SAP HANA – Real Time Computing

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SAP Software Portfolio

Applications

Analytics

Mobile

Database & Tech.

Cloud

Powered by SAP HANA
a completely re-imagined, modern platform for real-time business
Outline

Overview of HANA

Leveraging New Generation Commodity Hardware

HANA Architecture

Summary
Modern Enterprise Business Applications

The Need for Efficient and Flexible Data Management

- Combine different information access approaches: search, analysis, and exploration
- No clear separation between transactional and analytical parts of the application
- Leverage data of different degrees of structure and quality, from well-structured to irregularly structured to unstructured text data
- Flexibly combine internal and external data based on business decisions to be made not the set of available integrated data
- Are based on “real-time” current data and historical data
- Need to support different form factors and deployment models: on-premise, on-demand and on-device

External Sources
SAP HANA: The Challenge

Deep
Complex & interactive questions on granular data

Broad
Big data, many data types

High Speed
Fast response-time, interactivity

Real-time
Recent data, preferably real-time

Simple
No data preparation, no pre-aggregates, no tuning

OR

Deep
Complex & interactive questions on granular data

Broad
Big data, many data types

High Speed
Fast response-time, interactivity

Real-time
Recent data, preferably real-time

Simple
No data preparation, no pre-aggregates, no tuning
SAP HANA: The Challenge

Unify Transaction Processing and Analytics
Single System
Same Data Instance

Run Analytics in Real-Time

Run Analytics and Transactions at the “speed of thought”
SAP HANA: A New In-Memory Data Platform

One Foundation
for

OLTP + OLAP | Structured + Unstructured Data
Legacy + New Applications
Distribution | Single Lifecycle Management
Outline

Overview of HANA

Leveraging New Generation Commodity Hardware

HANA Architecture Overview

Summary
Hardware Advances: Moore’s Law - DRAM Pricing

1980: Memory $10,000/MB
2000: Memory $1/MB
2013: Memory $0.004/MB
Hardware Advances: Moore's Law - CPUs

2002
- 1 core
- 32 bits
- 4MB

2007
- 2 cores
- 2 CPUs per server
- External Controllers

2010
- 8 cores -16 threads / CPU
- 4 CPUs per server
- On-chip memory control
- Quick interconnect
- VM and vector support
- 64 bits; 256 GB - 1 TB

2013
- More cores, bigger caches
- 16 ... 64 CPUs per server
- Greater on-chip integration (PCIe, network, ...)
- Data-direct I/O
- Tens of TBs
Software Advances: Build for In-Memory Computing
Reduce Memory Access Stalls

- **In-Memory Computing:** It is all data-structures (not just tables)
- **Parallelism:** Take advantage of tens, hundreds of cores
- **Data Locality:** On-chip cache awareness
In-Memory Computing

Yes, DRAM is 100,000 times faster than disk, but DRAM access is still 6-200 times slower than on-chip caches.
In-Memory Computing – Data Structures

<table>
<thead>
<tr>
<th>Order</th>
<th>Country</th>
<th>Product</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>456</td>
<td>France</td>
<td>corn</td>
<td>1000</td>
</tr>
<tr>
<td>457</td>
<td>Italy</td>
<td>wheat</td>
<td>900</td>
</tr>
<tr>
<td>458</td>
<td>Italy</td>
<td>corn</td>
<td>600</td>
</tr>
<tr>
<td>459</td>
<td>Spain</td>
<td>rice</td>
<td>800</td>
</tr>
</tbody>
</table>

**Typical Database**

```sql
SELECT Country, SUM(sales) FROM SalesOrders WHERE Product = 'corn' GROUP BY Country
```

**SAP HANA: column order**

```
<table>
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</tr>
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</table>
```
SAP HANA: Dictionary Compression

Column „Name“ (uncompressed)

Column „Name“ (dictionary compressed)

Value-ID sequence
One element for each row in column

Dictionary

Value ID implicitly given by sequence in which values are stored

Value

sorted

point into dictionary

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SAP HANA: Multi-Core Parallelization
Single Instruction Multiple Data (SIMD)

- **Scalar processing**
  - traditional mode
  - one instruction produces one result

- **SIMD processing**
  - with Intel® SSE(2,3,4)
  - one instruction produces multiple results

```
X1 op X1
Y1 op Y1
X2 op X2
Y2 op Y2
X3 op X3
Y3 op Y3
X4 op X4
Y4 op Y4
```

```
SOURCE
Scalar OP
DEST

127
X4 X3 X2 X1
SSE/2/3 OP
Y4 Y3 Y2 Y1
DEST

X4 op X4
X3 op X3
X2 op X2
X1 op X1
```
Single Instruction Multiple Data (SIMD)

128-bit wide with Intel® SSE(2,3,4)
- 2 64-bit integer ops/cycle
- 4 32-bit integer ops/cycle
- 8 16-bit integer ops/cycle
- 16 8-bit integer ops/cycle

256-bit with AVX

Vector-Processing Unit built-in standard processors
Parallelization at All Levels

- Multiple user sessions
- Concurrent operations within a query (… T1.A … T2.B…)
- Data partitioning on one or more hosts
- Horizontal segmentation, concurrent aggregation
- Multi-threading at Intel processor core level
- Vector Processing
SAP HANA: True In-Memory Computing

Use Vector Based Processing (SIMD)
Leverage Data Locality
Act on Compressed Data
Cache Line (64K) Aligned Data
Hyper-Threading

3.2B Integer Scans / Second / Core
12.5M Aggregates / Second / Core
1.5M Inserts / Second
SAP HANA deployment options

Single Server
- 2 CPU 128GB to 8 CPU 1TB
- Single HANA deployments for data marts or accelerators

Scale Out Cluster
- 2 to n servers per cluster
- Each server is either 4 CPU/ 512GB or 8 CPU/ 1TB
- Largest certified configuration: 56 servers
- Largest tested configuration: 250 servers
- Support for high availability and disaster tolerance

Cloud Deployment
- HANA instances can be deployed to AWS
- Free developer license
- 99 cents per hour for productive use (+ EUR 2.50 for the AWS machine)
Outline

Overview of HANA

Leveraging New Generation Commodity Hardware

HANA Architecture Overview

Summary
SAP HANA Technology & Features
Combined in one DBMS Platform

Common DBMS features
• SQL
• ACID: isolation (MVCC), logging and recovery
• Stored procedures

Hybrid DBMS
• Column store, row store, graph store
• In-memory and disk based
• Insert only (temporal) and updatable tables

High Performance
• Efficient compression techniques
• Massive parallelization over CPU cores and nodes
• Data structures optimized for main memory
• Data aging concept

Reduced TCO: OLTP, OLAP, search in one system
SAP HANA Database
Multi-Engine for Different Application Needs

- Business Applications
  - Connection and Session Management
    - Authorization Manager
      - SQL
      - SQL Script
      - MDX
      - WIPE (Graphs)
      - FOX (Planning)
    - Calculation Engine
    - Optimizer and Plan Generator
    - Execution Engine
  - Metadata Manager
    - In-Memory Processing Engines
      - Relational Engine (Row and Column Store)
      - Graph Engine
      - Text Engine
  - Persistance Layer
    - Logging and Recovery
    - Page Management
Diverse Set of Operators

- **Engine Layer**
  - a collection of different physical operators with some local optimization logic to adapt the fragment of the global plan to the specifics of the actual physical operator.
  - implement standard data transfer protocol as well as highly specialized communication protocols within operator groups
  - all operators exploit a common interface to the unified table layer
- **Set of plan operators**
  - Relational Operators: classic relational query graph processing
  - OLAP operators: optimized for star-join scenarios with fact and dimension tables
  - L runtime: runtime for the internal language to execute L code
  - Text operators: set of text search analysis operators (e.g. entity resolution capabilities)
  - Graph operators: provide support for graph-based algorithms
SAP HANA Column Store

High data compression

• Efficient compression methods (dictionary, run length, cluster, prefix, etc.)

• Compression works well with columns and can speedup operations on columns (~ factor 10)

• Because of compression, write changes into less compressed delta storage
  • Needs to be merged into columns from time to time or when a certain size is exceeded
  • Delta merge can be done in background
  • Trade-off between compression ratio and delta merge runtime

• Updates into delta data storage and periodically merged into main data storage
  • High write performance not affected by compression
  • Data is written to delta storage with less compression which is optimized for write access. This is merged into the main area of the column store later on.
SAP HANA: Column Store

Write-optimized representation

READO log

DML

Merge

Data area

Main store

Read-optimized representation
SAP HANA Database
Optimized Communication with the Application Layer

Browser-Based Clients

**Lightweight Application Server**
- Protocol Handler
- OData Service

Other HTTP Clients

**Application Container**
- Application

Core Services

Connection and Session Management
- SQL
- SQL Script
- MDX
- WIPE (Graphs)
- FOX (Planning)

Request Processing and execution Control

In-Memory Processing Engines
- Relational Engine
- Graph Engine
- Text Engine

Persistency Layer
SAP HANA Database
Optimized Communication with the Application Layer

- HANA integrates a lightweight application server component into the database cluster infrastructure to allow efficient communication and data exchange between database layer and application layer.

- The lightweight application server component in HANA provides core application services like:
  - Application service runtime engine
  - Application lifecycle management (versioning/transport) via content repository
  - Programming model
  - Standardized data exchange (OData: JSON / ATOM / XML)
  - Session and connection management
  - Outbound connectivity (HTTP, SMTP) etc.)
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HANA Architecture Overview

Summary
A New Data Management Platform for Modern Business Applications

Much more than a Relational Database

OLTP + OLAP | Structured + Unstructured Data
Legacy + New Applications
Distribution | Single Lifecycle Management
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