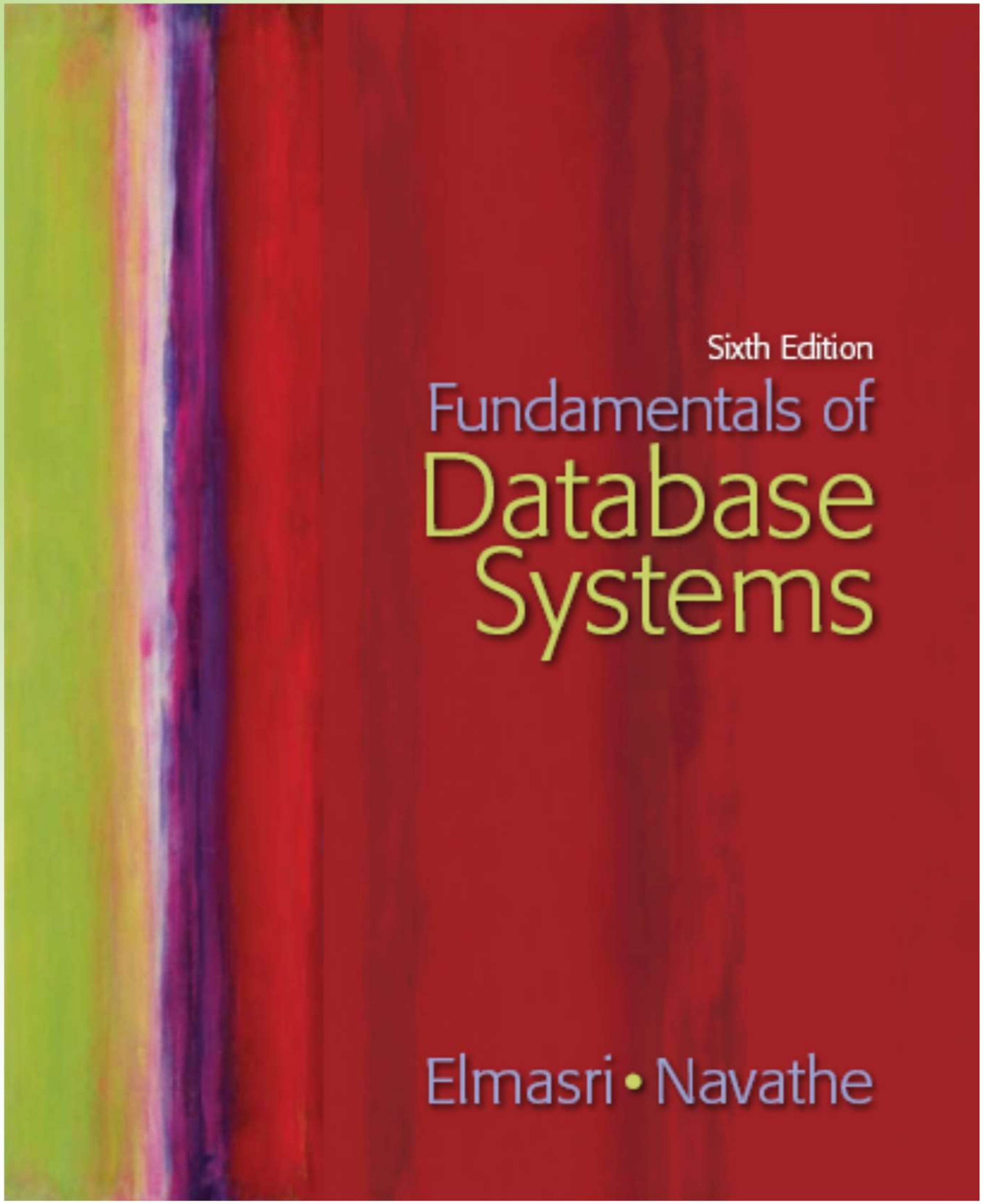
Chapter 2

Database System Concepts and Architecture



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Chapter 2 Outline

- Data Models, Schemas, and Instances
- Three-Schema Architecture and Data Independence
- Database Languages and Interfaces
- The Database System Environment
- Centralized and Client/Server Architectures for DBMSs
- Classification of Database Management Systems

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Database System Concepts and Architecture

- **Basic client/server DBMS architecture**
  - Client module
  - Server module

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Data Models, Schemas, and Instances

- **Data abstraction**
  - Suppression of details of data organization and storage
  - Highlighting of the essential features for an improved understanding of data

Data Models, Schemas, and Instances (cont'd.)

- **Data model**
  - Collection of concepts **that describe the structure of a database**
  - Provides means to achieve data abstraction
  - **Basic operations**
    - Specify retrievals and updates on the database
  - **Dynamic aspect** or **behavior** of a database application
    - Allows the database designer to specify a set of valid operations allowed on database objects

Categories of Data Models

- **High-level** or **conceptual data models**
  - Close to the way many users perceive data
- **Low-level** or **physical data models**
  - Describe the details of how data is stored on computer storage media
- **Representational data models**
  - Easily understood by end users
  - Also similar to how data organized in computer storage

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Categories of Data Models (cont'd.)

- **Entity**
  - Represents a real-world object or concept
- **Attribute**
  - Represents some property of interest
  - Further describes an entity
- **Relationship** among two or more entities
  - Represents an association among the entities
  - **Entity-Relationship model**

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Categories of Data Models (cont'd.)

- **Relational data model**
  - Used most frequently in traditional commercial DBMSs
- **Object data model**
  - New family of higher-level implementation data models
  - Closer to conceptual data models

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Categories of Data Models (cont'd.)

- **Physical data models**
  - Describe how data is stored as files in the computer
  - **Access path**
    - Structure that makes the search for particular database records efficient
  - **Index**
    - Example of an access path
    - Allows direct access to data using an index term or a keyword

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Schemas, Instances, and Database State

- **Database schema**
  - Description of a database
- **Schema diagram**
  - Displays selected aspects of schema
- **Schema construct**
  - Each object in the schema
- **Database state** or **snapshot**
  - Data in database at a particular moment in time

http://english.stackexchange.com/questions/40702/difference-between-scheme-and-schema

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Two Components of Database

1) Database Schema (Meta Data)

Intension:

Database Schema Converted from Designed ER Model

Tables

Attributes: Columns

Constraints: Relationships among Entities, Database Rules

Stored as System Catalogues by System (SQL Server)

2) Database State : **Extension**

Instances of database: Records of Tables

Keep Changing

Initial State: First Populated Database State

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Schemas, Instances, and Database State (cont'd.)

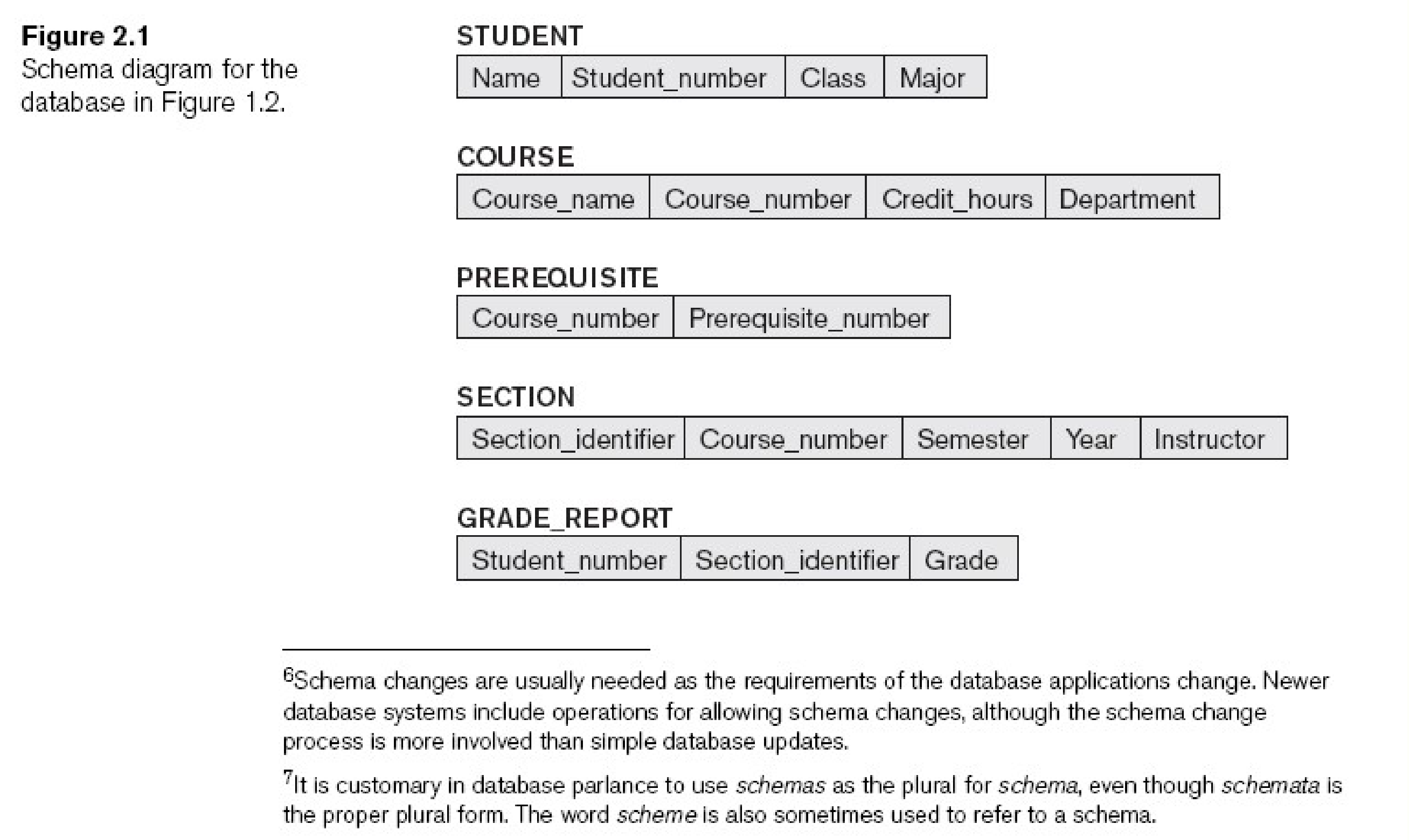

Figure 2.1
Schema diagram for the database in Figure 1.2.

STUDENT

Name	Student_number	Class	Major

COURSE

Course_name	Course_number	Credit_hours	Department

PREREQUISITE

Course_number	Prerequisite_number

SECTION

Section_identifier	Course_number	Semester	Year	Instructor

GRADE_REPORT

Student_number	Section_identifier	Grade

[6] Schema changes are usually needed as the requirements of the database applications change. Newer database systems include operations for allowing schema changes, although the schema change process is more involved than simple database updates.

[7] It is customary in database parlance to use *schemas* as the plural for *schema*, even though *schemata* is the proper plural form. The word *scheme* is also sometimes used to refer to a schema.

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Schema Diagram

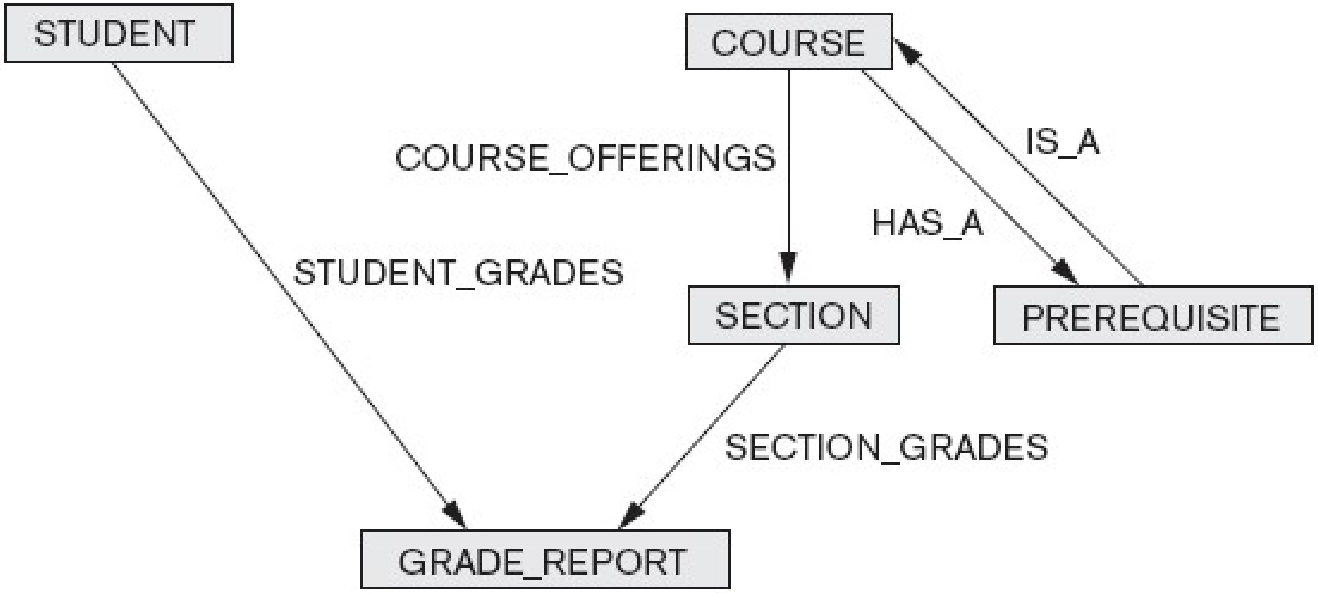

Figure 2.8
The schema of Figure 2.1 in network model notation.

[14] CODASYL DBTG stands for Conference on Data Systems Languages Database Task Group, which is the committee that specified the network model and its language.

Three-Schema Architecture and Data Independence

- **Internal level**
  - Describes physical storage structure of the database
- **Conceptual level**
  - Describes structure of the whole database for a community of users
- **External** or **view level**
  - Describes part of the database that a particular user group is interested in

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Three-Schema Architecture and Data Independence (cont'd.)

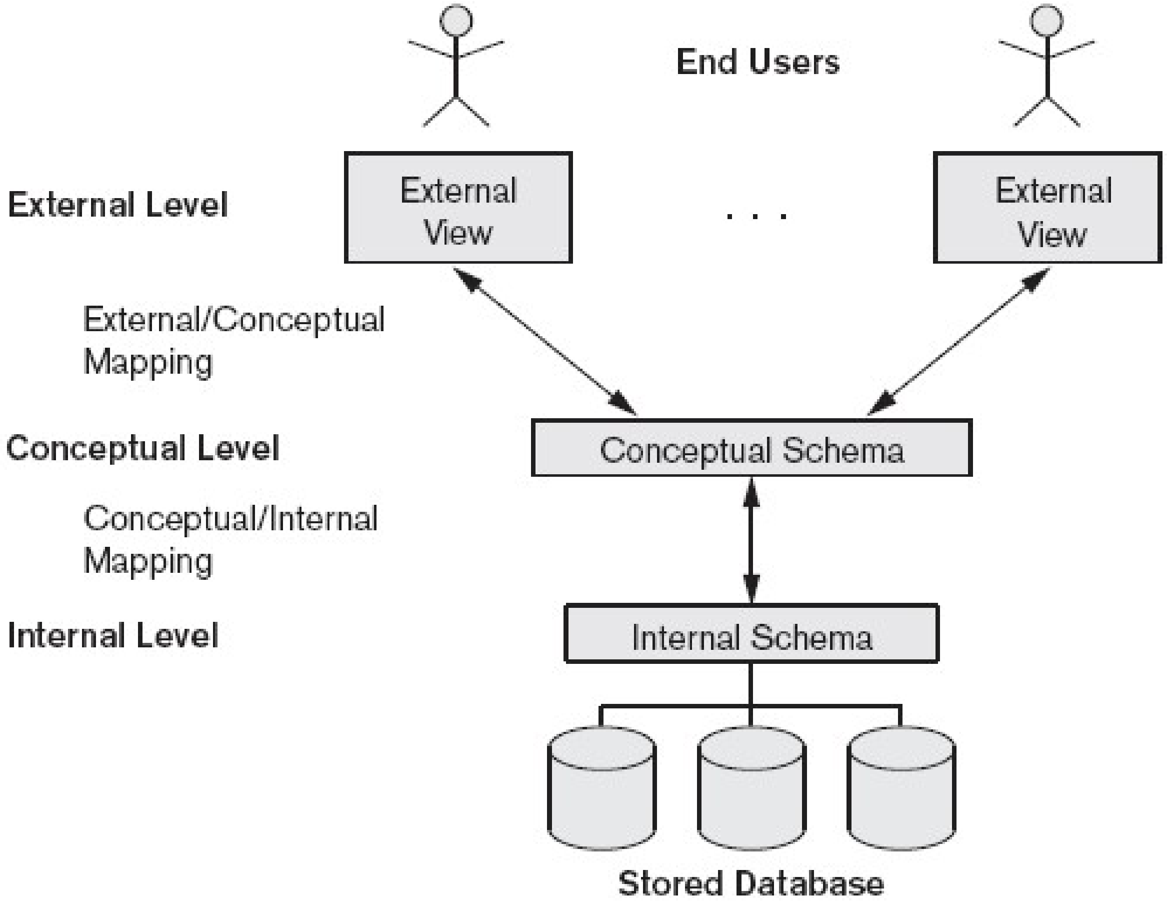

Figure 2.2
The three-schema architecture.

Data Independence

- Capacity to change the schema at one level of a database system
  - Without having to change the schema at the next higher level

- Types:
  - **Logical**
  - **Physical**

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DBMS Languages

- **Data definition language (DDL)**
  - Defines both schemas
- **Storage definition language (SDL)**
  - Specifies the internal schema
- **View definition language (VDL)**
  - Specifies user views/mappings to conceptual schema
- **Data manipulation language (DML)**
  - Allows retrieval, insertion, deletion, modification

Database Language: SQL

- Data Definition Language (DDL)
  - To create Database Schema
  - **Create Table**
- Data Manipulation Language (DML)
  - To populate, modify, and maintain database
  - **Insert**
  - **Delete**
  - **Update**
- Data Retrieval Language :
  - **Select**
- View Definition Language (VDL)
  - **Create View As Select**

DBMS Languages (cont'd.)

- **High-level** or **nonprocedural** DML
  - Can be used on its own to specify complex database operations concisely
  - **Set-at-a-time** or **set-oriented**
- **Low-level** or **procedural** DML
  - Must be embedded in a general-purpose programming language
  - **Record-at-a-time**

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DBMS Interfaces (Client Forms)

- Menu-based interfaces for Web clients or browsing
- Forms-based interfaces
- Graphical user interfaces (**GUI**)
- Natural language interfaces
- Speech input and output
- Interfaces for parametric users
- Interfaces for the DBA

The Database System Environment

- DBMS component modules
  - Buffer management
  - Stored data manager
  - DDL compiler
  - Interactive query interface
    - Query compiler
    - Query optimizer
  - Precompiler

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The Database System Environment (cont'd.)

- DBMS component modules
  - Runtime database processor
  - System catalog
  - Concurrency control system
  - Backup and recovery system

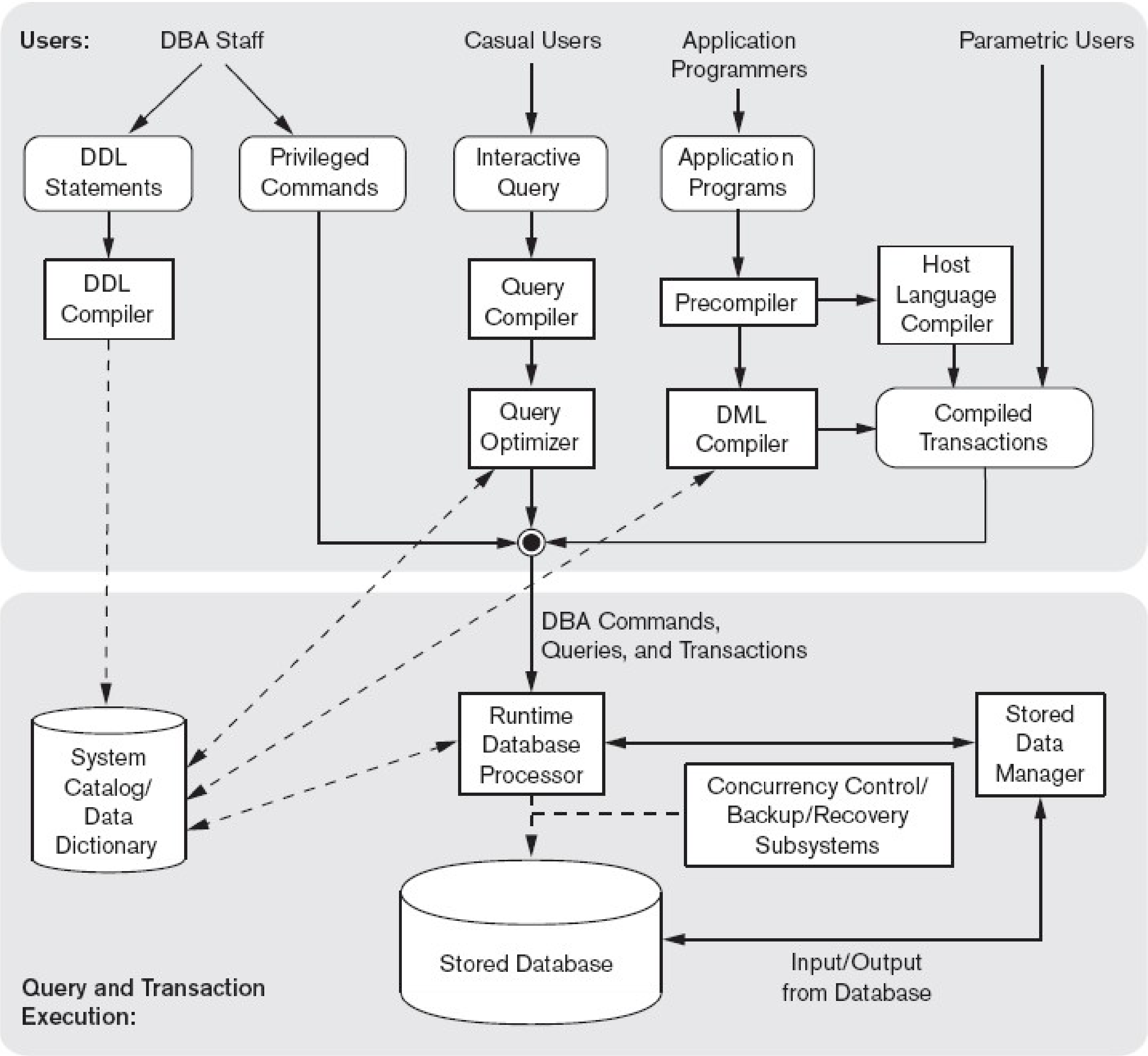

Figure 2.3
Component modules of a DBMS and their interactions.

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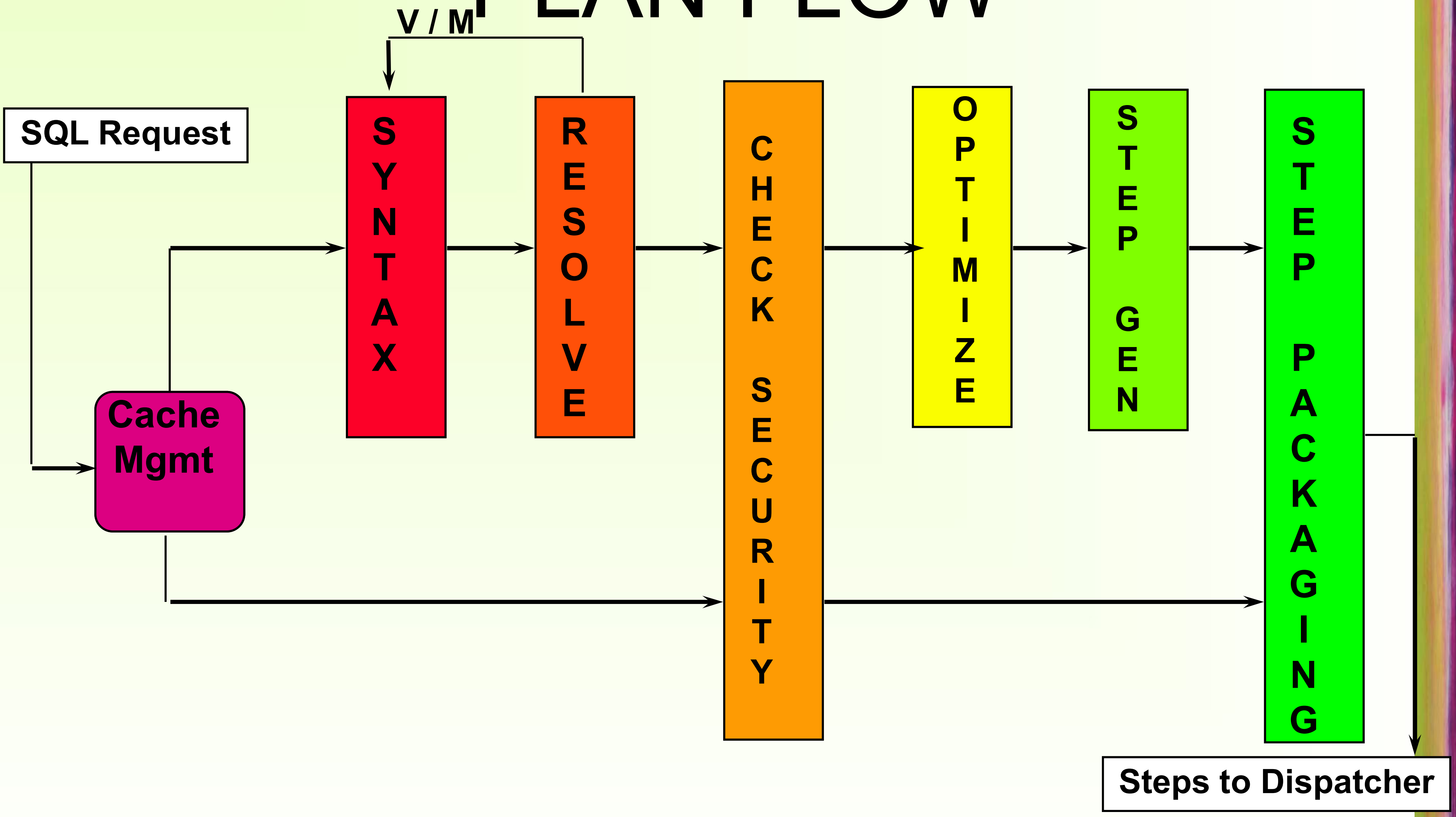
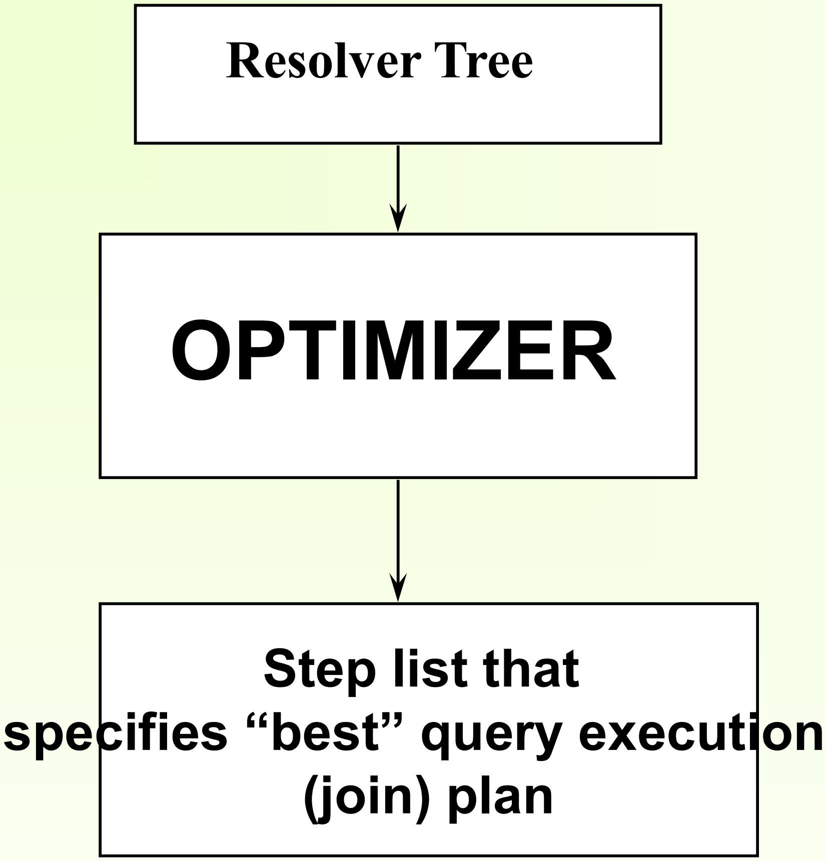
PARSER and EXECUTION PLAN FLOW



Resolver

- Retrieve dictionary information
  - From dictionary cache if possible
  - Annotate skeleton tree (database, table, column)
- Derive new conditions using transitivity
- Handle views and macros
- Handle derived tables
- Identify access requirements
- Report semantic errors

Optimizer Input and Output

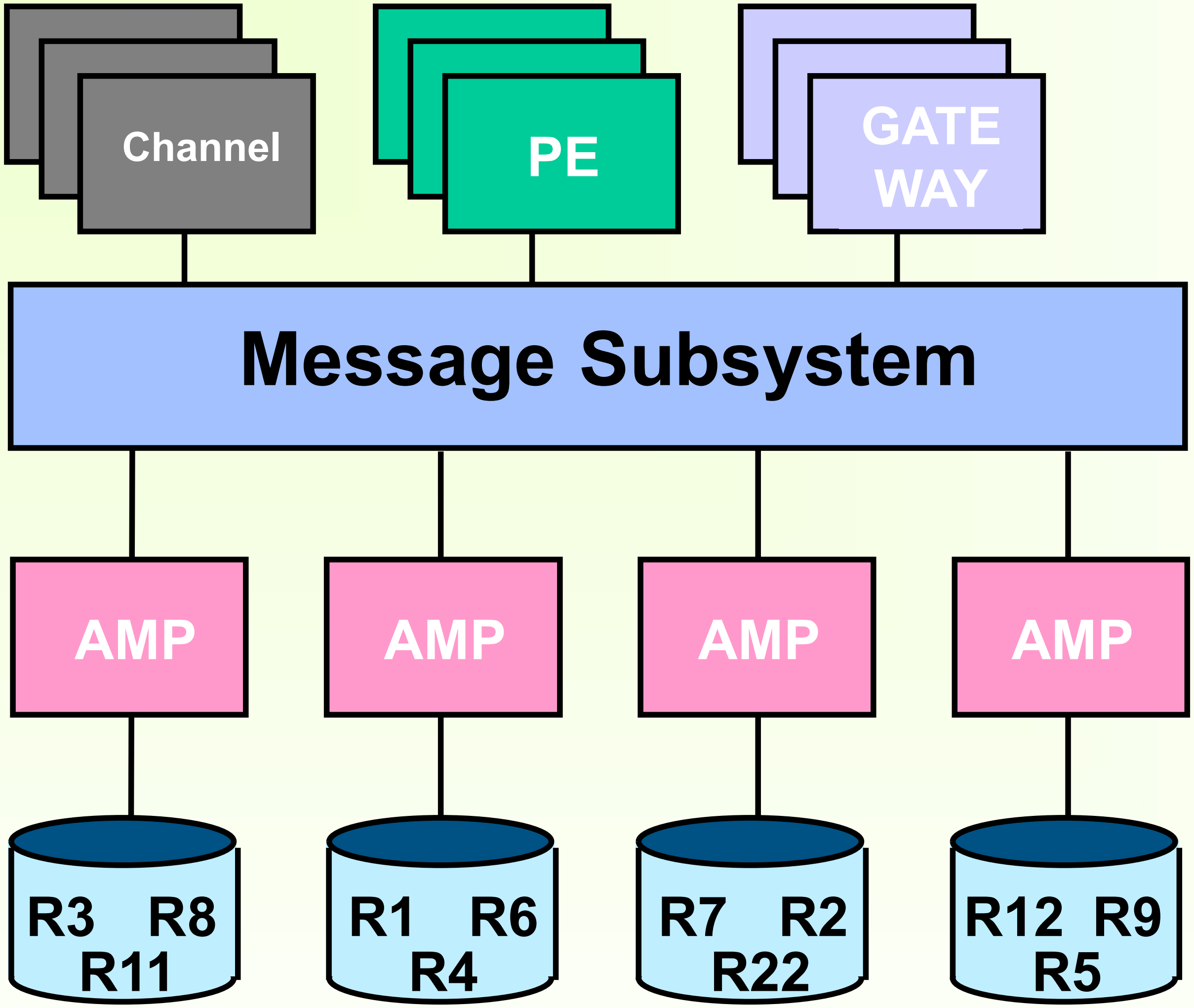


Resolver Tree

OPTIMIZER

Step list that specifies “best” query execution (join) plan

Parallel DBMS Architecture



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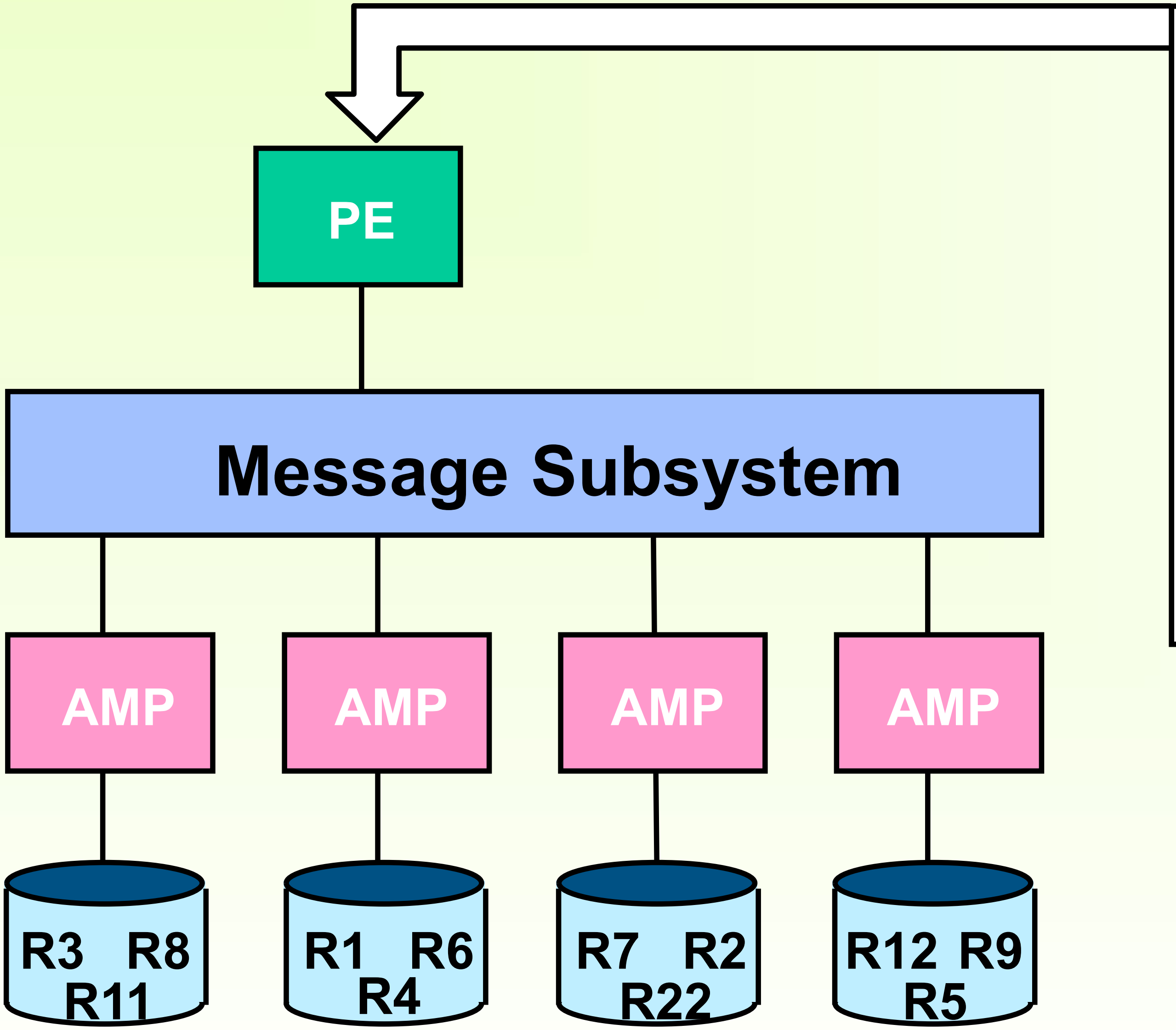
DBMS Parallel Architecture



PARSING & OPTIMISING ENGINE (PE)

- **SQL Parser & Optimizer**
- **Query Step Dispatcher**
- **Session Manager**
- **Input Data Conversion**

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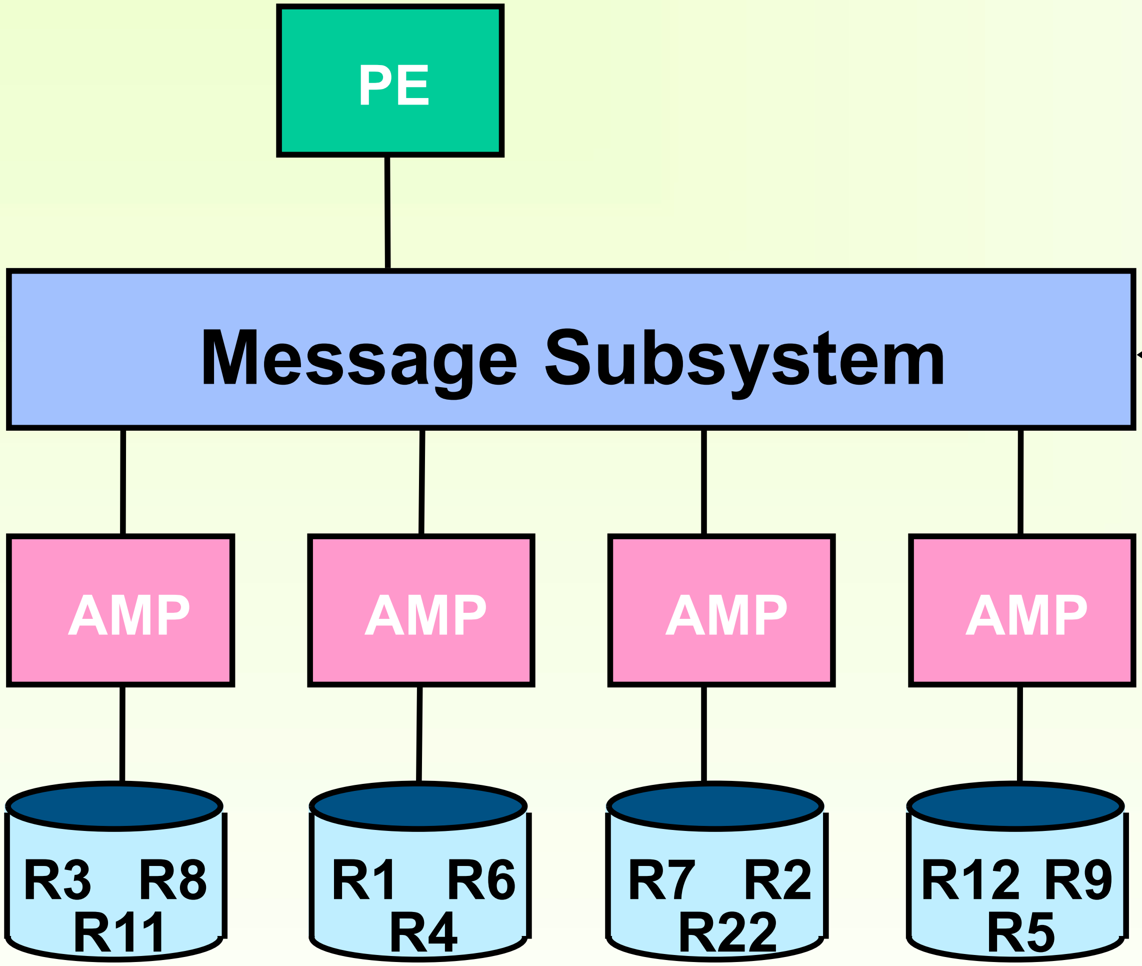
DBMS Parallel Architecture



Message Subsystem

- **Software/Hardware Communications Network -- BYNET**
- **Enables Scalability**
- **Dual BYNETs for Fault Tolerance**

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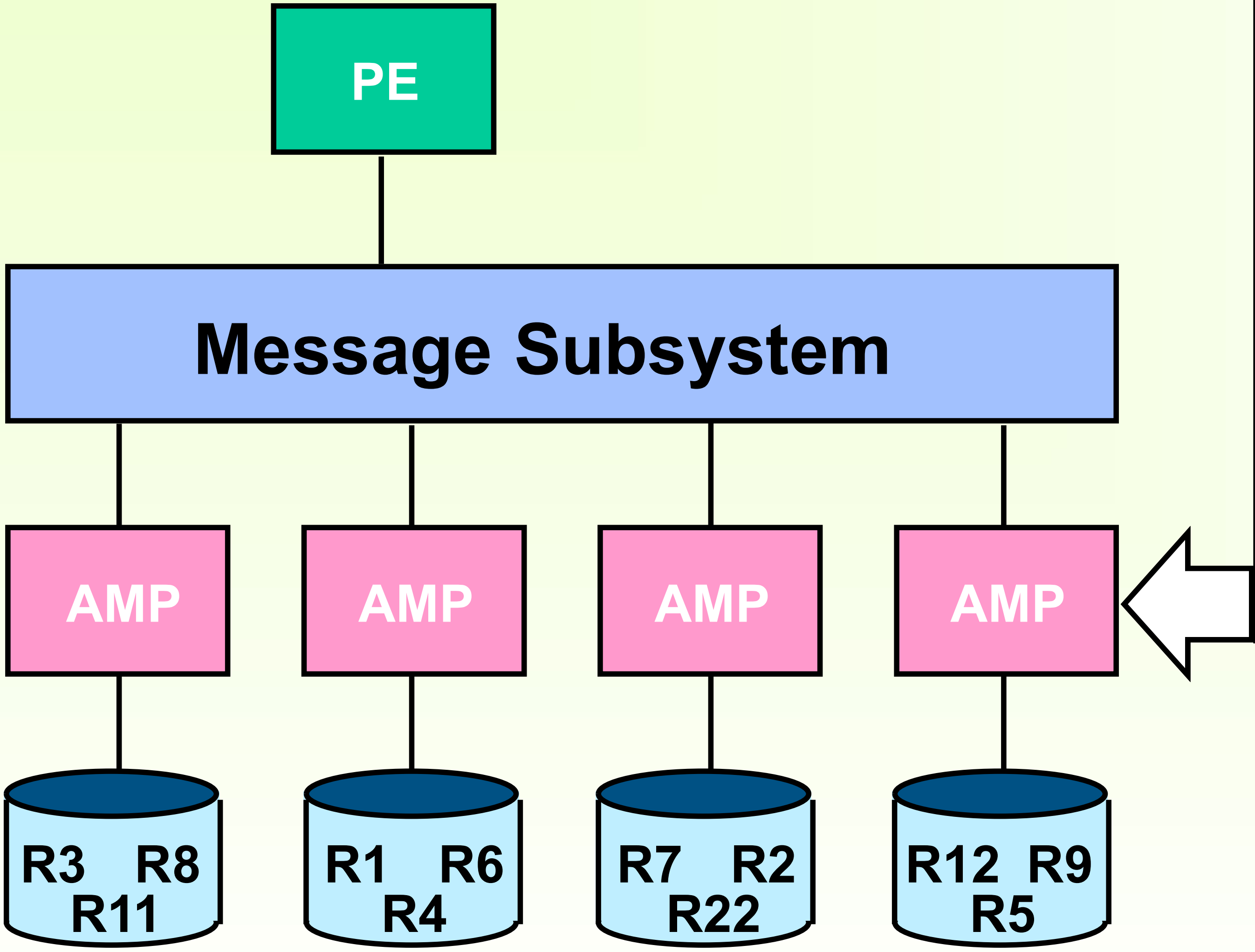
DBMS Parallel Architecture



ACCESS MODULE PROCESS (AMP)

- **Searching & Sorting**
- **Row Joins**
- **Aggregations**
- **Index Management**
- **Journaling & Rollback**

Database System Utilities

- **Loading**
  - Load existing data files
- **Backup**
  - Creates a backup copy of the database

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Database System Utilities (cont'd.)

- **Database storage reorganization**
  - Reorganize a set of database files into different file organizations
- **Performance monitoring**
  - Monitors database usage and provides statistics to the DBA

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Tools, Application Environments, and Communications Facilities

- CASE Tools (Computer-aided software engineering)
- Data dictionary (data repository) system
  - Stores design decisions, usage standards, application program descriptions, and user information
- Application development environments
- Communications software

Centralized and Client/Server Architectures for DBMSs

- **Centralized DBMSs Architecture**
  - All DBMS functionality, application program execution, and user interface processing carried out on one machine

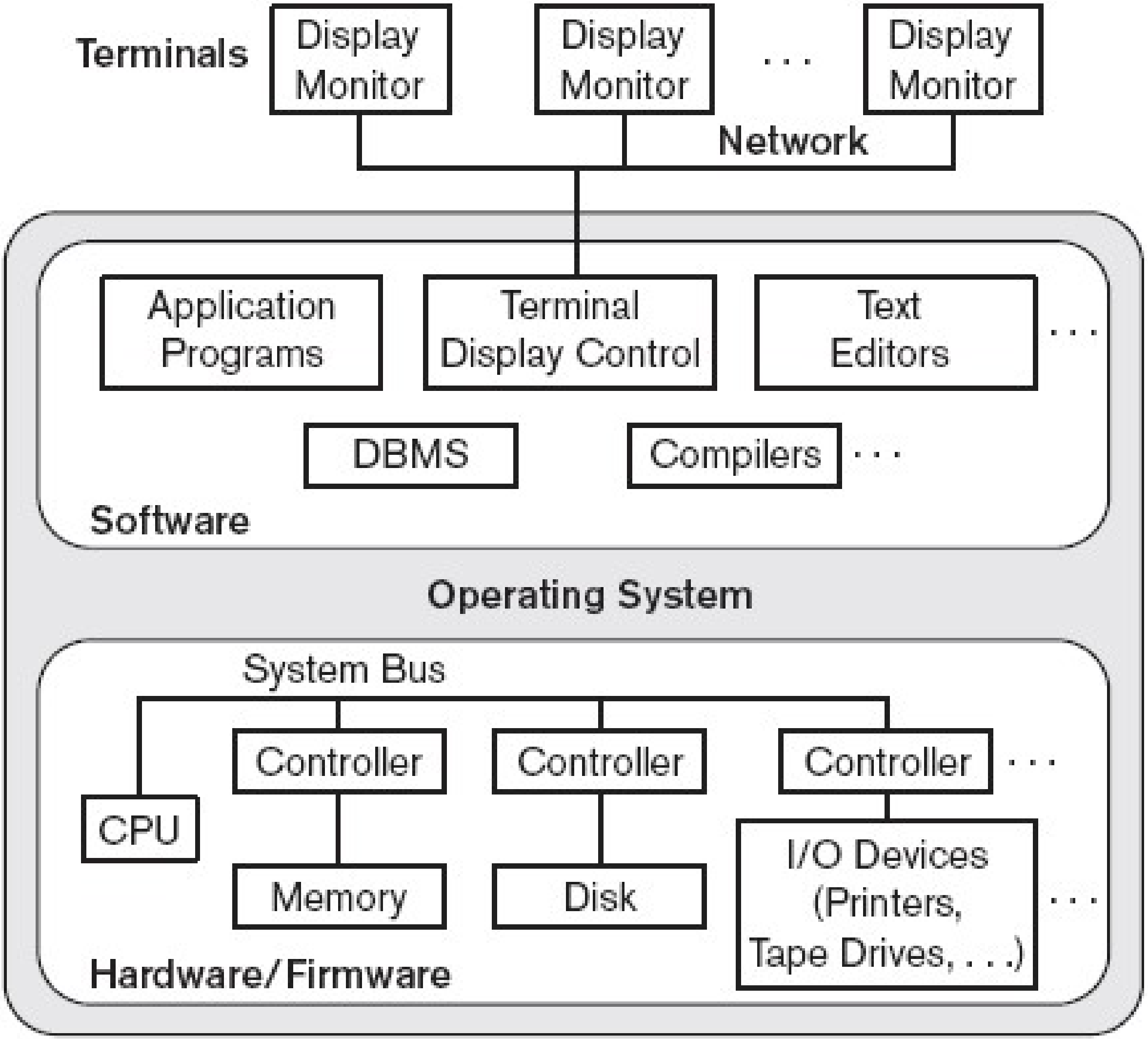

Figure 2.4
A physical centralized architecture.

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Basic Client/Server Architectures

- **Servers** with specific functionalities
  - **File server**
    - Maintains the files of the client machines.
  - **Printer server**
    - Connected to various printers; all print requests by the clients are forwarded to this machine
  - **Web servers** or **e-mail servers**

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Basic Client/Server Architectures (cont'd.)

- **Client machines**
  - Provide user with:
    - Appropriate interfaces to utilize these servers
    - Local processing power to run local applications

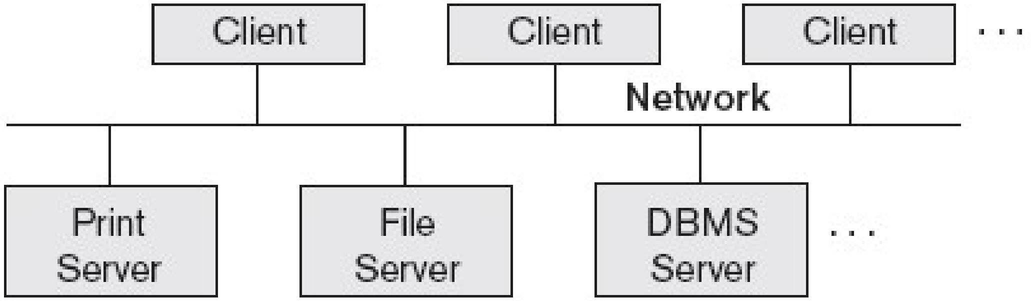

Figure 2.5
Logical two-tier client/server architecture.

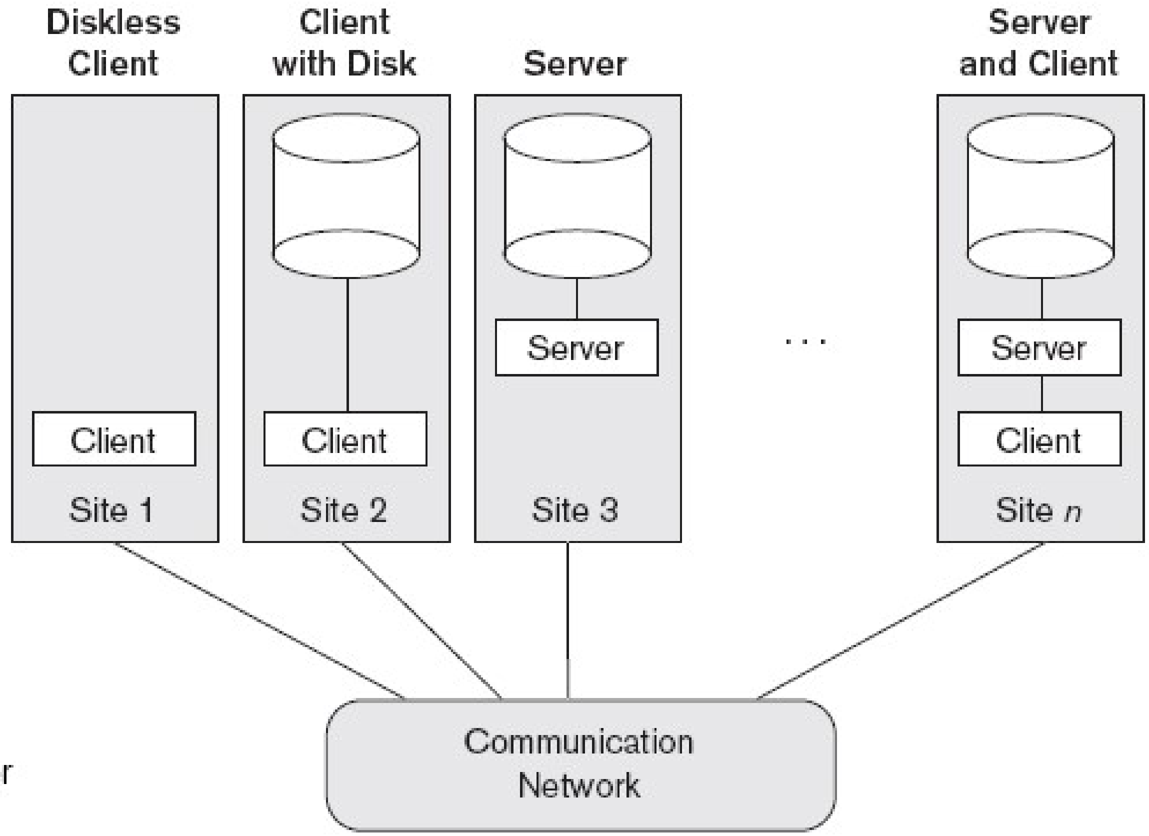

Figure 2.6
Physical two-tier client/server architecture.

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Basic Client/Server Architectures (cont'd.)

- **Client**
  - User machine that provides user interface capabilities and local processing
- **Server**
  - System containing both hardware and software
  - Provides services to the client machines
    - Such as file access, printing, archiving, or database access

Two-Tier Client/Server Architectures for DBMSs

- Server handles
  - Query and transaction functionality related to SQL processing
- Client handles
  - User interface programs and application programs

Two-Tier Client/Server Architectures (cont'd.)

- Open Database Connectivity (ODBC)
  - Provides application programming interface (API)
  - Allows client-side programs to call the DBMS
  - Both client and server machines must have the necessary software installed
- JDBC
  - Allows Java client programs to access one or more DBMSs through a standard interface

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Three-Tier and n-Tier Architectures for Web Applications

- **Application server** or **Web server**
  - Adds intermediate layer between client and the database server
  - Runs application programs and stores business rules

- **N-tier**
  - Divide the layers between the user and the stored data further into finer components

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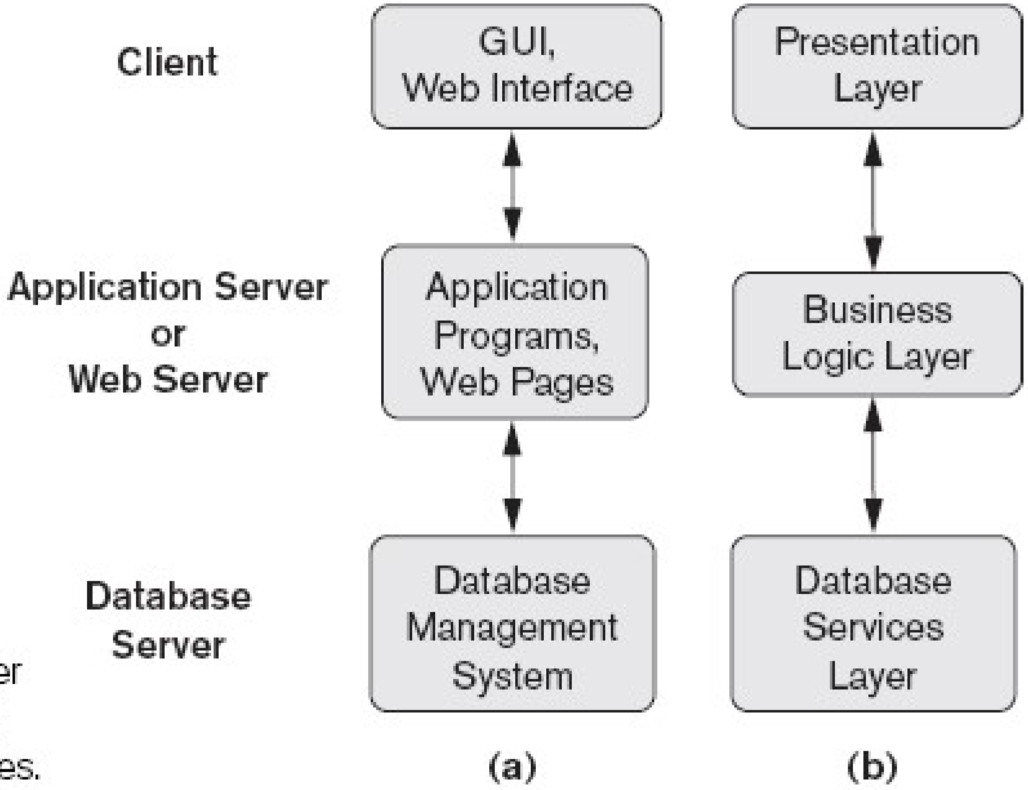

Figure 2.7
Logical three-tier client/server architecture, with a couple of commonly used nomenclatures.

Classification of Database Management Systems

- **Data model**
  - Relational
  - Object
  - Hierarchical and network (legacy)
  - Native XML DBMS
- **Number of users**
  - Single-user
  - Multiuser

Classification of Database Management Systems (cont'd.)

- **Number of sites**
  - **Centralized**
  - **Distributed**
    - Homogeneous
    - Heterogeneous
- **Cost**
  - Open source
  - Different types of licensing

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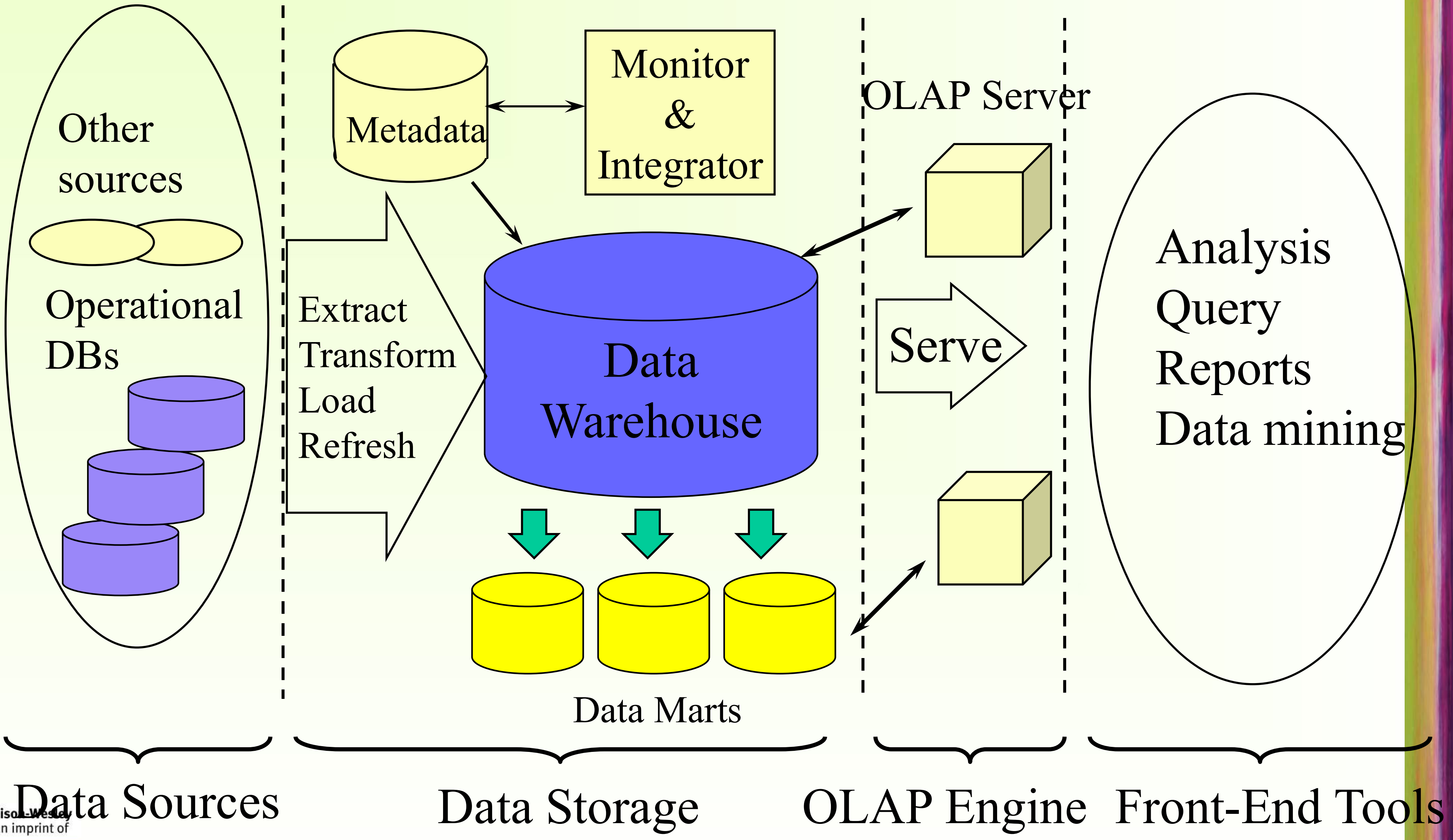
Data Warehouse: A Multi-Tiered Architecture



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Summary

- Concepts used in database systems
- Main categories of data models
- Types of languages supported by DMBSs
- Interfaces provided by the DBMS
- DBMS classification criteria:
  - Data model, number of users, number of sties, access paths, cost