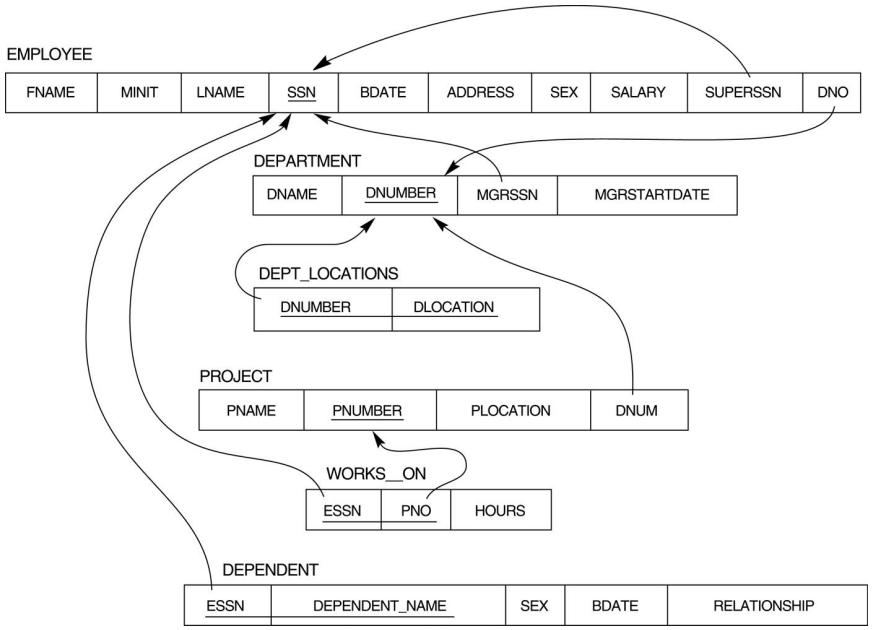
Chapter 3

The Basic (Flat) Relational Model



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia									
Jennifer									
Ramesh									
Joyce									
Ahmad									
James									

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Adm			
Hea			

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555				
333445555				
987654321				
123456789				
123456789				
123456789				

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

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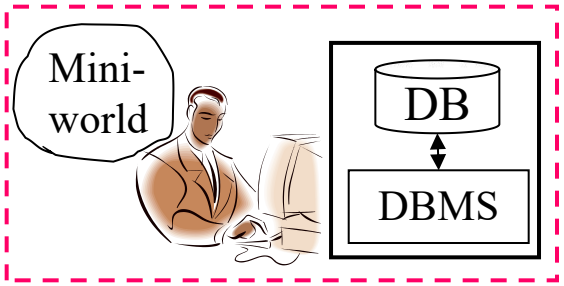
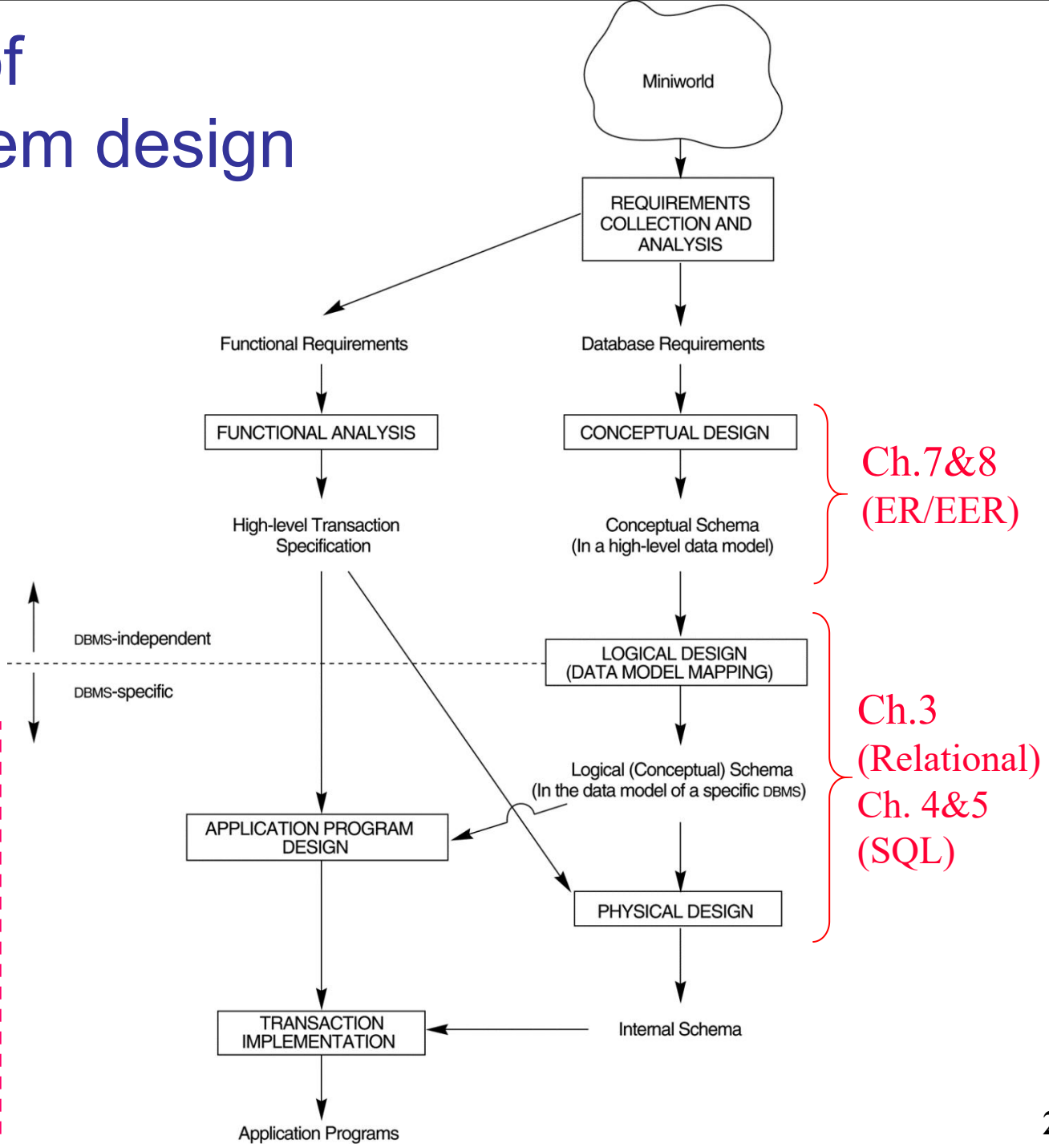
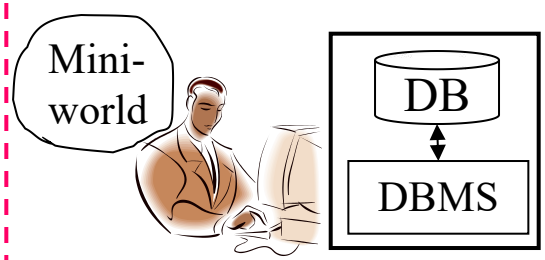


Main phases of database system design



Construct DB

1. **Design DB**
2. Define DB
3. Load DB



Conceptual Database Design

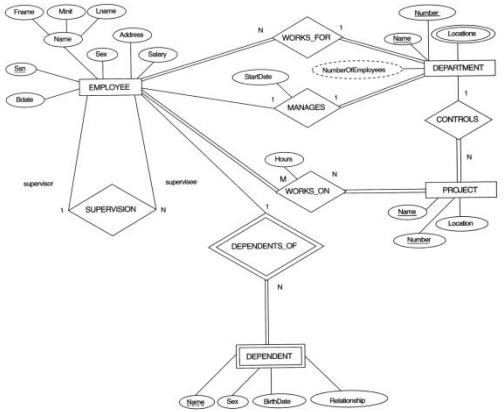
Entity
Attribute
Relationship
…

Ch.7&8
(ER/EER)
(data model)

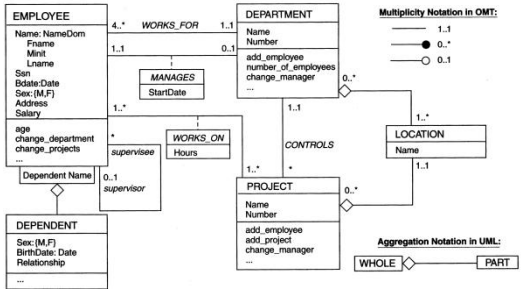
ER or OO

Mini-world

Conceptual design



ER diagram

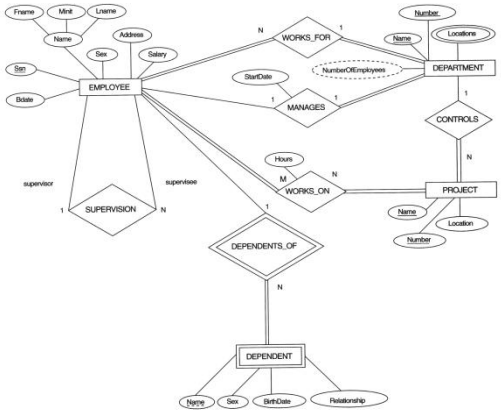


class diagram

?

Conceptual DB Schema
(DB structure)

Logical Database Design



ER diagram

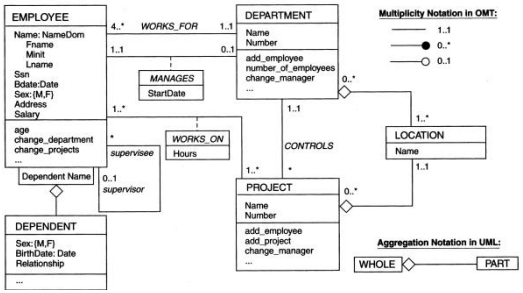
(data model)

Relational

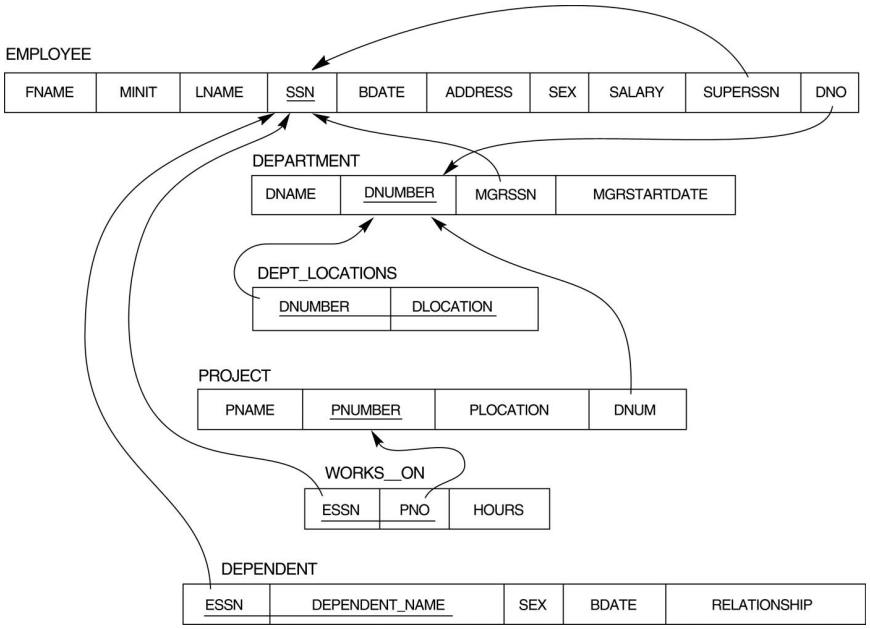
Ch.3

Logical design

Ch.8



class diagram



Relational DB Schema
(DB structure)

Chapter Outline

- Relational Model Concepts
  - Informal definitions
  - Formal definitions
  - Characteristics of relations
- Relational Model Constraints and Relational Database Schemas
- Update Operations and Dealing with Constraint Violations

Relational Model Concepts

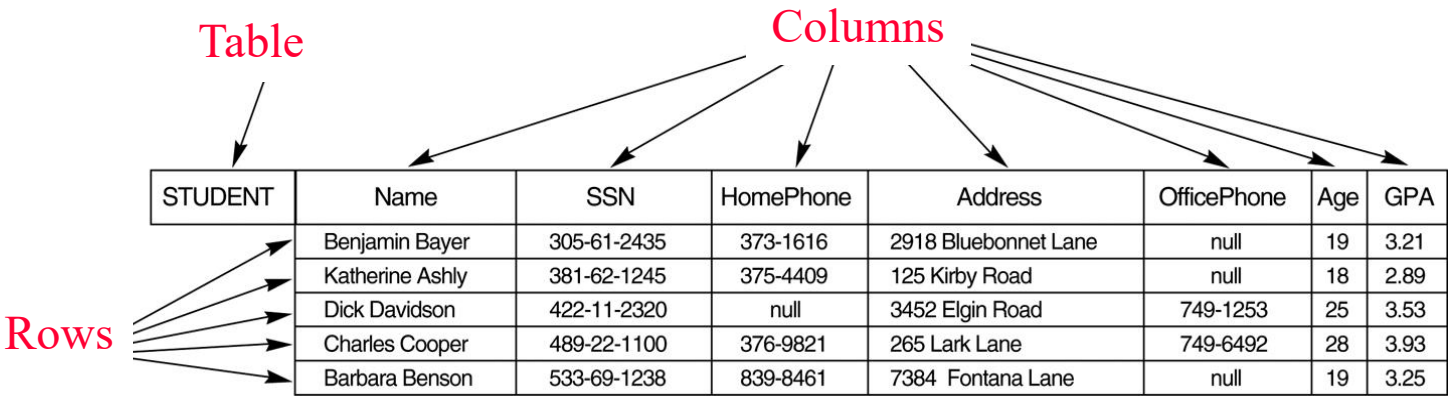
- First proposed by Dr. E.F. Codd of IBM in *Communications of the ACM*, June 1970:
  - A Relational Model for Large Shared Data Banks
  - The paper caused a major revolution in the field of Database management and earned Ted Codd the coveted ACM Turing Award.
- The Relational Model of Data is based on the concept of a Relation.
- A Relation is a mathematical concept based on the ideas of sets.
- The strength of the relational approach to data management comes from the formal foundation provided by the theory of relations.

A Relation

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25

INFORMAL DEFINITIONS

- RELATION: A table of values
  - A **Relation** may be defined in multiple ways.
    - ✓ A relation may be thought of as a **set of rows**.
    - ✓ A relation may alternately be though of as a **set of columns**.
  - Each row represents a fact that corresponds to a real-world **entity** or **relationship**.
  - Each row has a value of an item or set of items that uniquely identifies that row in the table.
  - Sometimes row-ids or sequential numbers are assigned to identify the rows in the table.



STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25

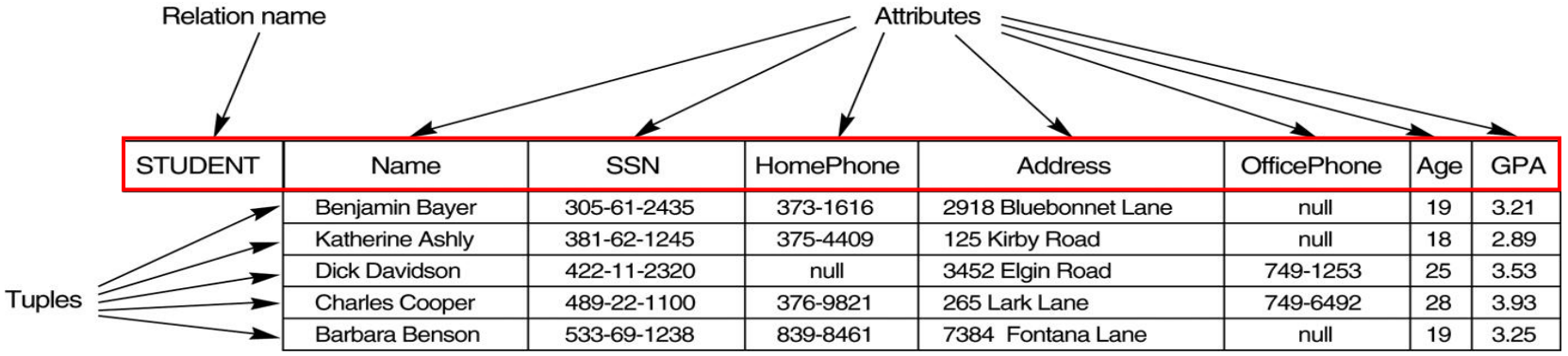
FORMAL DEFINITIONS

- The **Schema** of a Relation:

  R(A1, A2, ...An)

  STUDENT(Name, SSN, HomePhone, Address, OfficePhone, Age, GPA)

  - STUDENT is a relation defined over the seven attributes.
  - Each of which has a **domain** or a set of valid values.
  - The domain of HomePhone is 7 digit numbers.



STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
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	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25

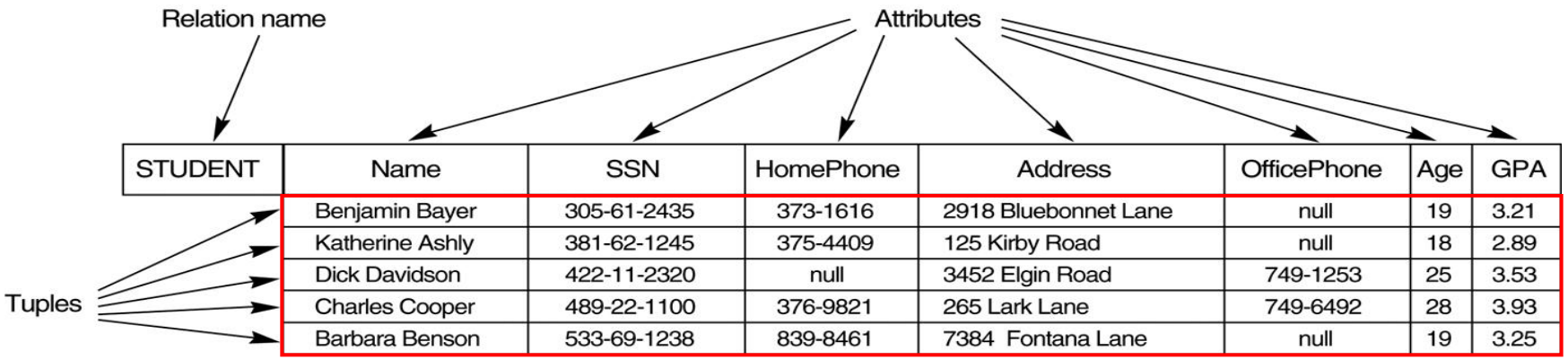
FORMAL DEFINITIONS

- A **tuple** is an ordered set of values.
  - Each value is derived from an appropriate domain.
- Each row in the STUDENT table may be referred to as a tuple in the table and would consist of seven values.

<"Dick Davidson", 422-11-2320, null, "3452 Elgin Road", 749-1256, 25, 3.53>

is a tuple belonging to the STUDENT relation.

- A relation may be regarded as a ***set of tuples*** (rows).
- Columns in a table are also called ***attributes*** of the relation.



STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
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	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25

FORMAL DEFINITIONS

- A **domain** *D* is a set of atomic (indivisible) values.
  - "Phone_numbers" are the set of 9 digit phone numbers valid in the U.S.
- A domain may have a data-type or a format defined for it.
  - The Phone_numbers may have a format:
    (dd)-ddd-dddd where each d is a decimal digit.
  - Dates have various formats such as
    monthname, date, year or yyyy-mm-dd, or dd mm,yyyy etc.
- An attribute designates the **role** played by the domain
  - the domain Date may be used to define attributes "Invoice-date" and "Payment-date".

domain (Phone_numbers) =
{(00)-000-0001, (00)-000-0002, …, (99)-999-9998, (99)-999-9999}

…
Hours **Int;**
Tel_No **Phone_numbers**;
Bdate **DATE;**

Cartesian Product

- Let dom(A1) = {0, 1}, dom(A2) = {a, b, c}

  Cartesian product of dom(A1) and dom(A2)

  dom(A1) × dom(A2)

  = {<0,a> <0,b> <0,c> <1,a> <1,b> <1,c>}

- Let dom(A1) = {0, 1} dom(A2) = {a, b, c} dom(A3) = {7, 8}

  Cartesian product of dom(A1), dom(A2) and dom(A3)

  dom(A1) × dom(A2) × dom(A3)

  = {<0,a,7> <0,a,8> <0,b,7> <0,b,8> <0,c,7> <0,c,8>
  <1,a,7> <1,a,8> <1,b,7> <1,b,8> <1,c,7> <1,c,8>}

- No. of Cartesian product result
  - |dom(A1)| × … × |dom(An)|

Relation and Cartesian Product

- Give a relation r(R) over A1 and A2, then

  $r(R) \subseteq dom(A1) \times dom(A2)$

- Let dom(A1) = {0, 1}, dom(A2) = {a, b, c}

  $r(R) \subseteq dom(A1) \times dom(A2)$

  $= \{<0,a>\ <0,b>\ <0,c>\ <1,a>\ <1,b>\ <1,c>\}$

- E.g.: r(R) = {<0,b> <0,c> <1,a> }

  is one possible "state" or "population" or "extension" r of the relation R, defined over domains A1 and A2. It has three tuples.

- No. of Cartesian product result, or maximum size of r(R):
  - |dom(A1)| × |dom(A2)|

R

A1	A2
0	a
0	b
0	c
1	a
1	b
1	c

r (R)

R

A1	A2
0	b
0	c
1	a

r (R)

FORMAL DEFINITIONS

- The relation is formed over the Cartesian product of the sets; each set has values from a domain; that domain is used in a specific role which is conveyed by the attribute name.
  - Attribute **Name** is defined over the **domain of strings of 25 characters**. The role these strings play in the STUDENT relation is that of the name of students.
- Formally,

  Given $R(A_1, A_2, ..., A_n)$

  $r(R) \subseteq dom(A_1) \times dom(A_2) \times .... \times dom(A_n)$

  where

  R: schema of the relation . (also called the **intension** of a relation)

  r of R: a specific "value" or population of R. (also called the **extension**)

R

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
r(R)	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53

DEFINITION SUMMARY

Informal Terms	Formal Terms
Table	Relation
Column	Attribute/Domain
Row	Tuple
Values in a column	Domain
Table Definition	Schema of a Relation
Populated Table	Extension

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21

CHARACTERISTICS OF RELATIONS

- **Ordering of tuples in a relation r(R)**:
  - ***not*** considered to be ordered, even though they appear to be in the tabular form.
- **Ordering of attributes in a relation schema R** (and of values within each tuple):
  - We will consider the attributes in $R(A_1, A_2, ..., A_n)$ and the values in $t = <v_1, v_2, ..., v_n>$ to be *ordered* .
  - However, a more general *alternative definition* of relation does **not** require this ordering, i.e., $t = <A_2:v_2, A_1:v_1, \ldots A_n:v_n>$
- **Values in a tuple**:
  - considered *atomic* (indivisible).
  - A special **null** value is used to represent values that are **unknown** or **inapplicable** to certain tuples.

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21

FIGURE 5.3

Two identical tuples when the order of attributes and values is not part of relation definition.

t = < (Name, Dick Davidson),(SSN, 422-11-2320),(HomePhone, null),(Address, 3452 Elgin Road), (OfficePhone, 749-1253),(Age, 25),(GPA, 3.53)>

t = < (Address, 3452 Elgin Road),(Name, Dick Davidson),(SSN, 422-11-2320),(Age, 25), (OfficePhone,749-1253),(GPA, 3.53),(HomePhone, null)>

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21

CHARACTERISTICS OF RELATIONS

- Notation
  - We refer to **component values** of a tuple **t** by

    $\mathbf{t[A_i] = v_i}$ (the value of attribute A_i for tuple t).
  - Similarly, $\mathbf{t[A_u, A_v, ..., A_w]}$

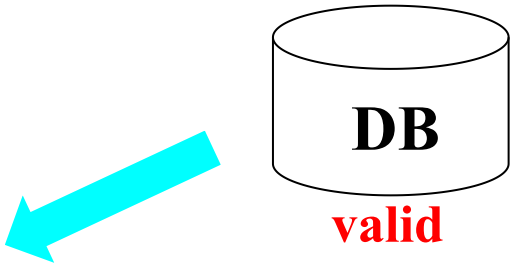
    refers to the subtuple of t containing the values of attributes A_u, A_v, ..., A_w, respectively.

STUDENT	Name	SSN	HomePhone	Address	OfficePhone	Age	GPA
	Dick Davidson	422-11-2320	null	3452 Elgin Road	749-1253	25	3.53
	Barbara Benson	533-69-1238	839-8461	7384 Fontana Lane	null	19	3.25
	Charles Cooper	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
	Katherine Ashly	381-62-1245	375-4409	125 Kirby Road	null	18	2.89
t	Benjamin Bayer	305-61-2435	373-1616	2918 Bluebonnet Lane	null	19	3.21

t[Name] = [Benjamin Bayer]
t[SSN, Name, Age] = [305-61-2435, Benjamin Bayer, 19]

Relational Integrity Constraints

- Constraints are *conditions* that must hold on *all* valid relation instances.
- There are three main types of constraints:
  1. **Key** constraints
  2. **Entity integrity** constraints
  3. **Referential integrity** constraints



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn
Research	5	333445555
Administration	4	987654321
Headquarters	1	888665555

- **Can John's Ssn be 333445555? Or be NULL?**
- **Can John's Dno be 7?**

Key Constraints

- **Superkey** of R:
  - **A set of attributes SK** of R such that **no two tuples *in any valid relation instance r(R)* will have the same value for SK**.
  - For any distinct tuples t1 and t2 in r(R), **t1[SK] ≠ t2[SK].**

    SK={LicenseNumber}?, SK={Make}?, SK={LicenseNumber, Make}?
- **Key** of R:
  - A "**minimal**" superkey;
  - A superkey K such that removal of any attribute from K results in a set of attributes that is not a superkey.
    - ✓ Key1 = {LicenseNumber}, Key2 = {EngineSerialNumber} are two keys of relation CAR; Key = {Dnumber, Dlocation}
    - ✓ SK1={EngineSerialNumber, Make}, SK2={LicenseNumber, Make, Year} are superkeys but ***not*** keys

t1 →
t2 →

CAR	LicenseNumber	EngineSerialNumber	Make	Model	Year
	Texas ABC-739	A69352	Ford	Mustang	96
	Florida TVP-347	B43696	Oldsmobile	Cutlass	99
	New York MPO-22	X83554	Oldsmobile	Delta	95
	California 432-TFY	C43742	Mercedes	190-D	93
	California RSK-629	Y82935	Toyota	Camry	98
	Texas RSK-629	U028365	Jaguar	XJS	98

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

Candidate keys and Primary key

- If a relation has *several* **candidate keys**, one is chosen arbitrarily to be the **primary key**. The primary key attributes are *underlined*.

Figure 7.4 The CAR relation with two candidate keys: LicenseNumber and EngineSerialNumber.

CAR	LicenseNumber	EngineSerialNumber	Make	Model	Year
	Texas ABC-739	A69352	Ford	Mustang	96
	Florida TVP-347	B43696	Oldsmobile	Cutlass	99
	New York MPO-22	X83554	Oldsmobile	Delta	95
	California 432-TFY	C43742	Mercedes	190-D	93
	California RSK-629	Y82935	Toyota	Camry	98
	Texas RSK-629	U028365	Jaguar	XJS	98

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

Figure 7.5 Schema diagram for the COMPANY relational database schema; the primary keys are underlined.

EMPLOYEE

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

DEPARTMENT

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

DEPT_LOCATIONS

DNUMBER	DLOCATION

- **Superkey**
- **Key**
- **Candidate key**
- **Primary key**

Figure 3.6
One possible database state for the COMPANY relational database schema.

- Superkey
- Key
- Candidate key
- Primary key

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

- What is the primary key of EMPLOYEE?
- Is {Fname, Address} a superkey of EMPLOYEE? A key?
- Is {Dnumber, Mgr_ssn} a superkey key of DEPARTMENT? A key?

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

- **Superkey**
- **Key**
- **Candidate key**
- **Primary key**

Entity Integrity

- **Relational Database Schema**:
  - A set S of relation schemas that belong to the same database. S is the *name* of the **database**.

$$S = \{R_1, R_2, ..., R_n\}$$

- **Entity Integrity**:
  - The ***primary key attributes*** **PK** of each relation schema R in S **cannot** have **null values** in any tuple of r(R).

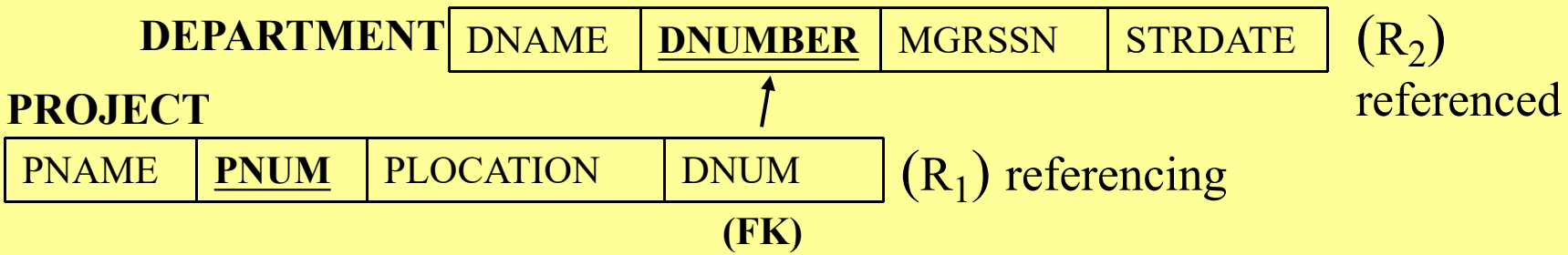
$$t[PK] \neq \text{null for any tuple t in r(R)}$$

  - This is because primary key values are used to *identify* the individual tuples.
- Note: Other attributes of R may be similarly constrained to disallow null values, even though they are not members of the primary key.

CAR	LicenseNumber	EngineSerialNumber	Make	Model	Year
	Texas ABC-739	A69352	Ford	Mustang	96
NULL ?	Florida TVP-347	B43696	Oldsmobile	Cutlass	99
	New York MPO-22	X83554	Oldsmobile	Delta	95
	California 432-TFY	C43742	Mercedes	190-D	93

Referential Integrity

- A constraint involving ***two*** relations (the previous constraints involve a ***single*** relation).
- Tuples in the ***referencing relation*** R_1 have attributes FK (called **foreign key** attributes) that reference the primary key attributes PK of the ***referenced relation*** R_2.
  - A tuple t_1 in R_1 is said to **reference** a tuple t_2 in R_2 if $t_1[FK] = t_2[PK]$.



PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

Can Reorganization's Dnum be 7 in PROJECT?

Can Reorganization's Dnum be NULL?

Referential Integrity Constraint

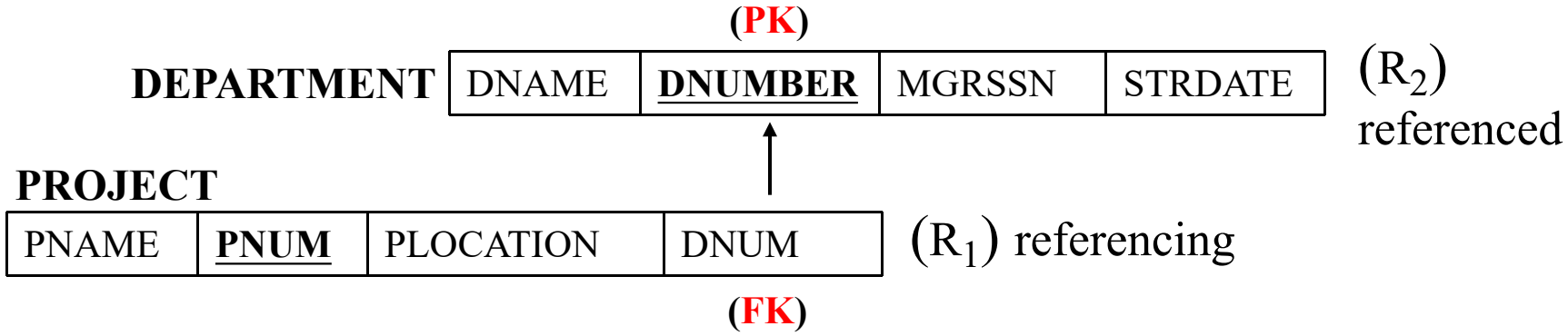
- **Referential Integrity Constraint**

  The value in the foreign key column (or columns) FK of the **referencing relation** R_1 can be either:

  (1) a value of an existing primary key value of the corresponding primary key PK in the **referenced relation** $R_{2,}$, or

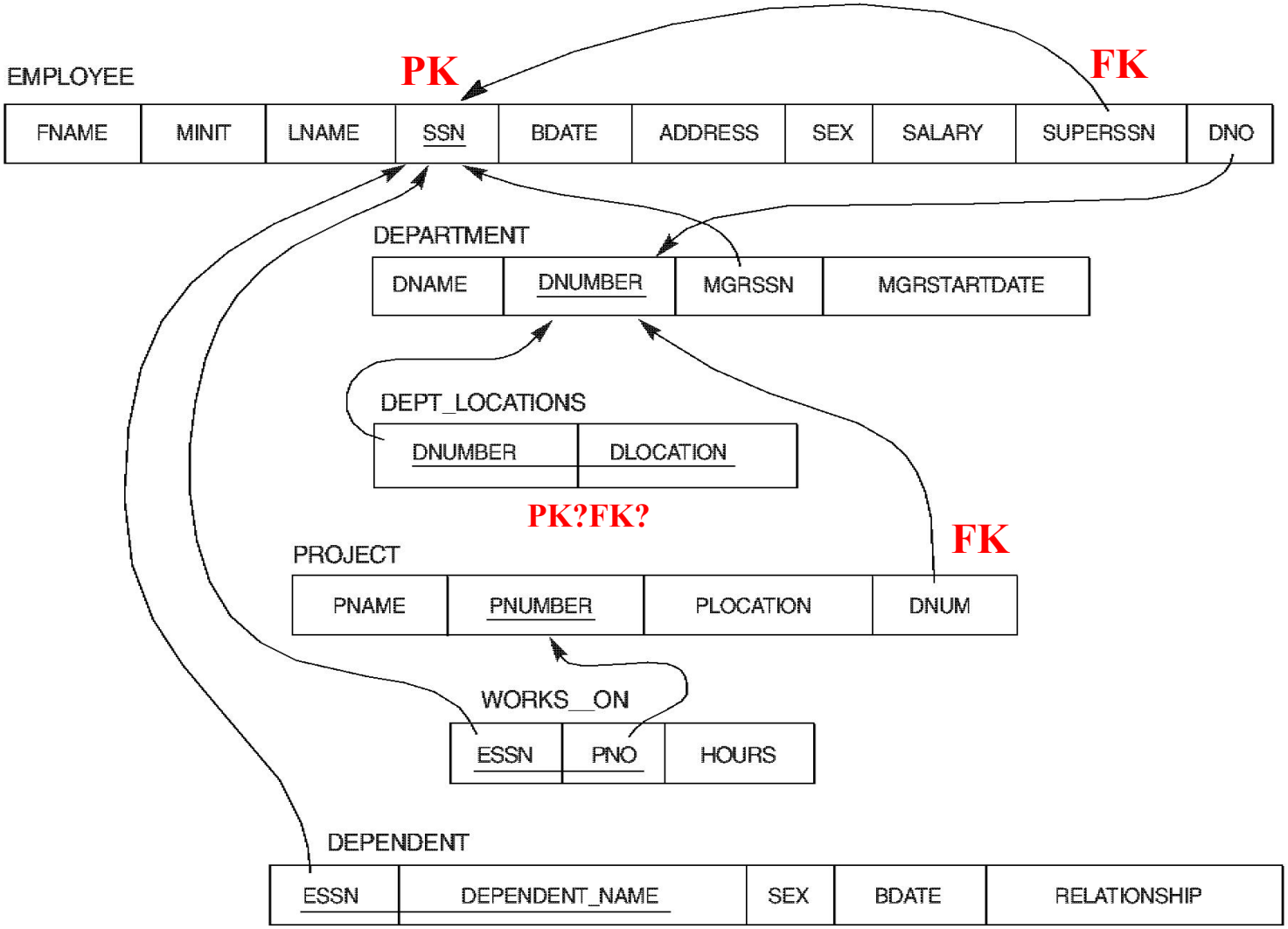
  (2) a null.

- In case (2), the FK in R_1 should not be a part of its own primary key.



A referential integrity constraint can be displayed in a relational database schema as a directed arc from R_1.FK to R_2.PK.

Figure 5.7 Referential integrity constraints displayed on the COMPANY relational database schema diagram.



Other Types of Constraints

- **Semantic Integrity Constraints:**

  based on application semantics and cannot be expressed by the model per se

  "the maximum number of hours per employee for all projects he or she works on is 56 hrs per week"

- A *constraint specification language* may have to be used to express these.
- SQL-99 allows triggers and ASSERTIONS to allow for some of these

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0

Can the following constraints express the above constraint?

1. **Key** constraints
2. **Entity integrity** constraints
3. **Referential integrity** constraints

Update Operations on Relations

- Update operations
  - INSERT a tuple.
  - DELETE a tuple.
  - MODIFY a tuple.
- Integrity constraints should not be violated by the update operations.
- Updates may ***propagate*** to cause other updates automatically. This may be necessary to maintain integrity constraints.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

1. **Key** constraints
2. **Entity integrity** constraints
3. **Referential integrity** constraints

Update Examples

1. Update the DNO of the EMPLOYEE ‘999887777’ TO 7

EMPLOYEE (PK) (FK) (FK)

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Update

DEPARTMENT (PK) (FK)

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0

(FK) (FK)

1. **Key** constraints
2. **Entity integrity** constraints
3. **Referential integrity** constraints (FK→PK)

Update Examples

2. Delete the EMPLOYEE tuple with SSN='333445555'

Delete →

EMPLOYEE (PK) (FK) (FK)

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT (PK) (FK)

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0

(FK) (FK)

1. **Key** constraints
2. **Entity integrity** constraints
3. **Referential integrity** constraints (FK→PK)

Update Examples

3. Update the SALARY of the EMPLOYEE tuple with SSN='888665555' to 60000.

4. Delete the WORKS_ON tuple with ESSN='123456789' and PNO=1.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

3. Modify to 60000

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

WORKS_ON

4. Delete

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0

1. **Key** constraints
2. **Entity integrity** constraints
3. **Referential integrity** constraints (FK→PK)

Update Operations on Relations

- In case of integrity violation, several actions can be taken:
  - Cancel the operation that causes the violation (**REJECT** option)
  - Perform the operation but inform the user of the violation
  - Trigger additional updates so the violation is corrected (**CASCADE** option, **SET NULL** option, **SET DEFAULT** option)
  - Execute a user-specified error-correction routine

EMPLOYEE (PK) (FK) (FK)

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

Delete

Modify

DEPARTMENT (PK) (FK)

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0

(FK) (FK)

In-Class Exercise

(Taken from Exercise in the textbook)

Consider the following relations for a database that keeps track of student enrollment in courses and the books adopted for each course:

STUDENT(SSN, Name, Major, Bdate)

COURSE(Course#, Cname, Dept)

ENROLL(SSN, Course#, Quarter, Grade)

BOOK_ADOPTION(Course#, Quarter, Book_ISBN)

TEXT(Book_ISBN, Book_Title, Publisher, Author)

Draw a relational schema diagram specifying the foreign keys for this schema.