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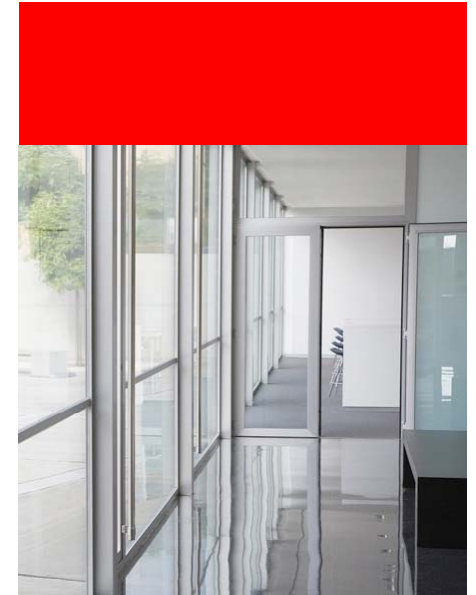
## Oracle Net Services: Performance, Scalability, HA and Security Best Practices

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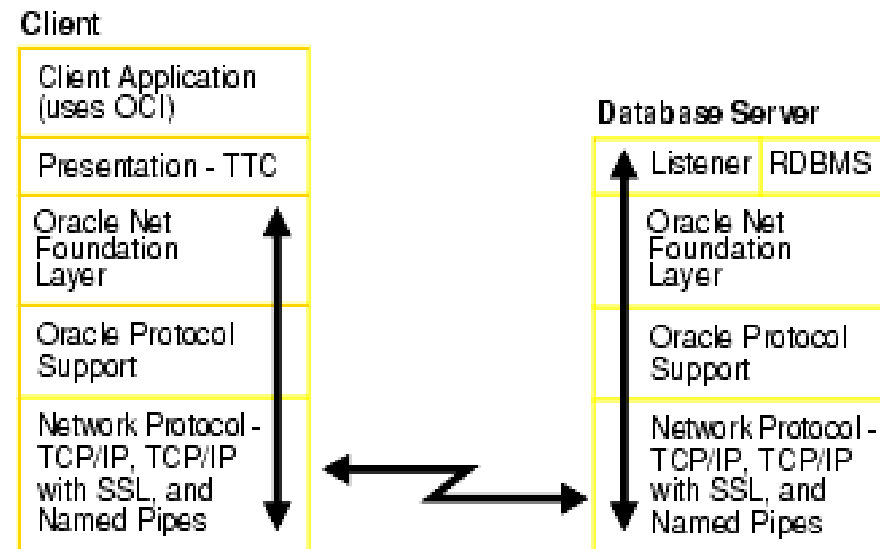
# Program

- Overview of Oracle Net
- Why Optimize Oracle Net?
- 11g New Features
- Best Practices
  - Operating System and Network
  - Database Client
  - Net Listener
  - Database Server
- Q/A



# Oracle Net Overview

- Primary Communication Foundation for DB
- Formerly known as SQL\*Net
- Oracle's Family of Networking Features:
  - Oracle Net
  - Oracle Net Listener
  - Connection Manager
  - Configuration Tools
    - Net Manager
    - NetCA





## Why Optimize Oracle Net?

- System Performance
  - Increase Network bandwidth utilization
  - Lower database CPU utilization
- High Availability
  - Better respond to database/host/network failures
- Network Scalability
  - Scale better with more client connections
  - Load-balance to improve application experience
- Network Manageability
  - Simplify deployment and configuration
- Network Security
  - Protect and recover from Denial of Service attacks



# Net Configuration Files

- `sqlnet.ora`
  - Main Oracle Net configuration file
  - On both Client and Server
- `listener.ora`
  - Configuration for the Net Listener
  - On Server only
- `tnsnames.ora`
  - Contains Connect Name to Descriptor mappings
  - Used by the TNSNames Naming adapter
  - On both Client and Server
- `ldap.ora`
  - Contains LDAP configuration information
  - Used the LDAP Naming adapter
  - On both Client and Server



# Oracle Net 11g New Features

- Performance & Scalability
  - Support for large SDU (11.2.0.2)
  - Optimized networking stacks for various data transfer needs
    - Network Fast Path for SQL operations
    - Zero Copy I/O Path for bulk data transfers
  - Support for Database Resident Connection Pools
  - Support for Scalable Operating System Event Models
- High Availability & Manageability
  - IP address list traversal for each hostname during connect (11.2.0.1)
  - Efficient dead-node detection for failover (11.2.0.1)
  - Option to enable connection retries (11.2.0.1)
  - Easy Connect Naming enhancements
  - Integration with Automatic Diagnostic Repository
  - Option for Default Service in Listener



## Oracle Net 11g New Features

- Network Security
  - CIDR and wildcard support for valid node checking (11.2.0.1)
  - Authenticated LDAP name lookup - OID and Active Directory
  - Protocol level access control for Listener administration
- IPv6 (11.2.0.1)
  - Support for all features and components in single-instance mode
  - Support for single listener address across all IP(v4/v6) interfaces

	IPv4-only Server	Dual-stack Server	IPv6-only Server
IPv4-only Client	Supported (v4)	Supported (v4)	<i>Not Supported</i>
Dual-stack Client	Supported (v4)	Supported (v4,v6)	Supported (v6)
IPv6-only Client	<i>Not Supported</i>	Supported (v6)	Supported (v6)





# Operating System Tuning

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## Why is OS tuning critical?

- Key role in data transmission!
- Some default OS configurations cannot handle modern Ethernet speeds
- Bandwidth x Delay Product (BDP)
  - Amount of data on the “wire” at any given point in time
  - Default OS buffers not large enough to handle this data
  - For example, with 40 Mbits/sec bandwidth, 25 msec delay,  
 $BDP = (40 \times 1000 \div 8 \text{ Kbytes/sec}) \times (0.025 \text{ sec}) \sim 128 \text{ Kbytes}$
- TCP a benevolent algorithm – one size fits all
  - Slow-start
  - Exponential back-off
  - Small Window Sizes
  - TCP performance features may not be enabled by default



## TCP Optimization - Linux

- Use TCP auto-tuning in kernel (2.4.27, 2.6.7)
  - `/proc/sys/net/ipv4/tcp_moderate_rcvbuf` (1=on)
- Tune TCP Max Memory
  - `/proc/sys/net/ipv4/tcp_rmem` and `tcp_wmem`
  - 4096      87380      174760 ← Tune this to 2xBDP
- Tune the socket buffer sizes
  - `/proc/sys/net/core/rmem_max` and `wmem_max`
  - Set this to 2xBDP
- 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`



## TCP Optimization - Windows

- Vista / Server 2008 supports TCP auto-tuning
- For other versions, tuning necessary under RegKey  
`HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\  
Services\Tcpip\Parameters`
  - Turn on Window Scaling and Timestamps  
`Tcp1323Opts = 3`
  - Set TCP Window Size to 2xBDP  
`GlobalMaxTcpWindowSize = <2xBDP>`
  - If desired, tune Window Size at the Interface Level  
`Tcpip\Parameters\Interfaces\<interfaceGUID>\  
TcpWindowSize`



## Don't forget the Hardware

- Use Jumbo Frames for GigE networks
- Use NICs with TCP off-loading capabilities
- Monitor switches and OS for packet loss
  - Causes numerous issues



**Database Client  
Performance**

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## Tuning the Socket Buffers

- Set send and receive socket buffer sizes in tnsnames.ora or sqlnet.ora using:
  - SEND\_BUF\_SIZE – OS send buffer size
  - RECV\_BUF\_SIZE – OS receive buffer size
- Set this size to accommodate the BDP (2x)
- Also set on the server
- Large buffer sizes help
  - Application queue more data to the OS
  - Have more data on the wire
  - Better utilize available bandwidth
  - In WAN deployments



## Tuning the Session Data Unit

- Controls SQL\*Net packet size
  - 11g default 8k, Pre-11g default 2k
  - Max is 64k
- Set in
  - sqlnet.ora: DEFAULT\_SDU\_SIZE
  - tnsnames.ora: SDU in address
- Larger SDU gives
  - Better Network throughput
  - Fewer system calls to send and receive data
  - Less CPU usage – system and user
- Side-effect of larger SDU: Network buffers take up more memory





## SDU Recommendations

- Optimal SDU varies with application
- Increase SDU on both client and server
  - SDU for a connection negotiated down to the lower of the two peers
- Increase SDU to 8k
  - Good default value for most users
- For bulk data transfer scenarios, increase to 64k
  - LOB transfers
  - XML DB
- Do not set to MTU value
  - SDU and MTU are independent



# Database Client Manageability

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## Introduction to Net Naming

- Descriptors can be mapped from a Connect Name

`sales = ← Connect Name`

`(DESCRIPTION=`

`(ADDRESS=(PROTOCOL=tcp)(HOST=sales-server)(PORT=1521))`

`(CONNECT_DATA=(SERVICE_NAME=sales))) ← Connect Descriptor`

- Naming Adapters map Name to Descriptor:
  - Local file: `tnsnames.ora`
  - Hostname based: Easy Connect
  - Directory: Oracle Internet Directory, Active Directory



## Easy Connect

- Simple, easy to use connect syntax for TCP/IP

```
[//]host[:port][ /service_name ][ :server ][ /instance_name ]
```

Example:        `sqlplus scott/tiger@sales-server/sales`

- Useful when no connect descriptor customization is necessary
- No need for any client side configuration files

```
sales-server/sales
```

is equivalent to

```
(DESCRIPTION=
  (ADDRESS=(PROTOCOL=tcp)(HOST=sales-server)(PORT=1521))
  (CONNECT_DATA=(SERVICE_NAME=sales)))
```



## Oracle Net 11g and Easy Connect

- Support for IPv6 hostnames and addresses
- Use URL syntax to specify IPv6 addresses

```
[2001:fe8::12]:1522/sales.us.example.com:dedicated/inst1
```

is equivalent to

```
(DESCRIPTION=
  (ADDRESS=(PROTOCOL=tcp)(HOST=2001:fe8::12)(PORT=1522))
  (CONNECT_DATA=(SERVICE_NAME=sales.us.example.com)
    (INSTANCE_NAME=inst1)
    (SERVER=dedicated)))
```



## Naming Recommendations

- Use Easy Connect whenever possible
- If Descriptors do not change often, use tnsnames.ora
  - Best for small deployments
  - TNS\_ADMIN can be on a shared file system
- If Descriptors change often or for large deployments, use a directory
  - Oracle Internet Directory
  - Active Directory on Windows
  - Enable authenticated binds if needed



**Database Client**  
**High-Availability**

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## Connection Establishment Timeouts

- Detect dead hosts faster
- Timeout for TCP connection establishment
  - TCP.CONNECT\_TIMEOUT – 11g feature
  - Enabled by default (60 seconds) in 11gR2
- Timeout for connection to a DB server process
  - SQLNET.OUTBOUND\_CONNECT\_TIMEOUT – 10gR2 feature
  - Set if session establishment takes a long time
- Configurable at connect string level
- Can be used individually or at the same time
  - Outbound Connect Timeout must be greater than TCP Timeout
- Option to enable connection retries





## Address and Description Lists

- Use client side load-balancing when using RAC

```
(DESCRIPTION=(ADDRESS_LIST=
  (LOAD_BALANCE=on)
  (ADDRESS=(PROTOCOL=tcp)(HOST=sales-1)(PORT=1521))
  (ADDRESS=(PROTOCOL=tcp)(HOST=sales-2)(PORT=1521))))
```

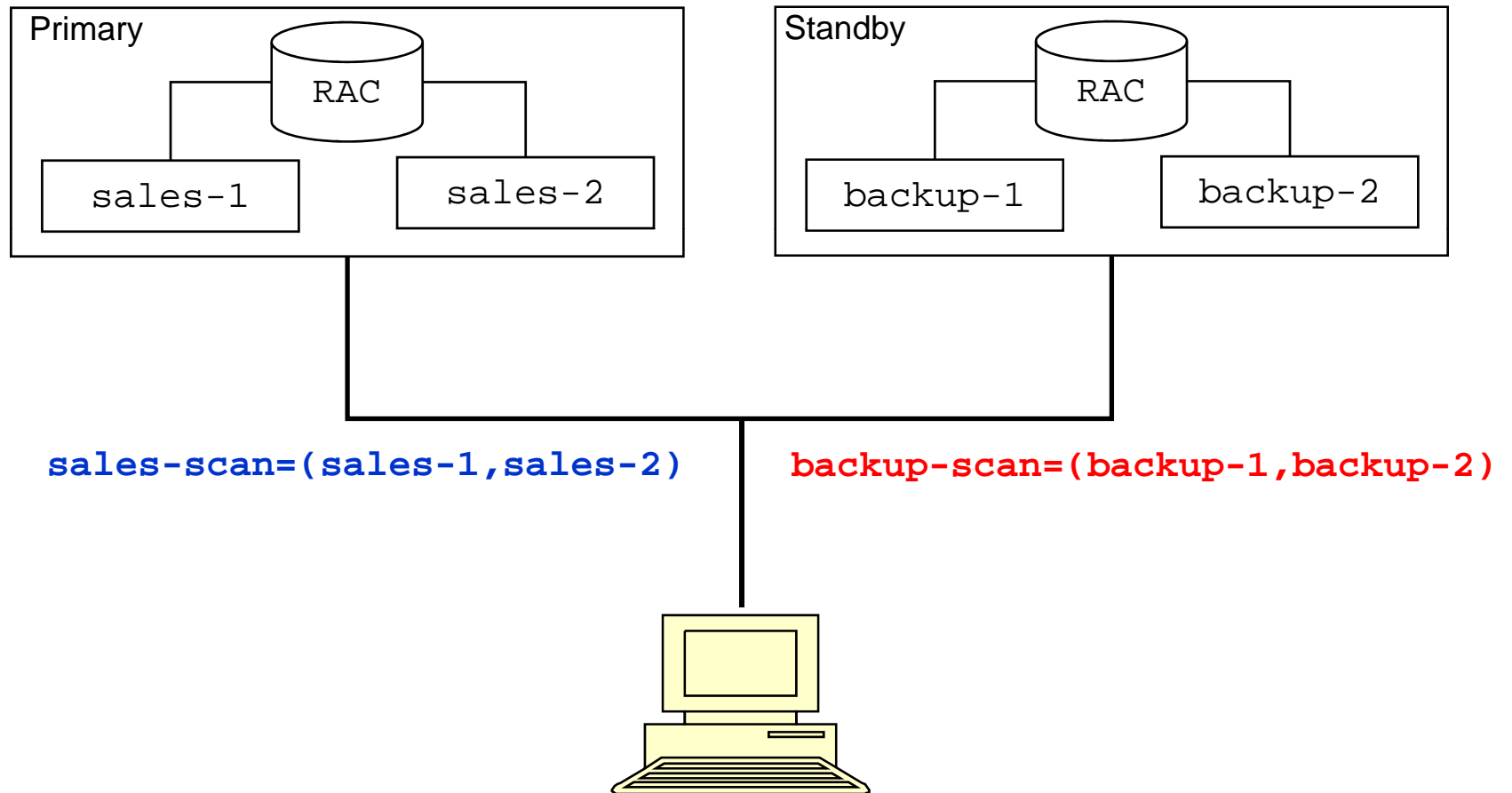
– Address to use picked at random

- Use Failover when using Dataguard

```
(DESCRIPTION_LIST =
  (LOAD_BALANCE=off)(FAILOVER=on)
  (DESCRIPTION = ...)
  (DESCRIPTION = ...))
```

- Usage not limited to RAC and Dataguard

# RAC + Data Guard Example





## The Optimal Connect Descriptor would be

```
(DESCRIPTION_LIST =  
  (LOAD_BALANCE=off) (FAILOVER=on)  
  (DESCRIPTION =  
    (LOAD_BALANCE=on)  
    (ADDRESS=(PROTOCOL=tcp) (HOST=sales-scan) (PORT=1521))  
    (CONNECT_DATA=(SERVICE_NAME=sales.example.com)))  
  (DESCRIPTION =  
    (LOAD_BALANCE=on)  
    (ADDRESS=(PROTOCOL=tcp) (HOST=backup-scan) (PORT=1521))  
    (CONNECT_DATA=(SERVICE_NAME=sales.example.com))))
```



## The Connect Descriptor internally expands to

```
(DESCRIPTION_LIST =  
  (LOAD_BALANCE=off) (FAILOVER=on)  
  (DESCRIPTION =  
    (ADDRESS_LIST=  
      (LOAD_BALANCE=on)  
      (ADDRESS=(PROTOCOL=tcp)(HOST=sales-1)(PORT=1521))  
      (ADDRESS=(PROTOCOL=tcp)(HOST=sales-2)(PORT=1521)))  
    (CONNECT_DATA=(SERVICE_NAME=sales.example.com)))  
  (DESCRIPTION =  
    (ADDRESS_LIST=  
      (LOAD_BALANCE=on)  
      (ADDRESS=(PROTOCOL=tcp)(HOST=backup-1)(PORT=1521))  
      (ADDRESS=(PROTOCOL=tcp)(HOST=backup-2)(PORT=1521)))  
    (CONNECT_DATA=(SERVICE_NAME=sales.example.com))))
```



## Fail-over for Connected Sessions

- Established client connections could hang when
  - Database host crashes
  - Remote Networks fail
- Detection of such failures could take a while
  - TCP behavior - timeouts in minutes
  - Depends on what the client does
- To catch such failures
  - Set a Receive Timeout
    - If your application is active and does not use long-running queries
  - Use Fast Application Notification (FAN)



## Thin-JDBC Tuning

- SDU passed through the connect string  
`"jdbc:oracle:thin:@(DESCRIPTION... (SDU=...)...)"`
- Connect Timeout set through property  
`oracle.net.CONNECT_TIMEOUT`
- Read Timeout set through  
`oracle.net.READ_TIMEOUT`
  - Note: Do not use as a query-timeout.
- For Query Timeout, use  
`Statement.cancel` or  
`Statement.setQueryTimeout`



# Net Listener

## Scalability. HA. Security.

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## What is the Net Listener?

- First process that clients talk to
- Brokers client requests, handing them off to service handlers
  - Dispatchers
  - Dedicated servers
  - Connection Broker – DRCP (11g)
- Receives load updates from the database
- Does server side load-balancing across instances in RAC
- Does server side failover across nodes in RAC
- Can listen on multiple end-points or protocol addresses
- Also supports other presentations – HTTP, FTP

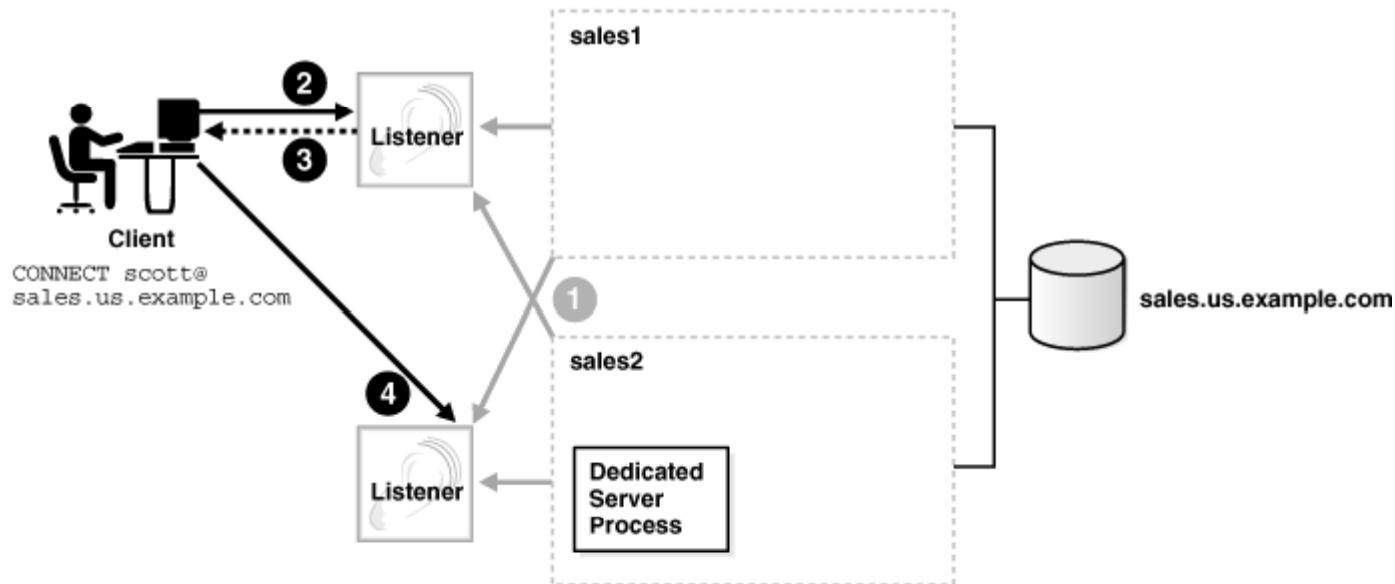




## Database Registration with Listener

- Use Dynamic Registration
  - PMON updates the listener about
    - Offered services and available service handlers
    - Load statistics – frequently updated
  - To configure, set in init.ora
    - LOCAL\_LISTENER: Address of listeners on local host
    - REMOTE\_LISTENER: Address of listeners on remote hosts
  - By default
    - PMON connects to listener on port 1521
    - Automatically setup with RAC
- Remove static SID\_LIST configuration in listener.ora
  - Keep only if you want to remotely start the database

# Server-side Load Balancing



- Change behavior by setting Connection Load Balancing Goal
  - Long – for applications with long-lived connections (default)
  - Short – for applications with short-lived connections



## Listener Logon Storm Handler

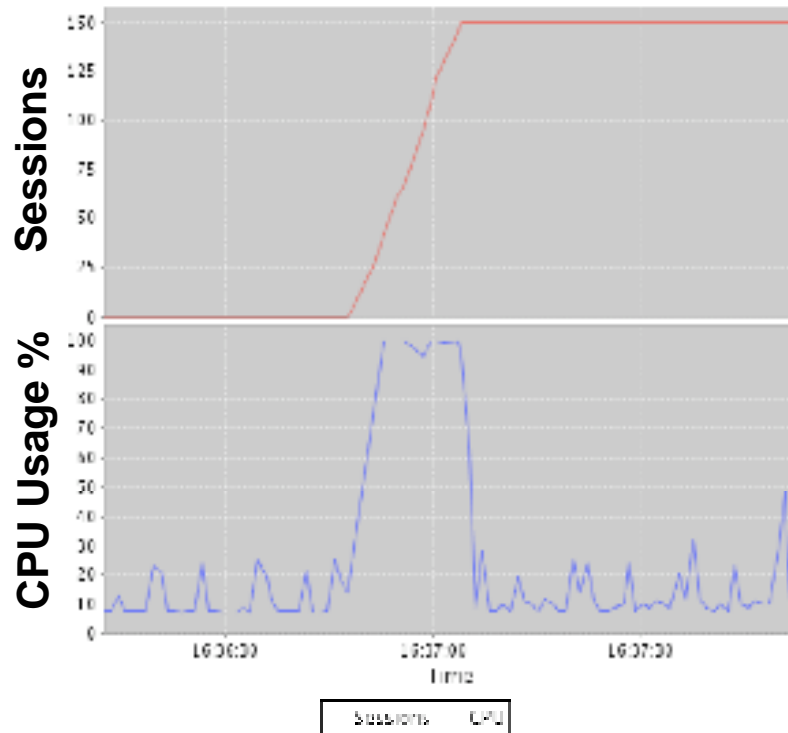
- Logon storm
  - Sudden spike in incoming connection rate
    - Normal – middle-tier reboot
    - Abnormal – DoS attack
  - Storms cause CPU starvation for existing sessions
- Enable the Connection Rate Limiter feature
  - Configure in LISTENER.ORA
  - Provides end-point level control of throttling

```
LISTENER=(ADDRESS_LIST=
  (ADDRESS=(PROTOCOL=tcp)(HOST=sales)(PORT=1521)(RATE_LIMIT=3))
  (ADDRESS=(PROTOCOL=tcp)(HOST=lmgmt)(PORT=1522)(RATE_LIMIT=no)))
```
  - Set the Rate Limit to a value that matches your machine capabilities

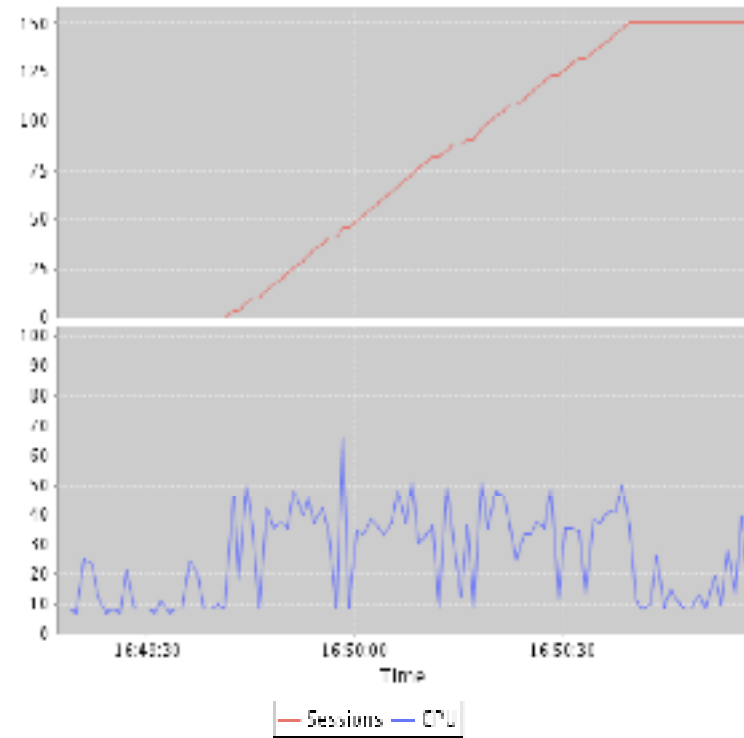
# Logon Storm Comparison

- 150 concurrent connections

RATE\_LIMIT = no



RATE\_LIMIT = 3/sec





## Other Best Practices

- Increase the maximum concurrent requests per end-point
  - QUEUESIZE parameter in listener.ora
  - Set to your expected Connection Request rate
  - Definitely set on Windows
- Do not set a listener password
  - Listener administration secure by default – OS User Authentication
- Optimize Environment variables for the oracle account
  - Longer the PATH, longer it takes to fork off the Oracle process
    - Ensure that PATH is small
    - Does not include any network shares
  - Cut down the number of environment variables



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**Scalability**

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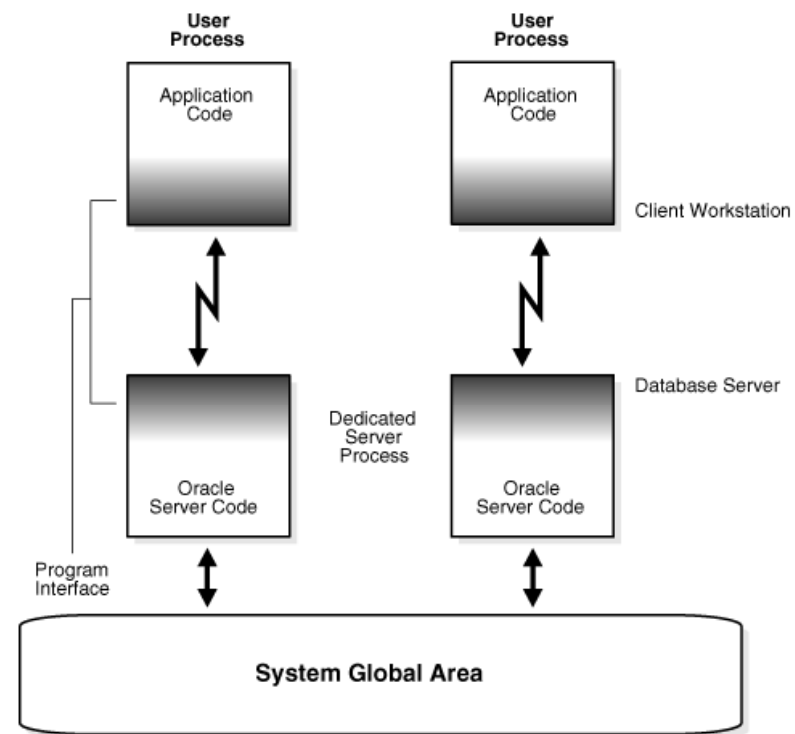


## Oracle Server Architecture Overview

- Choosing the right server architecture is critical to meeting scalability requirements
- Oracle Database Server supports three architectures
  - Dedicated Server (default)
  - Shared Server aka MTS
  - Database Resident Connection Pool (11g)

# Dedicated Servers

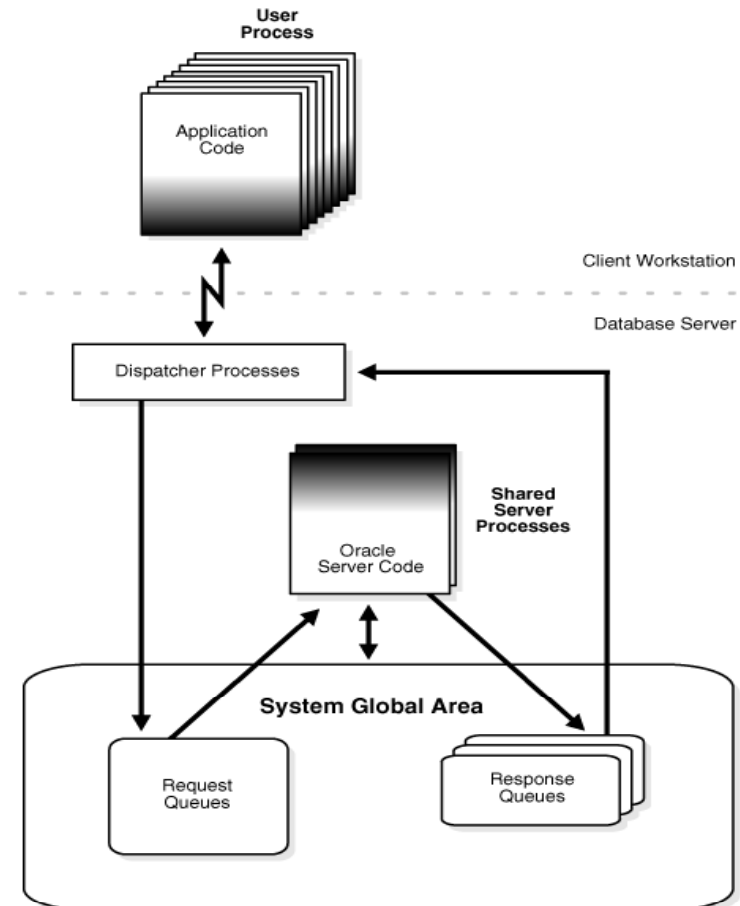
- Each client connection has its own process (thread on Windows)
- Dedicated process ensures lower latencies
- Have to start a new process on connect
- Have to tear down a process on disconnect
- Scalability limits
  - Memory
  - Number of Processes





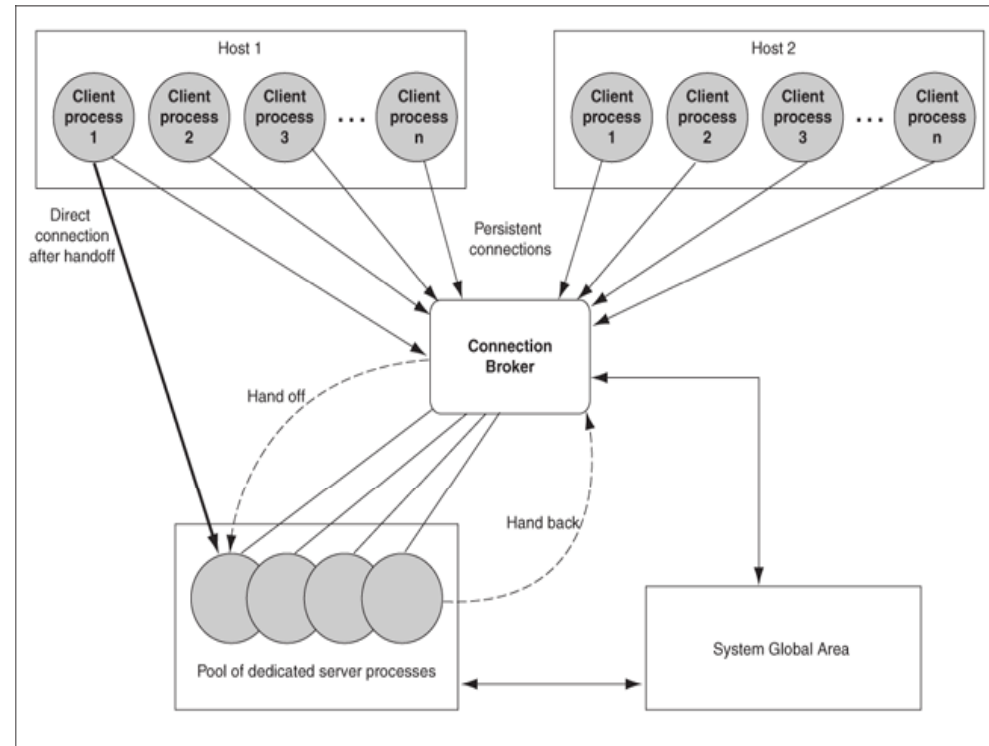
## Shared Servers (aka MTS)

- Each server handles multiple clients
- Dispatchers relay requests and responses between clients and servers
- Idle connections will not consume much memory
- Good for large number of connections with many idle
- Latency increase due to man-in-the-middle



## Database Resident Connection Pool (11g)

- Pooled dedicated servers shared across client systems and processes
- Low connect/disconnect costs
  - Server “locked” on connect
  - Server “released” on disconnect
- Low-latency performance of dedicated servers
- Extreme scalability with a DRCP-capable client driver





## Dedicated vs. Shared vs. DRCP

- Use dedicated for:
  - High-performance connections
  - Active, long-running, data transfer intensive operations
- Use shared for:
  - Sessions that may be idle for some time
  - Clients that frequently connect and disconnect
- Use DRCP (11g):
  - When you have thousands of clients which need access to a database server session for a short period of time
  - Applications mostly use same database credentials, and have identical session settings
  - PHP (OCI8 extension), Python (cx\_Oracle), Perl (DBI)



## Using Shared Servers

- Enable shared servers with init.ora parameters
  - Becomes new default
- To force server type, specify server type during connect
  - Dedicated:  
`sales-server/sales.us.example.com:dedicated`
  - Shared:  
`sales-server/sales.us.example.com:shared`
- Rough guidelines:
  - 20 or 30 Shared Servers per 500 sessions, then tune from there
  - 1 dispatcher for every 50-100 sessions
- Significant performance improvements in 11g



## Using DRCP

- Pooling is enabled by the DBA using

```
EXECUTE DBMS_CONNECTION_POOL.START_POOL  
      ( 'SYS_DEFAULT_CONNECTION_POOL' );
```

- Change connect string on client in tnsnames.ora:

```
(DESCRIPTION=  
  (ADDRESS=(PROTOCOL=tcp)(HOST=sales-server)(PORT=1521))  
  (CONNECT_DATA=(SERVICE_NAME=sales)(SERVER=pooled)))
```

- Can use Easy Connect syntax too

```
sqlplus joeuser@sales-server:1521/sales:POOLED
```

- In test environment, we were able to support more than 20,000 connections to a 2 GB Database Server
- <http://www.oracle.com/technology/tech/php/>



## Scalable Event Models

- Oracle uses the poll system call on most platforms
  - Poll does not scale well for more than 1000 connections
- Newer, more efficient polling methods now supported on some platforms
  - epoll on Linux – Kernel 2.6
  - /dev/poll on Solaris and HP-UX (11.2.0.1)
  - pollset on AIX (11.2.0.2)
  - other platforms (in the works)
- Excellent scalability for Shared servers and DRCP
- Enabled by default for DRCP
- To enable, set in server sqlnet.ora
  - USE\_ENHANCED\_POLL = on

A man in a dark suit, light blue shirt, and striped tie is sitting in a black office chair. He is gesturing with his right hand as if speaking. Behind him are several rows of server racks. The racks have perforated metal doors. The background is a blurred office setting with large windows.

# Database Server Security

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## Inbound Connect Timeouts

- Limits the time taken for a client to connect and authenticate
- `SQLNET.INBOUND_CONNECT_TIMEOUT`
  - Controls timeout for Database server processes
- `INBOUND_CONNECT_TIMEOUT_listener_name`
  - Controls timeout for the listener
- Available from 10gR1 onwards
- Default value of 60 seconds in 10gR2 and above
- Independent of client-side timeouts






## TCP Valid Node Checks

- Use TCP Invited Nodes
  - List of IPs or hostnames that are permitted to connect
- Use TCP Excluded Nodes
  - List of IPs or hostnames that are NOT permitted to connect
- Use CIDR notation and wildcard format for ease of configuration whenever possible
- Invited nodes takes precedence over excluded
- To enable, set in sqlnet.ora

```
VALIDNODE_CHECKING = YES
TCP.INVITED_NODES   = (hostname1, hostname2)
TCP.EXCLUDED_NODES  = (hostname3, hostname4)
```

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