Software systems

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I. Overview

A. Analysing software systems

- Aspects to consider:
  - System high-level functions
  - System nodes
  - Types of data managed and processed
  - Data movement within the system
- Usually expressed with pictures

B. Modelling data (Database)

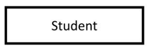
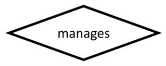
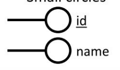
- Data is always stored, transformed and analysed
- **Abstract Data Model** used to understand process
- **Database theory** creates the Abstract Data Model
- Database theory considers:
  - Important entities in Database
  - **Attributes** of these entities
  - **Relationships** between these entities
- **Entity modelling** formally expresses database theory
- **Database systems** implements the Abstract Data Model

C. Moving data (Network)

- Process of data moving between nodes
- **Network models** defines the type of network structure
- **Network protocol** and **API** implements the model

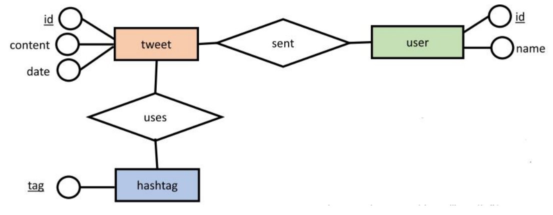
II. Entity Relation Modelling

- Creates **Entity Relationship Diagram**
- Establishing **relationships** in a given system:
  - **Entities**: Aspects within a given system
  - **Relationships**: How entities are related
  - **Attributes**: Properties of an entity or relationship
- Captures constraints and requirements on data
- Used as a guide to *implement* relations

Entity Sets	A set of distinguishable entities that all have the same set of properties (attributes). Could be physical things, events, conceptual, … Normally correspond to nouns	Rectangle 
Relationship	A relationship set describes how two or more entity sets are related to each other. Some times correspond to verbs : *owns, has, drives, ….* Entity sets can be involved in many relationship sets	Diamond 
Attributes	Properties or attributes of an entity or relationship set. Underlined attributes are ***primary keys***.	Small circles 

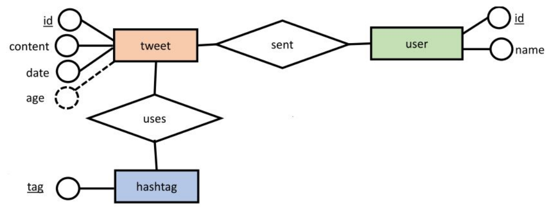
A. Primary keys

- An attribute that **uniquely identifies** an entity
- Properties:
  - There will never be two entities with the same key
  - Can contain **multiple** attributes if needed
  - Shown on ERD as <u>underlined attributes</u>
- Two types of primary keys:
  - **Natural keys**: Attributes from application data
  - **Surrogate keys**: *Invented* attributes

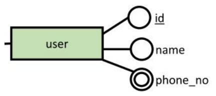


B. Complex attributes

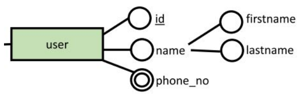
- **Computed attributes**: Calculated from other attributes



- **Multi-valued attributes**: Sets or lists of multiple values

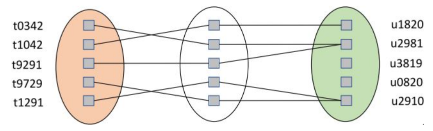


- **Composite attributes**: Properties that has sub-attributes



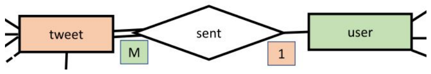
III. Relationships: Sets of relations

- Entity sets contain distinct entities
- **Relationships** contain sets of relations
- Each **relation** is a *pair of links* to an entity in the two entity sets

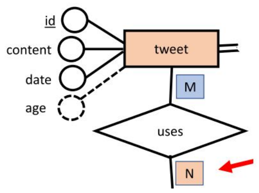


A. Relation constraints

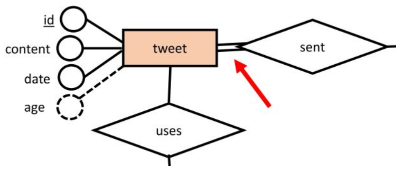
- **Cardinality constraint**: Number of times entity appears
  - One-to-one
  - One-to-many



  - Many-to-many

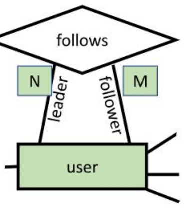


- **Total participation**: Entities **must** appear in relationships



B. Self relations

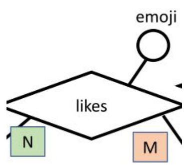
- Label the two connecting lines to show **roles**



- Cardinality constraints still apply

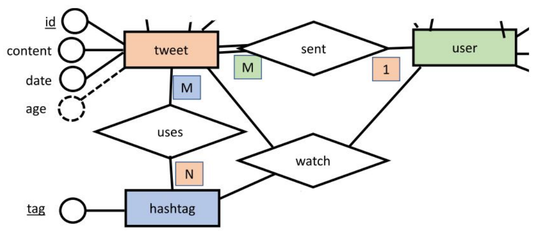
C. Relations with attributes

- Example: User can like a tweet with emojis



D. Three-way relationships

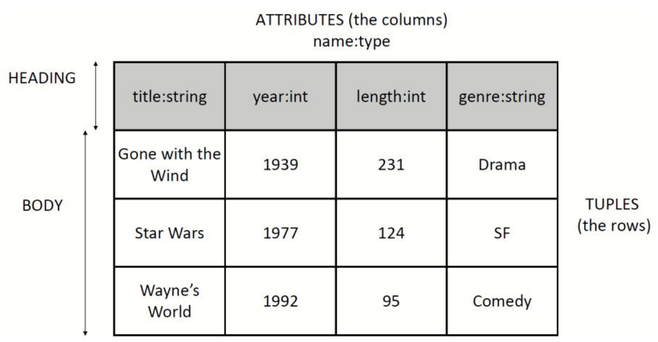
- Some relationships have more than two entity sets
- Example: User can *watch* for new retweets



IV. ERM and Relations

- Entities can be mapped into relations i.e. ERM
- ERM captures important aspects of the world
- With an ERM, work can be done on data e.g. SQL

A. Relations


ATTRIBUTES (the columns)
name:type
HEADING
BODY
TUPLES
(the rows)

title:string	year:int	length:int	genre:string
Gone with the Wind	1939	231	Drama
Star Wars	1977	124	SF
Wayne's World	1992	95	Comedy

- Relation composition:
  - Relation Name
  - Heading:
    - ∗ Attributes:
      - · Name
      - · Type
  - Body:
    - ∗ Tuples
      - · Attribute value i.e. name and value
- **Database**: Collection of relations
- **Relation Schema**: Relation name + Header
  - *movies(title:string, year:int, length:int, genre:string)*
- **Database Schema**: Collection of relation schema

B. ER diagrams → Relations → SQL

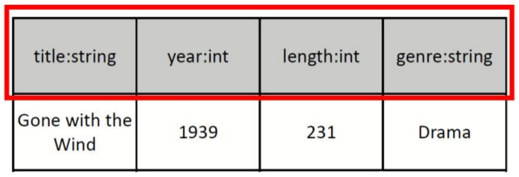
- Turning ER diagrams into concrete relations:
  - ER attributes → Relation attributes
  - ER entity → Relations
  - ER relationship sets → Relations or may disappear
- Relations are then turned into SQL

V. Structure Query Language (SQL) Introduction

- Domain specific language
- Defines, query and updates data
- Mostly portable and often performance tuning required
- Composed of **tokens**:
  - **Keywords**: CREATE, TABLE, SELECT …etc
  - **Ordinary identifier**: *x*, *y*, *movies*
  - **Numbers**:3, 4.1, 1e-9
  - **Delimited identifiers**: ”Peter, Mary”
- SQL are case-sensitive

A. Creating a table

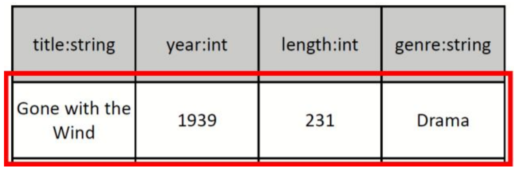
```
CREATE TABLE movies (
    title varchar(100),
    year int,
    length int,
    genre char(16)
);
```



title:string	year:int	length:int	genre:string
Gone with the Wind	1939	231	Drama

B. Inserting data into a table

```
INSERT INTO movies
    VALUES (
    "Gone with the Wind",
    1939,
    231,
    "Drama"
);
```

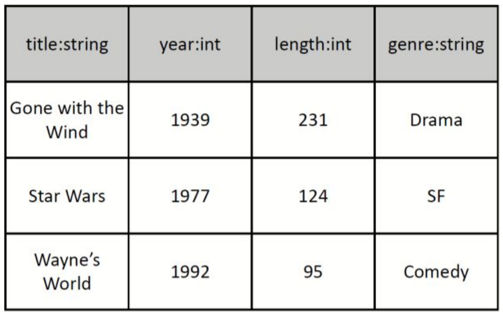


title:string	year:int	length:int	genre:string
Gone with the Wind	1939	231	Drama

C. Extracting data from table

```
SELECT * from movies;
sqlite> select * from movies;

Gone with the Wind|1939|231|Drama
Star Wars|1977|124|SF
Wayne's World|1992|95|Comedy
```



title:string	year:int	length:int	genre:string
Gone with the Wind	1939	231	Drama
Star Wars	1977	124	SF
Wayne’s World	1992	95	Comedy

D. Extracting data from a table with filter

```
SELECT * from movies WHERE year = 1977;

Star Wars|1977|124|SF
```