

# Database Management Systems

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# The relational model

Sets  $S_1, S_2, \dots, S_k$

$$S_1 \times S_2 \times \dots \times S_k = \{ \underbrace{(s_1, s_2, \dots, s_k)}_{\substack{\downarrow \\ \text{"width" is } k \\ \text{"arity"}}} \mid s_i \in S_i \}$$

Relation  $r \subseteq S_1 \times \dots \times S_k$

Relation  $\Leftrightarrow$  Table

Attributes  $\Leftrightarrow$  Columns

k-tuple  $\Leftrightarrow$  Rows

Define a relation schema

Description of columns

- Column heading
- Type of values

Populate the table

Consistent with schema

Always a finite set of rows

Tables can describe "relationships" between data

Family tree

Prerequisites among courses

Items in a column are "atomic"

C1 has prerequisites

Solu  
2 rows

C2 & C3

C1	C2
C1	C3

Pre-req

Course	PreReq
--------	--------

C1 {C2, C3}



Cannot have  
collection

A superkey is a set of columns whose values uniquely fix the rest of the row

- Entire table / relation is a set - no duplicates
- All columns together define superkey

Candidate key - minimal superkey

Phone Calls      Date    From    To    Start    End

Candidate key - minimal superkey

Phone calls      Date      From      To      Start      End

(Date, From, Start) —  
(Date, To, End) —  
⋮  
(

Choose one as a  
Primary Key

Keys are a property of data as a whole

- Not specific to this table

Concrete table has no duplicate birthdays

Is birthday a candidate key?

Providing info about keys helps DBMS work efficiently

## Course Table

Course Code | Title ...

## Prerequisite Table

Course Code

PreReq Code



Entries must appear in Course Table

General case

"Referential Integrity"

Specifically

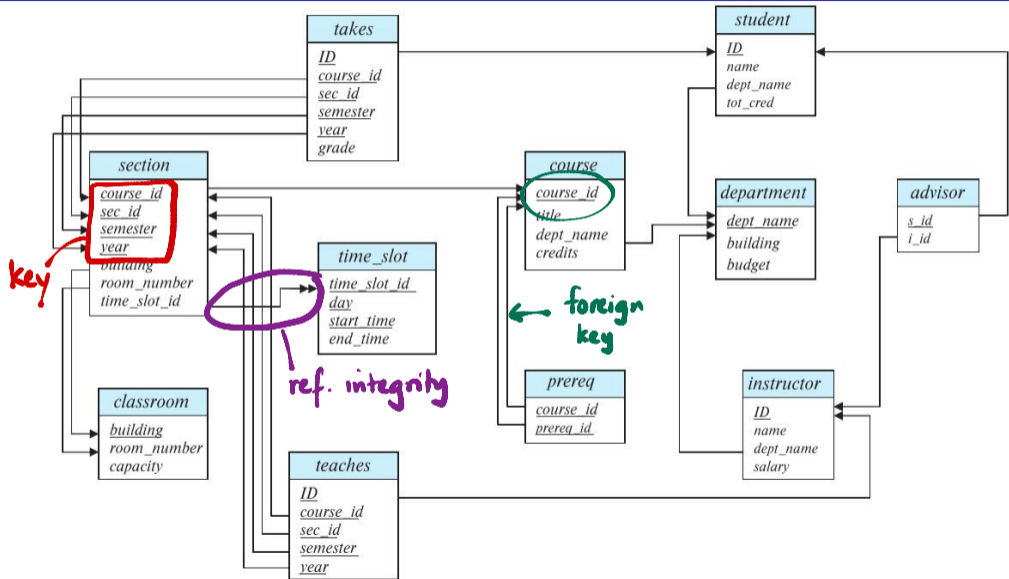
"Foreign key"



Foreign key constraints are typically checked  
by DBMS

Arbitrary referential integrity constraint is expensive  
to check

# Schema diagram



# A query language — select and project

- List instructors from Physics department with salary above 90,000

"Select" relevant rows

E.F.Codd

$\sigma$  (  $\sigma$  (Instructor))  
salary > 90,000      dept\_name = Physics

Outcome of  $\sigma$  is again a table

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

# A query language — select and project

- List instructors from Physics department with salary above 90,000

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
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76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

# A query language — select and project

- List instructors from Physics department with salary above 90,000

✓  $\sigma_{\text{dept\_name} = \text{Physics} \wedge \text{salary} > 90000}(\text{Instructor})$

Combine this

✓  $\sigma_{\text{dept\_name} = \text{Physics} \wedge \text{salary} > 90000}(\text{Instructor})$

AND

ID	name	dept_name	salary
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

# A query language — select and project

- List instructors from Physics department with salary above 90,000
- Find departments whose name is the same as the building name

<i>dept_name</i>	<i>building</i>	<i>budget</i>
Biology	Watson	90000
Comp. Sci.	Taylor	100000
Elec. Eng.	Taylor	85000
Finance	Painter	120000
History	Painter	50000
Music	Packard	80000
Physics	Watson	70000

# A query language — select and project

- List instructors from Physics department with salary above 90,000
- Find departments whose name is the same as the building name
- List (only) the names of all instructors

Projection  $\pi$   
 $\pi_{name}$  (Instructor)  
 $\pi_{ID, name}$  (Instructor)

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

# A query language — select and project

- List instructors from Physics department with salary above 90,000
- Find departments whose name is the same as the building name
- List (only) the names of all instructors
- List names of instructors from Physics department

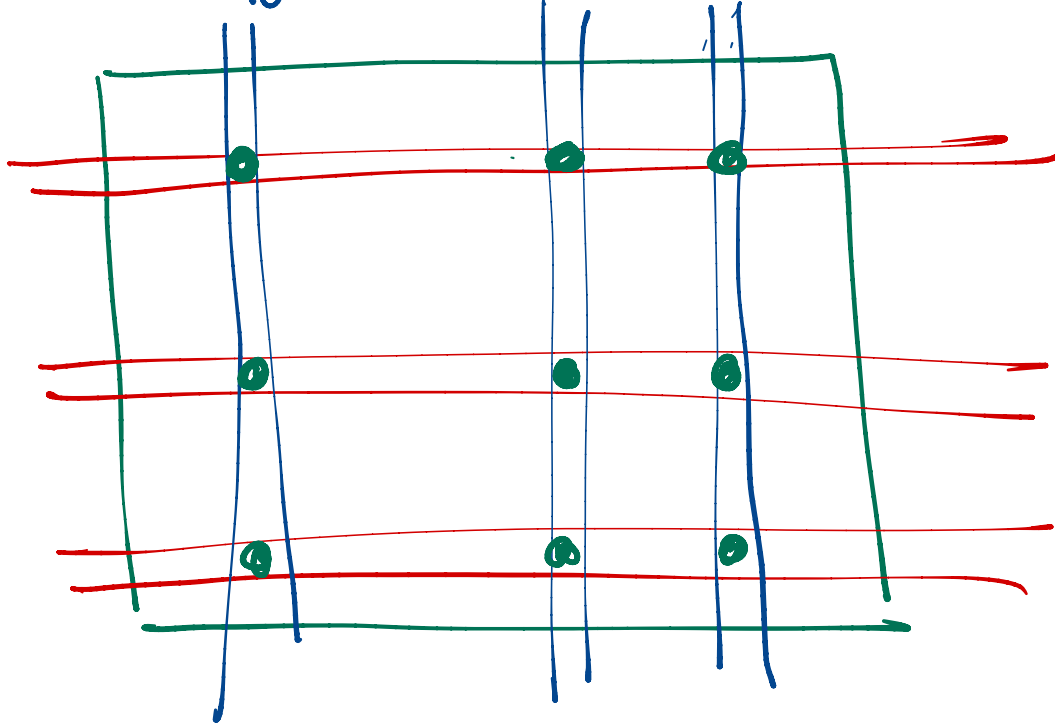
<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
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76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

$\pi_{name} (\sigma_{dept\_name = Physics} (Instructors))$   
 ~~$\sigma_{dept\_name} (\pi_{name})$~~



Table

$\pi$



# A query language — join

- List all taxpayers from Chennai with income above 5 crore

TN data

Name	District
------	----------

IT data

Name	Income
------	--------

Assume names are unique

for each IT assessee  
if income > 5 cr

for every TN voter

if name matches &  
dist. = Ch

=

# A query language — join

- List all taxpayers from Chennai with income above 5 crore

Combine 2 tables into 1

TN Data x IT data

Name	Dist	Name	Income
Kavita	Chery	Madhan	10

Select rows where  
names are same



Check Dist is Chennai  
Income > 5cr

# A query language — join

- List details of courses offered by instructors

Instructor details

Inst ID	Name	--
---------	------	----

Teaching Assignment

Inst ID	Course ID
---------	-----------

X

# A query language — join

- List details of courses offered by instructors

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
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76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

<i>ID</i>	<i>course_id</i>	<i>sec_id</i>	<i>semester</i>	<i>year</i>
10101	CS-101	1	Fall	2017
10101	CS-315	1	Spring	2018
10101	CS-347	1	Fall	2017
12121	FIN-201	1	Spring	2018
15151	MU-199	1	Spring	2018
22222	PHY-101	1	Fall	2017
32343	HIS-351	1	Spring	2018
45565	CS-101	1	Spring	2018
45565	CS-319	1	Spring	2018
76766	BIO-101	1	Summer	2017
76766	BIO-301	1	Summer	2018
83821	CS-190	1	Spring	2017
83821	CS-190	2	Spring	2017
83821	CS-319	2	Spring	2018
98345	EE-181	1	Spring	2017

# A query language — join

- List details of courses offered by instructors

<i>Instructor_ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>	<i>teaches_ID</i>	<i>course_id</i>	<i>sec_id</i>	<i>semester</i>	<i>year</i>
10101	Srinivasan	Comp. Sci.	65000	10101	CS-101	1	Fall	2017
10101	Srinivasan	Comp. Sci.	65000	10101	CS-315	1	Spring	2018
10101	Srinivasan	Comp. Sci.	65000	10101	CS-347	1	Fall	2017
10101	Srinivasan	Comp. Sci.	65000	12121	FIN-201	1	Spring	2018
1010	Srinivasan	Comp. Sci.	65000	15151	MU-199	1	Spring	2018
10101	Srinivasan	Comp. Sci.	65000	22222	PHY-101	1	Fall	2017
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
12121	Wu	Finance	90000	10101	CS-101	1	Fall	2017
12121	Wu	Finance	90000	10101	CS-315	1	Spring	2018
12121	Wu	Finance	90000	10101	CS-347	1	Fall	2017
12121	Wu	Finance	90000	12121	FIN-201	1	Spring	2018
12121	Wu	Finance	90000	15151	MU-199	1	Spring	2018
12121	Wu	Finance	90000	22222	PHY-101	1	Fall	2017
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

## A query language — join

- List details of courses offered by instructors

$\nabla$  Instructor\_id = teaches\_id (Instructor x Teaches)

# A query language — join

- List details of courses offered by instructors

<i>Instructor.ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>	<i>teaches.ID</i>	<i>course_id</i>	<i>sec_id</i>	<i>semester</i>	<i>year</i>
10101	Srinivasan	Comp. Sci.	65000	10101	CS-101	1	Fall	2017
10101	Srinivasan	Comp. Sci.	65000	10101	CS-315	1	Spring	2018
10101	Srinivasan	Comp. Sci.	65000	10101	CS-347	1	Fall	2017
12121	Wu	Finance	90000	12121	FIN-201	1	Spring	2018
15151	Mozart	Music	40000	15151	MU-199	1	Spring	2018
22222	Einstein	Physics	95000	22222	PHY-101	1	Fall	2017
32343	El Said	History	60000	32343	HIS-351	1	Spring	2018
45565	Katz	Comp. Sci.	75000	45565	CS-101	1	Spring	2018
45565	Katz	Comp. Sci.	75000	45565	CS-319	1	Spring	2018
76766	Crick	Biology	72000	76766	BIO-101	1	Summer	2017
76766	Crick	Biology	72000	76766	BIO-301	1	Summer	2018
83821	Brandt	Comp. Sci.	92000	83821	CS-190	1	Spring	2017
83821	Brandt	Comp. Sci.	92000	83821	CS-190	2	Spring	2017
83821	Brandt	Comp. Sci.	92000	83821	CS-319	2	Spring	2018
98345	Kim	Elec. Eng.	80000	98345	EE-181	1	Spring	2017



# A query language — join

Fundamental operators :  $\sigma$ ,  $\tau$ ,  $\times$

$\times$  along with  $\sigma$  = join

$\sigma_{\text{condition}} (T_1 \times T_2)$  — "bowtie"

Write as  $T_1 \bowtie_{\text{condition}} T_2$

Instructor  $\bowtie_{\text{Instructor.ID} = \text{Teacher.ID}}$  Teacher

# University database

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

Instructor

<i>ID</i>	<i>name</i>	<i>dept_name</i>	<i>salary</i>
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
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58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

Instructor, unsorted

# University database

