DISTRIBUTED DATABASE MANAGEMENT SYSTEM

CHAPTER 07

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- The Evolution of Distributed Database Management Systems
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- Characteristics of DDBMS
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The Evolution of Distributed Database Management Systems

- Distributed database management system (DDBMS)
  - Governs storage and processing of logically related data over interconnected computer systems in which both data and processing functions are distributed among several sites

Distributed Database System

- A distributed database system consists of loosely coupled sites that share no physical component
- Database systems that run on each site are independent of each other
- Transactions may access data at one or more sites

Homogeneous Distributed Databases

- In a homogeneous distributed database
  - All sites have identical software
  - Are aware of each other and agree to cooperate in processing user requests.
  - Each site surrenders part of its autonomy in terms of right to change schemas or software
  - Appears to user as a single system
- In a heterogeneous distributed database
  - Different sites may use different schemas and software
    - Difference in schema is a major problem for query processing
    - Difference in softwrae is a major problem for transaction processing
  - Sites may not be aware of each other and may provide only limited facilities for cooperation in transaction processing

Distributed Data Storage

- Assume relational data model
- Replication
  - System maintains multiple copies of data, stored in different sites, for faster retrieval and fault tolerance.
- Fragmentation
  - Relation is partitioned into several fragments stored in distinct sites
- Replication and fragmentation can be combined
  - Relation is partitioned into several fragments: system maintains several identical replicas of each such fragment.

Data Replication

- A relation or fragment of a relation is **replicated** if it is stored redundantly in two or more sites.
- Full replication of a relation is the case where the relation is stored at all sites.
- Fully redundant databases are those in which every site contains a copy of the entire database.

Data Replication (Cont.)

- Advantages of Replication
  - **Availability**: failure of site containing relation *r* does not result in unavailability of *r* is replicas exist.
  - **Parallelism**: queries on *r* may be processed by several nodes in parallel.
  - **Reduced data transfer**: relation *r* is available locally at each site containing a replica of *r*.
- Disadvantages of Replication
  - Increased cost of updates: each replica of relation *r* must be updated.
  - Increased complexity of concurrency control: concurrent updates to distinct replicas may lead to inconsistent data unless special concurrency control mechanisms are implemented.
    - One solution: choose one copy as **primary copy** and apply concurrency control operations on primary copy

Data Fragmentation

- Division of relation r into fragments r_1, r_2, …, r_n which contain sufficient information to reconstruct relation r.
- **Horizontal fragmentation**: each tuple of *r* is assigned to one or more fragments
- **Vertical fragmentation**: the schema for relation *r* is split into several smaller schemas
  - All schemas must contain a common candidate key (or superkey) to ensure lossless join property.
  - A special attribute, the tuple-id attribute may be added to each schema to serve as a candidate key.
- Example : relation account with following schema
- *Account-schema* = (*branch-name*, *account-number, balance*)

Horizontal Fragmentation of *account* Relation

branch-name	*account-number*	*balance*
Hillside	A-305	500
Hillside	A-226	336
Hillside	A-155	62

$account_1 = \sigma_{branch\text{-}name=\text{“Hillside”}}(account)$

branch-name	*account-number*	*balance*
Valleyview	A-177	205
Valleyview	A-402	10000
Valleyview	A-408	1123
Valleyview	A-639	750

$account_2 = \sigma_{branch\text{-}name=\text{“Valleyview”}}(account)$

Vertical Fragmentation of *employee-info* Relation

branch-name	*customer-name*	*tuple-id*
Hillside	Lowman	1
Hillside	Camp	2
Valleyview	Camp	3
Valleyview	Kahn	4
Hillside	Kahn	5
Valleyview	Kahn	6
Valleyview	Green	7

$deposit_1 = \Pi_{branch\text{-}name,\ customer\text{-}name,\ tuple\text{-}id}(employee\text{-}info)$

account number	*balance*	*tuple-id*
A-305	500	1
A-226	336	2
A-177	205	3
A-402	10000	4
A-155	62	5
A-408	1123	6
A-639	750	7

$deposit_2 = \Pi_{account\text{-}number,\ balance,\ tuple\text{-}id}(employee\text{-}info)$

Advantages of Fragmentation

- Horizontal:
  - allows parallel processing on fragments of a relation
  - allows a relation to be split so that tuples are located where they are most frequently accessed
- Vertical:
  - allows tuples to be split so that each part of the tuple is stored where it is most frequently accessed
  - tuple-id attribute allows efficient joining of vertical fragments
  - allows parallel processing on a relation
- Vertical and horizontal fragmentation can be mixed.
  - Fragments may be successively fragmented to an arbitrary depth.

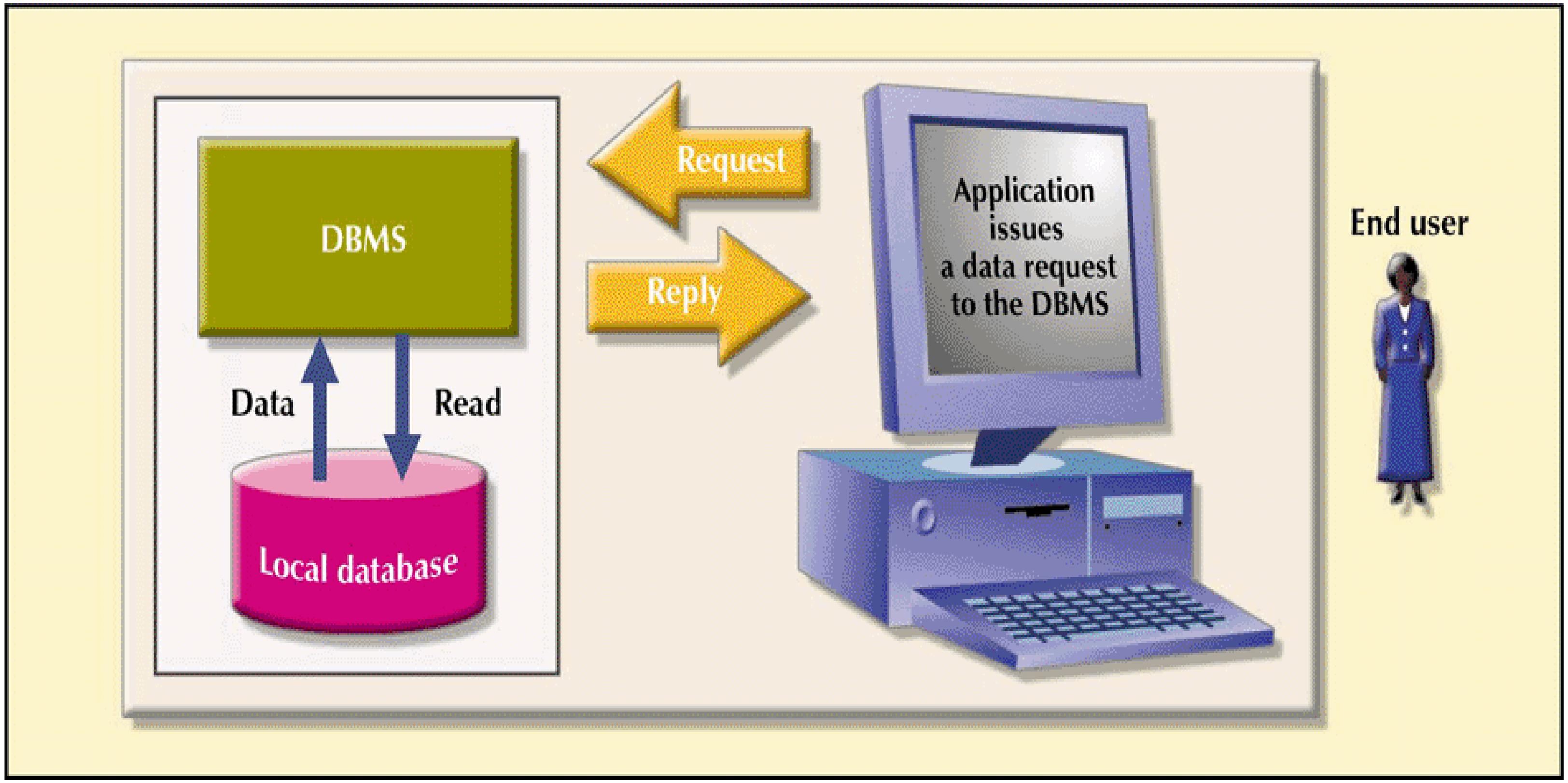
The Evolution of Distributed Database Management Systems (continued)

- Centralized database required that corporate data be stored in a single central site

- Dynamic business environment and centralized database’s shortcomings generate a demand for applications based on data access from different sources at multiple locations

Centralized Database Management System

FIGURE 10.1 CENTRALIZED DATABASE MANAGEMENT SYSTEM



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DDBMS Advantages

- Data are located near “greatest demand” site
- Faster data access
- Faster data processing
- Growth facilitation
- Improved communications
- Reduced operating costs
- User-friendly interface
- Less danger of a single-point failure
- Processor independence

DDBMS Disadvantages

- Complexity of management and control
- Security
- Lack of standards
- Increased storage requirements
- Greater difficulty in managing the data environment
- Increased training cost

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Characteristics of Distributed Management Systems

- Application interface
- Validation
- Transformation
- Query optimization
- Mapping
- I/O interface
- Formatting
- Security
- Backup and recovery
- DB administration
- Concurrency control
- Transaction management

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Characteristics of Distributed Management Systems (continued)

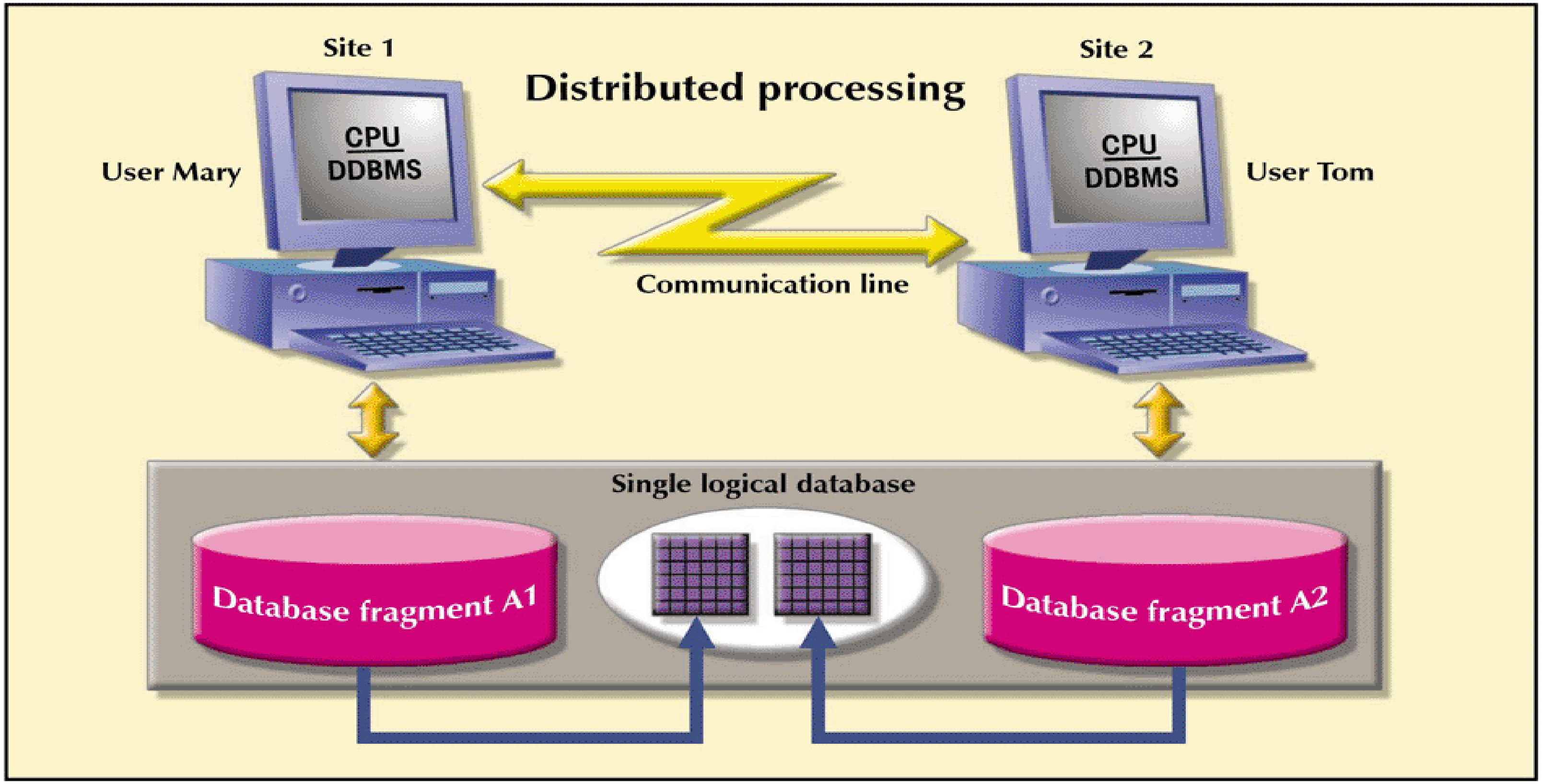
- Must perform all the functions of a centralized DBMS

- Must handle all necessary functions imposed by the distribution of data and processing

- Must perform these additional functions *transparently* to the end user

A Fully Distributed Database Management System

FIGURE 10.4 A FULLY DISTRIBUTED DATABASE MANAGEMENT SYSTEM



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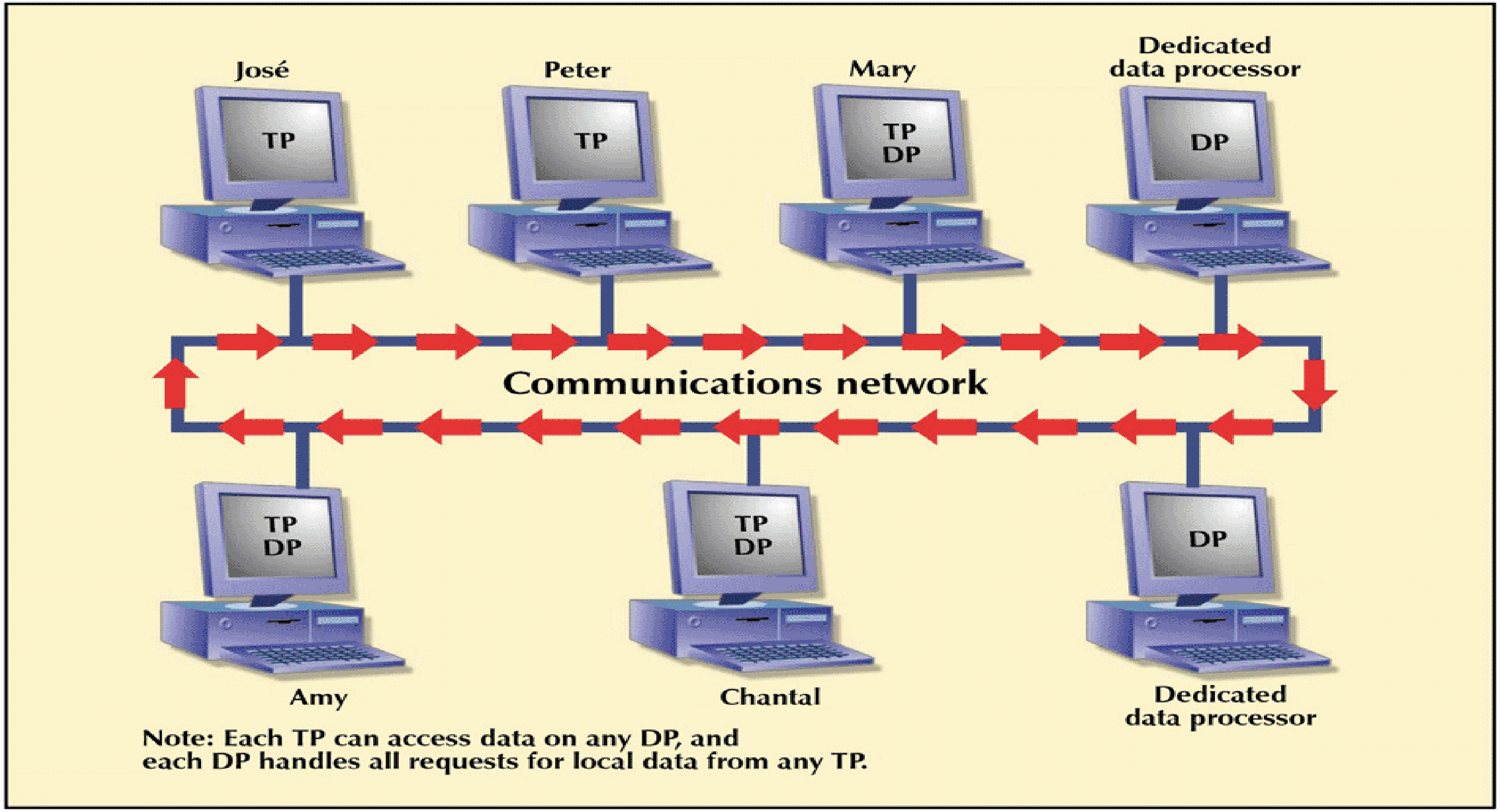
DDBMS Components

- Must include (at least) the following components:
  - *Computer workstations*
  - *Network hardware and software*
  - *Communications media*
  - Transaction processor (or, application processor, or transaction manager)
    - Software component found in each computer that requests data
  - Data processor or data manager
    - Software component residing on each computer that stores and retrieves data located at the site
    - May be a centralized DBMS

Distributed Database System Components

FIGURE 10.5 Distributed Database System Components



Note: Each TP can access data on any DP, and each DP handles all requests for local data from any TP.

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