Databases – Introduction to Relational Model (Chapter 2)

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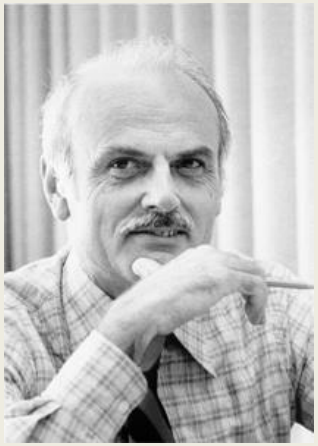
Schedule

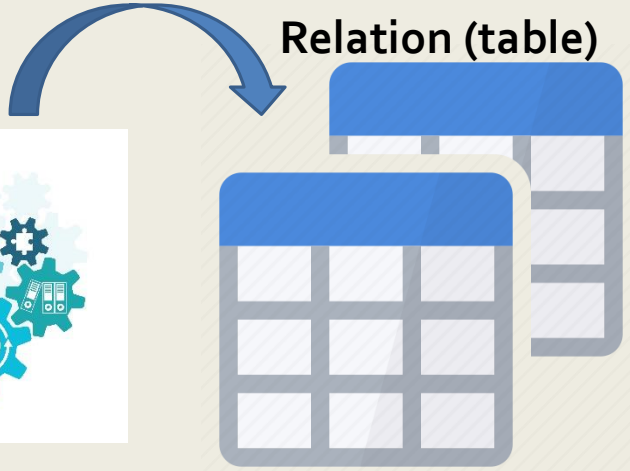
Week	Topic	Chapter	Note
1	Introduction to DBMS, Relational Model	1	
2	Relational Algebra : - Concept of Key - Relational algebra operators - Relational algebra expressions	2	추석
3	Introduction to SQL	3	
4	Advanced SQL : - Advanced expression of SQL - Nested SQL queries	4, 5	MOOC
5	Entity/Relationship Model	6	
6	Relational Database Design 1 Relational Database Design 2 (추석보강)	7	MOOC
7	Storage and File Structure	12, 13	MOOC
8	Mid-term Exam		

Relational Databases

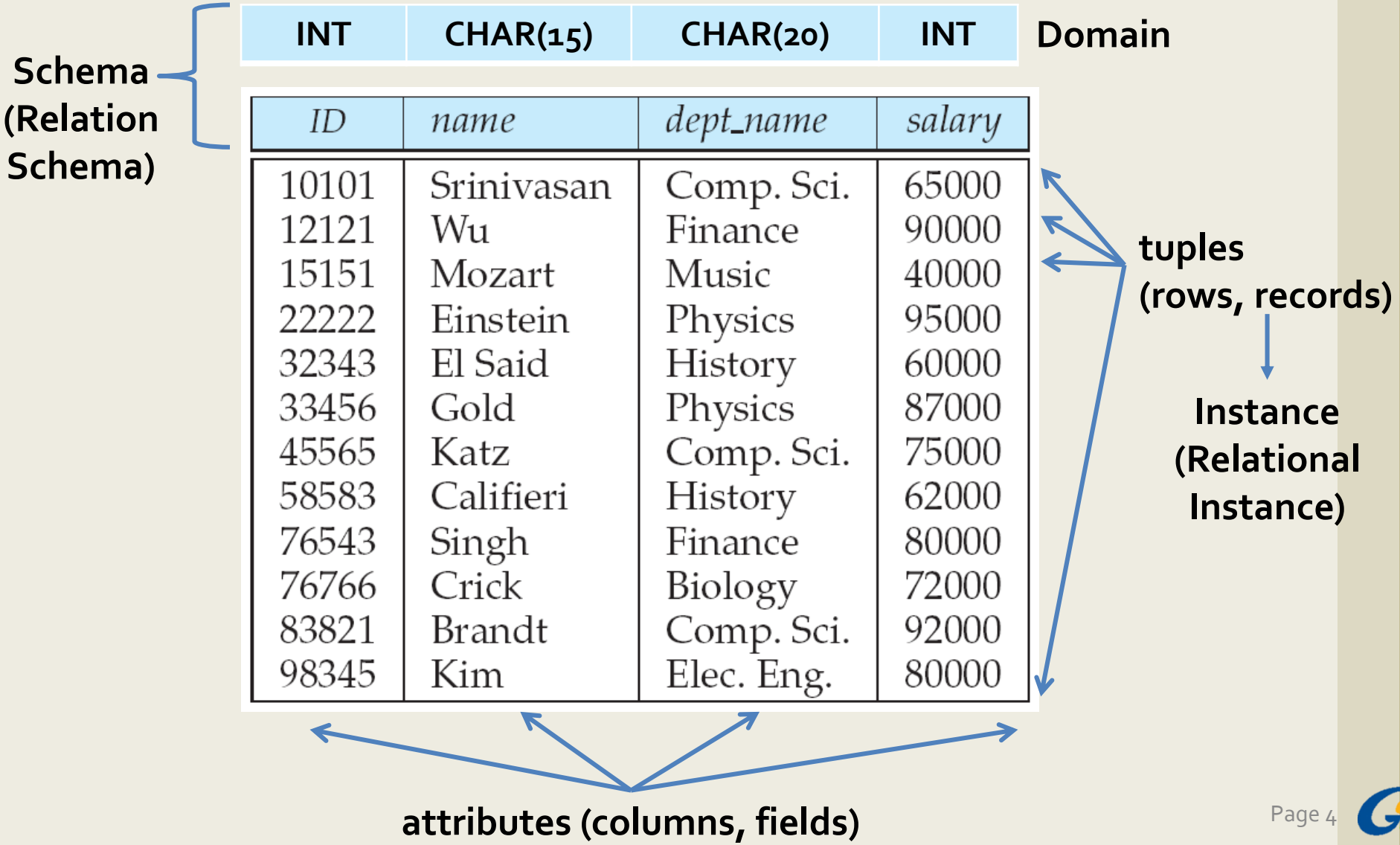
- **What is Relation (table) Data Model:**
  - a collection of *table* / *relations*
    - Records with pre-defined columns
    - Assigned a unique name (e.g., instructor, department, …)
  - Primary data model for commercial data-processing
  - Edgar F. Codd defines the Relational Data Model (1972)



Edger F. Codd



Structure of Relational Databases



Alternative Terminology

Table-oriented	Record-oriented	Relational DB
Table	File	**Relation**
Row	Record	**Tuple**
Column	Field	**Attribute**

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

Attribute types

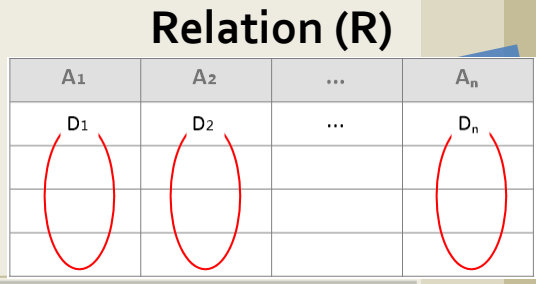
- The set of allowed values for each attribute is called the *domain* of the attribute
  - Same data type
  - Order is not important (unordered)
- Attribute values (domains) are (normally) required to be atomic, i.e., indivisible
- The special value *null* is a member of every domain indicating that the value is "unknown" or "non-existent"
  - Causes complications in the definition of many operations

Result Grid | Filter Rows: | Edit

course_id	title	dept_name	credits
CS-111	db	comp. sci	2
CS-437	Database Systems	comp. sci	4
NULL	NULL	NULL	NULL

ID	name	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 Schema



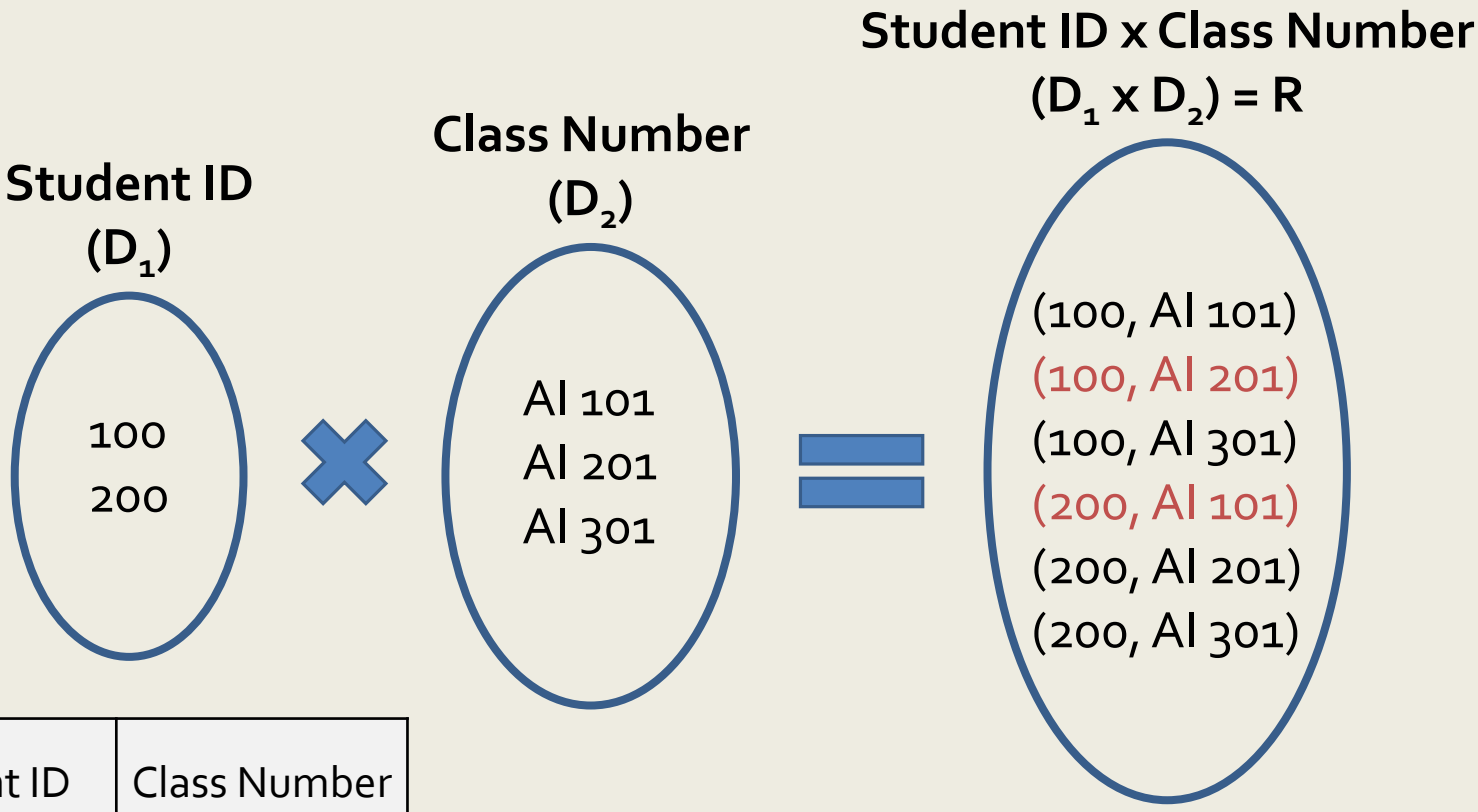
Relation Schema and Relation Instances

R = Relation
A = Attribute
r = Relation Instance
t = tuple
D = Domain

- $A_1, A_2, \ldots, A_n$ are attributes
- $R\,(A_1, A_2, \ldots, A_n)$ is a *relation schema*
  - E.g., *instructor* (*ID*, *name*, *dept_name*, *salary*)
- The current values (*relation instance r*) of a relation are specified by a table form
  - The element *t* of *r* is a *tuple*, represented by a row in a table
  - A table *r* is a set of tuples *t*
- Formally, given domains $D_1, D_2, \ldots, D_n$, a relation R is a subset of $D_1 \times D_2 \times \ldots \times D_n$
  - $R \subseteq D_1 \times D_2 \times \ldots \times D_n$ *(Cartesian Product)*
  - A relation is a set of *n*-tuples $(a_1, a_2, \ldots, a_n)$ where $a_i \in D_i$
- Relation = Relation Schema + Relation Instances

Example

$R \subseteq D_1 \times D_2 \times \ldots \times D_n$ *(Cartesian Product)*



Student ID	Class Number
100	Al 201
200	Al 101

$R_1 = D_1 \times D_2$

Domain example

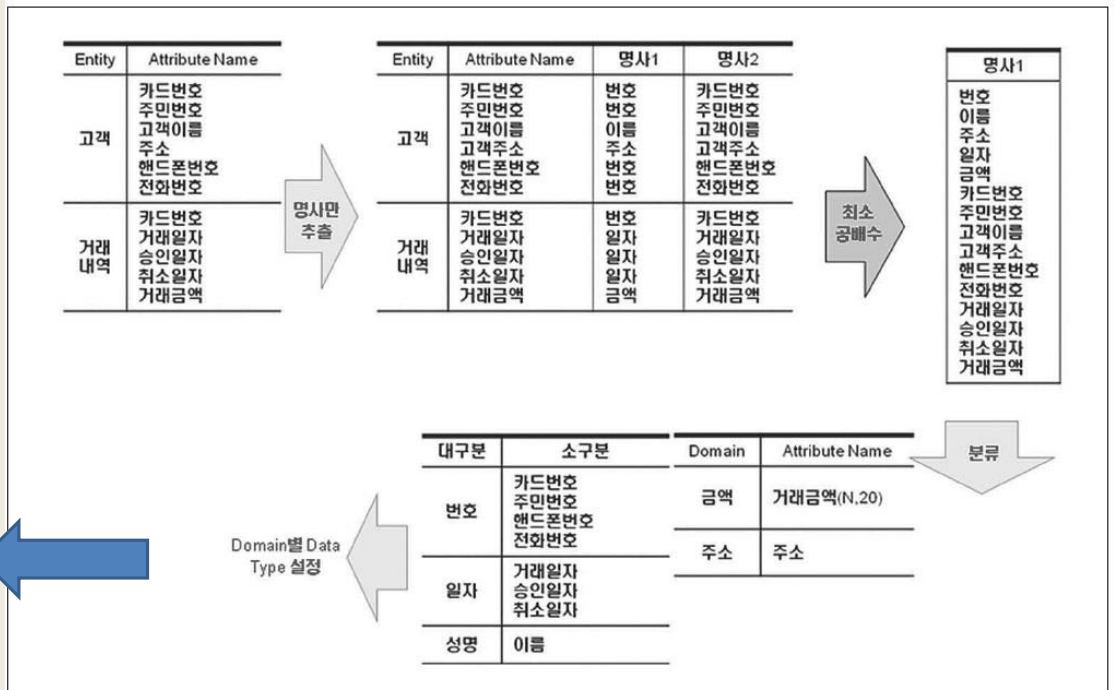
- A database *domain*, at its simplest, is the data type used by a column in a database. This data type can be a built-in type (such as an integer or a string) or a custom type that defines constraints on the data.

Customer

ID Number	Name	Age	Address
INT	CHAR(10)	INT	CHAR(20)

도메인그룹	도메인명	데이터 타입	설명
번호	전화번호	VARCHAR2(13)	
	우편번호	VARCHAR2(7)	
	비밀번호	VARCHAR2(10)	
	번호(PK)	NUMBER	시퀀스를 PK로 사용
금액	금액(N,13)	NUMBER(13)	
	금액(N,6)	NUMBER(6)	
명칭	이름	VARCHAR2(16)	
	제목	VARCHAR2(128)	
수량	주문수량	NUMBER	
여부	사용여부	VARCHAR2(1)	
날짜	일자	VARCHAR2(14)	YYYYMMDDHH24MISS
	월	VARCHAR2(2)	MM
	년도	VARCHAR2(4)	YYYY

〈표2〉 도메인 정의 예제



Examples

- *department* (*dept_name*, *building*, *budget*)
- *teaches* (*ID*, *course_id*, *sec_id*, *semester*, *year*)

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

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

Characteristics of Relation

- **One attribute contains same data type**
- **Relations are unordered**
  - Order of attributes / tuples is irrelevant
    - tuples may be stored in an arbitrary order
  - Example: *instructor* relation with unordered tuples

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
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ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
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32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
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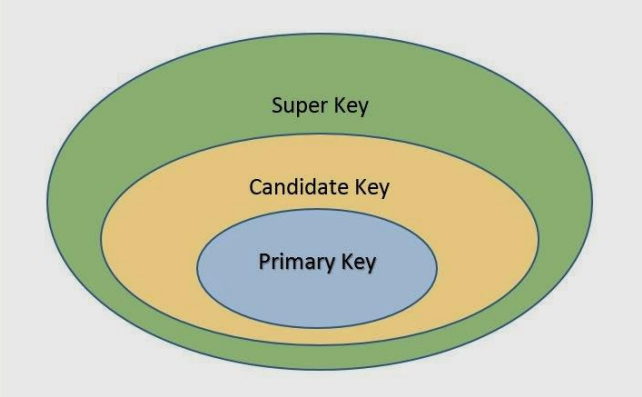
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

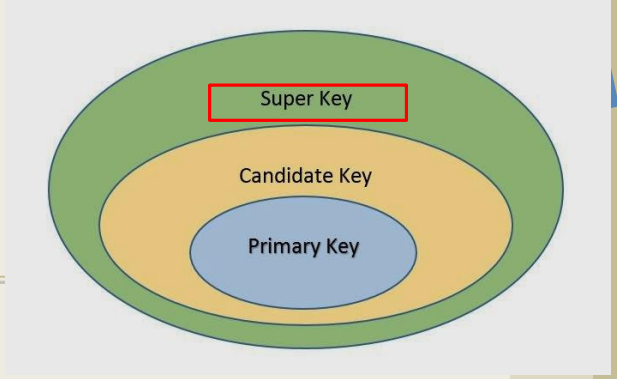
Keys

- Specify how tuples are distinguished

Student ID	Class Number	Grade
100	AI 101	A
200	AI 217	B
100	AI 314	B
200	AI 101	C



Keys



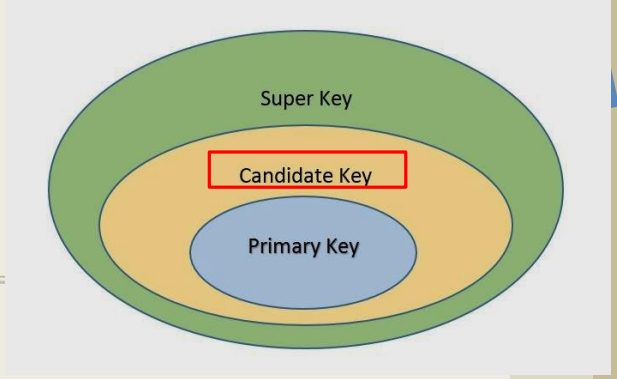
- ***Super Keys***
  - The **set** of attributes which can *uniquely* identify a tuple
  - *K* is a *superkey* of *R* ,if values for *K* are sufficient to identify a unique tuple of each possible relation *r*(*R*)
    - E.g., {*ID*} and {*ID*,*name*} are both superkeys of *instructor*
    - E.g., STUD_NO, {STUD_NO, STUD_NAME}
  - Superkey *K* is a *candidate key* if *K* is minimal
    - E.g., {*ID*} is a candidate key for *instructor*

STUDENT

STUD_NO	STUD_NAME	STUD_PHONE	STUD_STATE	STUD_COUNTRY	STUD_AGE
1	RAM	9716271721	Haryana	India	20
2	RAM	9898291281	Punjab	India	19
3	SUJIT	7898291981	Rajsthan	India	18
4	SURESH		Punjab	India	21

Table 1

Keys



- *Candidate key*
  - The *minimal* set of attribute which can uniquely identify a tuple is known as candidate key
    - The value is *unique* and *non-null* for every tuple.
    - There can be more than one candidate key in a relation.
      - E.g., STUD_NO
    - The candidate key can be only one attribute or composite as well.
      - E.g., {STUD_NO, COURSE_NO} is a composite candidate key for relation STUDENT_COURSE.

STUDENT

STUD_NO	STUD_NAME	STUD_PHONE	STUD_STATE	STUD_COUNTRY	STUD_AGE
1	RAM	9716271721	Haryana	India	20
2	RAM	9898291281	Punjab	India	19
3	SUJIT	7898291981	Rajsthan	India	18
4	SURESH		Punjab	India	21

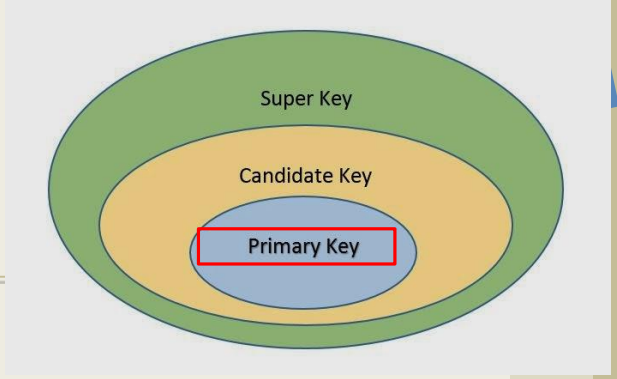
Table 1

STUDENT_COURSE

STUD_NO	COURSE_NO	COURSE_NAME
1	C1	DBMS
2	C2	Computer Networks
1	C2	Computer Networks

Table 2

Keys



- ***Primary key***
  - One of candidate keys is selected as a primary key by the database designer. Values are never, or rarely, changed
  - List the primary key attributes before the other attributes with underline
    - *department* (*dept_name*, *building*, *budget*)
    - *course* (*course_id*, *title*, *dept_name*, *credits*)
    - student(stud_no, stud_name, stud_phone, stud_state, stud,countray,stud_age)

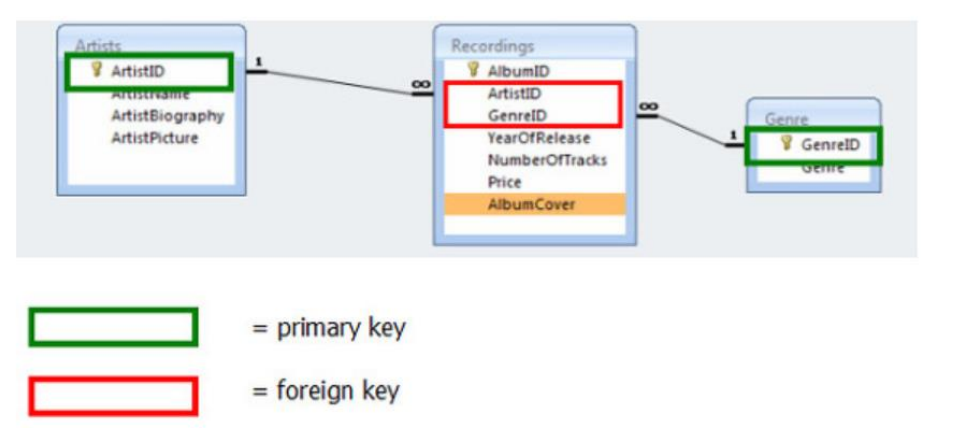
STUDENT

STUD_NO	STUD_NAME	STUD_PHONE	STUD_STATE	STUD_COUNTRY	STUD_AGE
1	RAM	9716271721	Haryana	India	20
2	RAM	9898291281	Punjab	India	19
3	SUJIT	7898291981	Rajsthan	India	18
4	SURESH		Punjab	India	21

Table 1

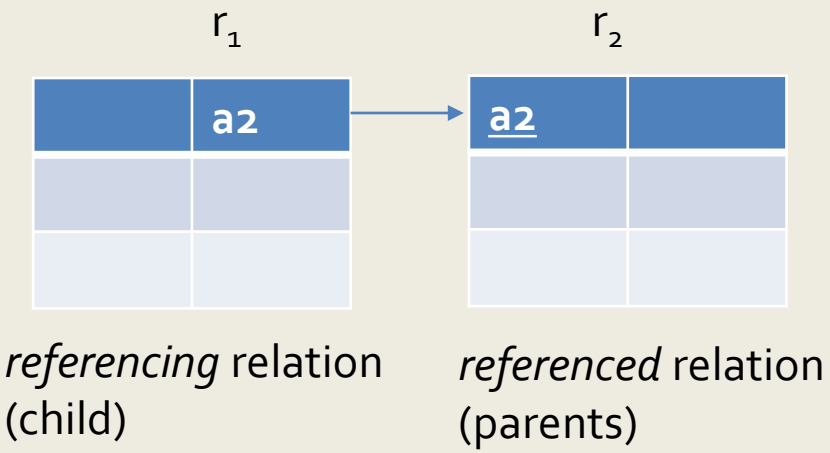
Keys

- *Foreign key*
  - A key used to link two tables together
  - A FOREIGN KEY is a field in one table that refers to the **PRIMARY KEY** in another table.
  - The table containing the foreign key is called the child table, and the table containing the candidate key is called the referenced or parent table.



Keys

- ***Foreign key***
  - The primary key of r_2, $\boldsymbol{a_2}$ is called **a foreign key** from r_1, referencing r_2 When r_1 includes a_1,
    - r_1 – *referencing* relation, r_2 – *referenced* relation
  - Referential integrity constraint
    - Values of a_2 in r_1 must appear in r_2

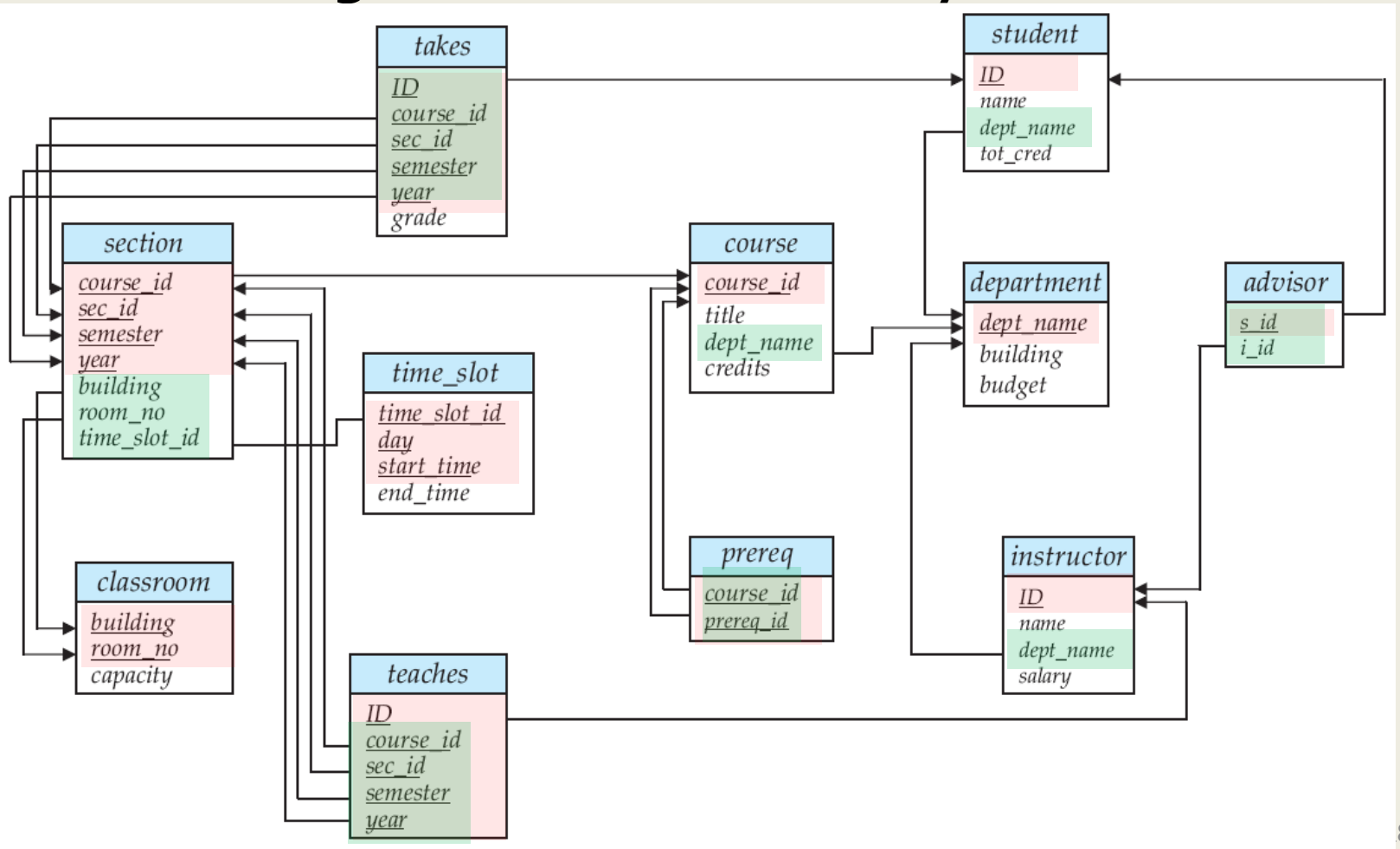


Schema Diagrams

Primary key

Foreign key

- Schema diagram for the university database



Example

Primary key

Foreign key

- **Foreign Key in the same relation**

FacSSN	FacFirstName	FacLastName	FacRank	RacSalary	FacSupervisor
598-76-5432	LEONARD	VINCE	ASST	$35,000	654-32-1098
543-21-0987	VICTORIA	EMMANUEL	PROF	$120,000	
654-32-1098	LEONARD	FIBON	ASSC	$70,000	543-21-0987
765-43-2109	NICKI	MACON	PROF	$65,000	
487-65-4321	JULIA	MILLS	ASSC	$75,000	765-43-2109

Languages of DBMS

- **Data Definition Language (DDL)**
  - define the *schema* and storage stored in a Data Dictionary
- **Data Manipulation Language (DML)**
  - Manipulative populate schema, update database
  - Retrieval querying content of a database
- **Data Control Language (DCL)**
  - permissions, access control etc…

Relational Query Languages

- **Relational query languages**
  - *Procedural* vs. *non-procedural* (*declarative*)
  - "Pure" languages:
    - **Relational algebra**
      - Theoretical basis of SQL query language
    - Tuple relational calculus
    - Domain relational calculus
  - We will concentrate in this chapter on relational algebra
    - Consists of 6 basic operations