CSE 344

JUNE 20TH

RELATIONAL DATABASES AND SQLITE

ADMINISTRATIVE MINUTIAE

- **Online Quizzes**
  - newgradiance.com
  - Course token: **6F084FB3**
- **Discussion board (Piazza)**
  - Link on web site
- **HW1**
  - We will create your gitlab repo today
  - Will have HW1 in it (with instructions)
- **Section**
  - Largely help with setup, but some practice with basic SQLite

REVIEW

What is a database?

- A collection of files storing related data

What is a DBMS?

- An application program that allows us to manage efficiently the collection of data files

EXAMPLE: YOUR NEW APP

What app should we build?

- disease finder app

What data do we need to store?

- diseases: name, category
  - list of symptoms, list of treatments
- users: age, phone
  - list of date, pulse, blood pressure, etc.
- searches: date, list of words
- sessions: list of actions and times
  - (not patient specific, can anonymize)

EXAMPLE: YOUR NEW APP

What operations do we need?

- search for disease matching symptoms
  - search through disease database
  - add search to search history
- list recent searches
- add new user
- user update:
  - change patient phone
  - add new pulse reading
- ...

What constraints can we put on the data?

- phone number must have 10 digits
- pulse must be >= 0
- ...

MORALS

Almost any application has lots of important data

Getting the data right is often half the battle

- what operations do you want to support?
- what data do you need for that?
- what constraints does the data have?

DBMSs

- make app development easier
- make apps more reliable
- make apps more efficient
- make apps more easily changeable

DATA MODELS

Recall our example: want to design a database of diseases:

- name, symptoms, tests, treatments, etc.

How should we describe this data precisely?

Data model = mathematical formalism (or conceptual way) for describing the data

DATA MODELS

Relational

- Data represented as relations

Semi-structured (Json/XML)

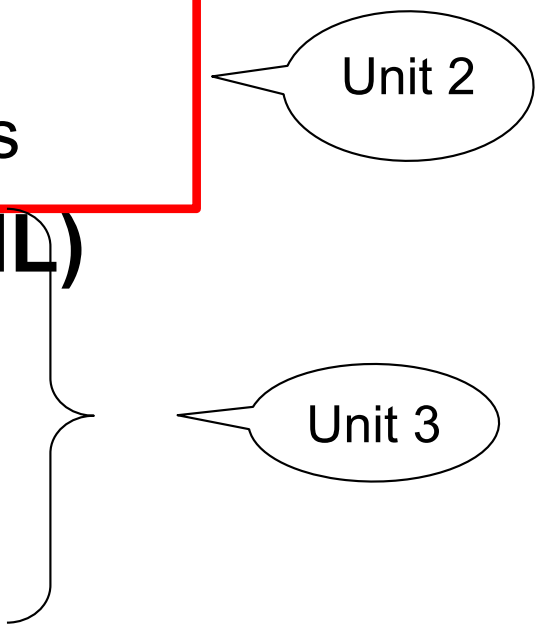
- Data represented as trees

Key-value pairs

- Used by NoSQL systems

Graph

Object-oriented



DATABASES VS. DATA STRUCTURES

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  - *Structure*: Java – concerned with “physical structure”. DBMS – concerned with “conceptual structure”
  - *Operations:* Java – low level, DBMS – restricts allowable operations. *Efficiency and data control*

DATABASES VS. DATA STRUCTURES

- **What are some important distinctions between database systems, and data structure systems?**
  - *Structure*: Java – concerned with "physical structure". DBMS – concerned with "conceptual structure"
  - *Operations:* Java – low level, DBMS – restricts allowable operations. *Efficiency and data control*
  - *Data constraints:* Enforced typing allows us to maximize our memory usage and to be confident our operations are successful

3 ELEMENTS OF DATA MODELS

Instance

- The actual data

Schema

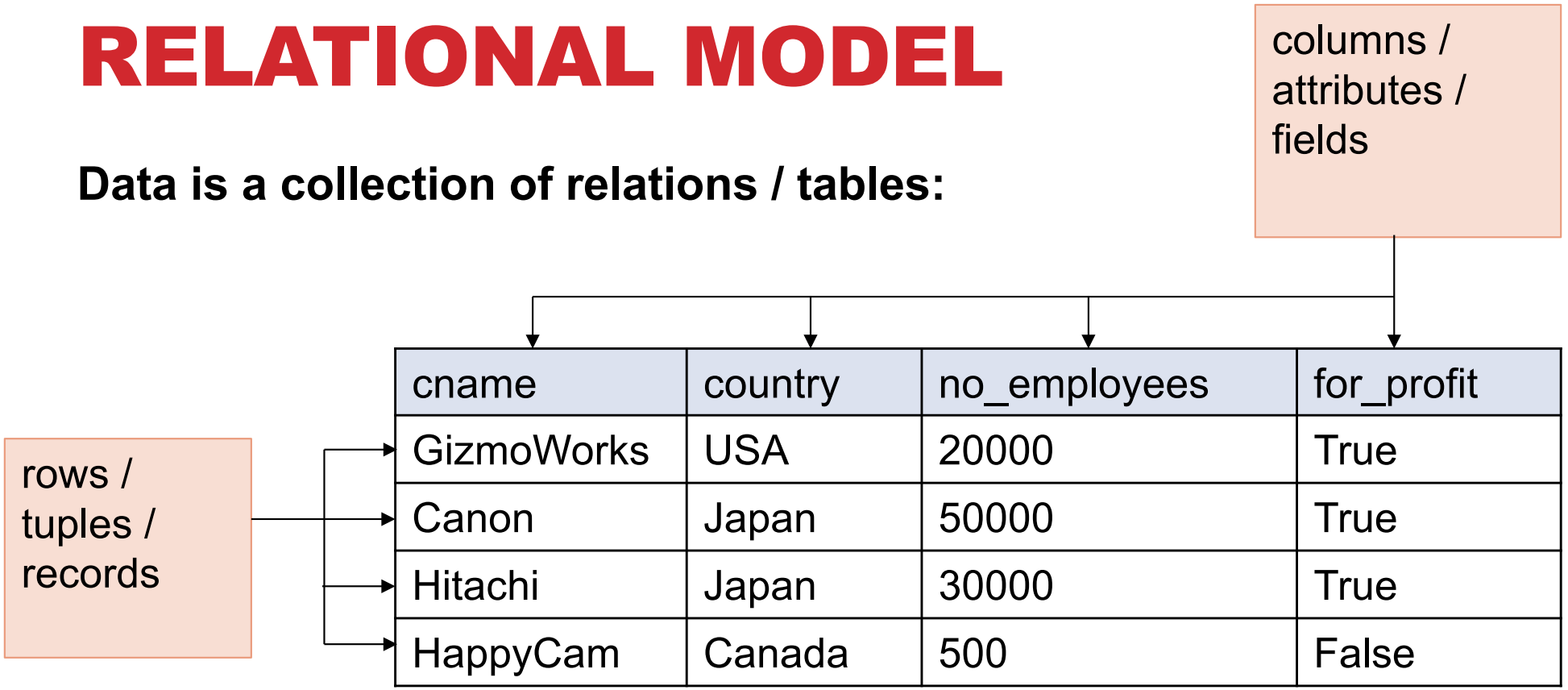
- Describe what data is being stored

Query language

- How to retrieve and manipulate data

RELATIONAL MODEL

Data is a collection of relations / tables:



cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

mathematically, relation is a set of tuples

- each tuple (or entry) must have a value for each attribute
- order of the rows is unspecified

What is the *schema* for this table?

Company(cname, country, no_employees, for_profit)

THE RELATIONAL DATA MODEL

- **Degree (arity) of a relation = #attributes**
- **Each attribute has a type.**
  - Examples types:
    - Strings: CHAR(20), VARCHAR(50), TEXT
    - Numbers: INT, SMALLINT, FLOAT
    - MONEY, DATETIME, …
    - Few more that are vendor specific
  - Statically and strictly enforced
- **Independent of the implementation of the tables**

TABLE IMPLEMENTATION

How would you implement this?

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GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

TABLE IMPLEMENTATION

How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Row major: as an array of objects

GizmoWorks USA 20000 True	Canon Japan 50000 True	Hitachi Japan 30000 True	HappyCam Canada 500 False

TABLE IMPLEMENTATION

How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
Canon	Japan	50000	True
Hitachi	Japan	30000	True
HappyCam	Canada	500	False

Column major: as one array per attribute

GizmoWorks	Canon	Hitachi	HappyCam
USA	Japan	Japan	Canada
20000	50000	30000	500
True	True	True	False

TABLE IMPLEMENTATION

How would you implement this?

cname	country	no_employees	for_profit
GizmoWorks	USA	20000	True
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HappyCam	Canada	500	False

Physical data independence
The logical definition of the data remains unchanged, even when we make changes to the actual implementation

KEYS

Key = one (or multiple) attributes that uniquely identify a record

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KEYS

Key = one (or multiple) attributes that uniquely identify a record

No: future updates to the database may create duplicate no_employees

cname	country	no_employees	for_profit
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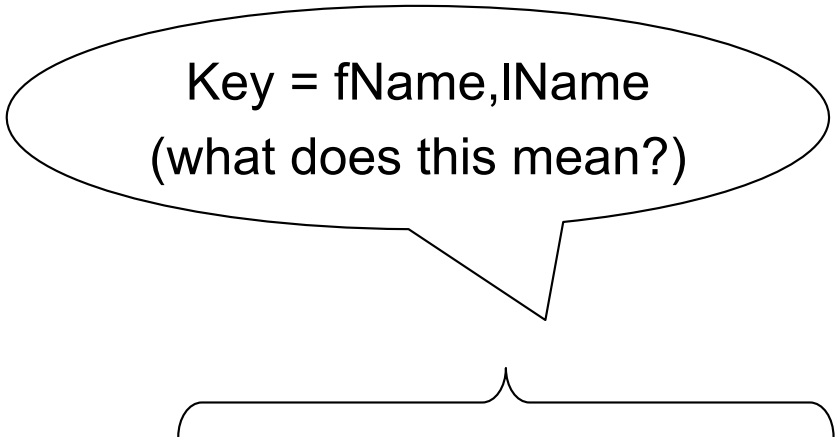
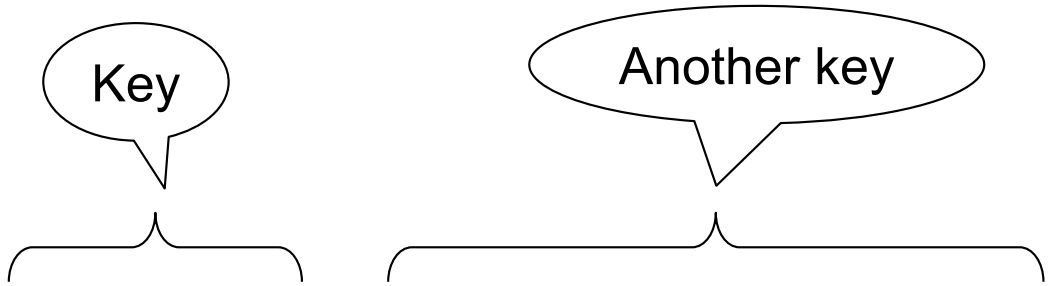
MULTI-ATTRIBUTE KEY



fName	lName	Income	Department
Alice	Smith	20000	Testing
Alice	Thompson	50000	Testing
Bob	Thompson	30000	SW
Carol	Smith	50000	Testing

MULTIPLE KEYS



SSN	fName	lName	Income	Department
111-22-3333	Alice	Smith	20000	Testing
222-33-4444	Alice	Thompson	50000	Testing
333-44-5555	Bob	Thompson	30000	SW
444-55-6666	Carol	Smith	50000	Testing

We can choose one key and designate it as *primary key*
E.g.: primary key = SSN

FOREIGN KEY

```
Company(cname, country, no_employees, for_profit)
Country(name, population)
```

Company

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

Country

name	population
USA	320M
Japan	127M

KEYS: SUMMARY

Key = columns that uniquely identify tuple

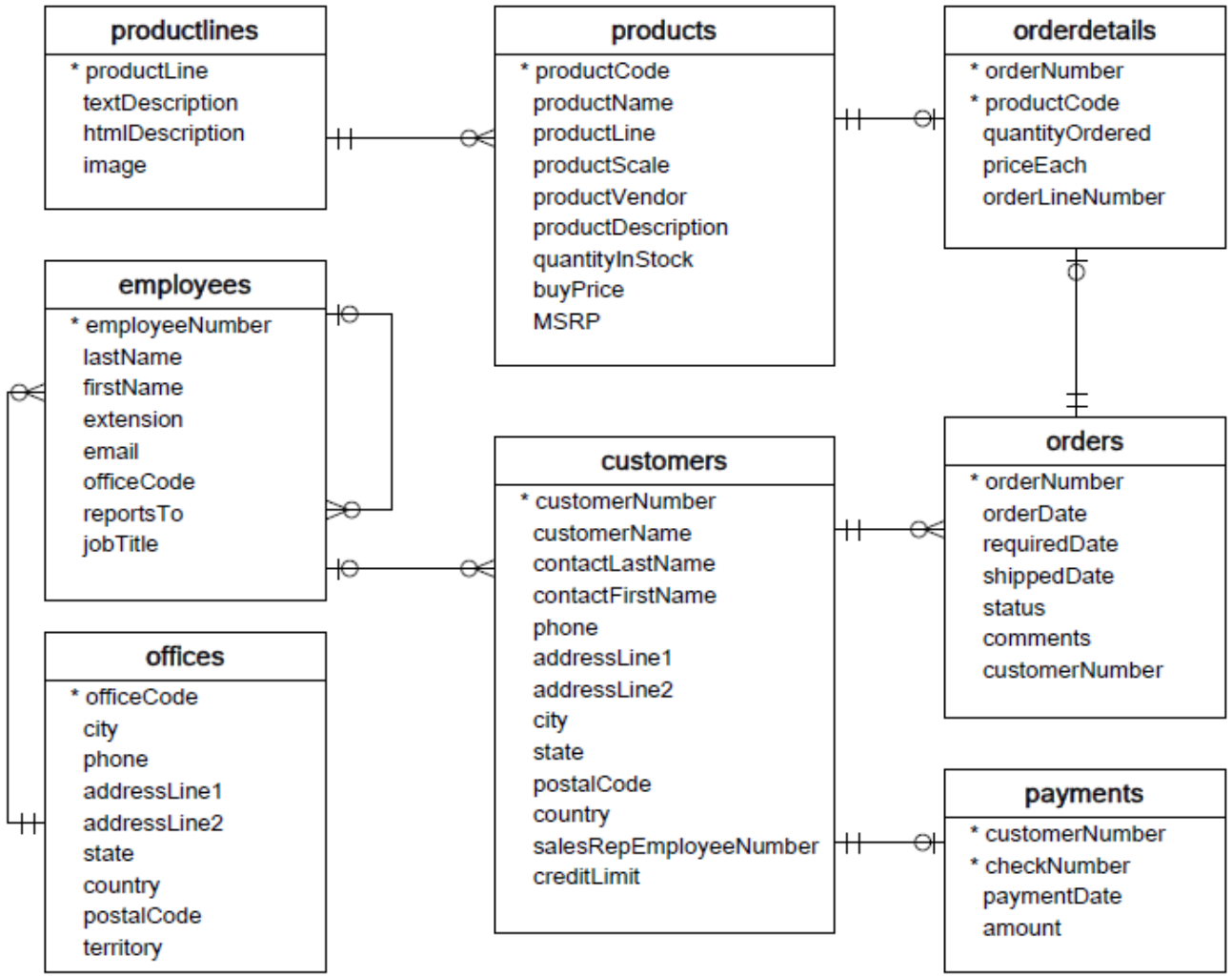
- Usually we underline
- A relation can have many keys, but only one can be chosen as *primary key*

Foreign key:

- Attribute(s) whose value is a key of a record in some other relation
- Foreign keys are sometimes called *semantic pointer*

(These are our first examples of *constraints*)

KEYS: EXAMPLE



RELATIONAL DATABASES

- **Why relations?**

RELATIONAL DATABASES

- **Why relations?**
  - Preserves data – if two objects refer to the same common object, that objects data are consistent
  - Saves space – no need to repeat relevant data if it can be relinked later

FIRST NORMAL FORM

cname	country	no_employees	for_profit
Canon	Japan	50000	Y
Hitachi	Japan	30000	Y

All relations must be flat: we say that the relation is in *first normal form*

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E.g. we want to add products manufactured by each company:

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Canon	Japan	50000	Y
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E.g. we want to add products manufactured by each company:

cname	country	no_employees	for_profit	products
Canon	Japan	50000	Y	pname / price / category SingleTouch / 149.99 / Photography Gadget / 200 / Toy
Hitachi	Japan	30000	Y	pname / price / category AC / 300 / Appliance

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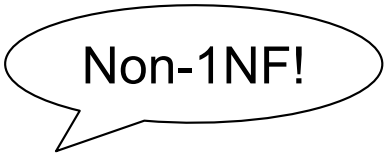

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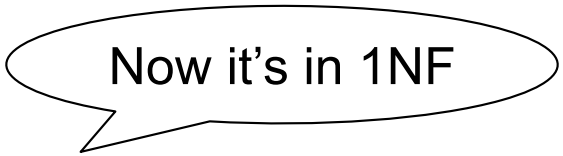

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Products

pname	price	category	manufacturer
SingleTouch	149.99	Photography	Canon
AC	300	Appliance	Hitachi
Gadget	200	Toy	Canon

DATA MODELS: SUMMARY

Schema + Instance + Query language

Relational model:

- Database = collection of tables
- Each table is flat: “first normal form”
- Key: may consists of multiple attributes
- Foreign key: “semantic pointer”
- Physical data independence

DEMO 1

- **What operations should we expect SQLite (or any DBMS) to support just on what we know right now?**

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  - create table
  - insert into
  - show rows (“select”)
  - delete from
- **What sorts of inputs do these functions need to have?**

DEMO 1

- **What operations should we expect SQLite (or any DBMS) to support just on what we know right now?**
  - create table
  - insert into
  - select
  - delete from
- **What sorts of inputs do these functions need to have?**
  - create table: table name, schema
  - insert into: table name, tuple
  - select: table name, attributes
  - delete from: table name, condition

DEMO 1

- **Common Syntax**
  - CREATE TABLE [tablename]
    ([att1] [type1],
    [att2] [type2]…);
  - INSERT INTO [tablename] VALUES ([val1],[val2]…);
  - SELECT [att1],[att2],… FROM [tablename]
    WHERE [condition]
  - DELETE FROM [tablename]
    WHERE [condition]

DEMO 1