Mapping Data Warehouse to Multiprocessor Architecture

Relational Database Technology for Data Warehouse

- The data warehouse environment is pursuing two goals:
  - **Speed-up- ability to execute the same request on the any amount of data in less time**
  - **Scale-up – ability to obtain the same performance even if database size increases.**
- Parallel hardware architectures are based on Multiprocessor architectures designed as a **shared memory model (SMPs) shared-disk model, or a distributed-memory model (MPPs) and clusters of uniprocessors**

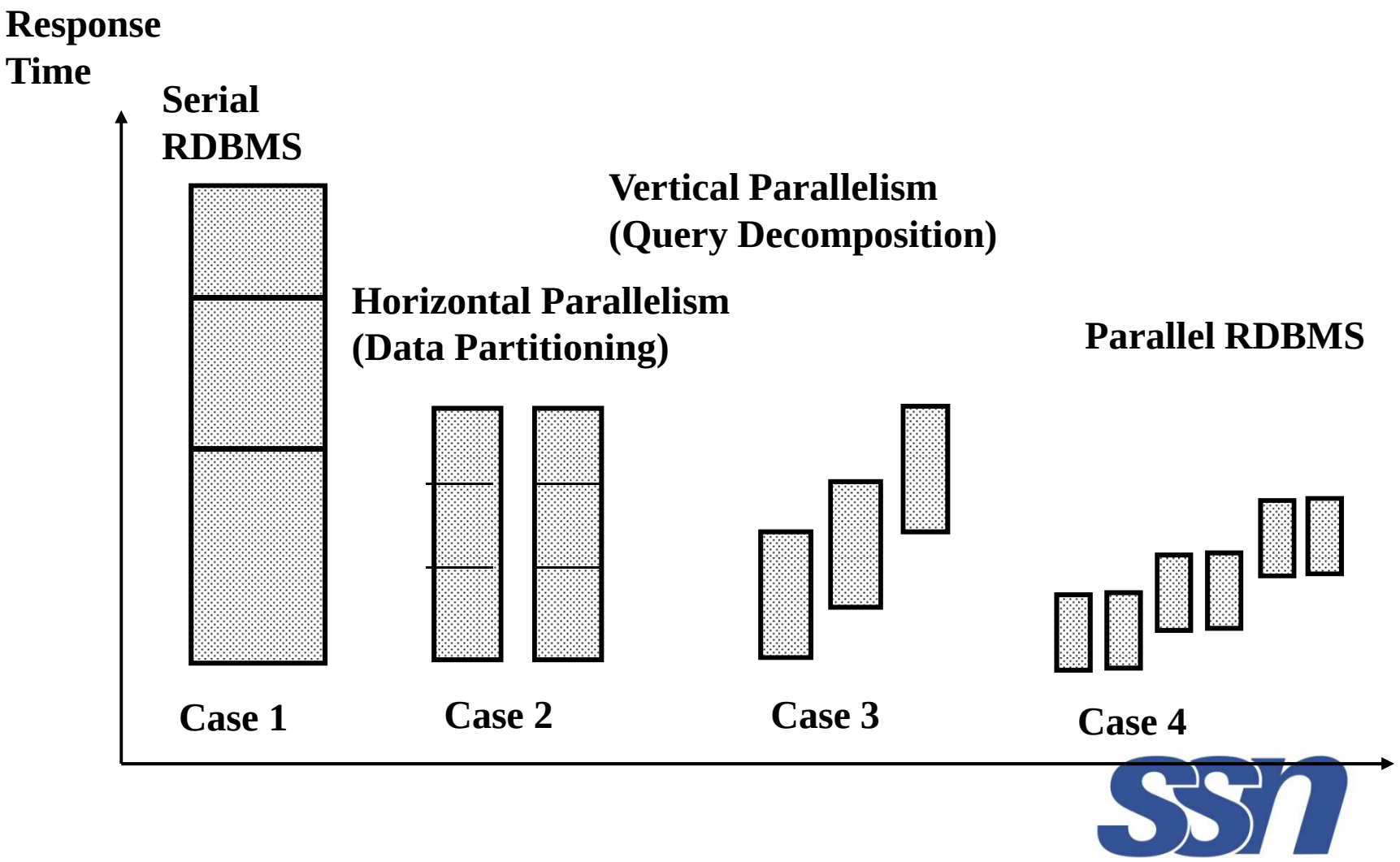
Types of Parallelism

- ***Interquery parallelism :*** *Different* threads (or process) handle multiple requests at the same time. Successfully implemented on the SMP systems.
- ***Intraquery parallelism – Decomposes the serial SQL query into lower-level*** operations such as scan, join, sort, and aggregation operations and they are executed concurrently in parallel.
- Intraquery parallelism can be done in either of two ways:

Types of Parallelism

- ***Horizontal parallelism:*** Database is partitioned across multiple disks, and parallel processing occurs within a specific task (table scan) that is performed concurrently on different sets of data.
- ***Vertical parallelism – All complex query operations are executed in parallel in*** a pipeline fashion.
  - An output from on tasks (e.g., scan) becomes are input into another task (e.g., join) as soon as records become available

Types of DBMS parallelism



Data Partitioning

- It is a key requirement for effective parallel execution of database operations.
- Spreads data from database tables across multiple disks so that I/O operations such as read and write can be performed in parallel.
- Two types – **random and intelligent partitioning.**
- ***Random partitioning:*** It includes random data striping across multiple disks on a single server.
- Another option for random partitioning is **round-robin partitioning in** which each new record is placed on the next disk assigned to the database.
- The effectiveness of round-robin partitioning is reduced depending upon the data distribution and query selectivity

Data Partitioning – Intelligent partitioning

DBMS knows where a specific record is located and does not waste time searching for it across all disks.

- ***Hash partitioning:*** A hash algorithm is used to calculate the partition number (hash value) based on the value of the portioning key for each row.
- ***Key range partitioning:*** Rows are placed and located in the partitions according to the value of the partitioning key (all rows with the key value from A to K are in partition 1, L to T are in partition 2 etc.).

Data Partitioning

- ***Schema partitioning:*** An entire table is placed on one disk, another table is placed on a different disk, etc. This is useful for small reference tables that are more effectively used when replicated in each partition rather than spread across partitions.
- ***User-defined partitioning:*** This is a partitioning method that allows a table to be partitioned on the basis of a user-defined expression.

Database Architectures for Parallel Processing

1. Shared-memory architecture- SMP (Symmetric Multiprocessors)
2. Shared-disk architecture
3. Shared-nothing architecture
4. Combined architecture

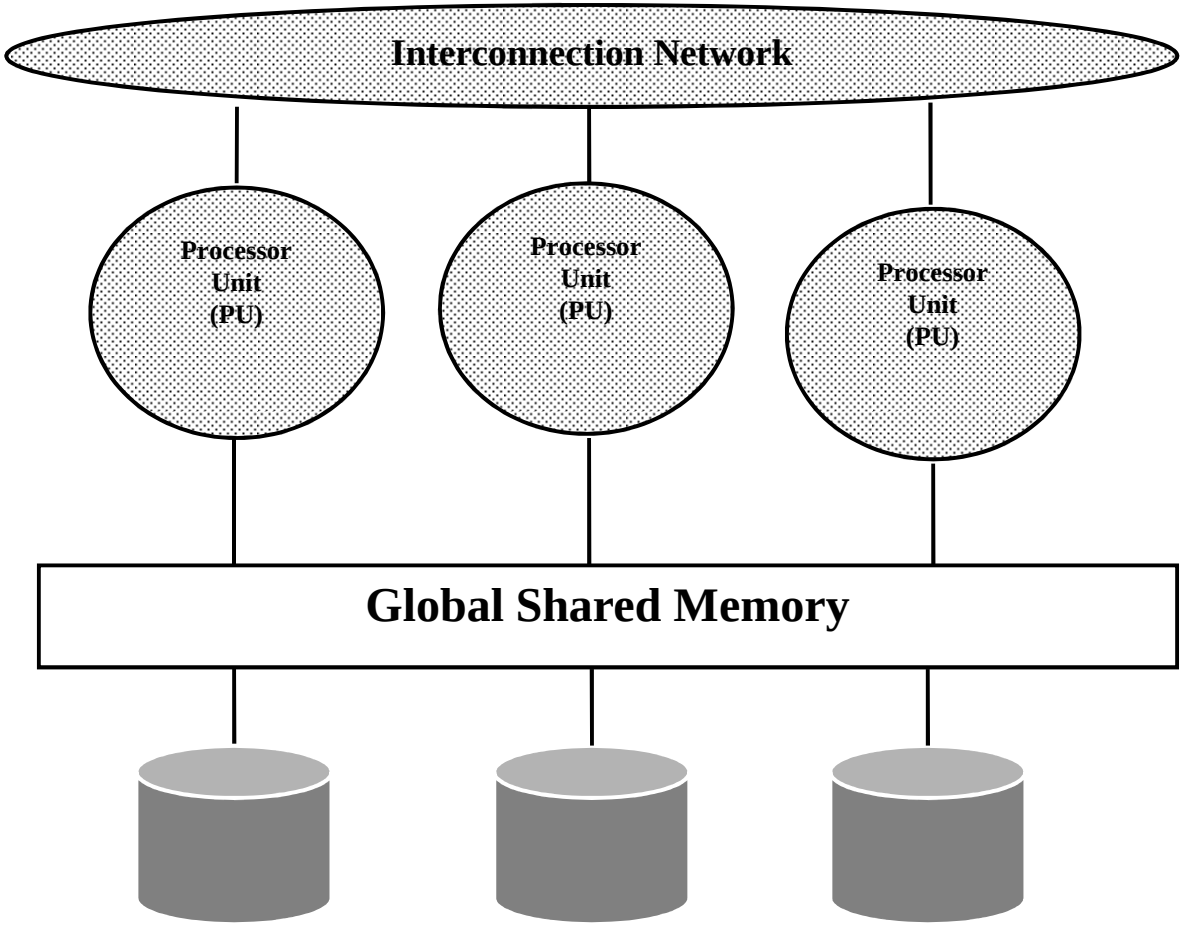
Shared-memory architecture - SMP (Symmetric Multiprocessors)

- Shared memory or Shared everything style is the **traditional approach to** implementing an RDBMS or SMP hardware.
- **A single RDBMS server can potentially utilize all processors, access all memory and access the entire database thus providing the user with a consistent single system image.**
- Multiple database components executing SQL statements communicate with each other by **exchanging messages and data via the shared memory.**
- Scalability can be achieved **through process-based multitasking or threadbased multitasking.**

Shared-memory architecture - SMP (Symmetric Multiprocessors)

- Advantage: Threads provide better resource utilization and faster context switching.
- Disadvantage: Threads tightly coupled with OS and may limit RDBMS portability

Shared-memory architecture - SMP (Symmetric Multiprocessors)



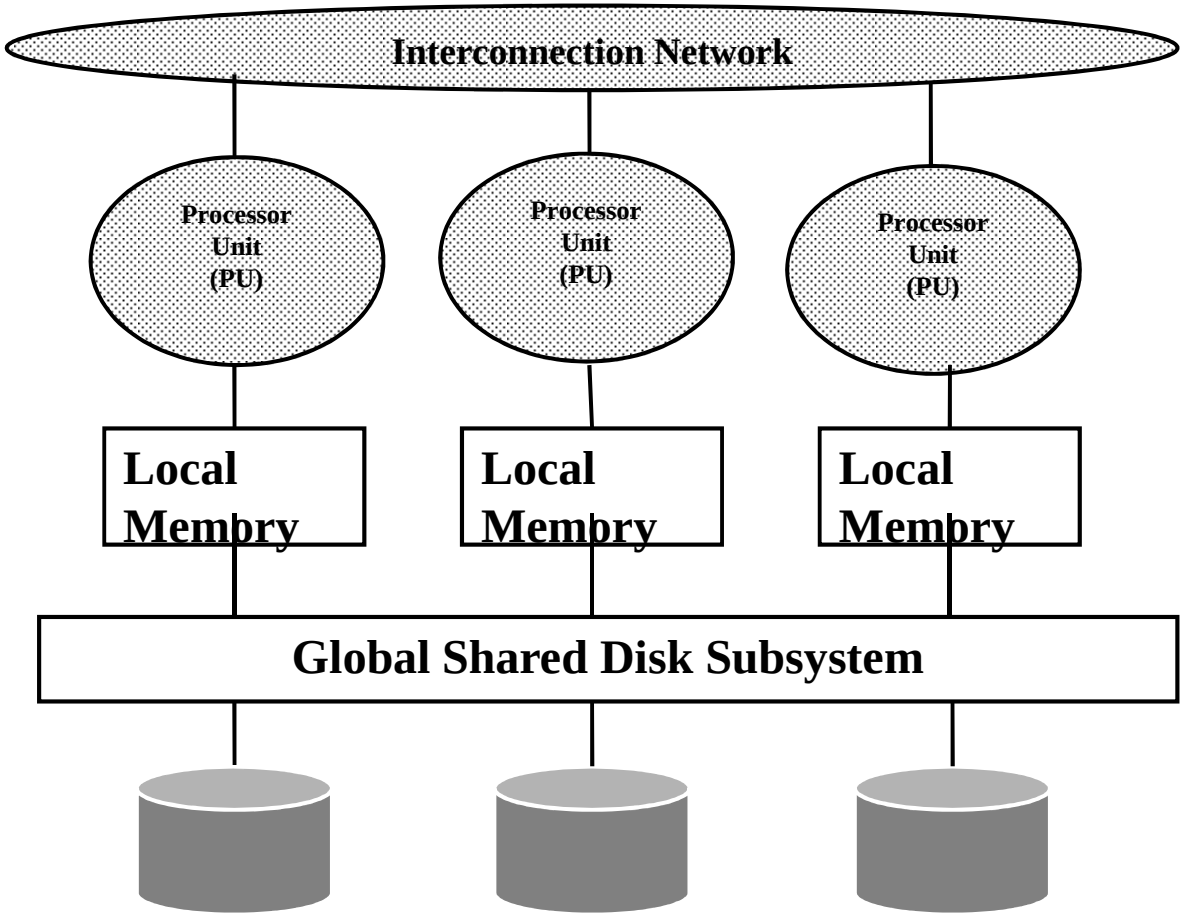
Shared-disk architecture

- Implements the concept of shared ownership of the entire **database between RDBMS servers**, each of which is running on a node of the distributed memory system.
- Each RDBMS server can read, write, update, and delete records from the same shared database.
- Implemented by using distributed lock manager (DLM).
- **Disadvantages: "Pinging problem": All nodes are reading and updating the same data, the RDBMS and** its DLM will have to spend a lot of resources synchronizing multiple buffer pools.
- It may have to handle **significant message traffic in a highly utilized RDBMS** environment.

Shared-disk architecture

- **Advantages:**
- It reduces performance bottlenecks resulting from data skew and can significantly increase system availability.
- It eliminates the memory access bottleneck typical of large SMP systems, and helps reduce DBMS dependency on data partitioning.

Shared-disk architecture



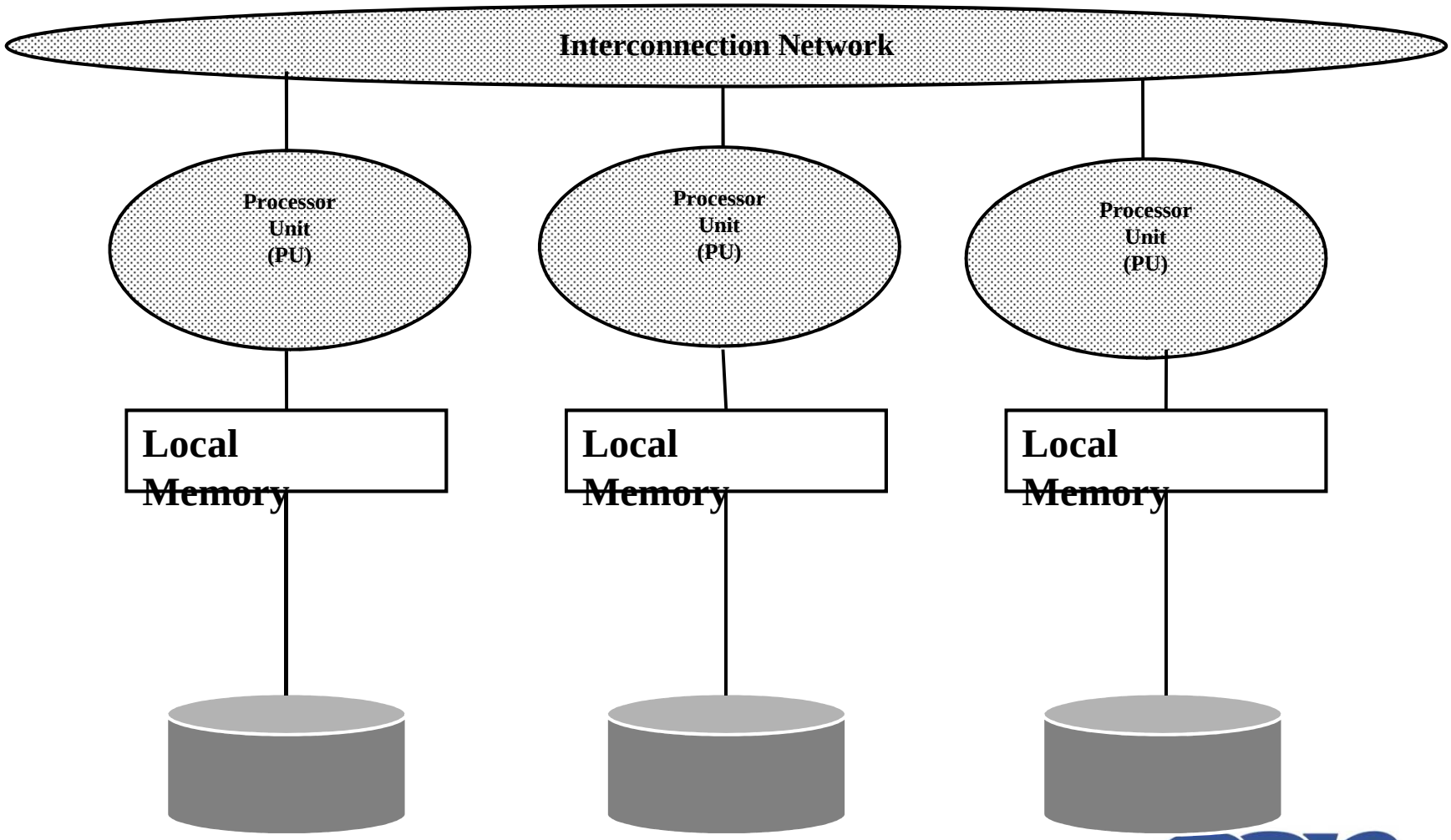
Shared-nothing architecture

- Data is partitioned across all disks and the DBMS is partitioned across multiple coservers which resides in individual nodes of the parallel system.
- Each processor has its own memory and disk, and communicates with other processors by exchanging messages and data over the interconnection network.
- Offer near-linear scalability.

Disadvantages:

- It is most difficult to implement.
- It requires a new programming paradigm, new OS, new compilers and new programming languages

Shared-nothing architecture



Combined architecture

Combined hardware architecture could be a cluster of SMP nodes.

Combined parallel DBMS architecture should support **intersever parallelism** of distributed memory MPPs and **intraserver parallelism** of SMP nodes.

Parallel DBMS Vendors

- Oracle
- Informix
- IBM
- Sybase
- Microsoft

Oracle

Oracle supports parallel database processing with its add-on oracle parallel server option(OPS) and parallel query option(PQO).

Architecture

- Virtual shared-disc capability
- Process-based approach
- Facilitate the inter query parallelism
- PQO supports parallel operations such as index build, database load, backup, and recovery

Data partitioning

- It supports random striping of data across multiple disks.
- Oracle supports dynamic data repartitioning

Oracle

Parallel operations

- Generates a parallel plan
- The oracle PQO query coordinator breaks the query into sub queries
- Parallelize the creation of indexes, database load, backup, and recovery
- PQO supports both horizontal and vertical parallelism

Informix

Architecture

- Support shared-memory, shared-disk, and shared-nothing models.
- It is thread based architecture.

Data partitioning

- Round-robin, schema, charts, key range, and user-defined partitioning methods .
- Both data and index can be partitioned

Parallel Operations

- Executes queries in parallel.

Client/Server database product-DB2 parallel Edition

Architecture

- DB2 PE is a shared-nothing architecture in which all data is partitioned across processor nodes.
- Each node is aware of the other nodes and how the data is partitioned

Data partitioning

- Allow a table to span multiple nodes.
- The master system catalog for each database is stored on one node and cached on every other node.

Parallel operations

- All database operations are fully parallelized

Sybase

Sybase has implemented its parallel DBMS functionality in a parallel product called DYBASE MPP.

Architecture

- It is a shared-nothing systems that partitions data across multiple SQL servers and supports both function shipping and data repartitions.
- Open server application that operates on top of existing SQL servers.
- All the knowledge about the environment, data partitions, and parallel query execution is maintained by SYBASE MPP software.

Sybase

SYBASE MPP consists of specialized servers.

- Data server, the smaller executable unit of parallelism that consists of SQL server, split server (performs joins across nodes), and control server (coordination of execution and communication)
- DBA server handles optimization, DDL statements, security and global systems catalog.
- Administrative server, a graphical user interface for managing SYBASE MPP.

Data partitioning.

- Supports hash, key range, and schema partitioning, indexes partitioning.

Parallel operations: All SQL statements and utilities in parallel across SQL servers

Microsoft

SQL server architecture is shared-everything design optimized for SMP systems. SQL server is tightly integrated with the NT operating systems threads