

Advanced Databases

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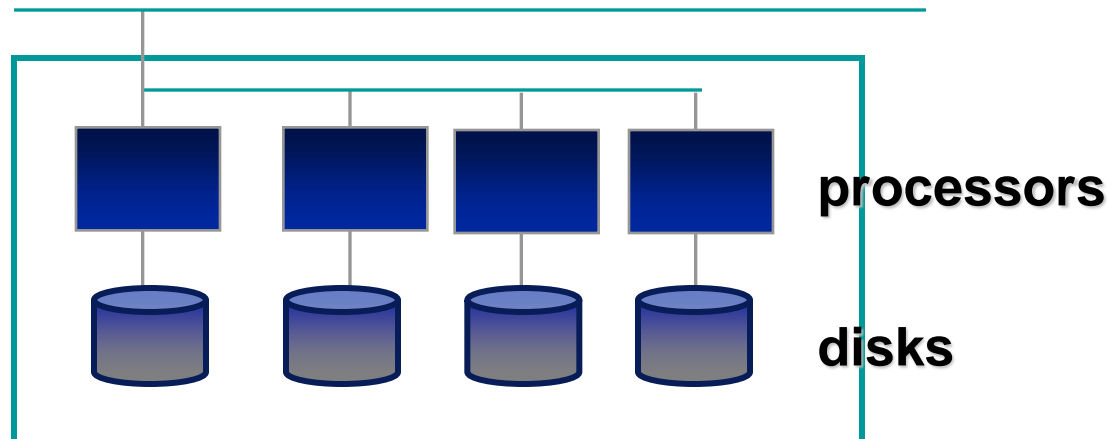
Parallel & Replicated Databases

Using Parallelism within the Servers

- Multiprocessor machines
- Identical computation on each processor
- Goal: increasing performances

➔ **PARALLEL DATABASE**

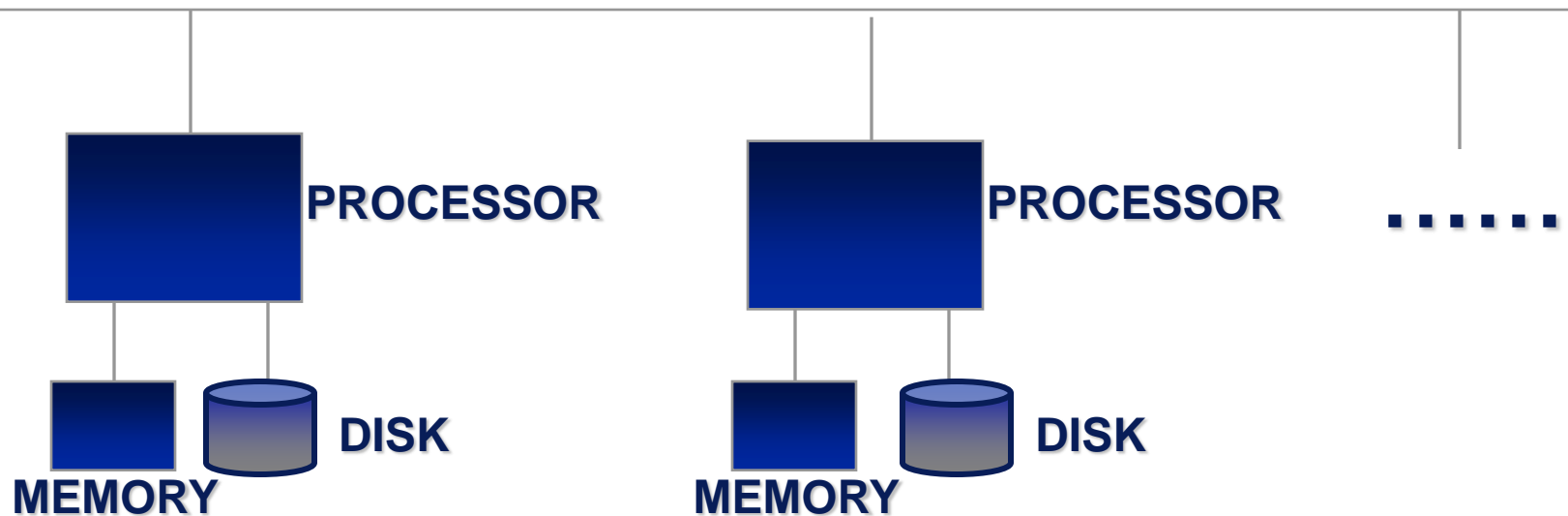
**Database server
With parallelism**



Architecture comparison

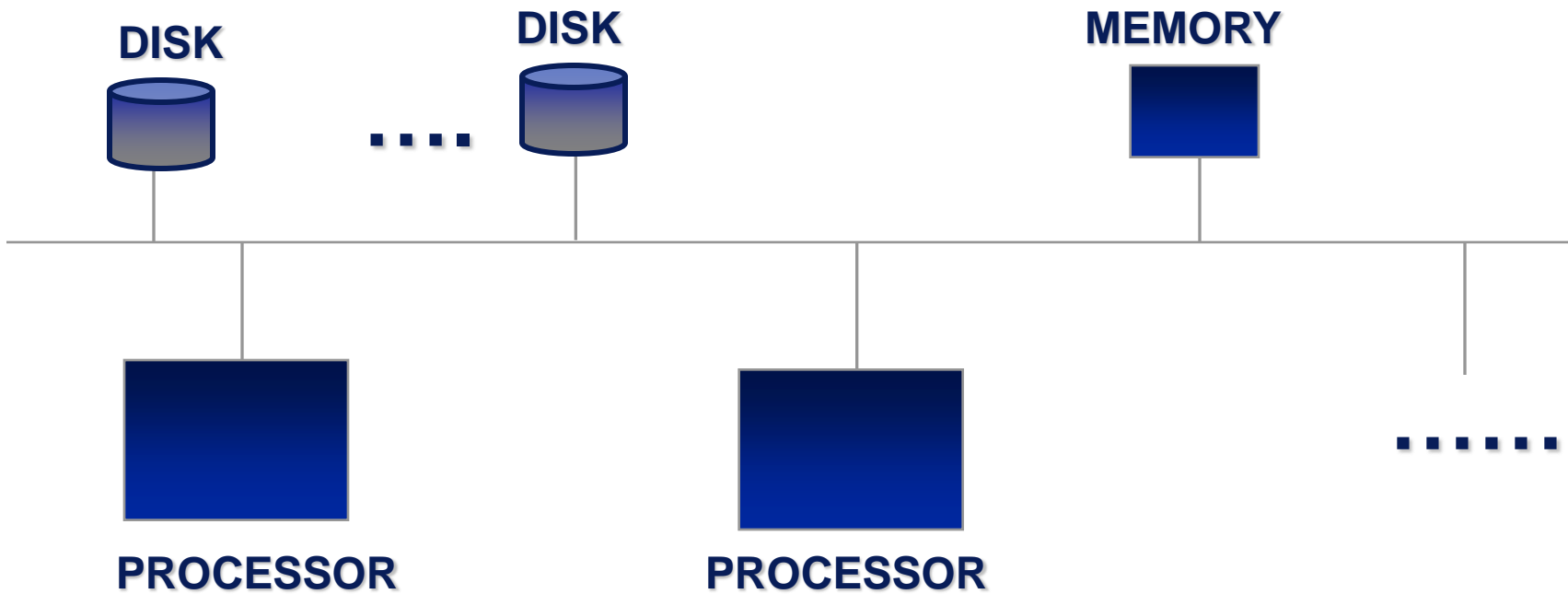
SHARED-NOTHING

Fast network



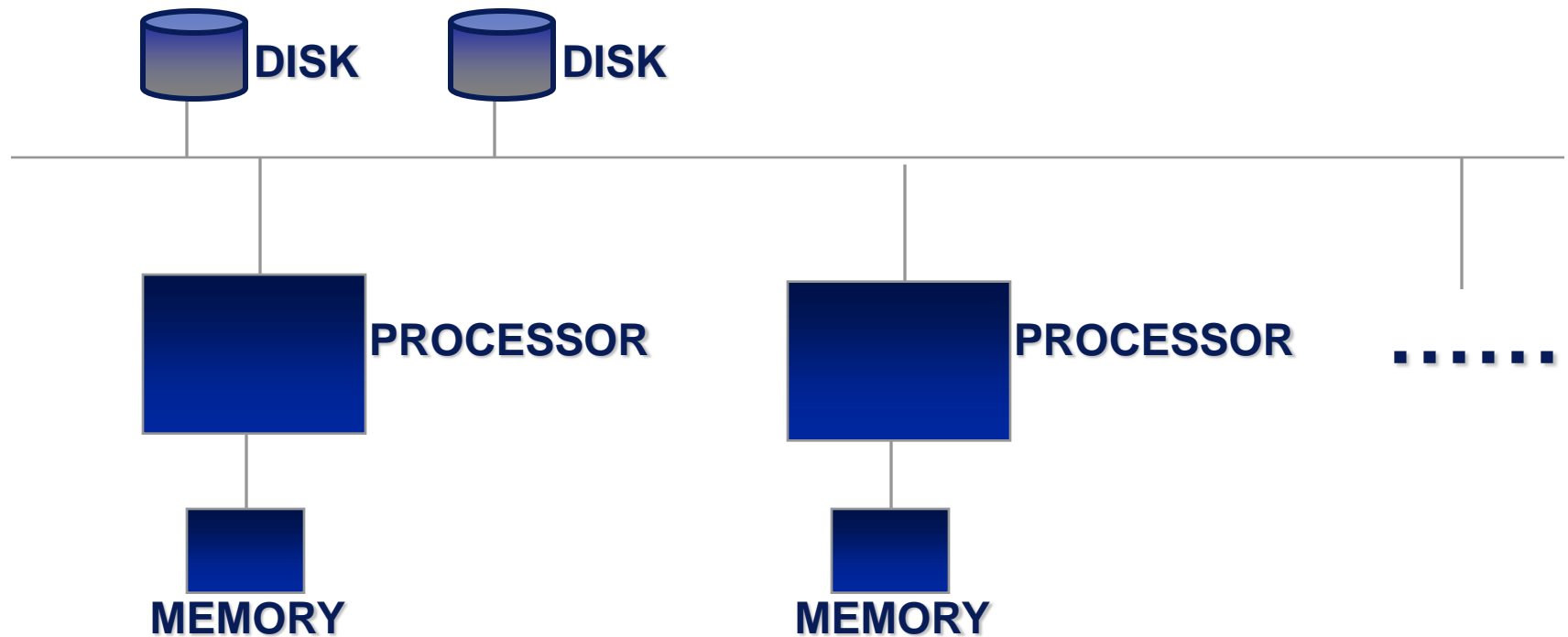
Architecture comparison

SHARED-MEMORY



Architecture comparison

SHARED-DISKS



Application scalability

- **Load:** set of all the applications (queries)
- **Scalability:** capability of a system to increase performance under an increased load
- **Load growth dimensions:**
 - Number of queries
 - Complexity of queries

Two Load Types

- Transactional
 - Load: short transactions
 - Measure: tps (transactions per second)
 - Response time: few seconds
- Data analysis
 - Load: complex SQL query
 - Response time: variable

Parallelism

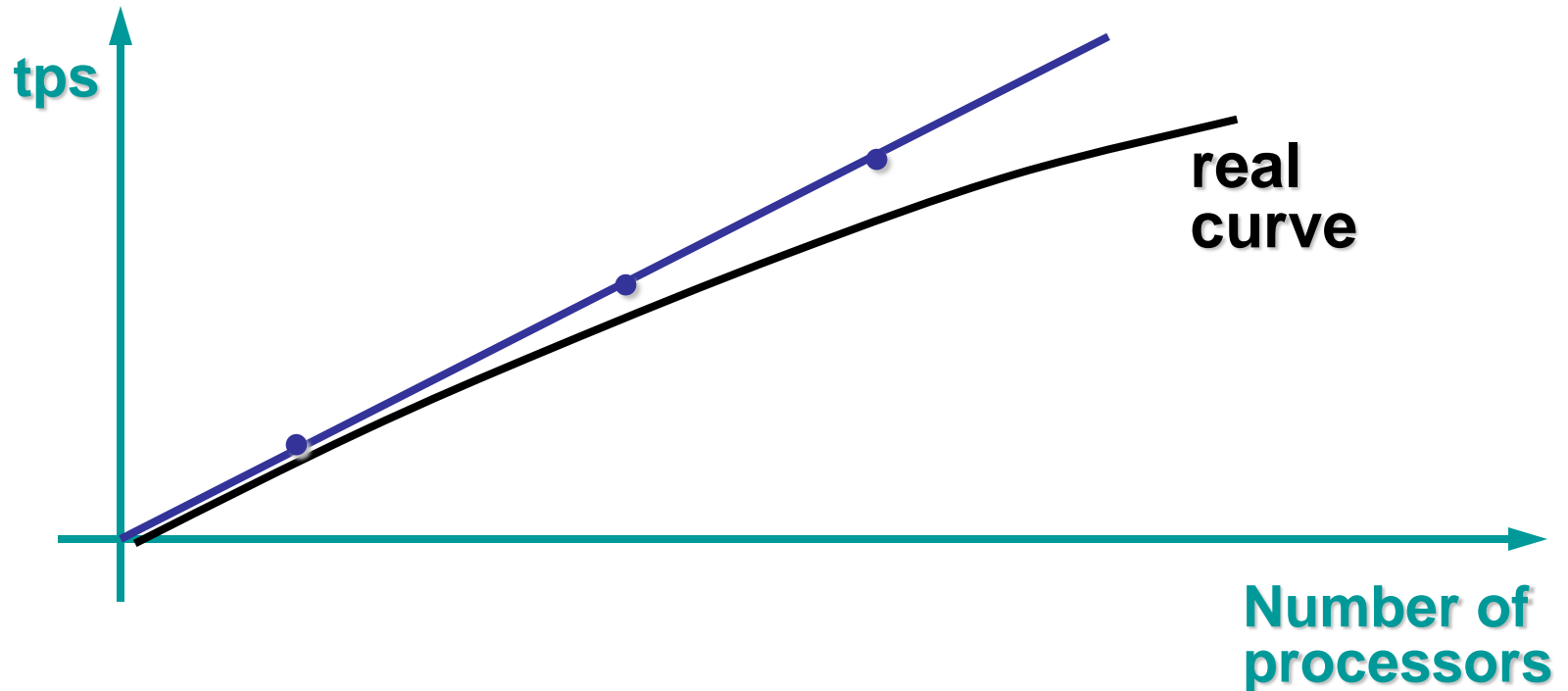
- Obtained through several cooperating processors, installed in a single system architecture
- Two types of parallelism:
 - **Inter-query:** each query is performed by a single processor (for transactional loads)
 - **Intra-query:** each query is performed by several processors (for data analysis loads)

Benchmark

- Methods for comparing performances of different (competing) systems
- Standardization
 - Of the Database
 - Of the load
 - Code of the transactions
 - Transmission
 - Frequency
 - Of the measuring conditions
- Different load types
 - Tpc-a: transactional
 - Tpc-b: mixed
 - Tpc-c: data analysis

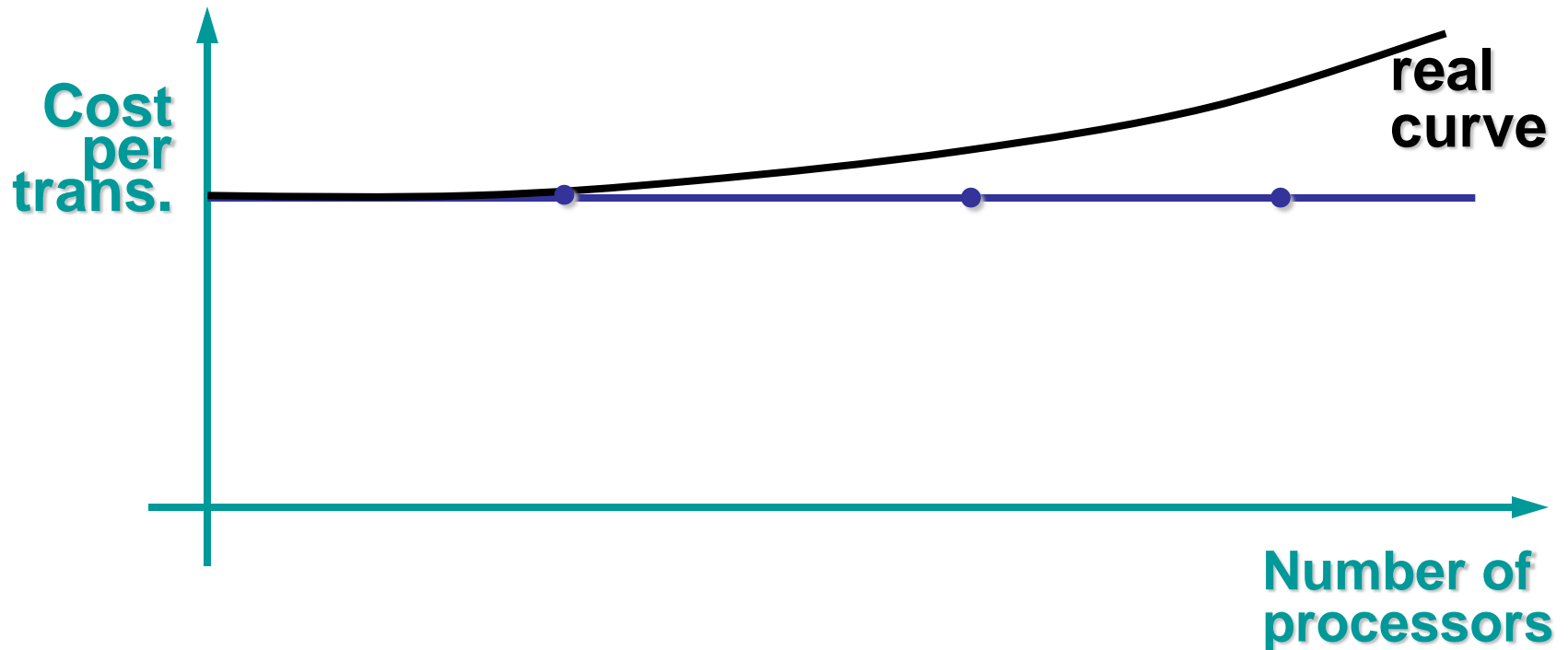
Speed-up curve

- Measures the increase of efficiency wrt the increasing number of processors



Scale-up curve

- Measures the total cost per transaction wrt the increasing number of processors



Distributed Join

- The most expensive distributed data analysis operation
- Let's consider:

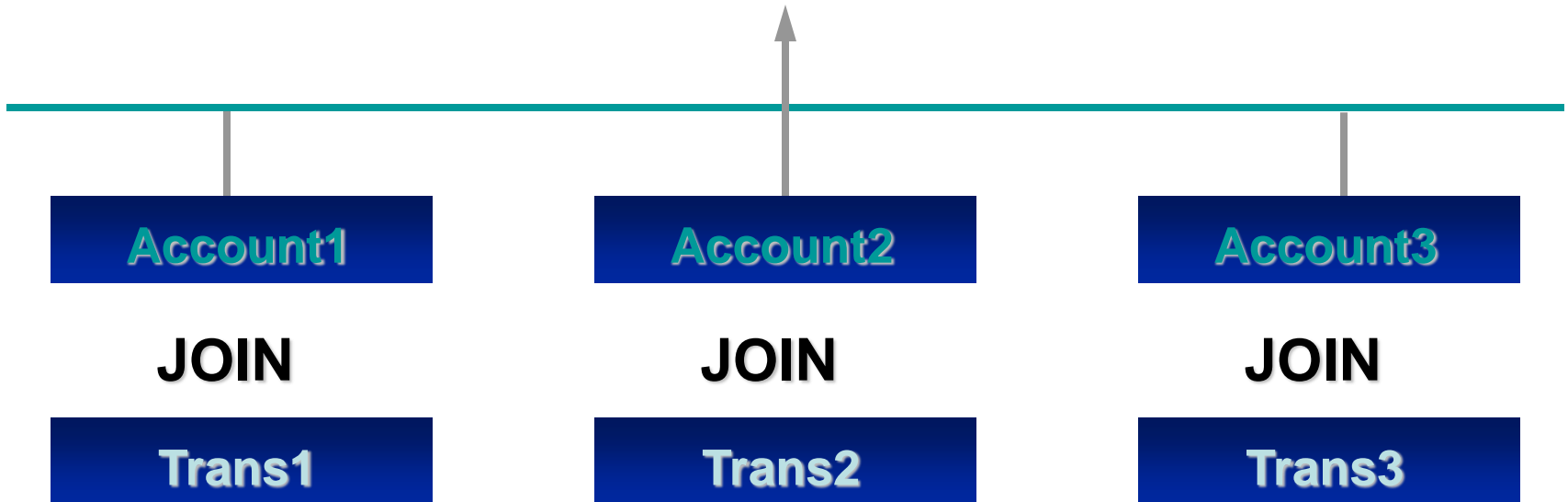
Account

Transaction

JOIN

Distributed Join

UNION



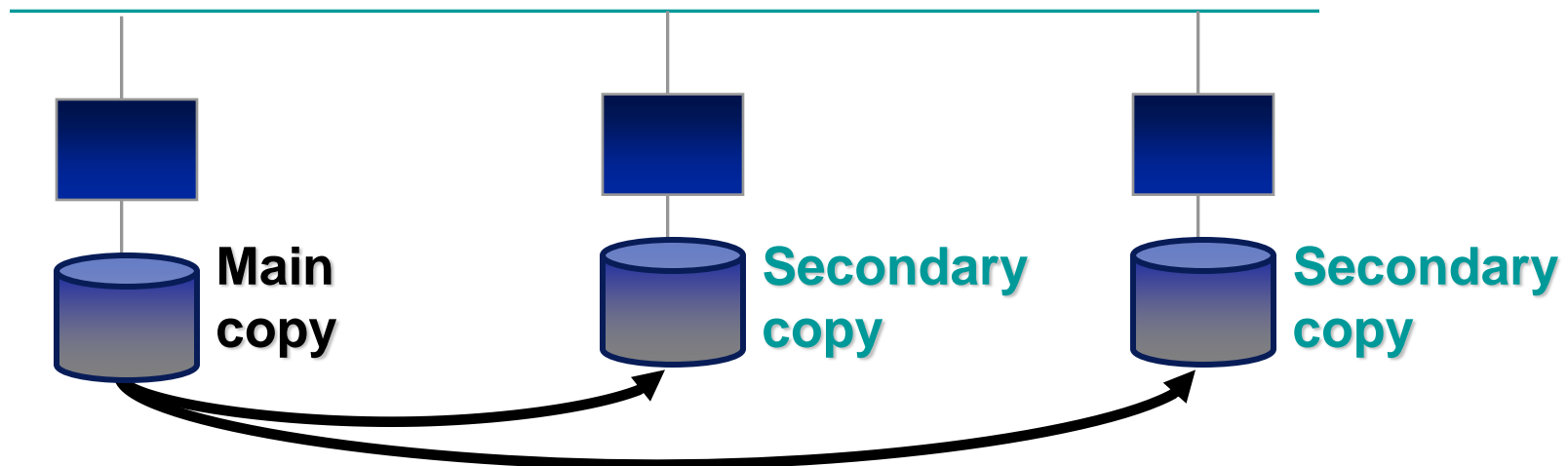
Requirements for Distributed Join

- The domains of the join attributes must be partitioned and each partition must be assigned to a couple of fragments
- **Example:** for numeric values between 1 and 30,000:
 - Partition 1 to 10,000
 - Partition 10,001 to 20,000
 - Partition 20,001 to 30,000
- Some parallel systems distribute the data on the disks at the beginning, to obtain this distribution

Data Replication

- Motivation:
 - Higher availability, efficiency, reliability,
 - Different data management

➔ Replicated Databases

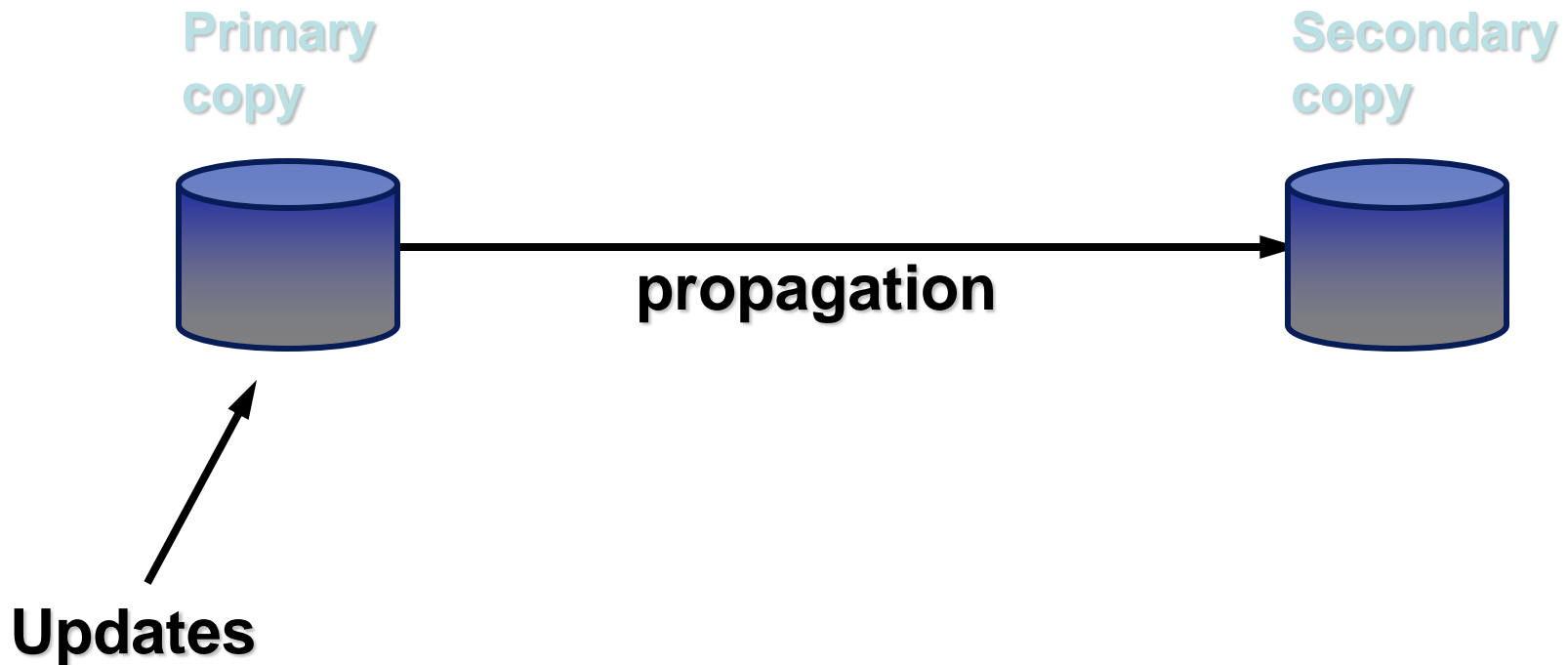


Data Replication

- A fundamental ingredient in information systems
- Motivations:
 - Efficiency
 - Reliability
 - Autonomy

Replication Methods

- Asymmetric Replication



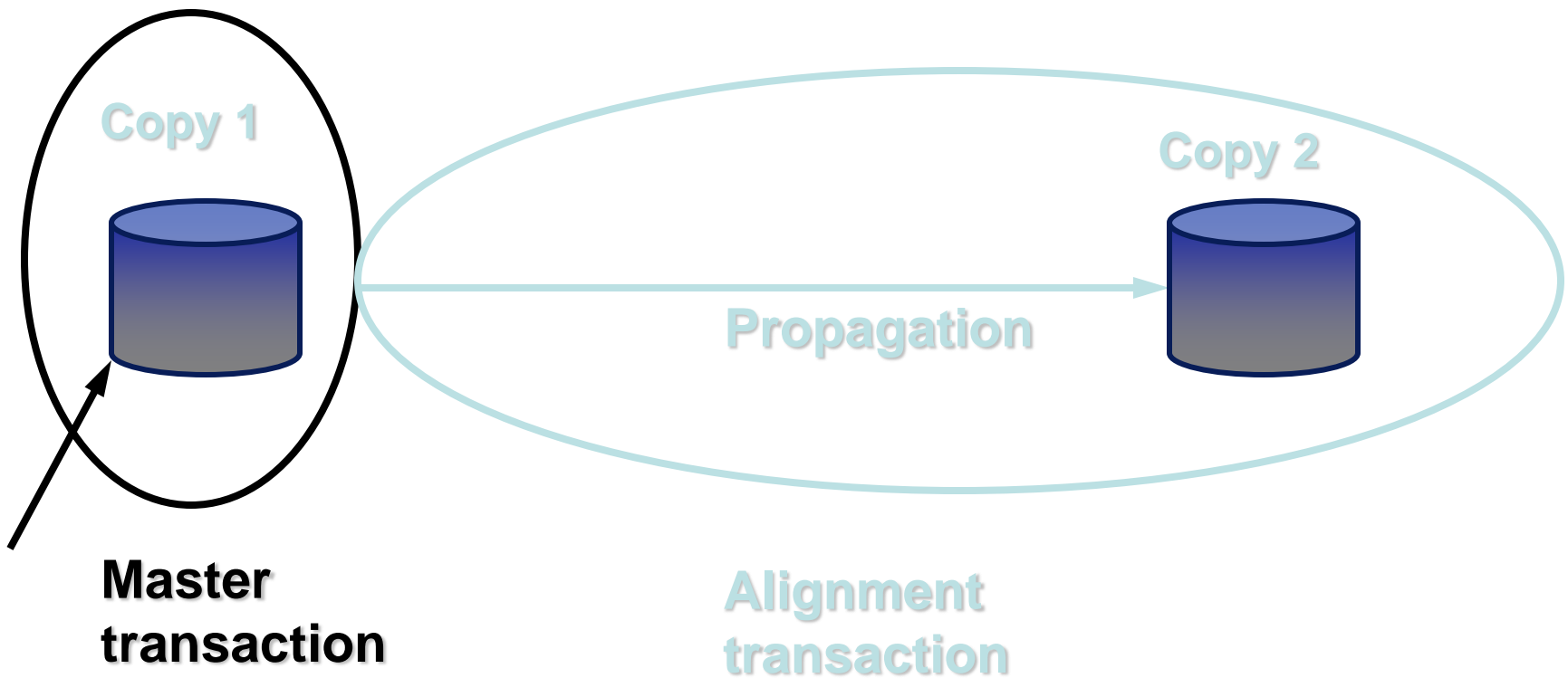
Replication Methods

- Symmetric replication



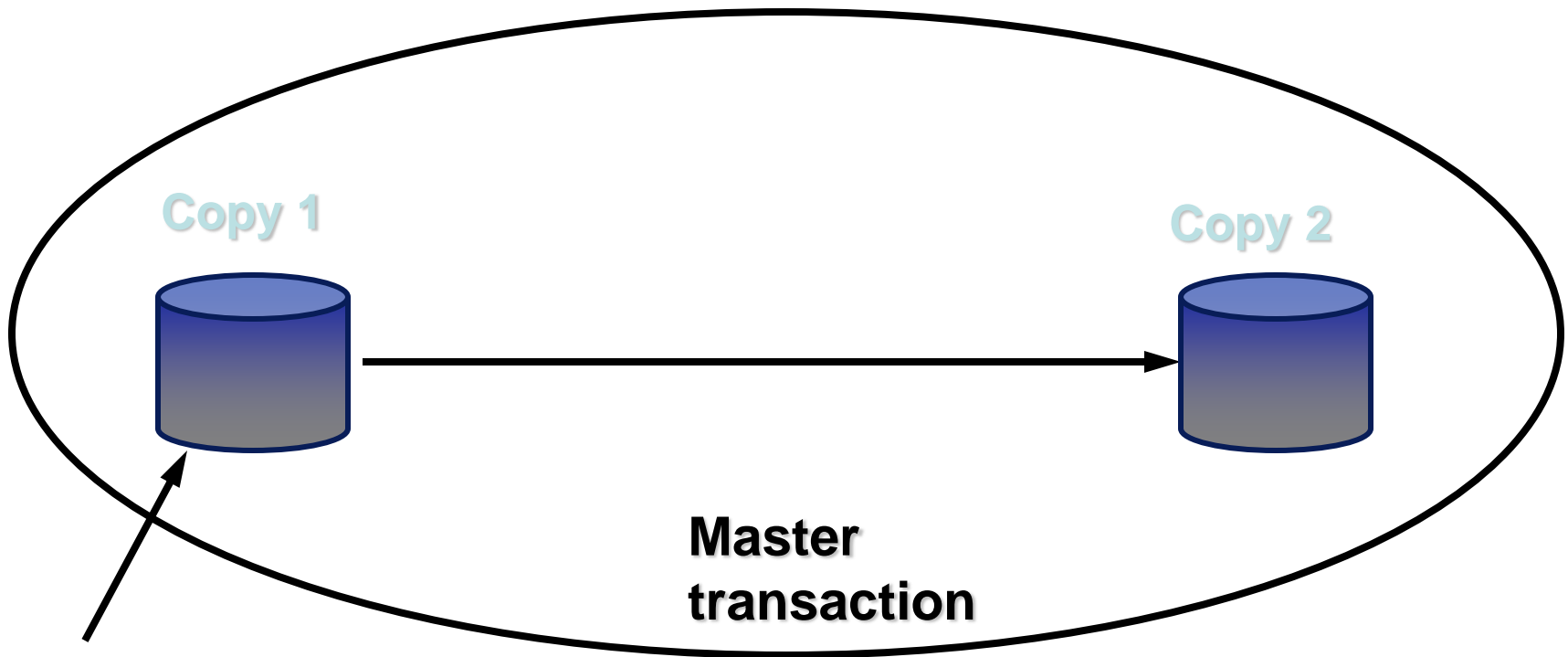
Transmission of Updates

- Asynchronous transmission



Transmission of Updates

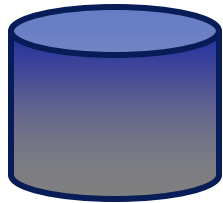
- Synchronous transmission



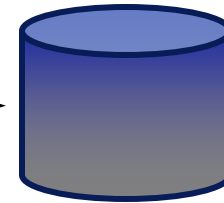
Alignment Techniques

- Refresh

Copy 1



Copy 2

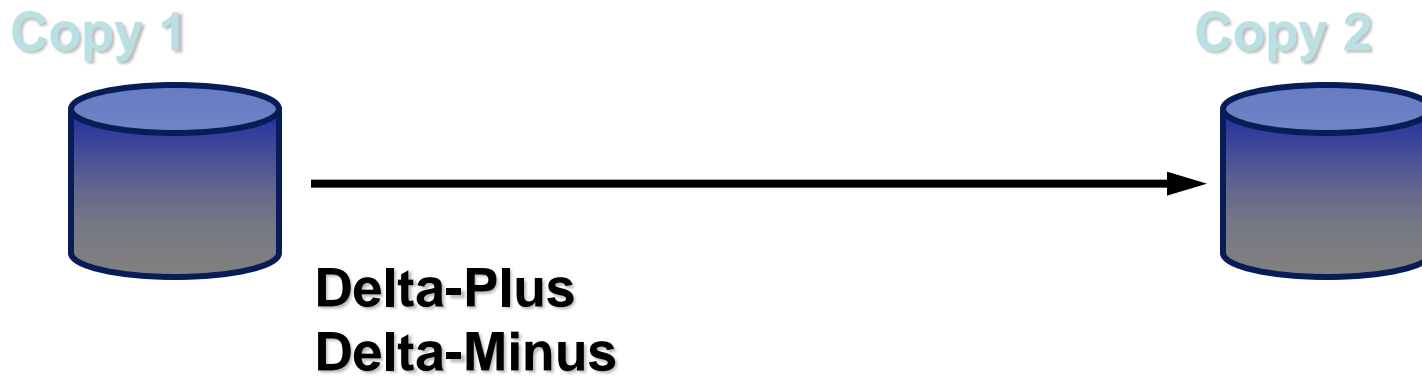


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- Alignment can be:
 - Periodic
 - On command
 - On update accumulation

Alignment Techniques

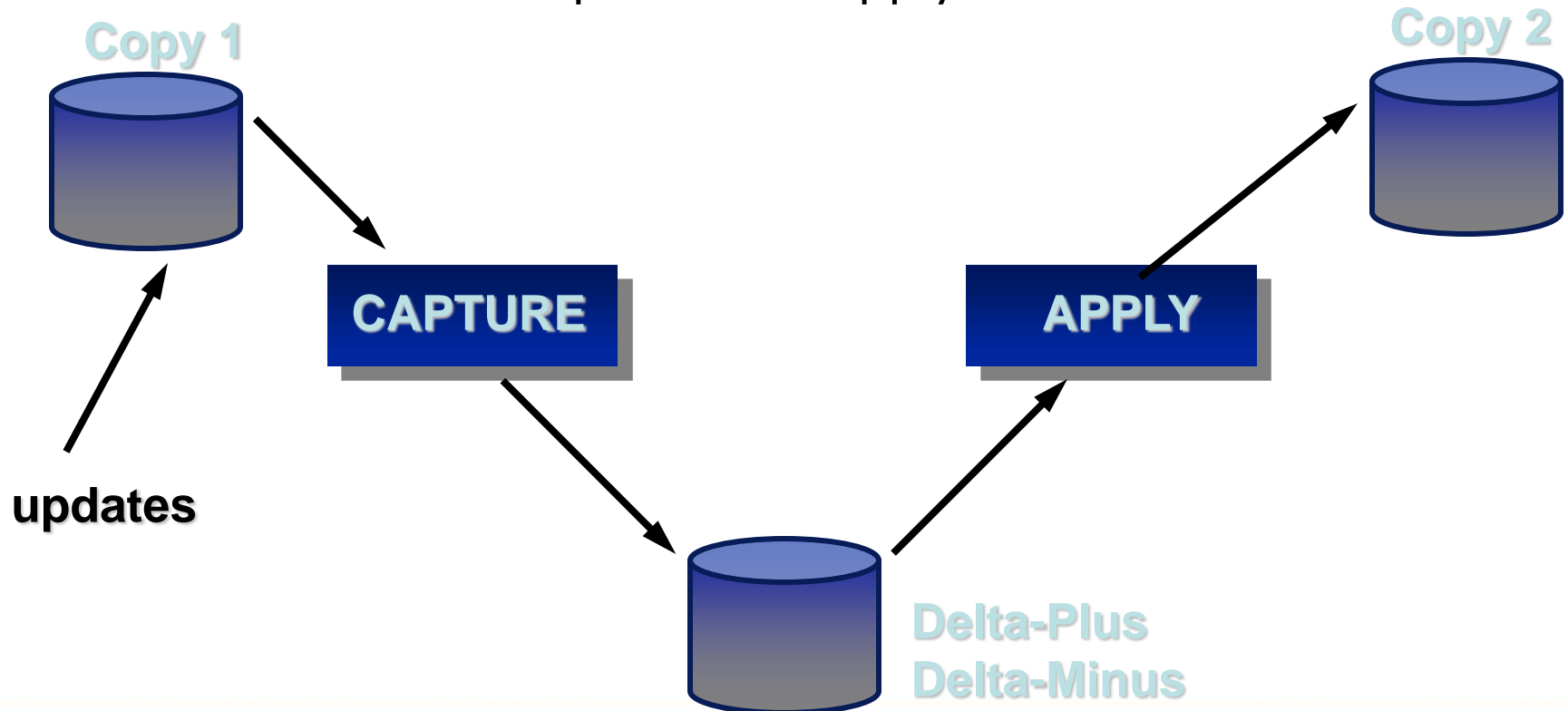
- Incremental



- Alignment can be:
 - Periodic
 - On command
 - On update accumulation

Replication Mechanisms

- asymmetric, asynchronous, incremental
- Product: [Replication Manager](#)
- Two modules: Capture and Apply



Replication Triggers

- Capture data variations within the tables Delta-Plus and Delta-Minus, transparently wrt the applications
- This technique was initially used to support replication, currently most systems prefer extracting deltas from logs and not from the database

Replication Triggers

```
CREATE TRIGGER Capture-Ins  
AFTER INSERT ON PRIMARY  
FOR EACH ROW  
INSERT INTO Delta-Plus VALUES (NEW.*)
```

```
CREATE TRIGGER Capture-Del  
AFTER DELETE ON PRIMARY  
FOR EACH ROW  
INSERT INTO Delta-Minus VALUES (OLD.*)
```

```
CREATE TRIGGER Capture-Upd  
AFTER UPDATE ON PRIMARY  
FOR EACH ROW  
BEGIN  
    INSERT INTO Delta-Plus VALUES (NEW.*)  
    INSERT INTO Delta-Minus VALUES (OLD.*)  
END
```

A Special Case: Replication in Mobile Computers

- Mobile computers: occasionally connected to the network
- Copies can be disconnected for hours or even days, then reconnected (reconciliation)
- Example Application: mobile sales agents

Disconnected Copies Re-alignment

- Often requires symmetric replication

