Oracle TimesTen In-Memory Database and TimesTen Velocity Scale

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Safe Harbor Statement

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AGENDA

1. TimesTen Introduction
2. TimesTen Velocity Scale
3. Q&A
<table>
<thead>
<tr>
<th>Relational Database</th>
<th>Persistent and Recoverable</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Pure in-memory</td>
<td>– Database and Transaction logs persisted on disk / flash</td>
</tr>
<tr>
<td>– ACID compliant</td>
<td>– Replication to standby and DR systems</td>
</tr>
<tr>
<td>– Standard SQL</td>
<td></td>
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<tr>
<td>– Entire database in DRAM</td>
<td></td>
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<table>
<thead>
<tr>
<th>Extremely Fast</th>
<th>Compatible with Oracle Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Microseconds response time</td>
<td>– Data types, PL/SQL, JDBC, OCI, ODP.NET, PHP, R</td>
</tr>
<tr>
<td>– Very high throughput</td>
<td>– Integrated with RAC, Data Guard, Enterprise Manager, SQL Developer, etc.</td>
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</tbody>
</table>
Oracle Database In-Memory vs Oracle TimesTen

• Database In-Memory Option
  – Feature of Oracle Database
  – Primarily intended for analytics workloads
    • Scans billions of rows/second
  – Optimized for set-oriented data processing

• TimesTen In-Memory Database
  – Runs in the application tier
  – Primarily for low-latency applications
    • Microsecond response time
  – Optimizes OLTP processing
    • E.g. insert a new stock trade, connect a cellular phone call
TimesTen In-Memory Database

Low Latency - Microseconds Response Time

![Graph showing low latency times for SELECT Query and UPDATE Transaction]

TPTBM Read and Update
E5-2699 v4 @ 2.20GHz
2 socket, 22 cores/socket,
2 threads/core
TimesTen 11.2.2.8.0
(100M rows, 17GB)
TimesTen In-Memory Database

5.6 Million Transactions Per Second Per Processor

Mixed Workload Throughput Per Processor

5,619,403

80-10-5-5 Workload = 80% select, 10% updates, 5% inserts, 5% deletes

TPTBM 100% Mixed Workload (80-10-5-5)
E5-2699 v4 @ 2.20GHz
2 socket, 22 cores/socket, 2 threads/core
TimesTen 11.2.2.8.0
(100M rows, 17GB)
TimesTen In-Memory Database

21.7 Million Transactions Per Second

Read-Only Workload Throughput

TPTBM 100% Read
E5-2699 v4 @ 2.20GHz
2 socket, 22
cores/socket,
2 threads/core
TimesTen 11.2.2.8.0
(100M rows, 17GB)
Oracle TimesTen In-Memory Database

Two Deployment Options

1. Standalone In-Memory Database for OLTP applications

2. Application-tier Database Cache for the Oracle Database - Targeted for OLTP applications
Oracle TimesTen – Pure In-Memory Relational Database

Mature In-Memory Technology

- 1996 Spinoff from HP Labs
- 1998 First commercial In-Memory RDBMS
- HA Replication
- Online Upgrades
- Application-tier Cache for Oracle Database

- Oracle RAC integration
- National Language Support
- Oracle Data Types support
- SQL Developer Integration
- Enterprise Manager integration

- PL/SQL and OCI Support
- Oracle Clusterware Integration
- Cache Grid for Scale Out
- ODP.NET Support
- BLOB, CLOB, NCLOB data types

- Parallel Replication
- In-Memory Analytics
- Columnar Compression
- Index Advisor
- Oracle R Support
- In-Memory Star Join
- Oracle Golden Gate Integration

- Parallel data import from Oracle Database
- Parallel database restart
- Highly concurrent range indexes
- Further Optimized Parallel Replication
TimesTen: Primary Use Case

High Velocity Applications

• What are High Velocity applications?
  – Event driven, no opportunity to batch
  – E.g. Stock trade, phone call, credit-card authorization, need to be processed immediately
  – Usually lightweight transactions – few rows, very high transaction volume
  – TimesTen ideal for these use cases

• TimesTen is light-weight & ultra-fast
  – Runs in application: no network required
  – 100X faster latency-critical applications
  – 1000s of customers
Most Widely Used In-Memory Database for OLTP
Deployed by Thousands of Companies
Global Broker-Dealer

Mutual Fund Trading

• Program trading application serving institutional clients

• Business challenges
  – J2EE caching of full objects was too slow
  – Homegrown Java object cache too expensive for in-house staff

• TimesTen deployment (since 2003)
  – Order transaction processing
    • Pre-trade validation, order preparation and release, post-trade allocation
  – Reference data lookup
  – Event publishing to back-end database

• Why TimesTen
  – Standards based, commercial product
  – Order of magnitude performance improvement
  – Can sustain high volume orders
### Real-Time Fraud Detection

**USPS – Total Revenue Protection (TRP)**

#### Challenges
- 4 billion mail scans per day peak (74,000/sec)
- 275 processing and distribution centers
- 33,000 postal facilities
- Find, track, and reject mail due to duplicate postage, short pay, or ineligible discounts
- 509 row inserts/sec (RIPS) → 275M txs per 15 hr processing window
- Sorting and capture time exceeded processing window

#### Solution
- Real-time data scans ingested into TimesTen
- 1.6TB TimesTen in-memory database
- Real-time TRP algorithms executed on TimesTen
- Results retained in TimesTen and propagated to Oracle Database for long term storage and analysis

#### TimesTen Values
- 190,222 RIPS (3 threads)
- 1,091,018 RIPS (18 threads)
- Processed 4 Billion txs in less than 6 hours
- Revenue protection performed in real-time upon first scan
- Sorting and capture easily fit within processing window
## Mobile Phone Charging System

**Ericsson Sweden**

### Challenges
- 5 Billion subscriptions in the world, 20% are charged via Ericsson
- Real-time Rating (price calculation, promotion and loyalty)
- Real-time accounting (spending control, multi-account and units, historical usage)
- Telecom grade, 99.999% availability, quick and automatic failover

### Solution
- TimesTen In-Memory Database
- TimesTen Replication
- Shared nothing clusters
- Standard SQL interface
- Low maintenance
- Wide platform support
- Low system impact

### TimesTen Values
- Predictable response time
- Very fast SQL performance
- High availability 99.999% up time (max down time 5 minutes per year)
AGENDA

1. TimesTen Introduction and Performance
2. TimesTen Velocity Scale
3. Q&A
What is TimesTen Velocity Scale In-Memory Database?

Scale-Out In-Memory Database for OLTP Applications

• An enterprise grade, distributed, highly available, shared nothing, scale-out, in-memory database
  – Based on TimesTen in-memory database technology
    • SQL relational
    • ACID compliant
    • Persistent and recoverable
    • Transactional
  – Scale-out architecture with single database image
  – Built-in high availability via multiple copies of the data
  – Elastic scalability
  – Easy to deploy, use and write apps for
• Designed for OLTP applications which require
  – Horizontal Scalability, High Throughput, High Availability
  – RDBMS semantics, consistency, functionality
Single Database Image

Connect to Any Host — Access ALL data

• Data distributed to all hosts
• Connect to any host and access all data
  – Execute queries and DML targeting data residing in any element(s)
  – Distributed queries, joins & transactions
• Concurrent transactions and parallel queries across all hosts
• All transactions may access / modify any data
  – Even across multiple hosts
Data Distribution Methods

Distribute by Hash and by Reference

- **Distribute by Hash**
  - Primary key or user-specified columns
  - Consistent hash algorithm
  - Examples: Customers, Subscribers, Accounts

- **Distribute by Reference**
  - Co-locate related data to optimize for joins
  - Based on FK relationship
  - Supports multi-level hierarchy
  - Customer ← Order ← Line Items

- **Distribute by Duplicate**
  - Identical copies on all elements
  - Useful for reference tables
  - No remote access costs for reads
  - Join optimization

![Data Distribution Methods Diagram]
Parallel Query Processing

• Application transparent parallel query processing
  – Joins data across elements
  – Aggregate results

Example

select cust.name from cust where cust.balance < 100;

• One request from application
  – Result set aggregated by TimesTen Velocity Scale
High Availability and Maximum Throughput

K-Safety, All Active

• Built-in HA via multiple copies of the data (K-safety)
  – Automatically kept in sync
• All replicas are active for reads and writes
• Transactions can be initiated from and executed on any replica
• Transactions may access / modify any data
  – Even across multiple hosts
Elastic Scalability
Expand the Database with Business Growth

- Add elements to the Grid
  - Data automatically redistributed to new hosts
  - Workload automatically uses the new hosts
  - Connections will start to use new hosts
  - Throughput increases with added compute resources
Grid Structure

• Each grid contains:
  • 1 or 2 management instances
  • A number of data instances
    • No fixed maximum
• Each grid uses:
  • A set of membership servers running Zookeeper (typically 1 or 3)
  • Can be shared by several grids
Grid management

- Management instances work in an active / standby configuration
- *All* installation, configuration, management and administration of the grid is done on the active management instance
- You **never** have to log on to or copy files to each host manually
- The standby management instance can become the active in case of failure
- Management via:
  - Command line
  - SQL Developer
TimesTen Velocity Scale IMDB vs Cassandra

YCSB (Yahoo Cloud Service Benchmark) – 95% reads 5% writes

- Configuration (NxK)
  - Cassandra
  - TimesTen Velocity Scale

Operations per second

<table>
<thead>
<tr>
<th>Configuration (NxK)</th>
<th>Cassandra</th>
<th>TimesTen Velocity Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x2</td>
<td>0</td>
<td>640,000</td>
</tr>
<tr>
<td>2x2</td>
<td>200,000</td>
<td>840,000</td>
</tr>
<tr>
<td>3x2</td>
<td>300,000</td>
<td>980,000</td>
</tr>
<tr>
<td>4x2</td>
<td>400,000</td>
<td>1,100,000</td>
</tr>
<tr>
<td>5x2</td>
<td>500,000</td>
<td>1,200,000</td>
</tr>
<tr>
<td>6x2</td>
<td>260,000</td>
<td>1,600,000</td>
</tr>
</tbody>
</table>

YCSB N*10M Rows
- Servers: 12 x X5-2
- Clients: 2 x ODA
- Network: 10Gbps
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