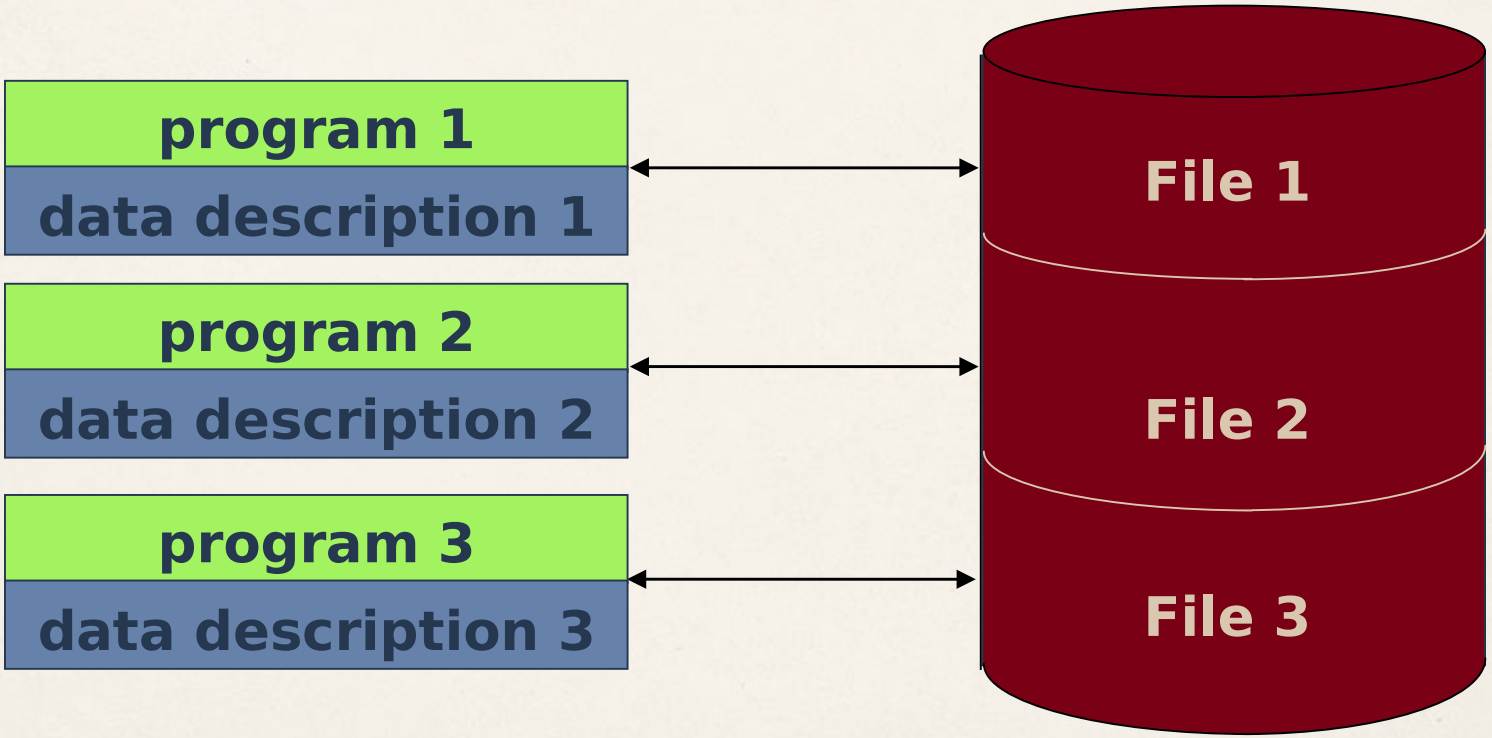
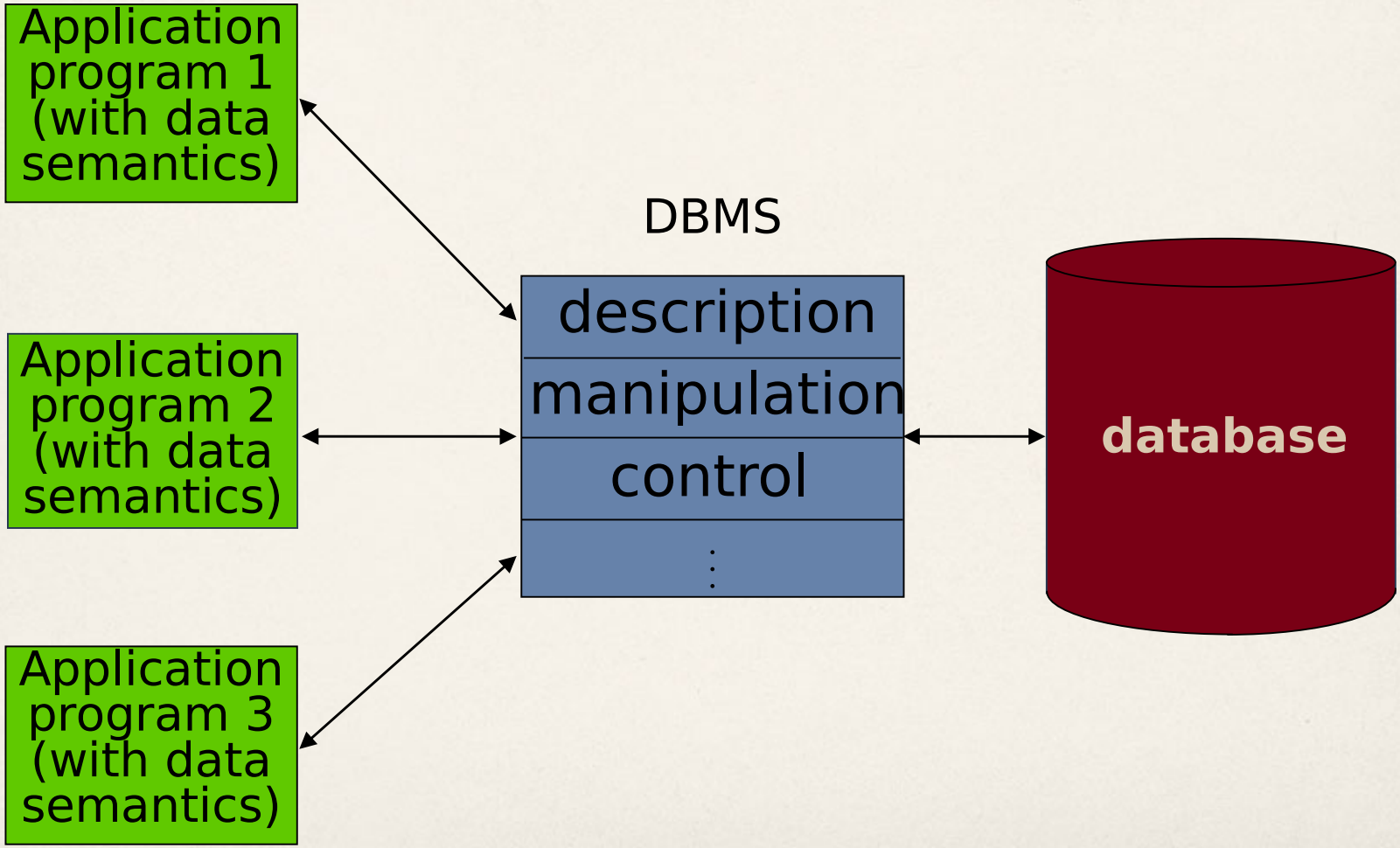
Outline

- Introduction
  - What is a distributed DBMS
  - Distributed DBMS Architecture
- Background
- Distributed Database Design
- Database Integration
- Semantic Data Control
- Distributed Query Processing
- Multidatabase query processing
- Distributed Transaction Management
- Data Replication
- Parallel Database Systems
- Distributed Object DBMS
- Peer-to-Peer Data Management
- Web Data Management
- Current Issues

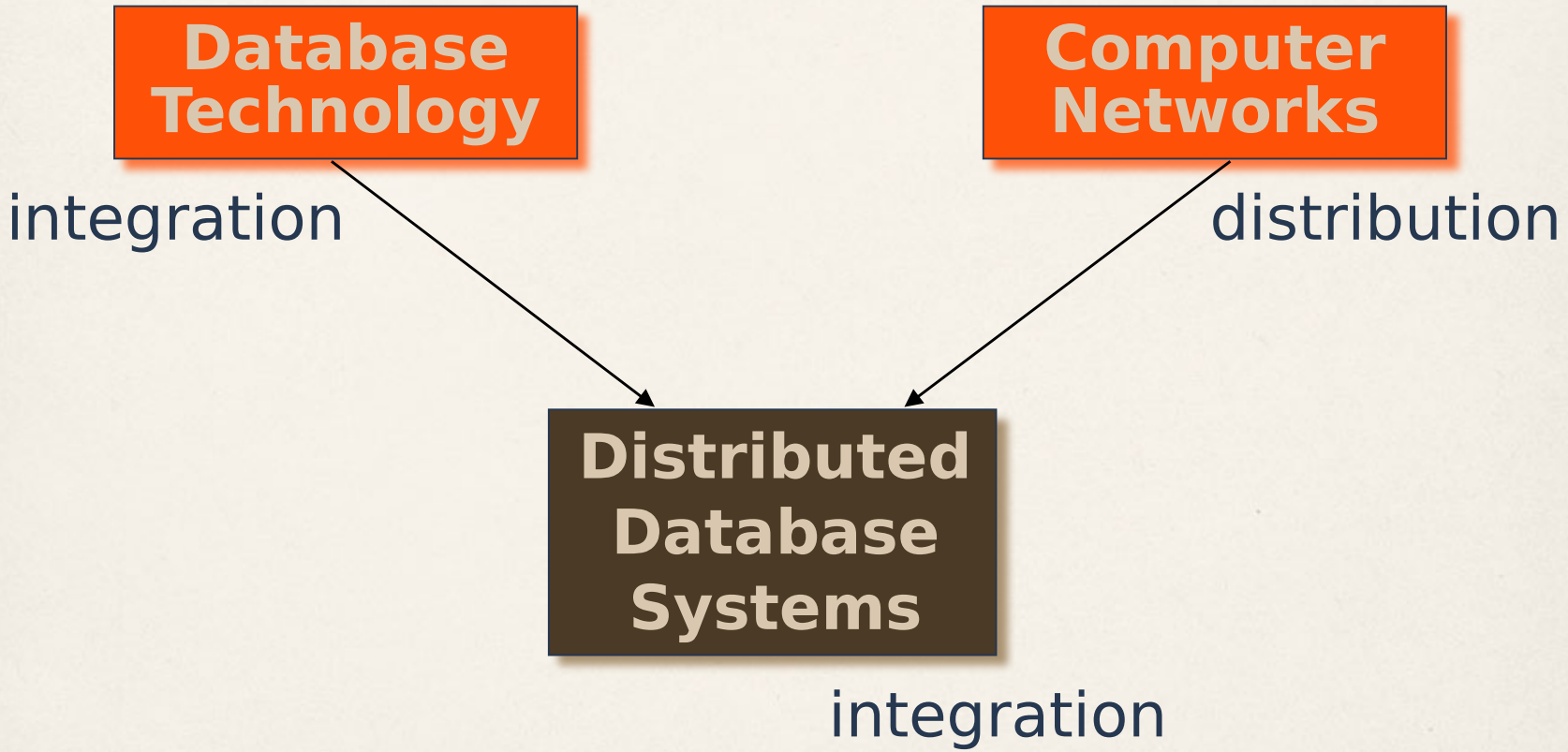
File Systems



Database Management



Motivation



integration ≠ centralization

Distributed Computing

- A number of autonomous processing elements (not necessarily homogeneous) that are interconnected by a computer network and that cooperate in performing their assigned tasks.
- What is being distributed?
  - Processing logic
  - Function
  - 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*.

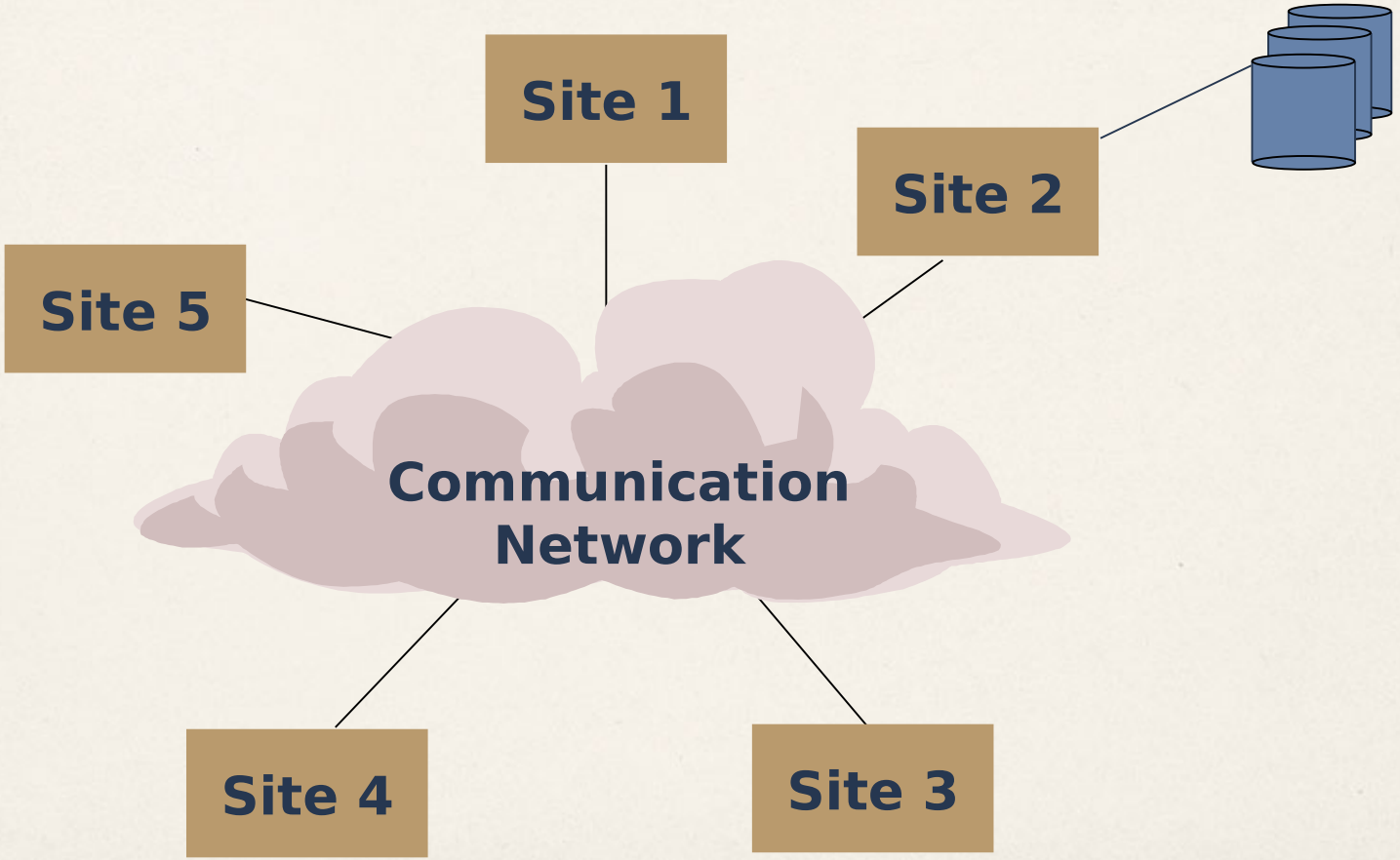
A distributed database management system (D–DBMS) is the software that manages the DDB and provides an access mechanism that makes this distribution transparent to the users.

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

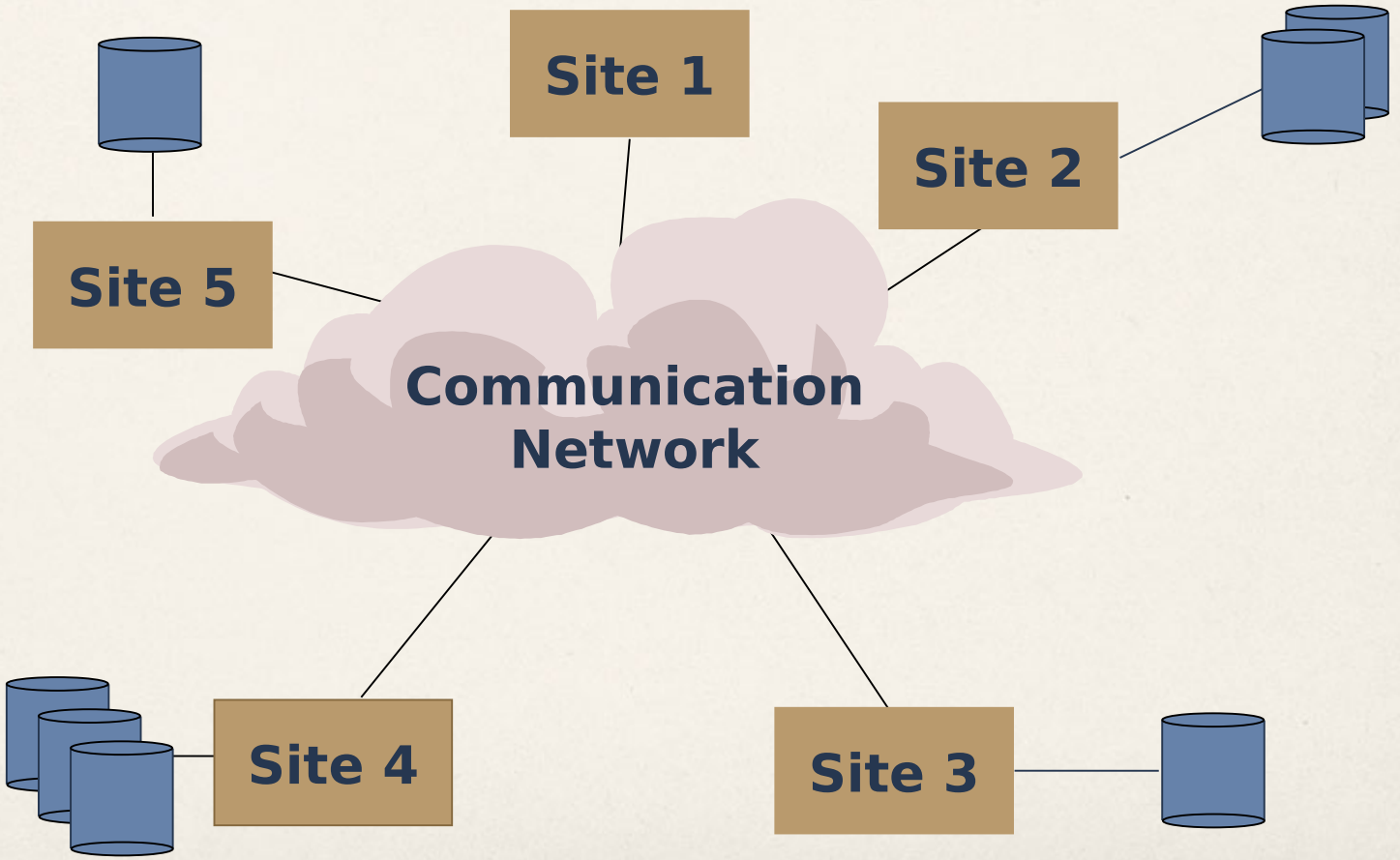
What is not a DDBS?

- 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 not a multiprocessor system

  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

Data Delivery Alternatives

- Delivery modes
  - Pull-only
  - Push-only
  - Hybrid
- Frequency
  - Periodic
  - Conditional
  - Ad-hoc or irregular
- Communication Methods
  - Unicast
  - One-to-many
- Note: not all combinations make sense

Distributed DBMS Promises

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

- 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

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
E8	P3	Manager	40

PROJ

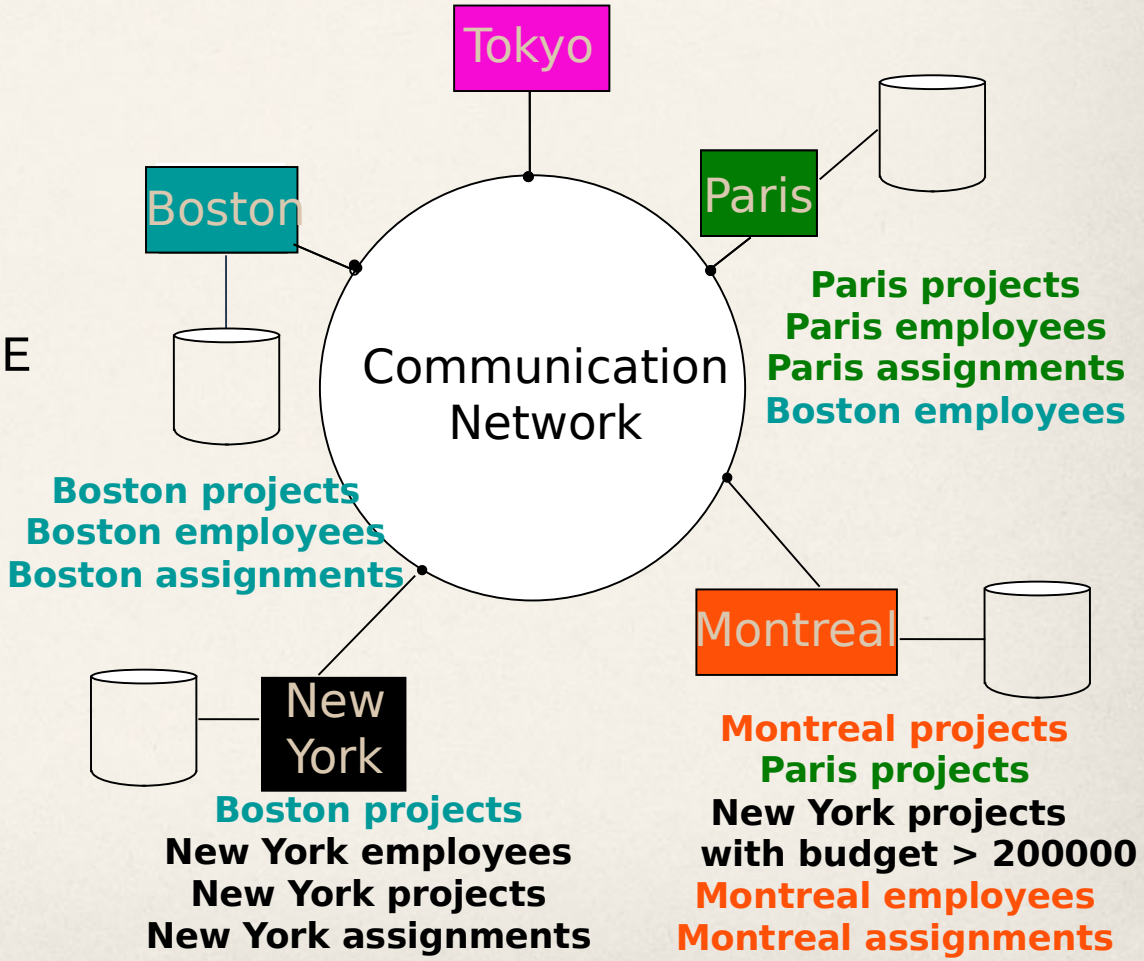
PNO	PNAME	BUDGET
P1	Instrumentation	150000
P2	Database Develop.	135000
P3	CAD/CAM	250000
P4	Maintenance	310000

PAY

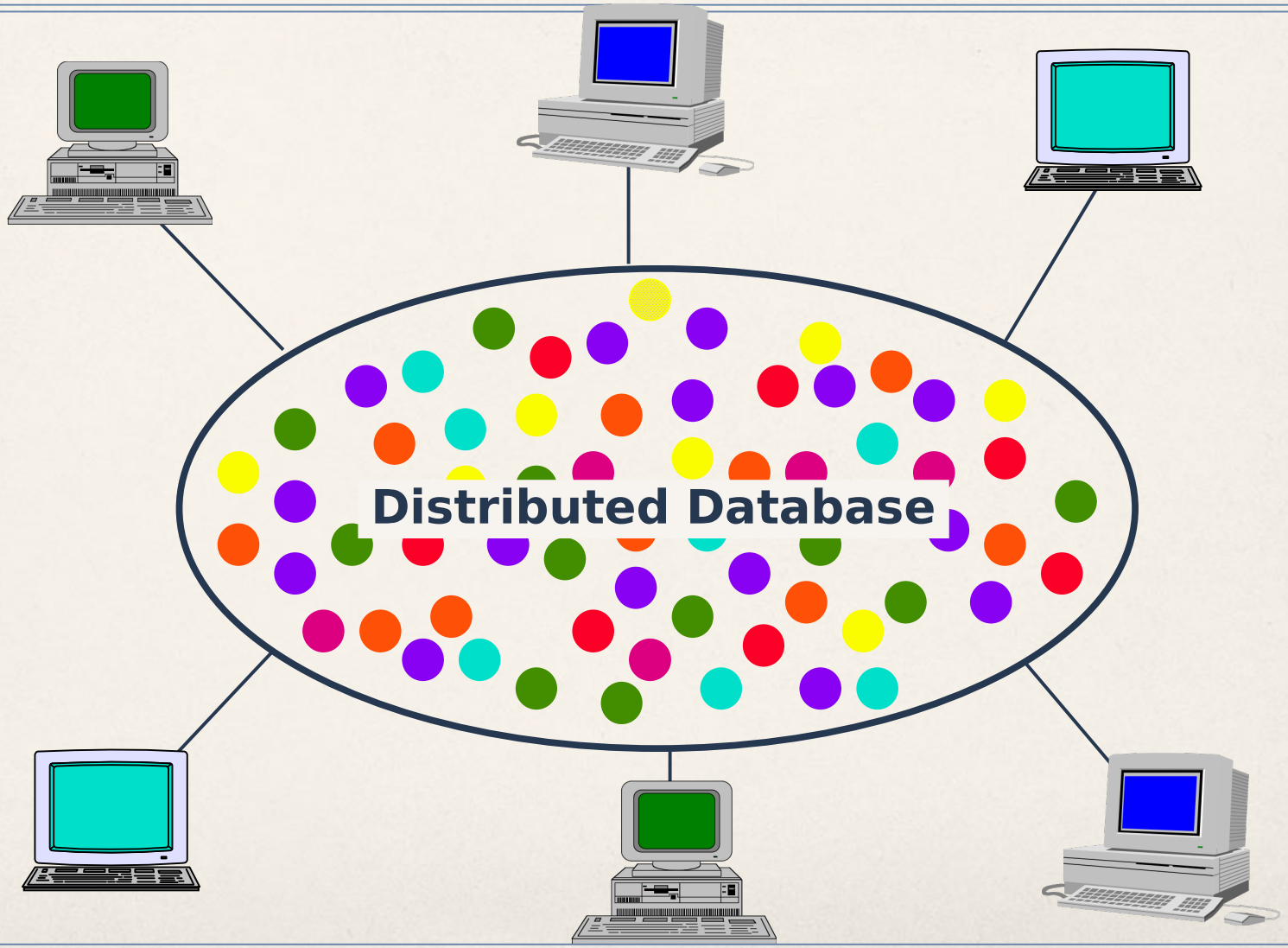
TITLE	SAL
Elect. Eng.	40000
Syst. Anal.	34000
Mech. Eng.	27000
Programmer	24000

Transparent Access

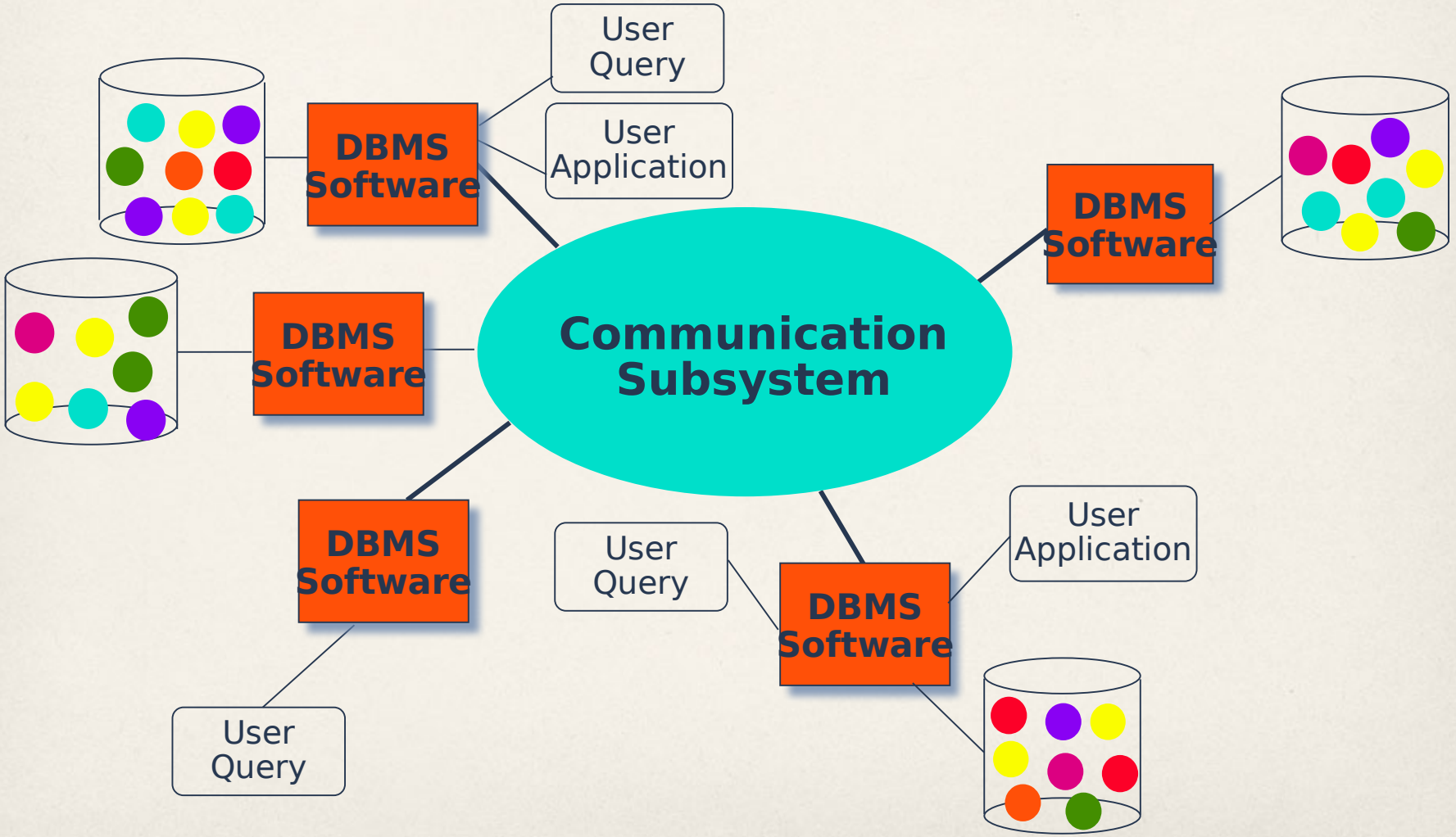
```
SELECT ENAME,SAL
FROM   EMP,ASG,PAY
WHERE  DUR > 12
AND    EMP.ENO = ASG.ENO
AND    PAY.TITLE = EMP.TITLE
```



Distributed Database - User View



Distributed DBMS - Reality



Types of Transparency

- Data independence
- Network transparency (or distribution transparency)
  - Location transparency
  - Naming transparency
- Replication transparency
  - Refers only to the existence of replicas, not to their actual location
- Fragmentation transparency
  - This is commonly done for reasons of performance, availability and reliability

Reliability Through Transactions

- Replicated components and data should make distributed DBMS more reliable.
- Distributed transactions provide
  - Concurrency transparency
  - Failure atomicity
- Distributed transaction support requires implementation of
  - Distributed concurrency control protocols
  - Commit protocols
- Data replication
  - Great for read-intensive workloads, problematic for updates
  - Replication protocols

Improved Performance

- Distributed DBMS fragments stored in close proximity to its points of use

  Each site handles only a portion of the database (contention is not as severe as centralized databases)

  Localization reduces remote access delays that are usually involved in WANs

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

Distributed DBMS Issues

- **Distributed Database Design**

  How to distribute the database

  Replicated & non-replicated database distribution

  A related problem in directory management (descriptions and locations about data items in the database)

- **Query Processing**

  Convert user transactions to data manipulation instructions

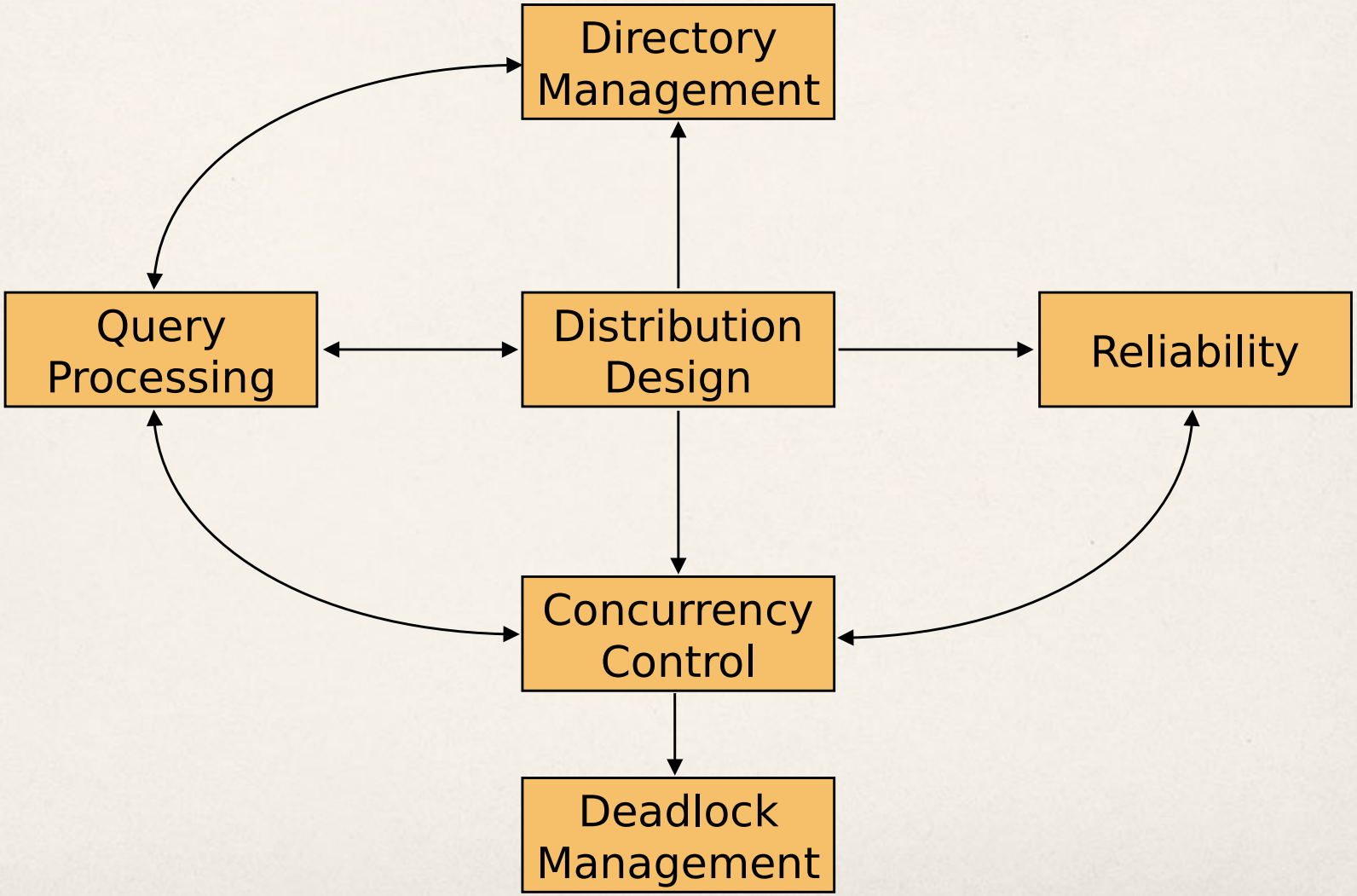
  Optimization problem

  - min{cost = data transmission + local processing}

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