Large-Scale and Multi-Structured Databases

In Memory Databases

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Not Only Big Data and Scalable Solutions

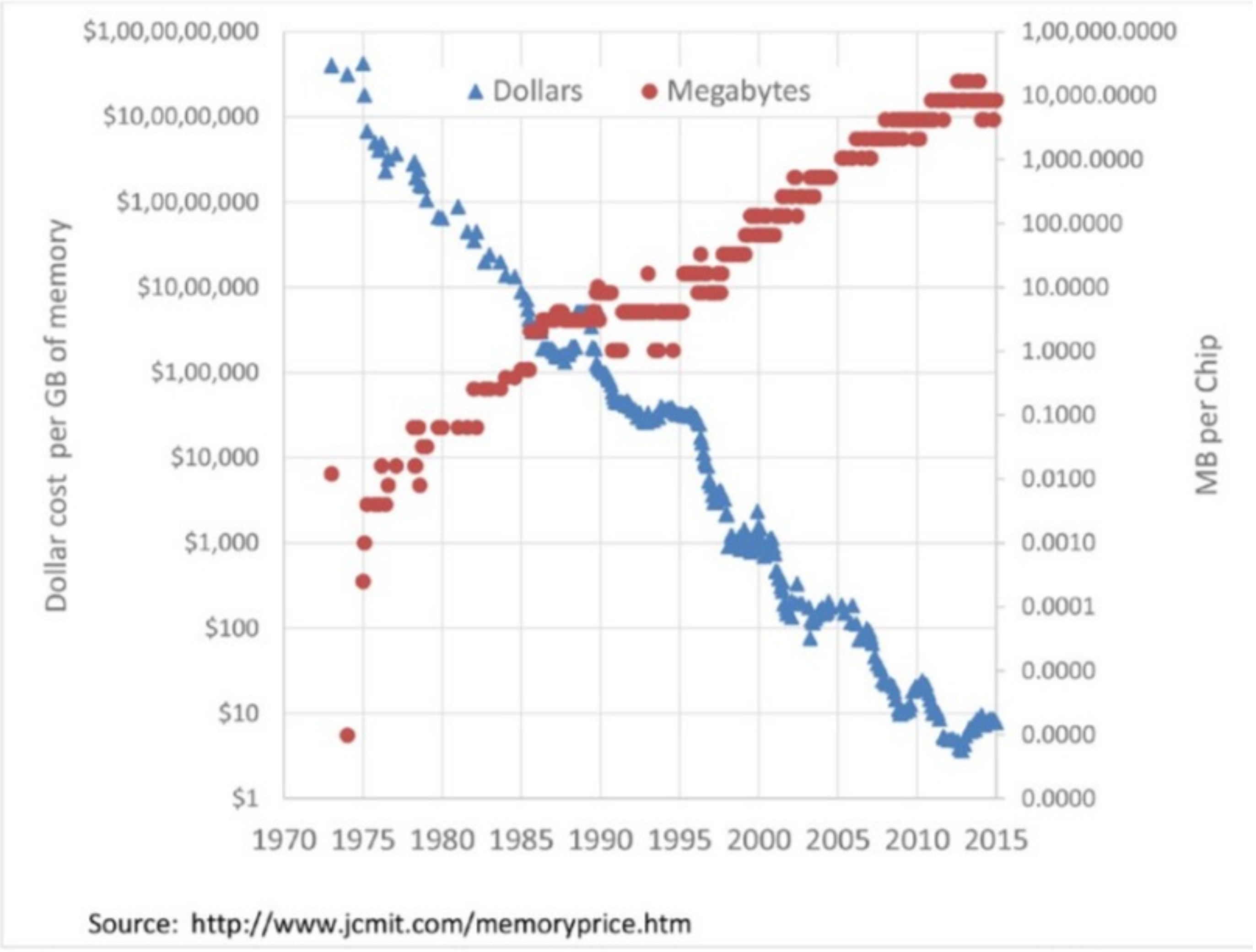
The design of a database solution is driven by the application ***requirements***.

Thus, if our application ***does not need*** to handle huge amount of data and to scale, both vertically and horizontally, we can think about adopting ***different solutions*** than the ones discussed so far.

In-memory databases may be suitable for applications whose handled data may ***fit all*** in the memory of a single server.

Moreover, there also can be databases that can reside in the memory capacity of a cluster (***if replication is needed***).

How Much Does Memory Cost?



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Features of In-Memory Databases

Very ***fast access*** to the data, avoiding the bottleneck of the I/O transfers.

Suitable for application that do not need ***to write continuously*** to a persistent medium.

Ad-hoc architecture for being aware that its data are resident in memory and for ***avoiding the data loss*** in the event of a power failure (***alternative persistency model***).

Cache-less architecture: despite traditional disk-based databases, a memory caching systems is not need (everything is already in memory!!!).

Solutions for Data Persistency

In the following, we show some solutions for avoiding data loss in case of ***system failure***:

- Writing complete database ***images*** (called snapshots or checkpoints) to disk files.
- Writing out transaction/operation records to an append-only disk file (called a ***transaction log*** or ***journal***).
- ***Replicating data*** to other members of a cluster.

TimesTen (Oracle Solution)

TimesTen implements a fairly familiar ***SQL-based*** relational model.

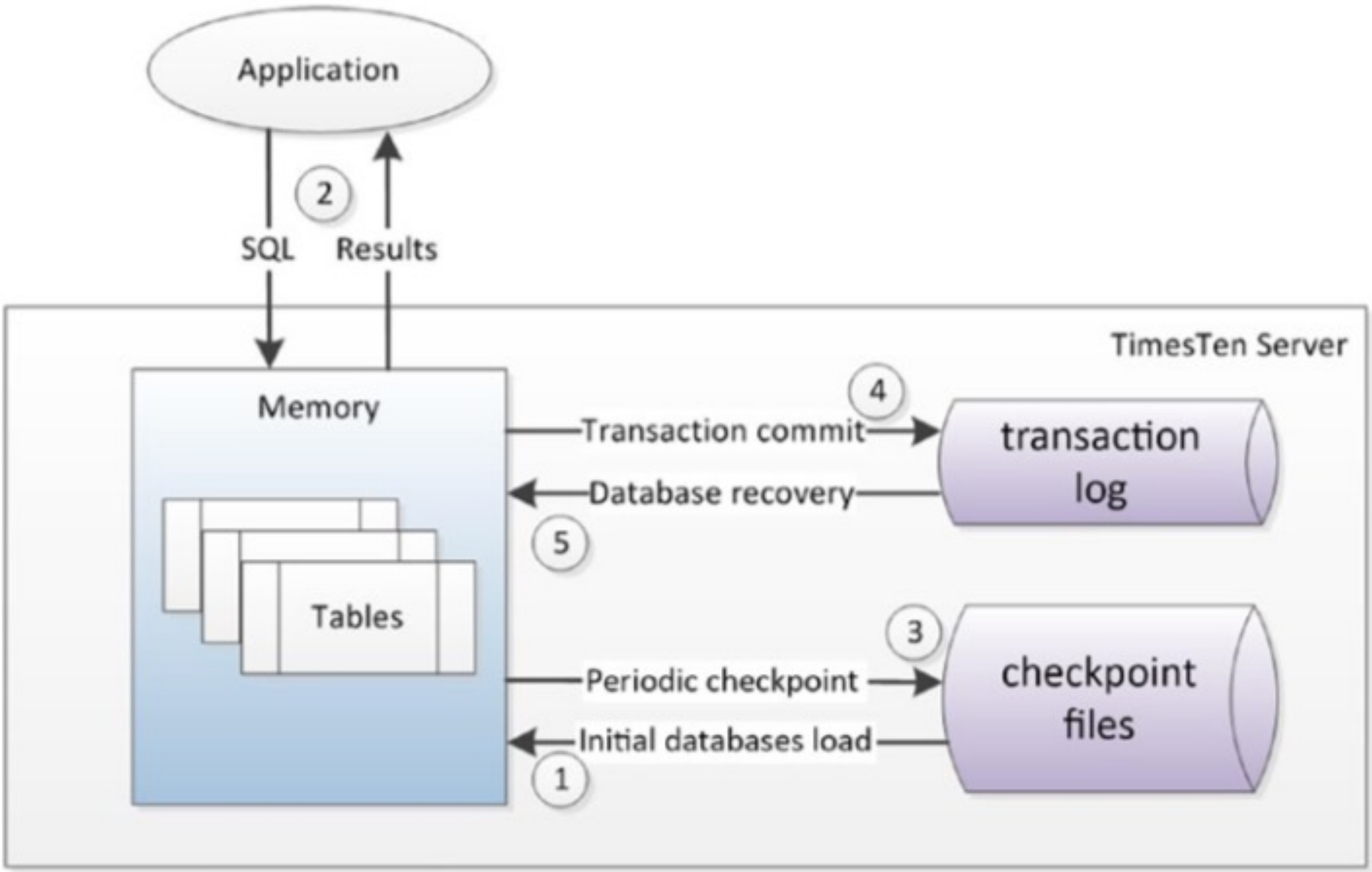
All data is ***memory resident.***

Persistence is achieved by writing:

- ***periodic snapshots*** of memory to disk
- ***transaction log*** following transaction commits.

By default, the disk writes are asynchronous! To ensure ACID transactions the database can be configured for synchronous writes to a transaction log after each write (performance loss).

TimesTen Architecture



Redis: Main Features

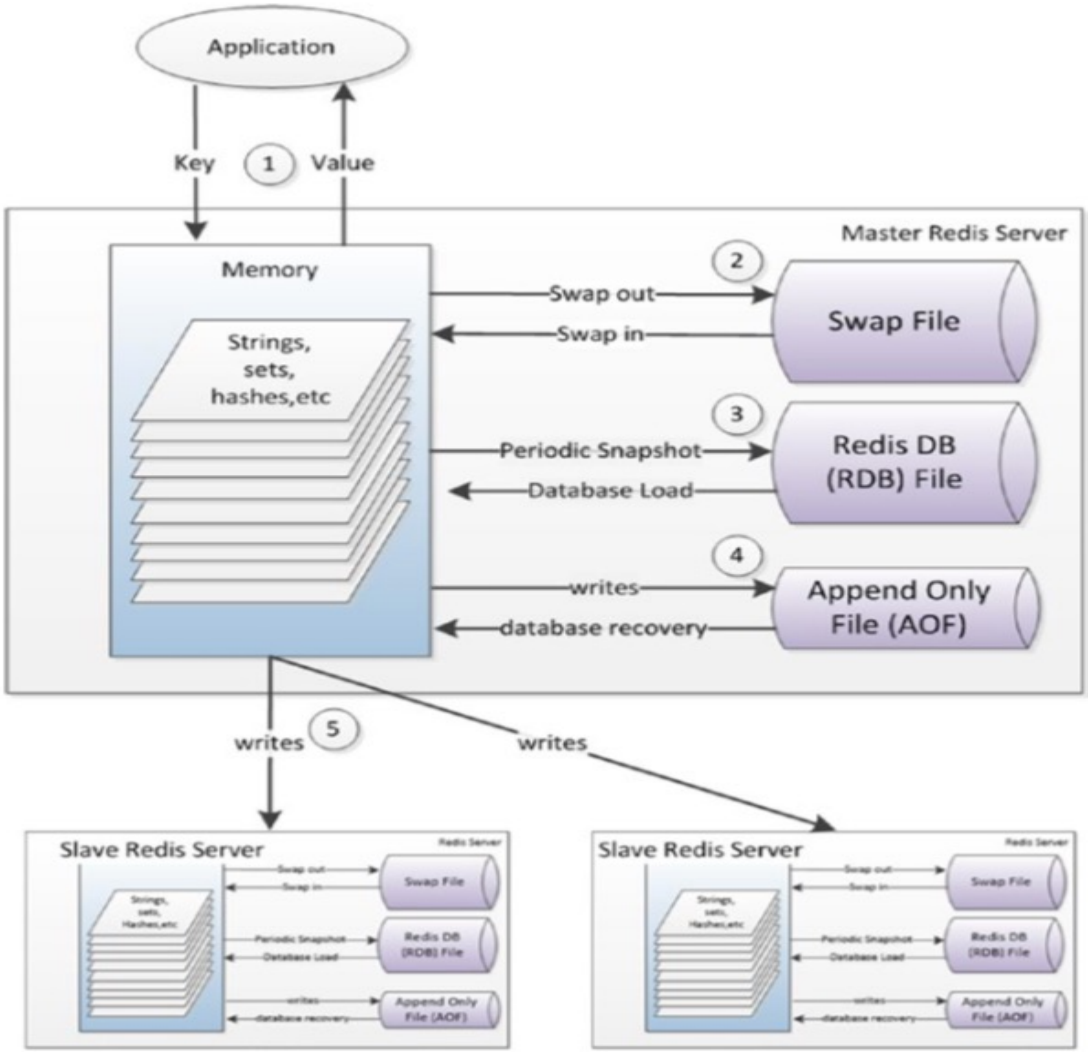
Redis is an in-memory ***key-value*** store.

Objects consist mainly of strings and various types of collections of strings, such as ***lists*** and ***hash maps***.

Only ***primary key*** lookups are supported (***special attention should be paied for managing secondary indexing***).

Redis may exploit a sort of "***virtual memory***" (***deprecated***) mechanism for storing an amount of data larger than the server memory. Old keys are ***swapped out*** to the disk and recovered if needed (***lost of performance***).

Redis: Architecture



Redis supports asynchronous master/slave ***replication***.

If ***performance is very critical*** and ***some data loss*** is acceptable, then a replica can be used as a backup database

In this case, the master is configured with ***minimal disk-based persistence***.

Redis may replicate the state of the master database asynchronously to slave Redis servers.

HANA DB (an SAP product)

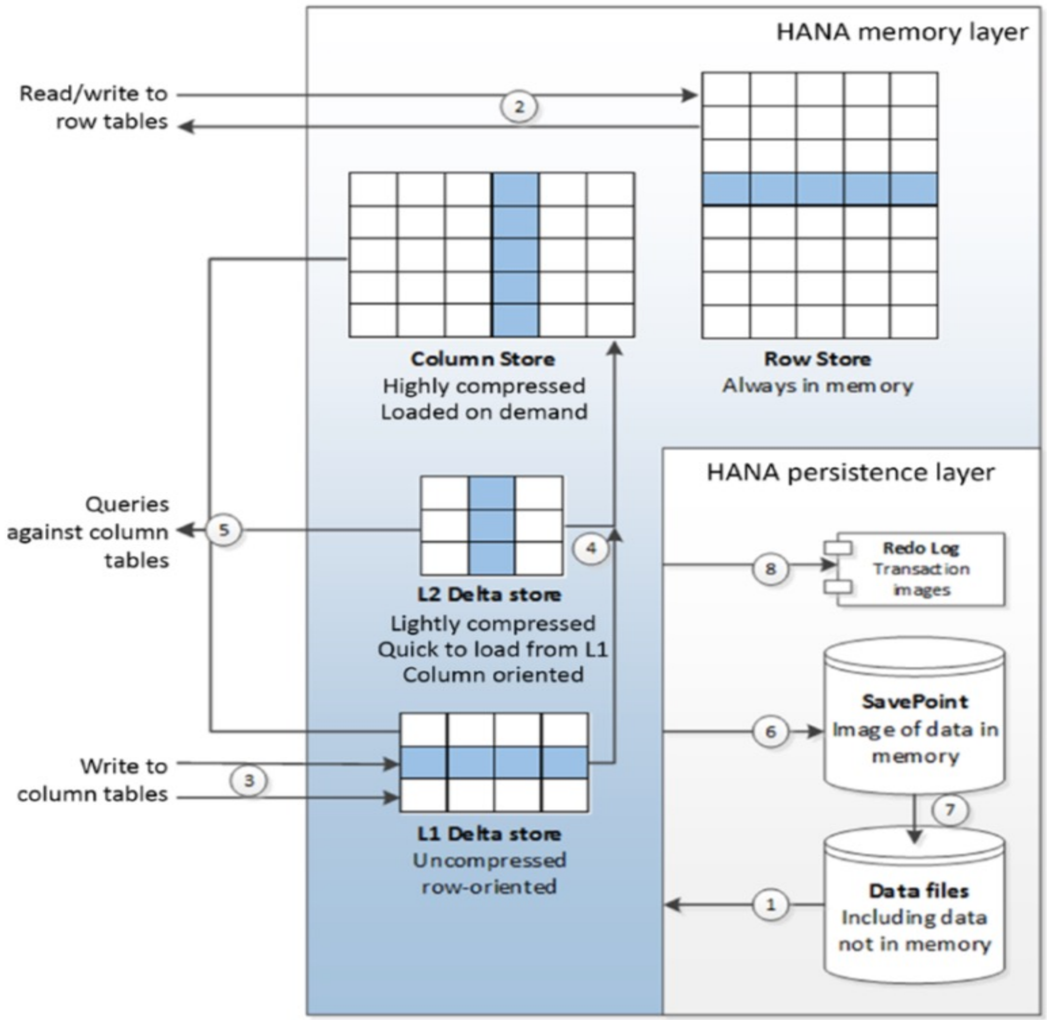
SAP HANA is ***a relational database*** which combines an ***in-memory*** technology with a ***columnar*** storage solution.

It must be installed on an ***optimized hardware configuration***.

Classical ***row tables*** are exploited for ***OLTP*** operations and are stored ***in memory***.

Columnar tables are often used for also ***OLAP*** operations. By default, they are ***loaded in memory by demand***. However, the database may be configured to load in memory a set of columns or entire tables since the beginning.

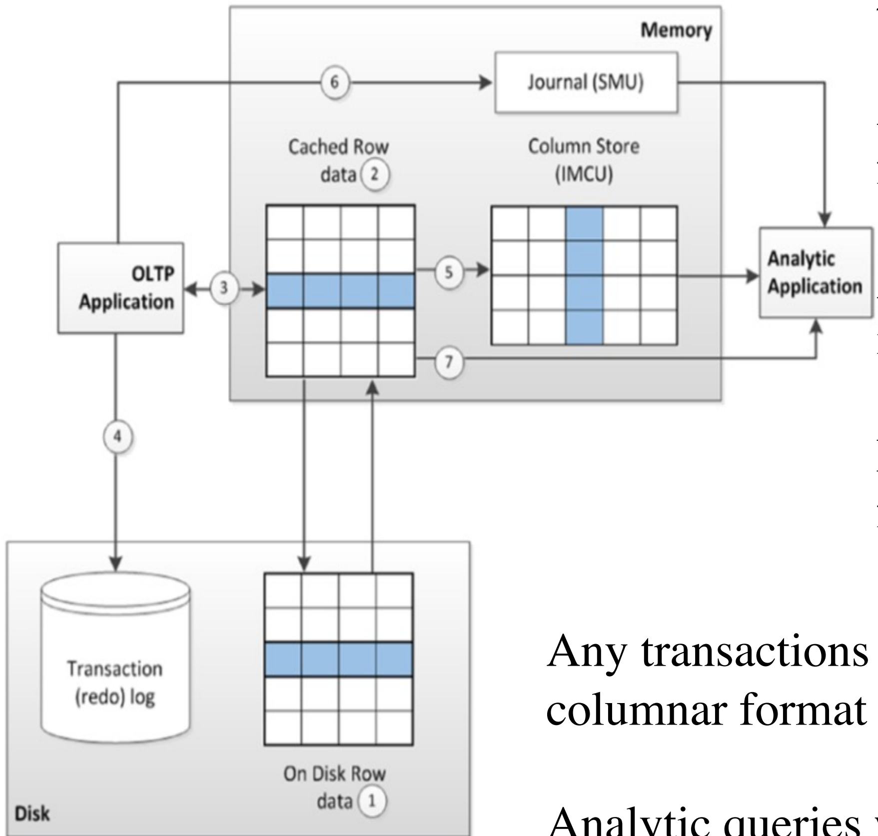
HANA DB: Architecture



Persistence:

- Images of memory are copied to save points periodically (6)-
- The save points are merged with the data files in due course (7).
- When a commit occurs, a transaction record is written to the redo log (8) (on fast SSD).

Oracle 12c: Architecture



Data is maintained in disk files (1), but ***cached in memory*** (2).

An *OLTP* application primarily reads and writes from memory (3),

Any ***committed transactions*** are written immediately to the transaction log on disk (4).

Row data is loaded into a ***columnar representation*** for use by ***analytic applications*** (5).

Any transactions that are committed once the data is loaded into columnar format are ***recorded in a journal*** (6),

Analytic queries will ***consult the journal*** to determine if they need to read updated data from the row store (7) or to rebuild the columnar structure.

Suggested Readings

Chapter 7 of the book *"Guy Harrison, Next Generation Databases, Apress, 2015"*

Images

All the images used in this presentation have been extracted from:

Chapter 7 of the book “*Guy Harrison, Next Generation Databases, Apress, 2015*”