+late_count current_raw_elements, summarised_online_count+summarised_late_count current_summary_elements, summarised_online_count-summarised_late_count SUM_ELEMENTS_AT5AM, late_count late_raw_elements, online_count-late_count available_at_cutoff, percent(num_of_sumrows, num_of_rows, 2) accuracy from ( select count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+3/24 then SGSN end) late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+3/24 then SGSN end) online_count, count (*) num_of_rows from NORTEL_PSCORE.GSDSTATS where datetime between trunc(sysdate)-1 and trunc(sysdate)-1/24/60 )rawt, ( select max(datetime)sunday, count(distinct case when trunc(datetime_ins, 'mi') > trunc(sysdate)+7/24 then SGSN end) summarised_late_count, count(distinct case when trunc(datetime_ins, 'mi') < trunc(sysdate)+7/24 then SGSN end) summarised_online_count, sum(entries) num_of_sumrows from NORTEL_PSCORE.GSDSTATS_DY where datetime = trunc(sysdate)-1 )sumt
```



Optimizer Plans (1:4)

```
SELECT DISTINCT E1_2.OBJECT_ID
FROM PMCM.ELEMENT_DETAIL E1_1, PMCM.ELEMENT_DETAIL E1_2, PMCM.MARK_NETW_HIERARCHY H1,
PMCM.ELEMENT_DETAIL E2_1, PMCM.ELEMENT_DETAIL E2_2, PMCM.MARK_NETW_HIERARCHY H2
WHERE E1_1.OBJECT_ID = H1.PARENT_ID
AND E1_2.OBJECT_ID = H1.OBJECT_ID
AND E2_1.OBJECT_ID = H2.PARENT_ID
AND E2_2.OBJECT_ID = H2.OBJECT_ID
AND E1_1.CURRENT_IND = 'Y' AND E2_1.CURRENT_IND = 'Y'
AND E2_1.CURRENT_IND = 'Y' AND E2_2.CURRENT_IND = 'Y'
AND H1.CURRENT_IND = 'Y' AND H2.CURRENT_IND = 'Y'
AND H1.HIERARCHY_TYPE = 'NETWORK' AND H2.HIERARCHY_TYPE = 'NETWORK'
AND H1.PARENT_TYPE IN ('BSC','RNC') AND H2.PARENT_TYPE IN ('BSC','RNC')
AND E2_2.ELEMENT_TYPE = 'CELL' AND E1_2.ELEMENT_TYPE = 'CELL'
AND H1.PARENT_TYPE IN ('BSC','RNC')
AND E1_1.ELEMENT_NAME = E2_1.ELEMENT_NAME
AND E1_1.ELEMENT_ID = E2_1.ELEMENT_ID
AND E1_2.ELEMENT_NAME = E2_2.ELEMENT_NAME
AND E1_2.ELEMENT_ID = E2_2.ELEMENT_ID
AND E1_2.USEID LIKE '*' AND E2_2.USEID NOT LIKE '*';
```

Id	Operation	Name	Rows	Bytes	TempSpc	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		1	78		74M (40)	50:54:42		
1	TEMP TABLE TRANSFORMATION								
2	LOAD AS SELECT								
3	PARTITION RANGE ALL		22M	1111M		38153 (11)	00:01:34	1	29
* 4	TABLE ACCESS FULL	ELEMENT_DETAIL	22M	1111M		38153 (11)	00:01:34		
5	LOAD AS SELECT								
6	PARTITION HASH ALL		337K	9231K		3514 (15)	00:00:09	1	16
* 7	TABLE ACCESS FULL	MARK_NETW_HIERARCHY	337K	9231K		3514 (15)	00:00:09		
8	SORT AGGREGATE		1	78					
* 9	HASH JOIN		927G	65T	534M	74M (40)	50:53:00		
10	VIEW		22M	277M		16808 (12)	00:00:42		
11	TABLE ACCESS FULL	SYS_TEMP_0FDA7485F_6A66C42E	22M	1111M		16808 (12)	00		
* 12	HASH JOIN		21G	1272G	534M	1616K (43)	01:06:04		
13	VIEW		22M	277M		16808 (12)	00:00:42		
14	TABLE ACCESS FULL	SYS_TEMP_0FDA7485F_6A66C42E	22M	1111M		16808 (12)	0		
* 15	HASH JOIN		476M	23G	524M	97327 (22)	00:03:59		
* 16	HASH JOIN		10M	401M	8704K	34520 (10)	00:01:25		
* 17	HASH JOIN		234K	5948K	8256K	783 (10)	00:00:02		
18	VIEW		337K	4286K		142 (14)	00:00:01		
19	TABLE ACCESS FULL	SYS_TEMP_0FDA74860_6A66C42E	337K	3956K		142 (14)	00:00:01		
20	VIEW		337K	4286K		142 (14)	00:00:01		
21	TABLE ACCESS FULL	SYS_TEMP_0FDA74860_6A66C42E	337K	3956K		142 (14)	00:00:01		
22	VIEW		22M	277M		16808 (12)	00:00:42		
23	TABLE ACCESS FULL	SYS_TEMP_0FDA7485F_6A66C42E	22M	1111M		16808 (12)	00:00:42		
24	VIEW		22M	277M		16808 (12)	00:00:42		
25	TABLE ACCESS FULL	SYS_TEMP_0FDA7485F_6A66C42E	22M	1111M		16808 (12)	0		



Optimizer Plans (2:4)

Id	Operation	Name	Rows	Bytes	TempSpc	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		1	78		14T(100)	999:59:59		
1	TEMP TABLE TRANSFORMATION								
2	LOAD AS SELECT								
3	PARTITION RANGE ALL		22M	1111M		38153 (11)	00:01:34	1	29
* 4	TABLE ACCESS FULL	ELEMENT_DETAIL	22M	1111M		38153 (11)	00:01:34		
5	LOAD AS SELECT								
6	PARTITION HASH ALL		337K	9231K		3514 (15)	00:00:09	1	16
* 7	TABLE ACCESS FULL	MARK_NETW_HIERARCHY	337K	9231K		3514 (15)	00:00:09		
8	SORT AGGREGATE		1	78					
9	MERGE JOIN		471P	15E		14T(100)	999:59:59		
10	MERGE JOIN		10P	616P		694G (81)	999:59:59		
11	MERGE JOIN		231T	10P		377G (64)	999:59:59		
12	SORT JOIN		334T	11P	28P	377G (64)	999:59:59		
13	MERGE JOIN CARTESIAN		334T	11P		140G (14)	999:59:59		
* 14	HASH JOIN		989M	23G	534M	96010 (38)	00:03:56		
15	VIEW		22M	277M		16808 (12)	00:00:42		
16	TABLE ACCESS FULL	SYS_TEMP_0FDA7485B_6A66C42E	22M	1111M		16808 (12)	00:00:42		
17	VIEW		22M	277M		16808 (12)	00:00:42		
18	TABLE ACCESS FULL	SYS_TEMP_0FDA7485B_6A66C42E	22M	1111M		16808 (12)	00:00:42		
19	BUFFER SORT		337K	4286K		140G (14)	999:59:59		
20	VIEW		337K	4286K		142 (14)	00:00:01		
21	TABLE ACCESS FULL	SYS_TEMP_0FDA7485C_6A66C42E	337K	3956K		142 (14)	00:00:01		
* 22	SORT JOIN		337K	4286K	12M	844 (14)	00:00:03		
23	VIEW		337K	4286K		142 (14)	00:00:01		
24	TABLE ACCESS FULL	SYS_TEMP_0FDA7485C_6A66C42E	337K	3956K		142 (14)	00:00:01		
* 25	SORT JOIN		22M	277M	855M	65084 (16)	00:02:40		
26	VIEW		22M	277M		16808 (12)	00:00:42		
27	TABLE ACCESS FULL	SYS_TEMP_0FDA7485B_6A66C42E	22M	1111M		16808 (12)	0		
* 28	SORT JOIN		22M	277M	855M	65084 (16)	00:02:40		
29	VIEW		22M	277M		16808 (12)	00:00:42		
30	TABLE ACCESS FULL	SYS_TEMP_0FDA7485B_6A66C42E	22M	1111M		16808 (12)	0		



Optimizer Plans (3:4)

```
WITH ed AS (SELECT object_id, element_id, element_name, element_type, useid
            FROM pmcm.element_detail
            WHERE element_type = 'CELL'
            AND current_ind = 'Y'),
     mn AS (SELECT parent_id, object_id
            FROM pmcm.mark_netw_hierarchy
            WHERE current_ind = 'Y'
            AND hierarchy_type = 'NETWORK'
            AND parent_type IN ('BSC', 'RNC'))
SELECT COUNT(*)
FROM ed e1_1, ed e1_2, ed e2_1, ed e2_2, mn h1, mn h2
WHERE e1_1.object_id = h1.parent_id AND e1_2.object_id = h1.object_id
AND e2_1.object_id = h2.parent_id AND e2_2.object_id = h2.object_id
AND e1_1.element_name = e2_1.element_name
AND e1_1.element_id = e2_1.element_id
AND e1_2.element_name = e2_2.element_name
AND e1_2.element_id = e2_2.element_id
AND e1_2.useid LIKE '%%'
AND e2_2.useid NOT LIKE '%%';
```

Id	Operation	Name	Rows	Bytes	TempSpc	Cost (%CPU)	Time
0	SELECT STATEMENT		1	214		100K (6)	00:04:08
1	HASH UNIQUE		1	214		100K (6)	00:04:08
* 2	HASH JOIN		1	214	12M	100K (6)	00:04:08
3	PARTITION HASH ALL		337K	9231K		3514 (15)	00:00:09
* 4	TABLE ACCESS FULL	MARK_NETW_HIERARCHY	337K	9231K		3514 (15)	00:00:00
* 5	HASH JOIN		207K	36M	22M	95860 (6)	00:03:56
6	PARTITION RANGE ALL		586K	15M		16233 (2)	00:00:40
7	TABLE ACCESS BY LOCAL INDEX ROWID	ELEMENT_DETAIL	586K	15M		16233	?:?:?:??
* 8	INDEX SKIP SCAN	ED_ET_TECH_CI	586K			12791 (1)	00:00:3?
* 9	HASH JOIN		207K	31M	22M	77982 (7)	00:03:12
10	PARTITION RANGE ALL		586K	15M		16233 (2)	00:00:40
11	TABLE ACCESS BY LOCAL INDEX ROWID	ELEMENT_DETAIL	586K	15M		16233	?:?:?:??
* 12	INDEX SKIP SCAN	ED_ET_TECH_CI	586K			12791 (1)	00:00:??
* 13	HASH JOIN		179K	22M	12M	60372 (8)	00:02:29
14	PARTITION HASH ALL		337K	9231K		3514 (15)	00:00:09
* 15	TABLE ACCESS FULL	MARK_NETW_HIERARCHY	337K	9231K		3514 (15)	00:00:??
* 16	HASH JOIN		184K	17M	10M	55886 (8)	00:02:18
17	PARTITION RANGE ALL		184K	9008K		37137 (8)	00:01:32
* 18	TABLE ACCESS FULL	ELEMENT_DETAIL	184K	9008K		37137 (8)	00:01:32
19	PARTITION RANGE ALL		576K	28M		17383 (8)	00:00:43
* 20	TABLE ACCESS BY LOCAL INDEX ROWID	ELEMENT_DETAIL	576K	28M		17383 (8)	?:?:?:??
* 21	INDEX SKIP SCAN	ED_ET_TECH_CI	583K			13939 (9)	00:00:35



Optimizer Plans (4:4)

Id	Operation	Name	Rows	Bytes	TempSpc	Cost (%CPU)	Time
0	SELECT STATEMENT					264T (100)	
* 1	VIEW		156P	15E		264T (79)	999:59:59
* 2	WINDOW SORT PUSHED RANK		156P	15E	15E	264T (79)	999:59:59
3	MERGE JOIN CARTESIAN		156P	15E		68T (16)	999:59:59
4	MERGE JOIN CARTESIAN		220G	205T		96M (16)	26:57:48
5	MERGE JOIN CARTESIAN		310K	302M		232 (11)	00:00:01
6	MERGE JOIN CARTESIAN		779	777K		22 (0)	00:00:01
7	NESTED LOOPS						
8	NESTED LOOPS		2	2044		20 (0)	00:00:01
9	NESTED LOOPS OUTER		2	1990		18 (0)	00:00:01
10	NESTED LOOPS		2	1868		17 (0)	00:00:01
11	NESTED LOOPS		2	1712		15 (0)	00:00:01
12	NESTED LOOPS		2	1564		13 (0)	00:00:01
13	MERGE JOIN CARTESIAN		2	1442		11 (0)	00:00:01
14	NESTED LOOPS OUTER		1	625		8 (0)	00:00:01
15	NESTED LOOPS OUTER		1	613		7 (0)	00:00:01
16	NESTED LOOPS		1	580		6 (0)	00:00:01
17	NESTED LOOPS OUTER		1	539		5 (0)	00:00:01
18	NESTED LOOPS OUTER		1	340		5 (0)	00:00:01
19	TABLE ACCESS BY INDEX ROWID	PA_STUDENT	1	316		3 (0)	00:00:01
* 20	INDEX UNIQUE SCAN	PK_STUDENT	1			2 (0)	00:00:01
21	TABLE ACCESS BY INDEX ROWID	PA_STUD_USER	1	24		2 (0)	00:00:01
* 22	INDEX UNIQUE SCAN	PK_STUD_USER	1			1 (0)	00:00:01
23	TABLE ACCESS BY INDEX ROWID	PA_ORG	1	199		0 (0)	
* 24	INDEX UNIQUE SCAN	PK_ORG	1			0 (0)	
25	TABLE ACCESS BY INDEX ROWID	PA_DOMAIN	13	533		1 (0)	00:00:01
* 26	INDEX UNIQUE SCAN	PK_DOMAIN	1			0 (0)	
27	TABLE ACCESS BY INDEX ROWID	PA_USRRF_STUD	100	3300		1 (0)	00:00:01
* 28	INDEX UNIQUE SCAN	PK_USRRF_STUD	1			0 (0)	
29	VIEW PUSHED PREDICATE	PV_STUD_USER	1	12		1 (0)	00:00:01
* 30	FILTER						
31	NESTED LOOPS OUTER		1	22		264 (11)	00:00:01
* 32	INDEX UNIQUE SCAN	PK_STUDENT	1	10		2 (0)	00:00:01
* 33	MAT VIEW ACCESS FULL	PV_AP_STUD_USER	1	12		262 (11)	00:00:01
34	BUFFER SORT		2	192		10 (0)	00:00:01
35	TABLE ACCESS BY INDEX ROWID	PA_CPNT_COMPLIANCE_DATA	2	192		3 (0)	00:00:01
* 36	INDEX RANGE SCAN	IX_CPNT_CD_EVTHST	2			1 (0)	00:00:01
37	TABLE ACCESS BY INDEX ROWID	PA_CPNT_TYPE	1	61		1 (0)	00:00:01
* 38	INDEX UNIQUE SCAN	PK_CPNT_TYPE	1			0 (0)	
39	TABLE ACCESS BY INDEX ROWID	PA_RQMT_TYPE	1	74		1 (0)	00:00:01
* 40	INDEX UNIQUE SCAN	PK_RQMT_TYPE	1			0 (0)	
41	TABLE ACCESS BY INDEX ROWID	PA_CMPL_STAT	1	78		1 (0)	00:00:01
* 42	INDEX UNIQUE SCAN	PK_CMPL_STAT	1			0 (0)	
43	TABLE ACCESS BY INDEX ROWID	PA_QUAL	1	61		1 (0)	00:00:01
* 44	INDEX UNIQUE SCAN	PK_QUAL	1			0 (0)	
* 45	INDEX UNIQUE SCAN	PK_CPNT	1			0 (0)	
46	TABLE ACCESS BY INDEX ROWID	PA_CPNT	1	27		1 (0)	00:00:01
47	BUFFER SORT		399			21 (0)	00:00:01
48	INDEX FAST FULL SCAN	PK_USRRF_STUD	399			1 (0)	00:00:01
49	BUFFER SORT		399			231 (11)	00:00:01
50	INDEX FAST FULL SCAN	PK_USRRF_STUD	399			0 (0)	
51	BUFFER SORT		710K			96M (16)	26:57:48
52	INDEX FAST FULL SCAN	IX_STUD_USER_STUDENT	710K			309 (16)	00:00:01
53	BUFFER SORT		710K			264T (79)	999:59:59
54	INDEX FAST FULL SCAN	IX_STUD_USER_STUDENT	710K			309 (16)	00:00:01



Poorly Written Applications

- There's nothing wrong with the SQL ... but there is definitely something wrong

SQL ordered by Executions

- Total Executions: 29,717,627
- Captured SQL account for 77.4% of Total

Executions	Rows Processed	Rows per Exec	CPU per Exec (s)	Elap per Exec (s)	SQL Id	SQL Module	SQL Text
10,128,178	2,506,529	0.25	0.00	0.00	932srzqfkr33	ASN_07B_DIP(004110016)	SELECT NE_TIMEZONE FROM CMPM.E...
7,576,759	7,579,197	1.00	0.00	0.00	1fb698sb62un99	asci_56_RANAPPProtocolStats(01611000E)	SELECT DISTINCT NE_TIMEZONE FR...
3,914,621	3,848,268	0.98	0.00	0.00	5tbzddgguu8cc	asci_56_RANAPPProtocolStats(01611000E)	SELECT SYS_VERSION FROM CMPM.T...
311,645	311,604	1.00	0.00	0.00	7qztzv329wg0		select c.name, u.name from co...
301,428	301,325	1.00	0.00	0.00	36s446f9cnwhw		SELECT C.NAME FROM COL\$ C VHER...
200,692	200,669	1.00	0.00	0.00	4vs91dcv7urtp6	OMS	insert into sys.aud\$(sessioni...
65,044	65,035	1.00	0.00	0.00	fz9xwpt2cvt0k		SELECT par_type, param_clob, ...
64,949	3,945,482	60.75	0.00	0.00	f5ra7dru5fk5n	XML_P7R_RNC_RCS(003110008)	SELECT NAME, PATH, READ, VR...
64,801	64,807	1.00	0.00	0.00	fbz09a7fnrnb	XML_V7I_IN_LP_DC(00811000V)	SELECT DBTIMEZONE, LENGTH(DBT...
64,632	64,542	1.00	0.00	0.00	15inrrb6016nd	XML_V7I_IN_LP_DC(00811000V)	SELECT SESSIONTIMEZONE, LENGT...

```
SELECT /*+ RESULT_CACHE */ srvr_id
FROM (
  SELECT srvr_id, SUM(cnt) SUMCNT
  FROM (
    SELECT DISTINCT srvr_id, 1 AS CNT
    FROM servers
    UNION ALL
    SELECT DISTINCT srvr_id, 1
    FROM serv_inst)
  GROUP BY srvr_id)
WHERE sumcnt = 2;
```

more examples: www.morganslibrary.org/reference/pkgs/dbms_result_cache.html



Optimizer Settings

- Default Oracle install favors data warehouse not OLTP

NAME	TYPE	VALUE
optimizer_adaptive_features	boolean	TRUE
optimizer_adaptive_reporting_only	boolean	FALSE
optimizer_capture_sql_plan_baselines	boolean	FALSE
optimizer_dynamic_sampling	integer	2
optimizer_features_enable	string	12.1.0.2
optimizer_index_caching	integer	0
optimizer_index_cost_adj	integer	100
optimizer_mode	string	ALL_ROWS
optimizer_secure_view_merging	boolean	TRUE
optimizer_use_invisible_indexes	boolean	FALSE
optimizer_use_pending_statistics	boolean	FALSE
optimizer_use_sql_plan_baselines	boolean	TRUE

```
SQL> show parameter optimizer_mode
```

NAME	TYPE	VALUE
optimizer_mode	string	ALL_ROWS

Best for Data Warehouse

```
SQL> ALTER SYSTEM SET OPTIMIZER_MODE='FIRST_ROWS_10';
```

System altered.

```
SQL> show parameter optimizer_mode
```

NAME	TYPE	VALUE
optimizer_mode	string	FIRST_ROWS_10

Best for OLTP

more examples: www.morganslibrary.org/reference/startup_parms.html



Optimizer Mode

- Establishes the default behavior for choosing an optimization approach for the instance
 - Maximum Throughput (Data Warehouse)

```
SQL> show parameter optimizer_mode
```

NAME	TYPE	VALUE
optimizer_mode	string	ALL_ROWS

Best Response Time (loading a web page)

```
SQL> ALTER SYSTEM SET OPTIMIZER_MODE='FIRST_ROWS_10';
```

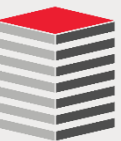
System altered.

```
SQL> show parameter optimizer_mode
```

NAME	TYPE	VALUE
optimizer_mode	string	FIRST_ROWS_10



Optimizer Statistics and Preferences



Optimizer Statistics

- Gather System Stats
- Gather Fixed Object Stats
- Gather Dictionary Stats
- Gather Table Stats
- Gather Column Stats
- Gather Index Stats
- Gather Extended Stats
- Stat Generation
 - Copy Stats
 - Set Stats
 - Fixing Stats

```
Terminal
Window Edit Options
MAXTHR
MBRC
MREADTIM
SLAVETHR
SREADTIM
9 rows selected.
SQL> /
PNAME-----PVAL1
CPUSPEED-----
CPUSPEEDNW680.062427
IOSEEKTIM10
IOTFRSPEED4096
MAXTHR
MBRC
MREADTIM
SLAVETHR
SREADTIM
9 rows selected.
SQL> exec dbms_stats.gather_system_stats('STOP');
PL/SQL procedure successfully completed.
SQL> select pname, pval1
2 from aux_stats$
3 where sname = 'SYSSTATS_MAIN';
PNAME-----PVAL1
CPUSPEED-----1081
CPUSPEEDNW680.062427
IOSEEKTIM10
IOTFRSPEED4096
MAXTHR
MBRC9
MREADTIM.107
SLAVETHR
SREADTIM.029
9 rows selected.
SQL> █
```

```
SQL> select type, count(*)
2 from v$fixed_table
3 group by type
4 order by 1;
```

TYPE	COUNT(*)
TABLE	1144
VIEW	1261

```
SQL> select name
2 from v$fixed_table
3 where rownum < 11;
```

NAME

X\$KQFTA
X\$KQFVI
X\$KQFVT
X\$KQFDT
X\$KQFCO
X\$KQFOPT
X\$KYWMPCTAB
X\$KYWMWRCTAB
X\$KYWMCLTAB
X\$KYWMNF

more examples: www.morganslibrary.org/reference/system_stats.html



Gathering Fixed Object Stats

- Gathers stats on "fixed objects"
 - fixed_obj\$
 - v\$fixed_table

```
dbms_stats.gather_fixed_objects_stats (  
stattab          IN VARCHAR2 DEFAULT NULL,  
statid           IN VARCHAR2 DEFAULT NULL,  
statown          IN VARCHAR2 DEFAULT NULL,  
no_invalidate    IN BOOLEAN  DEFAULT  
                  to_no_invalidate_type(get_param('NO_INVALIDATE')));
```

```
SQL> SELECT type, count(*)  
2    FROM v$fixed_table  
3    GROUP BY type;
```

TYPE	COUNT (*)
TABLE	1144
VIEW	1261

```
SQL> select name  
2    from v$fixed_table  
3    where rownum < 11;
```

NAME

X\$KQFTA
X\$KQFVI
X\$KQFVT
X\$KQFDT
X\$KQFCO
X\$KQFOPT
X\$KYWMPCTAB
X\$KYWMWRCTAB
X\$KYWMCLTAB
X\$KYWMNF



System Statistics

- System statistics are collected by the DBMS_STATS package only when the procedure is manually executed
- If you do not have system stats collected then the optimizer has no information about the server and storage environment

```
SQL> exec dbms_stats.gather_system_stats('INTERVAL', 15);
```

```
SQL> SELECT * FROM sys.aux_stats$;
```

SNAME	PNAME	PVAL1	PVAL2
SYSSTATS_INFO	STATUS		COMPLETED
SYSSTATS_INFO	DSTART		05-27-2015 09:45
SYSSTATS_INFO	DSTOP		05-27-2015 09:51
SYSSTATS_INFO	FLAGS	0	
SYSSTATS_MAIN	CPUSPEEDNW	3010	
SYSSTATS_MAIN	IOSEEKTIM	10	
SYSSTATS_MAIN	IOTFRSPEED	4096	
SYSSTATS_MAIN	SREADTIM	3.862	
SYSSTATS_MAIN	MREADTIM	1.362	
SYSSTATS_MAIN	CPUSPEED	2854	
SYSSTATS_MAIN	MBRC	17	
SYSSTATS_MAIN	MAXTHR		
SYSSTATS_MAIN	SLAVETHR		



Processing Rates (1:2)

- Besides the amount of work the optimizer also needs to know the HW characteristics of the system to understand how much time is needed to complete that amount of work
- Consequently, the HW characteristics describe how much work a single process can perform on that system, these are expressed as bytes per second and rows per second and are called processing rates
- As they indicate a system's capability it means you will need fewer processes (which means less DOP) for the same amount of work as these rates go higher; the more powerful a system is, the less resources you need to process the same statement in the same amount of time
- Processing rates are collected manually

```
SQL> exec dbms_stats.gather_processing_rate('START', 20);
```

```
SQL> SELECT operation_name, manual_value, calibration_value, default_value  
2    FROM v$optimizer_processing_rate  
3    ORDER BY 1;
```



Processing Rates (2:2)

- Processing Rate collection is new as of version 12cR1

OPERATION_NAME	MANUAL_VAL	CALIBRATIO	DEFAULT_VAL
AGGR			1000.00000
ALL			200.00000
CPU			200.00000
CPU_ACCESS			200.00000
CPU_AGGR			200.00000
CPU_BYTES_PER_SEC			1000.00000
CPU_FILTER			200.00000
CPU_GBY			200.00000
CPU_HASH_JOIN			200.00000
CPU_IMC_BYTES_PER_SEC			2000.00000
CPU_IMC_ROWS_PER_SEC			2000000.00
CPU_JOIN			200.00000
CPU_NL_JOIN			200.00000
CPU_RANDOM_ACCESS			200.00000
CPU_ROWS_PER_SEC			1000000.00000
CPU_SEQUENTIAL_ACCESS			200.00000
CPU_SM_JOIN			200.00000
CPU_SORT			200.00000
HASH			200.00000
IO			200.00000
IO_ACCESS			200.00000
IO_BYTES_PER_SEC			200.00000
IO_IMC_ACCESS			1000.00000
IO_RANDOM_ACCESS			200.00000
IO_ROWS_PER_SEC			1000000.00000
IO_SEQUENTIAL_ACCESS			200.00000
MEMCMP			500.00000
MEMCPY			1000.00000

```
SQL> exec dbms_stats.set_processing_rate('IO', 100);
```



Getting Optimizer Preferences

- DBMS_STATS.GET_PREFS returns the current preference for the identified parameter
- Parameters for which preferences can be set are CASCADE, DEGREE, ESTIMATE_PERCENT, METHOD_OPT, and NO_INVALIDATE

```
dbms_stats.get_prefs(  
pname    IN VARCHAR2,  
ownname  IN VARCHAR2 DEFAULT NULL,  
tabname  IN VARCHAR2 DEFAULT NULL)  
RETURN VARCHAR2;
```

```
SQL> SELECT dbms_stats.get_prefs('METHOD_OPT', USER)  
2 FROM dual;
```

```
DBMS_STATS.GET_PREFS('METHOD_OPT',USER)
```

```
-----  
FOR ALL COLUMNS SIZE AUTO
```

```
SQL> SELECT dbms_stats.get_prefs('CASCADE', USER, 'SERVERS')  
2 FROM dual;
```

```
DBMS_STATS.GET_PREFS('CASCADE',USER,'SERVERS')
```

```
-----  
DBMS_STATS.AUTO_CASCADE
```



Setting Optimizer Preferences

- Optimizer preferences can be set at the GLOBAL, DATABASE, SCHEMA, and TABLE levels
- Syntax

```
dbms_stats.set_table_prefs(  
  ownname IN VARCHAR2,  
  tabname IN VARCHAR2,  
  pname    IN VARCHAR2,  
  pvalue   IN VARCHAR2);
```

- Examples

```
exec dbms_stats.set_table_prefs(USER, 'SERVERS', 'CASCADE', 'DBMS_STATS.AUTO_CASCADE');  
  
exec dbms_stats.set_table_prefs(USER, 'SERVERS', 'ESTIMATE_PERCENT', '90');  
  
exec dbms_stats.set_table_prefs(USER, 'SERVERS', 'DEGREE', '8');
```

- The larger the table the smaller the sample size (ESTIMATE_PERCENT) and the larger the degree of parallelism (DEGREE) to consider



Create Extended Stats

- Where WHERE clause predicates utilize more than a single table column collect extended stats
- Allows for the creation of stats that relate to a data distribution across multiple columns in a single table

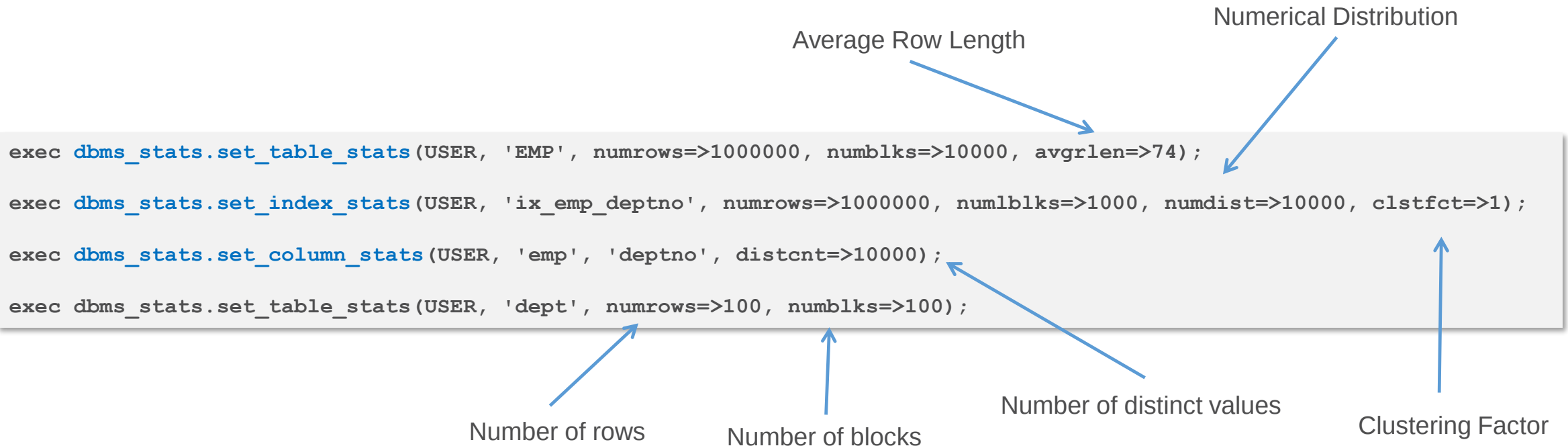
```
SELECT dbms_stats.create_extended_stats(USER, 'SERV_INST', '(srvr_id, si_status)')  
FROM dual;
```

more examples: www.morganslibrary.org/reference/pkg/dbms_stats.html



Manufacture Optimizer Statistics

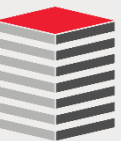
- Creating a new table or partition?
 - If you know approximately what will be in it when it is full set the statistics when you create it
 - If working in a DEV or TEST environment set or import stats to make these environments "look" more like production



more examples: www.morganslibrary.org/reference/pkgs/dbms_stats.html



Explain Plan and Diagnostics



Root Cause Analysis by Sophisticated Guessing

- Check data dictionary for collected stats
- Explain Plans
 - Very few people can read them ... I will prove it next
- AWR Reports
 - Data <> Information
 - If you want value from AWR ... create AWR Difference reports with **DBMS_WORKLOAD_REPOSITORY.AWR_DIFF_REPORT_HTML**
- ADDM Difference Reports
- ASH Reports
- SQL Tuning Advisor
- SQL Trace and TKPROF
- Baselines and Evolving Baselines
- DBMS_TRACE, DBMS_MONITOR, TRCSESS, TRACE ANALYZER, SQLTXPLAIN



Reading Explain Plans

- Very few people can read an explain plan
- Here are two plans from identical tables with identical stats
- Which one would you rely on?

Database 11gR2

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	6 (84)
1	INTERSECTION				
2	SORT UNIQUE NOSORT		141	564	2 (50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	SORT UNIQUE		999	3996	4 (25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	20 (10)
1	INTERSECTION				
2	SORT UNIQUE		141	564	10 (10)
3	TABLE ACCESS FULL	SERVERS	141	564	9 (0)
4	SORT UNIQUE		999	3996	10 (10)
5	TABLE ACCESS FULL	SERV_INST	999	3996	9 (0)

Database 12gR1

The SQL Statement

```
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

```
SQL> SELECT table_name, blocks
2 FROM user_tables
3* WHERE table_name IN ('SERVERS', 'SERV_INST');
```

TABLE_NAME	BLOCKS
SERVERS	28
SERV_INST	28

more examples: www.morganslibrary.org/reference/explain_plan.html



This Adds To The Confusion

```
SQL> SELECT blocks
      2 FROM dba_tables
      3 WHERE owner = 'UWCLASS'
      4 AND table_name = 'SERVERS';

      BLOCKS
-----
      28

SQL> SELECT blocks
      2 FROM dba_segments
      3 WHERE owner = 'UWCLASS'
      4 AND segment_name = 'SERVERS';

      BLOCKS
-----
      32
```



Creating Explain Plans (3:3)

- The challenge is to find the the most efficient way to access the data
- Which of these statements is best?

```
SELECT srvr_id  
FROM servers  
INTERSECT  
SELECT srvr_id  
FROM serv_inst;
```

```
SELECT srvr_id  
FROM servers  
WHERE srvr_id IN (  
    SELECT srvr_id  
    FROM serv_inst);
```

```
SELECT srvr_id  
FROM servers s  
WHERE EXISTS (  
    SELECT srvr_id  
    FROM serv_inst i  
    WHERE s.srvr_id = i.srvr_id);
```

```
SELECT DISTINCT s.srvr_id  
FROM servers s, serv_inst i  
WHERE s.srvr_id = i.srvr_id;
```



Creating The Plan

```
EXPLAIN PLAN FOR  
SELECT srvr_id  
FROM servers s  
WHERE EXISTS (  
    SELECT srvr_id  
    FROM serv_inst i  
    WHERE s.srvr_id = i.srvr_id);
```



Creating The Plan Report

```
SQL> EXPLAIN PLAN FOR
  2  SELECT srvr_id
  3  FROM servers s
  4  WHERE EXISTS (
  5    SELECT srvr_id
  6    FROM serv_inst i
  7    WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
```

PLAN_TABLE_OUTPUT

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	
0	SELECT STATEMENT		11	286	4 (25)	00:00:01	
1	NESTED LOOPS		11	286	4 (25)	00:00:01	
2	SORT UNIQUE		999	12987	3 (0)	00:00:01	
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01	
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01	

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement



Reading Explain Plans (1:6)

- Read from the most indented out and from the bottom to the top
- Sum costs with similar indents in the indent group
- Use the CPU Percentage to determine the portion of the cost that is CPU
- The difference is the disk I/O cost



Reading Explain Plans (2:6)

```
SQL> EXPLAIN PLAN FOR
2  SELECT srvr_id
3  FROM servers s
4  WHERE EXISTS (
5    SELECT srvr_id
6    FROM serv_inst i
7    WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	
0	SELECT STATEMENT		11	286	4 (25)	00:00:01	
1	NESTED LOOPS		11	286	4 (25)	00:00:01	
2	SORT UNIQUE		999	12987	3 (0)	00:00:01	
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01	
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01	

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement

1. Start with the most indented: Read 999 rows, ~13KB from the SERV_INST table's primary key index
2. Since there is no CPU percentage the cost indicates it will read 3 blocks



Reading Explain Plans (3:6)

```
SQL> EXPLAIN PLAN FOR
2  SELECT srvr_id
3  FROM servers s
4  WHERE EXISTS (
5    SELECT srvr_id
6    FROM serv_inst i
7    WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		11	286	4 (25)	00:00:01
1	NESTED LOOPS		11	286	4 (25)	00:00:01
2	SORT UNIQUE		999	12987	3 (0)	00:00:01
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement

3. Sort for the query of the PK_SERV_INST index for unique values



Reading Explain Plans (4:6)

```
SQL> EXPLAIN PLAN FOR
2  SELECT srvr_id
3  FROM servers s
4  WHERE EXISTS (
5    SELECT srvr_id
6    FROM serv_inst i
7    WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		11	286	4 (25)	00:00:01
1	NESTED LOOPS		11	286	4 (25)	00:00:01
2	SORT UNIQUE		999	12987	3 (0)	00:00:01
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement

4. Read one row, 13 bytes from the SERVER table's primary key index: The cost is negligible



Reading Explain Plans (5:6)

```
SQL> EXPLAIN PLAN FOR
2  SELECT srvr_id
3  FROM servers s
4  WHERE EXISTS (
5    SELECT srvr_id
6    FROM serv_inst i
7    WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		11	286	4 (25)	00:00:01
1	NESTED LOOPS		11	286	4 (25)	00:00:01
2	SORT UNIQUE		999	12987	3 (0)	00:00:01
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement

- 5. Use a NESTED LOOP to join the results of the two index queries
- 6. The cost after this operation will be 4 of which 25% is CPU (3+1=4)



Reading Explain Plans (6:6)

```
SQL> EXPLAIN PLAN FOR
  2 SELECT srvr_id
  3 FROM servers s
  4 WHERE EXISTS (
  5   SELECT srvr_id
  6   FROM serv_inst i
  7   WHERE s.srvr_id = i.srvr_id);
```

Explained.

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 2840037858

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		11	286	4 (25)	00:00:01
1	NESTED LOOPS		11	286	4 (25)	00:00:01
2	SORT UNIQUE		999	12987	3 (0)	00:00:01
3	INDEX FAST FULL SCAN	PK_SERV_INST	999	12987	3 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

Predicate Information (identified by operation id):

4 - access("S"."SRVR_ID"="I"."SRVR_ID")

Note

- dynamic sampling used for this statement

7. The result returned to the end-user will be 11 rows (286 bytes)



A More Complex Explain Plan (1:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

- 1. Read 999 rows, about 4K of disk, which is 8 blocks
- 2. Sort the query result for unique values



A More Complex Explain Plan (2:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

- 3. Read 141 rows, about 0.5K of disk, which is 1 block
- 4. Sort the query result for unique values



A More Complex Explain Plan (3:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

5. Subtract the result of the IX_SERV_INST query from the result of the PK_SERVERS query



A More Complex Explain Plan (4:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

6. Materialize the result of the subtraction as a view
7. The cost up to now has been 4 (3+1). Now the cost is 6 of which 1/3 (2) is CPU



A More Complex Explain Plan (5:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

8. Perform a second full scan of the PK_SERVERS index.
9. The cost had been 6 we just added one with the unnecessary duplicate index read



A More Complex Explain Plan (6:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

10. Join the results in the view with the results of the index read.
11. The cost has gone from 7 to 8 of which 38%, or 3, is CPU.



A More Complex Explain Plan (7:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

12. Use a hashing algorithm to collect a set of unique values for the result set
13. The cost has gone from 8 to 9 of which 45%, or 4, is CPU



A More Complex Explain Plan (8:8)

Id	Operation	Name	Rows	Bytes	Cost(%CPU)
0	SELECT STATEMENT		1	17	9 (45)
1	HASH UNIQUE		1	17	9 (45)
* 2	HASH JOIN ANTI		140	2380	8 (38)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	VIEW	VW_NSO_1	141	1833	6 (34)
5	MINUS				
6	SORT UNIQUE		141	564	
7	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
8	SORT UNIQUE		999	3996	
9	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

14. The result returned to the end-user will be 1 row (17 bytes)



Explain Plans: Bitmap Indexes

```
EXPLAIN PLAN FOR
SELECT *
FROM serv_inst
WHERE location_code = 30386
OR ws_id BETWEEN 326 AND 333;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		2	148	3 (0)	00:00:01
1	CONCATENATION					
2	TABLE ACCESS BY INDEX ROWID	SERV_INST	1	74	1 (0)	00:00:01
3	BITMAP CONVERSION TO ROWIDS					
* 4	BITMAP INDEX RANGE SCAN	BIX_SERV_INST_WS_ID				
* 5	TABLE ACCESS BY INDEX ROWID	SERV_INST	1	74	1 (0)	00:00:01
6	BITMAP CONVERSION TO ROWIDS					
* 7	BITMAP INDEX SINGLE VALUE	BIX_SERV_INST_LOCATION_CODE				

```
Predicate Information (identified by operation id):
4 - access("WS_ID">=326 AND "WS_ID"<=333)
5 - filter(LNNVL("WS_ID">=326) OR LNNVL("WS_ID"<=333))
7 - access("LOCATION_CODE"=30386)
```



Explain Plans: Join Syntax

```
explain plan for
select distinct i.srvr_id
from servers s, serv_inst i
where s.srvr_id = i.srvr_id;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		999	25974	9 (12)	00:00:01
1	HASH UNIQUE		999	25974	9 (12)	00:00:01
2	NESTED LOOPS		999	25974	8 (0)	00:00:01
3	TABLE ACCESS FULL	SERV_INST	999	12987	8 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

```
explain plan for
select distinct i.srvr_id
from servers s inner join serv_inst i
on s.srvr_id = i.srvr_id;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		999	25974	9 (12)	00:00:01
1	HASH UNIQUE		999	25974	9 (12)	00:00:01
2	NESTED LOOPS		999	25974	8 (0)	00:00:01
3	TABLE ACCESS FULL	SERV_INST	999	12987	8 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01



Explain Plans: Missing Joins Are Expensive

```
SQL> explain plan for
  2  select s.srvr_id
  3  from servers s, serv_inst i
  4  where s.srvr_id = i.srvr_id;
```

```
SQL> select * from table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		999	25974	8 (0)	00:00:01
1	NESTED LOOPS		999	25974	8 (0)	00:00:01
2	TABLE ACCESS FULL	SERV_INST	999	12987	8 (0)	00:00:01
* 3	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

```
SQL> explain plan for
  2  select s.srvr_id
  3  from servers s, serv_inst i;
```

```
SQL> select * from table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		140K	1788K	130 (1)	00:00:02
1	MERGE JOIN CARTESIAN		140K	1788K	130 (1)	00:00:02
2	INDEX FAST FULL SCAN	PK_SERVERS	141	1833	2 (0)	00:00:01
3	BUFFER SORT		999		128 (1)	00:00:02
4	BITMAP CONVERSION TO ROWIDS		999		1 (0)	00:00:01
5	BITMAP INDEX FAST FULL SCAN	BIX_SERV_INST_WS_ID				



Explain Plans: Unnecessary Joins Are Expensive

```
SQL> explain plan for
  2  select distinct s.srvr_id
  3  from servers s, serv_inst i
  4  where s.srvr_id = i.srvr_id;
```

```
SQL> select * from table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		999	25974	9 (12)	00:00:01
1	HASH UNIQUE		999	25974	9 (12)	00:00:01
2	NESTED LOOPS		999	25974	8 (0)	00:00:01
3	TABLE ACCESS FULL	SERV_INST	999	12987	8 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01

```
explain plan for
select distinct s1.srvr_id
from servers s1, servers s2, serv_inst i
where s1.srvr_id = s2.srvr_id
and s1.srvr_id = i.srvr_id;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		999	38961	10 (20)	00:00:01
1	HASH UNIQUE		999	38961	10 (20)	00:00:01
2	NESTED LOOPS		999	38961	9 (12)	00:00:01
3	NESTED LOOPS		999	25974	8 (0)	00:00:01
4	TABLE ACCESS FULL	SERV_INST	999	12987	8 (0)	00:00:01
* 5	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01
* 6	INDEX UNIQUE SCAN	PK_SERVERS	1	13	0 (0)	00:00:01



Explain Plans: Parallel Transactions (PX)

```
SQL> EXPLAIN PLAN FOR
2  SELECT SUM(salary)
3  FROM emp2
4  GROUP BY department_id;
```

Explained.

```
SQL> SELECT plan_table_output FROM table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Plan hash value: 3939201228

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	TQ	IN-OUT	PQ Distrib
0	SELECT STATEMENT		107	2782	3 (34)	00:00:01			
1	PX COORDINATOR								
2	PX SEND QC (RANDOM)	:TQ10001	107	2782	3 (34)	00:00:01	Q1,01	P->S	QC (
3	HASH GROUP BY		107	2782	3 (34)	00:00:01	Q1,01	PCWP	
4	PX RECEIVE		107	2782	3 (34)	00:00:01	Q1,01	PCWP	
5	PX SEND HASH	:TQ10000	107	2782	3 (34)	00:00:01	Q1,00	P->P	HASH
6	HASH GROUP BY		107	2782	3 (34)	00:00:01	Q1,00	PCWP	
7	PX BLOCK ITERATOR		107	2782	2 (0)	00:00:01	Q1,00	PCWC	
8	TABLE ACCESS FULL	EMP2	107	2782	2 (0)	00:00:01	Q1,00	PCWP	

Note

- dynamic sampling used for this statement



Explain Plans: Pstart -Pstop: Starting & Stopping Partitions

```
explain plan for
select * from part_zip where state = 'CA';
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		3	72	2 (0)	00:00:01		
1	PARTITION HASH SINGLE		3	72	2 (0)	00:00:01	1	1
* 2	TABLE ACCESS FULL	PART_ZIP	3	72	2 (0)	00:00:01	1	1

```
explain plan for
select * from part_zip where state = 'NY';
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		3	72	2 (0)	00:00:01		
1	PARTITION HASH SINGLE		3	72	2 (0)	00:00:01	2	2
* 2	TABLE ACCESS FULL	PART_ZIP	3	72	2 (0)	00:00:01	2	2

```
explain plan for
select * from part_zip where zipcode LIKE '%5%';
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		2	48	2 (0)	00:00:01		
1	PARTITION HASH ALL		2	48	2 (0)	00:00:01	1	3
* 2	TABLE ACCESS FULL	PART_ZIP	2	48	2 (0)	00:00:01	1	3



Explain Plans: Temp Tablespace Usage (ORDER BY clause)

```
SQL> SELECT * FROM TABLE(dbms_xplan.display);
```

PLAN_TABLE_OUTPUT

Plan hash value: 995087943

Id	Operation	Name	Rows	Bytes	TempSpc	Cost (%CPU)	Time	

0	SELECT STATEMENT		98128	12M		3435 (1)	00:00:42	
1	SORT ORDER BY		98128	12M	25M	3435 (1)	00:00:42	
2	TABLE ACCESS FULL	SOURCE\$	98128	12M		(2)	00:00:07	



Explain Plan Errors (1:8)

- Oracle can do math
- But not always as well as you can
- Consider the following SQL statement

```
EXPLAIN PLAN FOR  
SELECT srvr_id  
FROM servers  
INTERSECT  
SELECT srvr_id  
FROM serv_inst;
```



Explain Plan Errors (2:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	6 (84)
1	INTERSECTION				
2	SORT UNIQUE NOSORT		141	564	2 (50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	SORT UNIQUE		999	3996	4 (25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)



Explain Plan Errors (3:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	6 (84)
1	INTERSECTION				
2	SORT UNIQUE NOSORT		141	564	2 (50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	SORT UNIQUE		999	3996	4 (25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

1. Read 999 rows, ~4K from the SERV_INST table's index IX_SERV_INST: The cost is 3



Explain Plan Errors (4:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost	(%CPU)
0	SELECT STATEMENT		141	4560	6	(84)
1	INTERSECTION					
2	SORT UNIQUE NOSORT		141	564	2	(50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1	(0)
4	SORT UNIQUE		999	3996	4	(25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3	(0)

- Sort the IX_SERV_INST index entries
- The additional cost is 1 (3+1=4) and 25% of the cost of 4 is CPU (4 x 0.25 = 1): The math works



Explain Plan Errors (5:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	6 (84)
1	INTERSECTION				
2	SORT UNIQUE NOSORT		141	564	2 (50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	SORT UNIQUE		999	3996	4 (25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

- 4. Read 141 rows, 0.5K, from the primary key of the SERVERS table: The cost is 1
- 5. This line is indented so it is not added, directly, to the cost of operations 4 and 5



Explain Plan Errors (6:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT		141	4560	6 (84)
1	INTERSECTION				
2	SORT UNIQUE NOSORT		141	564	2 (50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1 (0)
4	SORT UNIQUE		999	3996	4 (25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3 (0)

- 6. A SORT UNIQUE NOSORT is used to remove potential duplicate rows
- 7. The additional cost is 1 (1+1=2) and 50% of the cost of 2 is CPU (2 x 0.50 = 1): The math works again



Explain Plan Errors (7:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost	(%CPU)

0	SELECT STATEMENT		141	4560	6	(84)
1	INTERSECTION					
2	SORT UNIQUE NOSORT		141	564	2	(50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1	(0)
4	SORT UNIQUE		999	3996	4	(25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3	(0)

8. Perform an intersection of the two result sets



Explain Plan Errors (8:8)

- Why is this wrong?

```
EXPLAIN PLAN FOR
SELECT srvr_id
FROM servers
INTERSECT
SELECT srvr_id
FROM serv_inst;
```

Id	Operation	Name	Rows	Bytes	Cost	(%CPU)
0	SELECT STATEMENT		141	4560	6	(84)
1	INTERSECTION					
2	SORT UNIQUE NOSORT		141	564	2	(50)
3	INDEX FULL SCAN	PK_SERVERS	141	564	1	(0)
4	SORT UNIQUE		999	3996	4	(25)
5	INDEX FAST FULL SCAN	IX_SERV_INST	999	3996	3	(0)

- 9. Add the two costs (2+4=6): The math works
- 10. 25% of the 4 is CPU (1) and 50% of the 2 is CPU (1) and (1+1=2). Is 2/6 equal to 84%?



Explain Planning a Statement After It Has Been Run

- Use the `DISPLAY_CURSOR` pipelined table function

```
dbms_xplan.display_cursor(  
  sql_id          IN VARCHAR2 DEFAULT NULL,  
  cursor_child_no IN INTEGER DEFAULT 0,  
  format          IN VARCHAR2 DEFAULT 'TYPICAL')  
RETURN dbms_xplan_type_table PIPELINED;
```

Format Constants	
ALIAS	If relevant, shows the "Query Block Name / Object Alias" section
ALLSTATS	A shortcut for 'IOSTATS MEMSTATS'
BYTES	If relevant, shows the number of bytes estimated by the optimizer
COST	If relevant, shows optimizer cost information
IOSTATS	Assuming that basic plan statistics are collected when SQL statements are executed (either by using the <code>gather_plan_statistics</code> hint or by setting the parameter <code>statistics_level</code> to <code>ALL</code>), this format will show IO statistics for ALL (or only for the LAST as shown below) executions of the cursor
LAST	By default, plan statistics are shown for all executions of the cursor. The keyword <code>LAST</code> can be specified to see only the statistics for the last execution
MEMSTATS	Assuming that PGA memory management is enabled (that is, <code>pga_aggregate_target</code> parameter is set to a non 0 value), this format allows to display memory management statistics (for example, execution mode of the operator, how much memory was used, number of bytes spilled to disk, and so on). These statistics only apply to memory intensive operations like hash-joins, sort or some bitmap operators
NOTE	If relevant, shows the note section of the explain plan
PARALLEL	If relevant, shows PX information (distribution method and table queue information)
PARTITION	If relevant, shows partition pruning information
PREDICATE	If relevant, shows the predicate section
PROJECTION	If relevant, shows the projection section
REMOTE	If relevant, shows the information for distributed query (for example, remote from serial distribution and remote SQL)
ROWS	If relevant, shows the number of rows estimated by the optimizer
RUNSTATS_LAST	Same as <code>IOSTATS LAST</code> : displays the runtime stat for the last execution of the cursor
RUNSTATS_TOT	Same as <code>IOSTATS</code> : displays IO statistics for all executions of the specified cursor



Explain Planning a Statement After It Has Been Run

- Use the DISPLAY_CURSOR pipelined table function

```
SELECT /* XPLAN_CURSOR */ DISTINCT s.srvr_id
FROM servers s, serv_inst I
WHERE s.srvr_id = i.srvr_id;

SELECT sql_id
FROM gv$sql
WHERE sql_text LIKE '%XPLAN_CURSOR%';

SELECT * FROM
TABLE(dbms_xplan.display_cursor('cpm9ss48qd32f'));
```



Explain Planning a Statement After It Has Been Run

First get the SQL_ID of the statement

```
SQL> SELECT DISTINCT sql_id  
2   FROM v$sqlarea  
3   WHERE executions = (SELECT  
MAX(executions) FROM v$sqlarea);
```

```
SQL_ID  
-----  
5sg7mjrpj21z7  
fnq8p3fj3r5as
```



Explain Planning a Statement After Execution

```
SQL> SELECT * FROM TABLE(dbms_xplan.display_cursor('5sg7mjrpj21z7'));
```

PLAN_TABLE_OUTPUT

SQL_ID 5sg7mjrpj21z7, child number 0

```
SELECT JOB, LAST_DATE, THIS_DATE, NEXT_DATE, FIELD1 FROM SYS."JOB$_REDUCED"  
"JOB$_REDUCED" WHERE "JOB$_REDUCED"."THIS_DATE" IS NULL AND  
("JOB$_REDUCED"."LAST_DATE" IS NULL AND "JOB$_REDUCED"."NEXT_DATE"<:1  
OR "JOB$_REDUCED"."NEXT_DATE">=:2 AND "JOB$_REDUCED"."NEXT_DATE"<=:3)  
AND ("JOB$_REDUCED"."FIELD1"=:4 OR "JOB$_REDUCED"."FIELD1"=0 AND  
'Y'=:5) AND ("JOB$_REDUCED"."JOB"<1000000000 AND  
"SYS"."DBMS_LOGSTDBY"."DB_IS_LOGSTDBY"()=0 OR "JOB$_REDUCED"."JOB">=1000000000 AND  
"SYS"."DBMS_LOGSTDBY"."DB_IS_LOGSTDBY"()=1)
```

Plan hash value: 3312758264

Id	Operation	Name	Rows	Bytes	Cost (%CPU)
0	SELECT STATEMENT				1 (100)
1	CONCATENATION				
* 2	TABLE ACCESS BY INDEX ROWID BATCHED	JOB\$	1	53	0 (0)
* 3	INDEX RANGE SCAN	I_JOB_NEXT	1		0 (0)
* 4	TABLE ACCESS BY INDEX ROWID BATCHED	JOB\$	1	53	0 (0)
* 5	INDEX RANGE SCAN	I_JOB_NEXT	1		0 (0)



Related Dynamic Performance View

- The following dynamic performance views give information vital to understanding how SQL is running in the real-world environment
 - V\$SQL
 - V\$SQLAREA
 - V\$SQLSTATS
 - V\$SQL_BIND_CAPTURE
 - V\$SQL_BIND_DATA
 - V\$SQL_BIND_METADATA
 - V\$SQL_PLAN



One Way To Look At Performance

```
SQL> EXPLAIN PLAN FOR
2  SELECT COUNT(*)
3  FROM parent p, child c
4  WHERE p.parent_id = c.parent_id;

SQL> select * From table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
-----
Plan hash value: 3584092213
-----
| Id | Operation          | Name | Rows | Bytes |TempSpc| Cost (%CPU)| Time      |
-----|-----|-----|-----|-----|-----|-----|-----|
| 0  | SELECT STATEMENT   |      | 1    | 10    |        | 3163  (5)| 00:00:38 |
| 1  | SORT AGGREGATE     |      | 1    | 10    |        |        |         |
|* 2  | HASH JOIN          |      | 1500K| 14M   | 8312K  | 3163  (5)| 00:00:38 |
| 3  | TABLE ACCESS FULL| PARENT| 500K | 2442K |        | 380   (4)| 00:00:05 |
| 4  | TABLE ACCESS FULL| CHILD | 1500K| 7324K |        | 1106  (5)| 00:00:14 |
-----

SQL> explain plan for
2  SELECT COUNT(*)
3  FROM parent p, child c
4  WHERE p.parent_id = c.parent_id
5  AND c.birth_date is NOT NULL;

SQL> select * From table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
-----
Plan hash value: 3584092213
-----
| Id | Operation          | Name | Rows | Bytes |TempSpc| Cost (%CPU)| Time      |
-----|-----|-----|-----|-----|-----|-----|-----|
| 0  | SELECT STATEMENT   |      | 1    | 16    |        | 3037  (5)| 00:00:37 |
| 1  | SORT AGGREGATE     |      | 1    | 16    |        |        |         |
|* 2  | HASH JOIN          |      | 999K | 15M   | 8312K  | 3037  (5)| 00:00:37 |
| 3  | TABLE ACCESS FULL| PARENT| 500K | 2442K |        | 380   (4)| 00:00:05 |
|* 4  | TABLE ACCESS FULL| CHILD | 999K | 10M   |        | 1116  (6)| 00:00:14 |
-----
```



Another Way To Look At Performance

```
SQL> set timing on
```

```
SQL> SELECT COUNT(*)  
2   FROM parent p, child c  
3   WHERE p.parent_id = c.parent_id;
```

```
      COUNT(*)  
-----  
      1500000
```

```
Elapsed: 00:00:00.59
```

```
SQL> SELECT COUNT(*)  
2   FROM parent p, child c  
3   WHERE p.parent_id = c.parent_id  
4   AND birth_date is NOT NULL;
```

```
      COUNT(*)  
-----  
      1000000
```

```
Elapsed: 00:00:00.53
```



Adaptive Execution Plans (1:2)

- New to Database version 12c is Adaptive Execution Plans and a newly tracked feature is use of "adaptive execution plans"
- An adaptive plan is one that learns about the data as it is executed

```
DECLARE
  i NUMBER;
  j NUMBER;
  k CLOB;
BEGIN
  dbms_feature_adaptive_plans(i, j, k);
  dbms_output.put_line('1: ' || i);
  dbms_output.put_line('2: ' || j);
  dbms_output.put_line('3: ' || k);
END;
/
1: 1
2:
3: Total number of queries: 501
Number of queries with an adaptive plan: 35
Percentage of queries with an adaptive plan:
6.98602794411177644710578842315369261477
Are the queries running in reporting mode ? : No
```



Adaptive Execution Plans (2:2)

- An option available to the DBMS_XPLAN built-in package is through the use of the format constant `ADAPTIVE` which
 - Displays the final plan, or the current plan if the execution has not completed
 - This section includes notes about runtime optimizations that affect the plan, such as switching from a Nested Loops join to a Hash join
 - Plan lineage
 - This section shows the plans that were run previously due to automatic reoptimization
 - It also shows the default plan, if the plan changed due to dynamic plans
 - Recommended plan
 - In reporting mode, the plan is chosen based on execution statistics displayed
 - Note that displaying the recommended plan for automatic reoptimization requires re-compiling the query with the optimizer adjustments collected in the child cursor
 - Displaying the recommended plan for a dynamic plan does not require this
 - Dynamic plans
 - This summarizes the portions of the plan that differ from the default plan chosen by the optimizer



This Makes It Even Worse

```
SQL> DECLARE
  2  uf  NUMBER;
  3  ub  NUMBER;
  4  f1  NUMBER;
  5  f1b NUMBER;
  6  f2  NUMBER;
  7  f2b NUMBER;
  8  f3  NUMBER;
  9  f3b NUMBER;
 10  f4  NUMBER;
 11  f4b NUMBER;
 12  fbl NUMBER;
 13  fby NUMBER;
 14 BEGIN
 15  dbms_space.space_usage('UWCLASS','SERVERS','TABLE', uf, ub, f1, f1b, f2, f2b, f3, f3b, f4, f4b, fbl, fby);
 16
 17  dbms_output.put_line('unformatted blocks:  ' || TO_CHAR(uf));
 18  dbms_output.put_line('unformatted bytes:   ' || TO_CHAR(ub));
 19  dbms_output.put_line('blocks 0-25% free:   ' || TO_CHAR(f1));
 20  dbms_output.put_line('bytes 0-25% free:   ' || TO_CHAR(f1b));
 21  dbms_output.put_line('blocks 25-50% free:  ' || TO_CHAR(f2));
 22  dbms_output.put_line('bytes 25-50% free:  ' || TO_CHAR(f2b));
 23  dbms_output.put_line('blocks 50-75% free:  ' || TO_CHAR(f3));
 24  dbms_output.put_line('bytes 50-75% free:  ' || TO_CHAR(f3b));
 25  dbms_output.put_line('blocks 75-100% free: ' || TO_CHAR(f4));
 26  dbms_output.put_line('bytes 75-100% free: ' || TO_CHAR(f4b));
 27  dbms_output.put_line('full blocks:        ' || TO_CHAR(fbl));
 28  dbms_output.put_line('full bytes:         ' || TO_CHAR(fby));
 29 END;
 30 /
unformatted blocks:  16
unformatted bytes:  131072
blocks 0-25% free:  0
bytes 0-25% free:   0
blocks 25-50% free:  1
bytes 25-50% free:  8192
blocks 50-75% free:  0
bytes 50-75% free:  0
blocks 75-100% free: 11
bytes 75-100% free: 90112
full blocks:        0
full bytes:         0
```

only 12 blocks are formatted

more examples: www.morganslibrary.org/reference/pkg/dbms_space.html



AWR Reports: Used and Abused

Foreground Wait Events

- s - second, ms - millisecond - 1000th of a second
- Only events with Total Wait Time (s) >= .001 are shown
- ordered by wait time desc, waits desc (idle events last)
- %Timeouts: value of 0 indicates value was < .5%. Value of null is truly 0

Event	Waits	%Time-outs	Total Wait Time (s)	Avg wait (ms)	Waits /txn	% DB time
reliable message	6,594,174	44	3,293,838	500	0.96	9.88
enq: TX - row lock contention	21,667	15	3,150,728	145416	0.00	9.45
library cache pin	3,784,534	0	2,624,309	693	0.55	7.87
DFS lock handle	2,598,761	11	2,480,524	955	0.38	7.44
db file sequential read	719,646,074	0	2,364,757	3	104.53	7.09
enq: PS - contention	6,147,054	75	1,819,338	296	0.89	5.46
library cache lock	2,737,270	1	1,335,137	488	0.40	4.00
row cache lock	2,437,346	10	1,319,231	541	0.35	3.96
enq: FB - contention	683,161	0	651,060	953	0.10	1.95
PX Deq: Slave Session Stats	4,204,746	22	585,857	139	0.61	1.76
unspecified wait event	763,681,122	0	427,377	1	110.93	1.28
rdbms ipc reply	696,586	20	374,694	538	0.10	1.12
db file scattered read	11,920,396	0	259,432	22	1.73	0.78
direct path read temp	45,839,102	0	200,752	4	6.66	0.60
enq: HW - contention	189,193	0	194,056	1026	0.03	0.58
enq: TM - contention	416,868	92	170,082	408	0.06	0.51
gc cr grant 2-way	113,352,735	0	125,939	1	16.46	0.38
ksim generic wait event	488,898	99	97,114	199	0.07	0.29
enq: JS - queue lock	5,977	0	89,887	15039	0.00	0.27
gcs drmm freeze in enter server mode	198,923	78	87,797	441	0.03	0.26
resmgr:cpu quantum	6,065,202	0	87,304	14	0.88	0.26
latch free	2,863,085	0	83,028	29	0.42	0.25
enq: TT - contention	46,944	0	72,635	1547	0.01	0.22
read by other session	15,427,888	0	69,678	5	2.24	0.21



AWR Difference Reports (1:5)

- SQL scripts located at \$ORACLE_HOME/rdbms/admin

File Name	Strategy
awrddrpi.sql	Report on differences between differences between values recorded in two pairs of snapshots. This script requests the user for the dbid and instance number of the instance to report on, for each snapshot pair, before producing the standard report.
awrddrpt.sql	Defaults the dbid and instance number to that of the current instance connected-to, then calls awrddrpi.sql to produce the Compare Periods report.
awrextr.sql	SQL/Plus script to help users extract data from the AWR.
awrgdrpi.sql	RAC Version of Compare Period Report.
awrgdrpt.sql	This script defaults the dbid to that of the current instance connected-to, defaults instance list to all available instances and then calls awrgdrpi.sql to produce the Workload Repository RAC Compare Periods report.
awrg rpt.sql	This script defaults the dbid to that of the current instance connected-to, then calls awrg rpti.sql to produce the Workload Repository RAC report.
awrg rti.sql	SQL*Plus command file to report on RAC-wide differences between values recorded in two snapshots. This script requests the user for the dbid before producing the standard Workload Repository report.

more examples: www.morganslibrary.org/reference/awr_report.html



AWR Difference Reports (2:5)

- SQL scripts located at \$ORACLE_HOME/rdbms/admin

File Name	Strategy
awrinfo.sql	Outputs general AWR information such as the size, data distribution, etc. in AWR and SYSAUX. The intended use of this script is for diagnosing abnormalities in AWR and not for diagnosing issues in the database instance.
awrrpt.sql	Defaults the dbid and instance number to that of the current instance connected-to, then calls awrrpti.sql to produce the report.
awrrpti.sql	SQL*Plus command file to report on differences between values recorded in two snapshots. This script requests the user for the dbid and instance number of the instance to report on, before producing the standard report.
awrsqrpi.sql	SQL*Plus command file to report on differences between values recorded in two snapshots. This script requests the user for the dbid, instance number and the sql id, before producing a report for a particular sql statement in this instance.
awrsqrpt.sql	Defaults the dbid and instance number to that of the current instance connected-to then calls awrsqrpi.sql to produce a Workload report for a particular sql statement.
awrupd12.sql	This script updates AWR data to version 12c. It only modifies AWR data that has been imported using awrload.sql, or data from before changing the database DBID. In other words, it doesn't modify AWR data for the local, active DBID.

more examples: www.morganslibrary.org/reference/awr_report.html



WORKLOAD REPOSITORY COMPARE PERIOD REPORT

Snapshot Set	DB Name	DB Id	Instance	Inst num	Release	Cluster	Host	Std Block Size
First (1st)	ORAP09	2886124853	orap09	1	11.2.0.3.0	NO	db20p03sh	8192
Second (2nd)	ORAP09	2886124853	orap09	1	11.2.0.3.0	NO	db20p03sh	8192

Snapshot Set	Begin Snap Id	Begin Snap Time	End Snap Id	End Snap Time	Avg Active Users	Elapsed Time (min)	DB time (min)
1st	33759	02-Apr-14 04:00:19 (Wed)	33760	02-Apr-14 04:30:22 (Wed)	0.8	30.1	24.5
2nd	33807	03-Apr-14 04:00:13 (Thu)	33808	03-Apr-14 04:30:16 (Thu)	1.0	30.1	29.8
%Diff					22.2	0.0	21.6

Host Configuration Comparison

	1st	2nd	Diff	%Diff
Number of CPUs:	80	80	0	0.0
Number of CPU Cores:	40	40	0	0.0
Number of CPU Sockets:	4	4	0	0.0
Physical Memory:	1031464.9M	1031464.9M	0M	0.0
Load at Start Snapshot:	19.09	20.68	1.59	8.3
Load at End Snapshot:	11.49	11.18	-.31	-2.7
%User Time:	14.88	14.44	-.44	-3.0
%System Time:	1.08	1.05	-.03	-2.8
%Idle Time:	83.92	84.38	.46	0.5
%IO Wait Time:	.31	.45	.13	45.2



more examples: www.morganslibrary.org/reference/awr_report.html



AWR Difference Reports (4:5)

Wait Events

- Ordered by absolute value of 'Diff' column of '% of DB time' descending (idle events last)

Event	Wait Class	% of DB time			# Waits/sec (Elapsed Time)			Total Wait Time (sec)			Avg Wait Time (ms)		
		1st	2nd	Diff	1st	2nd	%Diff	1st	2nd	%Diff	1st	2nd	%Diff
db file scattered read	User I/O	0.01	4.46	4.45	2.30	544.72	23,583.48	0.21	79.69	37,847.62	0.05	0.08	60.00
read by other session	User I/O	0.00	0.88	0.87	0.35	66.08	18,780.00	0.03	15.65	52,066.67	0.05	0.13	160.00
log file parallel write	System I/O	3.80	3.41	-0.39	11.54	11.64	0.87	55.83	60.88	9.05	2.68	2.90	8.21
db file sequential read	User I/O	0.66	0.85	0.19	12.60	108.69	762.62	9.72	15.24	56.79	0.43	0.08	-81.40
enq: CR - block range reuse dkpt	Other	0.26	0.17	-0.09	0.40	0.31	-22.50	3.83	2.99	-21.93	5.24	5.35	2.10
log file sync	Commit	3.17	3.11	-0.06	8.42	9.28	9.98	46.65	55.59	19.16	3.07	3.33	8.47
SQL*Net message to client	Network	0.06	0.12	0.06	724.68	1,888.96	157.90	0.85	2.08	144.71	0.00	0.00	0.00
utl_file I/O	User I/O	0.23	0.19	-0.04	85.50	84.68	-0.96	3.40	3.34	-1.76	0.02	0.02	0.00
enq: RO - fast object reuse	Application	0.12	0.08	-0.03	0.41	0.31	-24.39	1.72	1.50	-12.79	2.34	2.68	14.53
db file async I/O submit	System I/O	1.29	1.26	-0.03	5.49	5.96	8.56	18.97	22.51	18.66	1.91	2.09	9.42
control file parallel write	System I/O	0.35	0.32	-0.03	0.75	0.73	-2.67	5.09	5.66	11.20	3.75	4.32	15.20
library cache: mutex X	Concurrency	0.05	0.02	-0.03	1.46	1.10	-24.66	0.77	0.42	-45.45	0.29	0.21	-27.59
latch free	Other	0.05	0.03	-0.02	0.34	0.31	-8.82	0.76	0.60	-21.05	1.23	1.08	-12.20
direct path write	User I/O	0.06	0.05	-0.01	1.67	2.14	28.14	0.90	0.85	-5.56	0.30	0.22	-26.67
direct path write temp	User I/O	0.37	0.39	0.01	1.52	2.30	51.32	5.46	6.88	26.01	1.99	1.66	-16.58
reliable message	Other	0.03	0.02	-0.01	0.81	0.62	-23.46	0.47	0.37	-21.28	0.32	0.33	3.13
log buffer space	Configuration	0.02	0.01	-0.01	0.01	0.01	0.00	0.23	0.11	-52.17	14.15	8.65	-38.87
db file parallel write	System I/O	0.03	0.02	-0.01	0.10	0.08	-20.00	0.40	0.38	-5.00	2.31	2.71	17.32
control file sequential read	System I/O	0.01	0.00	-0.00	5.45	4.86	-10.83	0.10	0.09	-10.00	0.01	0.01	0.00
SQL*Net more data from client	Network	0.01	0.01	-0.00	1.98	1.89	-4.55	0.11	0.10	-9.09	0.03	0.03	0.00
SQL*Net more data to client	Network	0.01	0.01	-0.00	3.84	3.94	2.60	0.12	0.12	0.00	0.02	0.02	0.00
asynch descriptor resize	Other	0.00	0.00	-0.00	2.45	2.43	-0.82	0.05	0.05	0.00	0.01	0.01	0.00
cursor: pin S	Concurrency	0.00	0.00	0.00	0.04	0.03	-25.00	0.00	0.01	100.00	0.01	0.23	2,200.00
latch: redo writing	Configuration	0.00	0.00	-0.00	0.06	0.04	-33.33	0.02	0.01	-50.00	0.17	0.16	-5.88
latch: messages	Other	0.00	0.00	-0.00	0.16	0.13	-18.75	0.04	0.04	0.00	0.14	0.17	21.43
direct path read temp	User I/O	0.00	0.00	-0.00	0.63	0.48	-23.81	0.02	0.01	-50.00	0.02	0.02	0.00
direct path sync	User I/O	0.01	0.00	-0.00	0.02	0.03	50.00	0.08	0.09	12.50	2.19	1.76	-19.63
latch: cache buffers chains	Concurrency	0.00	0.00	0.00	0.14	0.63	350.00	0.02	0.03	50.00	0.06	0.02	-66.67

more examples: www.morganslibrary.org/reference/awr_report.html



AWR Difference Reports (5:5)

Other Instance Activity Stats

Ordered by statistic name

Statistic	Value			per Second (DB time)			per Second (Elapsed Time)			per Trans		
	1st	2nd	%Diff	1st	2nd	%Diff	1st	2nd	%Diff	1st	2nd	%Diff
calls to komgas	44,985	48,775	8.43	30.62	27.31	-10.81	24.94	27.04	8.42	2.48	2.51	1.21
calls to komgos	327,166	351,412	7.41	222.67	196.76	-11.64	181.40	194.84	7.41	18.03	18.07	0.22
cell physical IO interconnect bytes	2,106,564,608	100,858,843,136	4,687.84	1,433,726.13	56,473,555.08	3,838.94	1,167,996.50	55,921,065.97	4,687.78	116,108.95	5,186,077.91	4,366.56
change write time	518	488	-9.65	0.35	0.26	-25.71	0.29	0.26	-10.34	0.03	0.02	-33.33
cleanout - number of ktugct calls	1,431	1,349	-5.73	0.97	0.76	-21.65	0.79	0.75	-5.06	0.08	0.07	-12.50
cleanouts and rollbacks - consistent read gets	10	29	190.00	0.01	0.02	100.00	0.01	0.02	100.00	0.00	0.00	0.00

more examples: www.morganslibrary.org/reference/awr_report.html



DBMS_ADDM

- COMPARE_DATABASES **NEW** new in Database 12c
 - Create a report comparing the performance of a database over two different time periods or the performance of two different databases over two different time periods
- COMPARE_INSTANCES **NEW** new in Database 12c
 - Create a report comparing the performance of a single instance over two different time periods or the performance of two different instances over two different time periods

```
dbms_addm.compar_databases(  
  base_dbid           IN NUMBER,  
  base_begin_snap_id  IN NUMBER,  
  base_end_snap_id    IN NUMBER,  
  comp_dbid           IN NUMBER,  
  comp_begin_snap_id  IN NUMBER,  
  comp_end_snap_id    IN NUMBER,  
  report_type         IN VARCHAR2 := 'HTML')  
RETURN CLOB
```

```
dbms_addm.compare_instances(  
  base_dbid           IN NUMBER,  
  base_instance_id    IN NUMBER,  
  base_begin_snap_id  IN NUMBER,  
  base_end_snap_id    IN NUMBER,  
  comp_dbid           IN NUMBER,  
  comp_instance_id    IN NUMBER,  
  comp_begin_snap_id  IN NUMBER,  
  comp_end_snap_id    IN NUMBER,  
  report_type         IN VARCHAR2 := 'HTML')  
RETURN CLOB;
```



Application Design



Too Many Columns (1:2)

- Oracle claims that a table can contain up to 1,000 columns: It is not true. No database can do 1,000 columns no matter what their marketing claims may be
- The maximum number of real table columns is 255
- Break the 255 barrier and optimizations such as advanced and hybrid columnar compression no longer work
- A 1,000 column table is actually four segments joined together seamlessly behind the scenes just as a partitioned table appears to be a single segment but isn't
- Be suspicious of any table with more than 50 columns. At 100 columns it is time to take a break and re-read the Codd-Date rules on normalization
- Think vertically not horizontally



Too Many Columns (2:2)

- Be very suspicious of any table with column names in the form "SPARE1", "SPARE2", "..."
- The more columns a table has the more cpu is required when accessing **columns to the right** (as the table is displayed in a `SELECT *` query ... or at the bottom if the table is displayed by a `DESCRIBE`)



Column Ordering (1:2)

- Computers are not humans and tables are not paper forms
- CBO's column retrieval cost
 - Oracle stores columns in variable length format
 - Each row is parsed in order to retrieve one or more columns
 - Each subsequently parsed column introduces a cost of 20 cpu cycles regardless of whether it is of value or not
 - These tables will be accessed by person_id or state: No one will ever put the address2 column into the WHERE clause as a filter ... they won't filter on middle initial either

Common Design

```
CREATE TABLE customers (  
  person_id    NUMBER,  
  first_name   VARCHAR2(30) NOT NULL,  
  middle_init  VARCHAR2(2),  
  last_name    VARCHAR2(30) NOT NULL,  
  address1     VARCHAR2(30),  
  address2     VARCHAR2(30),  
  city         VARCHAR2(30),  
  state        VARCHAR2(2));
```

Optimized Design

```
CREATE TABLE customers (  
  person_id    NUMBER,  
  last_name     VARCHAR2(30) NOT NULL,  
  state         VARCHAR2(2)  NOT NULL,  
  city          VARCHAR2(30) NOT NULL,  
  first_name    VARCHAR2(30) NOT NULL,  
  address1      VARCHAR2(30),  
  address2      VARCHAR2(30),  
  middle_init   VARCHAR2(2));
```



Column Ordering (2:2)

- Proof column order matters

```
CREATE TABLE read_test AS
SELECT *
FROM apex_040200.wv_flow_page_plugs
WHERE rownum = 1;
```

```
SQL> explain plan for
      2  select * from read_test;
```

PLAN_TABLE_OUTPUT

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	

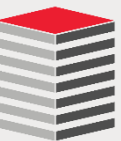
0	SELECT STATEMENT		1	214K	2 (0)	00:00:01	
1	TABLE ACCESS FULL	READ_TEST	1	214K	2 (0)	00:00:01	

```
-- fetch value from column 1
Final cost for query block SEL$1 (#0) - All Rows Plan:
Best join order: 1
Cost: 2.0002 Degree: 1 Card: 1.0000 Bytes: 13
Resc: 2.0002 Resc_io: 2.0000 Resc_cpu: 7271
Resp: 2.0002 Resp_io: 2.0000 Resc_cpu: 7271
```

```
-- fetch value from column 193
Final cost for query block SEL$1 (#0) - All Rows Plan:
Best join order: 1
Cost: 2.0003 Degree: 1 Card: 1.0000 Bytes: 2002
Resc: 2.0003 Resc_io: 2.0000 Resc_cpu: 11111
Resp: 2.0003 Resp_io: 2.0000 Resc_cpu: 11111
```



More Object Optimizations



Index Mythology

- Full Table Scans are bad
 - The above statement is pure unadulterated nonsense: Easily proven false and yet it persists year-after-year
- Queries should use an index
- There is a magic number, like 10% or rows, over which an index won't be used
- All indexes are of equal value
- Indexes need to be rebuilt regularly
 - Rebuilds are DDL and require substantial resources and locking
 - Indexes almost never need to be rebuilt
 - Coalesced perhaps but not rebuilt





```
SQL> explain plan for
 2  SELECT doc_name
 3  FROM t
 4  WHERE person_id = 221;
```

```
SQL> select * from table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time		

0	SELECT STATEMENT		216	6264	64 (4)	00:00:01		
* 1	TABLE ACCESS FULL	T	216	6264	64 (4)	00:00:01		

```
SQL> explain plan for
 2  SELECT /*+ INDEX(t ix_t_person_id) */ doc_name
 3  FROM t
 4  WHERE person_id = 221;
```

```
SQL> select * from table(dbms_xplan.display);
PLAN_TABLE_OUTPUT
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time		

0	SELECT STATEMENT		216	6264	216 (0)	00:00:03		
1	TABLE ACCESS BY INDEX ROWID	T	216	6264	216 (0)	00:00:03		
* 2	INDEX RANGE SCAN	IX_T_PERSON_ID	216		1 (0)	00:00:01		



Oracle Index Types

- Unlike SQL Server, and other products, Oracle has many types of indexes so your choice of index type can be optimized for the application's needs
 - B*Tree
 - Bitmap
 - Bitmap Join
 - Compressed
 - Descending
 - Function Based
 - Hash
 - IndexType
 - Invisible
 - Reverse
 - XML



B*Tree Indexes (1:2)

- Balance Tree
- Upside down Tree-like structure where each branch represents a different set of data
- Contains branch blocks and leaf blocks
- Leaf blocks contain index values and the ROWID that points to the physical location of a row with that value
- The default index type in Oracle
- The only index type in most RDBMSs

```
SQL> CREATE INDEX ix_postal_codes  
2   ON postal_codes(state, city)  
3   TABLESPACE uwdata;
```



Concatenated Indexes

- With concatenated indexes, the leading column should be the most selective
- If the leading column is the most selective and the most frequently used in the limiting conditions
- Then the second and subsequent columns of the index will have the most effect if they are the next most selective and the next most frequently queried
- This will have the biggest impact on the biggest number of queries, assuming that the same column is used most frequently in the limiting conditions of queries
- It also makes possible BASIC Index compression



Concatenated Indexes vs. Multiple Single Column Indexes

- If the other columns are frequently referenced with the leading column, there will be significant performance advantages by creating a concatenated index instead of separate indexes
- Less I/O will be required
- The results from the separate index reads won't need to be merged, resulting in less filtering



Bitmap and Bitmap Join Indexes

- Use with low cardinality (a small number of distinct values) and essentially no updates or deletes
- The word possible example of low cardinality for a bitmap index is a gender column with the values "F" and "M": Why?
- When you modify one byte in one row of a table with a bitmap index on the changed column how much redo is written? This is critically important to know
- If it isn't a traditional Data Warehouse do not use a Bitmap Index
- If you update a single byte in a B*Tree index how much redo is generated?



Descending Indexes

- Optimal when an index read is associated with an ORDER BY DESCENDING clause

```
SQL> CREATE TABLE orders(  
  2  order_id    NUMBER(9,0),  
  3  ship_date   DATE;  
  
SQL> CREATE INDEX ix_orders_reg  
  2  ON orders(cust_id, ship_date);  
  
SQL> CREATE INDEX ix_orders_desc  
  2  ON orders(cust_id, ship_date DESC);  
  
SQL> EXPLAIN PLAN FOR  
  2  SELECT order_id  
  3  FROM orders  
  4  WHERE ship_date IS NOT NULL  
  5  ORDER BY ship_date DESC;
```

```
-----  
| Id  | Operation                      | Name                |  
-----  
|  0  | SELECT STATEMENT                |                     |  
|  1  |   SORT ORDER BY                 |                     |  
|*  2  |    INDEX FAST FULL SCAN         | IX_ORDERS_DESC      |  
-----
```



Function Based Indexes (1 of 2)

- Index the result of a function applied to a column or multiple columns within the row
- Can be used to enhance performance by not indexing that which is of no value to index ... for example a column with 10% "Y" and 90% "No" values
- Without a Function Based Index a full table scan would be required as well as a calculation of every row

```
conn scott/tiger@pdborcl
```

```
SQL> desc emp
```

Name	Null?	Type
EMPNO	NOT NULL	NUMBER(4)
ENAME		VARCHAR2(10)
JOB		VARCHAR2(9)
MGR		NUMBER(4)
HIREDATE		DATE
SAL		NUMBER(7,2)
COMM		NUMBER(7,2)
DEPTNO		NUMBER(2)

```
CREATE INDEX fbi_emp_sal_x_comm  
ON emp (sal + comm);
```

```
SELECT ename  
FROM emp  
WHERE (sal + comm) < 300000;
```



Function Based Indexes (2 of 2)

- A regular index would index 99% "N" values wasting substantial space and the index will never be used to find the value "N"
- As a normal B*Tree index IX_FBIDEMO will have what leaf block distribution?

```
SQL> CREATE TABLE fbidemo AS
  2  SELECT object_name, object_type, temporary
  3  FROM dba_objects;

SQL> CREATE INDEX ix_fbidemo
  2  ON fbidemo (temporary);

SQL> CREATE INDEX fbi_fbidemo
  2  ON fbidemo (DECODE(temporary, 'Y', 'Y', NULL));
```



Invisible Indexes

- Invisible indexes are real indexes and are maintained as like any other index but, by default, are not visible to the optimizer
- Excellent for use when inappropriate use of an index might slow down the system but a small number of sessions will benefit from it

```
CREATE INDEX ix_invis  
ON invis(table_name)  
INVISIBLE;  
  
ALTER SESSION SET optimizer_use_invisible_indexes = TRUE;
```



Sorted Hash Clusters

- Sorted hash clusters, applied appropriately, can eliminate substantial overhead created by an ORDER BY clause

```
CREATE CLUSTER sorted_hc (  
  program_id  NUMBER(3),  
  line_id     NUMBER(10) SORT,  
  delivery_dt DATE SORT)  
TABLESPACE uwdata  
HASHKEYS 9  
SIZE 750  
HASH IS program_id;  
  
CREATE TABLE shc_airplane (  
  program_id  NUMBER(3),  
  line_id     NUMBER(10) SORT,  
  delivery_dt DATE SORT,  
  customer_id VARCHAR2(3),  
  order_dt    DATE)  
CLUSTER sorted_hc (program_id, line_id, delivery_dt);
```



Chained Rows

- A chained row is a row that is written to two or more blocks
- Row chaining inevitably leads to more I/O than would be required if the entire row fit within a single block

```
SQL> @?/rdbms/admin/utlchn1.sql
```

```
SQL> ANALYZE TABLE t LIST CHAINED ROWS INTO chained_rows;
```

```
SQL> SELECT sys_op_rpb(rowid), table_name, head_rowid, analyze_timestamp  
2 FROM chained_rows;
```

```
SQL> SELECT rowid, dbms_rowid.rowid_block_number(rowid) BN, sys_op_rpb(rowid), length(col1), length(col2)  
2 FROM t;
```



Index Use and Abuse

- What is the right number of indexes on a table?
- It depends but a number between 0 and 6 is reasonable
- One way to determine if an index is being used is to monitor usage ... but it can be misleading because while the index may not be read ... the stats on it may be of great value to the optimizer in choosing the correct execution path
 - If an index that is not used is dropped it may affect execution plans
 - If an index that is not used is altered it may affect execution plans
 - If an index that is not used is created it may affect execution plans

```
SQL> ALTER INDEX ix_index_demo_gender_state MONITORING USAGE;
```

```
SQL> SELECT *  
2 FROM v$object_usage;
```



Sequence Caching

- If you see something like this invest some time in sequence tuning
- Cache Size specifies how many values of the sequence the database preallocates and keeps in memory for faster access
- In the event of a system failure all unused cached sequence values are lost
- There is substantial overhead, and locking each time the sequence pre-allocates a new set of values
- Oracle's default cache value of 20 is a bad joke and should never be used for anything other than demos of what is wrong with a value of 20

```
SQL> SELECT order_flag, cache_size, COUNT(*)  
2  FROM dba_sequences  
3  WHERE sequence_owner NOT LIKE '%SYS%'  
4  GROUP BY order_flag, cache_size  
5* ORDER BY order_flag, cache_size;
```

O	CACHE_SIZE	COUNT (*)
N	0	7
N	9	4
N	10	4
N	20	52
Y	0	52
Y	20	8
Y	100	1



Sequence Ordering

- By default sequences are guaranteed to create unique numbers but when you force ordering you force serialization which will always negatively impact performance
- Do not order sequences unless the application demands it



Sequences and RAC

- On RAC clusters watch for the DFS Lock Handle wait as an indication of incorrectly sized caching: If found increase the caching size
- If a sequence is used to create a surrogate key and there are 1,000 inserts each second caching 20 values means that 500 times a second the cache will need to be refreshed
- This will negatively impact performance
- For this example cache 5,000+ values



Binary XML Partitioning Example

- High performance means not running version 7.3.4 code in 11.2.0.4+

```
CREATE TABLE orders OF XMLType
XMLTYPE STORE AS BINARY XML
VIRTUAL COLUMNS (
  SITE_ID AS (XMLCast(XMLQuery('/Order/@SiteId' PASSING OBJECT_VALUE RETURNING CONTENT) AS NUMBER)))
PARTITION BY RANGE (site_id) (
  PARTITION p1 VALUES LESS THAN (10),
  PARTITION p2 VALUES LESS THAN (20),
  PARTITION pm VALUES LESS THAN (MAXVALUE));

DECLARE
  x XMLTYPE;
BEGIN
  x := XMLTYPE('<?xml version="1.0" encoding="utf-8"?>
    <Order orderId="1" orderRevision="1" orderTimeStamp="01-JAN-2012">
      <OrderHeader>
        <AlternateIds>
          <AlternateId altIdType="SiteId">12</AlternateId>
          <AlternateId altIdType="MerchantOrderNumber">Merch</AlternateId>
          <AlternateId altIdType="MarketplaceOrderNumber">Place</AlternateId>
          <AlternateId altIdType="CustomerReferenceId">Ref</AlternateId>
          <AlternateId altIdType="CartId">Cart</AlternateId>
          <AlternateId altIdType="SessionId">1</AlternateId>
        </AlternateIds>
      </OrderHeader>
    </Order>');
  INSERT INTO orders VALUES (x);
END;
/
...
```



More ...



Jonathan Lewis' Rules for Hints

1. Don't
2. If you must use hints, then assume you've used them incorrectly
3. On every patch or upgrade to Oracle, assume every piece of hinted SQL is going to do the wrong thing

Because of (2) above; you've been lucky so far, but the patch/upgrade lets you discover your mistake

4. Every time you apply some DDL to an object that appears in a piece of hinted SQL assume that the hinted SQL is going to do the wrong thing

Because of (2) above; you've been lucky so far, but the structural change lets you discover your mistake



Aliasing and Fully Qualified Names

- When you do not use fully qualified names Oracle must do the work for you
- You write code once ... the database executes it many times

```
SELECT DISTINCT s.srvr_id  
FROM servers s, serv_inst i  
WHERE s.srvr_id = i.srvr_id;  
  
SELECT DISTINCT s.srvr_id  
FROM uwclass.servers s, uwclass.serv_inst i  
WHERE s.srvr_id = i.srvr_id;
```



Advanced Rewrite

- The DBMS_ADVANCED_REWRITE package is fully documented and supported
- With Advanced Rewrite you can replace "bad" SQL with "good" SQL without having access to, or fixing, application code

```
ALTER SYSTEM SET query_rewrite_integrity = 'TRUSTED'  
COMMENT='Permanent Change Rewrite From ENFORCED to TRUSTED'  
SCOPE=BOTH;
```

```
dbms_advanced_rewrite.declare_rewrite_equivalence(  
name          VARCHAR2,  
source_stmt   CLOB,  
destination_stmt CLOB,  
validate      BOOLEAN := TRUE,  
mode          VARCHAR2 := 'TEXT_MATCH');
```

- In 12c look at DBMS_SQL_TRANSLATOR



Automatic Memory Management

- In Oracle Database 10g memory management was ASMM (Automatic Shared Memory Management)
- In Oracle 11g through 11.2.0.3 the default was AMM (Automatic Memory Management) which was found to produce too many memory resizings and, as a result, performance issues
- As of Database 11.2.0.4 Oracle has reverted to ASMM as the preferred algorithm
- To determine the number of resize operations run the following SQL statement and if using AMM convert back to ASMM: If using ASMM optimize your memory parameters to reduce their frequency

```
SELECT TRUNC(start_time), status, oper_type, oper_mode, parameter  
FROM v$sga_resize_ops  
WHERE initial_size <> final_size;
```



Block Change Tracking (1:3)

- If a database is small it is possible to perform a full RMAN backup every night: This is rarely possible or necessary
- When configuring incremental backups we generally configure a separate back every 15 to 120 minutes for archive logs and perform a nightly incremental backup
 - Level 0 once or twice a week
 - Level 1 every night on which a Level 0 is not taken
- Incremental Level 1 backups will always benefit from block change tracking
- To enable block change tracking you must create a block change tracking file

```
conn / as sysdba
```

```
SQL> SELECT filename, status, bytes  
2 FROM v$block_change_tracking;
```

FILENAME	STATUS	BYTES
-----	-----	-----
	DISABLED	



Block Change Tracking (2:3)

- The size of the file created is determined by the number of blocks in your database's data files: The more blocks the larger the file

```
SQL> ALTER DATABASE ENABLE BLOCK CHANGE TRACKING
      2* USING FILE 'c:\app\oracle\fast_recovery_area\ORABASE\bctf01.log';
Database altered.
```

```
SQL> SELECT filename, status, bytes
      2 FROM v$block_change_tracking;
```

FILENAME	STATUS	BYTES
C:\APP\ORACLE\FAST_RECOVERY_AREA\ORABASE\BCTF01.LOG	ENABLED	11599872



Block Change Tracking (3:3)

- When Block Change Tracking is enabled the instance spawns the CTWR process which is responsible for writing log file entries

```
SQL> SELECT *
  2  FROM v$sgastat
  3  WHERE name LIKE '%CTWR%';
```

INST_ID	POOL	NAME	BYTES	CON_ID
1	large pool	CTWR dba buffer	1728512	1

```
SQL> SELECT inst_id, sid, program, status
  2  FROM v$session
  3  WHERE program LIKE '%CTWR%';
```

INST_ID	SID	PROGRAM	STATUS
1	248	ORACLE.EXE (CTWR)	ACTIVE



Block Corruption (2:2)

- If corruption is found use the following SQL to identify the corrupted segment(s)

```
SELECT de.owner, de.segment_name, de.segment_type  
FROM dba_extents de, v$database_block_corruption vdbc  
WHERE de.file_id = vdbc.file#  
AND vdbc.block# BETWEEN de.block_id AND (de.block_id+(de.blocks-1));
```

- To eliminate the corruption
 - DBMS_REPAIR
 - Drop and rebuild the segment
 - Open an SR with Oracle



Connection Pooling and Middle Tier Caching

- Opening and maintaining a database connection for each user
 - Especially when dynamically creating sessions for requests made to a dynamic database-driven web application are costly and waste resources
- A cache with multiple persistent database connections
- After a connection is created, it is placed in the pool, and it is reused so that a new connection does not have to be established for each new session or inquiry
- Each persistent connection can be reused when a future request to the database is made
- Used to enhance the performance of executing commands in a database



Implicit Casts

- Code that does not correctly define data types will either fail to run or run very inefficiently

The following example shows both the correct way and the incorrect way to work with dates. The correct way is to perform an explicit cast

```
SQL> create table t (  
    2  datecol date);  
  
Table created.  
  
SQL> insert into t values ('01-JAN-2015');  
  
1 row created.  
  
SQL> insert into t values (TO_DATE('01-JAN-2015'));  
  
1 row created.
```

In Oracle dates are dates ... not strings. Similarly numbers should either be explicitly cast with TO_NUMBER or only processed using numeric variables.



Implicit Commits

- An explicit commit must be present at the end of any transaction
- You can not rely on an ODBC or JDBC driver configuration to commit your changes in a reliable and consistent way
- Similarly ... you must explicitly rollback in exception handlers as the ODBC driver may perform an unintended commit

```
CREATE OR REPLACE PROCEDURE test AUTHID DEFINER IS
BEGIN
  FOR i IN 1..10 LOOP
    INSERT INTO t
      (testcolumn)
    VALUES
      (i);
  END LOOP;

  COMMIT;
EXCEPTION
  WHEN dup_val_on_index THEN
    ROLLBACK;
END;
/
```



Inactive Sessions

- Ignoring, for the moment, issues of grammar and spelling ... clearly there is a technology problem

Attachments

Hi Bob

we have killed 250 sessions only that are blocking other sessions.

1. What session was causing the blocking lock? The client would normally like to know what SCHEMA and WHAT WAS THE LAST SQL STATEMENT ISSUED...

Ans:blocking session

id's: (25,153,889,967,1098,1356,552,554,620,740,949,1172,2,224,410,596,610,635,814,817,937,1089,1177,1195,1307,1316,1458,24,53,68,304,467,509,556,825,970,1035,1119,1925,38,686,830,832,1414,1511,333,506,792,932,942,115,1008,1014,19,313,1198,1202,1224,1376);

Please Note: Not killed any active sessions for these blocking sessions. Killed only INACTIVE sessions.



Invalid Objects and Unusable Indexes

- Look for newly invalidated objects and unusable indexes

```
conn / as sysdba

SELECT owner, object_type, COUNT(*)
FROM dba_objects_ae
WHERE status = 'INVALID'
GROUP BY owner, object_type;

SELECT owner, table_name, index_name
FROM dba_indexes
WHERE status = 'UNUSABLE';
```



Java Fetch Size

- Most applications that connect to the Oracle database do so through a driver such as JDBC or ODBC
- By default these drivers are configured with an array size, usually about 10 that lead to slow response due to their inefficiency
- An optimal array size is likely between 100 and 250 yielding $1/10^{\text{th}}$ to $1/25^{\text{th}}$ the number of I/O requests
- In JDBC the array size is set with the `java.sql.Statement.setFetchSize()` parameter
- The following are other parameters that can be used to optimize application performance
 - User `statement.cancel` or `Statement.setQueryTimeout`
 - `jdbc:oracle:thin:@(DESCRIPTION ... (SDU=32767) ...)`



"Jobs" and Human Nature

- Jobs that do not real work can be very expensive
 - Find them
 - Try to identify an owner
 - Try to fix them
 - If you can't ... disable them

```
SQL> SELECT owner, job_name, job_type, trunc(start_date) SDATE, trunc(next_run_date) nxtrun, failure_count
2  FROM dba_scheduler_jobs
3* WHERE failure_count <> 0;
```

OWNER	JOB_NAME	STATE	SDATE	NXTRUN	FAILURE_COUNT
SYS	SM\$CLEAN_AUTO_SPLIT_MERGE	SCHEDULED	14-MAR-2011 00:00:00	14-AUG-2013 00:00:00	17
SYS	RSE\$CLEAN_RECOVERABLE_SCRIPT	SCHEDULED	14-MAR-2011 00:00:00	14-AUG-2013 00:00:00	20
SYS	DRA_REEVALUATE_OPEN_FAILURES	SCHEDULED			10
ORACLE_OCM	MGMT_CONFIG_JOB	SCHEDULED			4
EXFSYS	RLM\$SCHDNEGATION	SCHEDULED	13-AUG-2013 00:00:00	13-AUG-2013 00:00:00	3
EXFSYS	RLM\$EVTCLEANUP	SCHEDULED	27-APR-2011 00:00:00	13-AUG-2013 00:00:00	2
RDBA5	LONG_RUN_SESS_JOB	SCHEDULED	12-AUG-2013 00:00:00	13-AUG-2013 00:00:00	1
EISAI_PROD_TMS	POPULATE_MORGAN_CATALOG	DISABLED	01-JUN-2009 00:00:00	08-AUG-2013 00:00:00	2559



Redo Log Switch Anomalies (1:3)

- Redo log switches should occur between 4 and 12 times per hour (once every 5 to 15 minutes) to balance performance with transaction security
- Monitoring redo log switches aggregated by the hour can alert you to incorrectly sized redo logs, behavioral changes, unexpected workloads, and outages
- The SQL statement on the following page can be used to monitor the switches on stand-alone and RAC One-Node systems and provide general guide with RAC clusters



Redo Log Switch Anomalies (2:3)

```
SELECT TO_CHAR(first_time, 'MMDD') MMDD,  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '00', 1, 0)), '99') "00",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '01', 1, 0)), '99') "01",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '02', 1, 0)), '99') "02",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '03', 1, 0)), '99') "03",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '04', 1, 0)), '99') "04",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '05', 1, 0)), '99') "05",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '06', 1, 0)), '99') "06",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '07', 1, 0)), '99') "07",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '08', 1, 0)), '99') "08",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '09', 1, 0)), '99') "09",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '10', 1, 0)), '99') "10",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '11', 1, 0)), '99') "11",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '12', 1, 0)), '99') "12",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '13', 1, 0)), '99') "13",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '14', 1, 0)), '99') "14",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '15', 1, 0)), '99') "15",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '16', 1, 0)), '99') "16",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '17', 1, 0)), '99') "17",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '18', 1, 0)), '99') "18",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '19', 1, 0)), '99') "19",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '20', 1, 0)), '99') "20",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '21', 1, 0)), '99') "21",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '22', 1, 0)), '99') "22",  
TO_CHAR(SUM(DECODE(TO_CHAR(first_time, 'HH24'), '23', 1, 0)), '99') "23"  
FROM v$log_history  
GROUP BY TO_CHAR(first_time, 'MMDD')  
ORDER BY 1;
```



Redo Log Switch Anomalies (3:3)

MMDD	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0609	16	11	9	8	8	10	12	8	8	10	8	10	14	10	11	15	15	8	12	8	7	6	9	7
0610	13	12	8	9	7	6	11	9	6	8	7	8	12	6	7	6	8	7	10	7	4	4	4	5
0611	12	8	5	9	9	7	11	7	6	7	8	5	12	9	10	8	9	12	12	10	6	6	9	8
0612	13	12	7	9	7	9	10	10	7	7	9	8	11	7	7	8	7	7	11	9	5	6	8	7
0613	12	11	7	8	8	7	13	7	9	7	8	7	13	10	9	8	8	8	11	8	7	5	7	6
0614	15	10	9	9	8	9	13	9	9	7	11	13	11	9	8	9	13	9	12	9	7	9	7	7
0615	15	10	10	8	10	9	12	8	9	8	9	7	13	6	8	7	7	7	15	10	7	7	7	5
0616	13	8	8	7	7	6	10	8	11	7	8	6	11	7	12	13	13	14	13	9	9	9	7	8
0617	15	13	10	9	8	9	16	8	8	10	9	10	16	11	10	10	8	11	13	8	9	9	7	9
0618	12	13	15	15	13	13	15	13	9	12	8	11	14	9	10	9	9	8	14	9	8	8	9	8
0619	16	11	10	11	9	9	13	12	10	9	12	12	17	8	9	9	11	11	14	9	9	11	10	12
0620	19	15	11	10	10	10	19	11	9	9	9	9	13	7	15	10	11	11	12	10	9	11	11	10
0621	13	16	11	9	10	13	16	8	14	9	11	12	17	10	10	11	8	11	14	8	11	14	8	11
0622	16	13	13	11	11	9	16	9	9	11	10	11	17	10	9	10	10	10	13	14	9	10	10	8
0623	19	13	12	13	13	11	16	12	11	11	11	11	16	9	10	13	2	14	14	8	9	8	8	8
0624	14	9	9	9	7	9	11	8	8	7	8	8	14	7	8	7	9	3	6	0	0	0	0	0
0625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
0626	0	1	0	0	0	0	0	0	0	4	0	0	0	2	2	3	2	7	5	6	1	0	0	0
0627	3	10	0	0	0	5	0	1	10	0	0	0	0	0	1	0	1	0	2	5	3	7	1	0
0629	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4	0	0	6	7	6
0630	7	4	23	19	9	10	5	6	7	17	19	17	15	17	15	43	40	32	17	15	14	20	13	15
0701	15	12	14	12	13	12	13	17	15	17	20	20	18	18	17	15	14	13	10	10	15	15	13	19
0702	21	22	20	18	14	14	12	13	11	11	14	14	14	10	9	10	9	10	11	9	11	9	10	12
0703	9	13	10	17	14	17	15	17	23	20	19	20	17	19	16	17	15	17	15	15	15	16	16	18
0704	22	19	19	18	16	15	13	13	14	11	13	10	12	14	10	12	14	11	9	11	12	13	12	9
0705	14	13	9	11	10	12	13	11	11	8	10	10	11	11	11	12	10	10	9	10	8	9	12	7
0706	14	15	11	12	9	15	13	12	12	9	12	14	12	12	12	12	13	11	8	9	12	13	2	0
0707	0	0	1	0	3	15	10	10	7	8	10	11	12	8	6	9	13	12	9	8	9	8	10	10
0708	16	9	8	15	10	11	9	8	8	14	9	10	10	8	8	14	15	10	9	9	8	9	10	10
0709	13	12	9	10	10	9	9	10	11	11	8	9	9	8	9	13	8	9	6	9	9	11	10	9
0710	12	10	9	10	9	12	9	8	8	11	7	10	11	9	9	13	10	9	8	9	11	12	10	10
0711	15	12	9	13	9	12	8	10	11	13	9	8	10	9	8	12	11	12	9	9	10	11	10	8
0712	13	12	10	13	10	10	9	7	10	11	9	10	12	12	12	15	12	9	8	9	11	12	12	12
0713	14	12	12	11	10	10	12	12	12	15	10	11	11	10	4	5	15	14	10	9	8	8	13	6
0714	12	12	9	9	11	10	10	9	10	9	14	7	7	8	8	9	14	9	9	10	12	8	13	10
0715	10	10	9	14	12	15	12	14	13	15	10	11	9	4	8	6	8	7	6	7	8	8	8	8
0716	10	11	9	8	8	9	9	6	6	7	7	12	7	9	15	14	13	16	12	14	11	9	6	7
0717	10	10	9	9	9	10	12	14	11	10	12	9	8	12	7	3	0	0	0	0	0	0	0	0



Redo Log Switch Anomalies (4:4)

- Another real-world example of redo log switches helping to focus attention

RAC Server Node 1

MMDD	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0804	0	0	0	0	0	0	0	0	0	0	0	0	5	32	18	65	91	13	12	20	84	9	14	9
0805	137	112	26	27	141	17	21	9	85	13	21	17	96	23	23	24	91	13	11	21	86	11	14	9
0806	151	111	21	24	96	41	50	14	84	22	20	22	91	18	17	18	92	24	10	11	83	9	14	20
0807	139	100	32	30	99	43	49	19	105	17	31	14	76	23	27	25	111	20	15	18	86	13	13	10
0808	145	99	29	30	109	52	48	11	102	25	47	24	101	23	20	23	117	31	30	16	91	12	11	9
0809	123	83	65	37	93	17	25	10	102	23	44	25	111	37	24	29	98	19	29	16	92	16	15	9
0810	169	120	52	32	125	58	38	9	109	17	26	14	104	13	17	15	93	13	16	11	61	10	10	9
0811	107	82	51	34	85	17	22	10	73	10	12	11	92	32	13	69	65	11	11	10	60	9	12	9
0812	149	121	26	15	70	16	24	11	95	34	15	18	34	67	21	21	87	11	13	9	77	9	14	9
0813	115	76	55	56	27	9	9	9	11	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0

60 corresponds to one change per minute ... the ideal range is 4 to 12
Addressed by resizing redo logs from 400MB to 4GB
And rescheduling many of the jobs



Scheduler Job Failures

- It is a common occurrence that DBMS_SCHEDULER jobs fail and no one notices because
 - The job has been automatically running for a long time but no one using the output
 - Job failures are not reported in the alert log
- The following example shows how to identify failed jobs
- The job shown was disabled on discovering the failure count

```
SQL> SELECT owner, job_name, job_type, trunc(start_date) SDATE, trunc(next_run_date) nxtrun, failure_count
2  FROM dba_scheduler_jobs
3* WHERE failure_count <> 0;
```

OWNER	JOB_NAME	STATE	SDATE	NXTRUN	FAILURE_COUNT
SYS	SM\$CLEAN_AUTO_SPLIT_MERGE	SCHEDULED	14-MAR-2011 00:00:00	14-AUG-2013 00:00:00	17
SYS	RSE\$CLEAN_RECOVERABLE_SCRIPT	SCHEDULED	14-MAR-2011 00:00:00	14-AUG-2013 00:00:00	20
SYS	DRA_REEVALUATE_OPEN_FAILURES	SCHEDULED			10
ORACLE_OCM	MGMT_CONFIG_JOB	SCHEDULED			4
EXFSYS	RLM\$SCHDNEGATION	SCHEDULED	13-AUG-2013 00:00:00	13-AUG-2013 00:00:00	3
EXFSYS	RLM\$EVTCLEANUP	SCHEDULED	27-APR-2011 00:00:00	13-AUG-2013 00:00:00	2
RDBA5	LONG_RUN_SESS_JOB	SCHEDULED	12-AUG-2013 00:00:00	13-AUG-2013 00:00:00	1
EISAI_PROD_TMS	POPULATE_MORGAN_CATALOG	DISABLED	01-JUN-2009 00:00:00	08-AUG-2013 00:00:00	2559



Objects Named With Keywords

- How to test a word to determine whether it can be used

```
SQL> SELECT keyword  
      2 FROM v$reserved_words  
      3 WHERE keyword LIKE 'ID%';
```

```
KEYWORD
```

```
-----
```

```
ID
```

```
IDENTIFIED
```

```
IDGENERATORS
```

```
IDLE_TIME
```

```
IDENTITY
```

```
IDENTIFIER
```

```
6 rows selected.
```

Columns should never be named "ID." Best practice is to identify the nature of the ID, for example, MEMBER_ID or ORDER_ID. This holds true for columns such as COMMENTS and DATES.



Where Are Sorts Taking Place?

- In memory or on disk?

```
SELECT a.value "Disk Sorts", b.value "Memory Sorts",  
ROUND((100*b.value)/DECODE((a.value+b.value), 0,1,(a.value+b.value)),2) "Pct Memory Sorts"  
FROM v$sysstat a, v$sysstat b  
WHERE a.name = 'sorts (disk)'  
AND b.name = 'sorts (memory)';
```



Undo Tablespace Size and Retention

- Check undo tablespace size and resize in accordance with any advisory

```
set serveroutput on

DECLARE
  prob VARCHAR2(100);
  reco VARCHAR2(100);
  rtnl VARCHAR2(100);
  retn PLS_INTEGER;
  utbs PLS_INTEGER;
  retv PLS_INTEGER;
BEGIN
  retv := dbms_undo_adv.undo_health(prob, reco, rtnl, retn, utbs);
  dbms_output.put_line('Problem: ' || prob);
  dbms_output.put_line('Recmmnd: ' || reco);
  dbms_output.put_line('Rationl: ' || rtnl);
  dbms_output.put_line('Retentn: ' || TO_CHAR(retn));
  dbms_output.put_line('UTBSize: ' || TO_CHAR(utbs));
END;
/
```



PL/SQL



Debug Mode Compilation

- It is "Best Practice" to always build new schemas, and compile database code, using SQL*Plus running pure ASCII scripts
- Many of the GUI tools used by Developers, and sometimes by DBAs, by default compile PL/SQL objects in debug mode
- If debug mode objects are found they should be recompiled using SQL*Plus

```
SELECT owner, name, type  
FROM dba_plsql_object_settings  
WHERE plsql_debug='TRUE'  
ORDER BY 1,3,2;
```



PL/SQL Warnings

- New warnings in 10g and 11g: No new warnings in 12c
- Invaluable for finding suboptimal code, use of reserved words, inappropriate usages, and orphans Embedded SQL vs. Database APIs
 - Severe
 - 5018 - omitted optional AUTHID clause
 - 5019 - deprecated language element
 - 5020 - parameter name must be identified
 - Informative
 - 6016 - native code generation turned off (size/time)
 - 6017 - operation will raise an exception
 - 6018 - an infinity or NaN value computed or used
 - Performance
 - None



Wrap-Up



Summary

- Do not guess
 - If your problem is not caused by slow hardware then faster hardware will just create a problem faster
 - Gather information from a date-time range when everything was good and compare with the date-time range when the problem was observed
 - If the problem is slow SQL ... is the SQL statement itself slow or is it the entire environment that should be examined?
 - If the problem is related to CPU ... do you need more/faster CPUs or a better design?
 - If the problem is related to I/O ... do you need a new SAN or better indexing?
 - If the problem is related to network bandwidth ... do you need new NIC cards and to stop network virtualization? Yes you probably do



Conclusion

- Do not tune by guessing
 - Do not blame everything on bad SQL statements
 - Until you can prove that the root cause is the SQL
 - Use the scientific method
 - Construct a hypothesis
 - Test the hypothesis by doing experiments
 - Validate your conclusion
 - Only rewrite SQL after you have established conclusively that the root cause is the way a statement has been written and that rewriting the SQL statement will address ALL issues
-
- You will most likely not be rewriting a lot of SQL statements



Conclusion

- Do not tune by guessing
 - Do not blame everything on bad SQL statements
 - Until you can prove that the root cause is the SQL
 - Use the scientific method
 - Construct a hypothesis
 - Test the hypothesis by doing experiments
 - Validate your conclusion
 - Only rewrite SQL after you have established conclusively that the root cause is the way a statement has been written and that rewriting the SQL statement will address ALL issues
- SELECT more_information
FROM experience
WHERE topic = 'performance Tuning'
AND database = 'Innocent Bystander';**
- You will most likely not be rewriting a lot of SQL statements



*

ERROR at line 1:

ORA-00028: your session has been killed

Thank You

Daniel A. Morgan
email: dmorgan@forsythe.com
mobile: +1 206-669-2949
skype: damorgan11g
twitter: @meta7solutions

