DATABASE MANAGEMENT SYSTEMS

AN OVERVIEW OF DBMS

Trong Nhan Phan, PhD

DATABASE SYSTEMS REMARKS

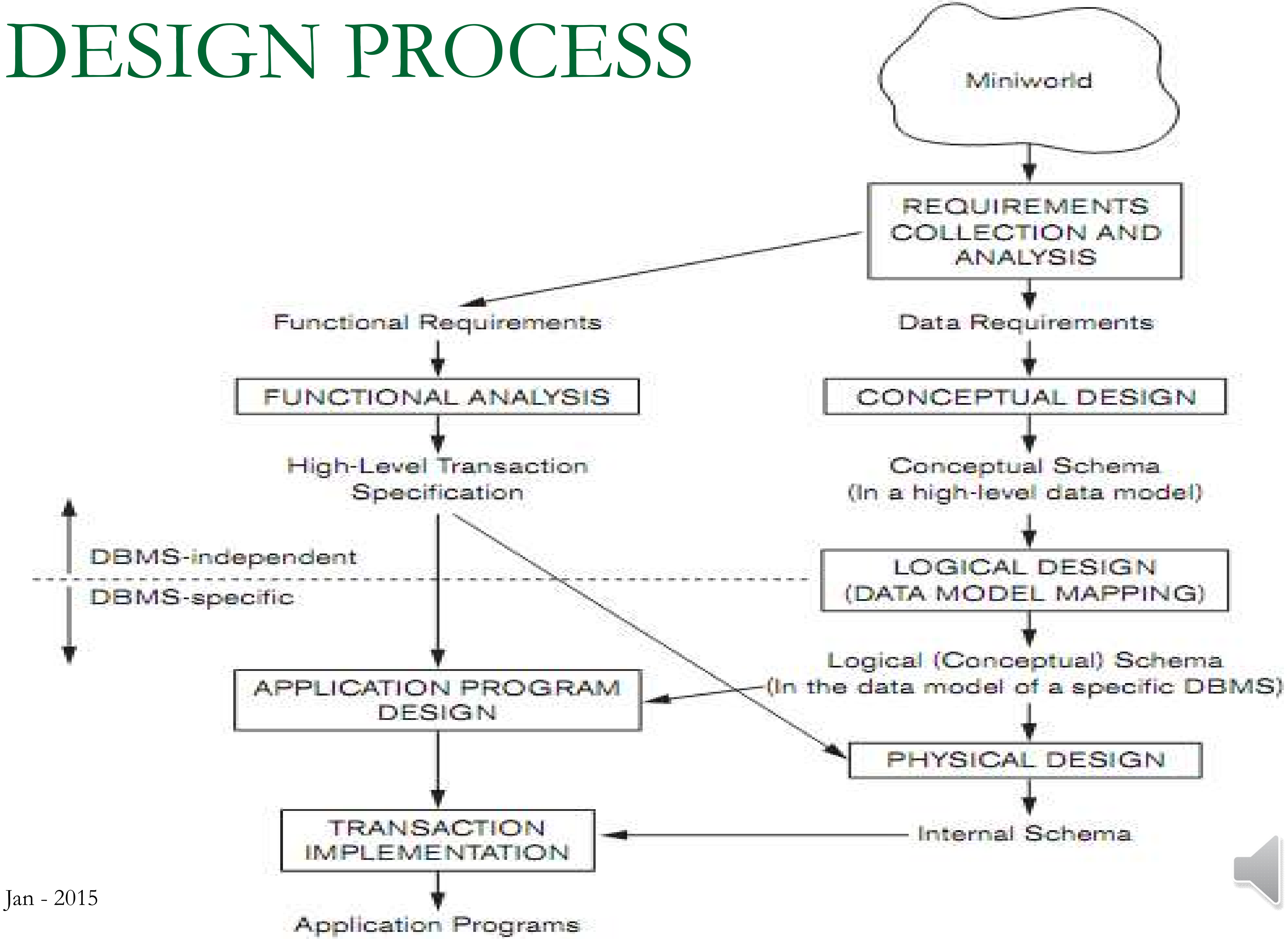
- Key concepts
- Database design process
- DBMS
- SQL
- Relational algebra

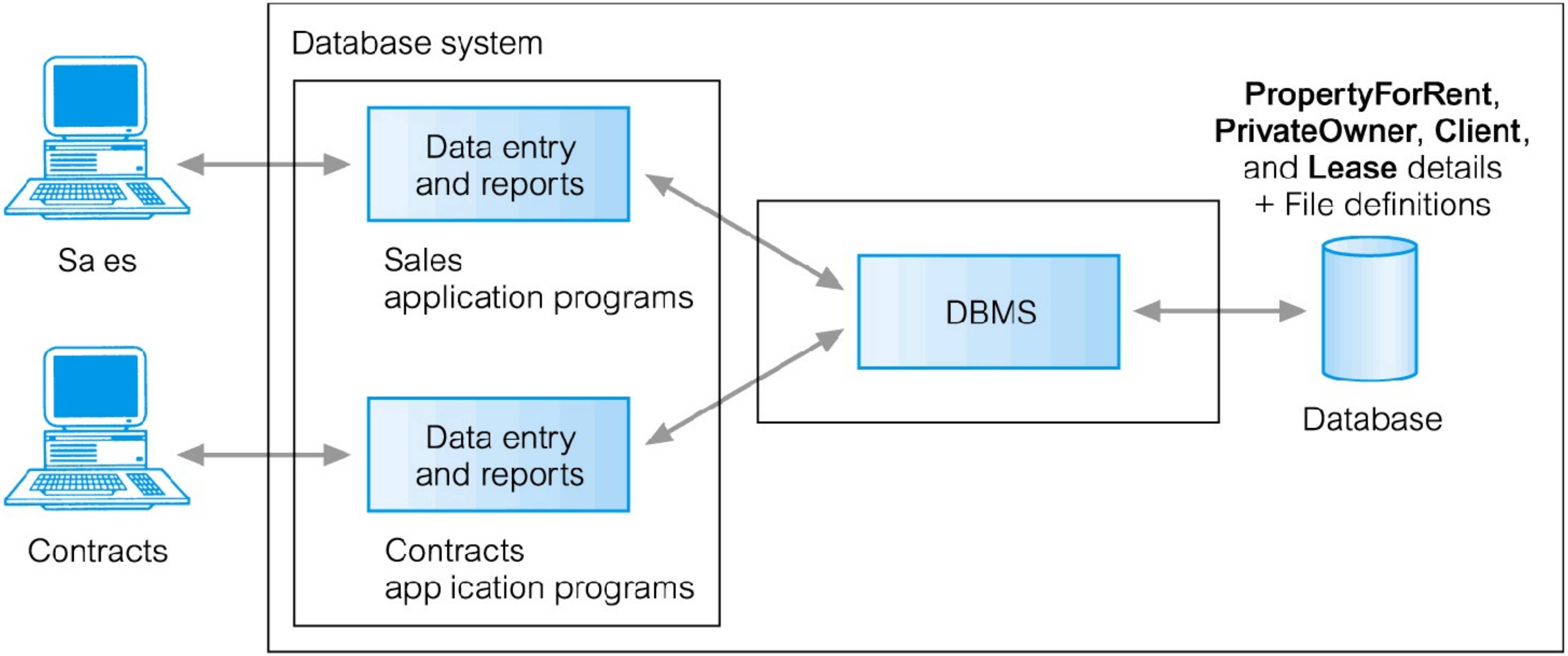
KEY CONCEPTS

1. Data
2. Information
3. Metadata
4. Database (DB)
5. Database Management System(DBMS)
6. Database System (DBS)
7. Data Model

1. Database Schema
2. Database State
3. Relation
4. Relation Cardinality
5. Relation Degree
6. Database Normalization
7. Primary key, candidate key, superkey, foreign key, partial key, surrogate key

OVERVIEW OF DATABASE DESIGN PROCESS


Miniworld
REQUIREMENTS COLLECTION AND ANALYSIS
Functional Requirements
Data Requirements
FUNCTIONAL ANALYSIS
CONCEPTUAL DESIGN
High-Level Transaction Specification
Conceptual Schema (In a high-level data model)
DBMS-independent
DBMS-specific
LOGICAL DESIGN (DATA MODEL MAPPING)
Logical (Conceptual) Schema (In the data model of a specific DBMS)
APPLICATION PROGRAM DESIGN
PHYSICAL DESIGN
TRANSACTION IMPLEMENTATION
Internal Schema
Application Programs


Database system
Data entry and reports
Sales application programs
Data entry and reports
Contracts app ication programs
DBMS
PropertyForRent, **PrivateOwner**, **Client**, and **Lease** details + File definitions
Database
Sa es
Contracts

PropertyForRent (propertyNo, street, city, postcode, type, rooms, rent, ownerNo)

PrivateOwner (ownerNo, fName, lName, address, telNo)

Client (clientNo, fName, lName, address, telNo, prefType, maxRent)

Lease (leaseNo, propertyNo, clientNo, paymentMethod, deposit, paid, rentStart, rentF nish)

[5]

WHAT IS A DBMS?

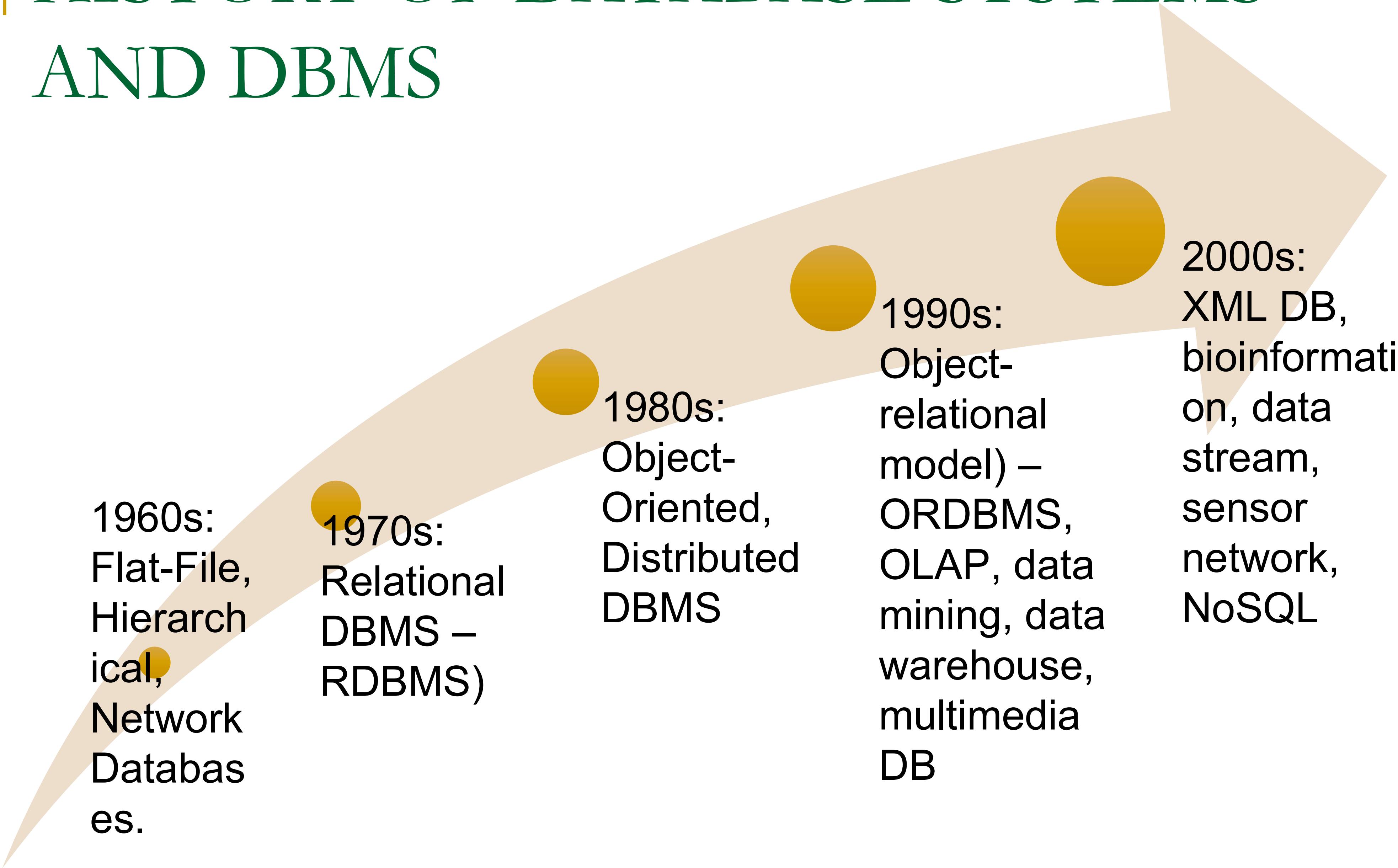
- **D**ata**B**ase **M**anagement **S**ystem (DBMS): a general-purpose software system that facilitates the processes of defining, constructing, manipulating, and sharing databases among various users and applications (or a software system that enables users to define, create, maintain, and control access to the database)
- A DBMS is a powerful tool for creating and managing large amount of data efficiently and allowing it to persist over long periods of time safely.

DBMS CAPABILITIES

The capabilities that a DBMS provides the user are:

- **Persistent Storage**. A DBMS supports the storage of very large amounts of data that exists independently of any processes that are using the data.
- **Programming Interface**. A DBMS allows the user to access and modify data through a powerful query language.
- **Transaction management**. A DBMS supports concurrent access to data, i.e., simultaneously access by many distinct processes (called transaction) at once. To avoid some of the undesirable consequences of simultaneous access, the DBMS supports:
  - isolation
  - atomicity
  - resiliency
- And much more!

HISTORY OF DATABASE SYSTEMS AND DBMS



1960s: Flat-File, Hierarchical, Network Databases.

1970s: Relational DBMS – RDBMS)

1980s: Object-Oriented, Distributed DBMS

1990s: Object-relational model) – ORDBMS, OLAP, data mining, data warehouse, multimedia DB

2000s: XML DB, bioinformation, data stream, sensor network, NoSQL

EXAMPLE OF NETWORK MODEL SCHEMA

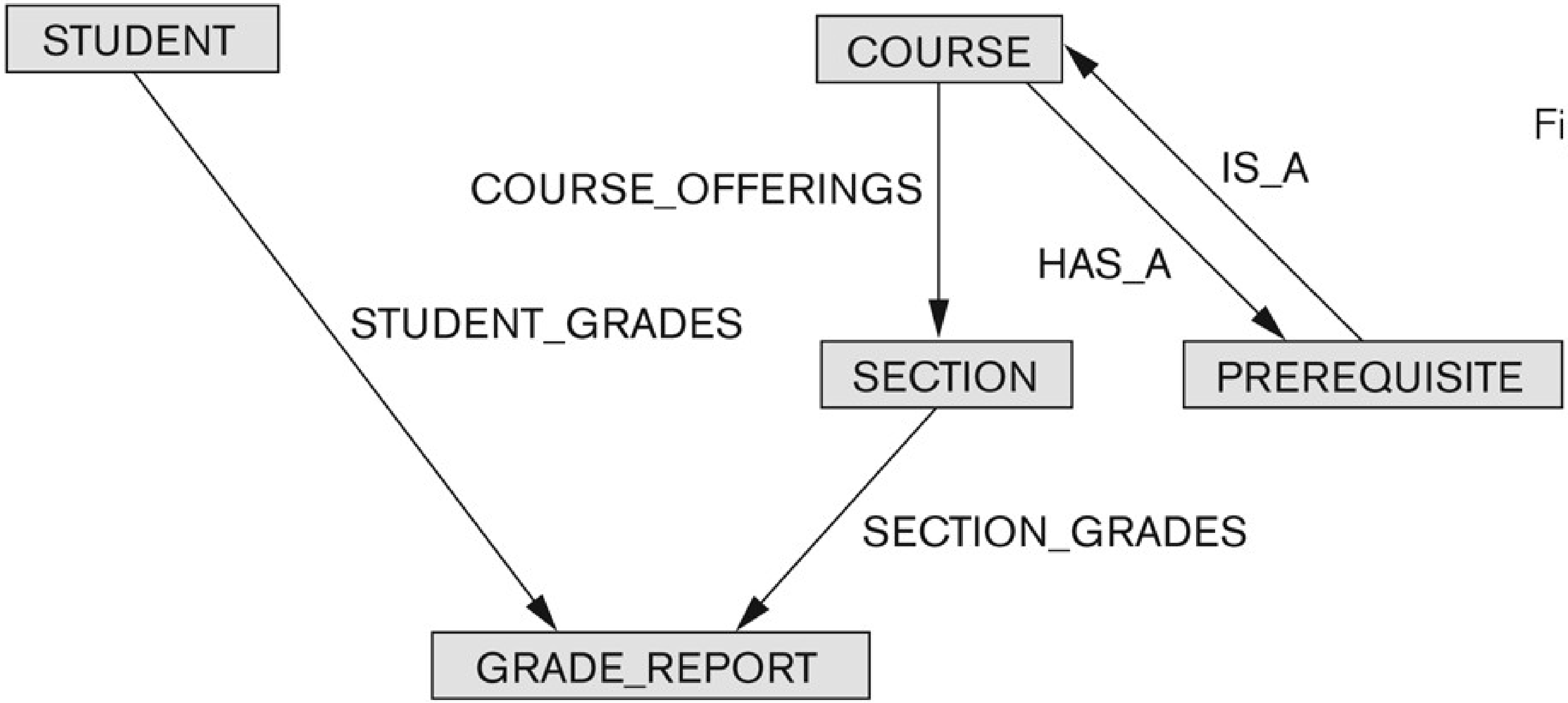
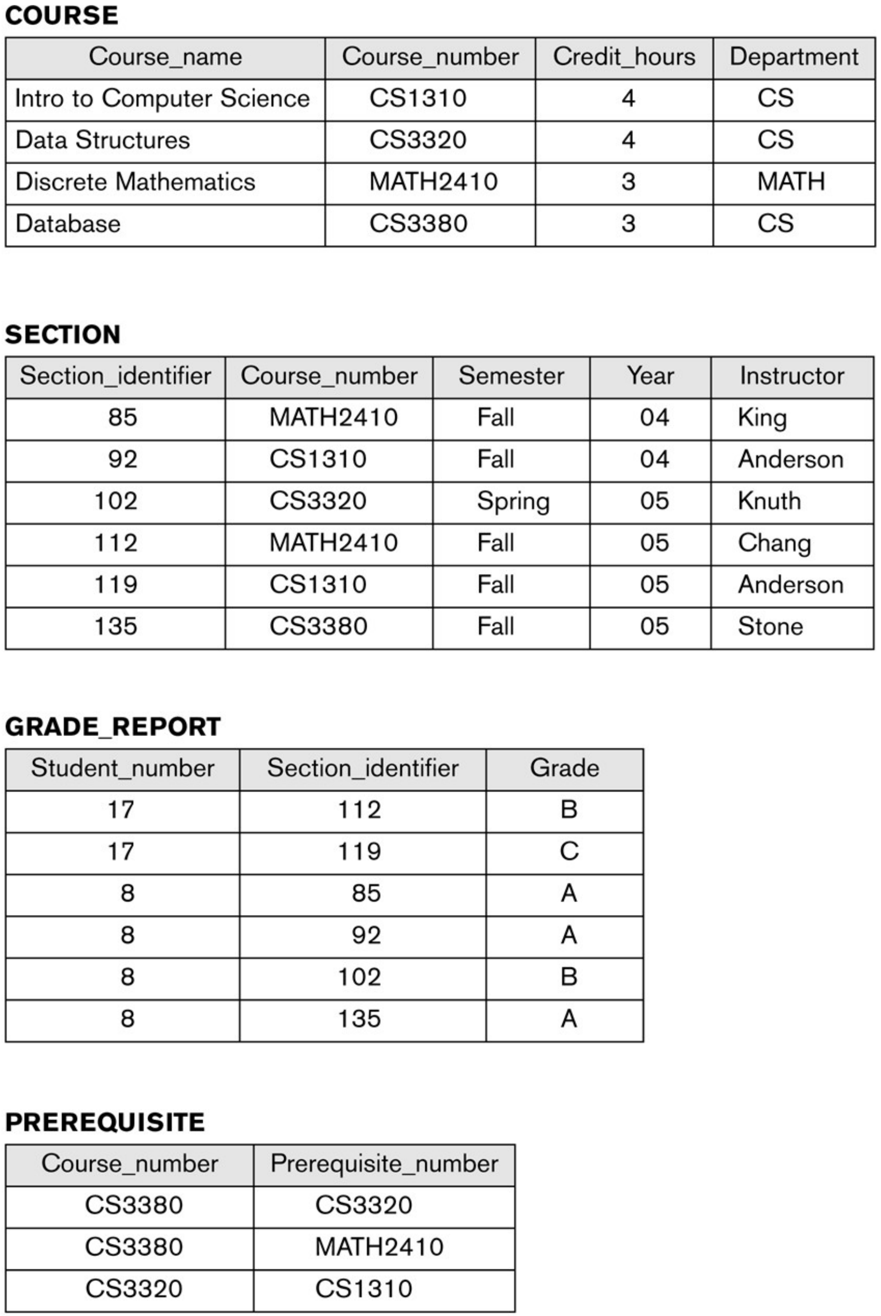


Figure 2.8
The schema of Figure 2.1 in network model notation.

EXAMPLE OF RELATIONAL MODEL SCHEMA



COURSE

Course_name	Course_number	Credit_hours	Department
Intro to Computer Science	CS1310	4	CS
Data Structures	CS3320	4	CS
Discrete Mathematics	MATH2410	3	MATH
Database	CS3380	3	CS

SECTION

Section_identifier	Course_number	Semester	Year	Instructor
85	MATH2410	Fall	04	King
92	CS1310	Fall	04	Anderson
102	CS3320	Spring	05	Knuth
112	MATH2410	Fall	05	Chang
119	CS1310	Fall	05	Anderson
135	CS3380	Fall	05	Stone

GRADE_REPORT

Student_number	Section_identifier	Grade
17	112	B
17	119	C
8	85	A
8	92	A
8	102	B
8	135	A

PREREQUISITE

Course_number	Prerequisite_number
CS3380	CS3320
CS3380	MATH2410
CS3320	CS1310

Figure 1.2
A database that stores student and course information.

DATABASE APPROACH CHARACTERISTICS

- Self-describing nature of a database system
- Insulation between programs and data, and data abstraction
  - Program-data independence + Program-operation independence = Data abstraction
  - A data model is a type of data abstraction
- Support of multiple views of the data
- Sharing of data and multi-user transaction processing
- Restricting redundancy, unauthorized access
- Support efficient query processing, backup and recovery, multiple user interfaces, integrity constraints
- Other advantages of using the DBMS approach: see [1]-1.6

DATABASE CONSTRAINTS

- Key constraint
- Entity integrity constraint
- Reference integrity constraint
- Semantic constraint

THE DATABASE SYSTEM ENVIRONMENT (1/2)

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

THE DATABASE SYSTEM ENVIRONMENT (2/2)

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

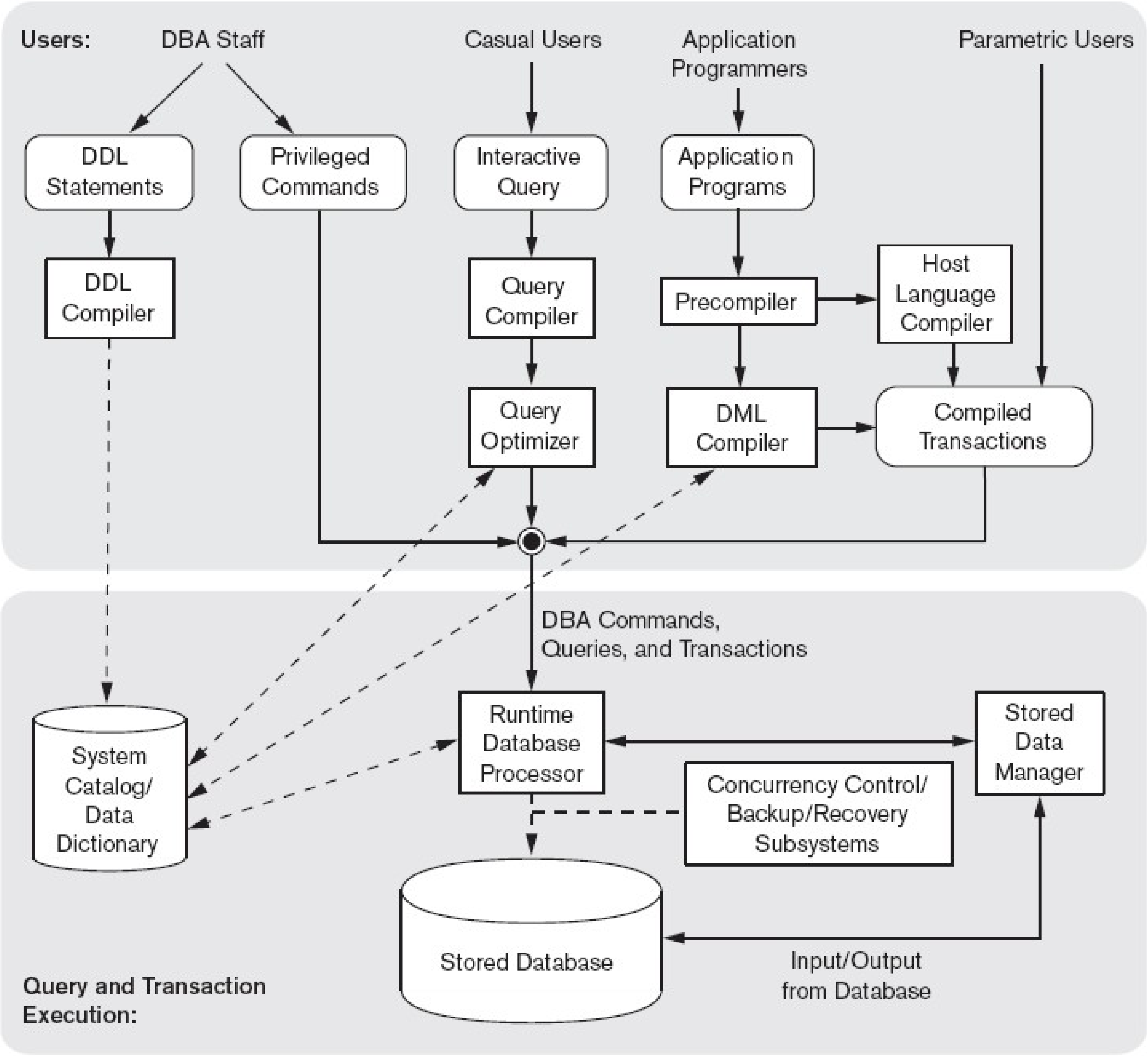


Figure 2.3
Component modules of a DBMS and their interactions.

QUERY LANGUAGE

- Data Definition Language (DDL)
  - Permits specification of data types, structures and any data constraints to be stored in the database
  - All specifications are stored in the database
- Data Manipulation Language (DML).
  - Query language: retrieve (query), update (insert, delete, modify)
- Data Control Language (DCL)
  - Used to control access to data in a database (Commit, Rollback, Grant, Revoke)

ROLES IN THE DATABASE ENVIRONMENT

- Database Administrator (DBA), responsible for
  - authorizing access to DB
  - coordinating & monitoring its use
  - acquiring software and hardware resources
  - security breach, poor response time
- Database Designers, responsible for:
  - identifying the data to be stored in DB
  - choosing appropriate structures to represent and store this data
- Application Programmers
- End Users
- More details: see [1]-chapter 1

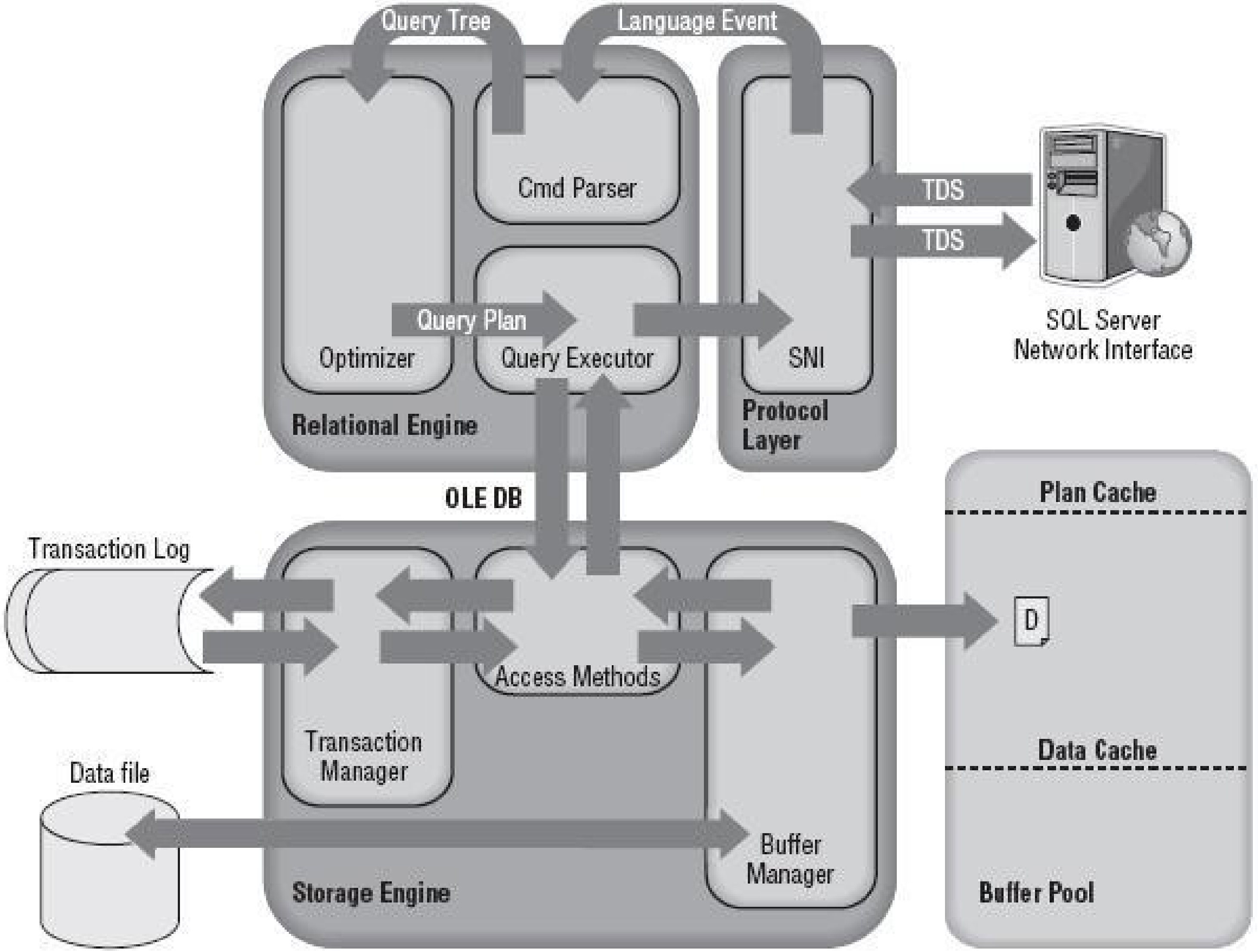
(RELATIONAL) DBMSs IN PRACTICE

- MySQL
- Oracle
- MS SQL Server
- IBM DB2
- PostgreSQL
- …

DISCUSSION

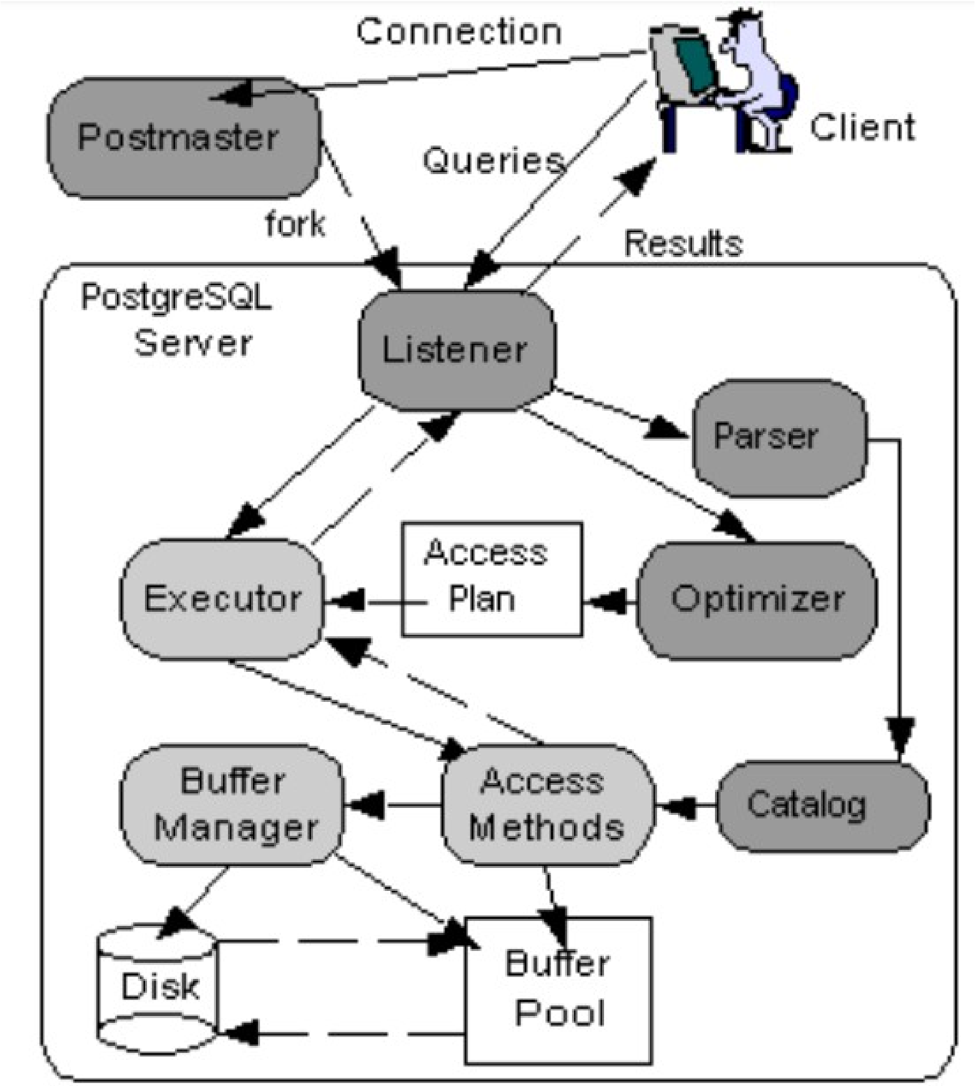
WHAT'S MORE?

MICROSOFT SQL SERVER ARCHITECTURE



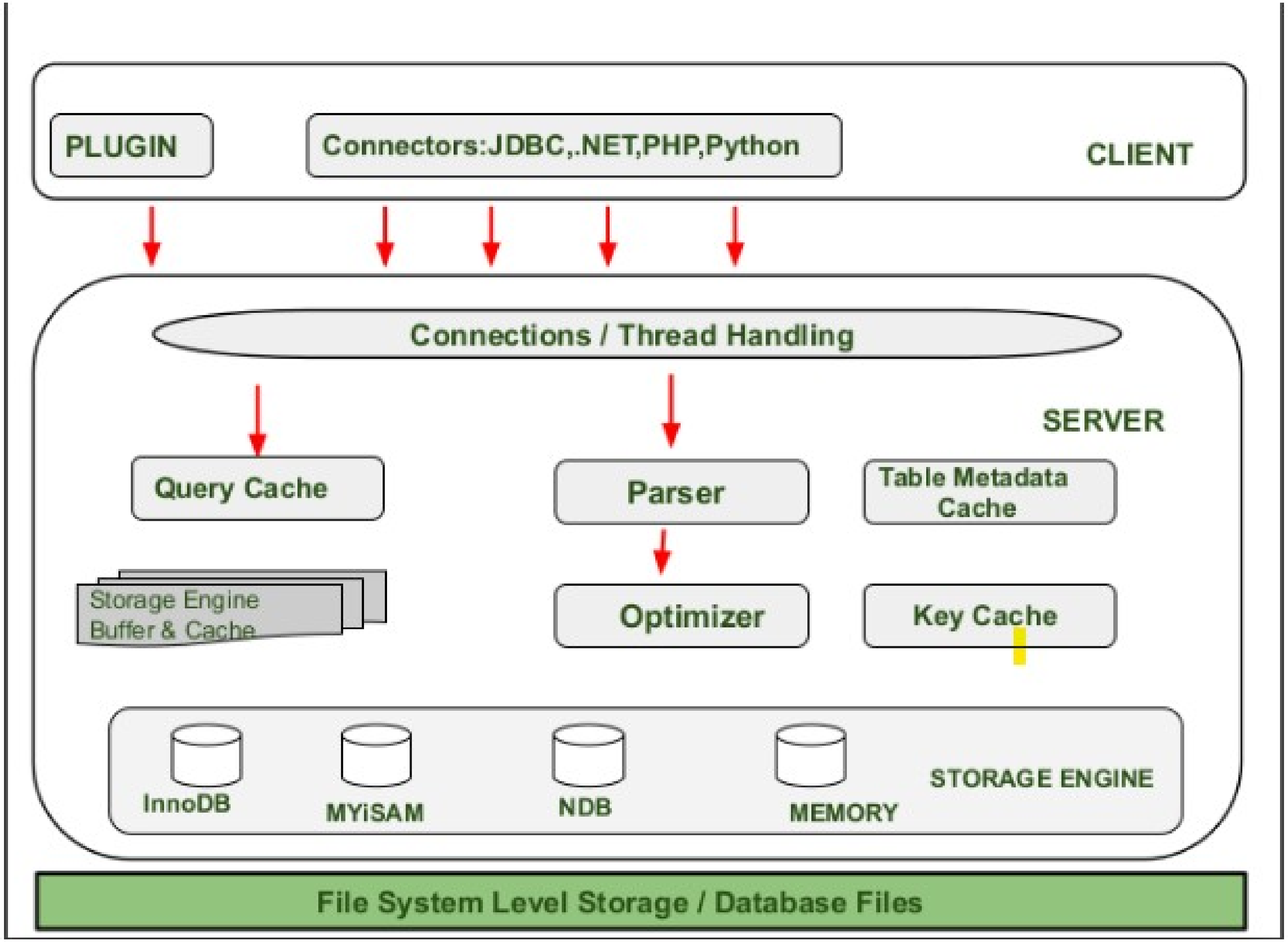
https://learn.microsoft.com/en-us/answers/questions/279400/looking-for-sql-server-2019-architecture-diagram

POSTGRESQL ARCHITECTURE



Krishnamurthy, Sailesh & Chandrasekaran, Sirish & Cooper, Owen & Deshpande, Amol & Franklin, Michael & Hellerstein, Joseph & Hong, Wei & Madden, Samuel & Reiss, Frederick & Shah, Mehul. (2003). TelegraphCQ: An Architectural Status Report. IEEE Data Eng. Bull.. 26. 11-18.

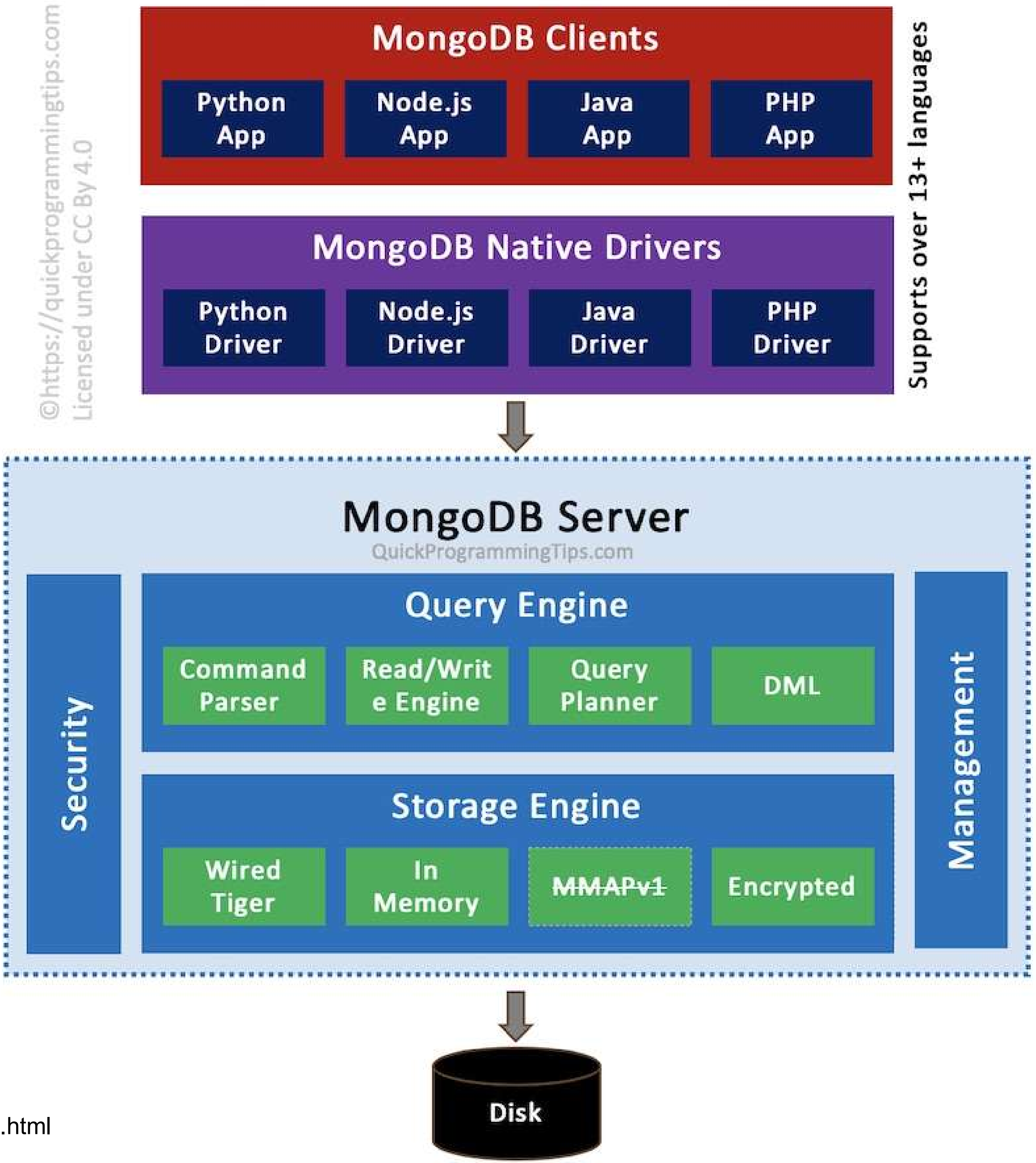
MYSQL ARCHITECTURE



PLUGIN
Connectors:JDBC,.NET,PHP,Python
CLIENT
Connections / Thread Handling
SERVER
Query Cache
Parser
Table Metadata Cache
Storage Engine Buffer & Cache
Optimizer
Key Cache
InnoDB
MYiSAM
NDB
MEMORY
STORAGE ENGINE
File System Level Storage / Database Files

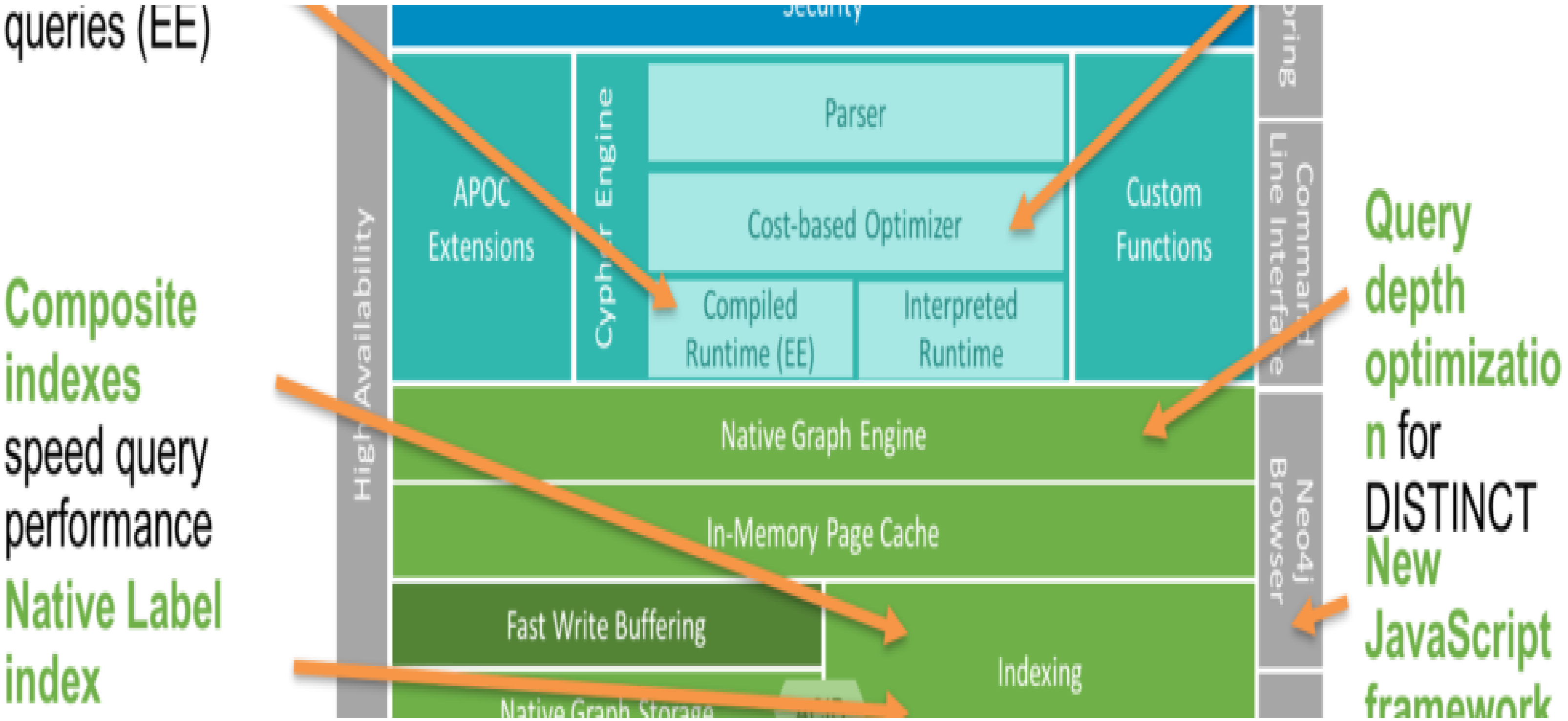
https://www.geeksforgeeks.org/mysql/architecture-of-mysql/

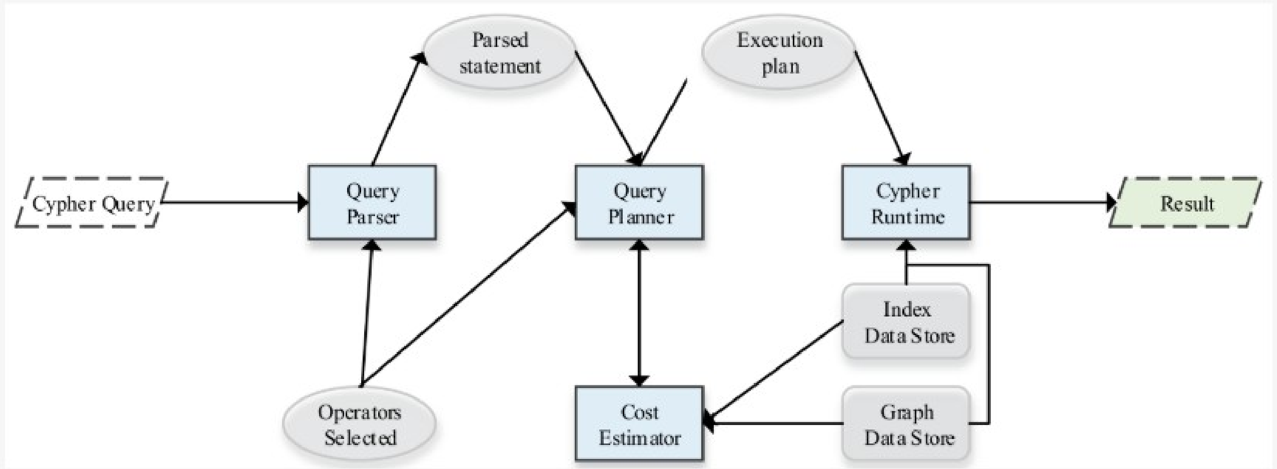
MONGODB



https://www.quickprogrammingtips.com/mongodb/mongodb-history.html

NEO4J





He, Z., Yu, J., & Guo, B. (2022). Execution Time Prediction for Cypher Queries in the Neo4j Database Using a Learning Approach. Symmetry, 14(1), 55. https://doi.org/10.3390/sym14010055; https://neo4j.com/blog/news/neo4j-3-2-ga-release/

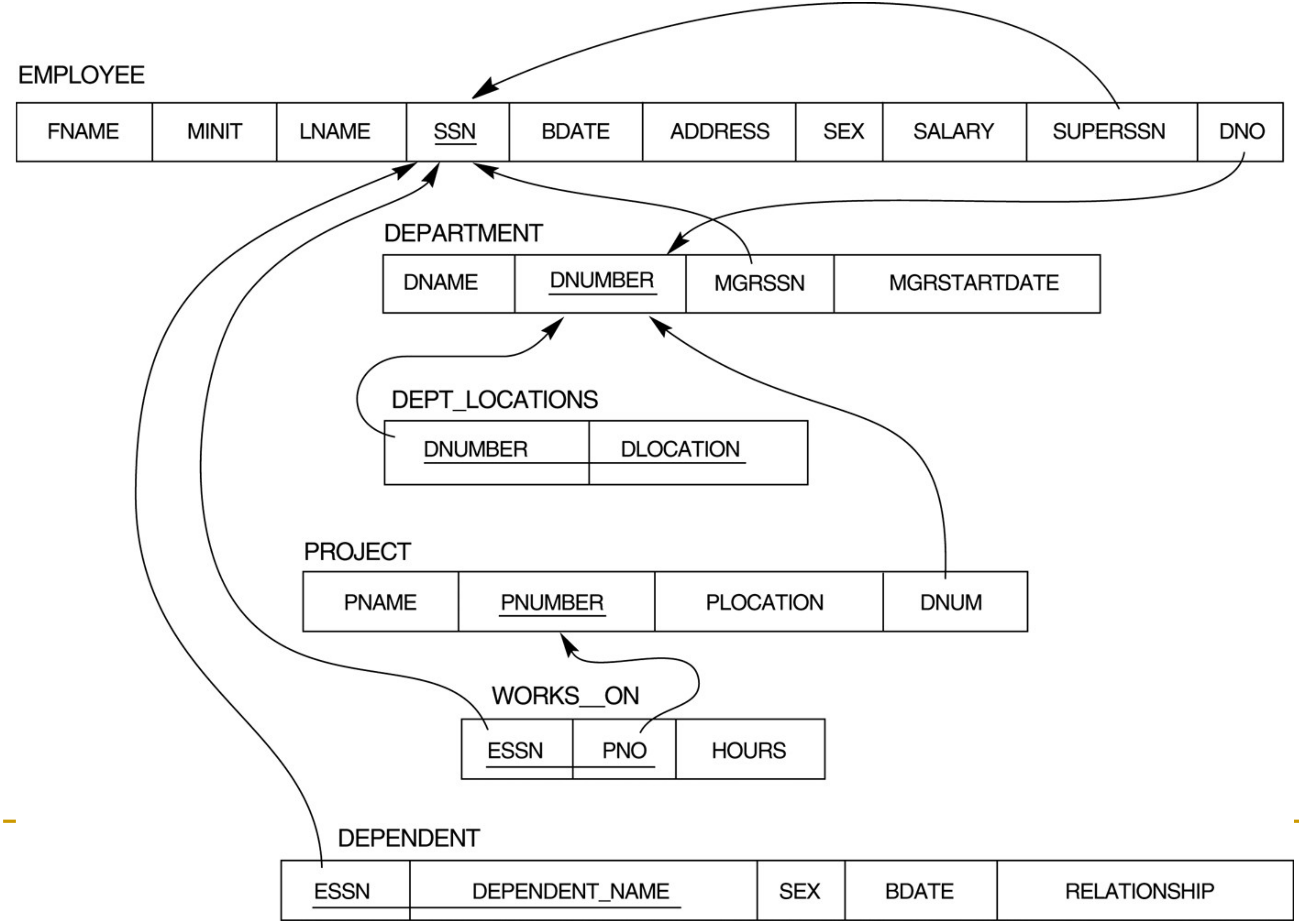
DISCUSSION

TOP DBMSs TODAY?

SQL

- SQL review
- Relational Algebra

COMPANY Relational Database Schema



EMPLOYEE

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

DEPARTMENT

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

DEPT_LOCATIONS

DNUMBER	DLOCATION

PROJECT

PNAME	PNUMBER	PLOCATION	DNUM

WORKS__ON

ESSN	PNO	HOURS

DEPENDENT

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP

REFERENCES

1. R. Elmasri & S.B. Navathe, AddisonWesley, Fundamentals of Database Systems, 7th Edition, 2016.
2. H. G. Molina, J. D. Ullman, J. Widom, Database System Implementation, Prentice-Hall, 2000.
3. A. Silberschatz, H.F. Korth & S. Sudarshan, Database Systems Concepts, 6th Edition, McGraw-Hill, 2006.
4. H.G. Molina, J.D. Ullman & J. Widom, Database Systems – The Complete Book, PrenticeHall, 2002.
5. T. Connolly & C. Begg, Database Systems – A Practical Approach to Design, Implementation, and Management, 6th Edition, Addison-Wesley, 2015.

QUESTIONS AND ANSWERS

Picture from: http://philadelphiasculpturegym.blogspot.com/2013/09/save-date-free-talk-and-q-on-affordable.html