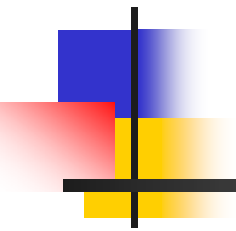
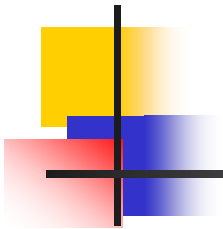


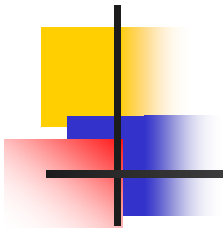
Distributed Databases and Client-Server Architectures

Chapter 25



Chapter Outline

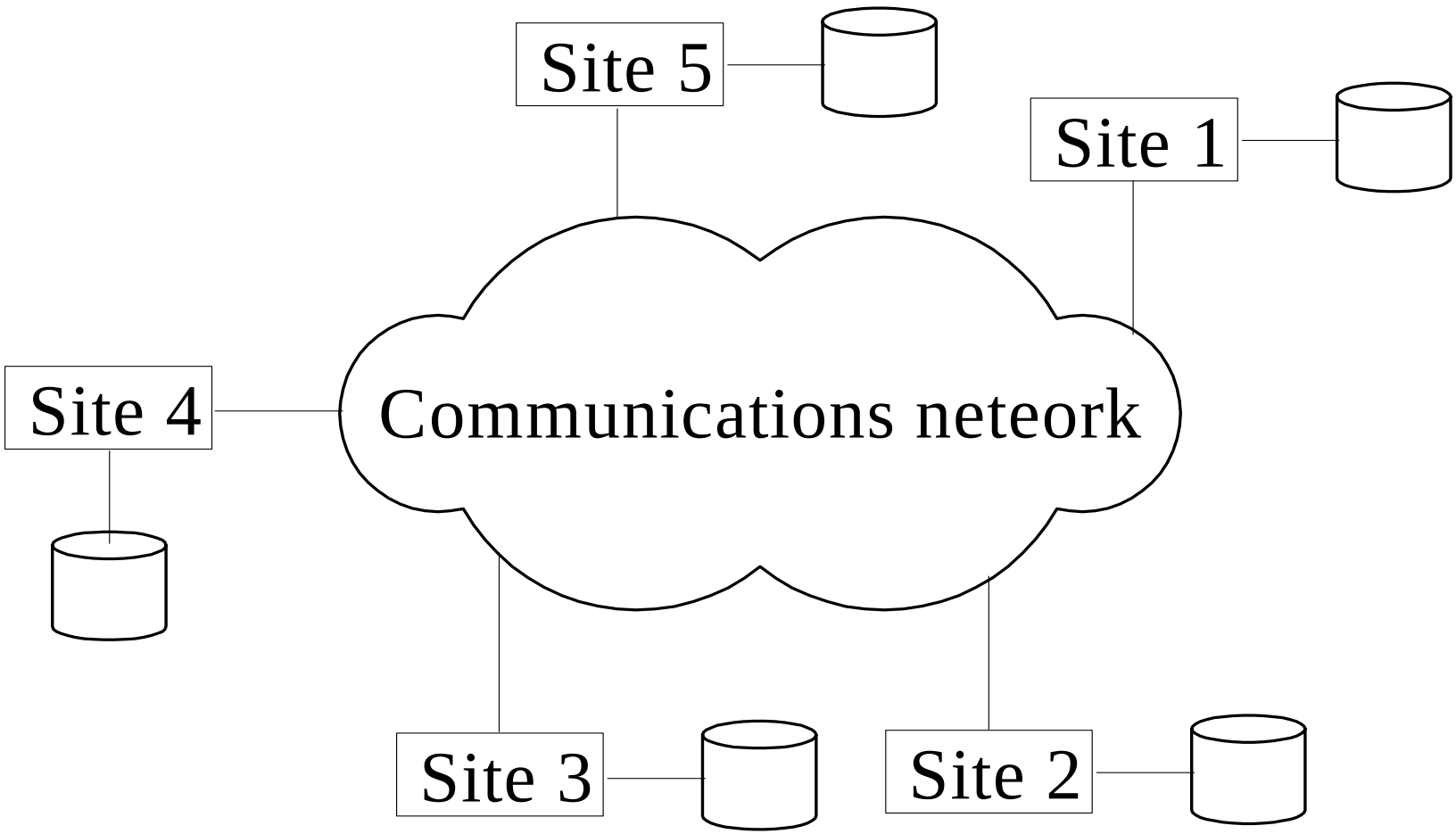
- Distributed Database (DDB) Concepts
- Data Fragmentation, Replication and Allocation
- Types of Distributed Database Systems
- Query Processing
- Concurrency Control and Recovery
- 3-Tier Client-Server Architecture

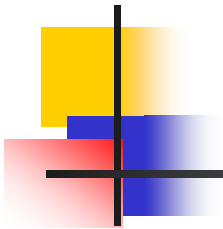


- Distributed Database (DDB) Concepts ...

- It is a system to process Unit of execution (a transaction) in a distributed manner. That is, a transaction can be executed by multiple networked computers in a unified manner.
- DDB can be defined as a collection of multiple logically related database distributed over a computer network.
- A distributed database management system (DDBMS) is a software system that manages a DDB while making the distribution transparent to the user

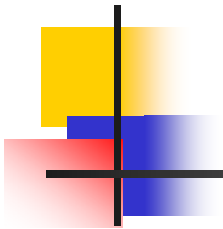
... - DDBs Concepts





- Advantages of DDB System

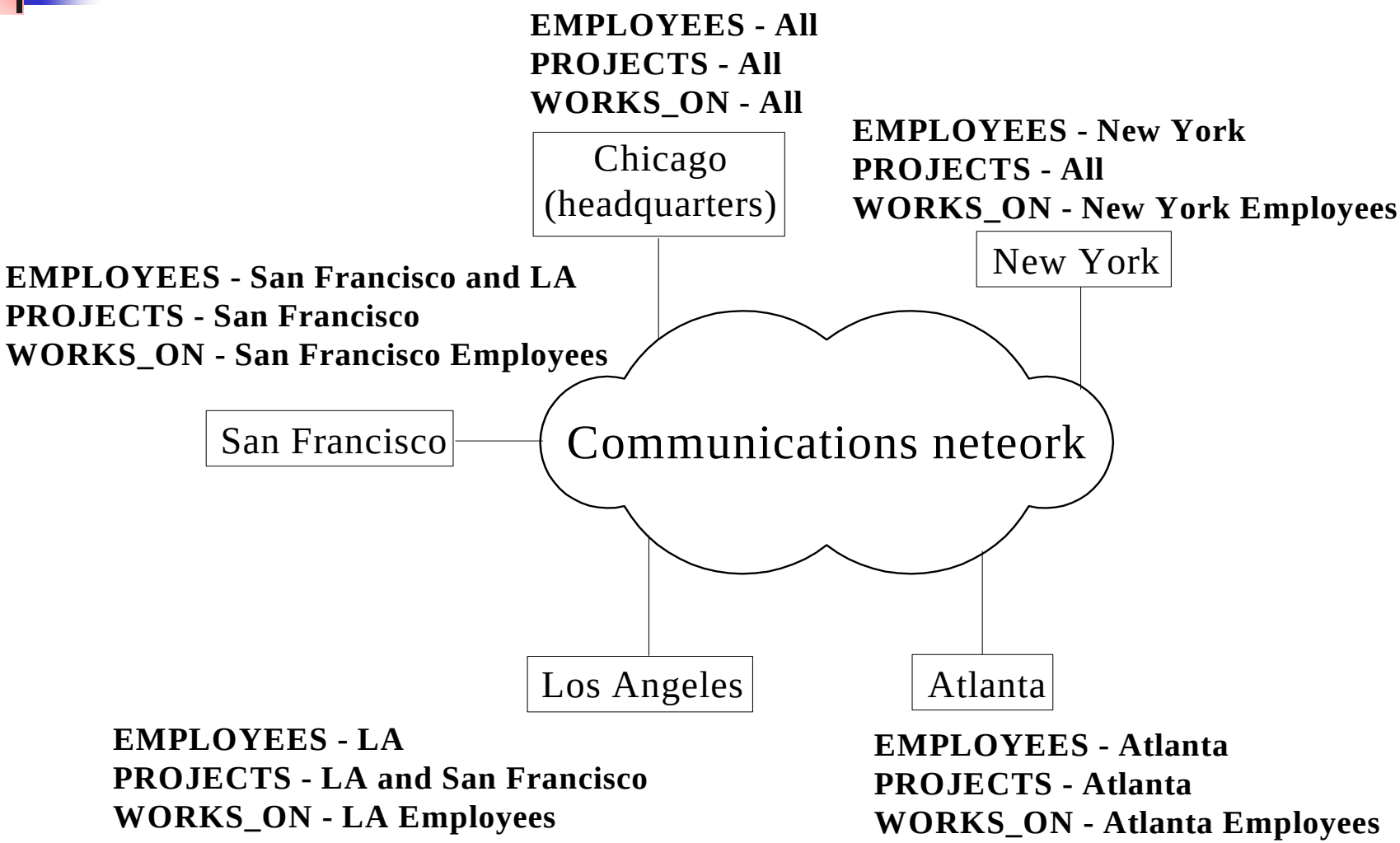
1. Management of distributed data with different levels of transparency
   - Distribution and Network transparency: (naming & location)
   - Replication transparency
   - Fragmentation transparency
2. Increased reliability and availability
3. Improved performance
4. Easier expansion (scalability)

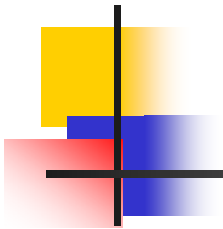


- Data Fragmentation and Replication ...

- Data Fragmentation
  - Horizontal fragmentation
  - Vertical fragmentation
  - Hybrid (Mixed) fragmentation
- Replication
  - Full
  - Partial

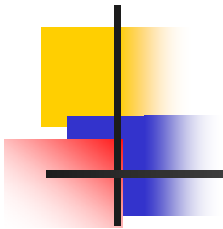
... - Data Fragmentation and Replication: e.g.





- Types of DDBs

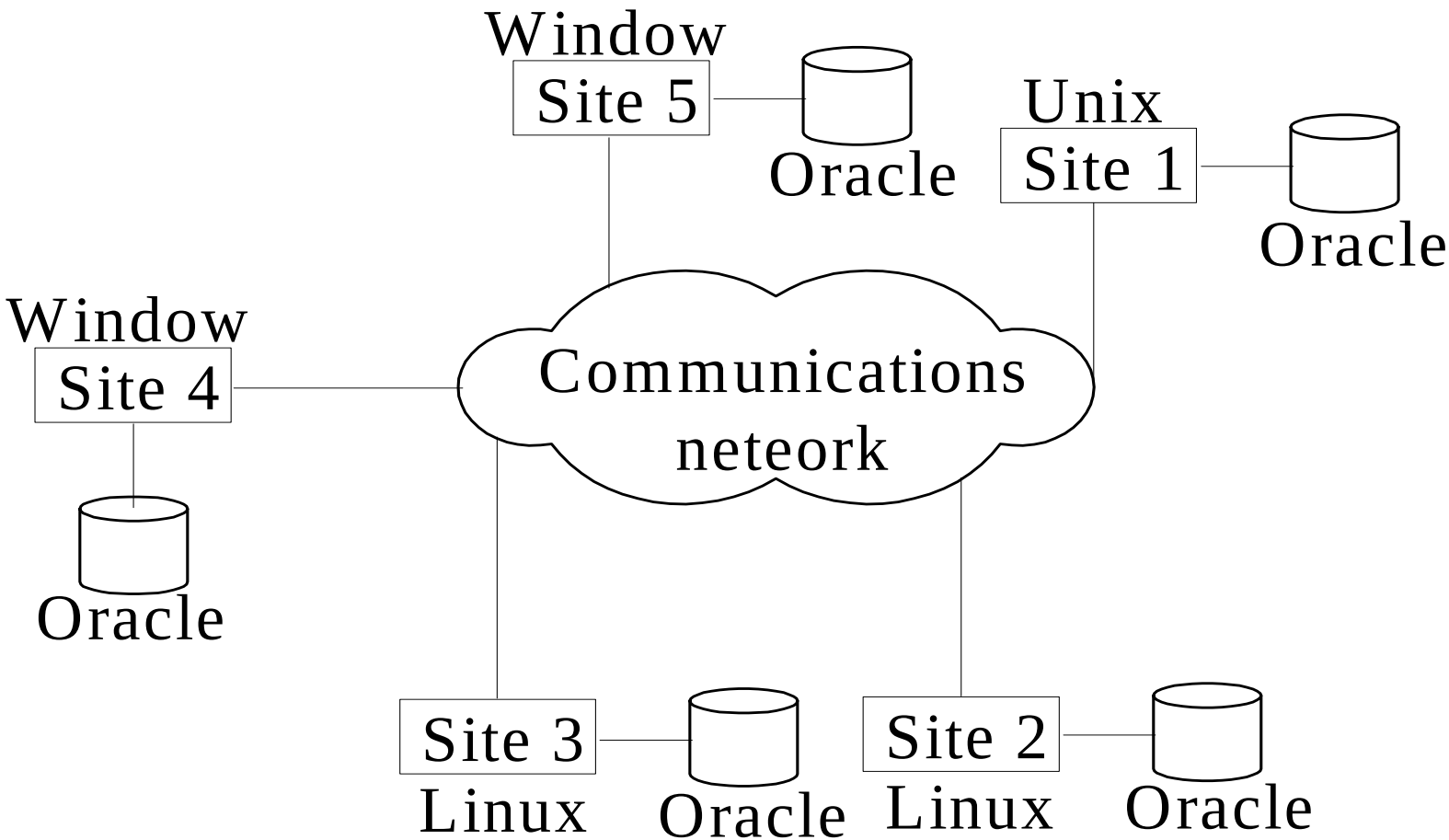
- **Homogeneous**: Each site runs the same database system
- **Heterogeneous**: Each site may run different database system
  - **Federated** : access is managed through a single conceptual schema. This implies that the degree of local autonomy is minimum. Each site must adhere to a centralized access policy. There may be a global schema.
  - **Multidatabase**: There is no one conceptual global schema. For data access a schema is constructed dynamically as needed by the application software.



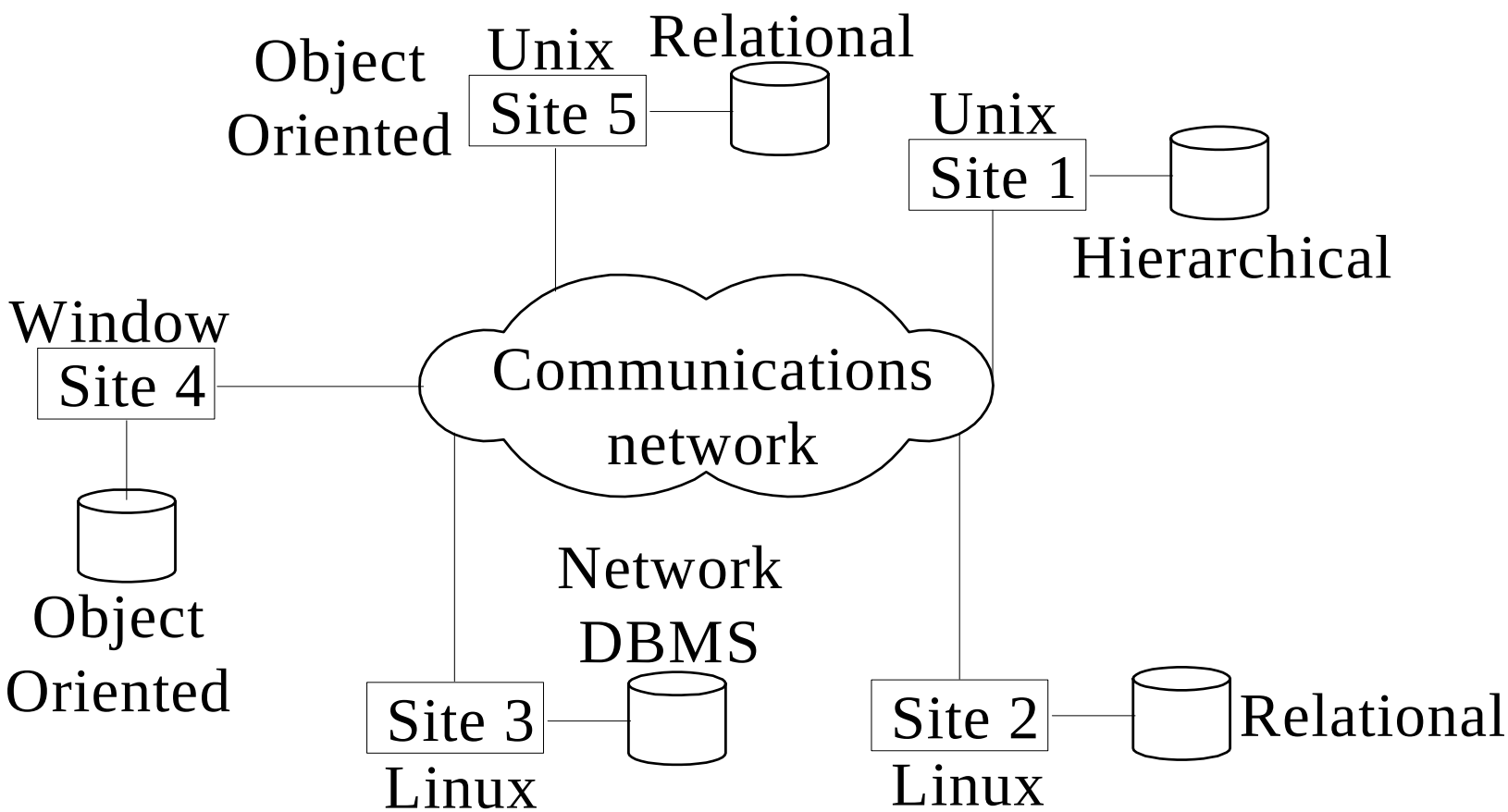
-- Federated DB Management Systems Issues

- **Differences in data models:** Relational, Objected oriented, hierarchical, network, etc.
- **Differences in constraints:** Each site may have their own data accessing and processing constraints.
- **Differences in query language:** Some site may use SQL, some may use SQL-89, some may use SQL-92, and so on.

-- Homogeneous



-- Heterogeneous



- Query Processing in DDBs ...

- **Emp**:

Fname	Minit	Lname	SSN	Bdate	Address	Sex	Salary	Superssn	Dno

  - Rows 10,000
  - Row size 100 bytes.
  - Table size 1,000,000 bytes

- **Dept**:

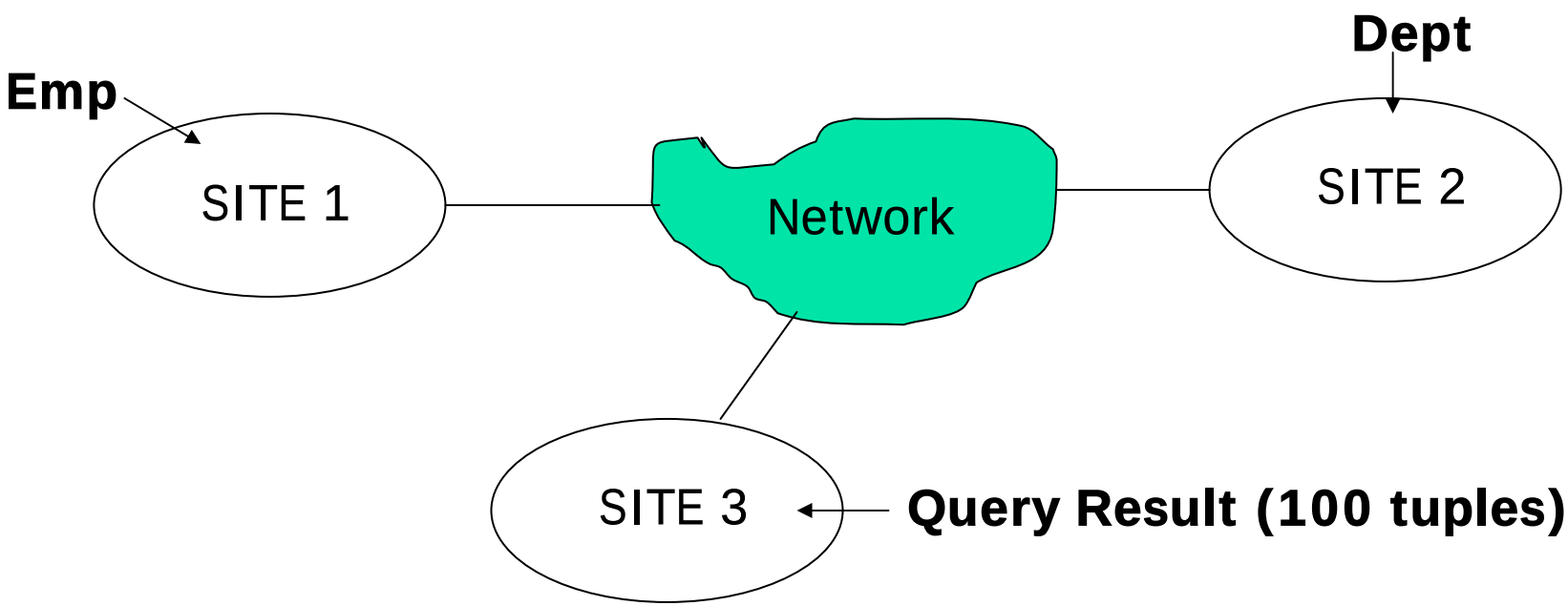
Dname	Dnumber	Mgrssn	Mgrstartdate

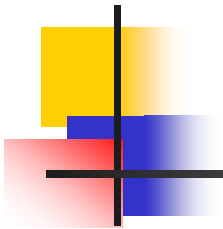
  - Rows 100
  - Row size 35 bytes.
  - Table size 3500 bytes

... - Query Processing in DDBs ...

- Assumption: cost of transferring data high: optimization necessary.
- Example:

```
SELECT Fname,Lname,Dname
FROM Dept, emp
WHERE MgrSSN = SSN
```





... - Query Processing in DDBs ...

- Strategies

1. Transfer Emp and Dept to the result site and perform the join at site 3. Total bytes transferred = 1,000,000 + 3500 = **1,003,500 bytes**.

2. Transfer Emp to site 2, execute join at site 2 and send the result to site 3. Query result size = 40 * 100 = 4000 bytes. Total transfer size = 4000 + 1,000,000 = **1,004,000** bytes. (Assume 40 is the size of the output record)

3. Transfer Dept relation to site 1, execute join at site 1 and send the result to site 3. Total transfer size = 4000 + 3500 = **7500 bytes**

... - Query Processing in DDBs

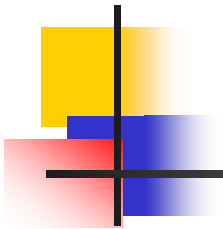
- Use **Semijoin** to reduce the number of tuples in a relation before transferring it to another site

- Example: Assume we want the results at site 2:

  1. Project the join attributes of Dept at site 2, and transfer them to site 1. 9 * 100 = 900 bytes are transferred.

  2. Join the transferred file with Emp at site 1, and transfer the required attributes from the resulting file to site 2. 39 * 100 = 3900 bytes are transferred.

  3. Execute the query by joining the transferred file with Department and present the result to the user at site 2.



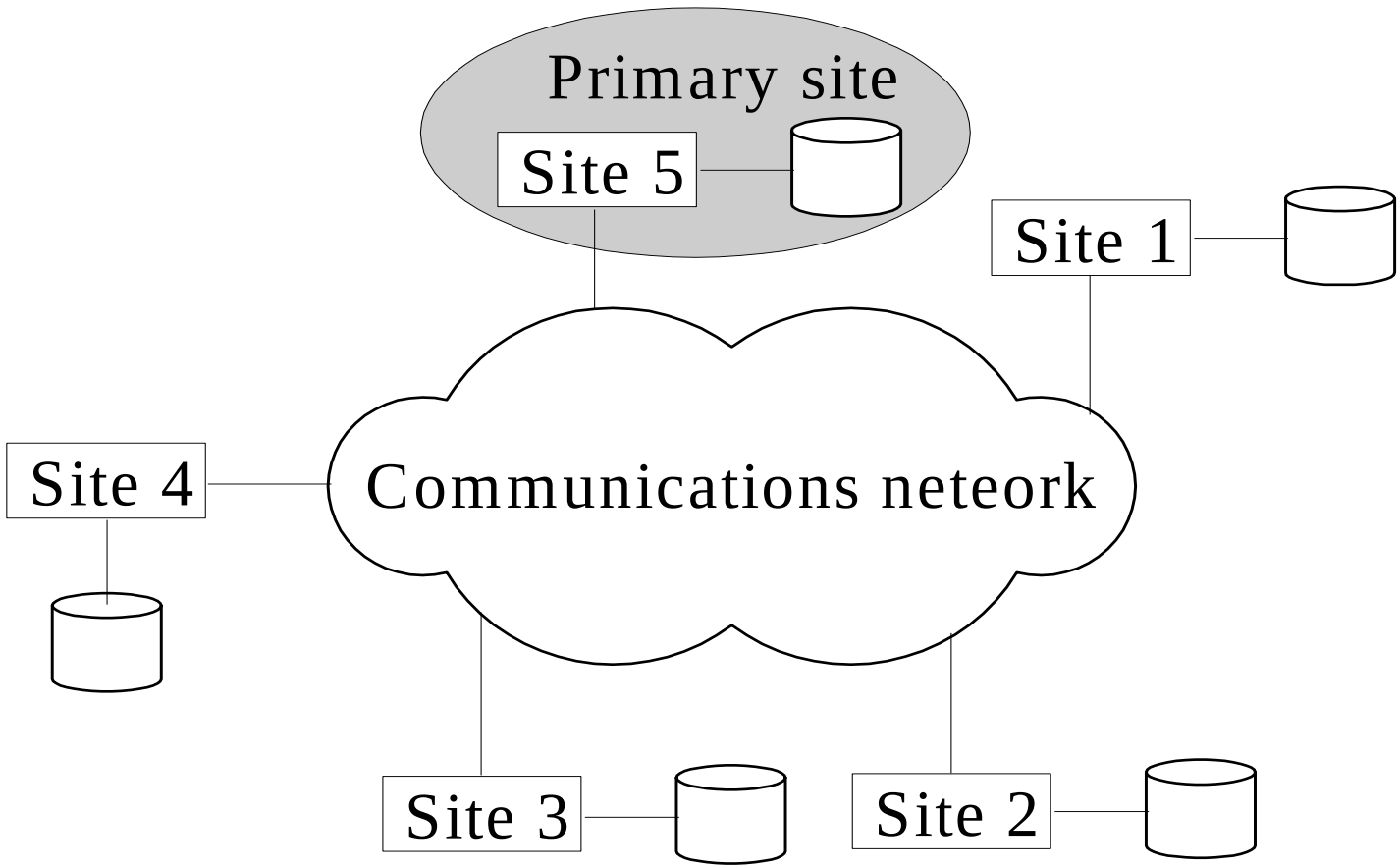
- Concurrency Control and Recovery in DDBs

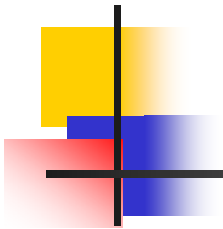
- Distributed Databases encounter a number of concurrency control and recovery problems which are not present in centralized databases. Some of them are listed below.
  - Dealing with multiple copies of data items
  - Failure of individual sites
  - Communication link failure
  - Distributed commit
  - Distributed deadlock

-- Techniques of Distributed Concurrency Control

- Based on Distinguished copy
  - Primary site with no backup site
  - Primary site with backup site
  - Primary copy Technique
- Based on voting

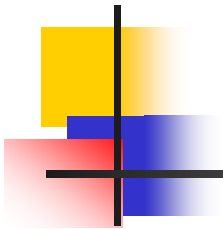
--- Primary site with no backup site ...





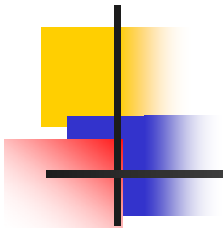
... --- Primary site with no backup site

- A single site is designated as a primary site which serves as a coordinator for transaction management. If all transactions follow two-phase locking policy at all sites, then serializability is guaranteed
- **Advantages**:
  - An extension to the centralized two phase locking so implementation and management is simple.
  - Data items are locked only at one site but they can be accessed at any site.
- **Disadvantages**:
  - Bottleneck problem
  - If the primary site fails, the entire system is inaccessible



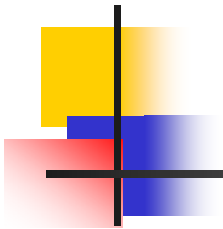
--- Primary site with backup site

- Behaves as a shadow of primary site.
  - All locking information must be copied to the backup site
- In case of primary site failure, backup site can act as primary site and a new backup site is chosen
- **Advantage**: Faster recover from a failed primary site.
- **Disadvantage**: Slow because both sites must be consistent.



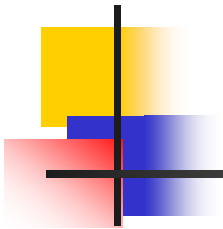
---- Recovery from a coordinator failure

- Failure of primary site with no backup site
  - All active transactions at all sites are aborted and restarted.
  - A new coordinator is selected and transaction processing is initiated
- Failure of primary site with backup site
  - All active transactions are suspended
  - The backup site is designated as the primary site
  - A new back up site is selected
  - The new backup site is sent all the location information from the new primary site.



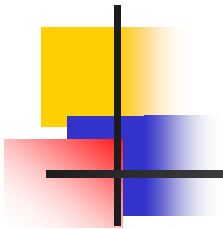
--- Primary Copy Technique

- Lock coordination is distributed among various sites having distinguished copies of different data.
- **Advantages**:
  - Since primary copies are distributed at various sites, a single site is not overloaded with locking and unlocking requests.
  - Failure of one site affects only transactions whose primary copy resides at that site.
- **Disadvantages**:
  - Identification of a primary copy is complex.
  - A distributed directory must be maintained, possibly at all sites.



-- Concurrency control based on voting

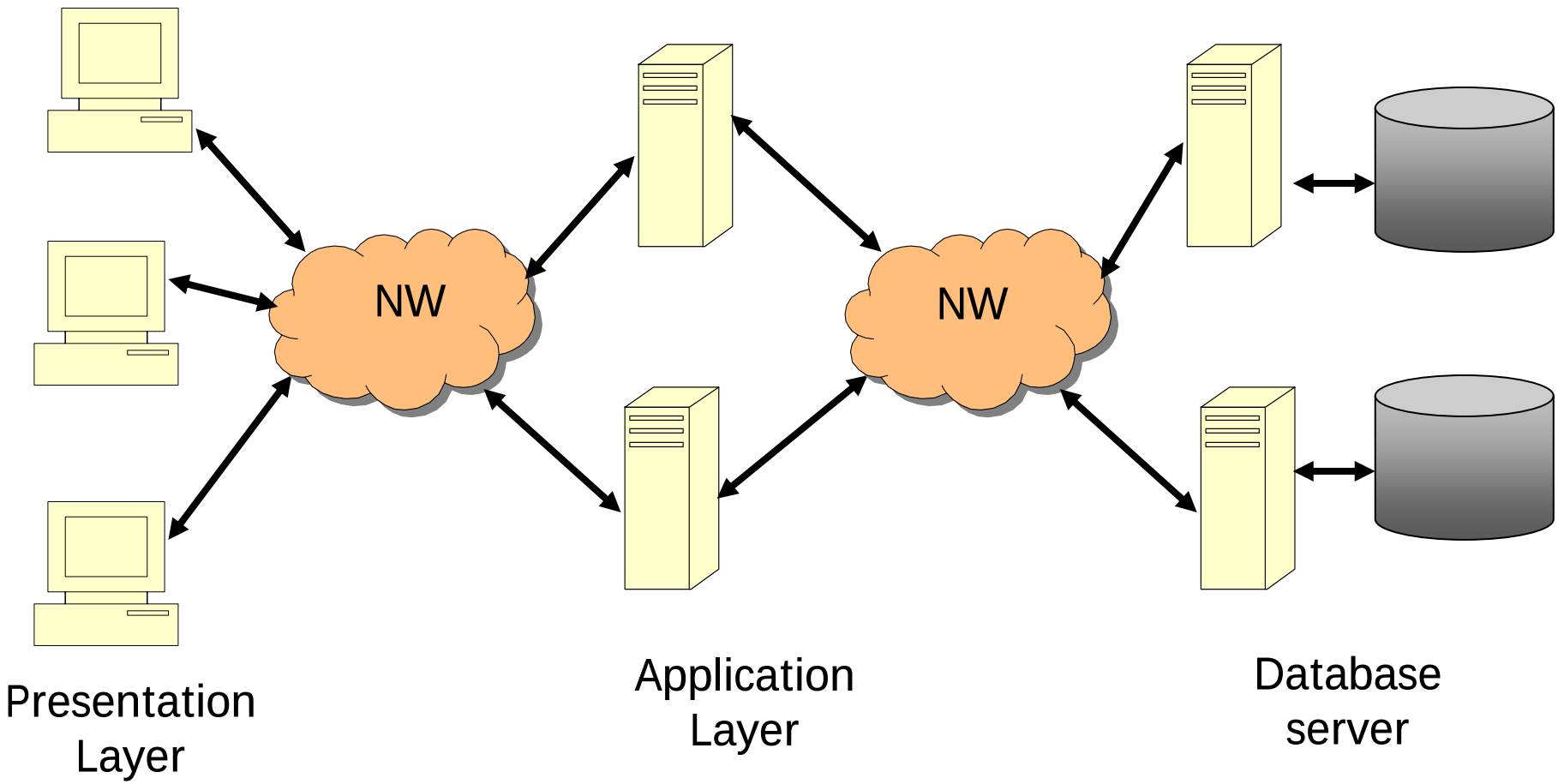
- There is no primary copy of coordinator
- Send lock request to sites that have data item.
- If majority of sites grant lock then the requesting transaction gets the data item.
- Locking information (grant or denied) is sent to all these sites.
- To avoid unacceptably long wait, a time-out period is defined. If the requesting transaction does not get any vote information then the transaction is aborted.

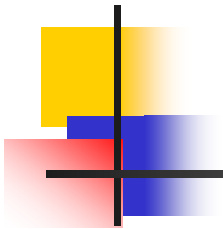


- Overview of 3-Tier C-S Architecture ...

- Full scale DDBMS which supports all mentioned functionalities have not been developed yet.
- So far DDB application are being developed in the context of client-server (C-S) architecture.
- The most common C-S architecture is the 3-tier. It consists of:
  1. Presentation layer
  2. Application layer
  3. Database server

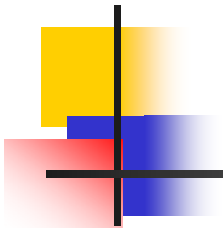
... - Overview of 3-Tier C-S Architecture





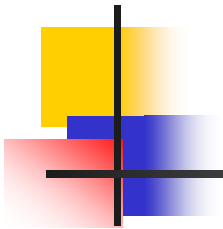
-- Presentation Layer

- Provides user Interface and interacts with the user using
  - Forms
  - Web interfaces
- Common programming languages used at this layer are:
  - HTML
  - JAVA
  - JavaScript
  - PERL
  - VB
- When web interface is used, the communication with the application layer is done via the HTTP protocol.



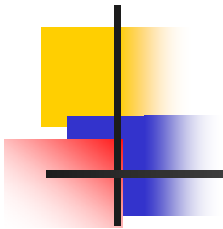
-- Application Layer

- Also called business logic layer
- Programs the application logic
- Can also handle additional application functionality, such as security checks and identity verification.
- Interacts with one or more databases servers using:
  - ODBC
  - JDBC
  - SQL/CLI
  - And other DB access techniques



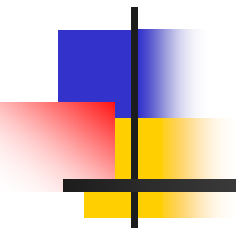
-- Database server

- Handles queries and update requests from the application layer, processes the requests and sends back the results
  - If DBMS is relation or Object relational, requests come as SQL
  - Results most of the time return as XML



-- Processing of a SQL queries goes as follows

- The user inters his request using web interface or forms in the presentation layer.
- The application server formulates a user query based on the input from the presentation layer, decomposes it into a number of independent site queries. Each site query is sent to appropriate database server.
- Each server processes its query and sends the result (most probably in XML format) to the application server.
- The application server combines the results of site queries and formats it into HTML or some other form and sends it to the presentation layer.



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