Database Systems (ISYS1001/ISYS5008)

Lecture 1

Overview, Relational Model , Creating tables with SQL

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Discipline of Computing
School of Electrical Engineering, Computing and Mathematical Sciences (EECMS)

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Objectives

- Identify the overview of Database Systems
- Describe the basic idea of Relational model
- Create SQL queries for creating Tables
- Additionally knowing,
  - unit outline
  - Assessments

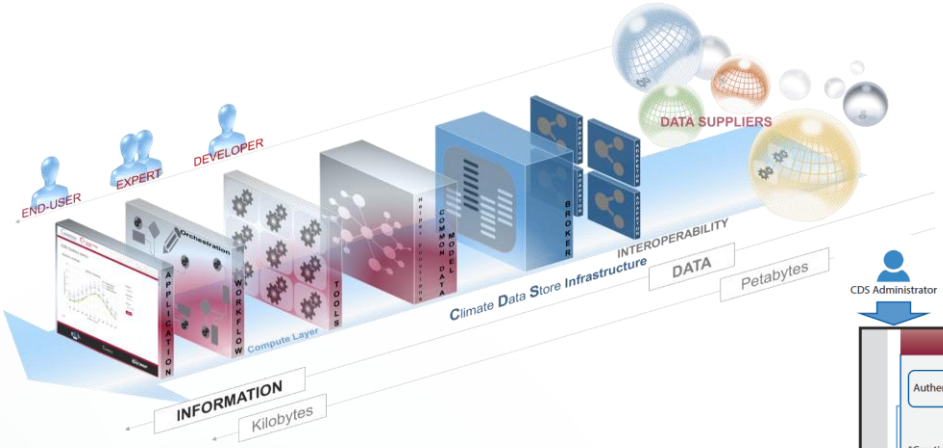
Databases and Database Management Systems

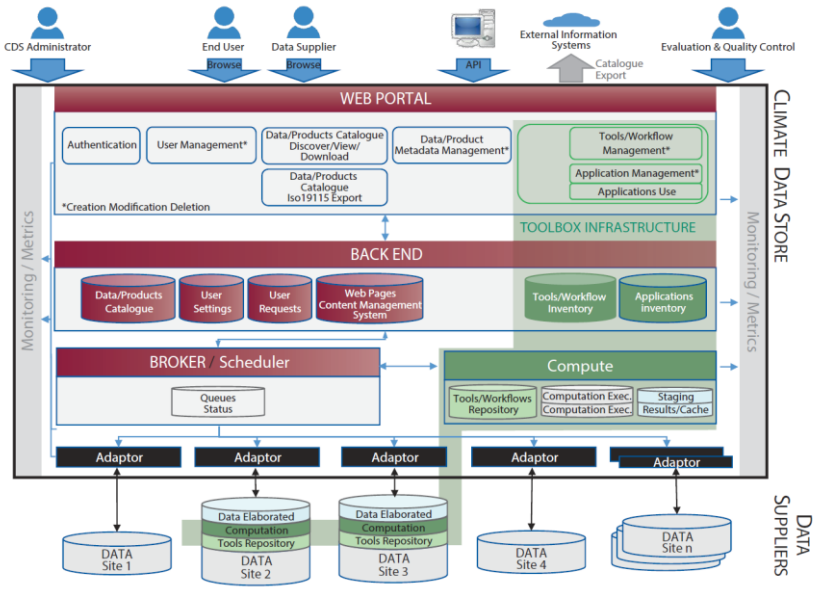
- How to store large volume of data effectively in a computer system?
- Files Vs Databases
- Database
  - Storage facility to keep large (can be extremely large) amount of data in a manageable manner
  - It used to be about boring stuff: employee records, bank records, etc.
  - Today, the field covers all the largest sources of data, with many new ideas
    - Web search
    - Data mining
    - Scientific and medical databases.
    - Integrating information
  - You may not notice it, but databases are behind almost everything you do on the Web.
    - Google searches
    - Queries at Amazon, eBay, etc.

Databases and Database Management Systems

- Database Management System
  - DBMS is a Software System manage Databases
  - DBMS is a Software system enabling creating, storing, updating and maintaining databases effective manner
  - Manage large data with efficiency, persistence, security
  - Available for Phones, PC's, workstations, mainframes, supercomputers
- Knowledge and techniques used in DBMS span many areas of computer science:
  - Languages, object orientation and other programming paradigms, compilation, operating systems, concurrent programming, data structures, algorithms, theory, parallel and distributed systems, dynamic programming, user interfaces, expert systems and AI, statistical techniques

Example : Satellite data for Climate analysis

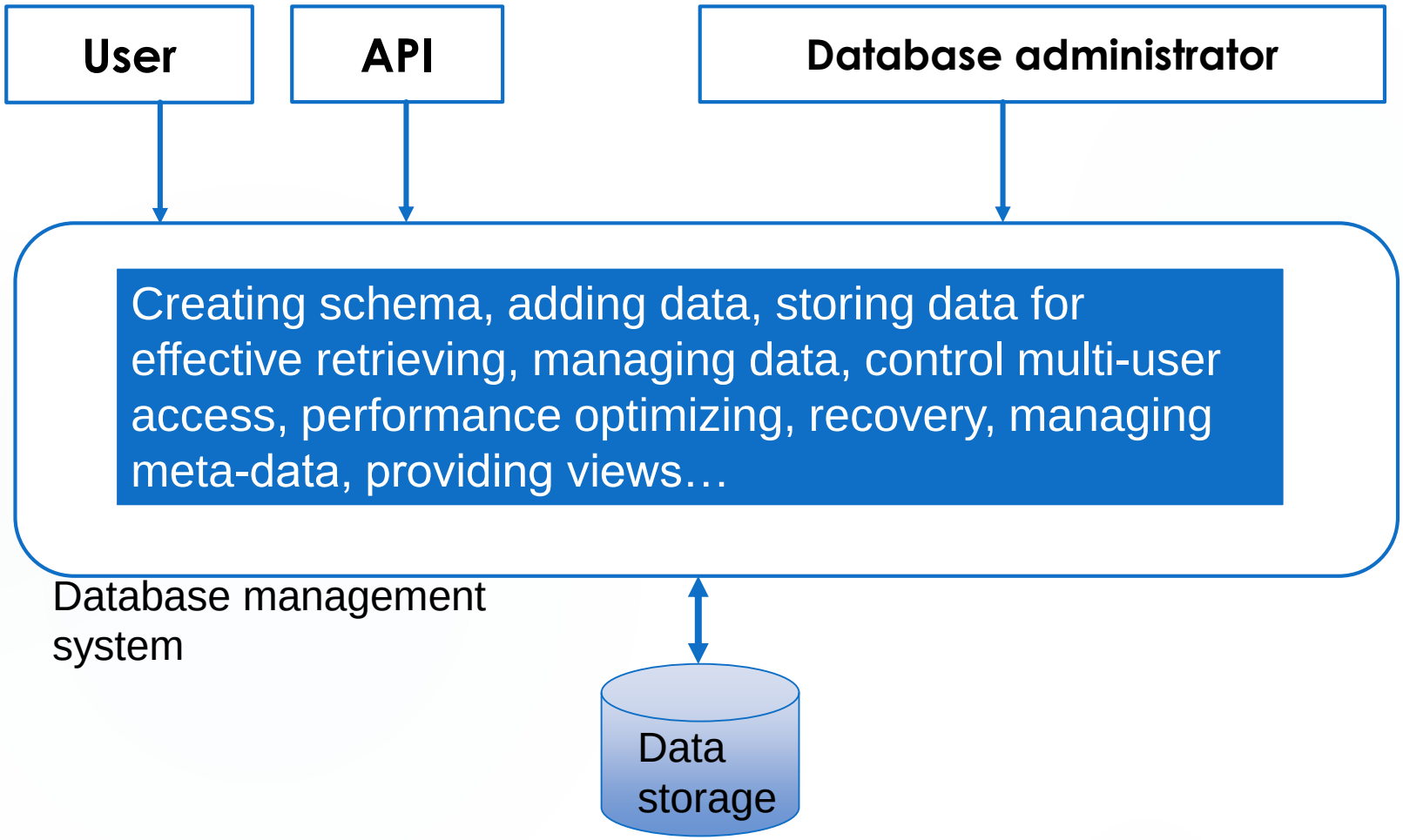




Providing services with Sentinel-2 satellite data

Image source: https://climate.copernicus.eu/climate-data-store#062e8d73-1d2f-497c-a202-54dfff86c960

Simplified overview of a database system



Functionalities provided by a DBMS

- Create new databases
  - Logical structure (schema)
  - **Data – Definition Language**
- Questioning about data (query)
  - **Data-manipulation language (query language)**
- Support storing large volume of data effectively
  - Massive volume of data; therefore need efficient ways to store
- Support Durability
  - Recovery from system failures
- Control access by many users at once (multi-user concurrent access)

Key People

Many roles exist in computing and other domains related to database systems

- Database designer
  - Establishes schema
- DBMS implementer
  - Builds system
- Database application developer
  - Programs that operate on database
- Database administrator
  - Loads data, provide access control, keeps DB running smoothly
- Software Engineers may need to work with databases as well

Major DBMS Products and Freeware

- Commercial products:
  - Oracle
  - IBM: DB2
  - Microsoft: SQL Server, Access
- Freeware:
  - **MySQL**
  - Postgres
- All are "**relational**" (or "object-relational") database systems at their core.
- There are non-relational databases, which are becoming increasingly popular, especially for data science.

Unit Learning Outcomes

- Be able to
  - **create, query, update and manage** Relational Databases in a DBMS environment.
  - **design** relational database schema using the ER model and normalization
  - **integrate** a Relational Database with Java or Python
  - **describe** the principles of correctness for concurrent transactions and explain the techniques for managing concurrent transactions in a DBMS.

Text and References

- Recommended text
  - Ullman, J.D. and Widom, J., A First Course in Database Systems, 3rd Ed., Pearson Prentice Hall, 2008.
- Other References
  - Mana Takahashi and Shoko Azuma. 2009. The Manga Guide to Databases. No Starch Press, San Francisco, CA, USA
  - Garcia-Molina, H., Ullman, J.D. and Widom, J., Database Systems: The Complete Book, 2nd Ed., Pearson Prentice Hall, 2008.
  - Ramakrishnan, R. and Gehrke, J., Database Management Systems, 3nd Editon, McGraw-Hill, 2003.

Unit Resources

- Unit Page
  - On Blackboard (http://lms.curtin.edu.au)
  - Lecture slides and other unit materials will be available from the unit page under “Unit materials”
  - Lectures from the previous semester is available also
  - There may be minor modifications of the lecturers from previous semester and new version would be available weekly basis
  - Lecture recordings will be available as ilectures after the lecture
- MySQL Documentation
  - http://dev.mysql.com/doc/

Pre-Requisite Knowledge

- Ability to program in Java of Python
  - Only when we look at using a Java/Python and connect to a database (close to the end)
- Working knowledge of Linux operating system

- Those are co-requisites, so learning this unit while learning FOP/PDI etc. is sufficient

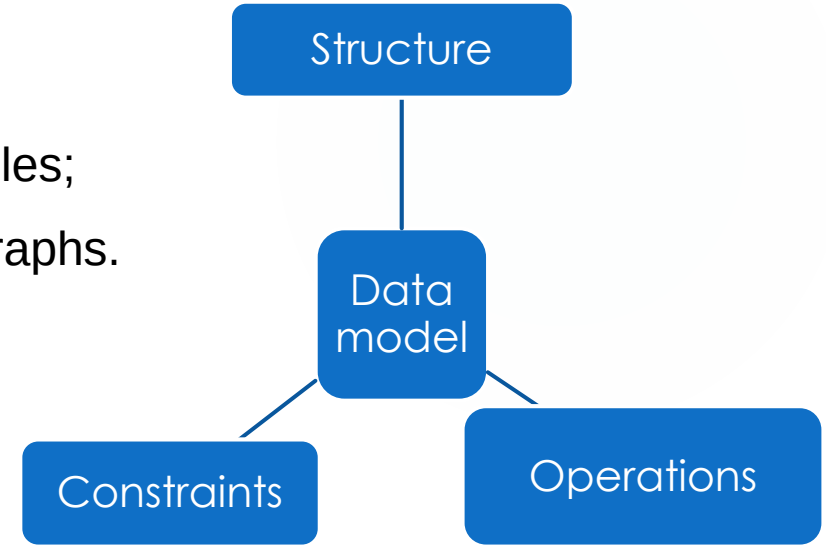
Unit outline

- Look at the complete unit outline in Blackboard
- Practical tests will be held during lab time
- Mid term test will be held during lecture time

Data models, Relational model and creating tables

What is a Data Model?

- A notation for describing data, consists of three parts:
  - Structure of the data:
    - Conceptual model
    - Examples: relational model = tables;
    - Semi-structured model = trees/graphs.
  - Operations on the data:
    - Limited but high level operations
  - Constraints:
    - Limitations on what data can do



Data models for DBMS

- There are a number of data models, and their relative importance has changed in the last decade.
  - hierarchical models
  - Network models
  - …
- Traditionally the most important has been the **Relational model**, including object-relational extensions
- Other models (including Network and unstructured) are becoming increasingly useful.
- Our focus is on the Relational model.

Relational data model

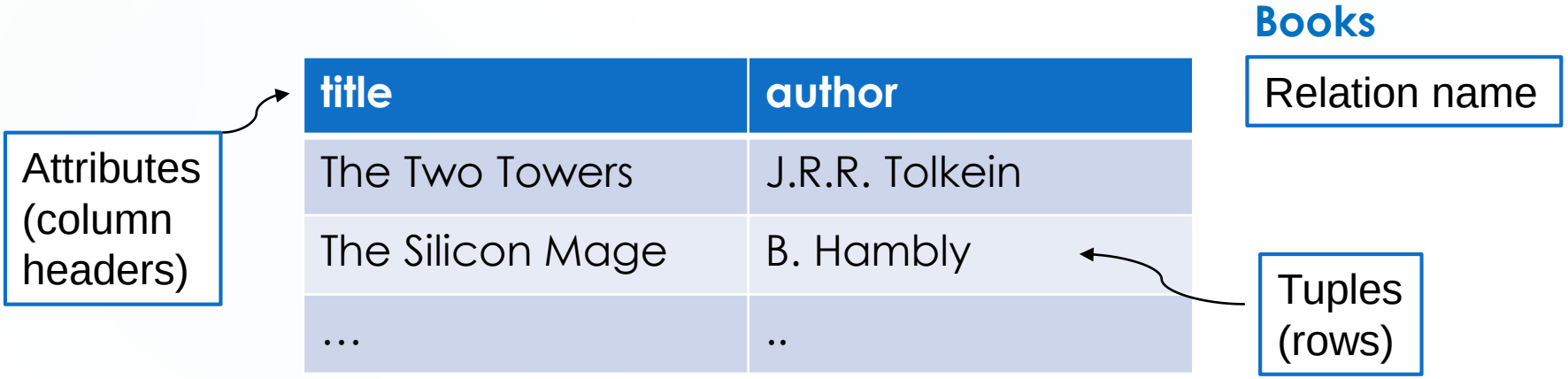
- "database system should present the user with a view of data organized as tables called relations."

  -Ted Codd -1970

- Data is representing as tables
  - Physical implementation

    might be different

A Relation is a Table



This isn't actually the Books relation, but it shows the concept.

Relational data model

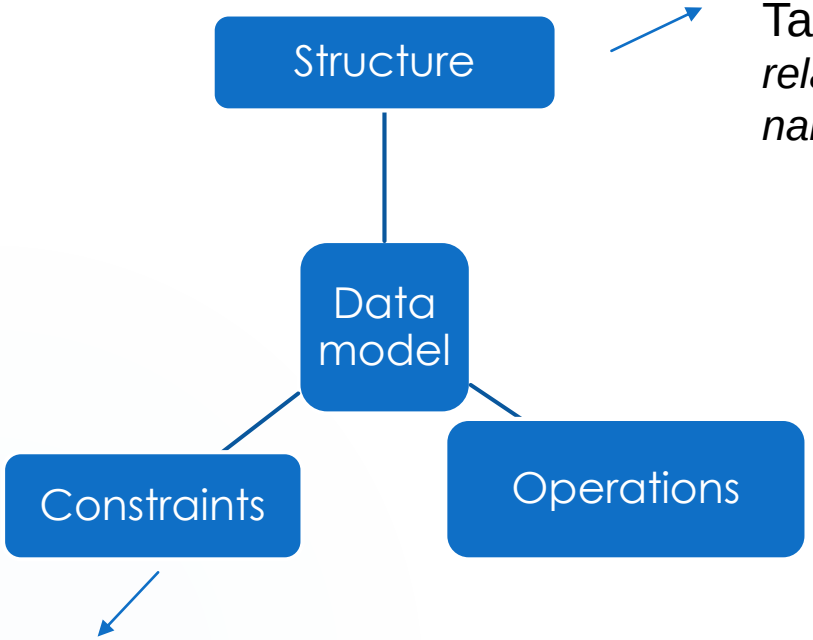


Table
relation name, attributes names

Key, referential integrity
….
(more later)

- Limited but high level operations
- Queries
- Based on relational algebra

Schemas

- *Relation schema* = relation name and attribute list.
  - Optionally include types of attributes
  - Example:

    Books(title, author) or

    Books(title:varchar(30), author:varchar(60))

- *Database* = collection of relations

- *Database schema* = set of all relation schemas in the database

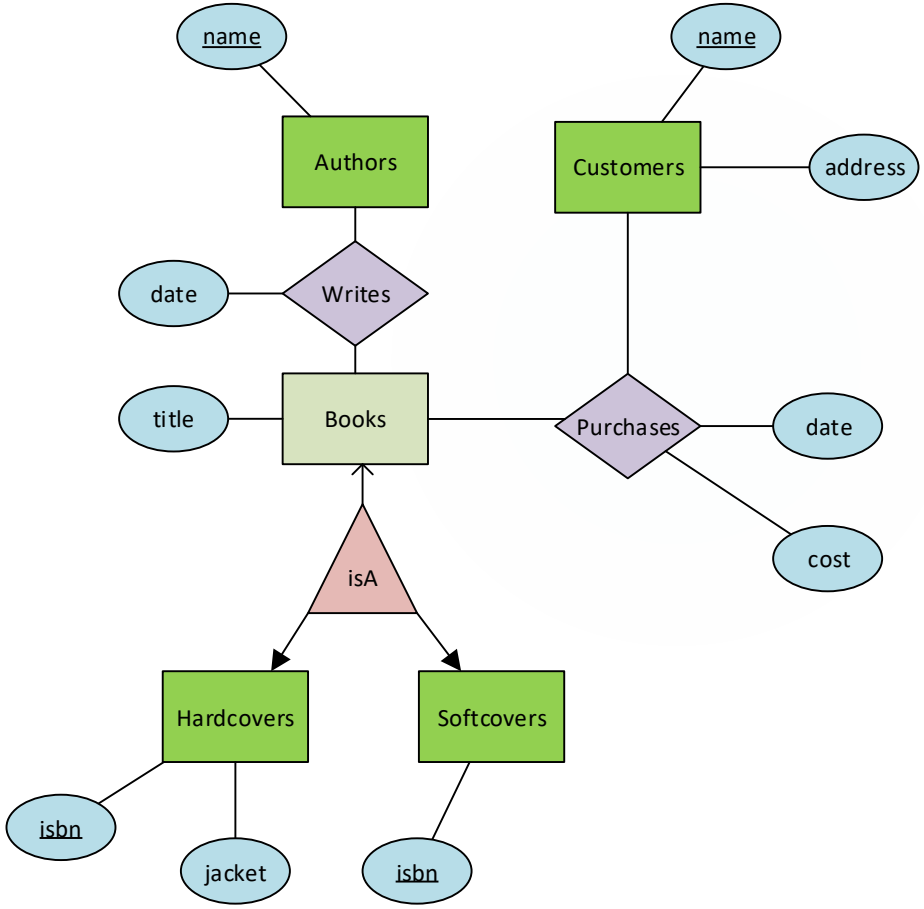
Why Relational model?

- Very simple and structured approach
- Provides a limited, but useful collection of operations
- *Often* matches how we think about data
  - most of the things can be modelled
- Abstract model that underlies SQL, the most important database language today.
- **Used by most major commercial database systems**

Relational model and ER model

- In order to represent data as tables, the required information has to be identified and model first
  - **Entity-relationship** diagrams (**ER model**)
  - UML diagrams
  - ….
- Diagrams are really useful to conceptualize ideas
- ER diagrams are very useful when designing a database
- ER model is converted to database schema by some standard methods
- More details :

Lecture 3-4, practical 4-6



ER Diagrams differentiate between Entities (such as Authors and Books) and the Relations between them.

Entities vs Relations

- An Entity is generally a collection of **things**.
  - Cars, Airplanes, Boats, Books
  - People, Students, Staff, Managers, Authors, Customers
  - Places, Buildings, Rooms, Venues, Destinations, Terminals
  - Units, Courses, Invoices

- A Relation **connects** two (or more) Entities.
  - A Student Enrolls in one or more Units.
  - A Customer Purchases one or more Books.
  - A Building Contains one or more Rooms.
  - A Tutorial is an instance of a Unit at a particular date and time, with many Students and a Staff member scheduled.

Database Example

- Adopt as our running example:

  Authors(name)

  Writes(author_name, book_id, date)

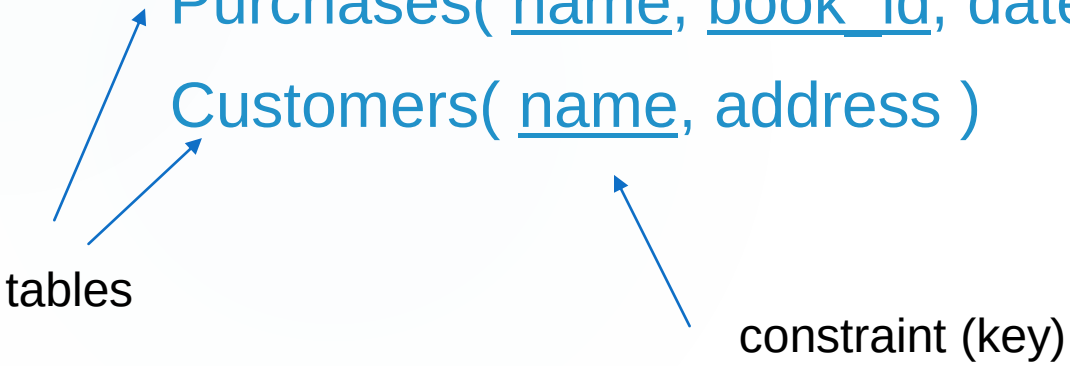
  Books(isbn,title)

  Hardcovers(isbn, jacket, price)

  Softcovers(isbn, price)

  Purchases(name, book_id, date, cost)

  Customers(name, address)



SQL

- SQL ("S.Q.L." or "sequel") - Structured Query Language
- Query language of most commercial relational DBMS's
- SQL is a big language, not just queries and updates.
- Components of the language:
  - Schema definition, Data retrieval, Data modification
  - Indexes, Constraints
  - Views, Triggers
  - Transactions, Authorization
  - *etc*.
- Structured language, therefore limited set of operations-> short and fast

SQL

- Basically two aspects :
  - Data –definition sub language (DDL part)

    for declaring database schema
  - Data manipulation sub-language (DML part)

    for querying (asking questions about data)
- Some operations from both aspects will be covered in this unit
- This unit discusses generic SQL but uses MySQL for details
- We will start with creating tables (assuming a database is already created and available)

Creating (Declaring) a Relation

- Simplest form is:

```
CREATE TABLE <name> (
        <list of elements>
    );
```

Note: replace the content within <> with actual values

Most basic element: an attribute and its type.

- To delete a relation:

```
DROP TABLE <name>;
```

Common Data Types

1. `INT` or `INTEGER` (synonyms).

   Also `SMALLINT`, `BIGINT`, *etc*.

2. `REAL` or `FLOAT` (synonyms)

   There are approximate.

3. `DECIMAL(`*n*`,`*m*`)` = total *n* digits of which *m* are to the right of the decimal point.

4. `CHAR(`*n*`)` = fixed length character string, padded with blanks.

5. `VARCHAR(`*n*`)` = variable-length strings up to *n* characters.

6. `DATE, TIME and DATETIME`

Example: Create Table


```
CREATE TABLE Purchases(
    name    VARCHAR(20),
    book_id    DECIMAL(13),
    date    DATETIME,
    cost    DECIMAL(5,2)
);
```

name	book	date	cost

Identifiers in SQL

- Identifiers (relation name, column names, etc.) in SQL **start with a letter** followed by alpha-numeric characters,
  - max length 30 in SQL and 64 for almost all in MySQL
  - MySQL allows identifiers to start with a non-character, but identifiers may not be entirely composed of numbers
  - MySQL also allows $ and _ (underscore) and a number of other symbols depending on whether the string is quoted (surround by quotes) or not.
- Reserved words not allowed as identifiers
  - *e.g.*, table, create, char, date, select, etc.
- Two objects in a name-space cannot have identical names
  - Example: two tables in a database; two columns in a table, *etc*.

Inserting rows

- To insert a single tuple:

```
INSERT INTO <relation>
VALUES(<list of values>);
```

- Example:
  - Add a tuple to **Purchases(name, book_id, date, cost):**

```
INSERT INTO  Purchases
VALUES  (‘Charlie Brown’, 9780312094119,
‘2021-04-13 14:22:01’, 32.99);
```

  - Values must be listed in column sequence

More on adding tuples

- Specify columns when values not in column sequence or data is missing:

```
INSERT
INTO Purchases (name, book_id, cost)
VALUES('Peter Pan',9780142001196, 12.50);
```

name	Book_id	date	cost
Peter Pan	9780142001196	NULL	12.50

Retrieving


```
SELECT < attribute1,
attribute2 ,..>
FROM <relation>
WHERE <condition>;
```

Purchases Table

name	Book_id	date	cost
Peter Pan	….	…	12.50
Charlie Brown	…	..	32.99

e.g.,

```
SELECT name, book_id
FROM Purchases
WHERE cost>25;
```

name	book
Charlie Brown	9780142001196

```
SELECT * FROM
Purchases;
```

name	Book_id	date	cost
Peter Pan	9780142001196	NULL	12.50
Charlie Brown	9780142001196	2021-04-13 14:22:01	32.99

Deleting rows

- To delete all tuples satisfying a condition from some relation:

```
DELETE FROM <relation>
WHERE <condition>;
```

- *e.g.*, name='Peter Pan':

```
DELETE
FROM Purchases
WHERE name = 'Peter Pan'
```

WHERE clause determines which rows deleted.

After deletion:

name	book_id	date	cost
Charlie Brown	9780142001196	2021-04-13 14:22:01	32.99

- Delete all tuples

```
DELETE FROM <relation>;
```

- Note: no WHERE clause needed.
- e.g., Make the relation Purchases empty:

```
DELETE FROM Purchases;
```

Modifying tuples

- To change certain attributes in certain tuples of a relation:

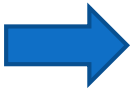
```
UPDATE <relation>
SET <list of attribute assignments>
WHERE <condition on tuples>;
```

Modifying tuples

- e.g.,

```
UPDATE Hardcovers
SET COST = 18.50
WHERE isbn = 9781435114944;
```

isbn	jacket	cost
9780330320559	fairy	16.28
9780786965625	None	49.95
9781435114944	None	**20.00**



isbn	jacket	cost
9780330320559	fairy	16.28
9780786965625	None	49.95
9781435114944	None	**18.50**

- What is no WHERE clause used?

SQL Values

- Integers and reals are represented as you would expect.
- Strings are too, except they require single quotes.
  - Two single quotes = real quote
  - *e.g.*, `'William Shakespeare''s The Phantom Menace'.`
- Any value can be NULL.

Summary

- DBMS used to store, maintain, and query large datasets
- DBMS draws knowledge from many areas of CS
- Data model: consist of structures, operations and constraints
- Relational model : represents data as tables
- In order to identify and conceptually model tables required for a database, ER diagrams can be used
- SQL: Language for defining tables, querying and other data manipulation (insert, delete, etc., based on relational model

Happy Database systems

next week : more on SQL