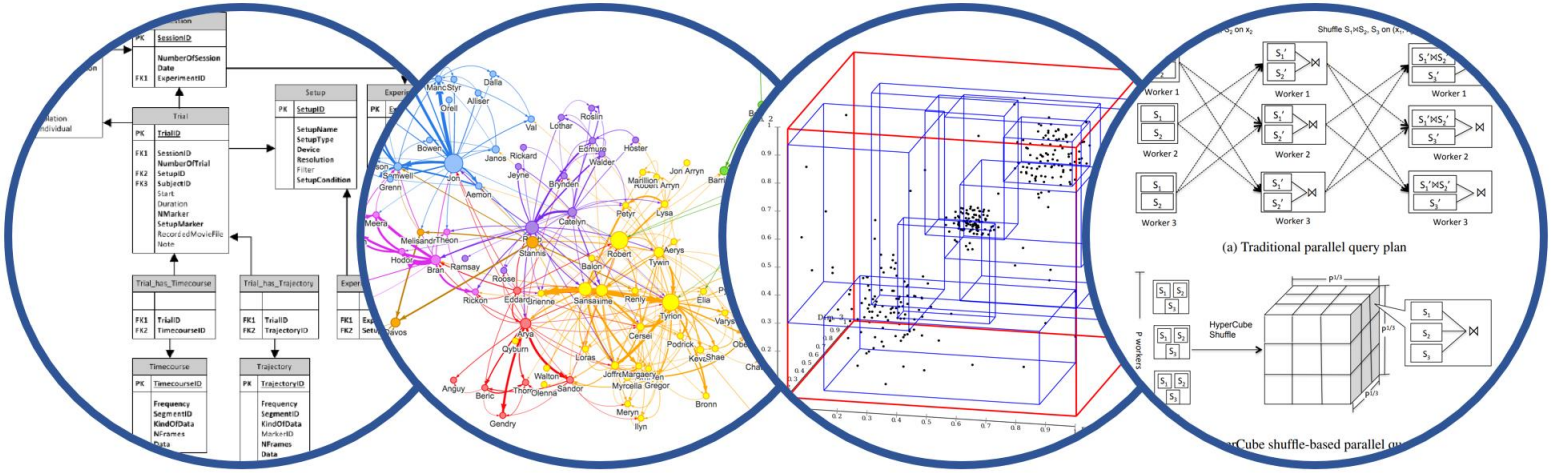

CSE 344: Intro to Data Management

SQL Basics

Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

Recap – The Relational Model

Table/ Relation

Columns/Attributes/Fields

Rows/ Tuples/ Records

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

A Few Lies

- Relations are sets, so are inherently unordered.
  - But tables are presented in an order?

- Relations are sets, so they have no duplicates.
  - But tables can have duplicates?

SQL Basics

Structured Query Language - SQL

- Domain-specific: for relational databases only
- Not general purpose like Java, python, C/C++, …
- Declarative, set-at-a-time
  - You describe **what** data you want
  - System figures out **how** to execute it

Basic SQL query: SELECT-FROM-WHERE

```
SELECT *
   FROM payroll;
```

Basic SQL query: SELECT-FROM-WHERE

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
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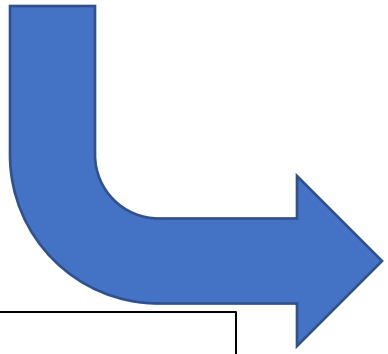

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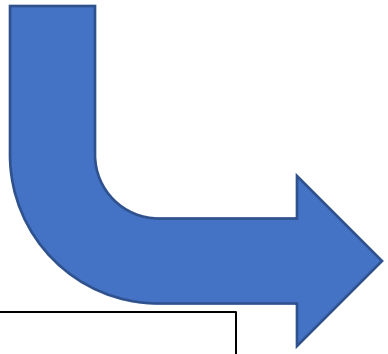

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```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Basic SQL query: SELECT-FROM-WHERE

payroll

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```
SELECT p.name, p.user_id
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 WHERE p.job = 'TA';
```

SELECT attributes

FROM table(s)

WHERE filter condition

Basic SQL query: SELECT-FROM-WHERE

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

?

```
SELECT p.name, p.user_id
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 WHERE p.job = 'TA';
```

Basic SQL query: SELECT-FROM-WHERE

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

name	user_id
Jack	123
Allison	345

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Basic SQL query: SELECT-FROM-WHERE

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

name	user_id
Jack	123
Allison	345

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

"payroll as p" makes p an alias. This lets us specify that the attributes come from payroll

Semantics:
What does a SQL query mean?

For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Q: What exactly does this return?

For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
for each row in payroll:
  if (row.job == 'TA'):
    output (row.name, row.user_id)
```

A: exactly what this returns! Let's see it

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Q: What exactly does this return?

For-each semantics

payroll

user_id	name	job	salary
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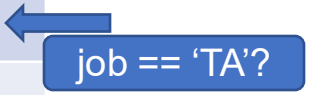


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```

For-each semantics

payroll

user_id	name	job	salary
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```
for each row in payroll:
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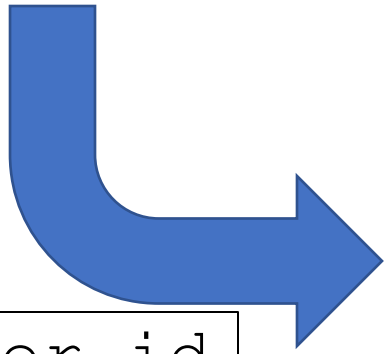
job == 'TA'?



name	user_id

```
SELECT p.name, p.user_id
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For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
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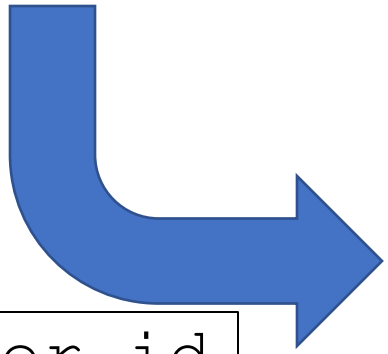

name	user_id
Jack	123

```
SELECT p.name, p.user_id
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 WHERE p.job = 'TA';
```

For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
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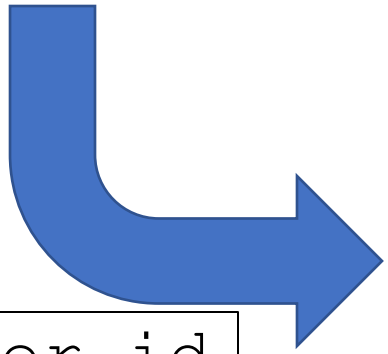

name	user_id
Jack	123

```
SELECT p.name, p.user_id
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 WHERE p.job = 'TA';
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For-each semantics

payroll

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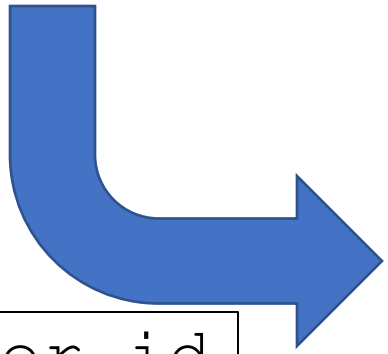

name	user_id
Jack	123
Allison	345

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SELECT p.name, p.user_id
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For-each semantics

payroll

user_id	name	job	salary
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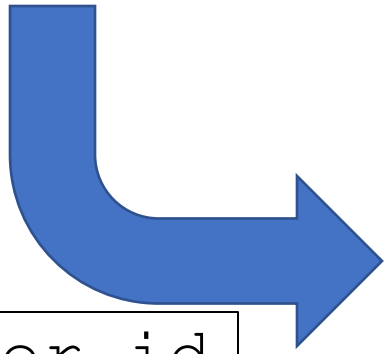

name	user_id
Jack	123
Allison	345

```
SELECT p.name, p.user_id
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```

For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
for each row in payroll:
  if (row.job == 'TA'):
    output (row.name, row.user_id)
```

job == 'TA'?

name	user_id
Jack	123
Allison	345

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

For-each semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
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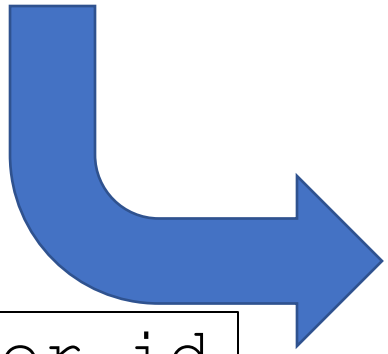
789	Dan	Prof	100000

```
for each row in payroll:
  if (row.job == 'TA'):
    output (row.name, row.user_id)
```



Final output

name	user_id
Jack	123
Allison	345

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Discussion

- For-each semantics is *what* SQL computes
- The system decides *how* to execute it

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

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- The system decides *how* to execute it, e.g.:
  - Iterate over payroll… (like the the for-each semantics)

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  - Or: lookup the job index for ‘TA’, read those records

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SELECT p.name, p.user_id
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Discussion

- For-each semantics is *what* SQL computes

- The system decides *how* to execute it, e.g.:
  - Iterate over payroll… (like the the for-each semantics)
  - Or: lookup the job index for ‘TA’, read those records
  - Or: iterate over a bit-map index for JOB …
  - …

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Another Semantics

Set-builder notation

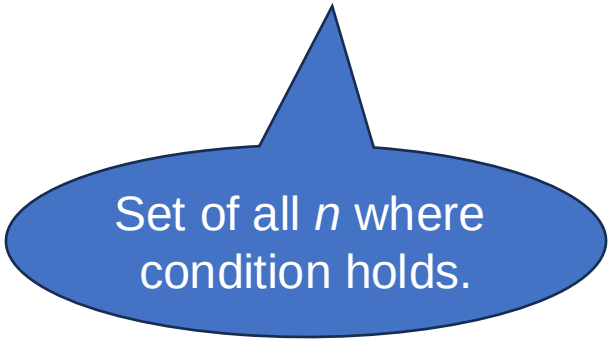
- Recall set-builder notation from CSE 311

$$\{ n \in \mathbb{N} \mid n \equiv 0 \pmod 2 \}$$

Set-builder notation

- Recall set-builder notation from CSE 311

$$\{ n \in \mathbb{N} \mid n \equiv 0 \pmod 2 \}$$



Set-builder semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
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```
SELECT p.name, p.user_id
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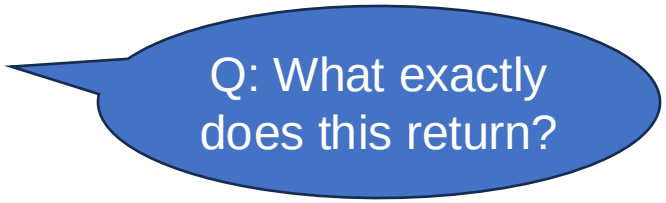

Set-builder semantics

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

A: exactly this set!

$$\{ (n, u) \mid (u, n, j, s) \in \text{payroll} \wedge j = \text{“TA”} \}$$

```
SELECT p.name, p.user_id
  FROM payroll as p
 WHERE p.job = 'TA';
```

Q: What exactly does this return?

ORDER-BY and DISTINCT

and other lies

Order By

```
SELECT *
FROM payroll
ORDER BY name;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
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789	Dan	Prof	100000

Order By

```
SELECT *
FROM payroll
ORDER BY name;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
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789	Dan	Prof	100000

user_id	name	job	salary
345	Allison	TA	60000
789	Dan	Prof	100000
123	Jack	TA	50000
567	Magda	Prof	90000

Order By

```
SELECT *
FROM payroll
ORDER BY job;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Order By

```
SELECT *
FROM payroll
ORDER BY job;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
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user_id	name	job	salary
567	Magda	Prof	90000
789	Dan	Prof	100000
123	Jack	TA	50000
345	Allison	TA	60000

Order By

```
SELECT *
FROM payroll
ORDER BY job,name;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
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789	Dan	Prof	100000

Order By

```
SELECT *
FROM payroll
ORDER BY job,name;
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

user_id	name	job	salary
789	Dan	Prof	100000
567	Magda	Prof	90000
345	Allison	TA	60000
123	Jack	TA	50000

Distinct

```
SELECT job
FROM payroll
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Distinct

```
SELECT job
FROM payroll
```

payroll

user_id	name	job	salary
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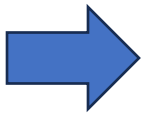
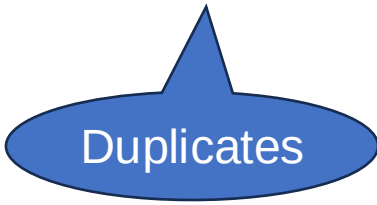


job
TA
TA
Prof
Prof



Bag semantics

Distinct

```
SELECT job
FROM payroll
```

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

job
TA
TA
Prof
Prof

Duplicates

Bag semantics

```
SELECT DISTINCT job
FROM payroll
```

job
TA
Prof

No duplicates

Set semantics

Tables in SQL

Create Table Statement

payroll(user_id, name, job, salary)

```
CREATE TABLE payroll (
  user_id INT,
  name TEXT,
  job TEXT,
  salary INT
);
```

Case-insensitive,
but use own guidelines
for readability

Data types

- Each attribute has a type
  - Strings: CHAR(20), VARCHAR(50), TEXT
  - Numbers: INT, SMALLINT, FLOAT, …
  - MONEY, DATETIME, …
  - ...many, many vendor specific types

- Statically enforced (except SQLite)

Insert

payroll(user_id, name, job, salary)

```
INSERT INTO payroll VALUES (123,'Jack','TA',50000);
INSERT INTO payroll VALUES (345,'Allison','TA',60000);
. . . . .
. . . . .
```

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Insert

payroll(user_id, name, job, salary)

```
INSERT INTO payroll VALUES (123,'Jack','TA',50000);
INSERT INTO payroll VALUES (345,'Allison','TA',60000);
. . . . .
. . . . .
```

user_id	name	job	salary
123	Jack	TA	50000
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Persistence

The table is *persistent*: it continues to exist after we shut down the computer

Keys

- We often need a way to select exactly one record
- A key attribute uniquely identifies the record
- Let’s see how this works…

Keys

Key

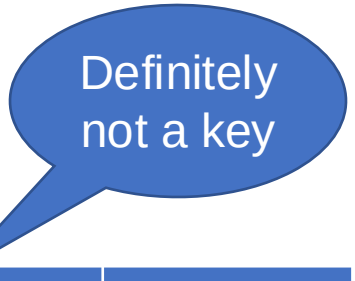
A **Key** is one or more attributes that **uniquely** identify a row.

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Keys

Key

A **Key** is one or more attributes that **uniquely** identify a row.



user_id	name	job	salary
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Keys

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A **Key** is one or more attributes that **uniquely** identify a row.

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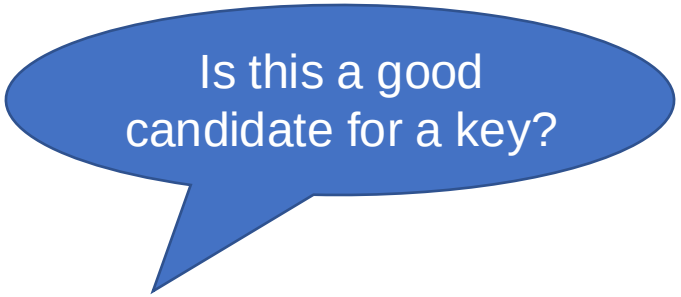

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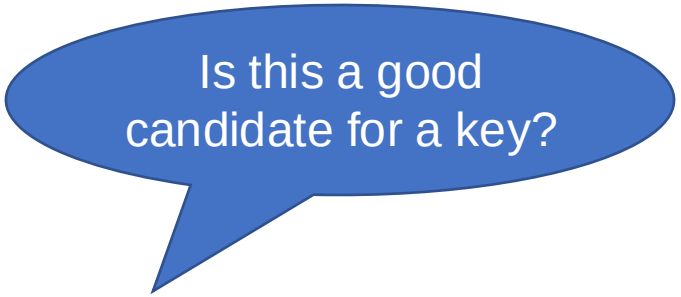


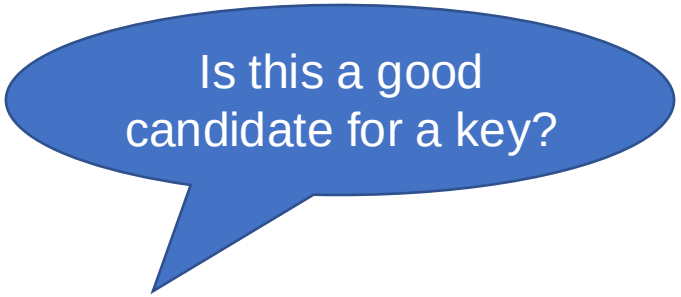
user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000
913	Peter	TA	60000

Keys

Key

A **Key** is one or more attributes that **uniquely** identify a row.

Data comes from the real world
so models ought to reflect that



user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000
913	Peter	TA	60000

Keys

```
CREATE TABLE payroll (
  user_id INT,
  name TEXT,
  job TEXT,
  salary INT
);
```

payroll(user_id, name, job, salary)

Keys

```
CREATE TABLE payroll (
  user_id INT PRIMARY KEY,
  name TEXT,
  job TEXT,
  salary INT
);
```

payroll(user_id, name, job, salary)

Keys

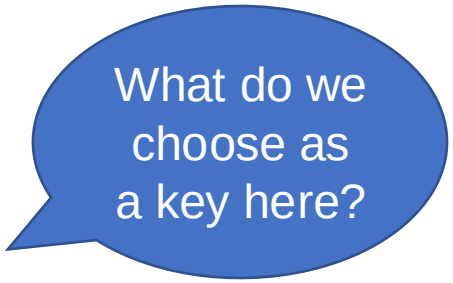
```
CREATE TABLE payroll (
  user_id INT,
  name TEXT,
  job TEXT,
  salary INT,
  PRIMARY KEY (user_id)
);
```

Can also define the PK at the end

payroll(<u>user_id</u>, name, job, salary)

Keys of more than one attribute

Sometimes no single attribute is unique, but combinations of attributes are a unique key for the table.



name	job	salary
Alice	TA	20000
Alice	Prof	200000
Bob	Prof	200000

Keys of more than one attribute

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Not a key

What do we choose as a key here?

name	job	salary
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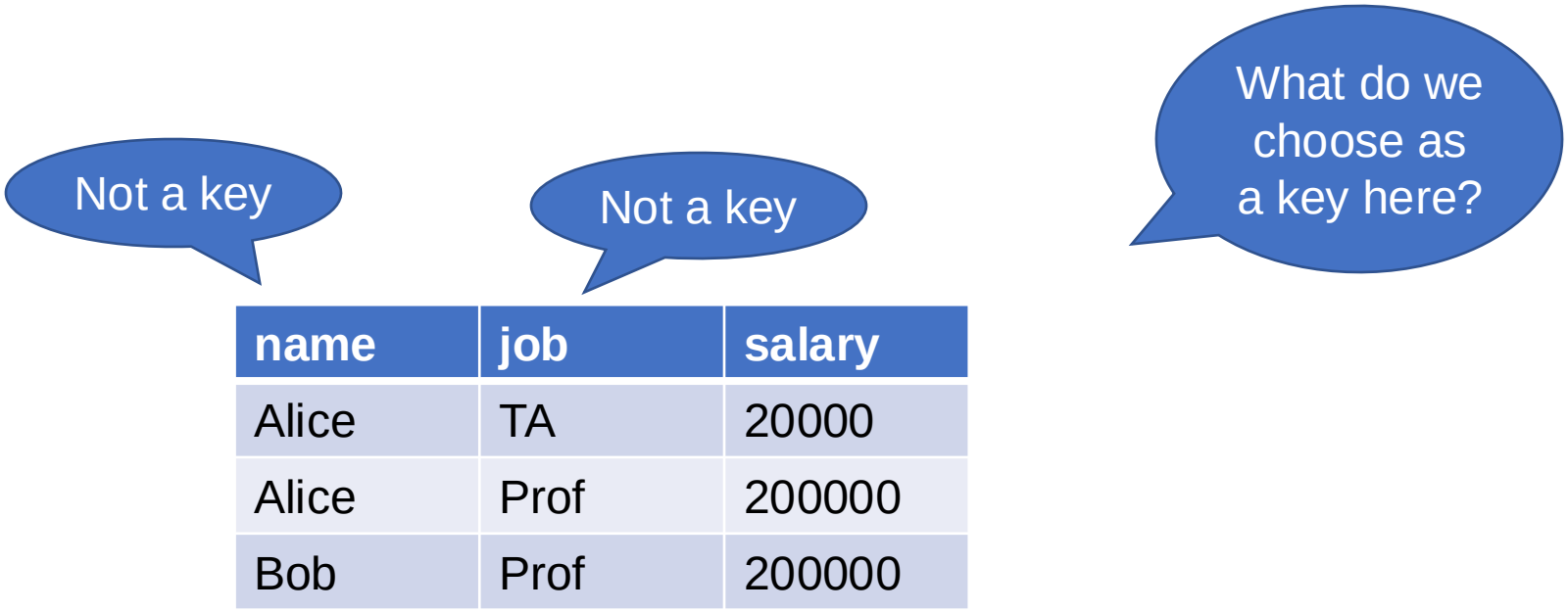

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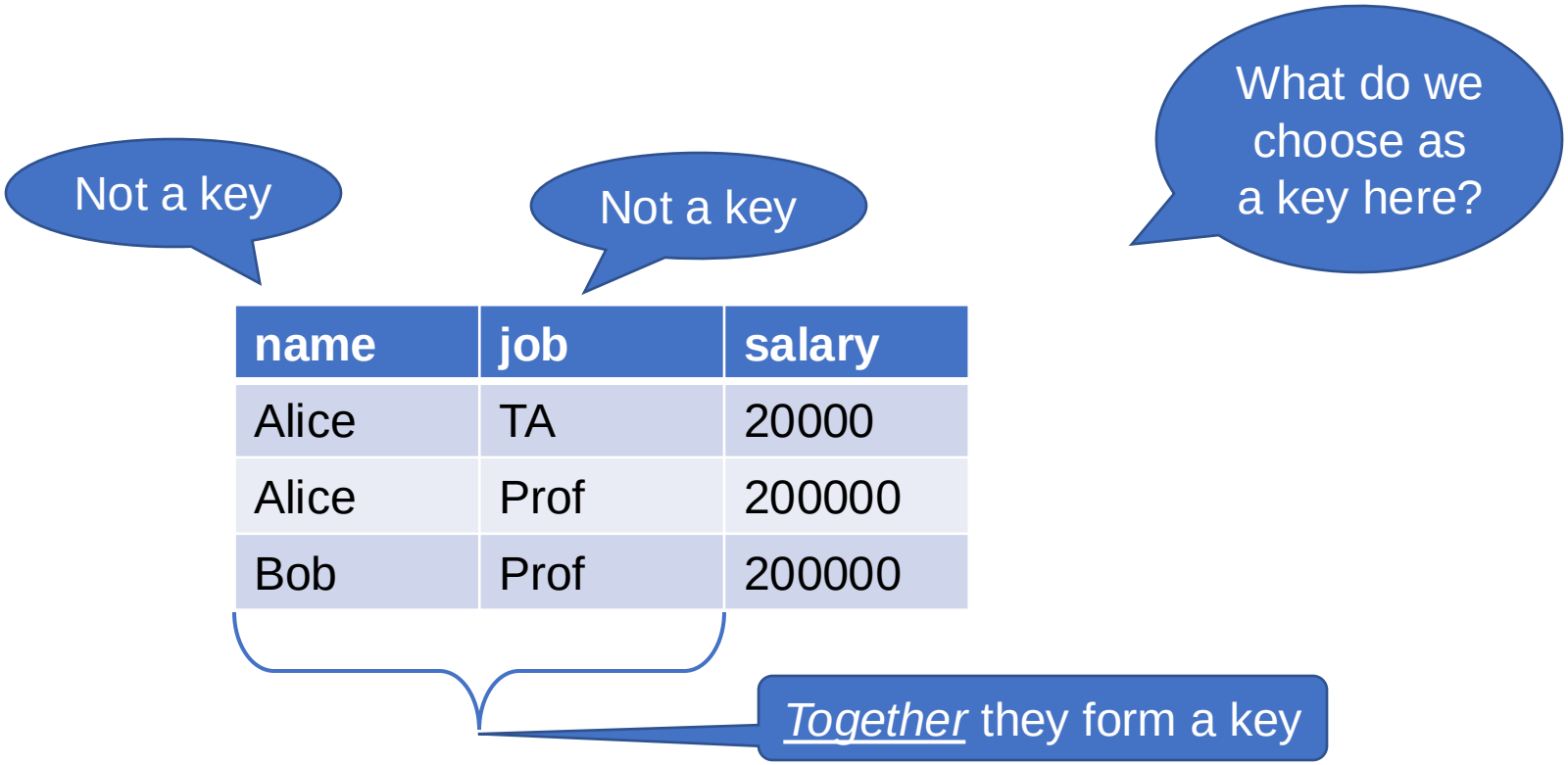

Keys of more than one attribute

Sometimes no single attribute is unique, but combinations of attributes are a unique key for the table.

```
CREATE TABLE payroll (
  name TEXT,
  job TEXT,
  salary INT,

);
```

name	job	salary
Alice	TA	20000
Alice	Prof	200000
Bob	Prof	200000

Together they form a key

Keys of more than one attribute

Sometimes no single attribute is unique, but combinations of attributes are a unique key for the table.

```
CREATE TABLE payroll (
  name TEXT,
  job TEXT,
  salary INT,
  PRIMARY KEY (name, job)
);
```

Must use this syntax for multi-attribute key

name	job	salary
Alice	TA	20000
Alice	Prof	200000
Bob	Prof	200000

Together they form a key

Discussion

- Key= attribute(s) that uniquely identifies a record
- Sometimes more than one choice
  SQL requires choosing one: **the primary key**
- Good practice: each table has a primary key
  (but there are exceptions)
- How do we use keys? With **foreign keys**. Next…

Foreign Keys

- Databases can hold multiple tables
- How do we capture relationships *between* tables?

payroll

user_id	name	job	salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

regist

user_id	car
123	Charger
567	Civic
567	Pinto

Foreign Keys

- Databases can hold multiple tables
- How do we capture relationships *between* tables?

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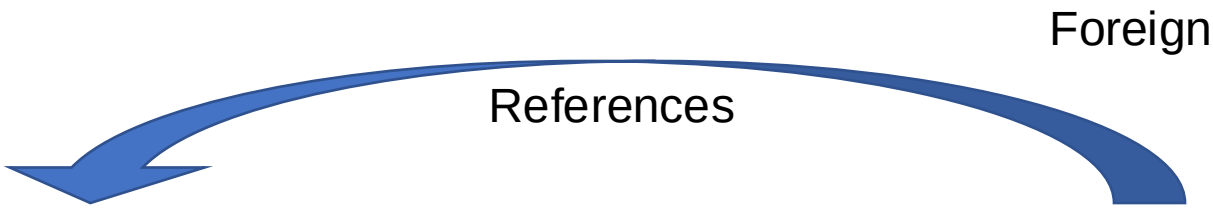

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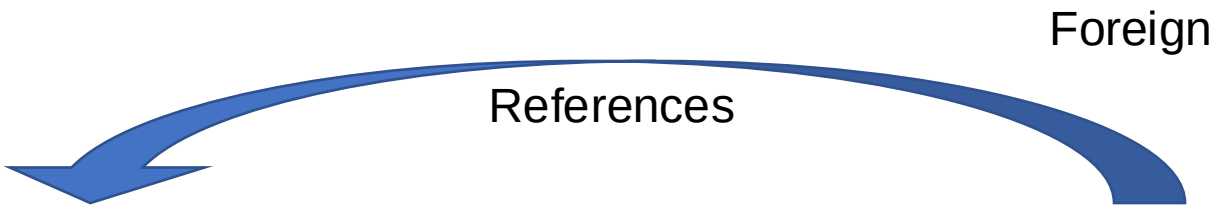
Foreign Keys

Foreign Key

A **Foreign Key** is one or more attributes that uniquely identify a row in *another table*.



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Foreign keys must reference (point to) a unique attribute, almost always a primary key

Foreign Keys

We add foreign key declaration in the same way as a primary key.

```
CREATE TABLE payroll (
  user_id INT PRIMARY KEY,
  name TEXT,
  job TEXT,
  salary INT);
```

```
CREATE TABLE regist (
  user_id INT,
  car TEXT);
```

payroll(user_id, name, job, salary)

regist(user_id, car)

Foreign Keys

We add foreign key declaration in the same way as a primary key.

```
CREATE TABLE payroll (
  user_id INT PRIMARY KEY,
  name TEXT,
  job TEXT,
  salary INT);
```

```
CREATE TABLE regist (
  user_id INT
      REFERENCES payroll(user_id),
  car TEXT);
```

payroll(user_id, name, job, salary)

regist(user_id, car)

Foreign Keys

We add foreign key declaration in the same way as a primary key.

```
CREATE TABLE payroll (
  user_id INT PRIMARY KEY,
  name TEXT,
  job TEXT,
  salary INT);
```

```
CREATE TABLE regist (
  user_id INT
      REFERENCES payroll(user_id),
  car TEXT);
```

or, when attribute name is the key:

```
CREATE TABLE regist (
  user_id INT REFERENCES payroll,
  car TEXT);
```

payroll(user_id, name, job, salary)

regist(user_id, car)

Foreign Keys

Can also put foreign key declaration on a new line, need to do this for multiple attributes

```
CREATE TABLE payroll (
  name TEXT,
  job TEXT,
  salary INT,
  PRIMARY KEY(name, job)
  );
```

```
CREATE TABLE regist (
  name TEXT,
  job TEXT
  car TEXT,
  FOREIGN KEY (name, job)
          REFERENCES payroll);
```

Recap for Today

- SELECT-FROM-WHERE
- DISTINCT, ORDER-BY
- Semantics: for-each, set-builder
- CREATE TABLE, INSERT
- Keys, PRIMARY KEY, FOREIGN KEY