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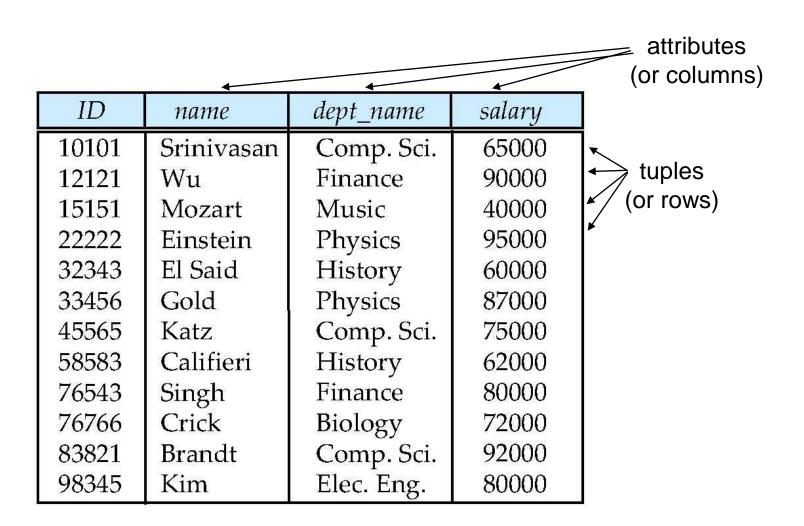
## **Chapter 2: Intro to Relational Model**

**Database System Concepts, 6th Ed.** 

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#### **Example of a Relation**





#### **Attribute Types**

- The set of allowed values for each attribute is called the domain of the attribute
- Attribute values are (normally) required to be atomic; that is, indivisible
- The special value *null* is a member of every domain
- The null value causes complications in the definition of many operations



#### **Relation Schema and Instance**

- $\blacksquare$   $A_1, A_2, ..., A_n$  are attributes
- R =  $(A_1, A_2, ..., A_n)$  is a relation schema Example:

instructor = (ID, name, dept\_name, salary)

- Formally, given sets D₁, D₂, .... Dₙ a relation r is a subset of D₁ x D₂ x ... x Dₙ
   Thus, a relation is a set of n-tuples (a₁, a₂, ..., aₙ) where each aᵢ ∈ Dᵢ
- The current values (relation instance) of a relation are specified by a table
- An element t of r is a tuple, represented by a row in a table



#### Relations are Unordered

- Order of tuples is irrelevant (tuples may be stored in an arbitrary order)
- Example: *instructor* relation with unordered tuples

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



#### **Database**

- A database consists of multiple relations
- Information about an enterprise is broken up into parts

```
instructor
student
advisor
```

Bad design:

```
univ (instructor -ID, name, dept_name, salary, student_Id, ..) results in
```

- repetition of information (e.g., two students have the same instructor)
- the need for null values (e.g., represent an student with no advisor)
- Normalization theory (Chapter 7) deals with how to design "good" relational schemas

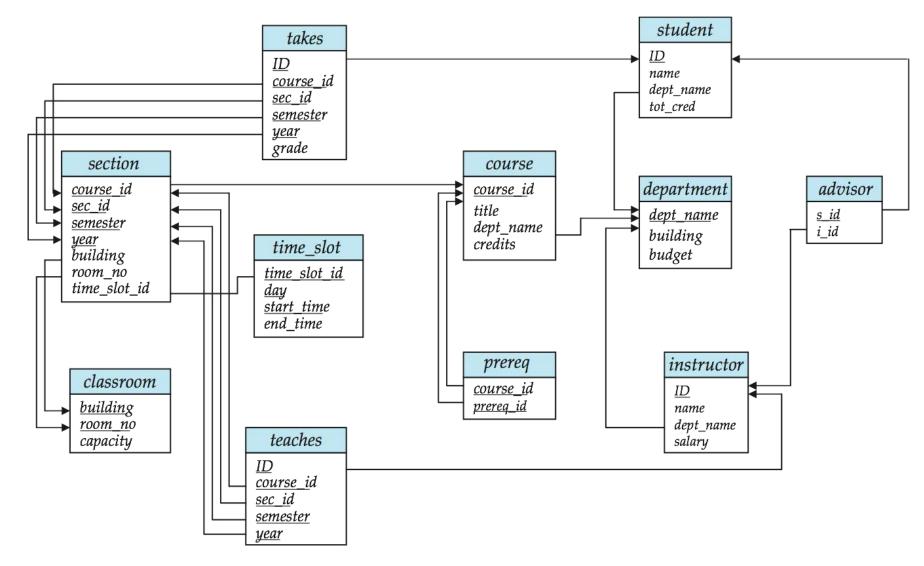


#### **Keys**

- Let  $K \subset R$
- K is a superkey of R if values for K are sufficient to identify a unique tuple of each possible relation r(R)
  - Example: {ID} and {ID,name} are both superkeys of instructor.
- Superkey K is a candidate key if K is minimal Example: {ID} is a candidate key for Instructor
- One of the candidate keys is selected to be the primary key.
  - which one?
- Foreign key constraint: Value in one relation must appear in another
  - Referencing relation
  - Referenced relation



#### **Schema Diagram for University Database**





## **Relational Query Languages**

- Procedural vs.non-procedural, or declarative
- "Pure" languages:
  - Relational algebra
  - Tuple relational calculus
  - Domain relational calculus
- Relational operators



#### Selection of tuples

Relation r

$\boldsymbol{A}$	В	C	D
α	α	1	7
$\alpha$	β	5	7
β	β	12	3
β	β	23	10

- Select tuples with A=B and D > 5
  - $\bullet$   $\sigma$  A=B and D > 5 (r)

A	В	C	D
α	α	1	7
β	β	23	10



## **Selection of Columns (Attributes)**

Relation r.

A	В	C
α	10	1
α	20	1
β	30	1
β	40	2

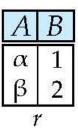
- Select A and C
  - ■Projection
  - ■П <sub>A, C</sub> (r)

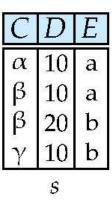
A	C	A	C
α	1	$\alpha$	1
α	1	β	1
β	1	β	2
β	2	<u>.</u>	



## Joining two relations – Cartesian Product

Relations *r*, *s*:





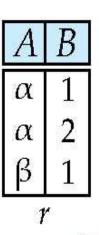
**r** x s:

A	В	C	D	Ε
α	1	α	10	a
α	1	β	10	a
α	1	β	20	Ъ
α	1	γ	10	Ъ
β	2	α	10	a
β	2	β	10	a
β	2	β	20	b
β	2	γ	10	b



#### Union of two relations

Relations *r*, *s*:



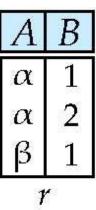
A	В
α	2
β	3
	3

 $r \cup s$ :



#### Set difference of two relations

Relations *r*, *s*:



A	В
α	2
β	3
P	s

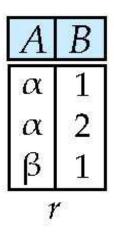
r - s:

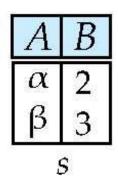
A	В
$\alpha$	1
β	1



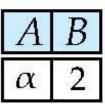
#### **Set Intersection of two relations**

Relation *r*, *s*:





 $r \cap s$ 





#### Joining two relations – Natural Join

- Let r and s be relations on schemas R and S respectively.
  Then, the "natural join" of relations R and S is a relation on schema R ∪ S obtained as follows:
  - Consider each pair of tuples  $t_r$  from r and  $t_s$  from s.
  - If  $t_r$  and  $t_s$  have the same value on each of the attributes in  $R \cap S$ , add a tuple t to the result, where
    - t has the same value as t<sub>r</sub> on r
    - t has the same value as t<sub>S</sub> on s



## **Natural Join Example**

Relations r, s:

$\boldsymbol{A}$	В	C	D
α	1	α	a
β	2	γ	a
γ	4	β	b
α	1	γ	a
δ	2	β	b

D	E
a	α
a	β
a	γ
b	δ
b	3
	a

- Natural Join
  - r ⋈ s

A	В	C	D	Ε
α	1	α	a	α
α	1	α	a	γ
α	1	γ	a	α
α	1	γ	a	γ
δ	2	β	b	δ



## Figure in-2.1

Symbol (Name)	Example of Use
σ (C-1)	σ salary>=85000 (instructor)
(Selection)	Return rows of the input relation that satisfy the predicate.
П (Визітаціять)	Π <sub>ID, salary</sub> (instructor)
(Projection)	Output specified attributes from all rows of the input relation. Remove duplicate tuples from the output.
×	instructor ⋈ department
(Natural Join)	Output pairs of rows from the two input relations that have the same value on all attributes that have the same name.
×	instructor × department
(Cartesian Product)	Output all pairs of rows from the two input relations (regardless of whether or not they have the same values on common attributes)
U (Union)	$\Pi_{name}(instructor) \cup \Pi_{name}(student)$
(Onion)	Output the union of tuples from the two input relations.



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#### **End of Chapter 2**

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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



course_id	title	dept_name	credits
BIO-101	Intro. to Biology	Biology	4
BIO-301	Genetics	Biology	4
BIO-399	Computational Biology	Biology	3
CS-101	Intro. to Computer Science	Comp. Sci.	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3
CS-319	Image Processing	Comp. Sci.	3
CS-347	Database System Concepts	Comp. Sci.	3
EE-181	Intro. to Digital Systems	Elec. Eng.	3
FIN-201	Investment Banking	Finance	3
HIS-351	World History	History	3
MU-199	Music Video Production	Music	3
PHY-101	Physical Principles	Physics	4



course_id	prereq_id
BIO-301	BIO-101
BIO-399	BIO-101
CS-190	CS-101
CS-315	CS-101
CS-319	CS-101
CS-347	CS-101
EE-181	PHY-101



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15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000



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



course_id	sec_id	semester	year	building	room_number	time_slot_id
BIO-101	1	Summer	2009	Painter	514	В
BIO-301	1	Summer	2010	Painter	514	A
CS-101	1	Fall	2009	Packard	101	H
CS-101	1	Spring	2010	Packard	101	F
CS-190	1	Spring	2009	Taylor	3128	E
CS-190	2	Spring	2009	Taylor	3128	A
CS-315	1	Spring	2010	Watson	120	D
CS-319	1	Spring	2010	Watson	100	В
CS-319	2	Spring	2010	Taylor	3128	C
CS-347	1	Fall	2009	Taylor	3128	Α
EE-181	1	Spring	2009	Taylor	3128	C
FIN-201	1	Spring	2010	Packard	101	В
HIS-351	1	Spring	2010	Painter	514	C
MU-199	1	Spring	2010	Packard	101	D
PHY-101	1	Fall	2009	Watson	100	A



ID	course_id	sec_id	semester	year
10101	CS-101	1	Fall	2009
10101	CS-315	1	Spring	2010
10101	CS-347	1	Fall	2009
12121	FIN-201	1	Spring	2010
15151	MU-199	1	Spring	2010
22222	PHY-101	1	Fall	2009
32343	HIS-351	1	Spring	2010
45565	CS-101	1	Spring	2010
45565	CS-319	1	Spring	2010
76766	BIO-101	1	Summer	2009
76766	BIO-301	1	Summer	2010
83821	CS-190	1	Spring	2009
83821	CS-190	2	Spring	2009
83821	CS-319	2	Spring	2010
98345	EE-181	1	Spring	2009



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33456	Gold	Physics	87000
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58583	Califieri	62000	History	Painter	50000
76543	Singh	80000	Finance	Painter	120000
76766	Crick	72000	Biology	Watson	90000
83821	Brandt	92000	Comp. Sci.	Taylor	100000
98345	Kim	80000	Elec. Eng.	Taylor	85000



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12121	90000
22222	95000
33456	87000
83821	92000