Oracle Net Services 12c
Best Practices for Database Performance and Scalability

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Program Agenda

• Overview of Oracle Net
  – Why Optimize Oracle Net?

• Best Practices
  – Database Client
  – Listener and Connection Manager
  – Database Server

• Q/A
Oracle Net Overview

• Primary Communication Foundation for Oracle DB
• Also known as SQL*Net
• Oracle’s Family of Networking Features:
  – Oracle Net
  – Oracle Net Listener
  – Connection Manager
  – Configuration Tools
Why Optimize Oracle Net?

• High Availability
  – Better respond to database/host/network failures

• Network Scalability and Performance
  – Scale better with more client connections
  – Load-balance to improve application experience
  – Increase Network bandwidth utilization
  – Lower database CPU utilization

• 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
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Tuning the Socket Buffers

What is BDP?

- Bandwidth x Delay Product (BDP)
  - Amount of data on the “wire” at any given point in time
  - Default Operating System buffers do not hold enough data to fill the wire
  - For example,

\[
BDP = \left(\frac{40 \times 1000}{8 \text{ Kbytes/sec}}\right) \times 0.025 \text{ sec} \approx 128 \text{ Kbytes}
\]

HQ

40 Mbps, 25msec delay

Austin Data Center
Tuning the Socket Buffers

• Set send and receive socket buffer sizes using:
  – SEND_BUF_SIZE – OS send buffer size
  – RECV_BUF_SIZE – OS receive buffer size

• Set this size to accommodate the BDP (2x)

• Set on both the server and the client

• Large buffer sizes help
  – Application queue more data to the OS
  – Have more data on the wire
  – Better utilize available bandwidth
  – In WAN deployments

Where to configure?
Client: sqlnet.ora and/or tnsnames.ora or LDAP
Server: sqlnet.ora and listener.ora
Tuning the Session Data Unit

- Controls SQL*Net packet size
  - Default: 8K
  - Max: 2MB (12c), 64K (11.2), 32K (pre-11.2)

- 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

Where to configure?
Client: sqlnet.ora and/or tnsnames.ora or LDAP
Server: sqlnet.ora
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 (for pre-11g clients)
  – Good default value for most users
• For bulk data transfer scenarios, increase to 64k
  – Large array fetch
  – LOB transfers
  – XML DB
• Do not set to MTU value
  – SDU and MTU are independent
Connect-time Failover for Applications

Oracle Net Timeouts

• Connection establishment timeouts
  – Timeout for TCP connection establishment
    • TCP.CONNECT_TIMEOUT
    • Enabled by default to 60 seconds since 11gR2
  – Timeout for connection to a DB server process
    • SQLNET.OUTBOUND_CONNECT_TIMEOUT
    • 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 and retry delay

Where to configure?
Client: sqlnet.ora and/or tnsnames.ora or LDAP
Single Client Access Name (SCAN)

Easy Connect + Address List

- Available since 11gR2
- Single name for clients to access an Oracle Database in a cluster
- Configured during the installation of Grid Infrastructure
- Typically resolves to three IP addresses in the cluster, each associated with a SCAN Listener

For example, if DNS resolves sales-scan to {10.1.1.1, 10.1.1.2, 10.1.1.3}

sales-scan:10240/sales

is equivalent to

(DESCRIPTION=
  (ADDRESS_LIST=
    (ADDRESS=(PROTOCOL=tcp)
      (HOST=10.1.1.1) (PORT=10240))
    (ADDRESS=(PROTOCOL=tcp)
      (HOST=10.1.1.2) (PORT=10240))
    (ADDRESS=(PROTOCOL=tcp)
      (HOST=10.1.1.3) (PORT=10240)))
  (CONNECT_DATA=
    (SERVICE_NAME=sales)))
SCAN in Connect Descriptors

sales=

(DESCRIPTION=

 (ADDRESS_LIST=

  (LOAD_BALANCE=on)

Address=

  (PROTOCOL=tcp)

  (HOST=10.1.1.1)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.2)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.3)

  (PORT=10240))

  (CONNECT_DATA=

  (SERVICE_NAME=sales)))

sales-

 (DESCRIPTION=

  (ADDRESS_LIST=

  (LOAD_BALANCE=on)

Address=

  (PROTOCOL=tcp)

  (HOST=10.1.1.1)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.2)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.3)

  (PORT=10240))

  (CONNECT_DATA=

  (SERVICE_NAME=sales)))

sales-

 (DESCRIPTION=

  (ADDRESS_LIST=

  (LOAD_BALANCE=on)

Address=

  (PROTOCOL=tcp)

  (HOST=10.1.1.1)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.2)

  (PORT=10240))

  (ADDRESS=

  (PROTOCOL=tcp)

  (HOST=10.1.1.3)

  (PORT=10240))

  (CONNECT_DATA=

  (SERVICE_NAME=sales)))

sales-scan:

  10.1.1.1, 10.1.1.2, 10.1.1.3
Client-side Failover using Address and Description Lists

RAC + Data Guard Example

**Primary**
- RAC
  - sales-1
  - sales-2

**Standby**
- RAC
  - backup-1
  - backup-2

`sales-scan=(sales-1,sales-2)`

`backup-scan=(backup-1,backup-2)`
Connect Descriptor

(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

```sql
(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)
Configuration Example – JDBC App

• Connect Timeout set through property
  `oracle.net.CONNECT_TIMEOUT`

• Read Timeout set through
  `oracle.jdbc.ReadTimeout`
  – Note: Do not use as a query-timeout.

• For Query Timeout, use
  `Statement.cancel` or
  `Statement.setQueryTimeout`

• How to set properties?
  specify in code

  Code Example:
  ```java
  Properties prop = new Properties();
  prop.setProperty("user","scott");
  prop.setProperty("password","tiger");
  prop.setProperty("oracle.net.CONNECT_TIMEOUT","3000");
  prop.setProperty("oracle.jdbc.ReadTimeout","3000");
  Conn = (new oracle.jdbc.OracleDriver()).connect(url, prop);
  ```
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Database Service Availability and Load Balancing

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
• 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 Service Availability and Load Balancing

Database Registration with Listener

- Use Dynamic Registration
  - **LREG** (or **PMON** in pre-12c) 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
    - LREG 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

Where to configure?
Database parameter file
Database Service Availability and Load Balancing *(Example)*

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

Where to configure?
On server, using `srvctl` utility, or `DBMS_SERVICE` package
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
  – Provides end-point level control of throttling

\[
\text{LISTENER= (ADDRESS\_LIST=}
\begin{align*}
\quad & \ (ADDRESS=(PROTOCOL=tcp) (HOST=sales) (PORT=1521) (\text{RATE\_LIMIT=3})) \quad \\
\quad & \ (ADDRESS=(PROTOCOL=tcp) (HOST=lmgmt) (PORT=1522) (\text{RATE\_LIMIT=no}) )
\end{align*}
\]

  – Can also be set globally at the listener level
  – Set the Rate Limit to a value that matches your machine capabilities

Where to configure?
Server: listener.ora
Logon Storm Comparison

150 concurrent connections
Other Best Practices

• Increase the maximum concurrent requests per listener end-point
  – QUEUESIZE parameter in listener.ora
  – Max `listen()` backlog for TCP (operating system parameter)
  – Set to your expected Connection Request rate

• 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
Oracle Connection Manager (CMAN)

• Firewall Proxy aware of Oracle database services
  – Fully Transparent: no application changes required
  – Can be used to hide database subnet, including RAC re-directs, from clients
  – Provides network isolation for multi-tenant environments

• Supports all SQL*Net protocols as well as protocol conversion
  – Can be used as a bridge between IPv4 and IPv6 networks

• Provides access control to services based on configurable rule lists

• Auto-updates when new databases and services are added
Oracle Connection Manager
Access Control

Separate Application Servers

1. 10.10.1.1
2. 10.12.1.1
3. 10.14.1.1
4. 10.16.1.1

Service.tenant 1.pdb
Allowed IPs: 10.10.*

Service.tenant 3.pdb
Allowed IPs: 10.14.*

CMAN as Firewall Proxy
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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
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

- 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:
  – 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
  – OCI, OCCI, JDBC, 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 Shared Servers per 500 sessions, then tune from there
  – 1 dispatcher for every 250 sessions
Using DRCP

• Pooling is enabled by the DBA using

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

• Change connect string on client in tnsnames.ora:

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

• Can use Easy Connect syntax too

```sql
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 (11g)
Database Server Security
Inbound Connection 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
• Enabled by default to 60 seconds
• Independent of client-side timeouts

Where to configure?
Server: sqlnet.ora
listener.ora
Dead Connection Detection

- Used by server to detect outage of client nodes
  - Enabled using `sqlnet.expire_time`
- Legacy DCD feature uses Oracle Net probe packets
  - Relies on TCP send failures
  - Slower and has more overhead
- New DCD (12c)
  - Relies on TCP keep-alive
  - Efficient detection of dead clients
  - Avoids probe buffering or out-of-buffer issues
  - Maintains backwards compatibility with older clients

Where to configure?
Server: `sqlnet.ora`
Database Server Security
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

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

Where to configure?
Server: sqlnet.ora
For More Information

search.oracle.com

Oracle Net Services Product Overview

or

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