

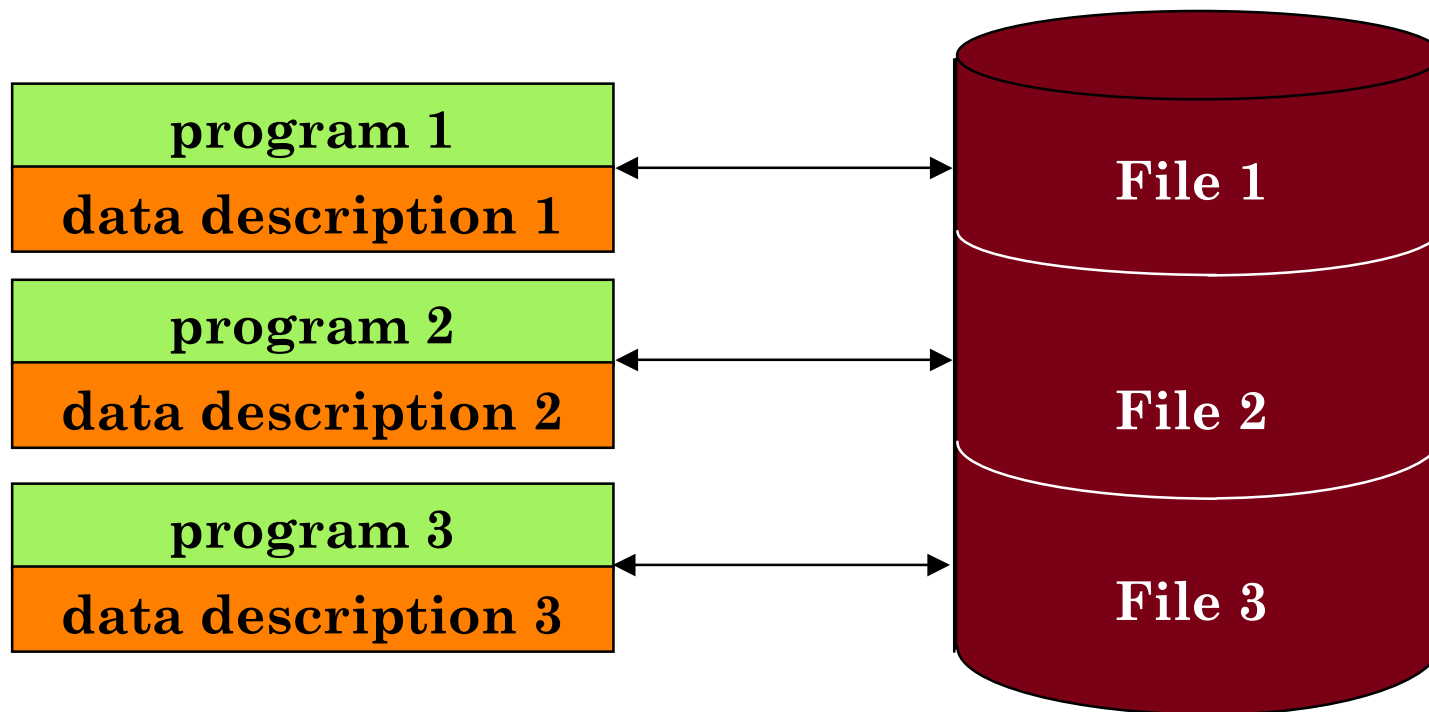
# Outline

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- ❑ Introduction
  - What is a distributed DBMS
  - Problems
  - Current state-of-affairs
- ❑ Background
- ❑ Distributed DBMS Architecture
- ❑ Distributed Database Design
- ❑ Semantic Data Control
- ❑ Distributed Query Processing
- ❑ Distributed Transaction Management
- ❑ Parallel Database Systems
- ❑ Distributed Object DBMS
- ❑ Database Interoperability
- ❑ Current Issues

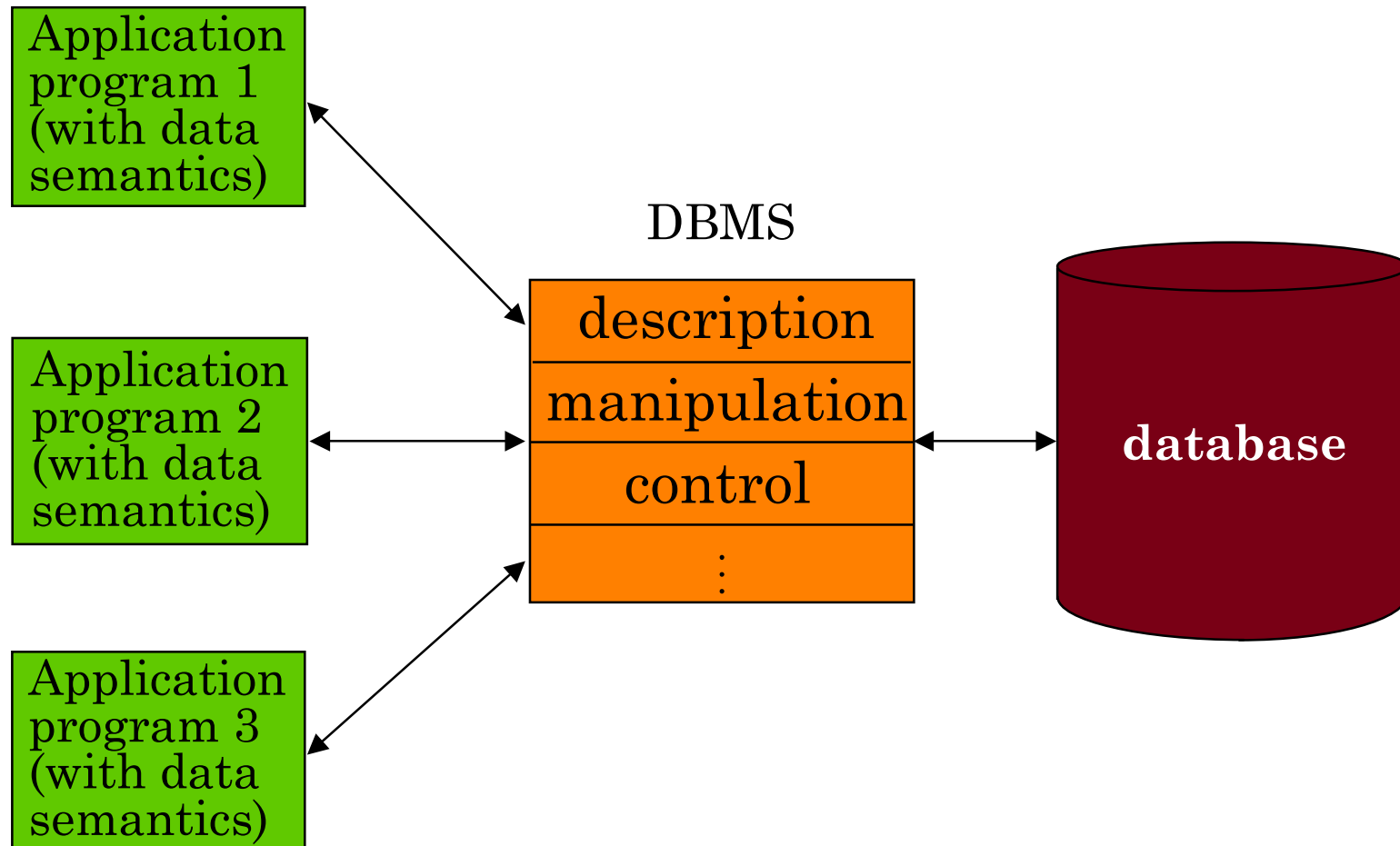
# File Systems

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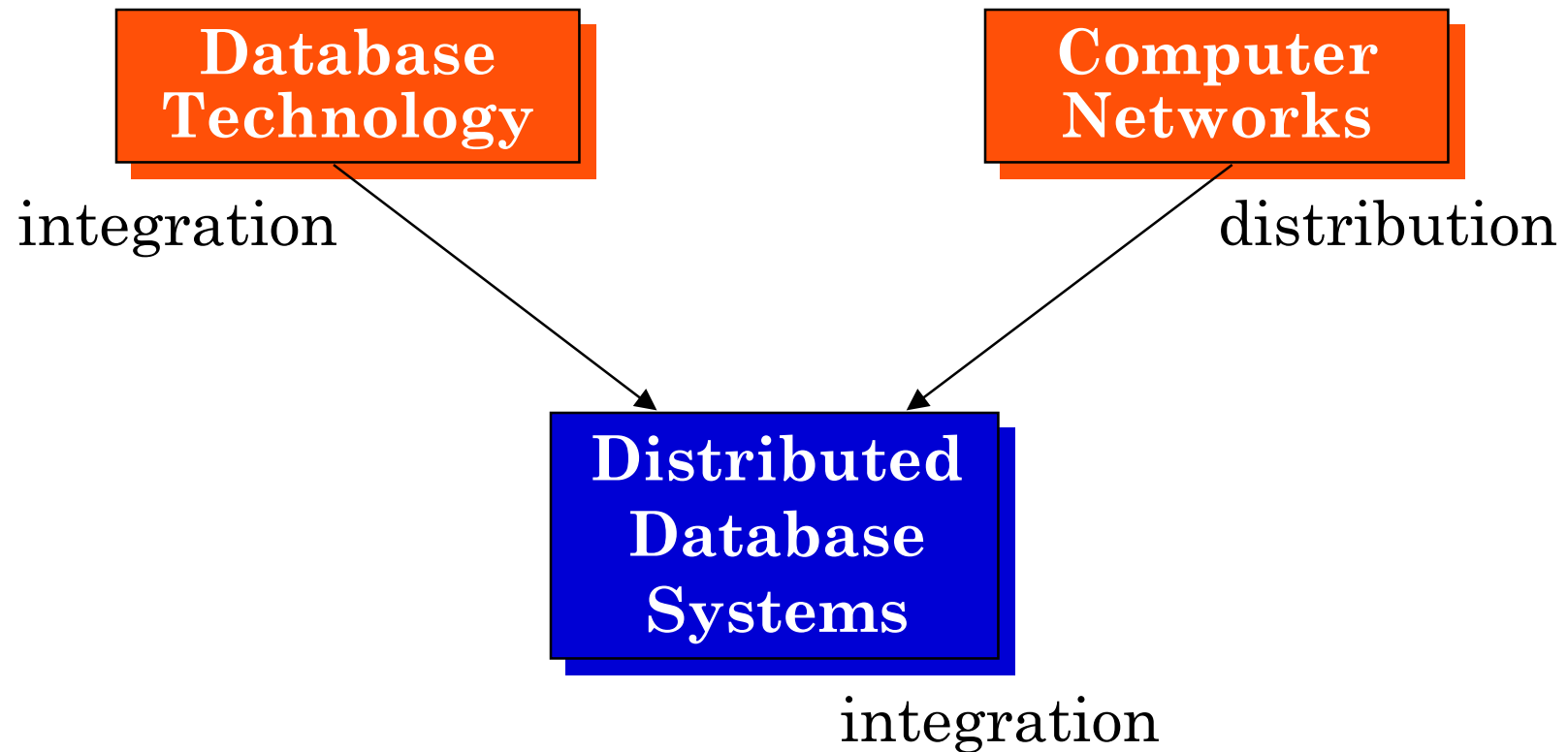
# Database Management

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# Motivation

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**integration  $\neq$  centralization**

# Distributed Computing

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- A concept in search of a definition and a name.
- A number of autonomous processing elements (not necessarily homogeneous) that are interconnected by a computer network and that cooperate in performing their assigned tasks.

# Distributed Computing

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## ■ Synonymous terms

- ▶ distributed function
- ▶ distributed data processing
- ▶ multiprocessors/multicomputers
- ▶ satellite processing
- ▶ backend processing
- ▶ dedicated/special purpose computers
- ▶ timeshared systems
- ▶ functionally modular systems

# What is distributed ...

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- Processing logic
- Functions
- Data
- Control

# What is a Distributed Database System?

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A distributed database (DDB) is a collection of multiple, *logically interrelated* databases distributed over a *computer network*.

A distributed database management system (D-DBMS) is the software that manages the DDB and provides an access mechanism that makes this distribution *transparent* to the users.

Distributed database system (DDBS) = DDB + D-DBMS



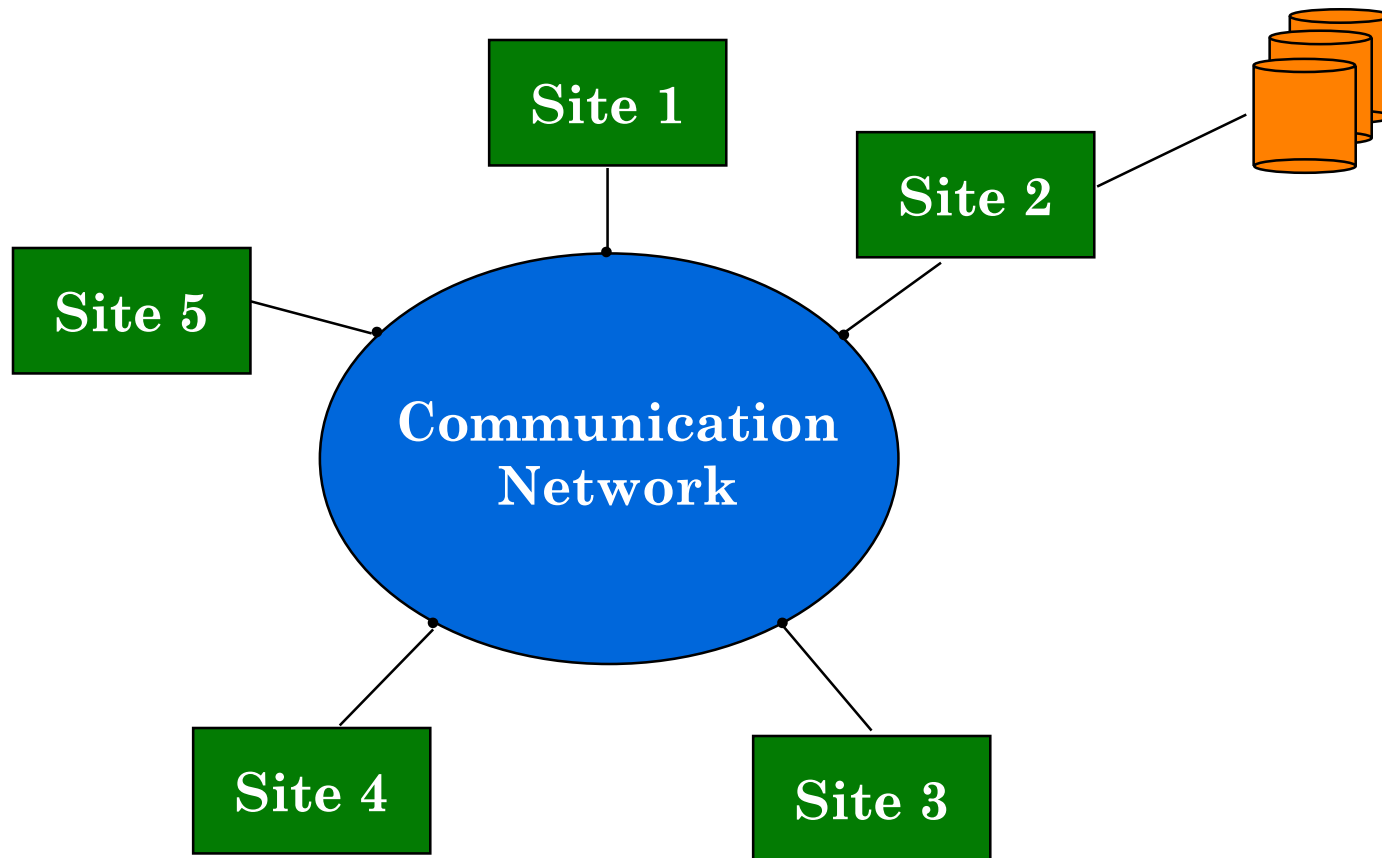
# What is not a DDBS?

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- A timesharing computer system
- A loosely or tightly coupled multiprocessor system
- A database system which resides at one of the nodes of a network of computers - this is a centralized database on a network node

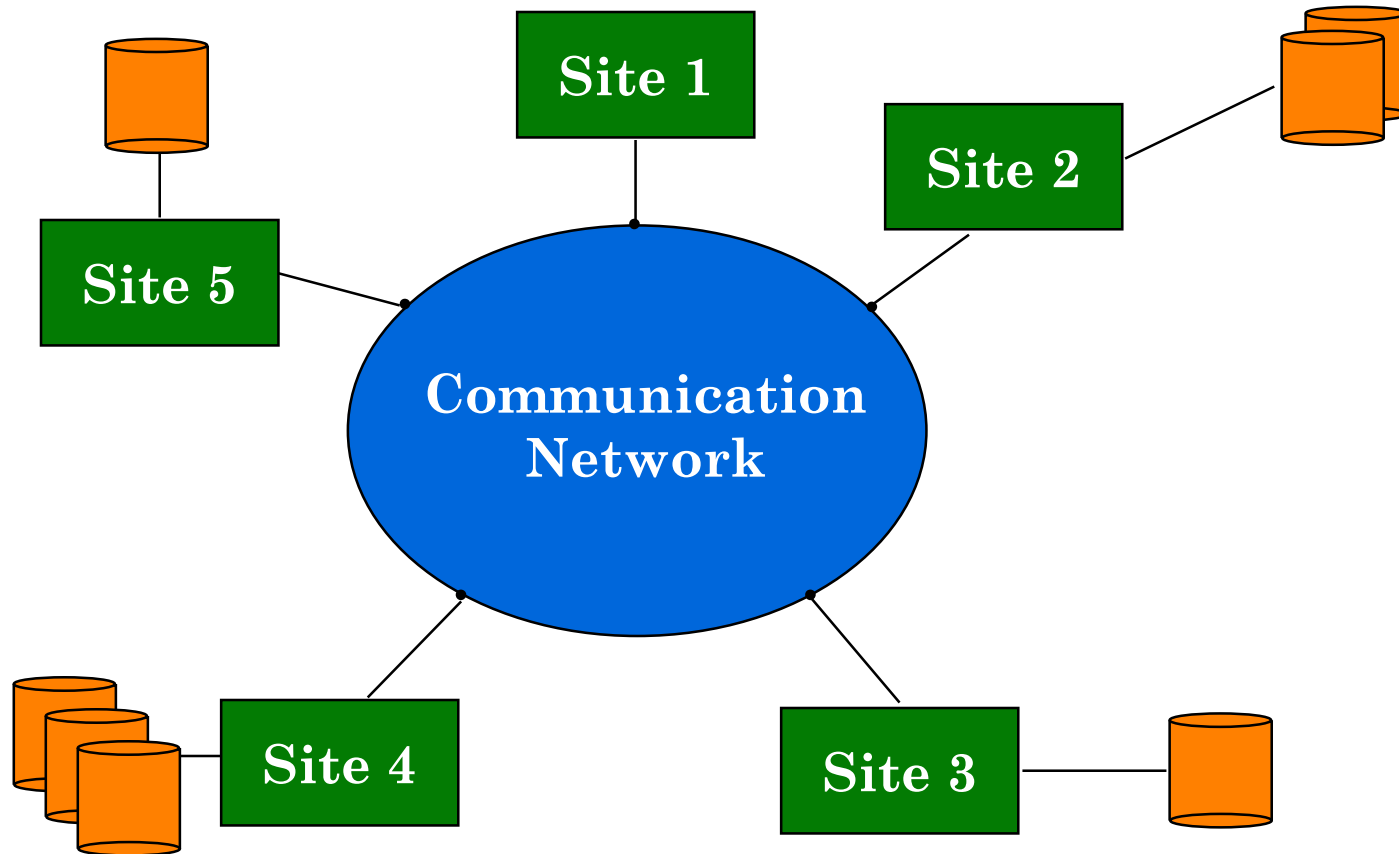
# Centralized DBMS on a Network

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# Distributed DBMS Environment

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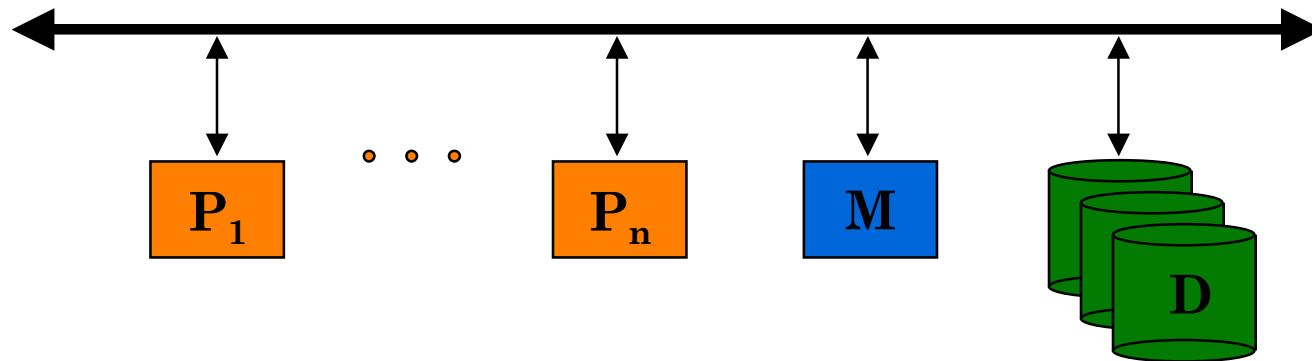
# Implicit Assumptions

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- Data stored at a number of sites    each site *logically* consists of a single processor.
- Processors at different sites are interconnected by a computer network    no multiprocessors
  - ▣ parallel database systems
- Distributed database is a database, not a collection of files    data logically related as exhibited in the users' access patterns
  - ▣ relational data model
- D-DBMS is a full-fledged DBMS
  - ▣ not remote file system, not a TP system

# Shared-Memory Architecture

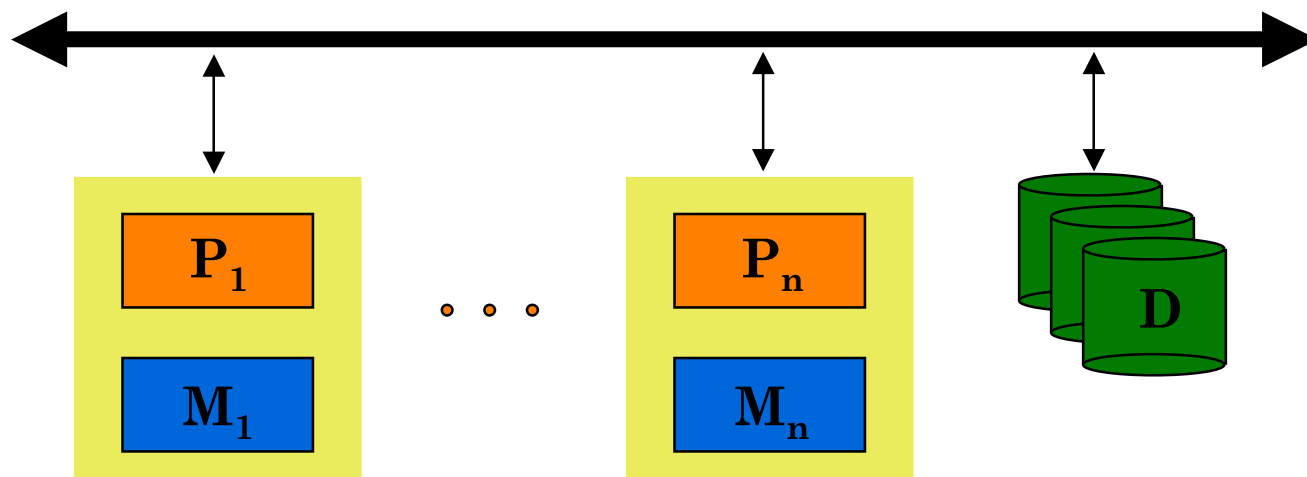
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Examples : symmetric multiprocessors (Sequent, Encore) and some mainframes (IBM3090, Bull's DPS8)

# Shared-Disk Architecture

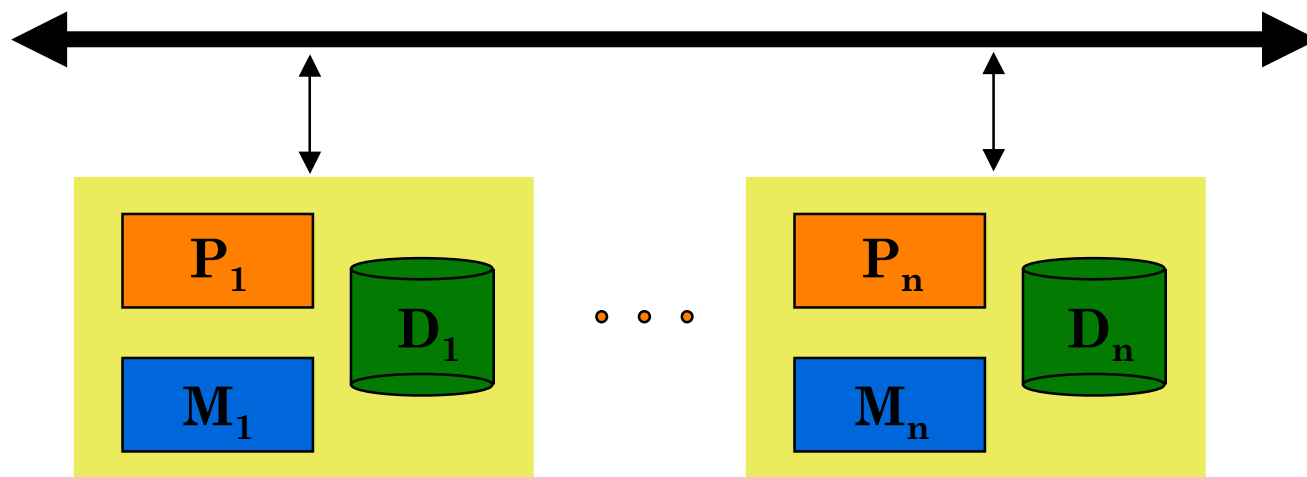
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Examples : DEC's VAXcluster, IBM's IMS/VS  
Data Sharing

# Shared-Nothing Architecture

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Examples : Teradata's DBC, Tandem, Intel's Paragon, NCR's 3600 and 3700

# Applications

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- Manufacturing - especially multi-plant manufacturing
- Military command and control
- EFT
- Corporate MIS
- Airlines
- Hotel chains
- Any organization which has a decentralized organization structure



# Distributed DBMS Promises

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- ① Transparent management of distributed, fragmented, and replicated data
- ② Improved reliability/availability through distributed transactions
- ③ Improved performance
- ④ Easier and more economical system expansion

# Transparency

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- Transparency is the separation of the higher level semantics of a system from the lower level implementation issues.
- Fundamental issue is to provide  
**data independence**  
in the distributed environment
  - ⇒ Network (distribution) transparency
  - ⇒ Replication transparency
  - ⇒ Fragmentation transparency
    - ◆ horizontal fragmentation: selection
    - ◆ vertical fragmentation: projection
    - ◆ hybrid

# Example

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EMP

ENO	ENAME	TITLE
E1	J. Doe	Elect. Eng.
E2	M. Smith	Syst. Anal.
E3	A. Lee	Mech. Eng.
E4	J. Miller	Programmer
E5	B. Casey	Syst. Anal.
E6	L. Chu	Elect. Eng.
E7	R. Davis	Mech. Eng.
E8	J. Jones	Syst. Anal.

ASG

ENO	PNO	RESP	DUR
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P5	Engineer	23
E8	P3	Manager	40

PROJ

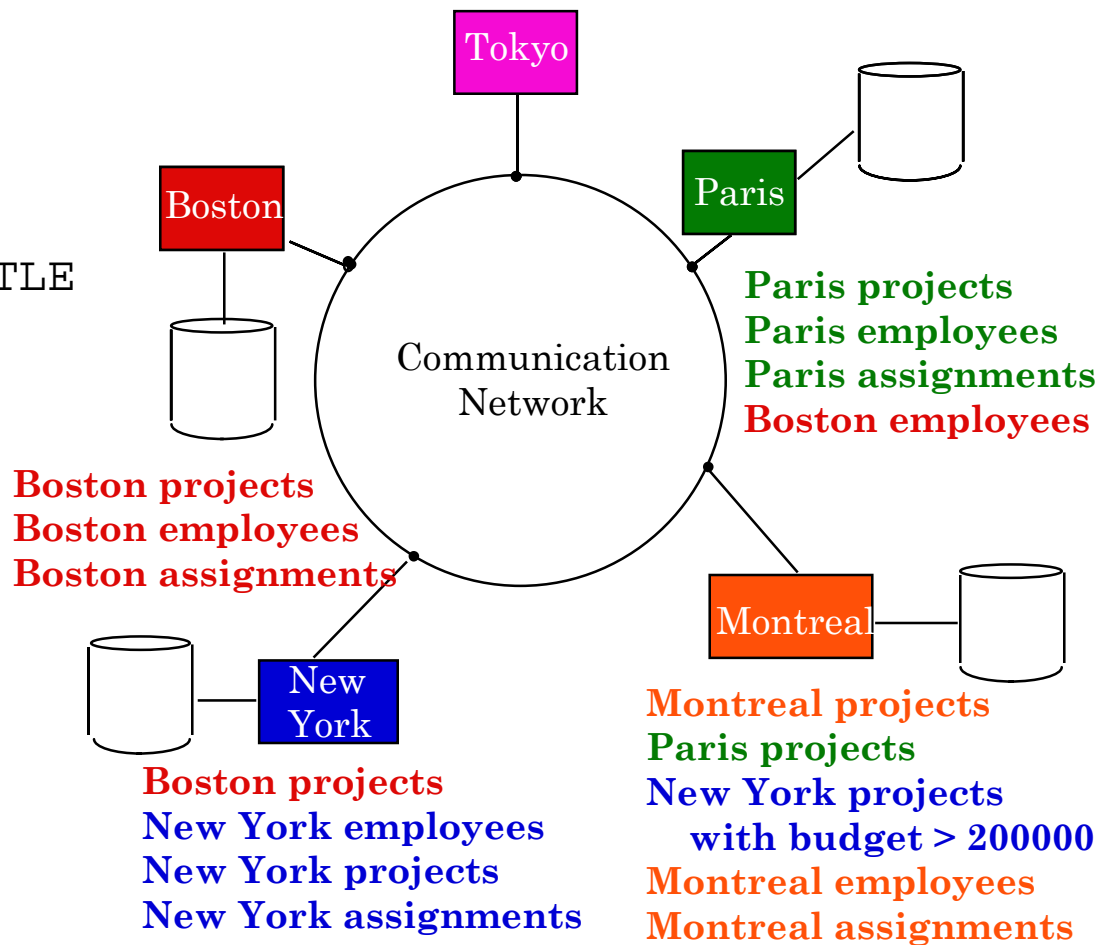
PNO	PNAME	BUDGET
P1	Instrumentation	150000
P2	Database Develop.	135000
P3	CAD/CAM	250000
P4	Maintenance	310000

PAY

TITLE	SAL
Elect. Eng.	40000
Syst. Anal.	34000
Mech. Eng.	27000
Programmer	24000

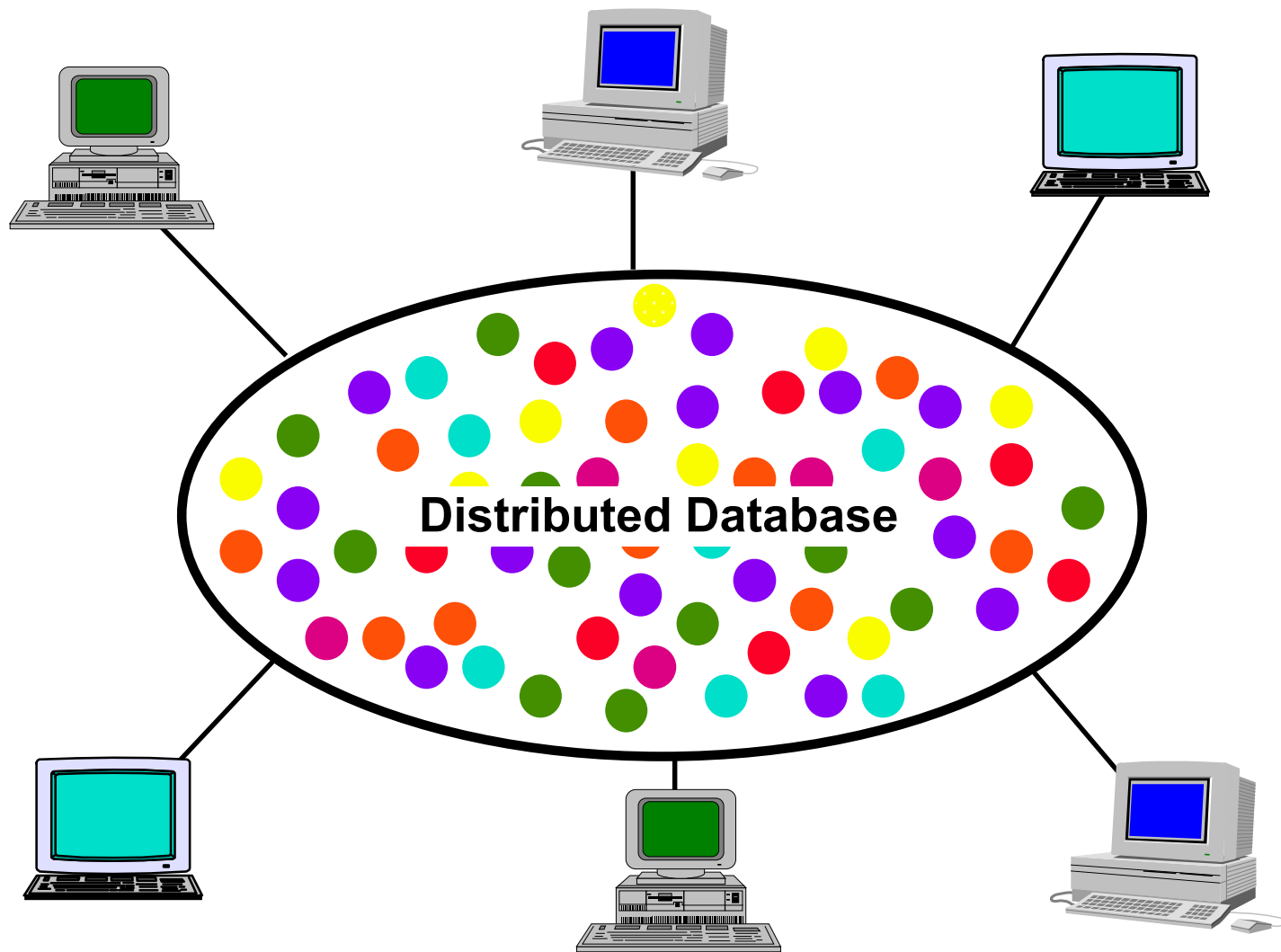
# Transparent Access

```
SELECT ENAME, SAL
FROM EMP, ASG, PAY
WHERE DUR > 12
AND EMP.ENO = ASG.ENO
AND PAY.TITLE = EMP.TITLE
```

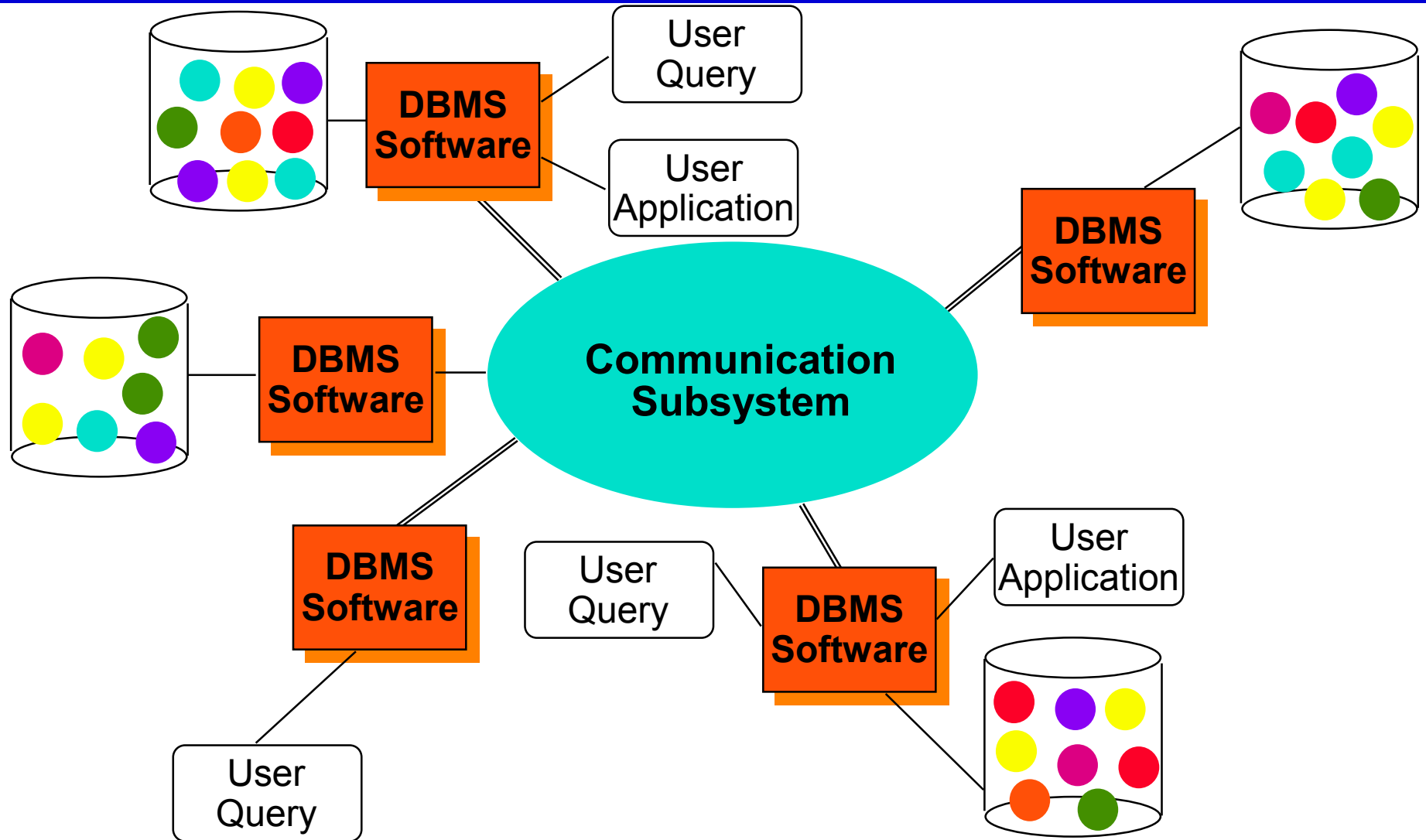


# Distributed Database - User View

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# Distributed DBMS - Reality



# Potentially Improved Performance

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- Proximity of data to its points of use
  - Requires some support for fragmentation and replication
- Parallelism in execution
  - Inter-query parallelism
  - Intra-query parallelism

# Parallelism Requirements

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- Have as much of the data required by *each* application at the site where the application executes
  - Full replication
- How about updates?
  - Updates to replicated data requires implementation of distributed concurrency control and commit protocols



# System Expansion

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- Issue is database scaling
- Emergence of microprocessor and workstation technologies
  - Demise of Grosh's law
  - Client-server model of computing
- Data communication cost vs telecommunication cost

# Distributed DBMS Issues

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## ■ Distributed Database Design

- how to distribute the database
- replicated & non-replicated database distribution
- a related problem in directory management

## ■ Query Processing

- convert user transactions to data manipulation instructions
- optimization problem
- $\min\{\text{cost} = \text{data transmission} + \text{local processing}\}$
- general formulation is NP-hard

# Distributed DBMS Issues

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## ■ Concurrency Control

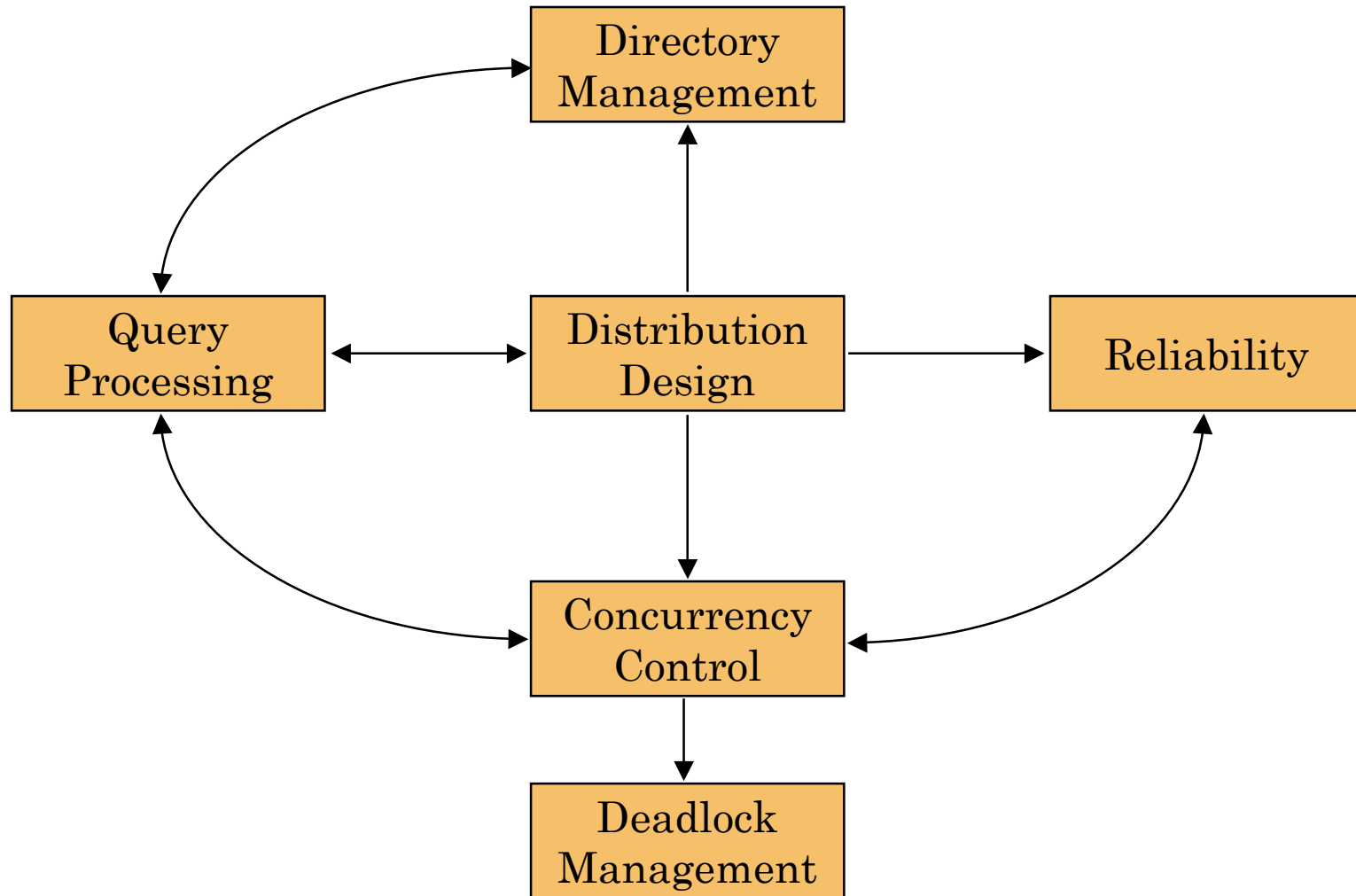
- ▶ synchronization of concurrent accesses
- ▶ consistency and isolation of transactions' effects
- ▶ deadlock management

## ■ Reliability

- ▶ how to make the system resilient to failures
- ▶ atomicity and durability

# Relationship Between Issues

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# Related Issues

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## ■ Operating System Support

- ▣ operating system with proper support for database operations
- ▣ dichotomy between general purpose processing requirements and database processing requirements

## ■ Open Systems and Interoperability

- ▣ Distributed Multidatabase Systems
- ▣ More probable scenario
- ▣ Parallel issues