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Software in Silicon

Innovations for Database

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November 19, 2015
Today’s Database Market Requirements

53% of executives say too much critical information is delivered too late

Source: Richard Hackathorn’s “components of action time”

46% of IT leaders are less than satisfied with their current availability strategy

Source: IOUG, Bringing Continuous Availability to Oracle Environments, January 2014

Data is growing at 40% a year, exceeding available storage space

Source: IDC, Digital Universe Study, December 2012

51% of CIOs are concerned that IT Enterprise is not setup to exploit new technologies and trends

Source: Gartner, “Taming the Digital Dragon: The 2014 CIO Agenda”

Real-Time Analytics

Return on Investment

High Availability

Flexibility
Oracle Database 12c

Exploit memory to improve performance
Reduce the cost of storing data
Provide continued access to data
Simplify the consolidation of Oracle databases
Simplify access to Big Data
Ensure secure access to data

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Oracle Database 12c
2 headline technologies and more than 500 innovative new features

Oracle Multitenant
• Database consolidation and foundation for hybrid cloud
• Fast Provisioning
• Manage many as one

Oracle In-Memory
• Real Time Analytics
• Exploit latest generation hardware
• No changes to the application
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Oracle Multitenant
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Oracle In-Memory
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Oracle Database In-Memory Goals

Real-Time Analytics
Enable Real-Time business Decisions

Accelerate Mixed Workload
Run analytics on operational Systems

Risk-Free
Proven Scale-Out, Availability, Security

Trivial to Implement
No Application Changes Not Limited by Memory
Optimizing Transaction and Query Performance

Row Format Databases vs. 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
  - Example: Report on sales totals by region
  - Fast accessing few columns, many rows

Until Now Must Choose One Format and Suffer Tradeoffs
Breakthrough: Dual Format Database

- **BOTH** row and column formats for same table
- Simultaneously active and transactionally consistent
- Analytics & reporting use new in-memory Column format
- OLTP uses proven row format
Improvements to All Aspects of Analytic Query

**Data Scans**
- Speed of memory
- Scan and Filter only the needed columns
- Vector Instructions

**Joins**
- Convert Star Joins into 10x Faster Column Scans
- Search large table for values that match small table

**In-Memory Aggregation**
- Create In-Memory Report Outline that is Populated during Fast Scan
- Runs Reports Instantly
Database In-Memory Accelerates Mixed Workloads

- Complex OLTP is Slowed by Analytic Indexes
  - Inserting one row into a table requires updating 10-20 analytic indexes: **Slow!**

- Column Store Replaces Analytic Indexes
  - Fast analytics on **any** columns
  - Column Store not persistent so update cost is much lower
Oracle Database In-Memory: Trivial to Implement

**Easy to Deploy**
- No data migration

**100% Compatible**
- No application changes

**Full Functionality**
- No SQL Restrictions

**Easy to use**
- No Complex Setup
  1. Set column store size
  2. Declare In-Memory tables
When and How Should I Use In-Memory
In-Memory Use Cases

**OLTP**
- Real-time reporting directly on OLTP source data
- Removes need for separate ODS
- Speeds data extraction

**Data Warehouse**
- Staging/ETL/Temp not a candidate
  - Write once, read once
- All or a subset of Foundation Layer
  - For time sensitive analytics
- Potential to replace Access Layer
Become a Real-Time Enterprise
Using Oracle Database In-Memory

- Data-Driven
  - Get immediate answers to any question with real-time analytics
- Agile
  - Eliminate latency with analytics directly on OLTP data
- Efficient
  - Easily and Non-disruptive deployment accelerates all applications
Summary: Oracle Database In-Memory
Powering the Real-Time Enterprise

- Extreme Performance: Analytics & OLTP
- Extreme Scale-Out & Scale-Up
- Extreme Availability
- Extreme Simplicity
Software in Silicon
What’s in there for Oracle Database
SPARC M7 Software in Silicon

- Traditional DB algorithms too complex for chips
- Big Change: In-memory algorithms are much simpler
- 5 years ago Oracle initiated a revolutionary project
  - Build fastest ever microprocessor
    - Most processing cores (32)
    - Most concurrent threads (256)
    - Fastest Memory Bandwidth (160 GB/sec)
  - Add In-Memory DB operations directly on chip
- Only high-volume CPU with native SQL optimizations
Why Oracle Database In-Memory is even better on M7

In-Memory Algorithms Natively Implemented in Silicon

SQL in Silicon
DB Acceleration

Capacity in Silicon
Decompression Engines

Silicon Secured Memory
Fine-Grained Memory Protection

Database Software Support Shipping Since Mid-Year
SQL in Silicon: Database In-Memory Acceleration Engines

- SIMD Vectors instructions are fast, but were designed for graphics, not database

- New SPARC M7 chip has 32 optimized database acceleration engines (DAX) built on chip

- Independently process streams of columns
  - E.g. find all values that match ‘California’
  - Up to 170 Billion rows per second!

- Frees processor cores to run other applications, such as OLTP

- Like adding 32 additional specialized cores to chip
  - Using less than 1% of chip space
M7 Query Accelerator Engine

- 32 In-Silicon Offload Engines
- Cores/Threads Operate Synchronous or Asynchronous to Offload Engines
- User Level Synchronization Through Shared Memory
- High Performance at Low Power
- 3x more Memory Bandwidth than x86
M7 In-Memory Database Advantages

DAX: Data Analytics Accelerator

- Industry-leading M7 memory bandwidth
- DAX decompresses data at same rate as scan-only
- DAX performs one-step scans, range scans, and assists Bloom filter joins

Processes:

- Decode values (DAX) & Sum aggregation (cores)
- Hash Joins (cores)
- Bloom Filter Joins (DAX & cores)
- Scans (DAX)
- Range Scans (DAX)

SQL:

```sql
select sum(lo_extendedprice*lo_discount) as revenue
from lineorder, date_dim
where lo_orderdate = d_datekey and
d_year = 2012 and
lo_quantity between 6 and 25 and lo_discount between 1 and 3
```
SQL In Silicon: Accelerating Oracle Database 12c
Decompress at memory speed >120 GB/sec

SQL:
SELECT count(*)
...WHERE lo_orderdate = d_datekey
...AND lo_partkey = 1059538
AND d_year_monthnum BETWEEN 201311 AND 201312;
Capacity in Silicon: Decompression Engines

- Compression is key to putting more data in-memory
- **Decompression** is far more important for databases than compression
  - Data is loaded once, queried many times
- Bit pattern decompression in normal cores is slow
  - 64 CPU cores needed to decompress at full memory speed
- SPARC M7 adds 32 optimized decompress engines
  - Run bit-pattern **decompress at memory speed**
Silicon Secured Memory: Fine Grained Memory Protection

• Database In-memory places terabytes of data in memory
  – More vulnerable to corruption by bugs/attacks than storage

• SPARC M7 locks memory as it is allocated so only the owner can access it
  – Hidden “color” bits added to pointers (key), and content (lock)
  – Pointer color (key) must match content color or program is aborted
  – Hardware support eliminates performance impact

• Helps prevent access off end of structure, stale pointer access, malicious attacks, etc. plus improves developer productivity
SPARC M7 with Oracle Database 12c In-Memory

Faster than flash storage, and speed increases with diversity of data

**T7-4 Beta System**

Oracle Solaris 11.3
Oracle Database 12.1.0.2 plus bundle patch

Product catalog of major on-line retailer with large number of parts

Query type: “How many unique products in stock?”

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**Single Query Execution**

<table>
<thead>
<tr>
<th>Queries per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

- In-Memory + SQL in Silicon
- Flash LUN

833X Faster
Software in Silicon Efficiency for In-Memory
With Oracle M7 You Can Run Both Analytics and OLTP

Oracle T7-1
1 chip, 32 cores
Solaris

5x Latest Generation HP DL380
10 chips, 180 cores
Linux

Running 1 TB Database compressed into 120 GB of memory
## Oracle Applications In-Memory Examples

<table>
<thead>
<tr>
<th>Oracle Application Module</th>
<th>Improvement</th>
<th>Elapsed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Memory Cost Management</td>
<td>1003x Faster</td>
<td>58 hours to 3.5 mins</td>
</tr>
<tr>
<td>In-Memory - Financial Analyzer</td>
<td>1,354x Faster</td>
<td>4.3 hours to 11 seconds</td>
</tr>
<tr>
<td>In-Memory Sales Order Analysis</td>
<td>1,762x Faster</td>
<td>22.5 minutes to &lt; 1 sec</td>
</tr>
<tr>
<td>Subledger Period Close Exceptions</td>
<td>200x Faster</td>
<td>600 seconds to 3 secs</td>
</tr>
<tr>
<td>Call Center Ad-hoc query pattern</td>
<td>1247x Faster</td>
<td>129 seconds to &lt; 1 secs</td>
</tr>
</tbody>
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Integrated Cloud
Applications & Platform Services