DASFAA 2011 Panel on
Challenges in Managing and Mining Large, Heterogeneous Data

# NoSQL vs. Parallel DBMS for Large-scale Data Management

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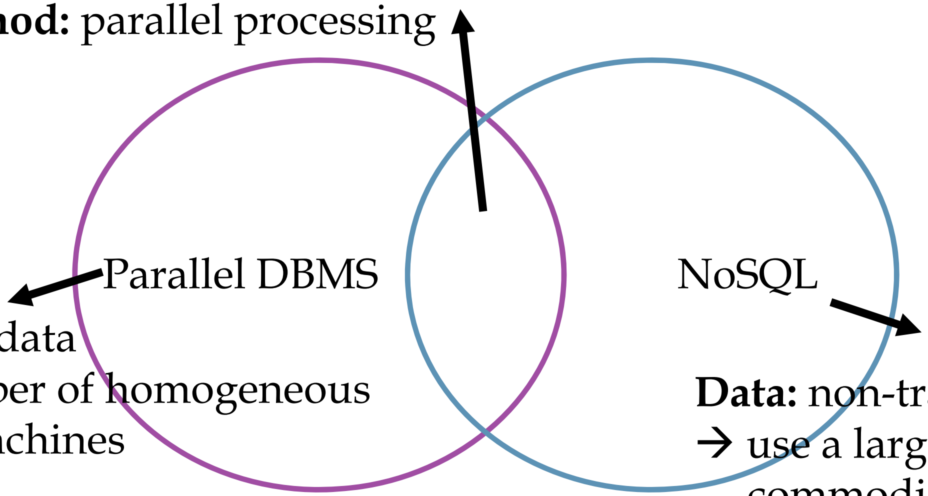
# NoSQL vs. Parallel DBMS

- NoSQL systems
  - Description
    - "Non-relational, distributed data stores that often did not attempt to provide ACID guarantees" [Wik11]
    - e.g., GFS, BigTable, MapReduce

- Parallel DBMSs
  - Description
    - "Systems attempt to exploit recent multiprocessor computer architectures in order to build a high-performance and high-availability database server" [Val93]
  - Classification
    - Shared memory architecture
    - Shared disk architecture
    - Shared nothing architecture

**Common Goal:** handling large-scale data management and processing
**Method:** parallel processing



Parallel DBMS

NoSQL

**Data:** transactional data
→ use a small number of homogeneous and powerful machines

**Data:** non-transactional data
→ use a large number of heterogeneous commodity machines

| data type | characteristics | consistency requirement | relevant strategy |
|---|---|---|---|
| transactional data | We assume relationship exists among items<br>An operation involves multiple data items | two-phase commit | a parallel DBMS with a small number of machines |
| non-transactional data | We assume no relationship among data items | eventual consistency | a NoSQL system with a large number of machines |

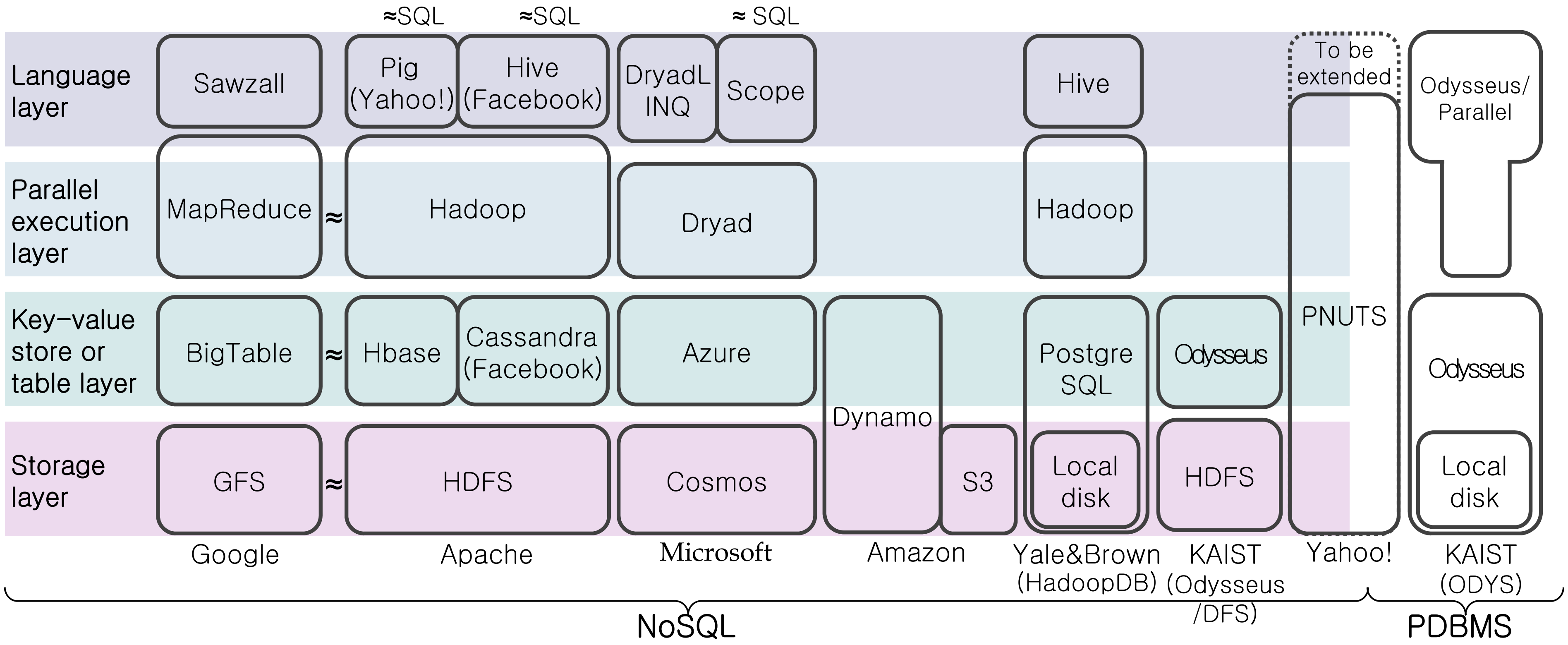
# NoSQL Systems vs. Parallel DBMSs

- NoSQL systems (e.g., Hadoop[Had])
  - Advantages
    - highly scalable
    - highly fault tolerant
    - inexpensive
    - easy to setup and use
  - Disadvantages
    - Weak functionalities
      - SQL
      - schemas
      - Indexes
      - query optimization
      - transactions

- Parallel DBMSs (e.g., Vertica[Ver])
  - Advantages
    - Strong functionalities
      - SQL
      - schemas
      - indexes
      - query optimization
      - transactions
  - Disadvantages
    - difficult to scale
    - expensive
    - not suitable where faults occur frequently
    - hard to setup and use

# Map of NoSQL systems

- Layers of NoSQL
  - Storage layer: replicated distributed storage for large-scale data
  - Key-value store or table layer: data storage storing data in the form of key-value pairs or tables
  - Parallel execution layer: parallel processing systems
  - Language layer: query interfaces



| | Google | Apache | | Microsoft | | Amazon | | Yale&Brown (HadoopDB) | KAIST (Odysseus /DFS) | Yahoo! | KAIST (ODYS) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Language layer | Sawzall | ≈SQL<br>Pig (Yahoo!) | ≈SQL<br>Hive (Facebook) | DryadLINQ | ≈ SQL<br>Scope | | | Hive | | To be extended | Odysseus/ Parallel |
| Parallel execution layer | MapReduce ≈ | Hadoop | | Dryad | | | | Hadoop | | PNUTS | |
| Key-value store or table layer | BigTable ≈ | Hbase | Cassandra (Facebook) | Azure | | Dynamo | | Postgre SQL | Odysseus | | Odysseus |
| Storage layer | GFS ≈ | HDFS | | Cosmos | | | S3 | Local disk | HDFS | | Local disk |

<Map of NoSQL systems> (modified & extended from [Bud09])

# Research Challenges

- [Goal] Building large-scale systems that have the best of both worlds, i.e., high scalability, fault tolerance, and rich functionality on cheap hardware
- [NoSQL ➔ PDBMS] Supporting DBMS features including SQL, schemas, indexes, query optimization, and transactions in NoSQL systems
  - Language layers
    - DryadLINQ [YIF+08], Hive [TSJ+09], Pig [ORS+08], Scope [CJL+08]
  - Join, iteration [DQJ+10] [WSS+10] [VCL10] [YDHP07] [BHBE10]
- [PDBMS ➔ NoSQL] Achieving high scalability and high fault tolerance in Parallel DBMSs
  - HadoopDB [ABA+09]
  - GreenPlum [Waa09]
  - PNUTS [CRS+08]
  - NoSQL-style fault tolerance [YYTM10]
  - ODYS – a parallel DBMS with limited functionality (shared nothing) [Wha09] (KAIST)
- Supporting random read and write operations in append-only distributed file systems
  - BigTable [CDG+06](Google), HBase[Had] (open source), Megastore[FKL+08] (Google)
  - Odysseus/DFS: a relational DBMS on top of the distributed file system (HDFS) [Kan11] (KAIST)

# Projects at KAIST

- ODYS: a Massively-Parallel Search Engine [Wha09]
  - Building a massively-parallel DBMS using a DB-IR tightly-integrated DBMS can be an attractive alternative to a specialized search engine
    - A parallel DBMS with limited functionality
      - limited join
      - single-node transactions
    - Based on DB-IR tight integrated DBMS
    - Performance comparable to or better than those of large-scale commercial search engines
    - Scalability
    - A massively-parallel configuration possible (e.g., 300 nodes for indexing 30 billion Web pages)

- Odysseus/DFS: a Relational DBMS on Top of HDFS [Kan11]
  - Integrating a general-purpose relational DBMS rather than a key-value store (e.g., BigTable, Hbase) on top of a distributed file system (e.g., GFS, HDFS)
    - Comparable to BigTable
      - high scalability, fault tolerance, and load balancing of DFS
      - can be driven by MapReduce
    - Additional to BigTable
      - all the functionalities of the relational DBMS such as SQL, schemas, and indexes
    - Different from BigTable
      - relational table compared to key-value store

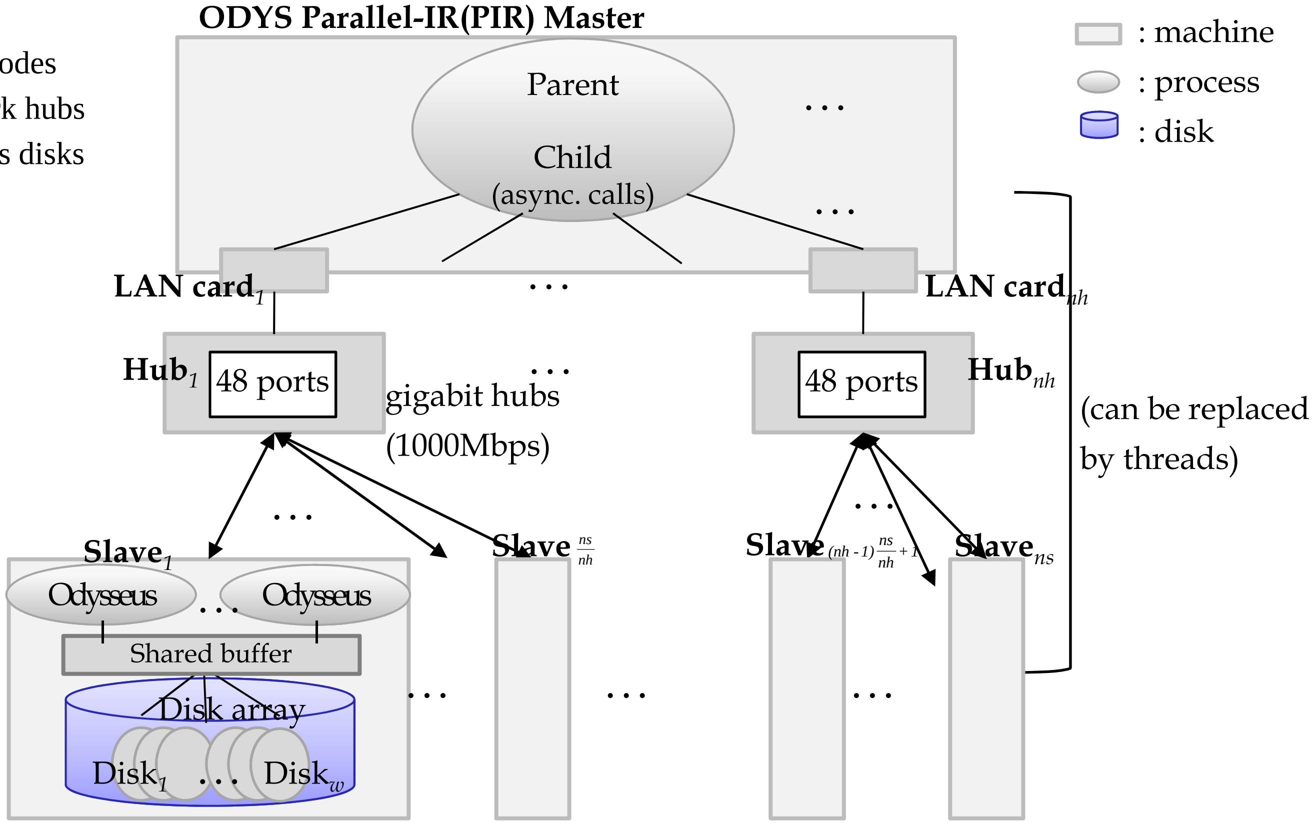
# A Massively-parallel Search Engine

- Building a massively-parallel search engine using a DB-IR tightly-integrated DBMS can be an attractive alternative to a specialized large-scale search engine such as Google
  - Efficiency : tight-coupling of DB and IR
  - Scalability: a massively-parallel configuration possible

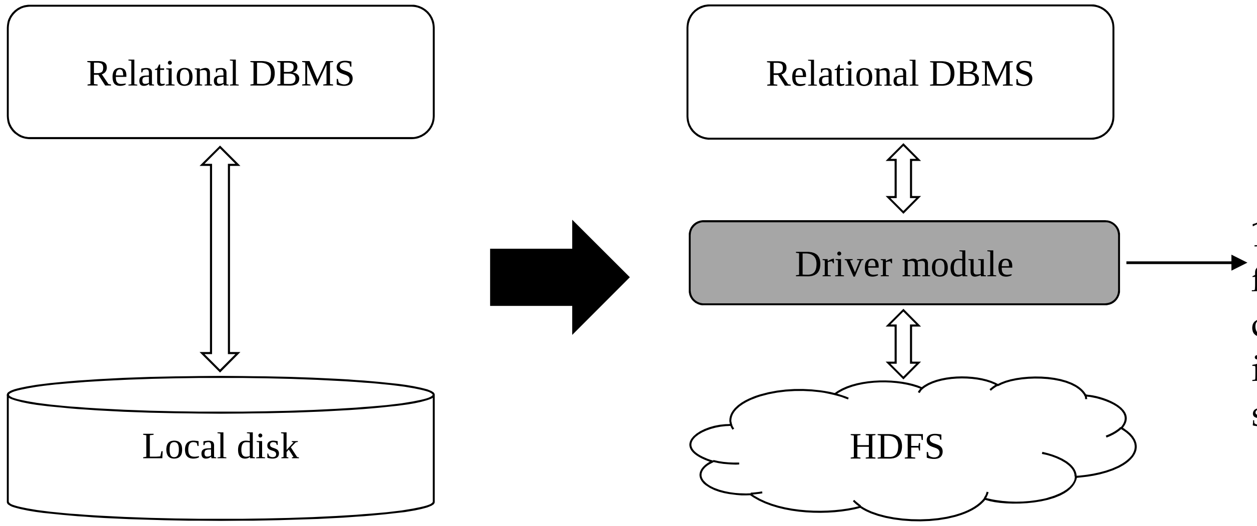
*ns*: the number of slave nodes

*nh*: the number of network hubs

*w*: the number of a slave's disks



# Odysseus/DFS: A Relational DBMS on top of HDFS

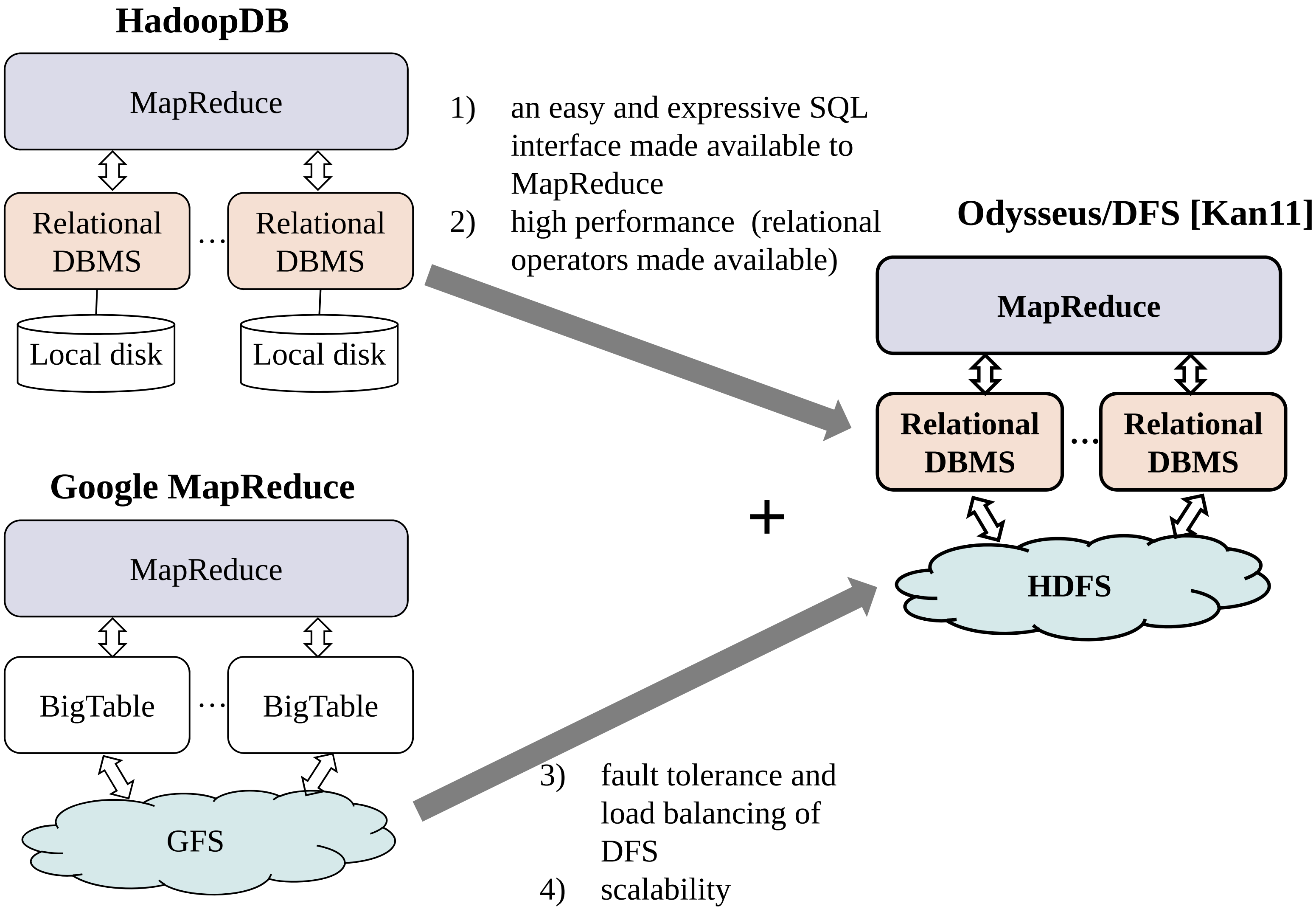


A relational DBMS on a local disk

A relational DBMS on HDFS

1. Make up for low functionality of HDFS compared to that of an O/S file, i.e., random as well as sequential read/write/update

# Parallelization of Architecture



**HadoopDB**

MapReduce

Relational DBMS … Relational DBMS

Local disk | Local disk

1) an easy and expressive SQL interface made available to MapReduce
2) high performance (relational operators made available)

**Google MapReduce**

MapReduce

BigTable … BigTable

GFS

+

**Odysseus/DFS [Kan11]**

**MapReduce**

**Relational DBMS** … **Relational DBMS**

**HDFS**

3) fault tolerance and load balancing of DFS
4) scalability
5) sharability

# Issues

No SQL vs. Parallel DBMS

- Best of both worlds

- What and How?

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