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Program Agenda

- Introduction
- Database Consolidation Strategies
- Consolidation Planning
- Consolidation Validation
- Capacity Planning: Advanced Use Cases
- Customer Experiences
Why Consolidate?

• Reduce complexity
  – Servers running standard configurations

• Improve efficiency
  – Drive up hardware utilization rates

• Lower costs
  – Hardware/Software
  – Energy and Floorspace

• Simplify maintenance
  – Fewer servers in fewer locations

• Better security
  – Smaller security perimeter
DB Consolidation Challenges

- What consolidation strategy to use?
- How to test the chosen consolidation strategy?
- Can the system handle peak workloads, can workloads co-exist together?
- How to minimize consolidation risk?
Database Consolidation Strategies
Server Consolidation
Consolidate Database in a VM

• Reasons for adoption
  • Simple to implement
  • Excellent isolation
  • Mixed workloads
  • As-is consolidation
  • Legacy support

• Potential concerns
  • Lower consolidation density
  • Lower ROI
  • Performance (latency)
  • Managing sprawl
  • Not suitable for all deployments
OS Consolidation

Consolidate Database on Shared OS Platform

• Reasons for adoption
  • Consolidation density
  • Good ROI
  • Performance
  • Supports any app

• Potential concerns
  • Requires OS standardization
  • Database only
Database Consolidation

Consolidate Schema in Shared Database

• Reasons for adoption
  • Efficient
  • Fast provisioning
  • Good ROI
  • Performance

• Potential concerns
  • App qualification required
  • Requires OS and DB standardization
  • Isolation
Next Generation Consolidation Technology
Pluggable Database

- Virtual databases with their own:
  - Schemas
  - Tablespaces
  - Data dictionary
  - Synonyms
  - Users
  - Roles
  - Services

- Ideal for consolidation
Pluggable Database Consolidation
Consolidate Database as Pluggable Database

• Reasons for adoption
  • Most efficient
  • Extremely fast provisioning
  • No application changes
  • Best ROI
  • Performance
  • Efficient memory use

• Potential concerns
  • Requires OS and DB standardization
  • Misbehaved PDB
# Summary

<table>
<thead>
<tr>
<th>Business Value</th>
<th>Server Consolidation</th>
<th>OS Consolidation</th>
<th>Schema Consolidation</th>
<th>Pluggable Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation</td>
<td>Easy</td>
<td>Easy</td>
<td>Difficult*</td>
<td>Easy</td>
</tr>
<tr>
<td>Isolation</td>
<td>Highest</td>
<td>High</td>
<td>Limited</td>
<td>High</td>
</tr>
<tr>
<td>Scalability</td>
<td>Limited</td>
<td>Limited</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Performance</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Resource mgmt</td>
<td>Fair</td>
<td>Fair</td>
<td>Limited</td>
<td>Excellent</td>
</tr>
<tr>
<td>Consolidation Density</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>ROI</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Highest</td>
</tr>
</tbody>
</table>

* Need to validate application schemas can co-exist
Consolidation Planning
Consolidation Suitability

- Applications have different workload profiles
- Multiple resources need to be analyzed
  - CPU
  - Memory
  - Storage
  - Network
Enterprise Manager Consolidation Planner

- Identifies under-utilized or over-utilized servers
- Helps administrator determine optimal solution for consolidation
- Works for physical and virtual environments
Consolidation Planner

• Leverages resource utilization and configuration data from Enterprise Manager repository
  – CPU, memory, storage, network
  – Over a representative period

• Administrator specifies servers and constraints for workload migration
  – Physical/virtual servers
  – Existing/planned servers
  – Business/technical constraints

• Detailed analysis on different scenarios of consolidated workloads
Consolidation Report

- Consolidation Scenario Report available after running analysis:
- Provides details on:
  - Consolidation ratio
  - Destination server utilization
  - Source to Target server mapping
  - Confidence of meeting requirements based on historical samples
  - Manually mapped consolidation constraint violations
  - Servers that cannot be consolidated (Exceptions)
Consolidation Migration
Consolidation Migration

• Server Consolidation
  – Use VM OS migration tools
  – Or do a fresh OS install and RMAN duplicate, replication or export import

• OS Consolidation
  – Use RMAN duplicate, replication or export import

• Schema Consolidation
  – Resolve name space clashes
  – Use schema level export import

• Pluggable Database
  – Pre-12c use transportable tablespace, RMAN duplicate, replication or export import
  – 12c and above – plug and unplug
Pluggable Database Migration
Consolidation of pre-12c Databases

- Provision empty PDBs per database that need to be consolidated
- Use datapump or replication to migrate a Database into a PDB
Pluggable Database Migration
Consolidation of 12c Databases

- Upgrade an existing pre-12c database to 12c
- Plug-in the database post upgrade into a CDB
Consolidation Validation
Consolidated Database Performance Testing

End-to-end testing with real workloads

<table>
<thead>
<tr>
<th>Consolidation Type</th>
<th>Tool</th>
<th>Performance Test</th>
</tr>
</thead>
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<tr>
<td>Server, OS, Schema, CDB</td>
<td>SQL Performance Analyzer</td>
<td>SQL unit testing for response time</td>
</tr>
<tr>
<td>Server, OS</td>
<td>Database Replay</td>
<td>Load, performance testing for throughput</td>
</tr>
<tr>
<td>Schema, CDB</td>
<td>Consolidated Database Replay</td>
<td>Replay multiple workloads against one database for throughput and scalability</td>
</tr>
</tbody>
</table>
SQL Performance Analyzer (SPA)

- Tests and predicts impact of system changes on SQL query performance
- Analyzes performance changes for improvements or regression
- Server, OS, CDB consolidation: run multiple SPA trials in parallel
- Schema Consolidation: merge SQL Tuning Sets, run trial
Consolidated SQL Performance Analyzer
Maximize ROI while Reducing Effort and Risk

- Validates SQL performance for consolidated database
- SQL workload captured for each database in STS
- SPA executes all workloads together in consolidated environment
- Identifies SQL regressions and helps remediate them

STS capture

Consolidate STS

Consolidated Database
Database Replay

- Database load and performance testing with real production workloads
  - Production workload characteristics such as timing, transaction dependency, think time, etc., fully maintained
- Test and measure transaction throughput improvements
- Identify application scalability and concurrency problems
- Use for server and OS consolidation
  - Capture individual workloads
  - Replay in parallel

Diagram:
- Production Clients
- Test Replay Driver
- Capture
- Process
- Replay
- Analysis & Reporting
Consolidated Database Replay

- Workload captured on different databases can be replayed concurrently
- Works for schema consolidation and Pluggable Databases
- Identify and remediate inter-application scalability and concurrency problems
- Allows scaleup, subsetting, scheduling of multiple workloads
- Use for schema and CDB consolidation
- Available for 11.2.0.2 and above, MOS Note: 1453789.1
Consolidated Database Replay

Production Systems

- DB1: Windows DB 10.2
- DB2: AIX DB 9.2.0.8
- DB3: HP-UX DB 11g

Directories:
- Capture 1: May: Month-end Close
- Capture 2: June 15: Daily Peak
- Capture 3: June 18: DW - ETL

Test System

- Replay on CDB OR Non-CDB

CDB – DB12c

Consolidated Replay Directory

Capture 1

Capture 2

Capture 3

Test System

Consolidated Replay Directory

Directories

Capture 1

Capture 2

Capture 3

Replay on CDB OR Non-CDB

Non-CDB (11.2.0.2+)

May: Month-end Close

June15: Daily Peak

June 18: DW - ETL

Directories

AIX

DB 9.2.0.8

HP-UX

DB 11g

Windows

DB 10.2

Production Systems

Capture 1

Capture 2

Capture 3

Directories

Datafiles

Control files

Redo Log files

root

Datafiles

MFG PDB

CRM PDB

HR PDB
Consolidated Database Replay

Container Database Support

- **Workload Capture**
  - Capture container database level
  - Capture filters *(include/exclude)* can specify multiple PDB targets by
    - PDB Name
    - Service Name

- **Workload Replay**
  - Multiple workload captures can be replayed against PDBs by re-mapping capture connections to services
EM Cloud Control 12c: Create Concurrent Capture Wizard Workflow
EM Cloud Control 12c: Create Concurrent Replay Task Page
EM Cloud Control 12c: Consolidated Database Replay - Summary Page

**Database Replay**

- **Target Database**: atlas.us.oracle.com
- **Database Version**: 12.1.0.6.2
- **Status**: Completed
- **Owner**: SYSMAN
- **Replay Duration (hh:mm:ss)**: 00:10:02
- **Replay Start Time**: Sep 10, 2012 3:40:59 PM (GMT-8:00) PST/PDT
- **Replay End Time**: Sep 10, 2012 3:51:01 PM (GMT-8:00) PST/PDT
- **Replay Error Code**: None
- **Replay Error Message**: None
- **Replay Host**: dc033j.us.oracle.com
- **Replay Directory Path**: /scratch/mmnias/replay
- **SQL Tuning Set Name**: REPLAY_TRIAL_CONS_r_5358761
- **Replay Job Name**: DBREPLAY_REPLAY_TRIAL_CONS_134731...

**Replay Statistics**

**Database Time (Minutes)**

- **Replay**: ERP_cap_1, CRM_cap_1, DW_cap_1
- **Capture**: ERP_cap_1, CRM_cap_1, DW_cap_1

**User Calls (Thousands)**

- **Replay**: ERP_cap_1, CRM_cap_1, DW_cap_1
- **Capture**: ERP_cap_1, CRM_cap_1, DW_cap_1
EM Cloud Control 12c: Consolidated Database Replay - Reports

ASH Analytics

Filters: Replay_TRIAL_CONS: replayed

Activity Load Map

Services

Show Total Activity CPU Cores

03:41PM 03:42PM 03:43PM 03:44PM 03:45PM 03:46PM 03:47PM 03:48PM 03:49PM 03:50PM

crm.us.oracle.com
erp.us.oracle.com
dw.us.oracle.com
When to Use Each Tool?

• SQL Performance Analyzer for all consolidation cases
  – Server, OS, Schema, CDB consolidation
  – Important to verify individual SQL perform well in new environment

• Database Replay
  – Server and OS consolidation
  – Verify target environment can handle consolidated load

• Consolidated Replay
  – Schema and CDB consolidation
  – New UI workflows simplify orchestration of load testing in new environment
Capacity Planning: Advanced Use Cases
Capacity Planning: Advanced Use Cases

• Will the consolidated system be able to handle future workload growth?

• Three use cases:
  – Time-shifting
  – Workload Folding
  – Schema Remapping
Peak Workload Testing Through Time-Shifting

- **Goal**
  - Exercise worst case scenario where workload peaks line up
  - Evaluate and experience fallout from the safety of a test system
Peak Workload Testing Through Time-Shifting

- Similar to consolidated replay, use parameters of add_capture() to create desired schedule for each workload to line-up peaks
- API example: To delay a workload replay 2 hrs from start of replay:
  - `exec select dbms_workload_replay.add_capture('cap2', 2* 60*60 ) from dual;`
Workload Folding

- High-Level Business Use Case
  - Your company expects 2X more SALES workload during holiday season and wants to test at this scale. CIO wants to make sure that the system being deployed can handle this workload without performance and stability issues

- Scale-up Scenario: Assumptions
  - Individual SALES transactions largely independent
  - Initial DB state not very crucial to recorded transactions

- Solution
  - Split a typical peak holiday 8h period into 2 workloads
  - Schedule the 2 workloads to run simultaneously
  - Restore the DB to the SCN at the beginning of capture. Second part of the workload will operate on earlier than strictly required versions of data.
  - For certain workloads this should be acceptable - mainly NEW sales are expected and some replay divergence is acceptable
Workload Folding

- Split workload into 2 subsets relative to capture start time, 0-24 hr capture
  - 8am-12pm
  - 12pm-16pm

- Schedule replay of the two workload subsets to start at the same time (no delay)
- Replay steps are the same as for consolidated replay previously covered
Scale-up with Schema Remapping

- Useful for scale-up testing when multiple instances of the same application are to be deployed
  - Adding a new LOB or geographical area
  - Multi-tenant applications
  - DB Schema As a Service
Scale-up With Schema Remapping

- Setup Test system with multiple schemas from the initial schema using any of the supported mechanisms (Data Pump, PDB migration, etc.)
- Copy workload multiple times into consolidated replay directory and remap users to different schemas to perform consolidated replay
- API support: Example: EXEC DBMS_WORKLOAD_REPLAY.SET_USER_MAPPING (1001, 'SALES', 'SALES01');
- This strategy can identify hardware, host bottlenecks, results in minimal divergence
Customer Experiences
Consolidated DB Replay in Oracle Database 11gR2

John Kanagaraj, PayPal
Speaker Qualifications

- Been working with Oracle Databases and UNIX for too many years 😊
- Author and Technical editor
- Frequent speaker at OOW, IOUG COLLABORATE and regional OUGs
- Oracle ACE
- Associate Editor, IOUG SELECT Journal
- Currently Database Engineer @ PayPal
- Loves to mentor new speakers & authors!
The Case for RAT – Covering your risk of change

- Technology changes/upgrades rapidly
  - Precipitated by DC moves, Capacity concerns, Hardware/Software EOL, Org changes, etc.

- Database Consolidation usually driven by
  - Cost: Many “miscellaneous” applications/DBs
    - Not just “hard” costs!
  - Server/DB sprawl: Optimistic/pessimistic models
    - Data Center/Power costs are significant

- Upgrade testing is essential… but hard to do
  - Load test prep, setup and execution is tedious
  - Load testing may not cover all scenarios

- Note: A chain is as weak as the weakest link
Consolidated Replay in 11.2.0.2

- Real Application Testing first available in Oracle DB 11.1.x
- Product maturity in Oracle Database 11gR2 – 11.2.0.2
- Consolidated Replay available in 11.2.0.2/0.3
- MOS Note 1453789.1 / Patch 13947480
  - Patch needs to be requested; conflicts to be resolved
- Useful for testing consolidation of multiple schemas into a single database – Now!!
  - Addresses DB/Server sprawl
  - Splices out “interesting” periods in long capture
  - Provides for multiple “what if” scenarios
  - Ability to “fold workload”
Use cases: Consolidated Replay in 11.2.0.2

• Consolidating schemas/databases
  – Understand application profiles: Trend from AWR and OS
  – For Oracle Service based connections, use data from DBA_HIST_SERV_STAT, DBA_HIST_SERVICE_WAIT_CLASS
  – Use Consolidated Replay to validate!

• Using a long capture / “Interesting” periods
  – Long captures => (Usually) required for better captures
  – But… a Replay is always at least as long as a Capture
  – Splicing out “interesting” periods in capture now possible

• “Folding” workload – Test scaling up Writes
  – Previous version scaled up Read queries only
  – Use two versions of same schema to double write workload
  – Flush out Redo Writer/Redo log writer rate and other issues
Best Practices: Consolidated Replay

- Understand your applications/schemas!
  - Load, Batch and access patterns
  - External/Internal application dependencies
- Backup source data just prior to capture
- Generate SQL Sets on source DB for SQL analysis
- Provide adequate disk space for capture files
- Provide realistic Test servers with DB Flashback
- Isolate the Test servers
- Run individual replays before consolidated replay
- Use SQL Performance Analyzer to fix regressing SQL
Hardware and Software

Engineered to Work Together