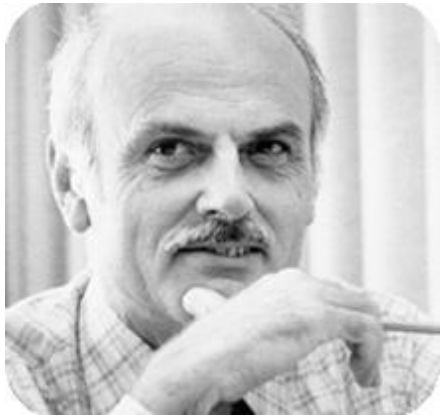
Chapter 5: The Relational Data Model and Relational Database Constraints

Introduction

- The **relational model** is first proposed by Dr. Codd of IBM research in 1970:
  - "A Relational Model for Large Shared Data Banks", *Communication of the ACM, June 1970*

- He was presented with the **Turing Award** on Nov. 9, 1981

  " for his fundamental and continuing contribution to the theory and practice of database management systems"



Introduction (cont.)

- A **relation** is a mathematical concept based on the ideas of **sets**

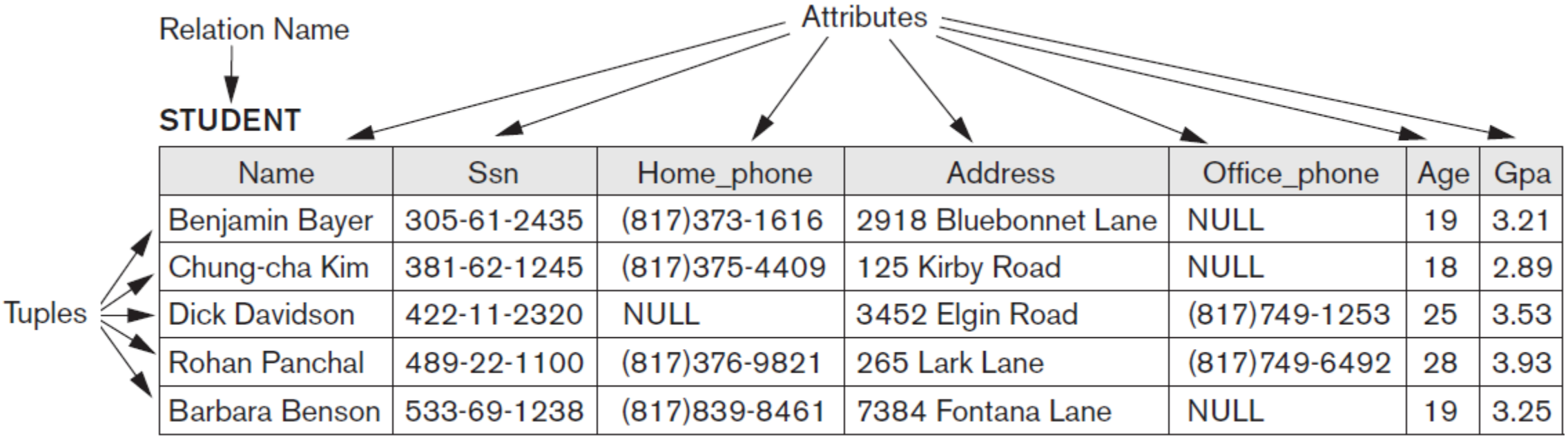
- The strength of the Relational model comes from the formal foundation of **relation**, which has its theoretical basic in **set theory**
  - Union, interest, project, Cartesian product

Objectives

- Describing the **basic principles** of the relational model of data
  - Concepts, notation, characteristics
- Discussion of relational **constraints**
  - An important part, automatically enforced in most relational DBMSs
- Defines the update operations. Violations of integrity constraints

Informal Definitions

- The **relational model** represents the database as a collection of ***relations***
- Informally, a **relation** resembles a table of values



Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Rohan Panchal	489-22-1100	(817)376-9821	265 Lark Lane	(817)749-6492	28	3.93
Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25

Informal Definitions - Domain

- Each attributes has a **domain** or a set of valid values:
  - Example: “USA_phone_numbers” are the set of 10 digit phone numbers valid in the U.S.

- **Logical definition** of domain
  - “Social_security_numbers”, The set of valid nine-digit Social Security numbers.
  - Academic_department_codes. The set of academic department codes, such as ‘CS’, ‘ECON’, and ‘PHYS’.

- A common method of specifying a domain:
  - Specify a **data type** from which the data values forming the domain are drawn
  - *phone-number*: *(ddd)-ddd-dddd*, where each d is a decimal digit.

Formal Definitions

- Formally,
  - Given $R(A_1, A_2, ..., A_n)$
  - $r(R) \subset$ dom (A_1) X dom (A_2) X ....X dom(A_n)

- $R(A_1, A_2, ..., A_n)$ is the schema of the relation
- R is the name of the relation
- $A_1, A_2, ..., A_n$ are the attributes of the relation
- $r(R)$: a specific state of relation R – this is a set of tuples (rows)
  - $r(R) = \{t_1, t_2, ..., t_n\}$ where each t_i is an n-tuple
  - $t_i = <v_1, v_2, ..., v_n>$ where each v_j is an element-of dom(A_j)

Formal Definitions - Example

- Let $R(A_1, A_2)$ be a relation schema:
  - A_1 = SSN, A_2 = Home_phone
  - Let dom(A_1) = Social_security_numbers
  - Let dom(A_2) = phone-number

- Then: dom(A_1) X dom(A_2) is all possible combinations:
  {<058723679, 404-757-8926> , <845768210, 678-92-1344> , ……}

- The relation state $r(R) \subset$ dom(A_1) X dom(A_2)
- For example: $r(R)$ could be {<058723679, 404-757-8926>}
  - This is one possible state of the relation R, defined over A_1 and A_2.

Formal Definitions – Example (cont.)

- Let $R(A_1, A_2)$ be a relation schema:
  - Let dom(A_1) = {0, 1}
  - Let dom(A_2) = {a, b, c}

- Then: dom(A1) X dom(A2) is all possible combinations:

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

- The relation state $r(R) \subset$ dom(A_1) X dom(A_2)
- For example: $r(R)$ could be {<0,a> , <0,b> , <1,c> }
  - This is one possible state of the relation R, defined over A1 and A2.
  - It has three 2-tuples: <0,a> , <0,b> , <1,c>

Characteristics of Relations — Ordering of Tuples

- Ordering of tuples in a relation *r*(*R*):
  - Tuples in a relation do not have any particular order

- Many tuple orders can be specified on the same relation

Figure 5.2
The relation STUDENT from Figure 5.1 with a different order of tuples.

STUDENT

Name	Ssn	Home_phone	Address	Office_phone	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
Rohan Panchal	489-22-1100	376-9821	265 Lark Lane	749-6492	28	3.93
Chung-cha Kim	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 Attributes

- Ordering of attributes in a relation schema *R* (and of values within each tuple):
  - An *n*-tuple is an ***ordered list*** of *n* values
  - Attributes in $R(A_1, A_2, ..., A_n)$ and the values in $t = <v_1, v_2, ..., v_n>$ is **ordered**

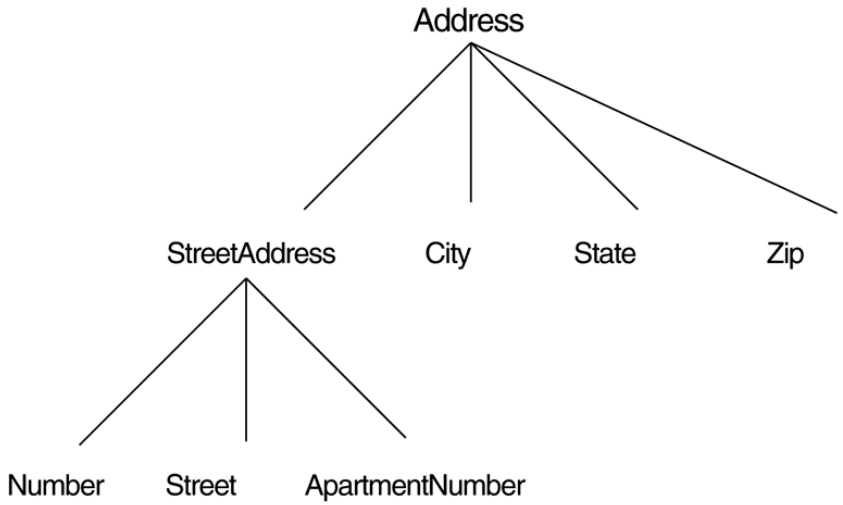
- However, for **self-describing data**, no ordering!

$t = <$ (Name, Dick Davidson),(Ssn, 422-11-2320),(Home_phone, NULL),(Address, 3452 Elgin Road),
(Office_phone, (817)749-1253),(Age, 25),(Gpa, 3.53)>

$t = <$ (Address, 3452 Elgin Road),(Name, Dick Davidson),(Ssn, 422-11-2320),(Age, 25),
(Office_phone, (817)749-1253),(Gpa, 3.53),(Home_phone, NULL)>

Characteristics of Relations — Attribute Values and Nulls

- **Values** in the tuples:
  - All values are considered **atomic** (indivisible).
  - Composite and multivalued attributes are **not** allowed



Multivalued attributes — represented by separate relations

Composite attributes — represented only be their simple component attributes

  - A special **null** value is used to represent values that are unknown or inapplicable to certain tuples.

Atomic Attributes

- Attribute values should be atomic
  - Present a single fact

- Allows for:
  - Simpler programming,
  - Greater reusability of data
  - Easier to implement changes

Atomic Attribute Example

Instead of 1 overloaded attribute:

VariableName = “Dissolved Oxygen, mg/L, surface water”

You might use three:

VariableName = “Dissolved Oxygen”
Units = “mg/L”
SampleMedium = “surface water”

Common Attribute Atomicity Violations

- Simple aggregation: Address = “8200 Old Main Hill, Logan, UT, 84322”

- Complex codes: VariableCode = “DO_mgL_Avg”

- Mixed domains: Where the value of an attribute can have different meaning under different conditions.

Characteristics of Relations — Attribute Values and Nulls (cont.)

- **Nulls** in the tuples:
  - A special **null** value is used to represent values that are **unknown** or **may not apply** to certain tuples.

Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
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Barbara Benson	533-69-1238	(817)839-8461	7384 Fontana Lane	NULL	19	3.25

Characteristics of Relations — Interpretation of a Relation

- **Relational model** represents facts about both **entities** and **relationships** *uniformly* as **relations**
  - Example: STUDENT (Name, Ssn, Home_phone, Address, Age, Gpa)
  - Example: MAJORS (Student_ssn, Department_code)

Categories of DB Constraints

- There are generally many **restrictions** or **constraints** on the actual values in a database state

- Constraints can be divided
  - Inherent model-based constraints (implicit constraints)
  - Schema-based constraints (explicit constraints)
  - Application-based constraints (semantics constraints)

Inherent Model-based Constraints

- Refers to the constraints associated with model itself
  - Examples
    - No duplicate tuples allowed
    - Ordering of values within a tuple

The **characteristics** of relations are the inherent constraints

Schema-based Constraints

- Constraints that can be directly expressed in the schemas
  - Key Constraints
  - Constraints on Null values
  - Entity Integrity Constraints
  - Referential Integrity Constraints

Key Constraints

- **Superkey** of R:
  - Subset of attributes SK of *R* with the following condition (uniqueness constraint):
    - No two tuples in any valid relation state *r*(*R*) will have the same value for SK
    - That is, for any distinct tuples t_1 and t_2 in *r*(*R*), $t_1[SK] \neq t_2[SK]$
    - Every relation has at least one default supersky?

- **Key** of R:
  - Uniqueness constraint
  - A "minimal" superkey (no redundancy)
  - Time-invariant

Key Constraints (cont.)

- Example: Consider the STUDENT relation schema:
  - CAR(Name, Ssn, Home_phone, Address, Office_phone, Age, Gpa)
    - Key = {Ssn}
  - Any set of attributes that includes Ssn is a superkey
    - Example, {Ssn, Name, Age} is a superkey
    - But not a key
- Property of Key: time-invariant
- If a relation has several **candidate keys**, one is chosen arbitrarily to be the **primary key**.
  - The primary key attributes are <u>underlined</u>.

Key Constraints (cont.)

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

CAR

License_number	Engine_serial_number	Make	Model	Year
Texas ABC-739	A69352	Ford	Mustang	02
Florida TVP-347	B43696	Oldsmobile	Cutlass	05
New York MPO-22	X83554	Oldsmobile	Delta	01
California 432-TFY	C43742	Mercedes	190-D	99
California RSK-629	Y82935	Toyota	Camry	04
Texas RSK-629	U028365	Jaguar	XJS	04

Not-Null Constraints

- Specifies whether NULL values **are** or **are not** permitted
  - Example: if every STUDENT tuple must have a valid, non-NULL value for the Name attribute
  - then Name of STUDENT is constrained to be NOT NULL.

Relational Database Schema

- **Relational Database Schema:**
  - A set *S* of relation schemas that belong to the same database.
  - *S* is the name of the whole **database schema**
  - $S = \{R_1, R_2, ..., R_n\}$
  - $R_1, R_2, \ldots, R_n$ are the names of the individual **relation schemas** within the database S

- Following slide shows a COMPANY database schema with 6 relation schemas

Company Database Schema

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Figure 5.5
Schema diagram for the COMPANY relational database schema.

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

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

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

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

DEPT_LOCATIONS

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

Entity Integrity Constraints

- **Entity Integrity:**
  - Primary key must exist, be unique, and **not null**

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

Referential Integrity Constraints

- A constraint involving **two** relations
  - The previous constraints involve a single relation

- Used to specify a **relationship** among tuples in two relations:
  - A tuple in one relation that refers to another relation must refer to an ***existing*** tuple in that relation
  - Maintain the **consistency** among tuples in the two relations

Referential Integrity Constraints (cont.)

- A set of attributes FK in R_1 is a **foreign key** of R_1 that **references** R_2 if it satisfies:
  - FK **refer** to PK, where PK is primary key of R_2 (i.e., FK and PK have the same domain)
  - A tuple t_1 in R_1 is said to reference a tuple t_2 in R_2 if $t_1[\text{FK}] = t_2[\text{PK}]$.

Referential Integrity Constraints (cont.)

referencing relation

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

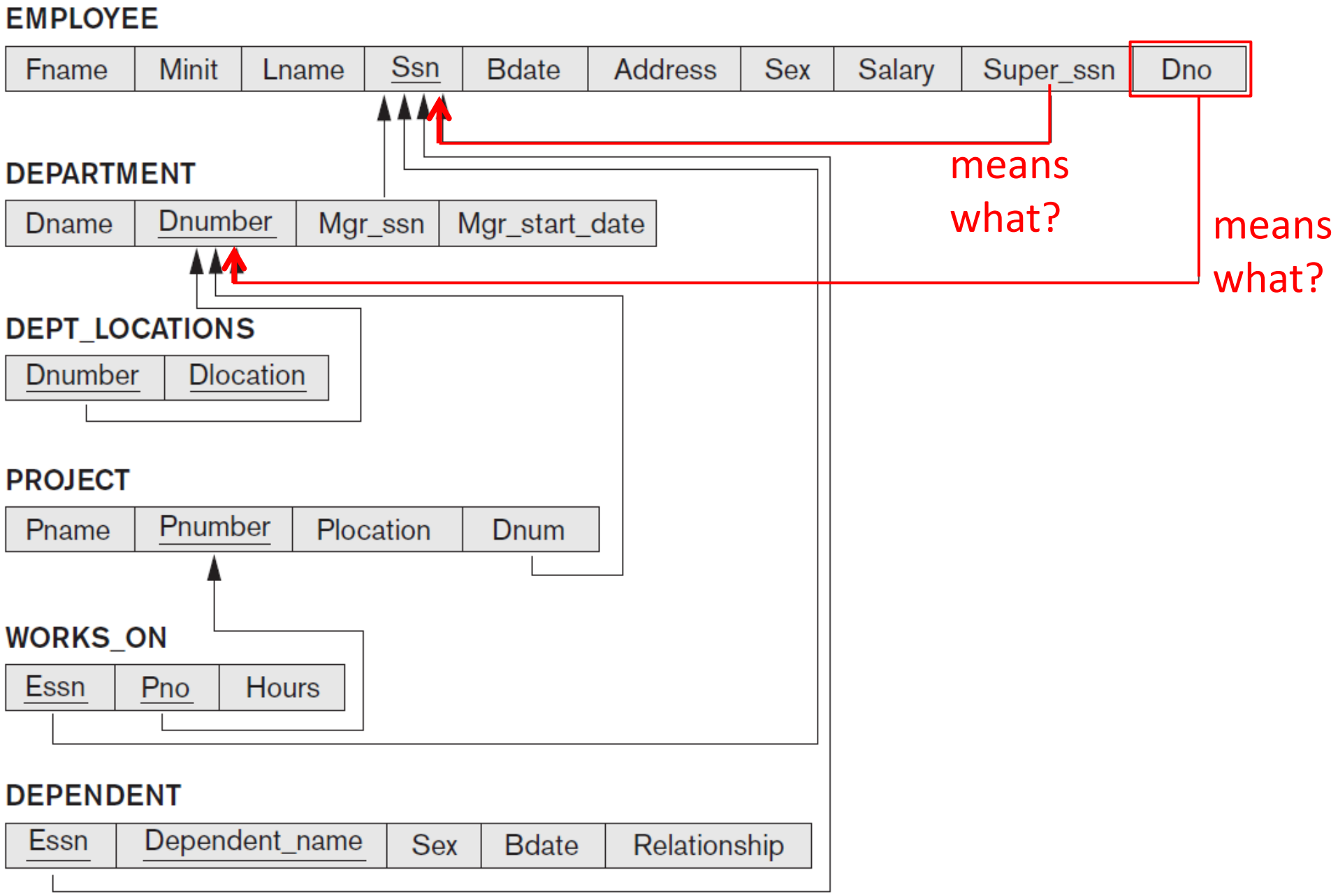
A referential integrity constraint from R1 to R2 is said to hold

referenced relation

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

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



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

Semantics integrity constraints

- A general constraints
  - Examples of constraints
    - *The salary of an employee should not exceed the salary of the employee's supervisor*
    - *The maximum number of hours an employee can work on all projects per week is 56*
  - Difficult to specify
  - Enforced on DB using application program that update the database

Update Operations and Constraints Violations

- The main operation of DB can be divided
  - Updates (writing)
    - Insert, Delete, Modify
  - Retrievals (reading)

- Relational Algebra operations can be used for retrievals (discuss later)

- Discuss the types of constraints that may be violated and actions that may be taken if an operation causes a violation
  - Key constraints, entity integrity, referential integrity constraints

Possible violations for Insert operation

- INSERT may violate any of the constraints:
  - Domain constraint:
    - if one of the attribute values provided for the new tuple is not of the specified attribute domain
  - Key constraint:
    - if the value of a key attribute in the new tuple already exists in another tuple in the relation
  - Entity integrity:
    - if the primary key value is null in the new tuple
  - Referential integrity:
    - if a foreign key value in the new tuple references a primary key value that does not exist in the referenced relation

Example: Insert Violates Domain Contraint

- Insert

<‘Tom’, ‘K’, ‘Lee’, ‘258701245’, ‘1960-04-05’, ‘6357 Windy Lane, Katy, TX’, **1**, 28000, ‘987654321’, 4> into **Employee**

- *Result*: NOT OK because it violates the **Domain** constraint, rejected !!!

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

Example: Insert Violates Key Contraint

- Insert

<'Tom', 'K', 'Lee', '**999887777**', '1960-04-05', '6357 Windy Lane, Katy, TX', F, 28000, '987654321', 4> into **Employee**

- *Result*: NOT OK because it violates the **Key** constraint, rejected !!!

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

Example: Insert Violates Entity Integrity Constraint

- Insert

<‘Cecilia’, ‘F’, ‘Kolonsky’, **NULL**, ‘1960-04-05’, ‘6357 Windy Lane, Katy, TX’, F, 28000, NULL, 4> into **EMPLOYEE**

Result: NOT OK because it violates the **Entity integrity** constraint (Null for PK), rejected!!

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

Example: Insert Violates Referential Integrity Constraint

- Insert

<‘Cecilia’, ‘F’, ‘Kolonsky’, ‘677678989’, ‘1960-04-05’, ‘6357 Windswept, Katy, TX’, F, 28000, ‘987654321’, **7**>into **EMPLOYEE**

- *Result*: NOT OK: Violates Referential integrity constraint because DNO=7 does not exist; rejected!!!

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

Example: Insert Satisfies All Constraints

- Insert

<‘Cecilia’, ‘F’, ‘Kolonsky’, ‘677678989’, ‘1960-04-05’, ‘6357 Windy Lane, Katy, TX’, F, 28000, NULL, 4> into **EMPLOYEE**

OK: Satisfies all constraints; Accepted!!!

The Delete Operations

- Delete operation can violate only referential integrity
  - If the tuple being deleted is referenced by foreign keys from other tuples

- Example 1: Delete the WORKS_ON tuple with Essn = ‘999887777’ and Pno = 10
- Results: this deletion is acceptable and deletes exactly one tuple

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

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

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

DEPT_LOCATIONS

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

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

Example: Delete Violates Referential Integrity Constraint

- Example 2: Delete the EMPLOYEE tuple with Ssn = ‘999887777’
- Results: not acceptable!

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

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

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

DEPT_LOCATIONS

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

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

Operations for Delete Violation (cont.)

- **Set default**
  - Modify the referencing attribute values that cause the viol
  - Each such value is either set to NULL or changed to referen valid tuple

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	S
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	3
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	4
~~Alicia~~	~~J~~	~~Zelaya~~	~~999887777~~	~~1968-01-19~~	~~3321 Castle, Spring, TX~~	~~F~~	~~2~~

Changed to other valid values or to NULL

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

The Update (modify) operations

- Used to change the values of one or more attributes in a tuple
  - Need to specify a condition to select the tuple (or tuples) to be modified

- Examples 1:
  - Update the salary of the EMPLOYEE tuple with Ssn = ‘999887777’ to 28000.
  - Result: Acceptable.

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

The Update (modify) operations (cont.)

- Examples 2:
  - Update the Dno of the EMPLOYEE tuple with Ssn = ‘999887777’ to 1.
  - Result: Acceptable

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

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

The Update (modify) operations (cont.)

- Examples 4:
  - Update the Ssn of the EMPLOYEE tuple with Ssn = ‘999887777’ to ‘987654321’
  - Result: Unacceptable, violates primary key constraint; violates referential integrity constraints

Summary

- Presented Relational Model Concepts
  - Definitions
  - Characteristics of relations
- Discussed Relational Model Constraints and Relational Database Schemas
  - Domain constraints’
  - Key constraints
  - Entity integrity
  - Referential integrity
- Described the Relational Update Operations and Dealing with Constraint Violations