UCS310 Database Management System

Introduction to Relational Data Model

Lecture-05

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Dr. Sumit Sharma
Assistant Professor
Computer Science and Engineering Department
Thapar Institute of Engineering and Technology, Patiala

Recap

- Introduction to the mathematical structure of relational model
  - Relational schema and instances
- Basic Terminologies
  - Attributes, degree, cardinality
- Keys of Relation
- Relational Model Constraints: Schema-Based
  - Domain
  - Key
  - Entity integrity
  - Referential integrity

Keys of Relation

- Keys in DBMS is an attribute or set of attributes that help to identify a row (tuple) in a relation (table)
- Allow to find the relation between two tables
- Help to enforce identity and integrity in the relationship

- Primary Key
- Candidate Key
- Alternate Key
- Composite Key
- Foreign Key
- Super Key

Keys

- Let, $K \subseteq R$
- 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 the Instructor
- One of the candidate keys is selected to be the **primary key**.
  - Which one?
- A **surrogate key** (or synthetic key) in a database is a unique identifier for either an entity in the modeled world or an object in the database
  - The surrogate key is not derived from the application data, unlike a natural (or business) key which is derived from the application data

Keys

- **Superkey**: Roll#, (Roll#,DOB)
- **Candidate key**: Roll#, (First Name, Last Name), Passport#, Aadhar#
  - Passport # cannot be a key. Why?
- **Primary key:** : Roll#
- **Secondary/ Alternate Key**: (First Name, Last Name), Aadhar#
- **Simple key**: consists of a single attribute
- **Composite Key**: (First Name, Last Name)
  - Consists of more than one attribute to uniquely identify an entity occurrence
  - One or more attributes, which make up the key, are not simple keys in their own right

Roll#	First Name	Last Name	DOB	Passport#	Aadhar#	Department
CS2022001	Prateek	Keserwani	07-Nov-1994	L4034654	1728-6174-9239	Computer
EC2022111	Apeksha	Aggarwal	04-Dec-1998	NULL	4388-2185-1248	Electronic
MA2022213	Prateek	Sharma	19-May-1997	NULL	1236-4583-0235	Maths
EC2022420	Amit	Aggarwal	19-Sept-1998	M8816623	2365-5698-1470	Electronic

Keys

- **Foreign key** constraint: Value in one relation must appear in another
  - **Referencing** relation
    - Enrolment: Foreign Key- Roll#, Course #
  - **Referenced** relation
    - Student, Course

Students

Roll#	First Name	Last Name	DOB	Passport#	Aadhar#	Department

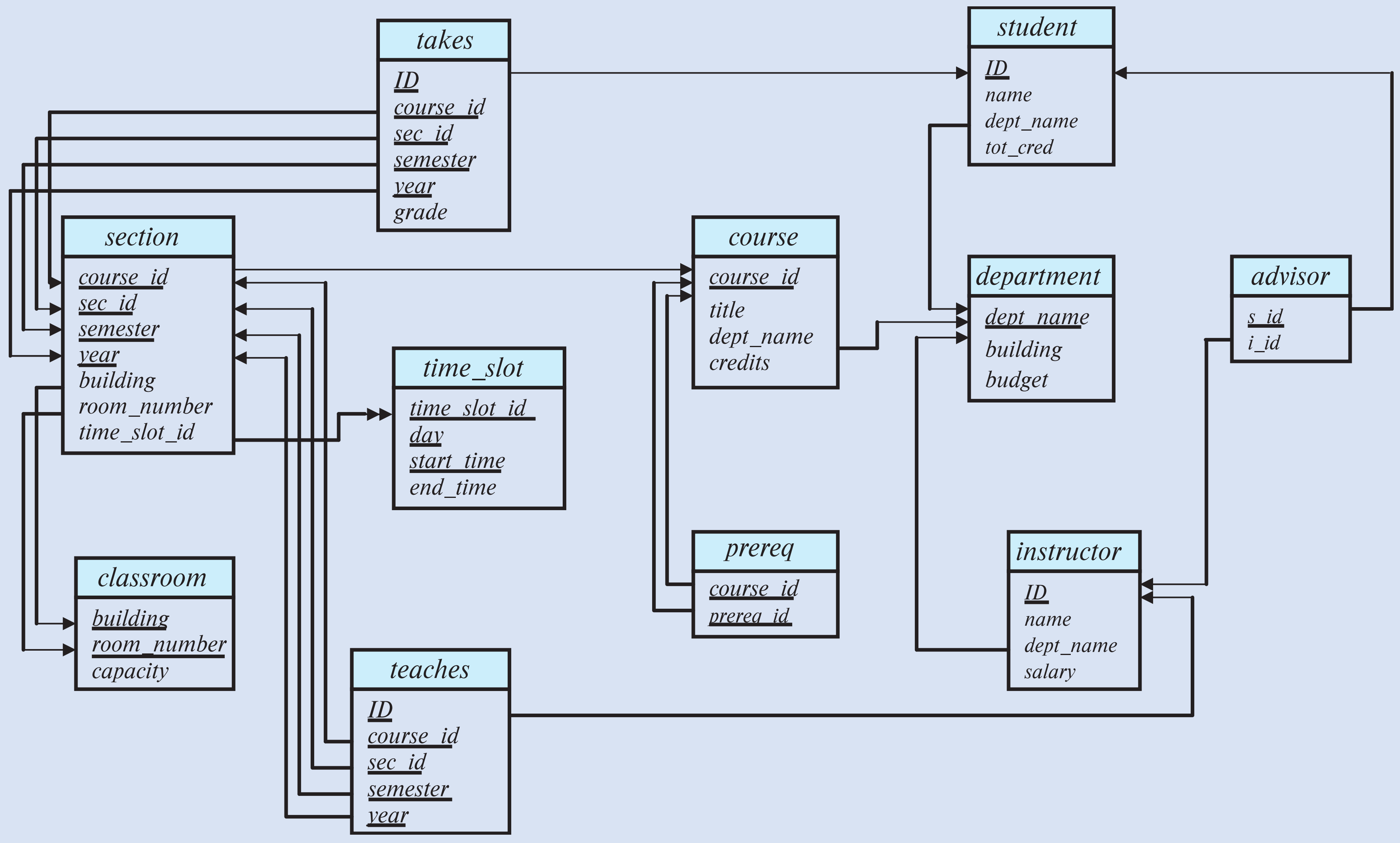
Courses

Course#	Course Name	Credit	L-T-P	Department

Enrolment

Course#	Roll#	Instructor ID

Schema Diagram for University Database



Relational Query Languages

- Procedural versus non-procedural, or declarative
- "Pure" languages:
  - Relational algebra - Procedural
  - Tuple relational calculus – Non- Procedural
  - Domain relational calculus – Non- Procedural
- The above 3 pure languages are equivalent in computing power
- We will concentrate in this chapter on relational algebra
  - Not Turing-machine equivalent
  - Consists of 6 basic operations

Relational Algebra

- A procedural language consisting of a set of operations that take one or two relations as input and produce a new relation as their result
- Six basic operators
  - select: σ
  - project: $\prod$
  - union: $\cup$
  - set difference: –
  - Cartesian product: $\times$
  - rename: ρ

Select Operation – selection of rows (tuples)

- Relation r

A	B	C	D
α	α	1	7
α	β	5	7
β	β	12	3
β	β	23	10

- $\sigma_{A=B \wedge D>5}(r)$

A	B	C	D
α	α	1	7
β	β	23	10

Select Operation

- The **select** operation selects tuples that satisfy a given predicate.
- Notation: $\sigma_p(r)$
- p is called the **selection predicate**
- Example: select those tuples of the *instructor* relation where the instructor is in the "Physics" department
  - Query

$$\sigma_{dept\_name = \text{“Physics”}}(instructor)$$

  - Result

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
33456	Gold	Physics	87000

Select Operation

- We allow comparisons using

  $=, \neq, >, \geq. <. \leq$

  in the selection predicate.
- We can combine several predicates into a larger predicate by using the connectives:

  $\wedge$ **(and)**, $\vee$ **(or)**, $\neg$ **(not)**
- Example: Find the instructors in Physics with a salary greater $90,000, we write:

  $\sigma_{dept\_name = \text{"Physics"} \wedge salary > 90{,}000}(instructor)$

- The select predicate may include comparisons between two attributes
  - Example, find all departments whose name is the same as their building name:
  - $\sigma_{dept\_name = building}(department)$

Project Operation

- A unary operation that returns its argument relation, with certain attributes left out
- Notation:

$$\prod_{A_1, A_2, A_3 \dots A_k} (r)$$

where $A_1, A_2, \dots, A_k$ are attribute names and r is a relation name

- The result is defined as the relation of k columns obtained by erasing the columns that are not listed
- Duplicate rows removed from result since relations are sets

Project Operation Example

- Example: eliminate the *dept_name* attribute of *instructor*
- Query:

$$\Pi_{ID,\ name,\ salary}\ (instructor)$$

- Result:

ID	*name*	*salary*
10101	Srinivasan	65000
12121	Wu	90000
15151	Mozart	40000
22222	Einstein	95000
32343	El Said	60000
33456	Gold	87000
45565	Katz	75000
58583	Califieri	62000
76543	Singh	80000
76766	Crick	72000
83821	Brandt	92000
98345	Kim	80000

Composition of Relational Operations

- The result of a relational-algebra operation is relation; therefore, relational-algebra operations can be composed together into a **relational-algebra expression**

- Consider the query -- Find the names of all instructors in the Physics department.

$$\Pi_{name}(\sigma_{dept\_name\ =\ \text{“Physics”}}\ (instructor))$$

- Instead of giving the name of a relation as the argument of the projection operation, we give an expression that evaluates a relation

Cartesian-Product Operation

- The Cartesian-product operation (denoted by X) allows us to combine information from any two relations.
- Example: the Cartesian product of the relations *instructor* and t*eaches* is written as:

  instructor X *teaches*

- We construct a tuple of the result out of each possible pair of tuples: one from the *instructor* relation and one from the *teaches* relation (see next slide)
- Since the instructor *ID* appears in both relations we distinguish between these attributes by attaching to the attribute the name of the relation from which the attribute originally came.
  - *instructor.ID*
  - *teaches.ID*

The instructor × teaches table

instructor.ID	*name*	*dept_name*	*salary*	*teaches.ID*	*course_id*	*sec_id*	*semester*	*year*
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
10101	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
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
15151	Mozart	Music	40000	10101	CS-101	1	Fall	2017
15151	Mozart	Music	40000	10101	CS-315	1	Spring	2018
15151	Mozart	Music	40000	10101	CS-347	1	Fall	2017
15151	Mozart	Music	40000	12121	FIN-201	1	Spring	2018
15151	Mozart	Music	40000	15151	MU-199	1	Spring	2018
15151	Mozart	Music	40000	22222	PHY-101	1	Fall	2017
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
22222	Einstein	Physics	95000	10101	CS-101	1	Fall	2017
22222	Einstein	Physics	95000	10101	CS-315	1	Spring	2018
22222	Einstein	Physics	95000	10101	CS-347	1	Fall	2017
22222	Einstein	Physics	95000	12121	FIN-201	1	Spring	2018
22222	Einstein	Physics	95000	15151	MU-199	1	Spring	2018
22222	Einstein	Physics	95000	22222	PHY-101	1	Fall	2017
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

Join Operation

- The Cartesian-Product

  $$instructor \times teaches$$

  associates every tuple of instructor with every tuple of teaches.
  - Most of the resulting rows have information about instructors who did NOT teach a particular course.
- To get only those tuples of "$instructor \times teaches$" that pertain to instructors and the courses that they taught, we write:

  $$\sigma_{instructor.id = teaches.id}\ (instructor \times teaches\ ))$$

  - We get only those tuples of "$instructor \times teaches$" that pertain to instructors and the courses that they taught.
- The result of this expression, shown in the next slide

Join Operation

- The table corresponding to:

$$\sigma_{instructor.id = teaches.id}(instructor \times teaches))$$

instructor.ID	*name*	*dept_name*	*salary*	*teaches.ID*	*course_id*	*sec_id*	*semester*	*year*
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

Join Operation

- The **join** operation allows us to combine a select operation and a Cartesian-Product operation into a single operation.
- Consider relations *r* (*R*) and *s* (*S*)
- Let "theta" be a predicate on attributes in the schema R "union" S. The join operation r $\bowtie_\theta$ s is defined as follows:

$$r \bowtie_\theta s = \sigma_\theta\, (r \times s)$$

- Thus

$$\sigma_{instructor.id = teaches.id}\, (instructor \text{ x } teaches\,))$$

- Can equivalently be written as

$$instructor \bowtie_{Instructor.id = teaches.id} teaches.$$

Thanks!