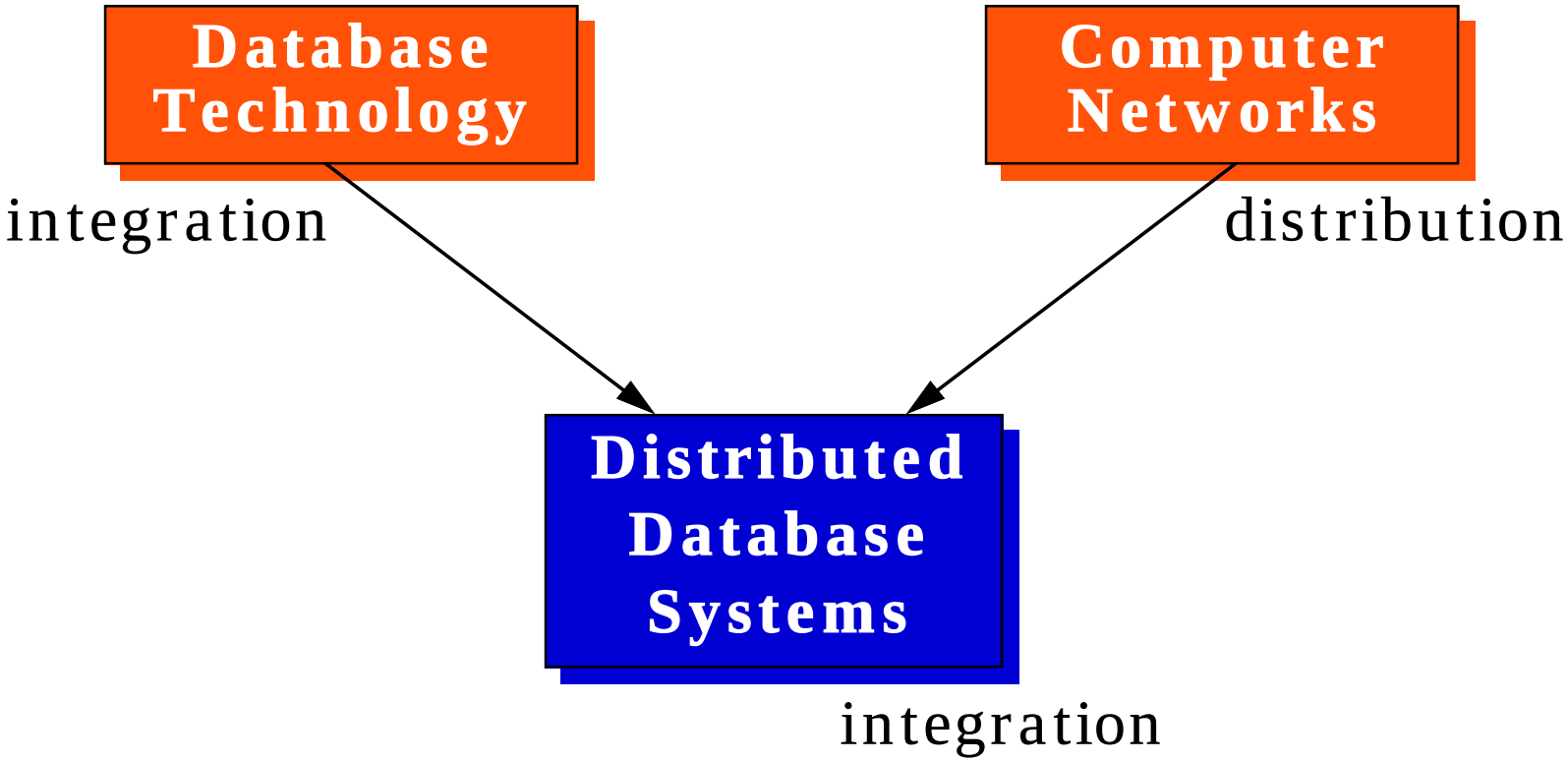
Outline

- 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
- Distributed Database Operating Systems
- Open Systems and Interoperability
- Parallel Database Systems
- Distributed Object Management
- Concluding Remarks

Motivation



integration ≠ centralization

Distributed Computing

- 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

- 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 ...

- Processing logic
- Functions
- Data
- Control

What is a Distributed Database System?

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

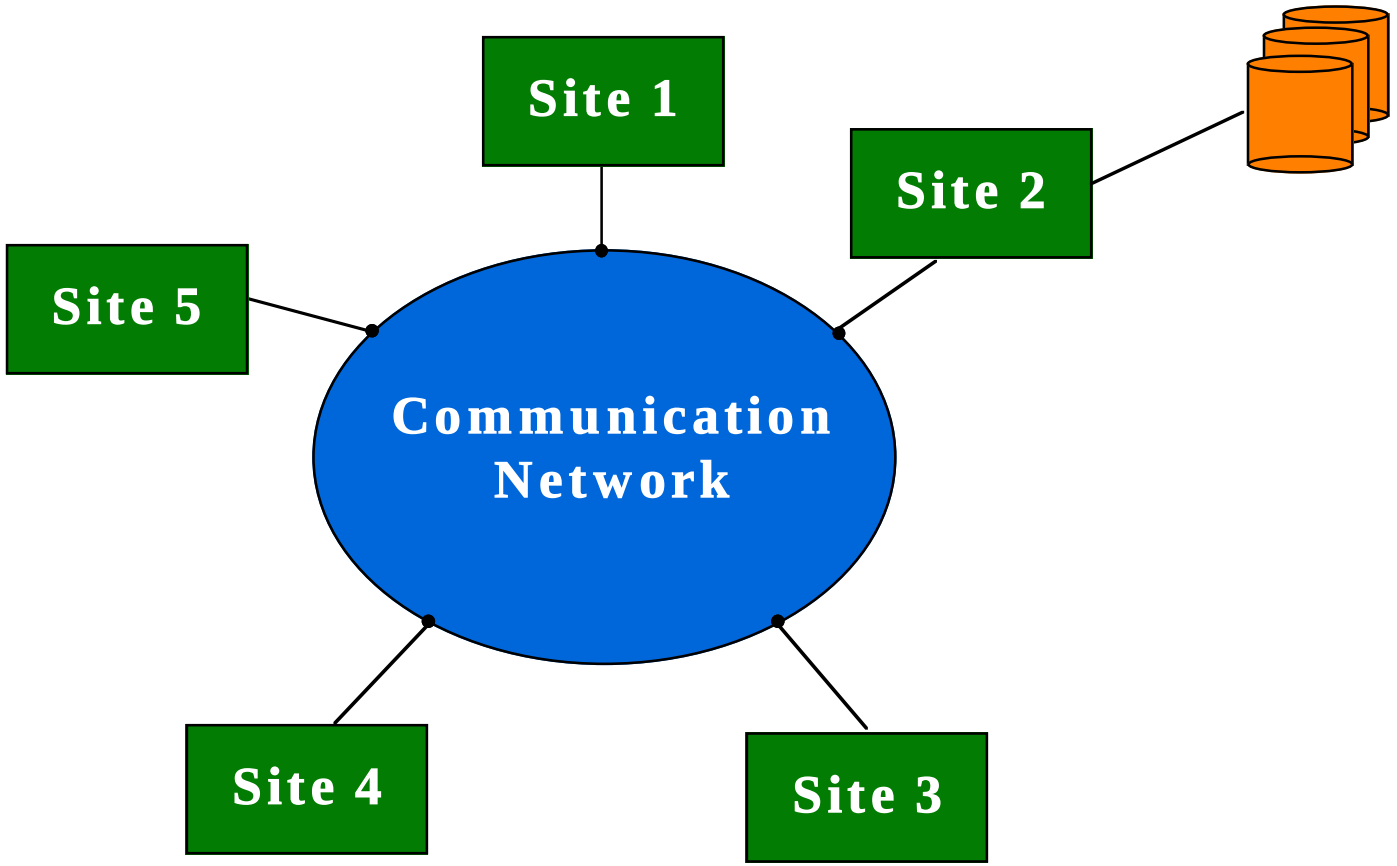
A distributed database management system (D–DBMS) is the software that manages the DDB and provides an access mechanism that makes this distribution transparent to the users.

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

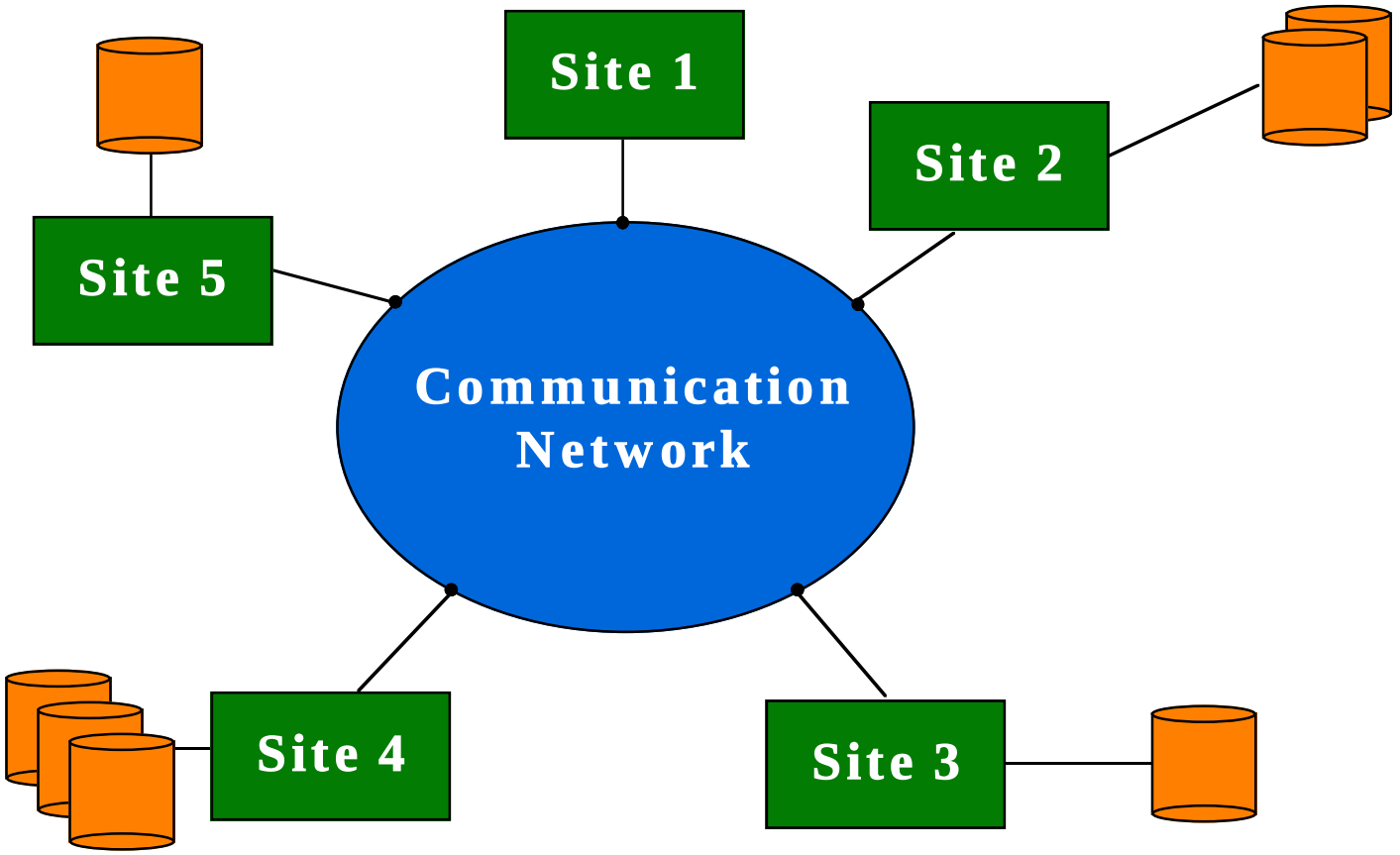
What is not a DDBS?

- 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



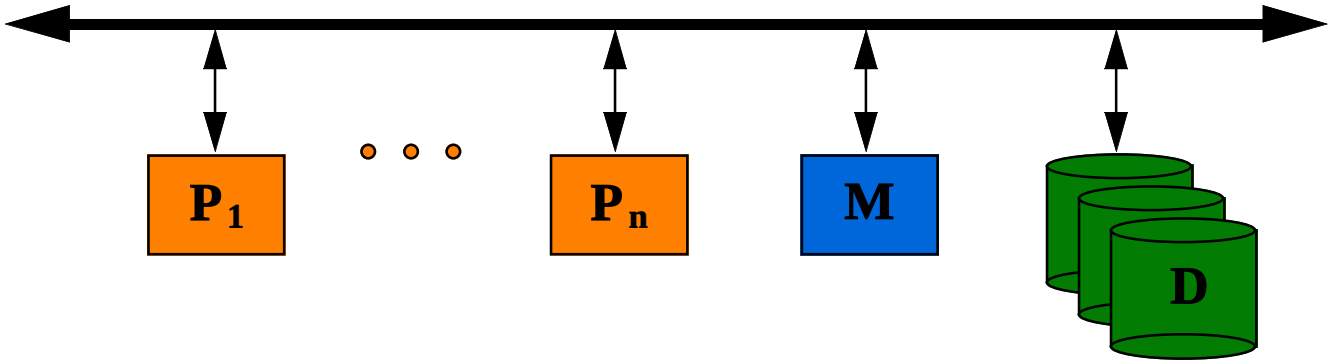
Distributed DBMS Environment



Implicit Assumptions

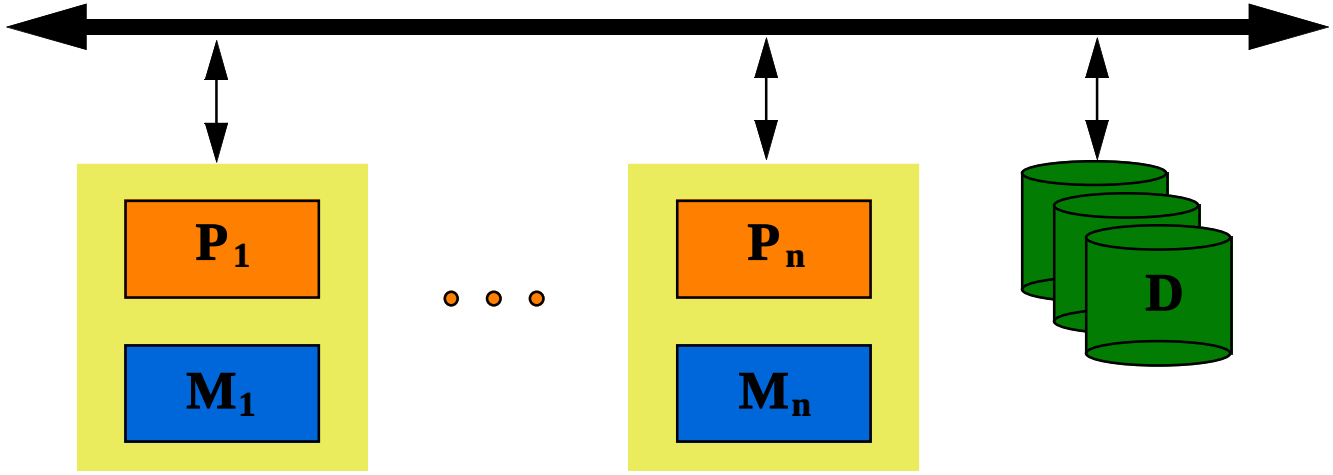
- Data stored at a number of sites ⇨ each site *logically* consists of a single processor.
- Processors at different sites are interconnected by a computer network ⇨ no multiprocessors
  - parallel database systems
- Distributed database is a database, not a collection of files ⇨ data logically related 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



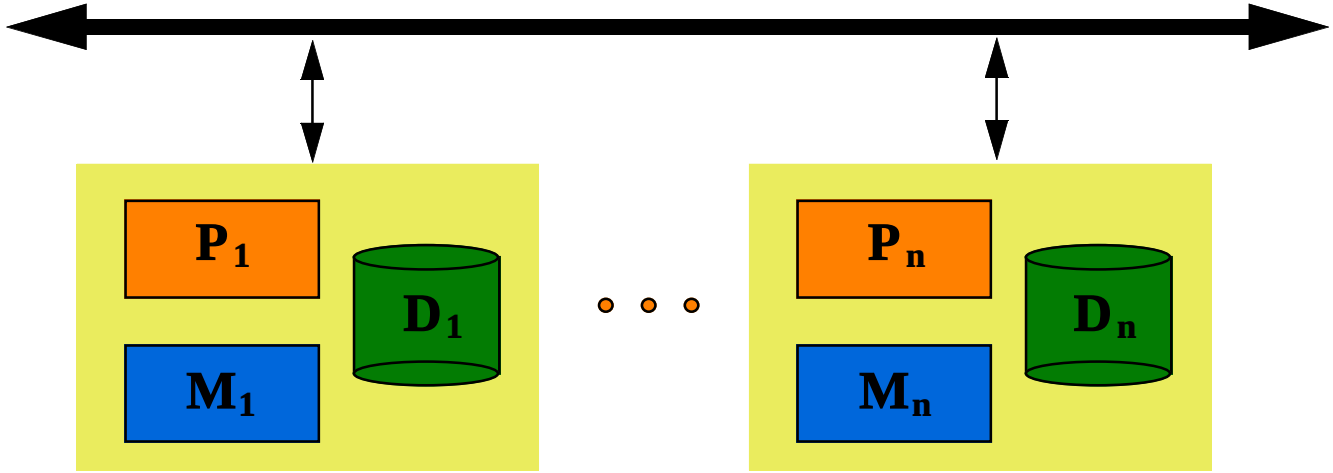
Examples : symmetric multiprocessors (Sequent, Encore) and some mainframes (IBM3090, Bull's DPS8)

Shared-Disk Architecture



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

Shared-Nothing Architecture



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

Applications

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

Advantages of DDBS

- Local autonomy
- Improved performance
- Improved reliability/availability
- Economics
- Expendability
- Shareability

Disadvantages of DDBS

- Lack of experience
- Complexity
- Cost
- Distribution of control
- Difficulty of change

Distributed DBMS Issues

Distributed Database Design

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

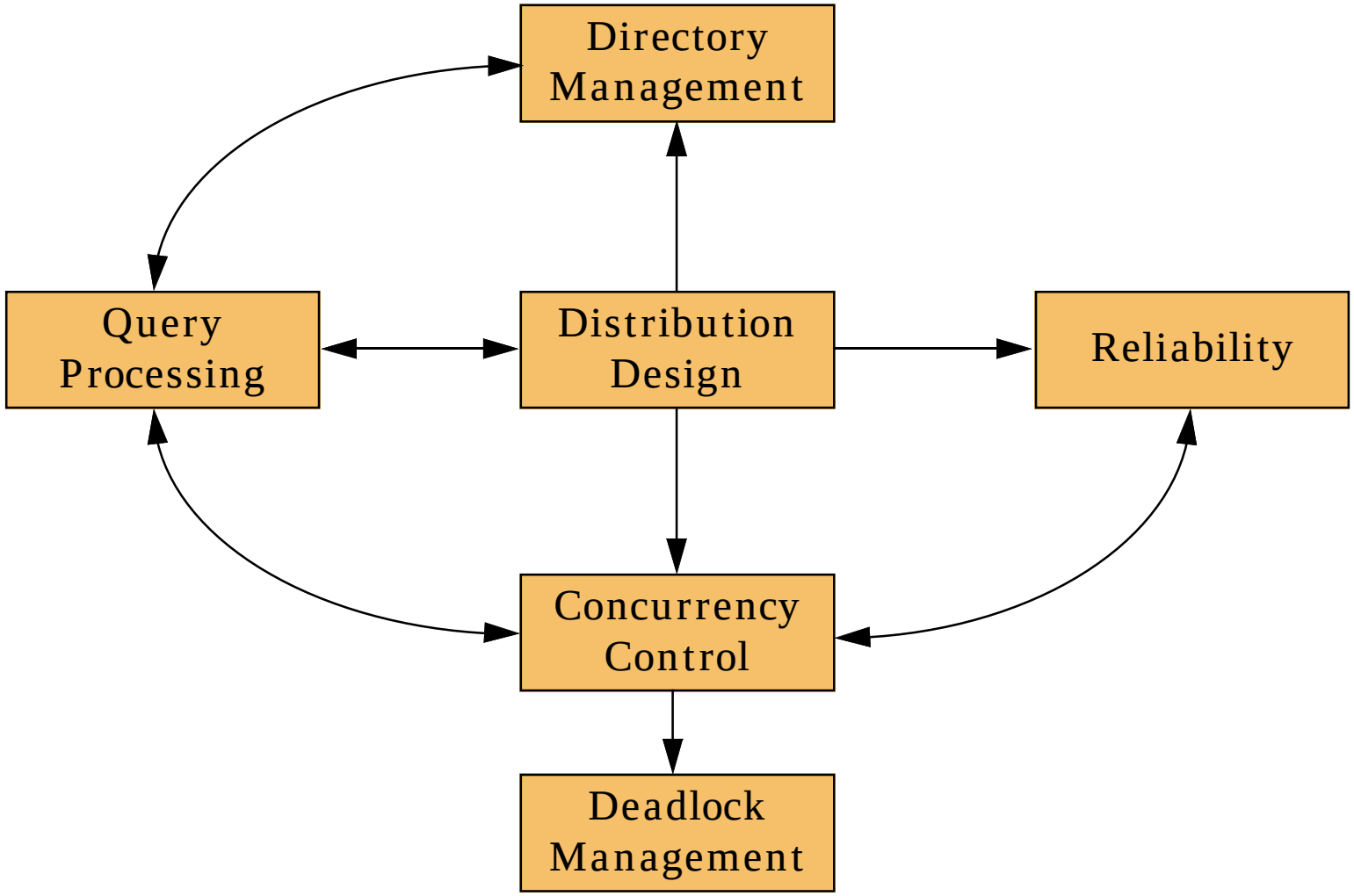
Query Processing

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

Distributed DBMS Issues

- **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



Related Issues

- **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

Distributed DBMS Promises

❶ Transparent management of distributed, fragmented, and replicated data

❷ Improved reliability/availability through distributed transactions

❸ Improved performance

❹ Easier and more economical system expansion

Transparency Support

- No replication yet
- Generally no fragmentation
  - Horizontal fragmentation may come
- Limited distribution transparency
  - path specification
  - aliasing
  - remote login to a DBMS
- Most are multiple-client/single-server

Distributed Transactions in Commercial Systems

- Some do not provide it at all
  - Oracle 6.x ⇨ have to open one database at a time
  - Sybase ⇨ primitives are there, applications have to implement distributed transactions themselves
- Others do
  - Ingres, NonStop SQL, Oracle V.7
- Replication support
  - Either nonexistent, or
  - ROWA rule: Read One Write All

Potentially Improved Performance

- 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

- 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

Commercial System Alternatives

- Multiplex time between read and updates
  - Have database open for reads during regular hours; perform updates after hours
  - Banks do this
- Multiplex the database
  - Query database
  - Production database

System Expansion

- 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

Example

E

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.

G

ENO	JNO	RESP	DUR
E1	J1	Manager	12
E2	J1	Analyst	24
E2	J2	Analyst	6
E3	J3	Consultant	10
E3	J4	Engineer	48
E4	J2	Programmer	18
E5	J2	Manager	24
E6	J4	Manager	48
E7	J3	Engineer	36
E7	J5	Engineer	23
E8	J3	Manager	40

J

JNO	JNAME	BUDGET	LOC
J1	Instrumentation	150000	Montreal
J2	Database Develop.	135000	New York
J3	CAD/CAM	250000	New York
J4	Maintenance	310000	Paris
J5	CAD/CAM	500000	Boston

S

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

