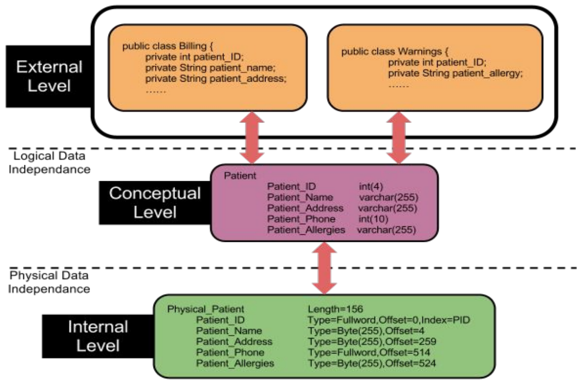
Information Management II

2. Database Architecture

CSU 34041

Yvette Graham
yvette.graham@tcd.ie

Today's Lecture

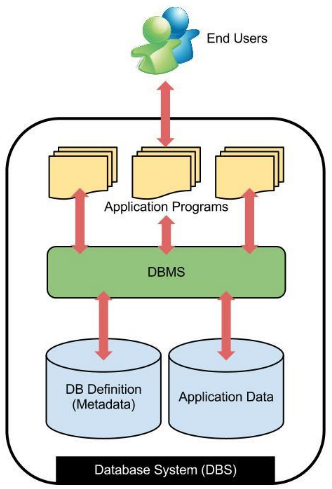


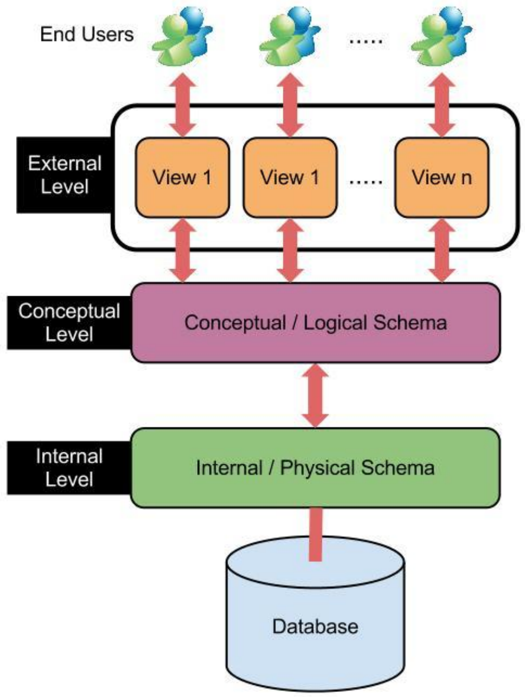
```
public class Billing {
        private int patient_ID;
        private String patient_name;
        private String patient_address;
        ......
```

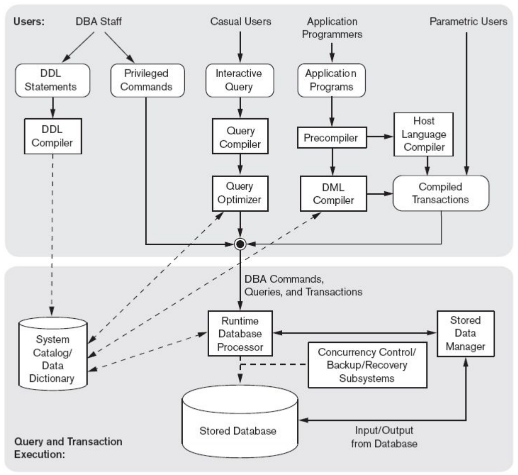
```
public class Warnings {
            private int patient_ID;
            private String patient_allergy;
            ......
```

```
Patient
        Patient_ID          int(4)
        Patient_Name        varchar(255)
        Patient_Address     varchar(255)
        Patient_Phone       int(10)
        Patient_Allergies   varchar(255)
```

```
Physical_Patient            Length=156
    Patient_ID              Type=Fullword,Offset=0,Index=PID
    Patient_Name            Type=Byte(255),Offset=4
    Patient_Address         Type=Byte(255),Offset=259
    Patient_Phone           Type=Fullword,Offset=514
    Patient_Allergies       Type=Byte(255),Offset=524
```





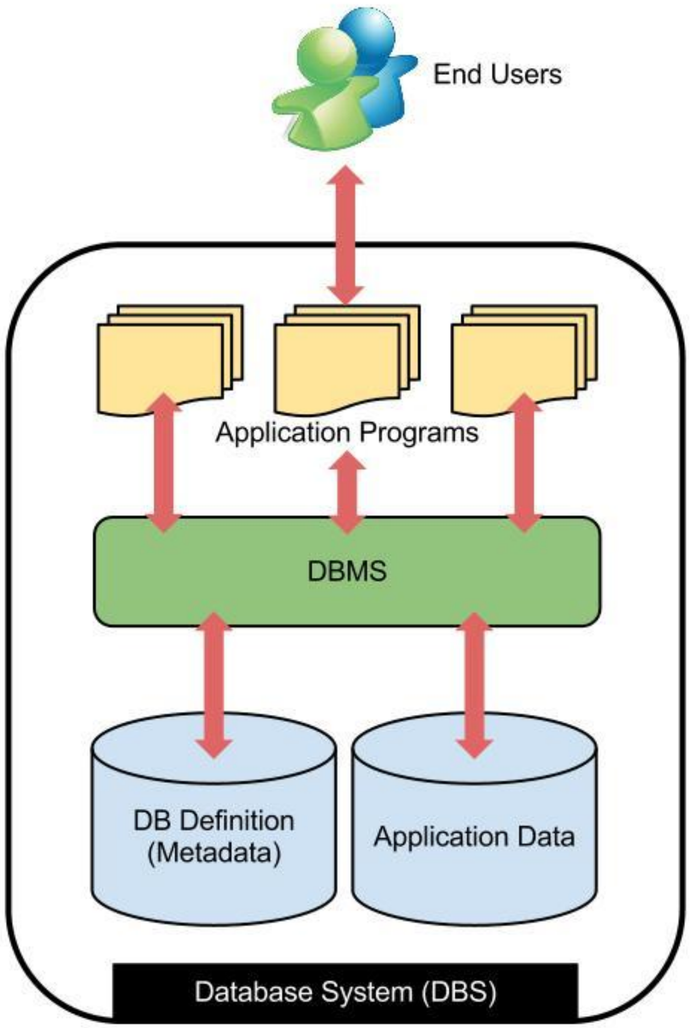


1) Database Systems
2) Database Architecture
3) Database Schemas
4) Database Components
5) System Catalog & Data Dictionary

Database Systems

Database Systems

- Database System (DBS)
  - DBMS
  - DB
    - application data
    - associated metadata
  - Application programs
- Metadata and data are stored separately

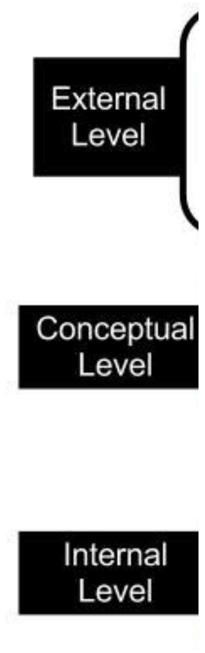


DBMS Architecture

- Database users are provided an abstract view of the data by hiding certain details of how it is physically stored
- DBMS describe Databases at three levels:
  - Internal (Physical) Level
  - Conceptual (Logical) Level
  - External (View) Level
- This is commonly referred to as the “three-level DBMS architecture”

DBMS Architecture

3-Level DBMS Architecture

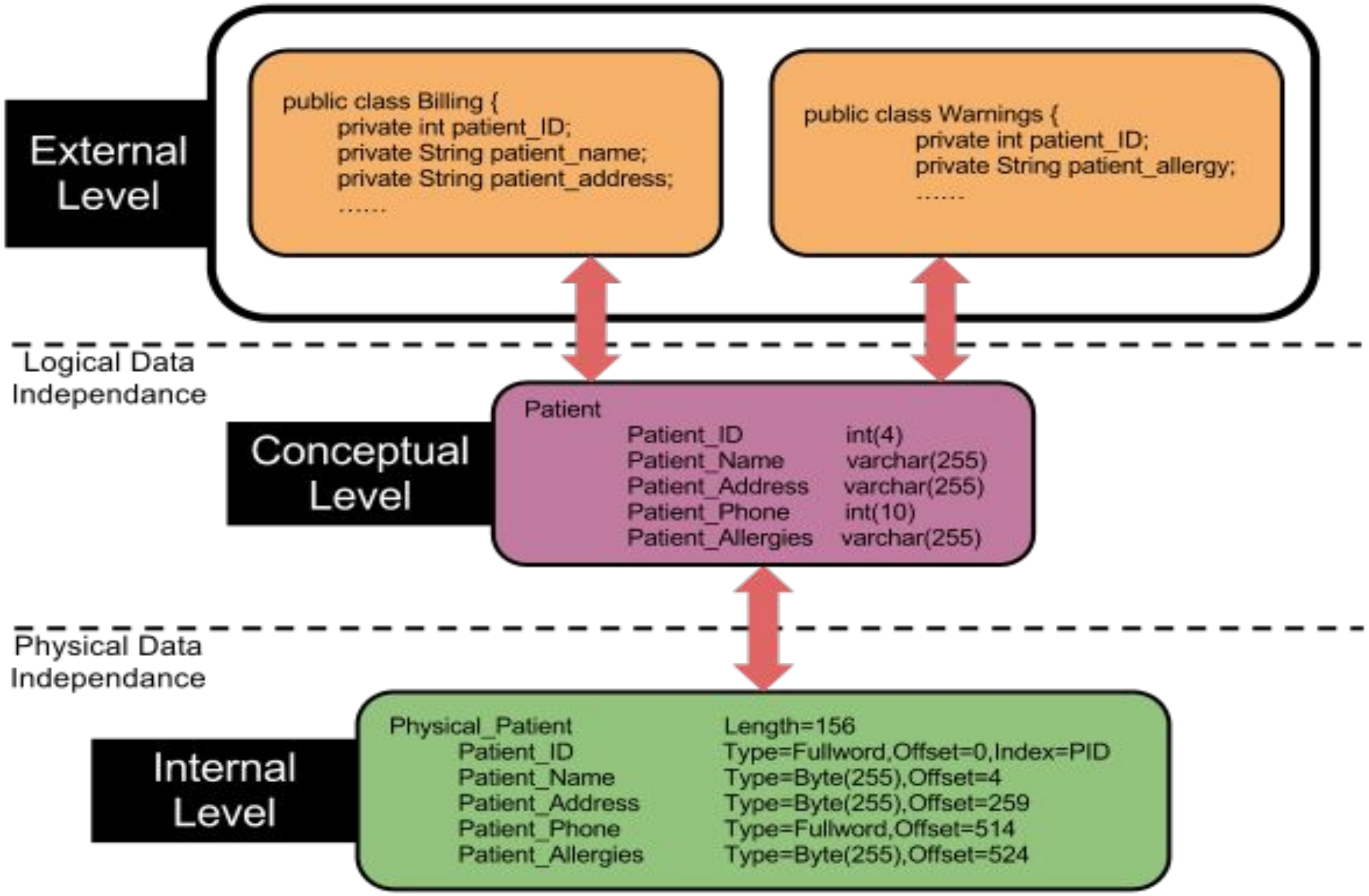


Database Schemas

Schemas

- Each level of the architecture consists of one or more views of the underlying data
- Views are described by *schemas* (meta-data)
- A DB consists of:
  - physical data
  - an internal schema (aka physical schema)
  - a conceptual schema (aka logical schema)
  - several external schemas

Example Schema Levels



```
public class Billing {
        private int patient_ID;
        private String patient_name;
        private String patient_address;
        .......
```

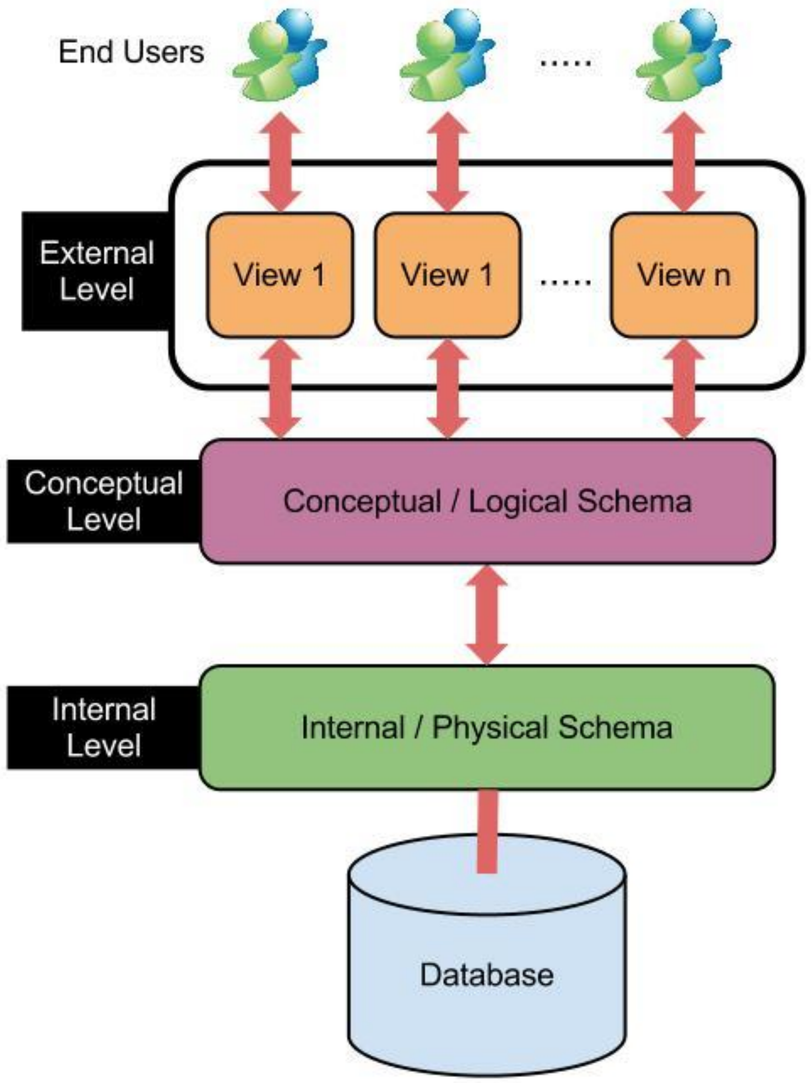
```
public class Warnings {
            private int patient_ID;
            private String patient_allergy;
            .......
```

```
Patient
        Patient_ID          int(4)
        Patient_Name        varchar(255)
        Patient_Address     varchar(255)
        Patient_Phone       int(10)
        Patient_Allergies   varchar(255)
```

```
Physical_Patient              Length=156
      Patient_ID              Type=Fullword,Offset=0,Index=PID
      Patient_Name            Type=Byte(255),Offset=4
      Patient_Address         Type=Byte(255),Offset=259
      Patient_Phone           Type=Fullword,Offset=514
      Patient_Allergies       Type=Byte(255),Offset=524
```

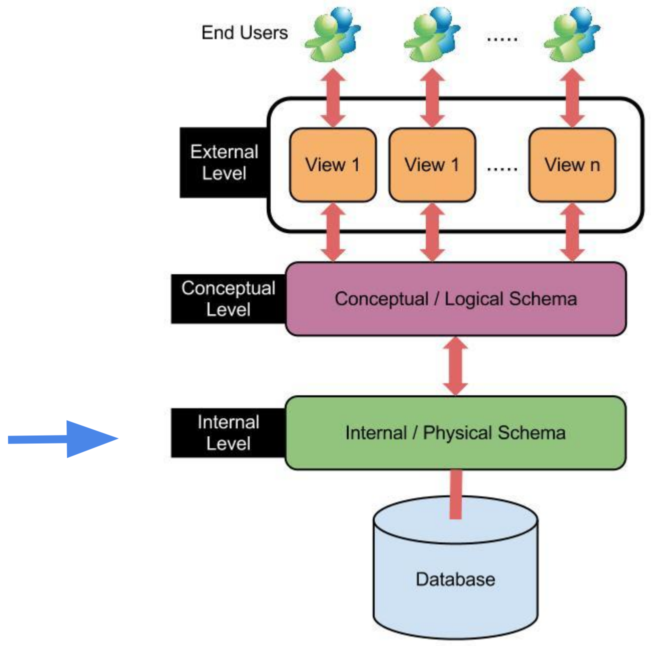
DBMS Architecture

DBMS Architecture



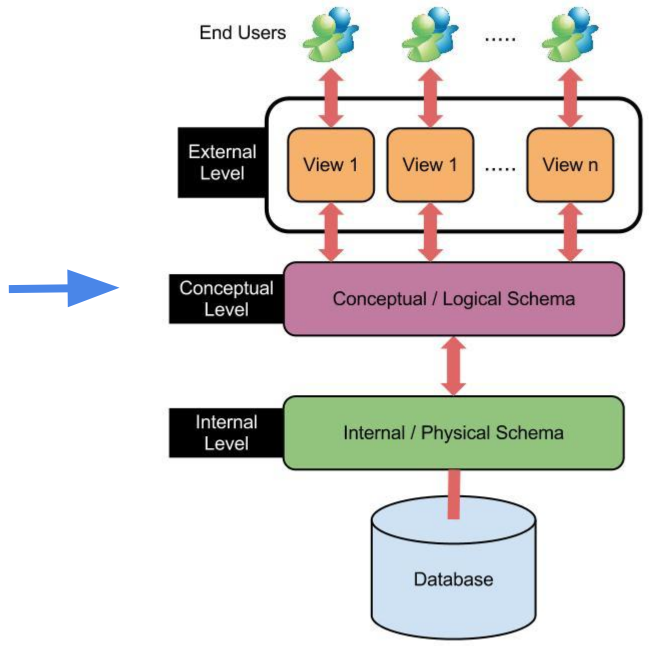
DBMS Architecture

- Internal or Physical level
  - The *lowest* level of data abstraction
  - Internal Schema describes how the data is physically stored and organized on the storage medium
  - Various aspects are considered to achieve optimal runtime performance and storage space utilization, including:
    - storage space allocation techniques
    - access paths such as indexes
    - data compression and encryption techniques



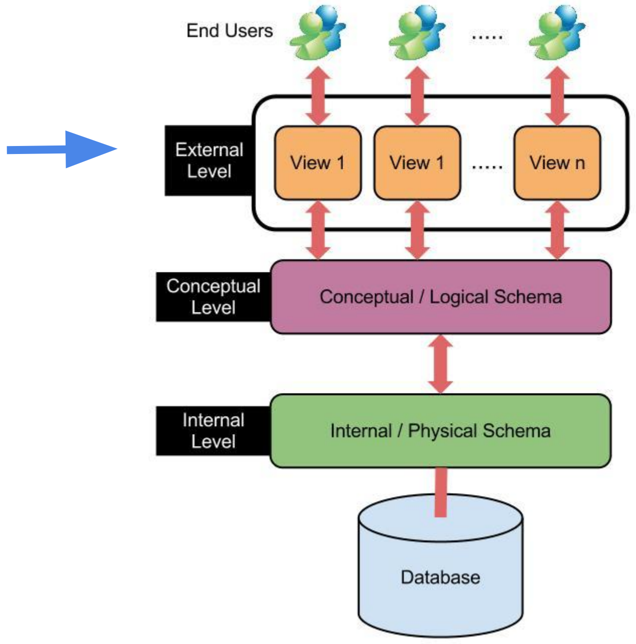
DBMS Architecture

- Conceptual or Logical level
  - Deals with the logical structure of the entire database
  - Conceptual Schema describes what data is stored in the database and the relationships among the data *without any concern for the physical implementation*
  - This is the *overall view* of the database and includes all the information that is going to be represented in the database

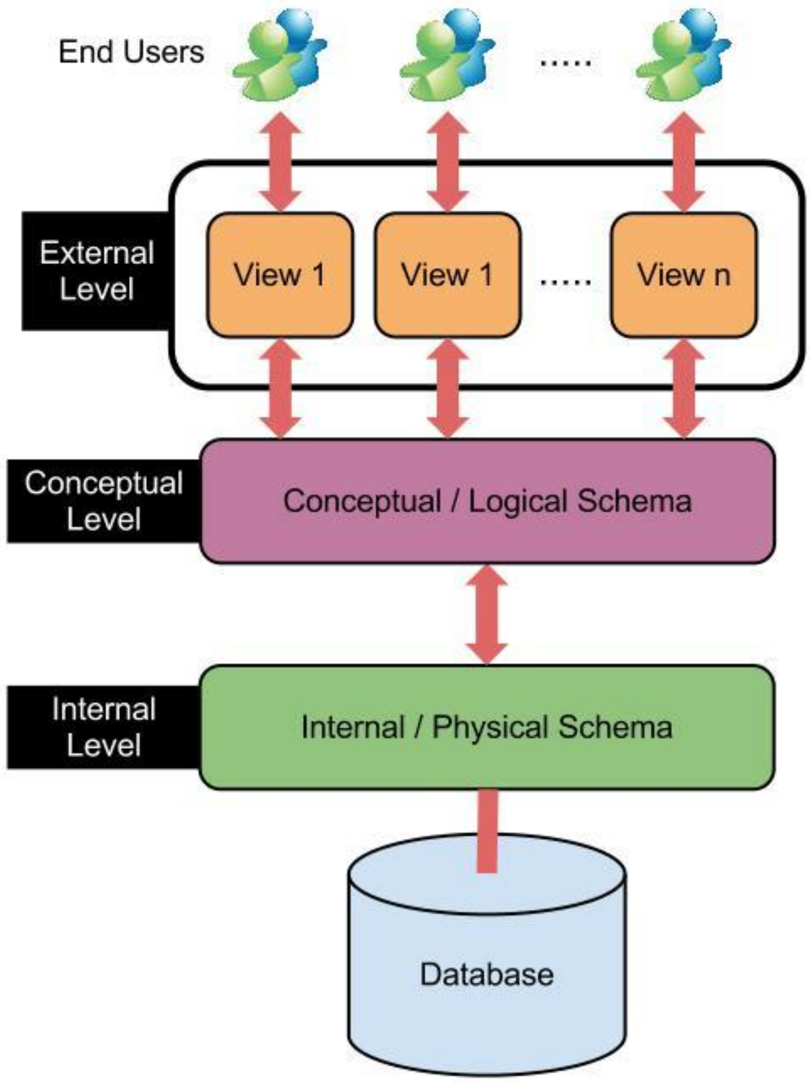


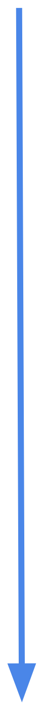
DBMS Architecture

- External or View level
  - The highest level of abstraction that deals with the *user's view* of the database
  - Most users and applications do not require access to the entire data stored in the database
  - External Schemas (or User Views) describe a part of the database for a particular group of users or applications
  - This is a powerful and flexible security mechanism, as parts of the database are hidden from certain users
    - the user is not aware of the existence of any attributes that are missing from the view



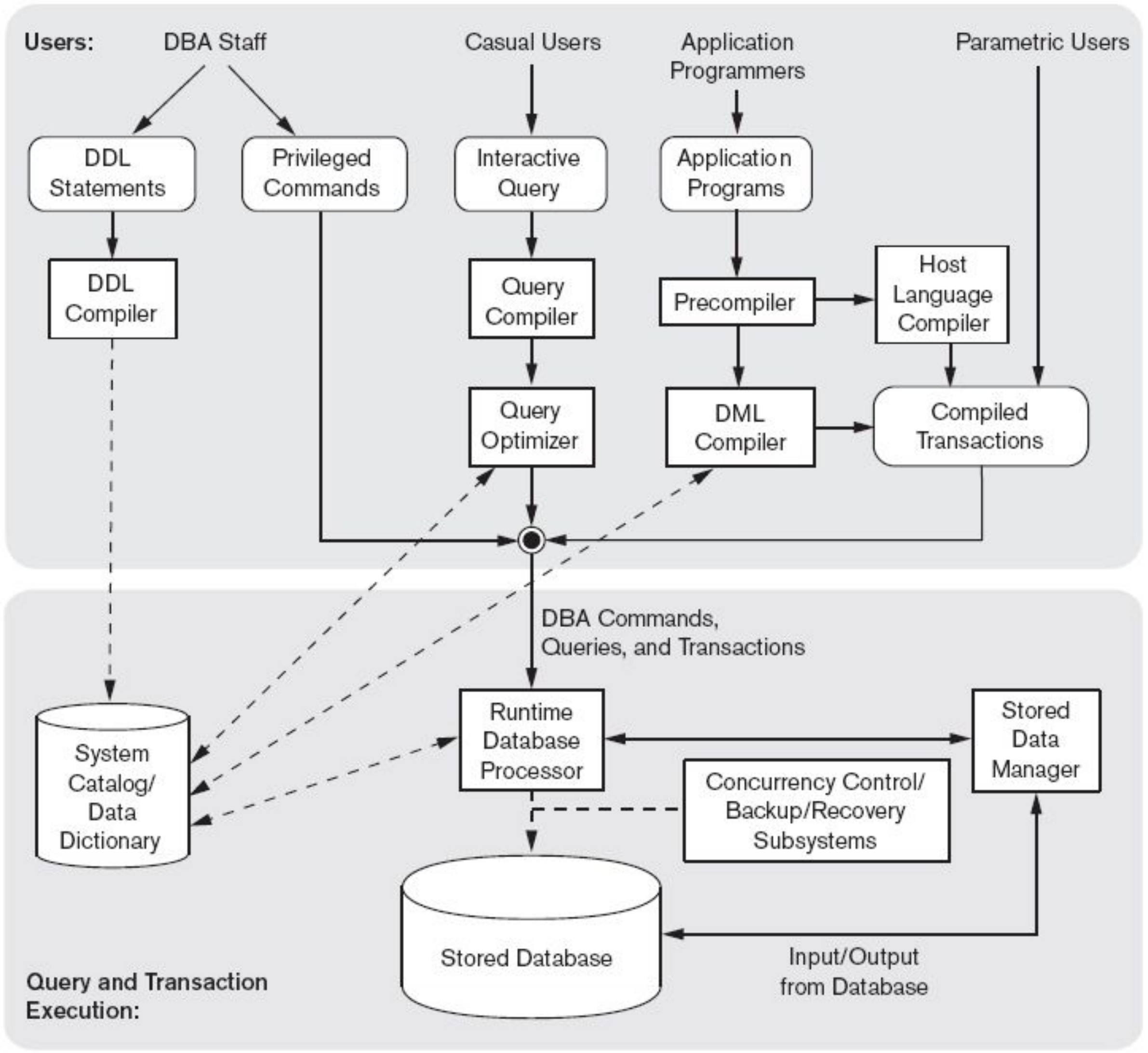
DBMS Architecture





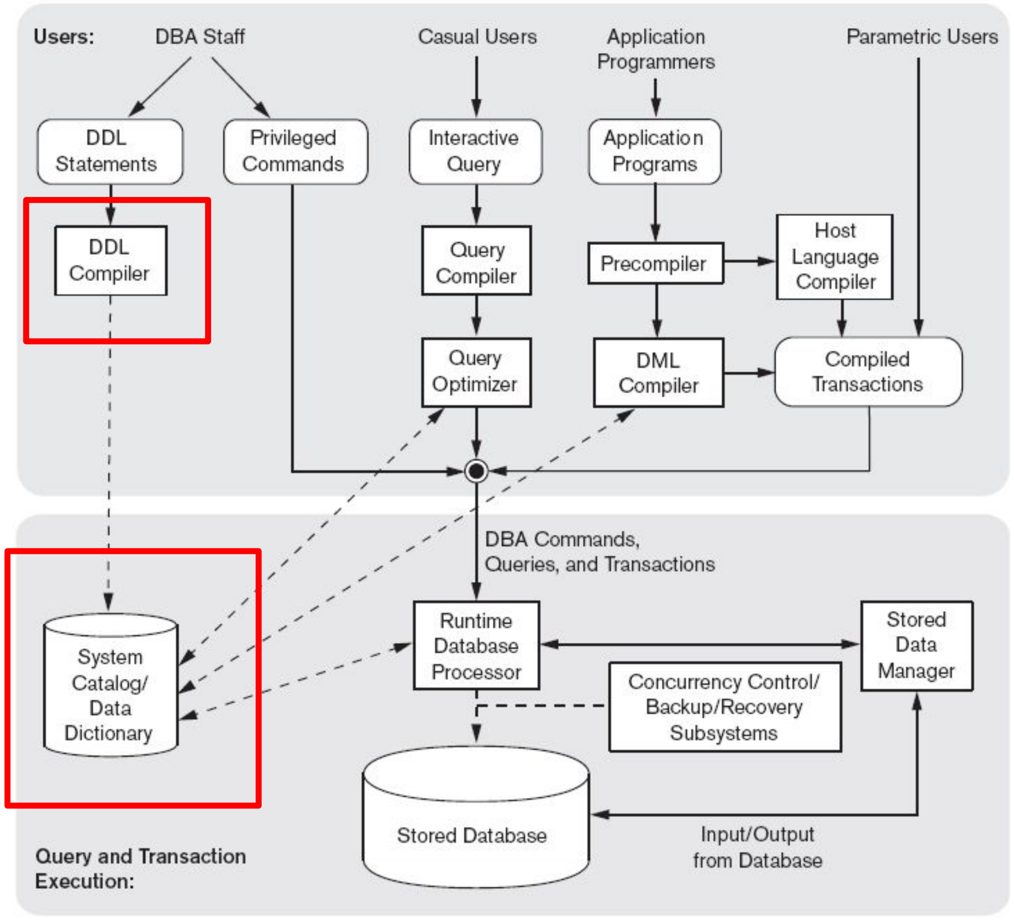
DBMS Components

DBMS Components



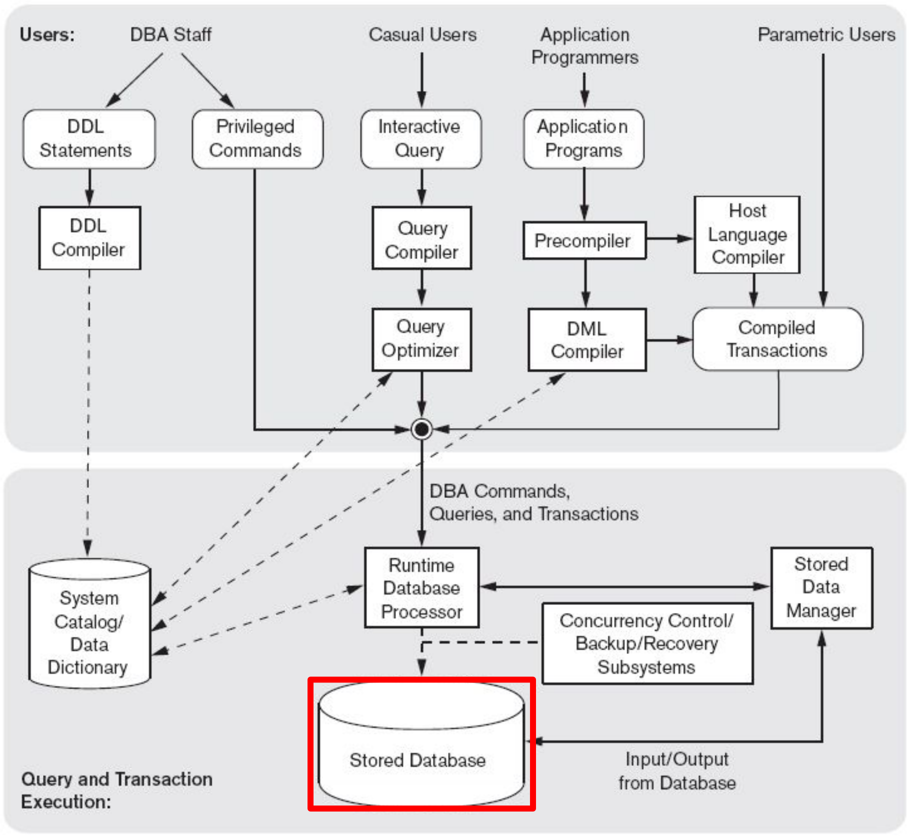
DBMS DDL Components

- **DDL compiler** processes schema definitions and stores them in catalogue
- **Catalogue** contains information such as:
  - Names and Sizes of Files
  - Names and Data Type of Data Items
  - Storage details
  - Mapping information among Schemas
  - Constraints
  - ….



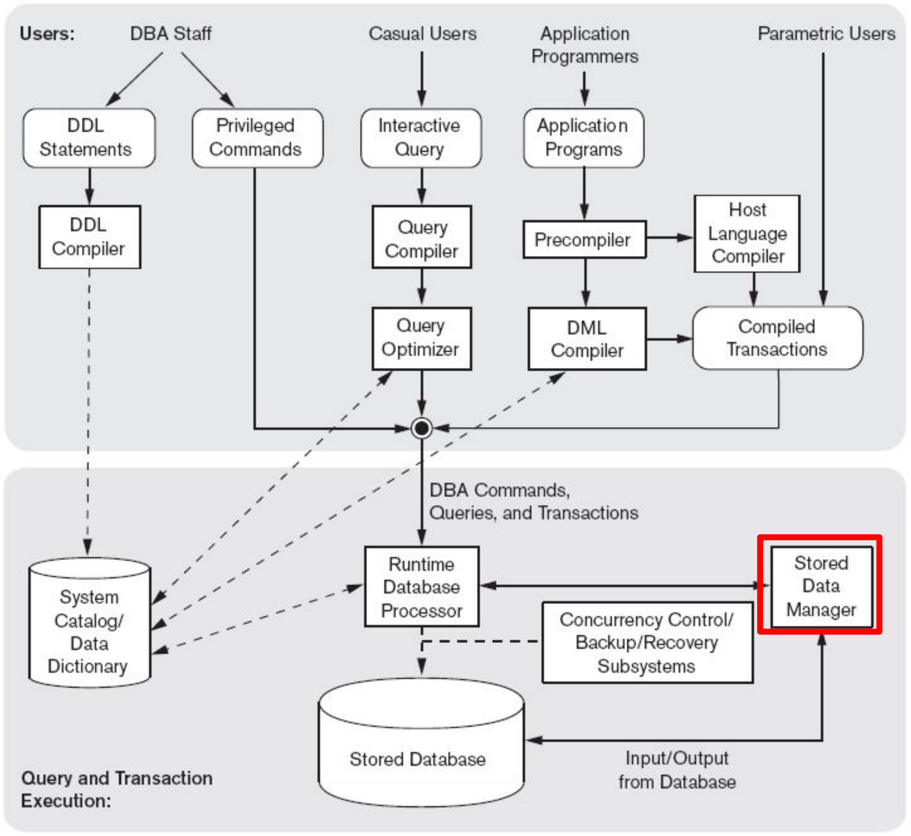
DBMS Storage & Physical Database Components

- The physical Database is usually stored on Hard Disk



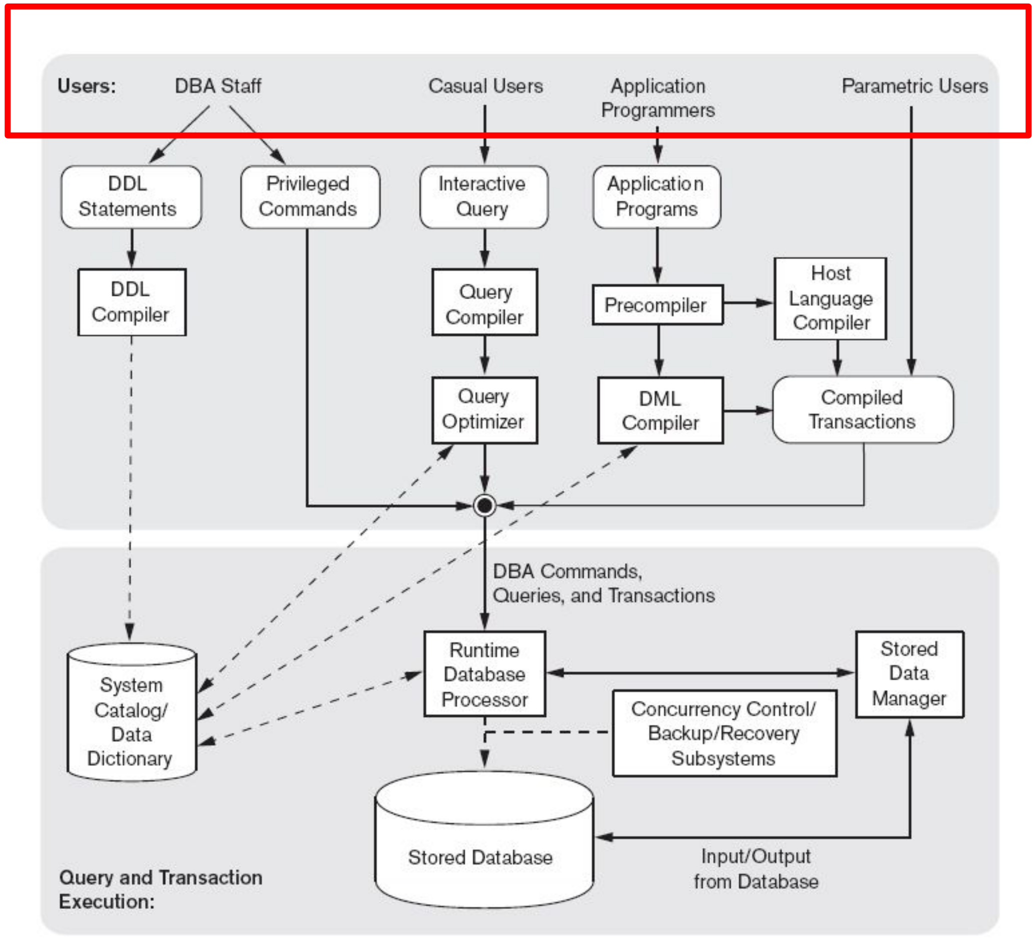
DBMS Storage & Physical Database Components

- The physical Database is usually stored on Hard Disk
    - The OS controls disk access
- The **Stored Data Manager (SDM)** controls access to DBMS information on disk
    - including buffer management



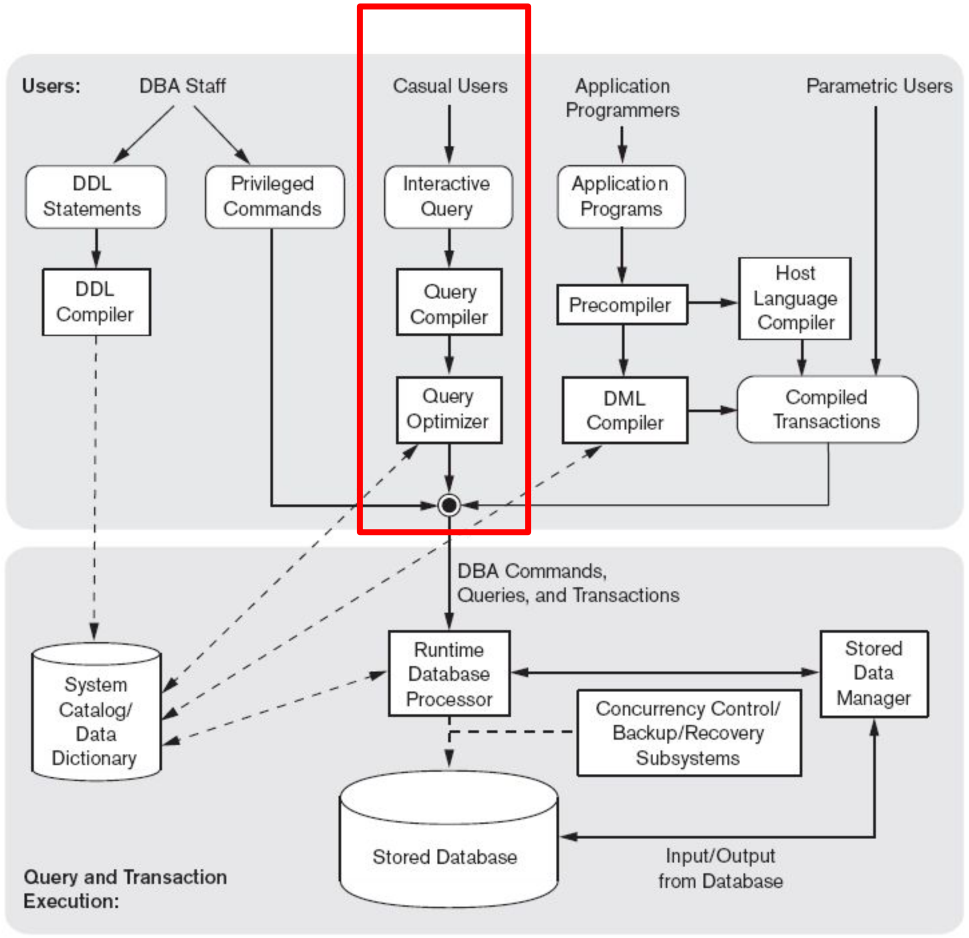
DBMS User Interface Components

- DBMS Users
  - Casual Users
  - Application Programmers
  - Parametric Users
  - DBA Staff
- Different Interfaces are ordinarily used by each type of user



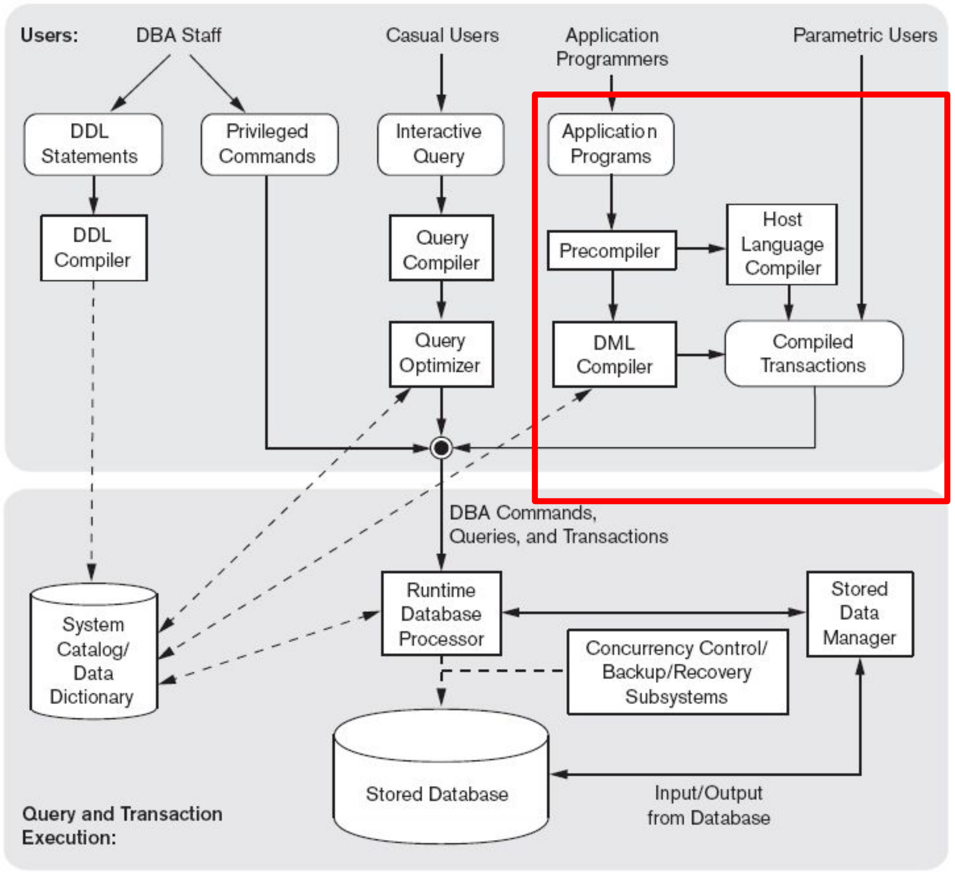
DBMS Interactive Query Components

- Casual Users use an **Interactive Query Interface**
- The **Query Compiler** parses and validates the submitted query
- The internal query is then processed for **Query Optimization**
    - Consults the DBMS Catalogue
    - Generates Executable Code



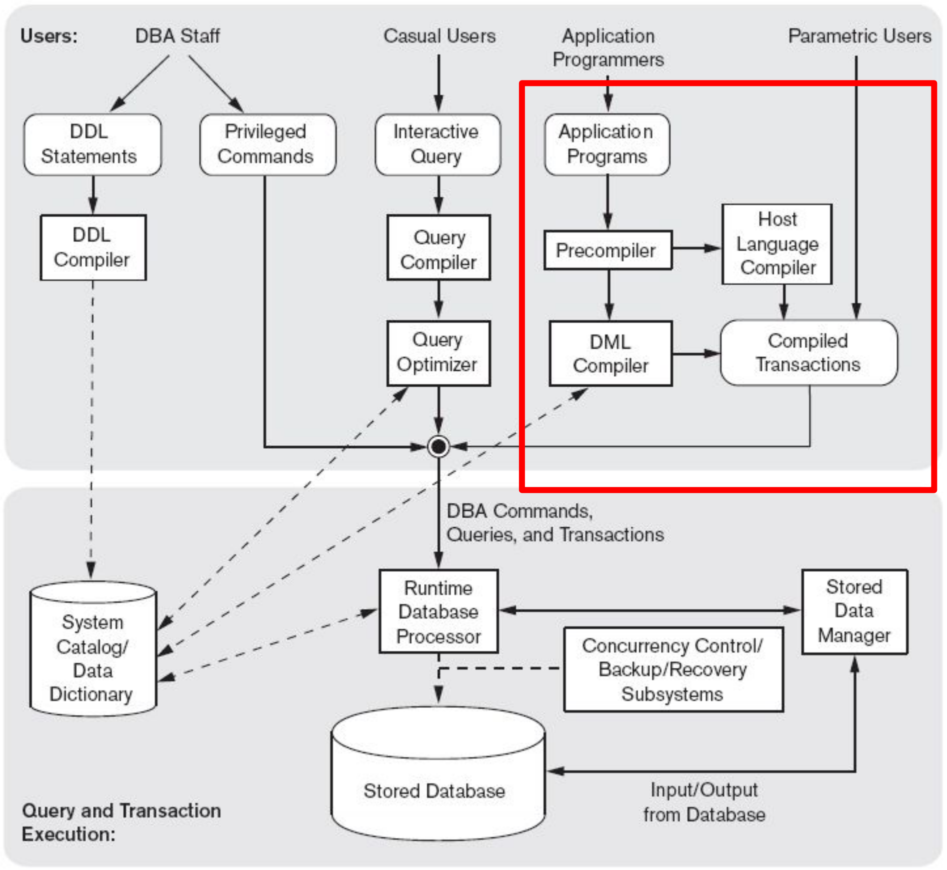
DBMS Programmer Interface Components

- Application Programmers write programs (Java, C++ etc.) which need to access a DB
- The **Precompiler** extracts DML commands from the host language program
- The extracted commands are sent to the **DML Compiler**
- The rest of the program is sent to the **Host Language Compiler**



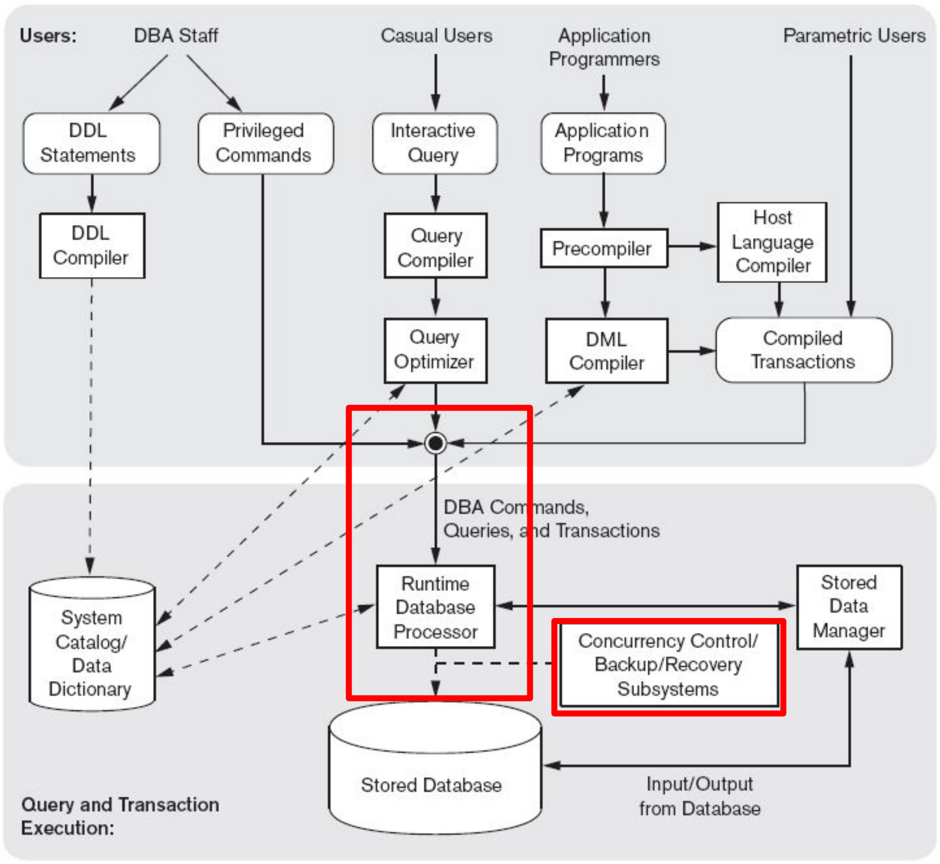
DBMS Compiled Application Components

- Object code for DML commands and the rest of the program are linked forming a **canned transaction**
  - The executable code of a canned transaction calls the run-time processor
  - Canned transactions are used by parametric users



DBMS Runtime Components

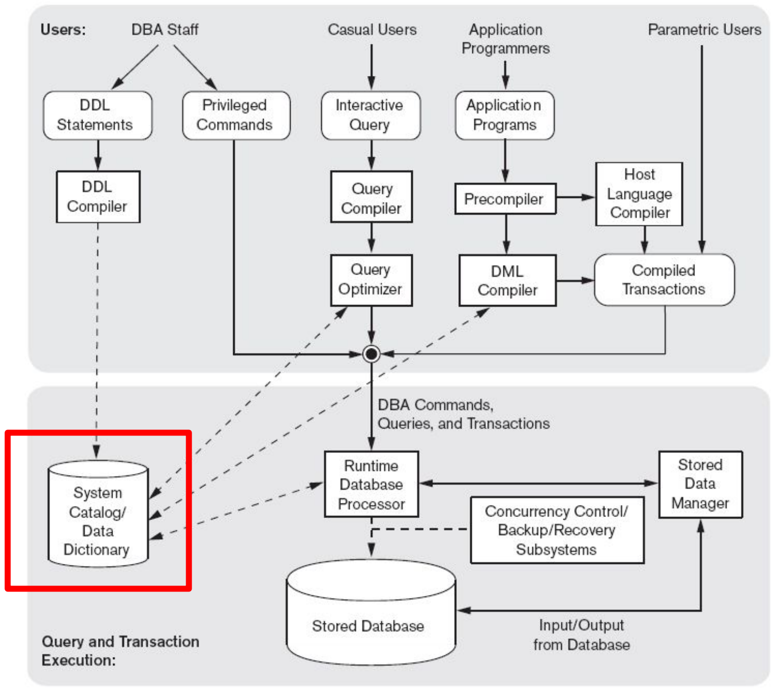
- **Run-time Database Processor** handles all Database access at run-time:
  - Privileged Commands
  - Executable Queries
  - Canned Transactions
- Utilises and Updates the Catalogue
- May be responsible for Buffer Management
- Manages **Concurrency Control** and **Backup and Recovery** as part of Transaction Management



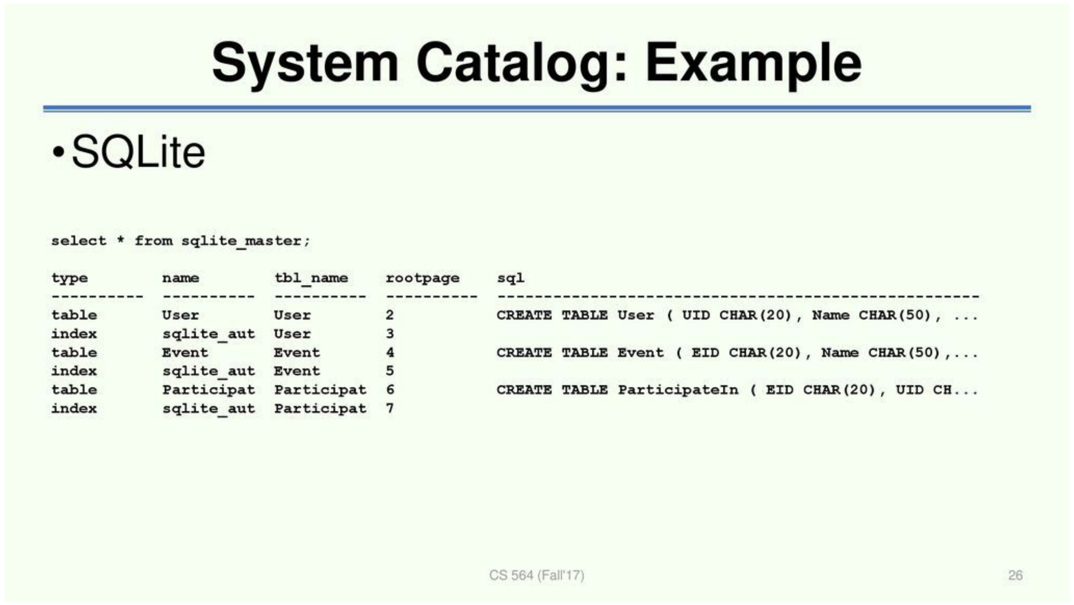
System Catalog & Data Dictionary

System Catalogue and Data Dictionary

- The DDL, and hence the system catalogue, are primarily concerned with *syntactic* definition of the data
- Data Dictionaries augment the internal DBMS catalogue with *semantic* support
  - Accessed directly by users (i.e. DBA)
  - Catalogue accessed by the DBMS



System Catalogue and Data Dictionary Examples



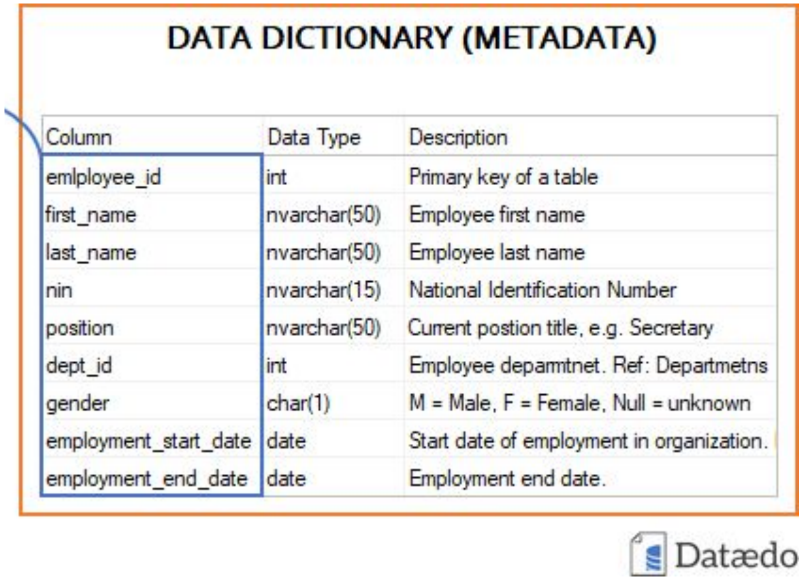
System Catalog: Example

- SQLite

```
select * from sqlite_master;

type        name        tbl_name    rootpage    sql
----------  ----------  ----------  ----------  ----------------------------------------------------
table       User        User        2           CREATE TABLE User ( UID CHAR(20), Name CHAR(50), ...
index       sqlite_aut  User        3
table       Event       Event       4           CREATE TABLE Event ( EID CHAR(20), Name CHAR(50),...
index       sqlite_aut  Event       5
table       Participat  Participat  6           CREATE TABLE ParticipateIn ( EID CHAR(20), UID CH...
index       sqlite_aut  Participat  7
```

CS 564 (Fall'17) 26

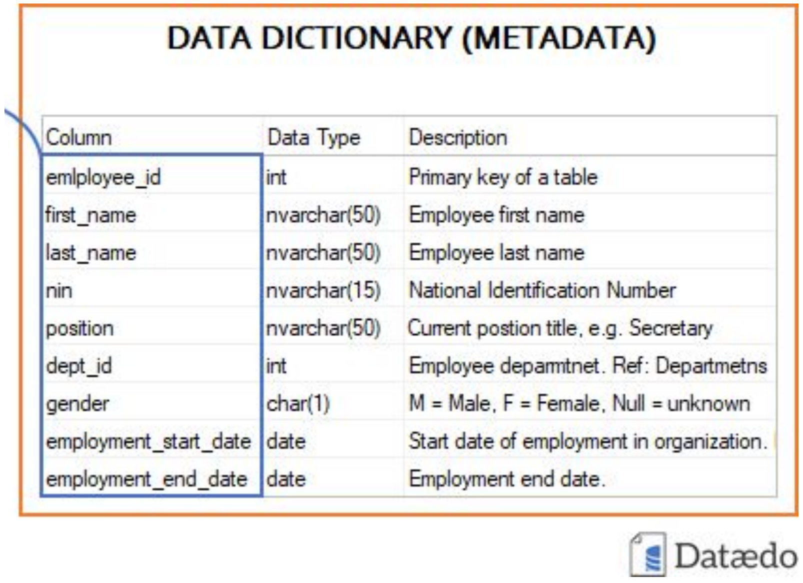


DATA DICTIONARY (METADATA)

Column	Data Type	Description
emlployee_id	int	Primary key of a table
first_name	nvarchar(50)	Employee first name
last_name	nvarchar(50)	Employee last name
nin	nvarchar(15)	National Identification Number
position	nvarchar(50)	Current postion title, e.g. Secretary
dept_id	int	Employee deparmtnet. Ref: Departmetns
gender	char(1)	M = Male, F = Female, Null = unknown
employment_start_date	date	Start date of employment in organization.
employment_end_date	date	Employment end date.

Dataedo

Integrated DB and Data Dictionary



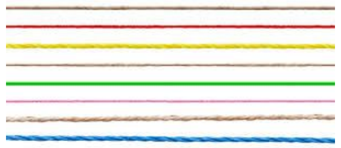
DATA DICTIONARY (METADATA)

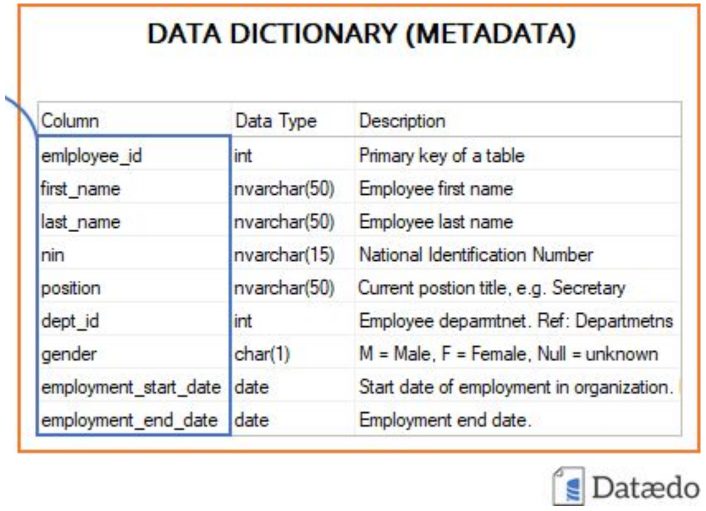
Column	Data Type	Description
emlployee_id	int	Primary key of a table
first_name	nvarchar(50)	Employee first name
last_name	nvarchar(50)	Employee last name
nin	nvarchar(15)	National Identification Number
position	nvarchar(50)	Current postion title, e.g. Secretary
dept_id	int	Employee depamtnet. Ref: Departmetns
gender	char(1)	M = Male, F = Female, Null = unknown
employment_start_date	date	Start date of employment in organization.
employment_end_date	date	Employment end date.

Dataedo

- The majority of DBMS have an **integrated** Data Dictionary
- Data Dictionary is an integral part of DBMS
  – Documents the meta-data that is managed by the DBMS
- It is generally fully active
  – accessed at run-time by DBMS software

Independent Data Dictionary systems





DATA DICTIONARY (METADATA)

Column	Data Type	Description
emlployee_id	int	Primary key of a table
first_name	nvarchar(50)	Employee first name
last_name	nvarchar(50)	Employee last name
nin	nvarchar(15)	National Identification Number
position	nvarchar(50)	Current postion title, e.g. Secretary
dept_id	int	Employee deparmtnet. Ref: Departmetns
gender	char(1)	M = Male, F = Female, Null = unknown
employment_start_date	date	Start date of employment in organization.
employment_end_date	date	Employment end date.

Datædo

- Independent, free-standing system performing its own data management functions
- Normally *passive*
  - No run-time link between the Data Dictionary and the DBMS
  - Hence DBMS has to have its own System Catalogue
- Often generates metadata automatically for a variety of DBMS in the form of DDL
  - Helps to ensure consistency of metadata between the Data Dictionary and the System catalogue

Data Dictionary System

A fully functional Data Dictionary System (DDS) should store and manage:

a) Descriptions of the **database schemas**

b) Detailed information on **physical database design**
   - Storage structures
   - Access paths
   - File and record sizes

c) Descriptions of the types of **database users**, their **responsibilities** and their **access rights**

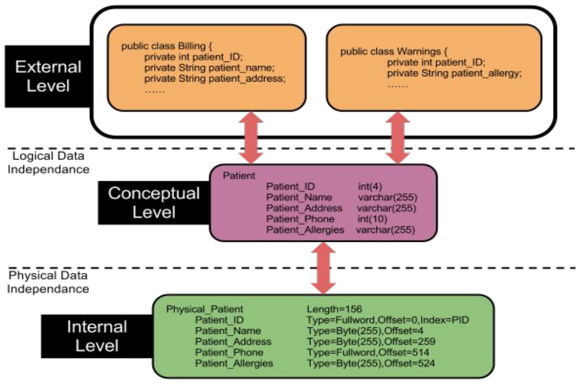
d) High-level descriptions of **transactions**, **applications** and the **relationships of users to transactions**

e) The **relationship between database transactions** and the **data items** referenced by them

f) **Usage statistics** such as frequencies of queries and transactions and access counts to different portions of the database

g) The **history** of any changes made to the database and applications, and documentation that describes the reasons for these changes

In Summary

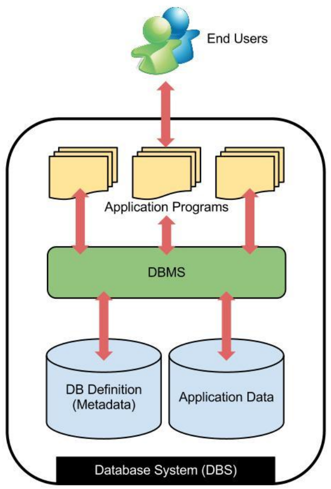


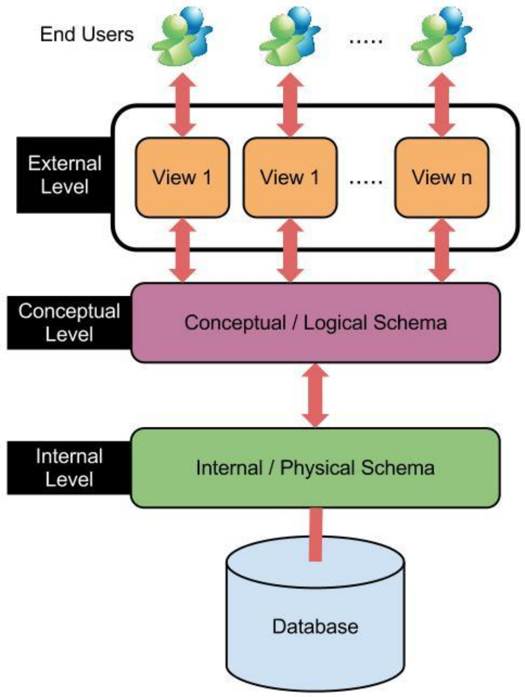
```
public class Billing {
    private int patient_ID;
    private String patient_name;
    private String patient_address;
    ......
```

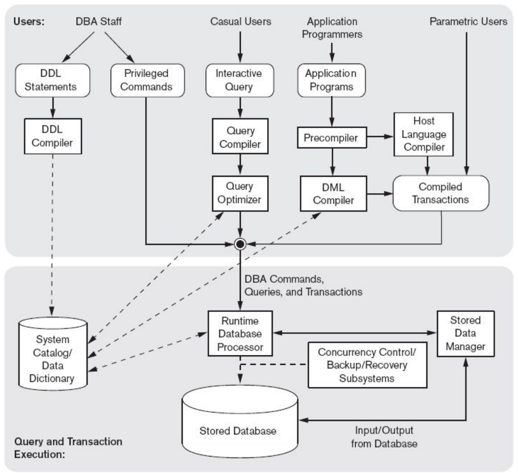
```
public class Warnings {
    private int patient_ID;
    private String patient_allergy;
    ......
```

```
Patient
    Patient_ID          int(4)
    Patient_Name        varchar(255)
    Patient_Address     varchar(255)
    Patient_Phone       int(10)
    Patient_Allergies   varchar(255)
```

```
Physical_Patient        Length=156
    Patient_ID          Type=Fullword,Offset=0,Index=PID
    Patient_Name        Type=Byte(255),Offset=4
    Patient_Address     Type=Byte(255),Offset=259
    Patient_Phone       Type=Fullword,Offset=514
    Patient_Allergies   Type=Byte(255),Offset=524
```







1) Database Systems
2) Database Architecture
3) Database Schemas
4) Database Components
5) System Catalog & Data Dictionary