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Trouble-free Upgrade to Oracle Database 12c with Real Application Testing

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Program Agenda

- Oracle Database Upgrades
- Validating Upgrades with Real Application Testing
- Two Upgrade Use Cases:
  - Consolidation into Multi-Tenant
  - Database In-Memory
- Customer Stories

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Oracle Database Upgrades

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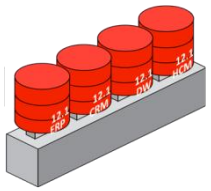
Why Upgrade to Database 12c?

- Database Consolidation to Multitenant
  - Ease management
  - Standardize on most recent version
  - Simplify future upgrades
- Database In-Memory
  - Real time analytics
- Migration to a new environment
  - Hardware / Software
- Take advantage of other new database features



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Validating Upgrades with Real Application Testing

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Database Upgrade Testing - Why

- Every customer has a unique environment
  - Hardware configuration
  - Application use of the database
- Upgrade testing in your environment provides validation of performance and correctness
  - Validates your unique hardware and software stack
  - Assures most important databases / applications perform to meet SLAs

Real Application Testing provides real-workload testing solution that is comprehensive & easy-to-use for system change assessment

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Real Application Testing – Two Complementary Solutions

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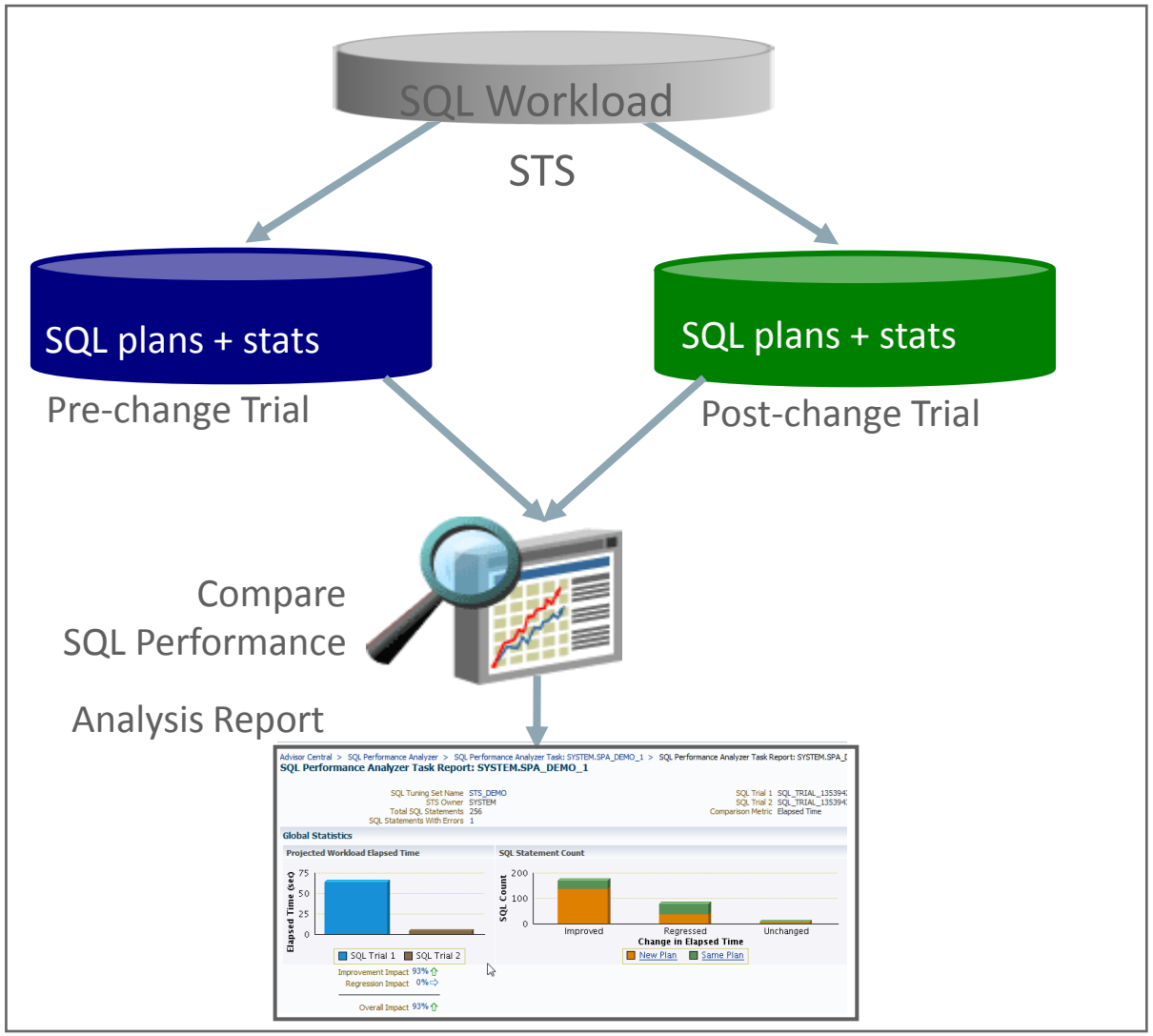
SQL Performance Analyzer

- Helps users predict the impact of system changes on SQL workload response time
- Low overhead capture of SQL workload to SQL Tuning Set (STS) on production system
- Build different SQL trials (experiments) of SQL statements performance by test execution
- Analyzes performance differences
- Offers fine-grained performance analysis on individual SQL
- Integrated with STS, SQL Plan Baselines, & SQL Tuning Advisor to form an end-to-end solution



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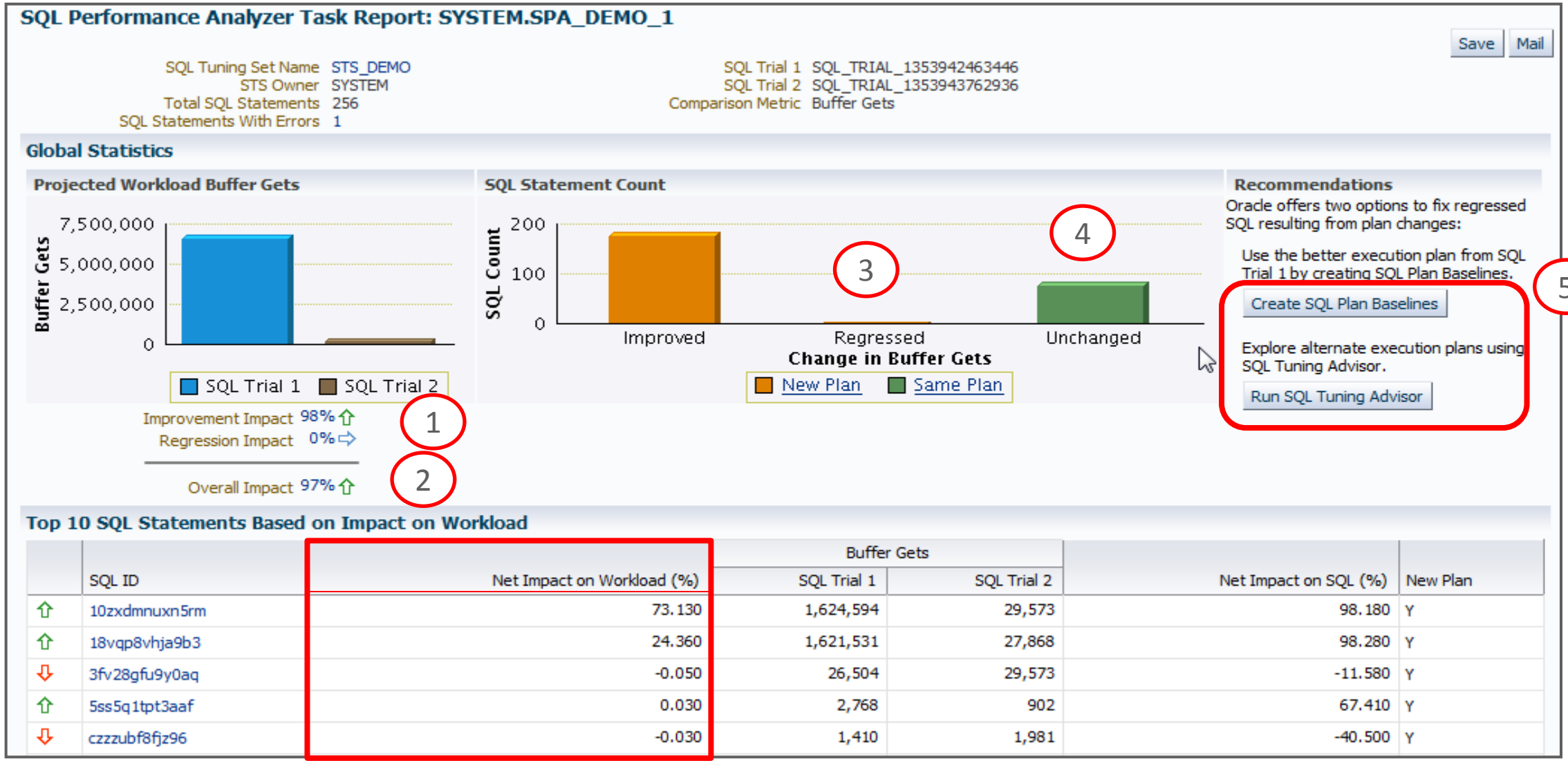
SPA Report



	SQL ID	Net Impact on Workload (%)	Buffer Gets		Net Impact on SQL (%)	New Plan
			SQL Trial 1	SQL Trial 2		
⇧	10zxdmnuxn5rm	73.130	1,624,594	29,573	98.180	Y
⇧	18vqp8vhja9b3	24.360	1,621,531	27,868	98.280	Y
⇩	3fv28gfu9y0aq	-0.050	26,504	29,573	-11.580	Y
⇧	5ss5q1tpt3aaf	0.030	2,768	902	67.410	Y
⇩	czzzubf8fjz96	-0.030	1,410	1,981	-40.500	Y

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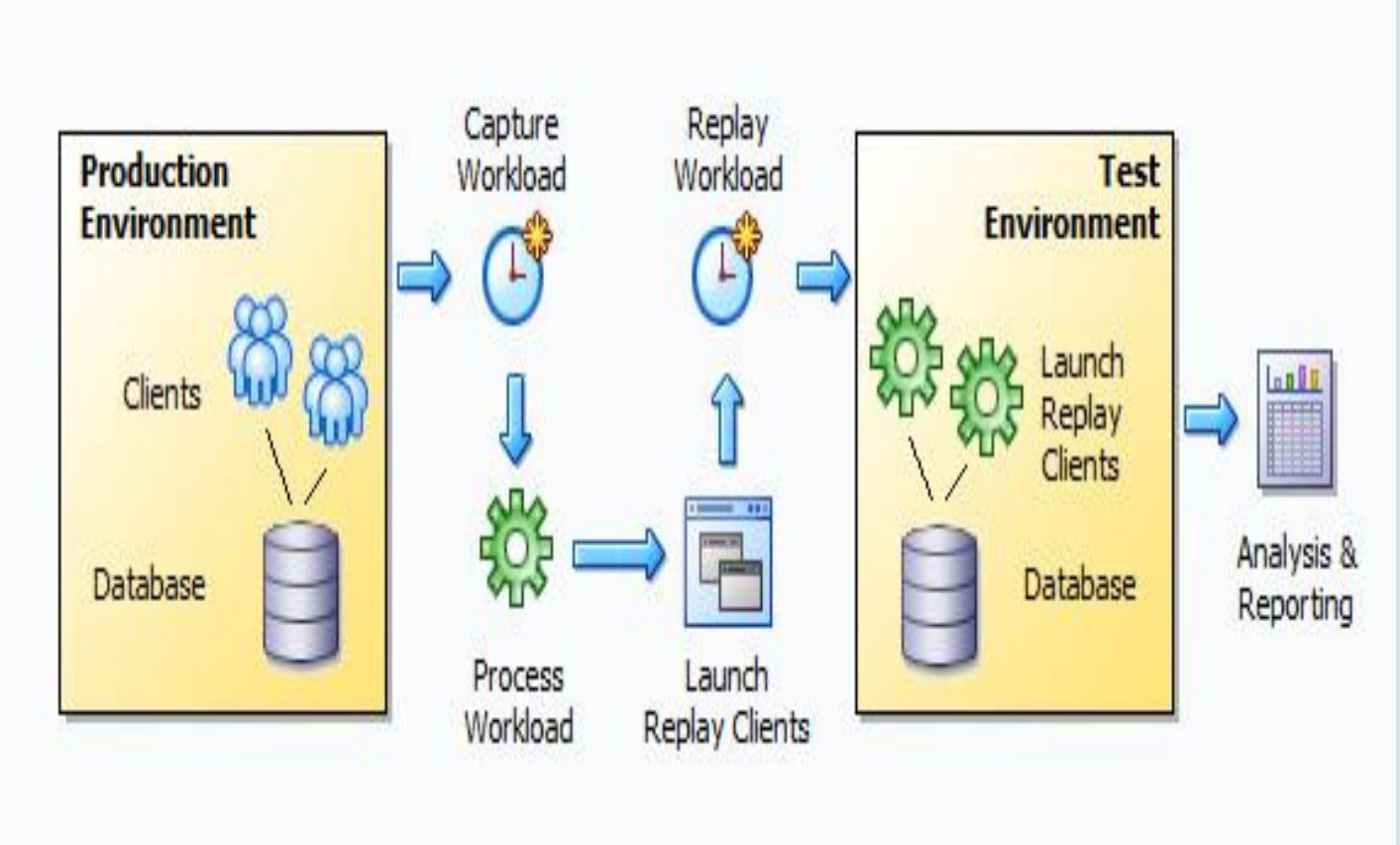
Database Replay

- Database load and performance testing with real production workloads
  - Production workload characteristics such as timing, transaction dependency, think time, etc., fully maintained
- Identify and remediate application scalability and concurrency problems in multitenant and non-CDB databases
- Allows scheduling, scaleup, subsetting, of multiple workloads
- Concurrent database replay available for 11.2.0.2 and above, MOS Note: 1453789.1



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Database Upgrade Testing Best Practices

- Always use SPA first
  - Unit test before load test
- Capture and replay a manageable amount of time – e.g. 1 to 2 hours
- Key metric for Database Replay is DB Time
- Capture SQL Tuning Sets during capture and replay for additional validation
- Use Enterprise Manager 12c with the latest DB Plugin
  - Implements best practices
  - Wizards guide you through the capture and replay process
  - Long term repository for storing and analyzing test results

Check MOS Note 560977.1 for recommended patch bundles

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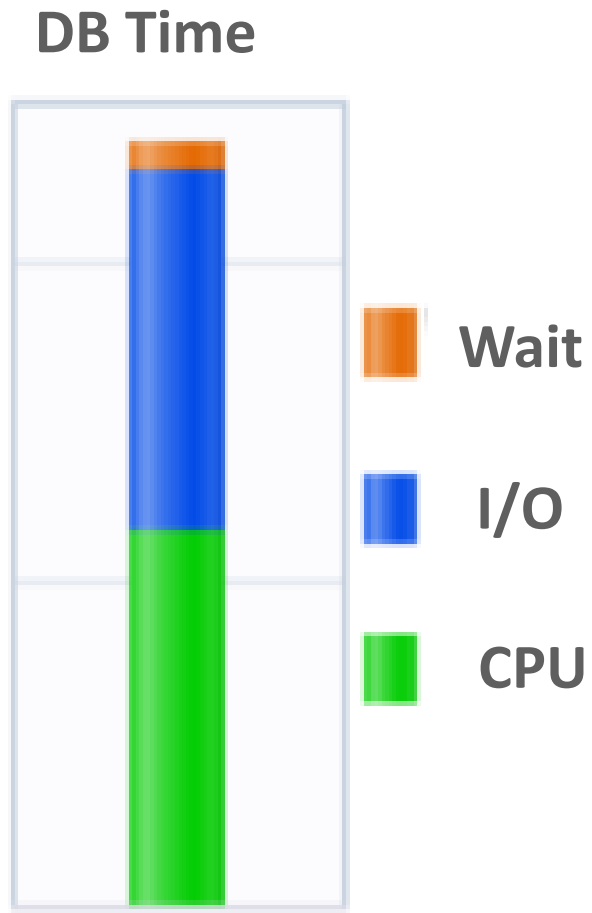
DB Time Definition

- Total time in database calls by foreground sessions
- Includes
  - CPU time
  - IO time
  - Active wait (non-idle wait) time
- Basic unit for Oracle performance analysis



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Database Consolidation Into Multitenant

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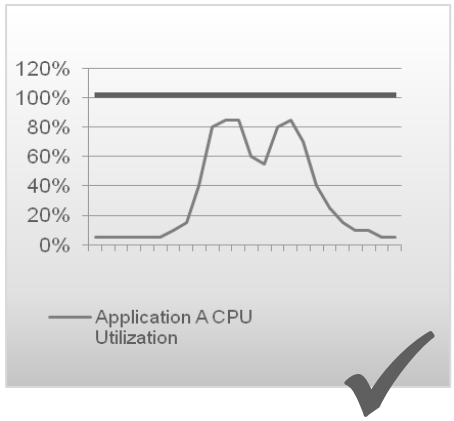
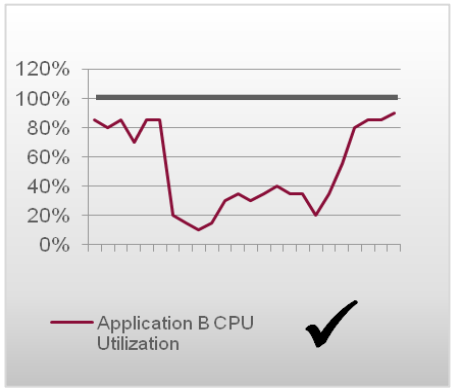
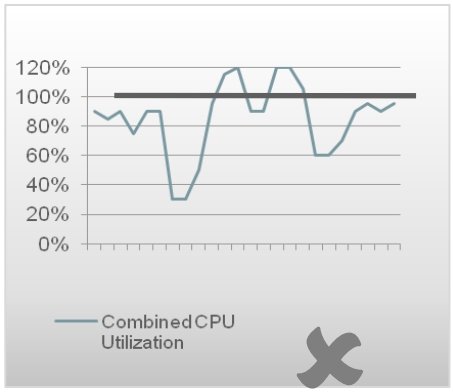
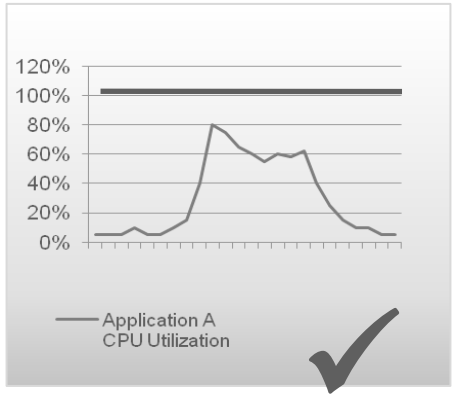
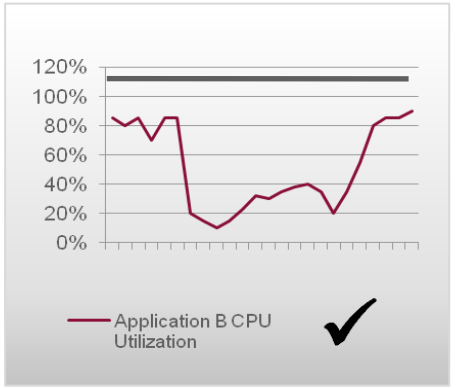
Database Workload Compatibility: Challenges

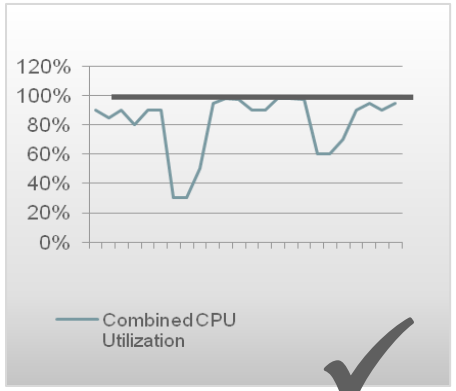












- Applications have different workload profiles
  - CPU
  - Memory
  - Storage
  - Network
- Will my Multitenant database handle peak workloads and co-exist?
- Is there enough headroom?
- How do I minimize risk?
- Use Real Application Testing to assess Multitenant workload compatibility and conduct capacity planning

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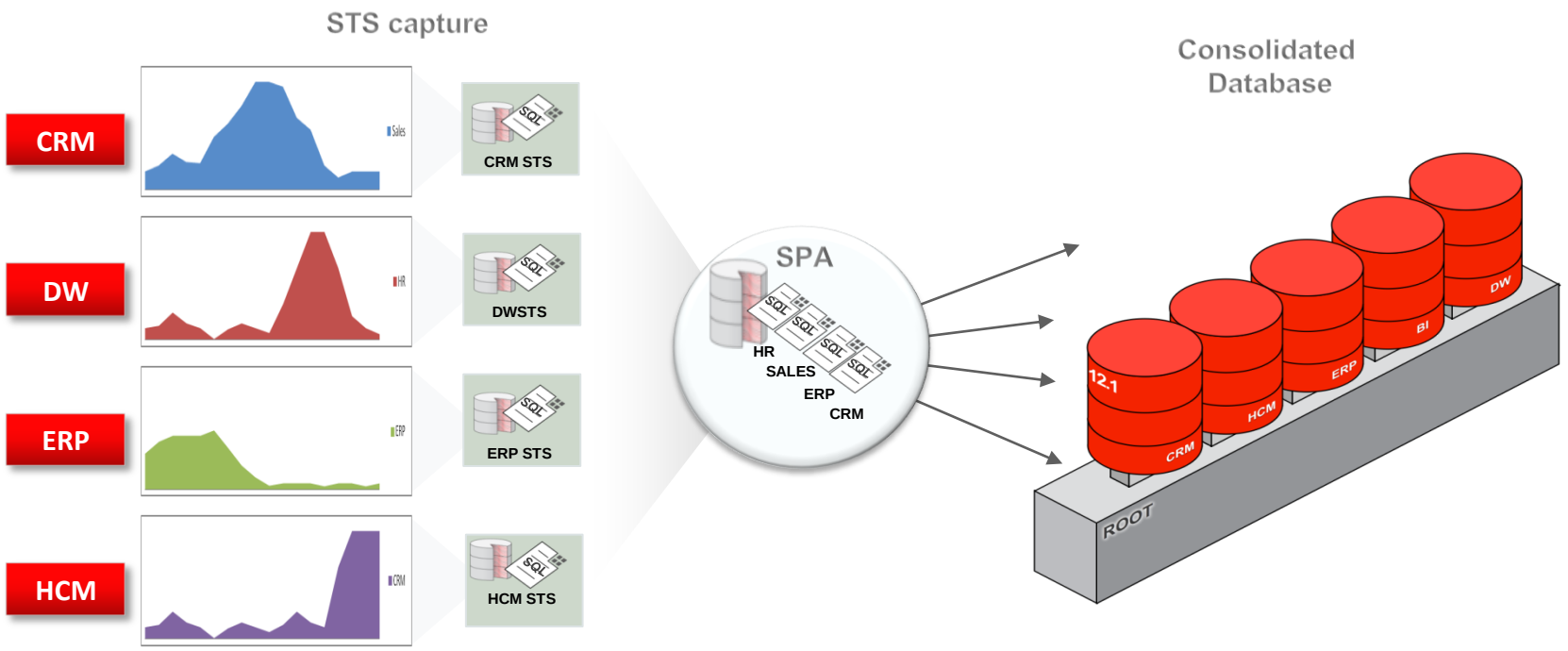
Using SPA in Multitenant Environment



Validate SQL performance for consolidated database:

- Capture SQL workload for each database in STS
- Execute SPA for all workloads together in consolidated environment
- Identify errors & SQL regressions
- Review response time
- Remediate

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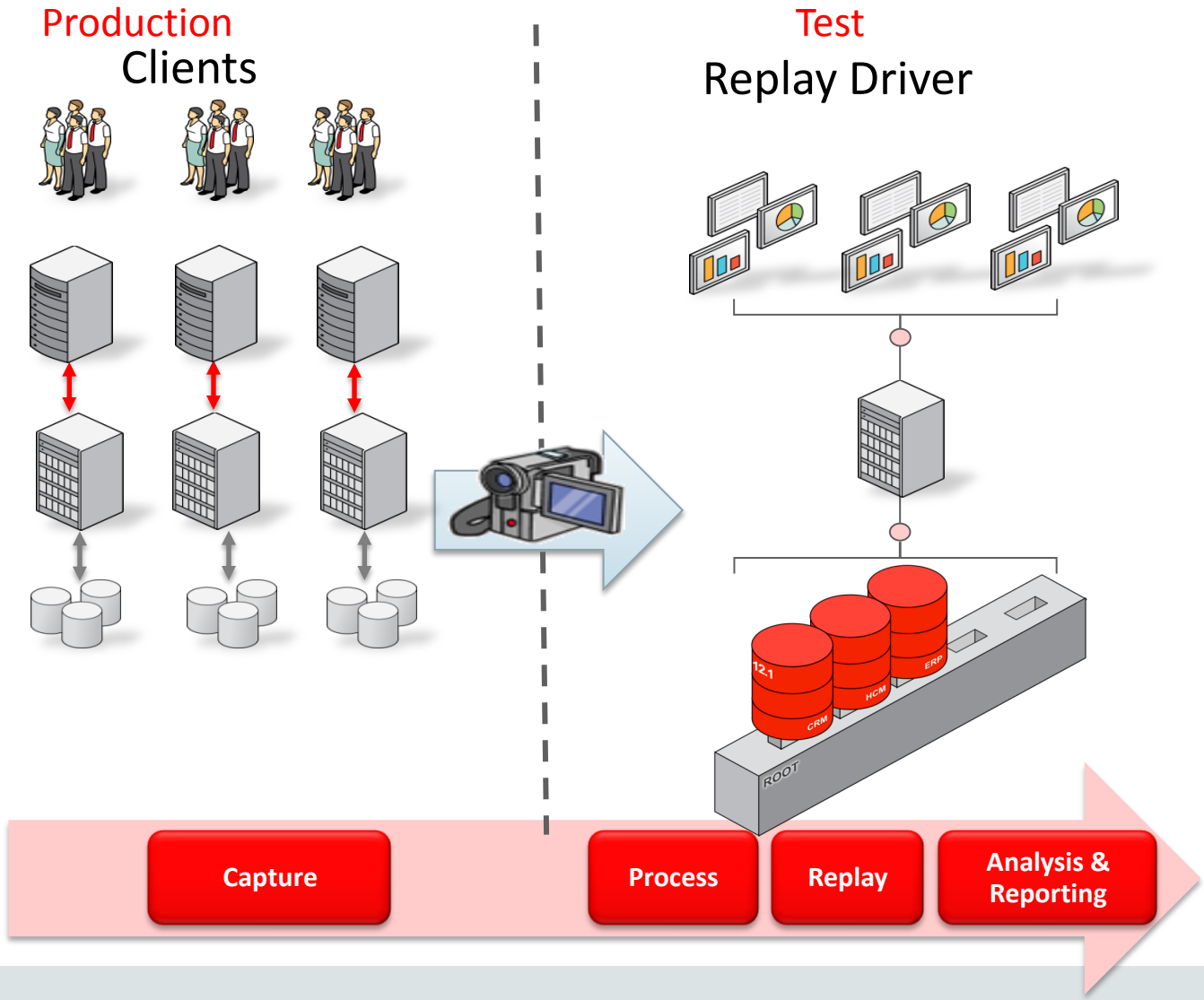
Multitenant Load Testing: Use Consolidated DB Replay

- Capture workload on different databases that needs to co-exists concurrently
- Works for schema consolidation and Pluggable Databases
- Use scaleup, subsetting, scheduling of multiple workloads
- Use for schema and CDB consolidation
- Identify and remediate inter-application scalability and concurrency problems
- Available for 11.2.0.2 and above, MOS Note: 1453789.1



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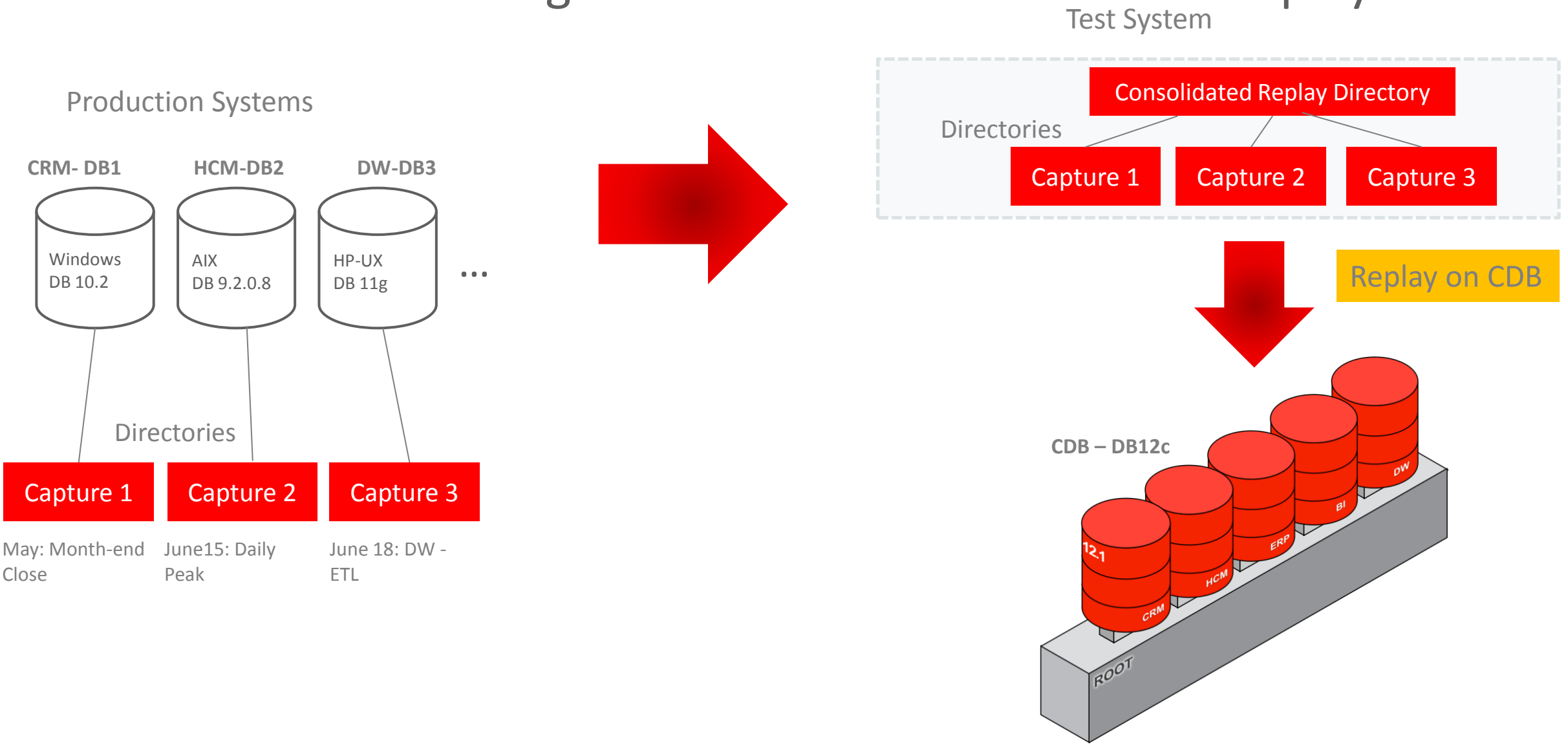
Multitenant Load Testing: Use Consolidated Database Replay



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How to Test For Consolidation

- If consolidating a few databases
  - Use SPA
  - Use Consolidated Replay
- If consolidating a large number of databases
  - Identify databases with similar workload profiles
  - Categorize them into small, medium and large
  - Scale up each category with workload scheduling and Consolidated Replay

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Use Case Example

- Move to new platform and consolidate to multitenant database

Production
2 Nodes with 2 CPUs, 8 GB Memory

Capture SQL Tuning Sets on each database → Capture Workload on each database with Database Replay

Target
1 Node, 4 CPU, 16 GB Memory

Upgrade Database to 12c → Configure PDBs → Run SPA Test → Run Database Replay

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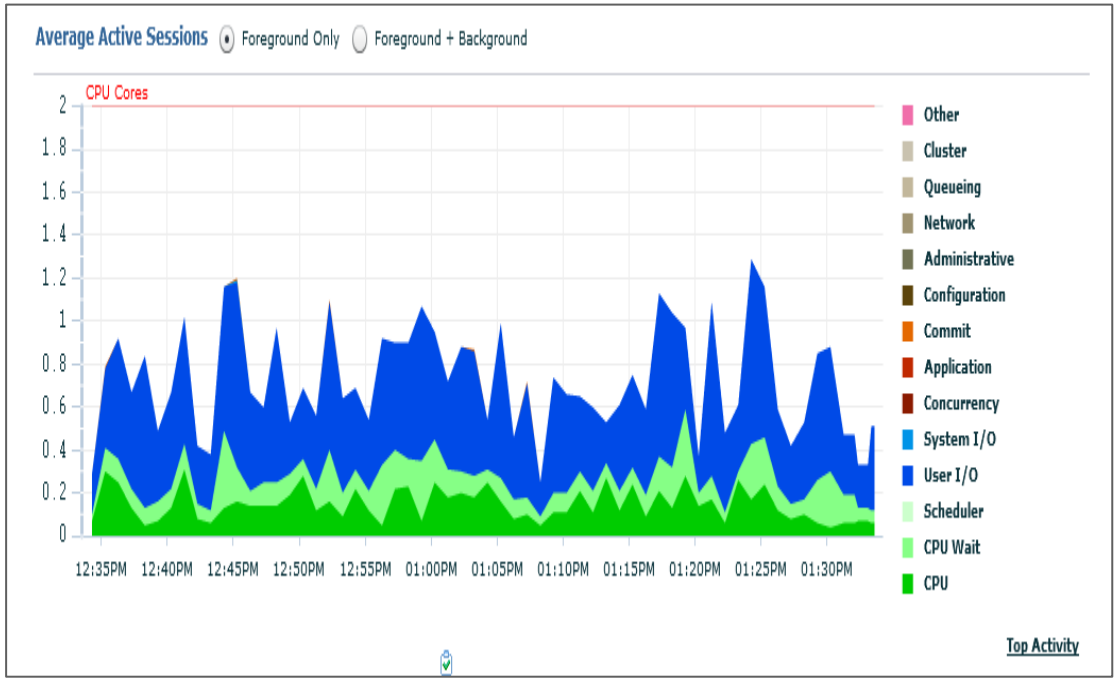
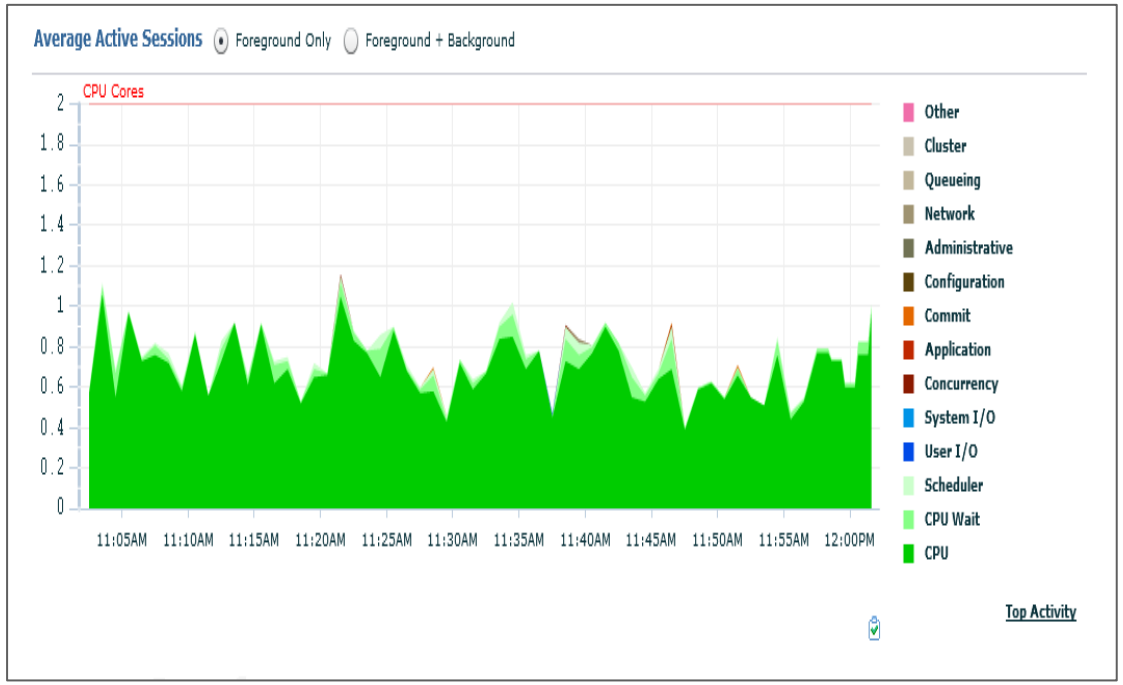
Capture Production Workload

Database 1



Database 2



- Capture SQL for each database into SQL Tuning Sets for SPA test
- Capture workloads for Database Replay

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On Test System

- Install Database 12c with Multitenant configuration
- Restore production backups into individual PDBs and run upgrade scripts
- Run SPA
  - Convert captured production STS into trial 1
  - Execute SPA trial 2 on each PDB
  - Evaluate results
  - Remediate any regressions before database replay

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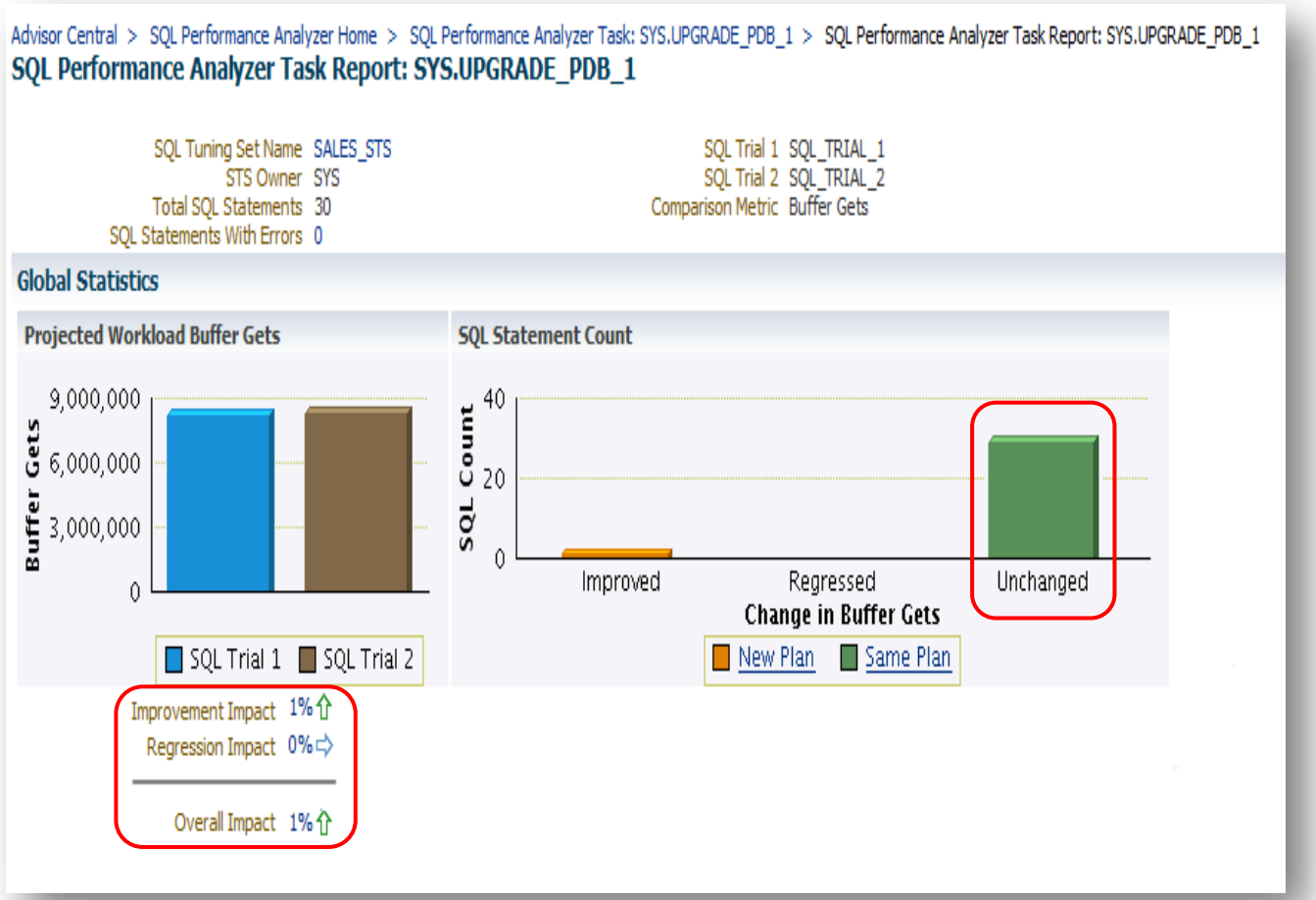
Consolidated Database SPA - Execution Plans Unchanged



- For consolidation into multitenant, most SQL should have unchanged execution plan
- For OLTP workload- ‘Buffer Gets’ is best metric
- Most SQL also have unchanged performance

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Test System – Consolidated Replay

- Execute Consolidated Replay on test system
  - Remap captured TNS connections to individuals PDBs
  - Run Consolidated Replay
  - Evaluate results

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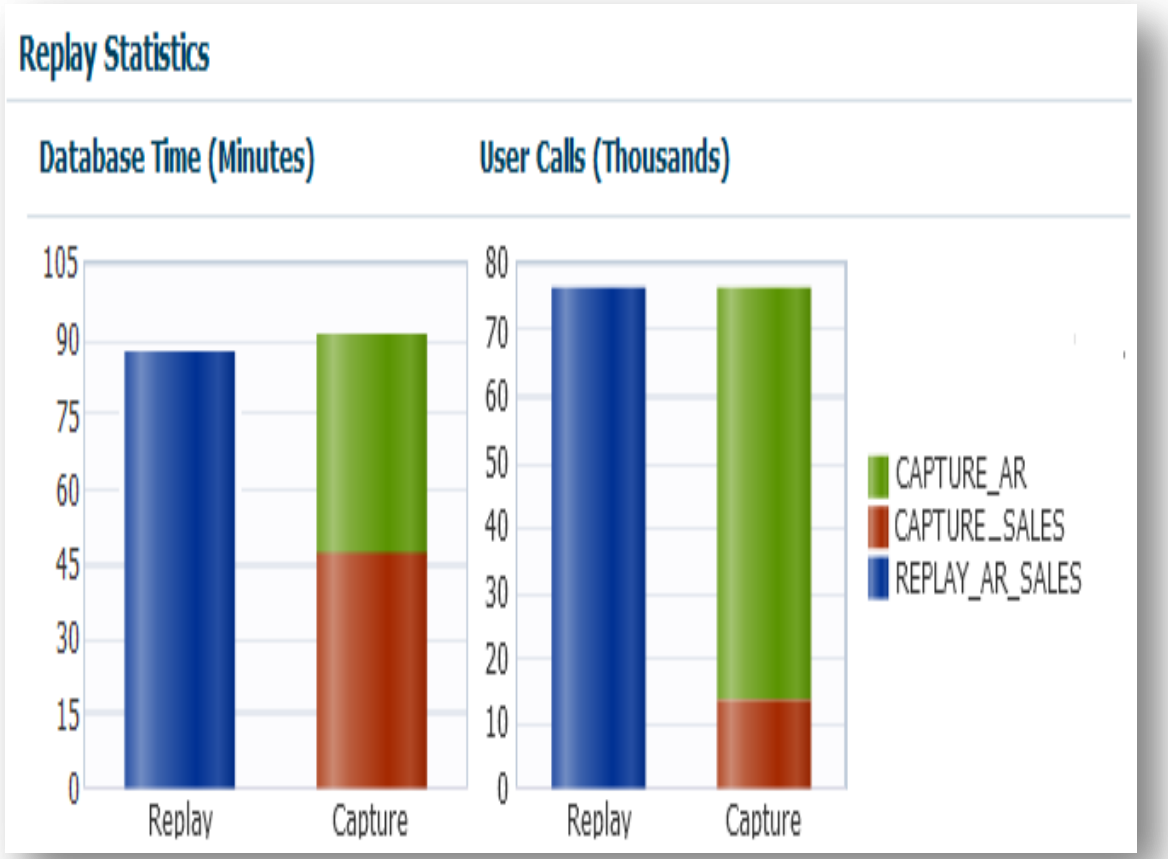
Consolidated Database Replay Result



- Replay ‘user calls’ identical to capture – same amount of database work was done
- DB Time slightly reduced
- Conclusion: Upgraded and consolidated database performance matches source ✓

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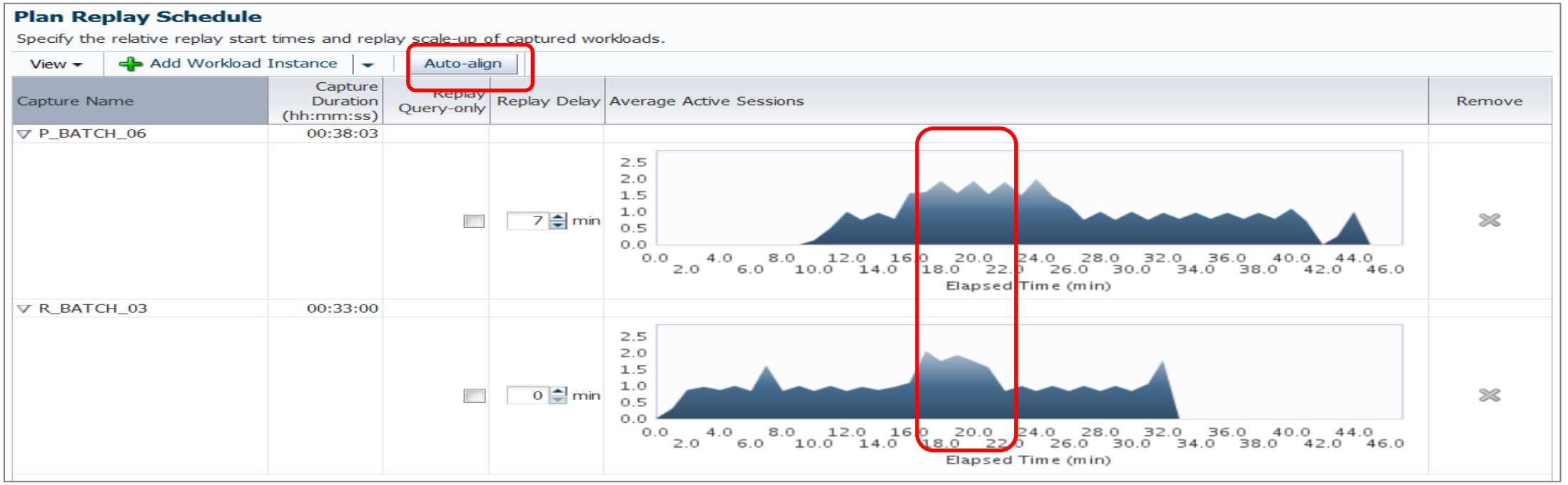
Stress Test with Workload Scheduling



- Consolidated Database Replay also includes workload scheduling
- Workload peaks can be aligned to maximize stress on replay system

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Upgrading to Database In-Memory

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Oracle Database In-Memory

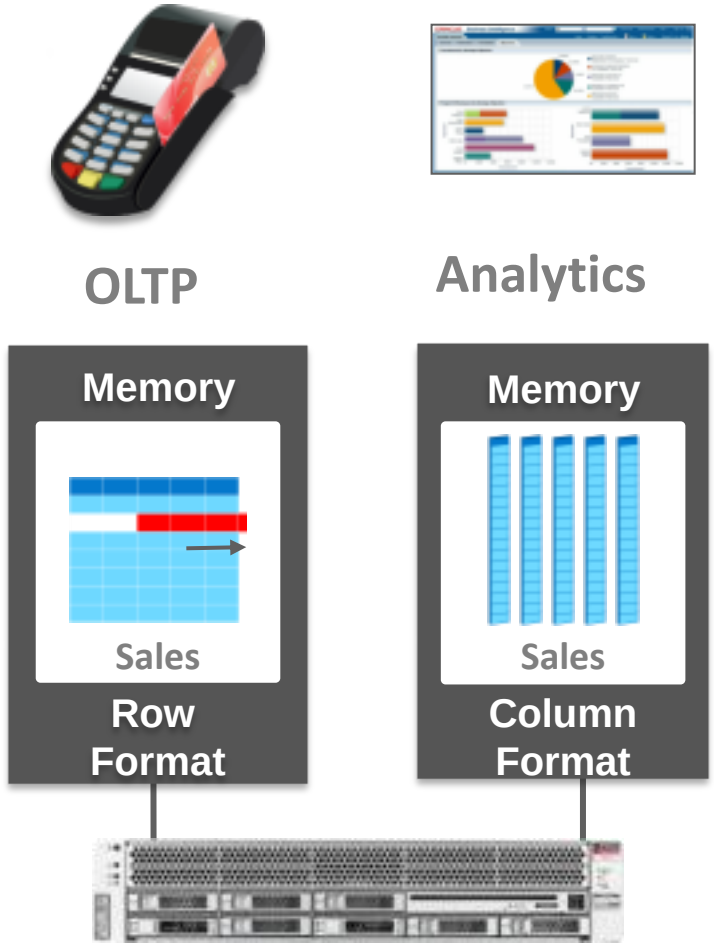
Unique Dual-Format Architecture

Up-to-date analytics

Both row and column in-memory formats

Simultaneously active and transactionally consistent ensuring access to freshest data

Eliminates manual tuning and expensive analytic indexes



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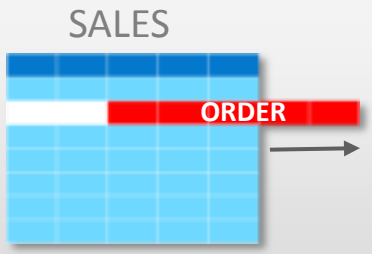
Optimizing Transaction and Query Performance

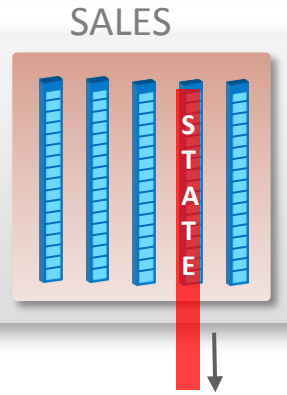
Row Format Databases versus Column Format Databases

Row



- **Transactions run faster on row format**
  - Insert or query a sales order
  - Fast processing few rows, many columns

Column



- **Analytics run faster on column format**
  - Report on sales totals by state
  - Fast accessing few columns, many rows

Oracle 12c: Stores Data in Both Formats Simultaneously

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Simple Implementation

1. Upgrade to database 12.1.0.2 (or higher)
2. Configure Memory Capacity
   - inmemory_size = XXX GB
3. Configure tables or partitions to be in memory
   - alter table | partition … inmemory;
4. Drop analytic indexes to speed up OLTP

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Use Case Example

- Upgrade to database 12.1.0.2 and Database In-Memory

Production

Run In-Memory Advisor → Capture SQL Tuning Set → Capture Workload with Database Replay

Test

Upgrade Database to 12c → Configure Database In-Memory Using Advisor Output → Run SPA Test → Run Database Replay

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Upgrade and Testing Steps

- Run Database In-Memory Advisor in existing database 11.2 environment
- Capture SQL Tuning Set
- Capture workload with Database Replay
- In test environment
  - Upgrade database and implement Database In-Memory Advisor recommendations
  - Run SPA trial
  - Run Database Replay
  - Evaluate results

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Run Oracle Database In-Memory Advisor

Object Type	Object	Estimated In-Memory Size	Estimated Analytic Performance Improvement
Table	SALES.ORDERS	2.19 GB	9.3X
Table	SALES.LINEITEM	1.03 GB	5.2X
Partition	SALES.PRODUCTS.201404	415 MB	4.3X
Sub-partition	SALES.PRODUCTS.20140330	200 MB	2.7X

- New In-Memory Advisor
- Analyzes existing DB workload via AWR & ASH repositories
- Provides list of objects that would benefit most from being populated into IM column store
- Works on database versions 11.2 and above

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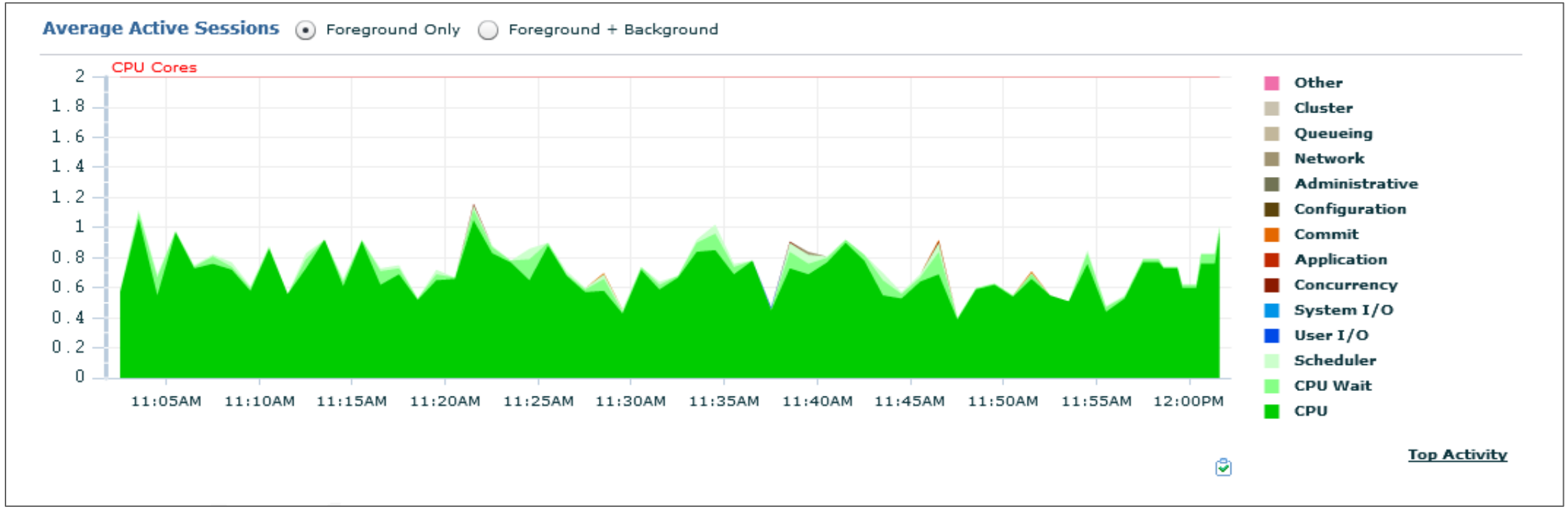
Capture Production Workload



- Capture SQL into a SQL Tuning Set
- Capture workload for Database Replay

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Configure In-Memory on Test System

- Restore production database
- Upgrade to database 12.1.02 or higher
- Set init.ora parameter **inmemory_size** to size In-Memory column store
- Restart database
- Execute SQL script from In-Memory Advisor to configure objects In-Memory

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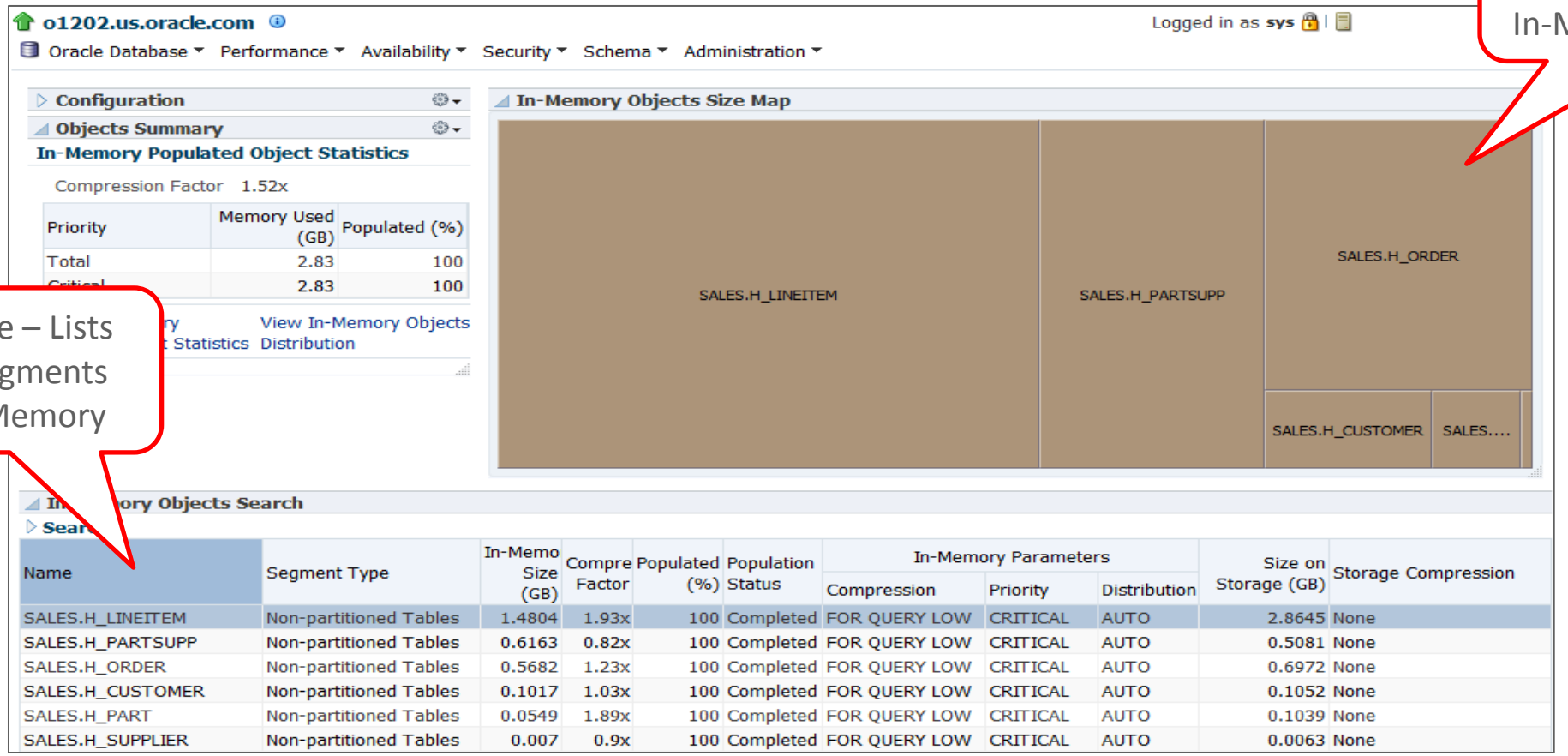
Validate In-Memory Configuration

Enterprise Manger 12c In-Memory Central

Object map – displays relative sizes of objects In-Memory

Object Table – Lists details of segments loaded In-Memory



Name	Segment Type	In-Memo Size (GB)	Compre Factor	Populated (%)	Population Status	In-Memory Parameters			Size on Storage (GB)	Storage Compression
						Compression	Priority	Distribution		
SALES.H_LINEITEM	Non-partitioned Tables	1.4804	1.93x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	2.8645	None
SALES.H_PARTSUPP	Non-partitioned Tables	0.6163	0.82x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	0.5081	None
SALES.H_ORDER	Non-partitioned Tables	0.5682	1.23x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	0.6972	None
SALES.H_CUSTOMER	Non-partitioned Tables	0.1017	1.03x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	0.1052	None
SALES.H_PART	Non-partitioned Tables	0.0549	1.89x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	0.1039	None
SALES.H_SUPPLIER	Non-partitioned Tables	0.007	0.9x	100	Completed	FOR QUERY LOW	CRITICAL	AUTO	0.0063	None

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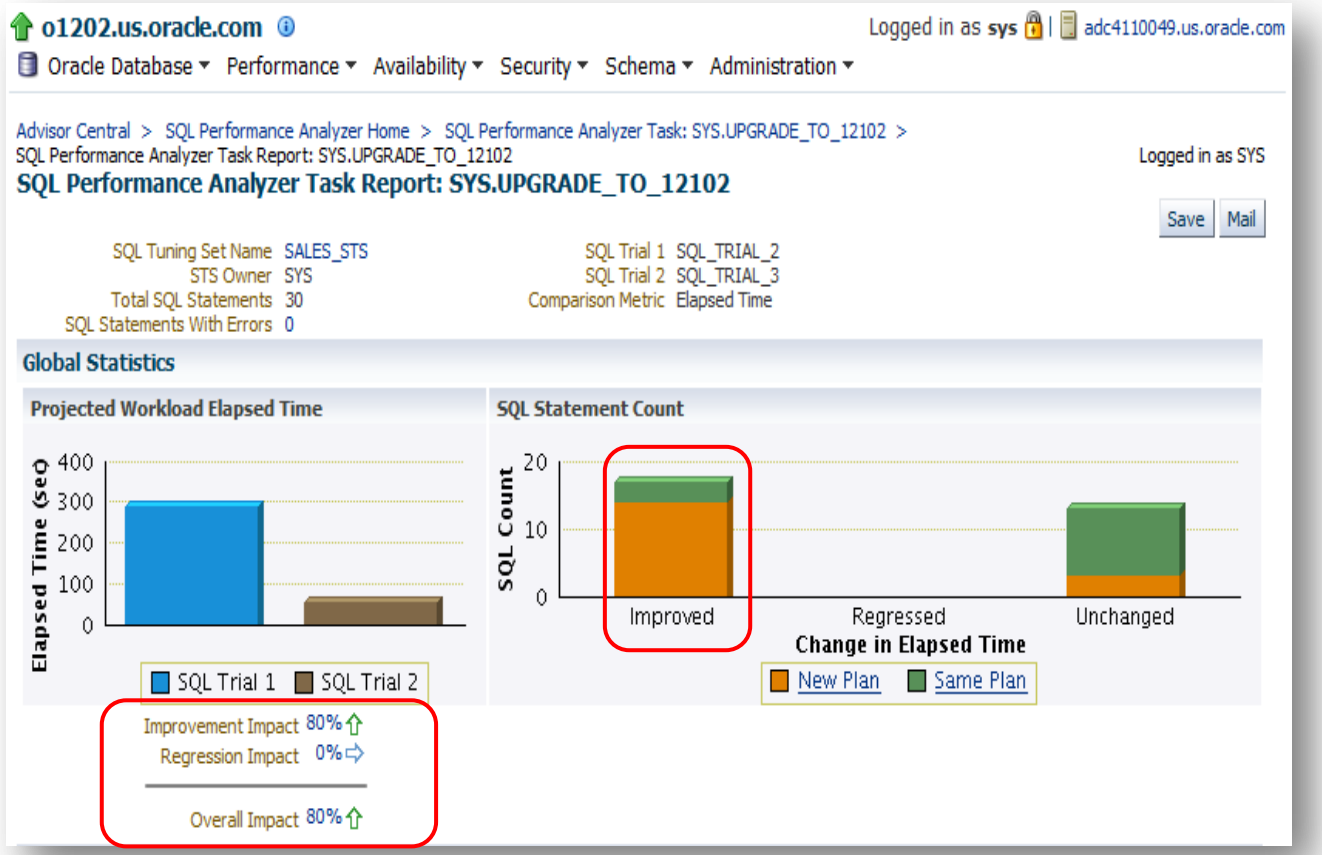
SPA – Look for Expected Plan Changes



- Convert production STS to trial 1
- Execute trial SPA trial 2
- Produce comparison report
- Best metric for analytic query workload is ‘Elapsed Time’
- Analytic SQL have changed execution plan with plan line **‘Table Access In Memory Full’**
- SQL are benefitting from In-Memory

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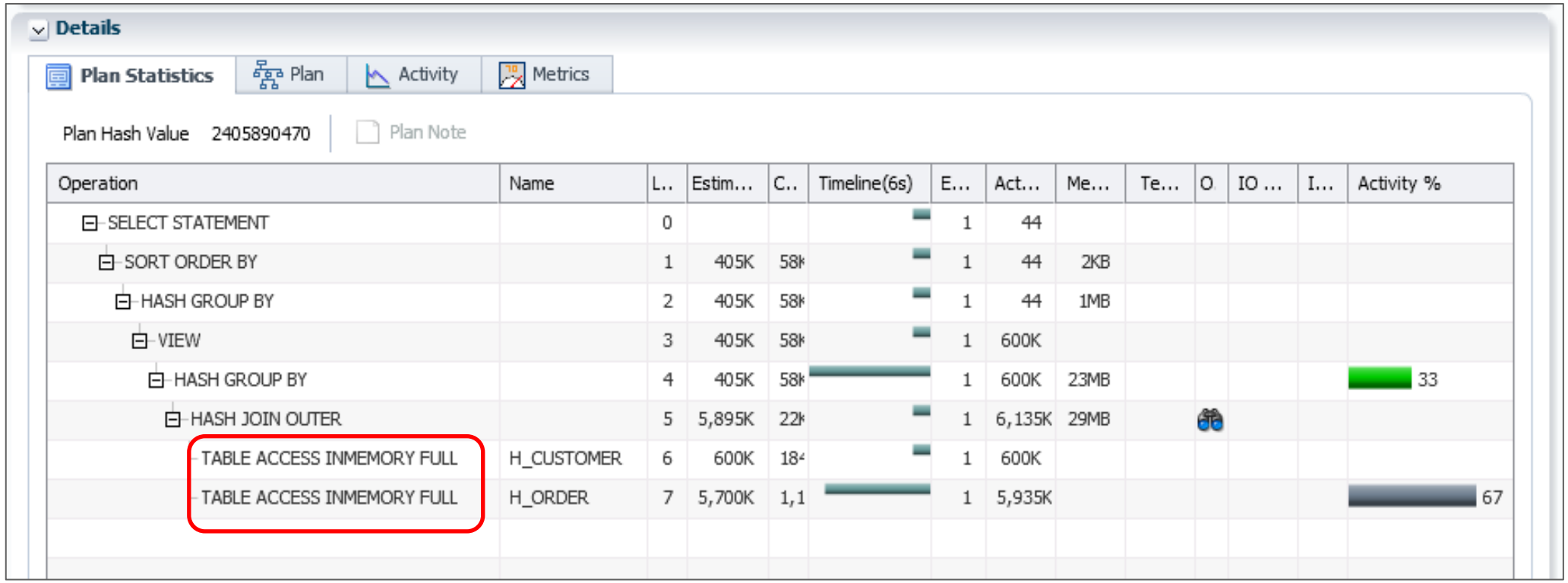
Identify Plan Change Improvements

Real Time SQL Monitoring



Operation	Name	L..	Estim...	C..	Timeline(6s)	E...	Act...	Me...	Te...	O	IO ...	I...	Activity %
SELECT STATEMENT		0				1	44						
SORT ORDER BY		1	405K	58K		1	44	2KB					
HASH GROUP BY		2	405K	58K		1	44	1MB					
VIEW		3	405K	58K		1	600K						
HASH GROUP BY		4	405K	58K		1	600K	23MB					33
HASH JOIN OUTER		5	5,895K	22K		1	6,135K	29MB					
TABLE ACCESS INMEMORY FULL	H_CUSTOMER	6	600K	184		1	600K						
TABLE ACCESS INMEMORY FULL	H_ORDER	7	5,700K	1,1		1	5,935K						67

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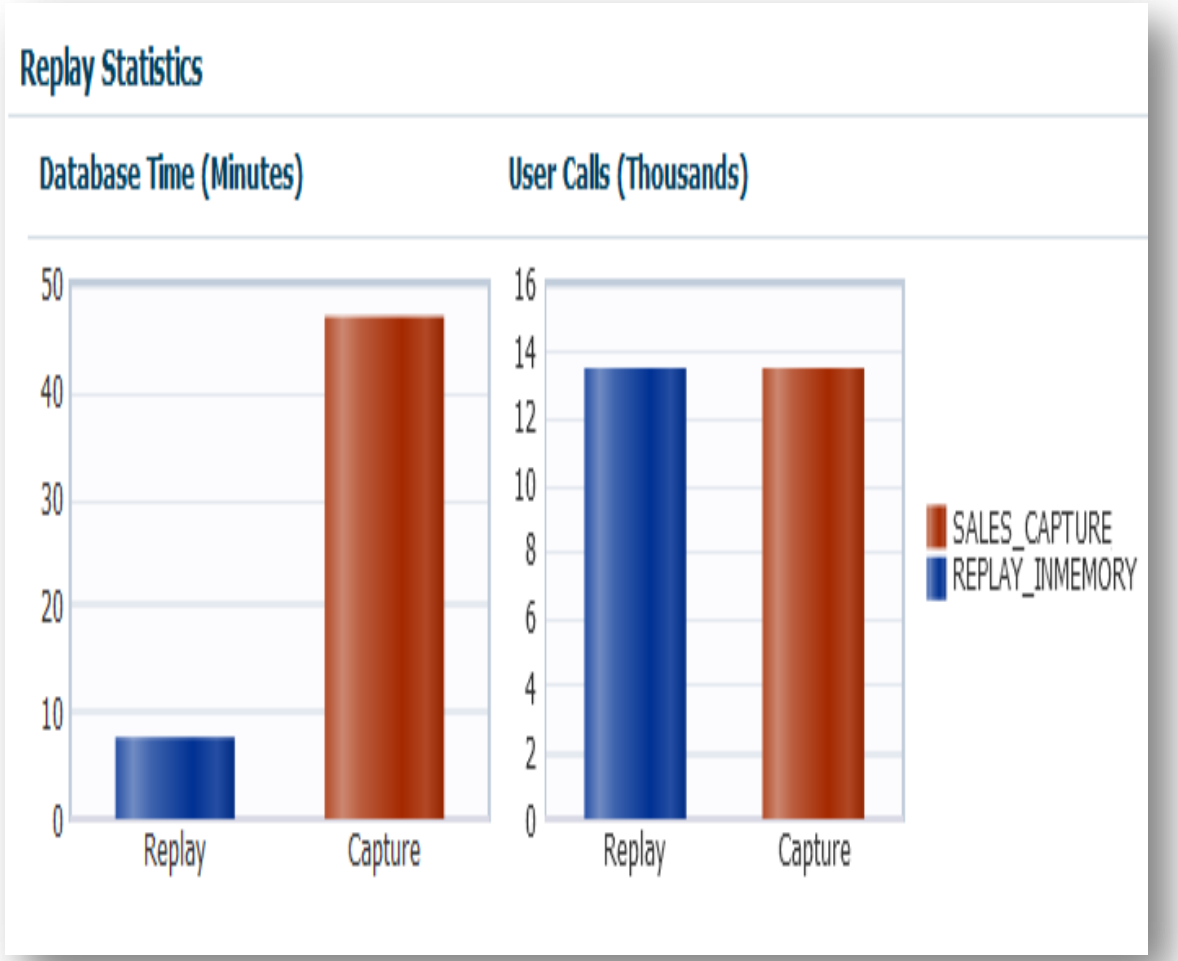
Execute Database Replay



- Validate concurrency and load improvement for consolidated workload
- Database Replay trial results:
  - User calls identical – same workload was executed
  - DB Time substantially reduced
- Success ✔

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Database In-Memory DB Time Improvement

Database 11.2.0.4

	Snap Id	Snap Time	Sessions	Cursors/Session
Begin Snap:	412	15:11:47	34	2.4
End Snap:	414	16:10:51	35	2.4
Elapsed:		59.06 (mins)		
DB Time:		48.16 (mins)		

Top 10 Foreground Events by Total Wait Time

Event	Waits	Total Wait Time (sec)	Wait Avg(ms)	% DB time	Wait Class
DB CPU		2736.1		94.7	
direct path read	16,284	69	4	2.4	User I/O
direct path write temp	4,511	60.7	15	2.1	User I/O
direct path read temp	7,785	52	6	1.8	User I/O

Top User Events

Event	Event Class	% Event	Avg Active Sessions
CPU + Wait for CPU	CPU	93.40	0.74
direct path read	User I/O	2.1	0.02
direct path write temp	User I/O	2.0	0.02
direct path read temp	User I/O	2.0	0.02

Database 12.1.0.2 + In-Memory

	Snap Id	Snap Time	Sessions	Cursors/Session
Begin Snap:	1290	13:45:58	44	1.7
End Snap:	1291	14:45:55	48	1.8
Elapsed:		59.05 (mins)		
DB Time:		7.64 (mins)		

Top 10 Foreground Events by Total Wait Time

Event	Waits	Total Wait Time (sec)	Wait Avg(ms)	% DB time	Wait Class
DB CPU		442		96.4	
db file sequential read	2,555	9.4	3.69	2.1	User I/O
direct path read temp	1,853	1.9	1.05	.4	User I/O
direct path write temp	2,713	1.4	0.50	.3	User I/O

Top User Events

Event	Event Class	% Event	Avg Active Sessions
CPU + Wait for CPU	CPU	45.84	0.07
CPU: IM Query	CPU	32.21	0.05
db file sequential read	User I/O	2.12	0.00

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Customer Case Studies

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Sumitomo Heavy Industries,Ltd.
Database Upgrade Project
Using RAT & GG Veridata

Customer Profile

Sumitomo Heavy Industries, Ltd.

Company Name: Sumitomo Heavy Industries, Ltd.

Head Office: ThinkPark Tower, 1-1 Osaki 2-chome, Shinagawa-ku, Tokyo 141-6025, Japan

Founded: November 20, 1888

Incorporated: November 1, 1934

Capital: JPY 30,871,650,000 (as of March 31, 2014)

Employees: Consolidated: 17,941 (as of March 31, 2014)

Annual Revenue: Consolidated: JPY 615,270,000,000 (for the 2013 Fiscal Year)

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Challenge & Solution

Database Upgrade 9i /10g -> 11gR2

Challenge

- Aim to reduce costs to around $2.5 M to 30-50%
- Upgrading in parallel in a short period of time about 30DB
- The data migration in a short period of time large-scale DB and Mission-Critical DB environment, to minimize business downtime
- Standardizing method for migrating and upgrading multiple databases efficiently
- Performing and automating application test by DBA for minimize cost

Solution

- Perform application test with completely the same workload using Oracle Real Application Testing
- Automate the Performance management using Diagnostics Pack & Tuning Pack
- Guarantee data consistency after testing on new environment using Oracle GoldenGate Veridata
- Use Oracle GoldenGate for minimizing downtime and fallback plan (under proposing)

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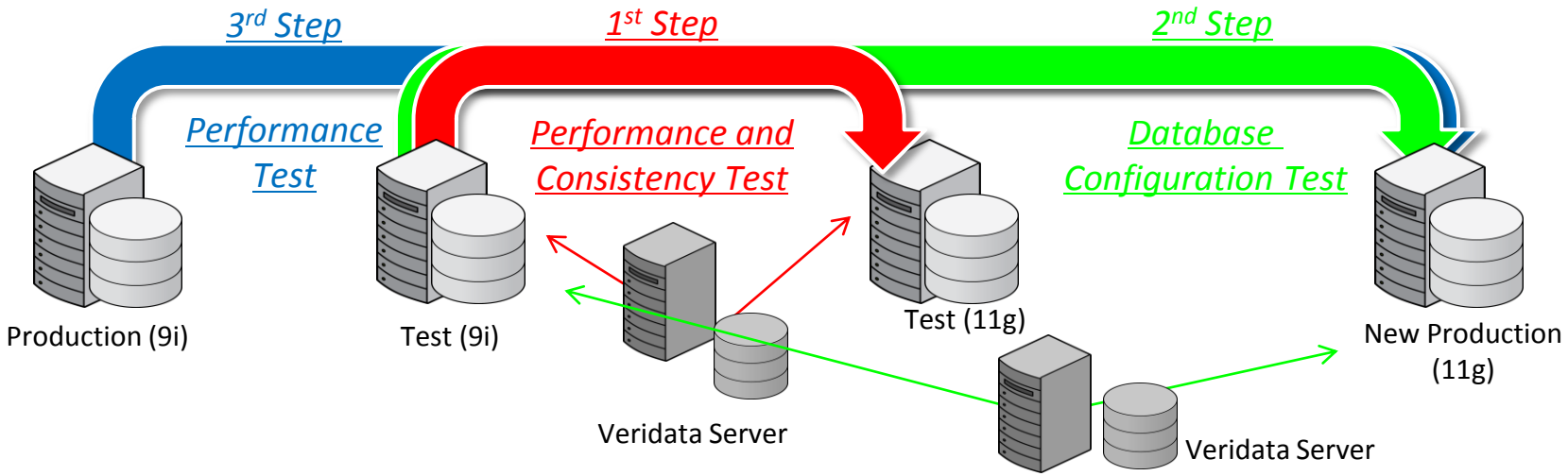
Solution Architecture

Architecture

- 1st step: Measure the SQL Elapsed time
  Check the workload consistency by using Veridata
- 2nd step: Check whether the new database has been created successfully by using Veridata
- 3rd step: Compare the whole throughput and workload between the production and the new production by using RAT



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Sumitomo Heavy Industries, Ltd.

30DBs Upgrade, reduce the verification Cost to take advantage of support tools

Customer Profile

Name：Sumitomo Heavy Industires, Ltd.
（http://www.shi.co.jp/english/）
Location：Tokyo (Japan)
Industry：manufacturing Industry
Employees：17,961

Oracle Products

- Oracle Real Application Testing (RAT)
- Oracle Diagnostics Pack /Oracle Tuning Pack (Diag/Tuning)
- Oracle GoldenGate Veridata(Veridata)
- Oracle GoldenGate (GG)

CHALLENGES/OPPORTUNITIES

- Upgrading in parallel in a short period of time about 30DB
- Aim to reduce costs to around $2.5 M to 30-50%
- Establishing an upgrade method utilizing a tool for efficient operation while ensuring the quality
- The data migration in a short period of time large-scale DB environment, to minimize business downtime
- Adopt the DB performance improvement technique method

CUSTOMER PERSPECTIVE

“I heard that Other Oracle Customer has efficiently implemented DB upgrade, to take advantage of tools(RAT, GG etc).
Therefore ,We accept the Challenge!!”

Engineer / Takayuki Okoshi
INFORMATION SYSTEMS DEVELOPMENT DEPT.
Sumitomo Heavy Industries Business Associates, Ltd.

RESULTS

- RAT realized the accurate verification and efficient online processing performance
- Diag/Tuning realized the performance improvement technique method
- Veridata realized the data validation of the old and new environment accurate and efficiently to a large extent
- To maintain business continuity, used GG to data migrate on the Critical DBs.

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Engineered to Work Together

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