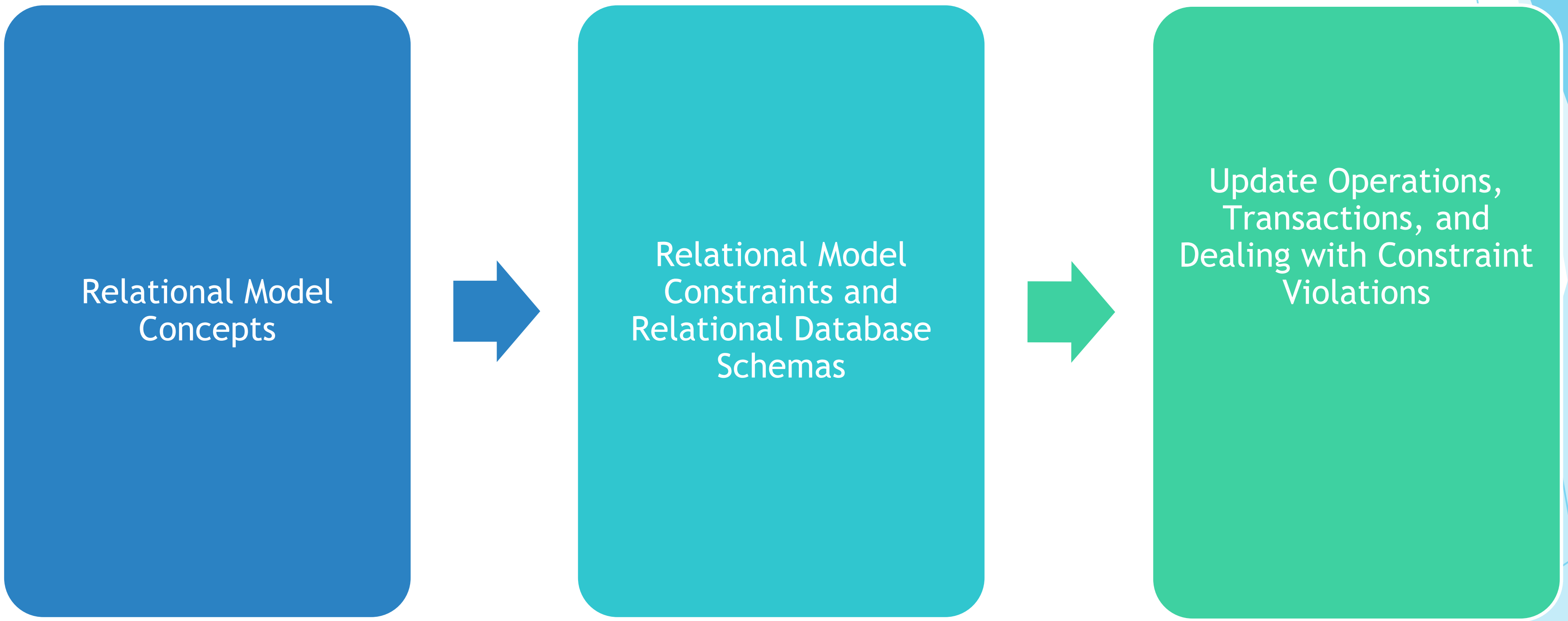
Chapter 5
The Relational Data Model and Relational Database Constraints

Content



Relational Model Concepts

Relational Model Constraints and Relational Database Schemas

Update Operations, Transactions, and Dealing with Constraint Violations

Relational Model Concepts

- Relational model: represents the database as **a collection of relations**. Each relation resembles a **table of values** or a **flat file of records**.
- It is called a flat file because each record has a simple linear or flat structure.
- Difference between relations & file will be discussed later.
- Row -> related data corresponding to real world entity.
- Column ->explain meaning of a value in each row (all values in a column have a same datatype).

Database terminologies:

Terms	Description
Tuple	A row
Attribute	A column header
Relation	Table
Domain of possible values	Data type - describing the types of values that can appear in each column

Relational Model Concepts

- **Domains, Attributes, Tuples, and Relations**

Domains

- Domain is a set of atomic values (that cannot be divided anymore).
- Examples:
  - **PTCL numbers** : set of 8 digits number valid in Pakistan (e.g., 31234567)
  - **Names**: The set of character strings that represent names of persons. (For example : 0 to 30)
  - **Grade_point_averages**: Possible values of computed GPA; each must be a real (floating-point) number between 0 and 4.
  - **Academic_department_names:** The set of academic department names in a university, such as Computer Science, Economics, and Physics.
- To specify a domain - specify a **domain name**, **data type, format used for storage** (e.g., date stored as dd/mm/yyyy),**unit of measurement** if any (e.g., kg/lb/m/cm etc.) from which the data values forming the domain are drawn (valid values which a data element may contain).

Relational Model Concepts

- **Domains, Attributes, Tuples, and Relations**

Attributes

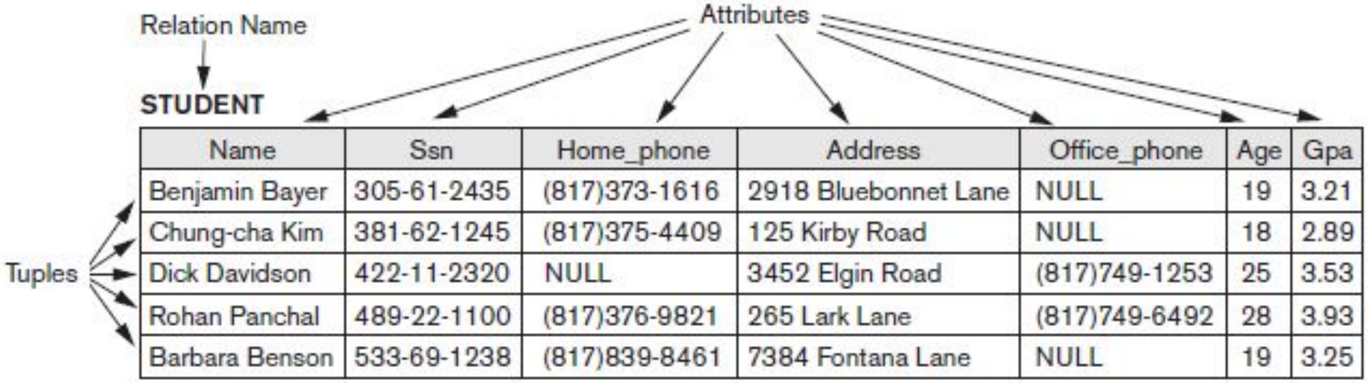
- A relation schema “R”, denoted by **R(A1, A2, … , An)**, is made up of a relation name “R” and a list of attributes, **A1, A2, … , An**.
- “D” is called the domain of **Ai** and is denoted by **dom(Ai)**. [dom(Attribute Name)]
- A relation schema is used to describe a relation;
  - “R” is called the **name of this relation**.
- The **degree (or arity)** of a relation = the number of attributes in a relation.
- A **relation of degree seven**, which stores information about university students, would **contain seven attributes** describing each student as follows:
  - STUDENT(Name, Ssn, Home_phone, Address, Office_phone, Age, Gpa)
- Using the data type of each attribute, the definition is sometimes written as:
  - STUDENT(Name: string, Ssn: string, Home_phone: string, Address: string, Office_phone: string, Age: integer, Gpa: real)

Relational Model Concepts

- **Domains, Attributes, Tuples, and Relations**

Tuples and Relations

- A **relation (or relation state)** r of the relation schema **R(A1, A2, … , An),** also denoted by r(R), is a set of n-tuples r = {t1, t2, … , tm}.
  - Tuples currently in the database
- Each n-tuple t is an ordered list of n values **t =<v1, v2, … , vn>**, where each value vi, 1 ≤ i ≤ n, is an element of dom (Ai) or is a special NULL value (values of a column w.r.t domain names).
- Figure shows an example of a STUDENT relation, which corresponds to the STUDENT schema specified.
- Each tuple in the relation represents a particular student entity (or object).
- Null values are unknown values or their values are not mentioned because if any reason.


Relation Name
Attributes
STUDENT
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
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

Figure 5.1
The attributes and tuples of a relation STUDENT.

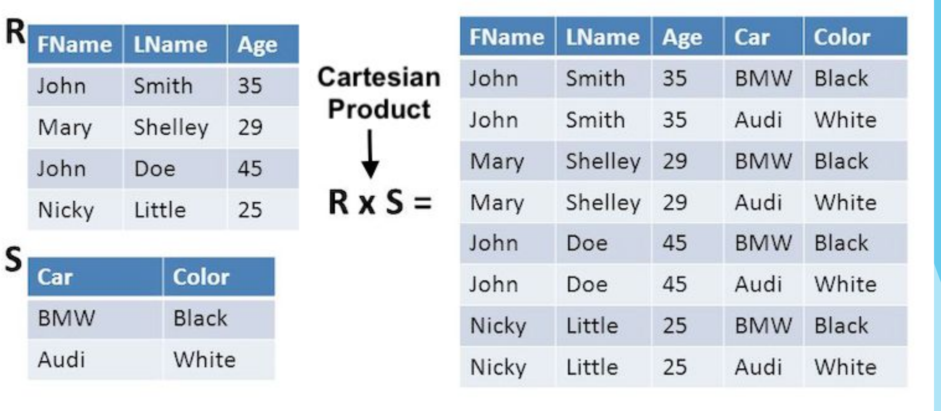
Relational Model Concepts

- **Domains, Attributes, Tuples, and Relations**

Tuples and Relations

- Definition of a relation can be restated using set theory concepts.
- “A relation (or relation state) r(R) is a mathematical relation of degree n on the domains dom(A1), dom(A2), … , dom(An), which is a subset of the Cartesian product (denoted by ×) of the domains that define R:
  - r(R) ⊆ (dom(A1) × dom(A2) × . . . × (dom(An))
- If we denote the total number of values, or cardinality, in a domain D by |D| (assuming that all domains are finite), the total number of tuples in the Cartesian product is

  |dom(A1)| × |dom(A2)| × . . . × |dom(An)|
- A relation state at a given time contains only the valid tuples that represent a particular state.
- Multiple attributes can have same domains. E.g., home phone or workphone.



R

FName	LName	Age
John	Smith	35
Mary	Shelley	29
John	Doe	45
Nicky	Little	25

S

Car	Color
BMW	Black
Audi	White

Cartesian Product

R x S =

FName	LName	Age	Car	Color
John	Smith	35	BMW	Black
John	Smith	35	Audi	White
Mary	Shelley	29	BMW	Black
Mary	Shelley	29	Audi	White
John	Doe	45	BMW	Black
John	Doe	45	Audi	White
Nicky	Little	25	BMW	Black
Nicky	Little	25	Audi	White

Relational Model Concepts

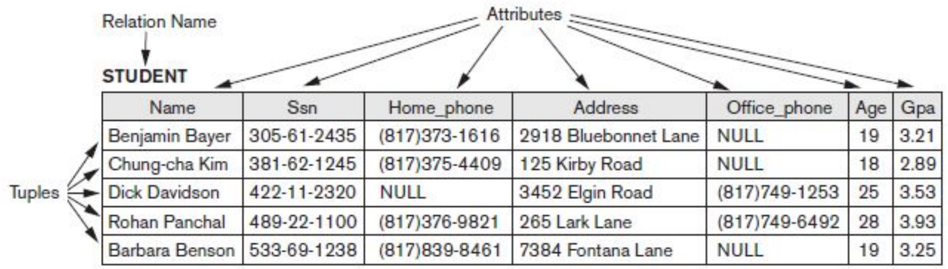
- **Domains, Attributes, Tuples, and Relations**

Tuples and Relations

- Let R(A1, A2) be a relation schema:
- Let dom(A1) = {0,1}
- Let dom(A2) = {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> }
- Hence, The relation state r(R) ⊆ dom(A1) X dom(A2)
  - For example: r(R) could be {<0,a> , <0,b> , <1,c> }
  - Or {<0,b> , <1,a> , <1,c> } etc.
- This is one possible state (or “population” or “extension”) r of the relation R, defined over A1 and A2.
- It has three 2D-tuples: <0,a> , <0,b> , <1,c>

Relational Model Concepts

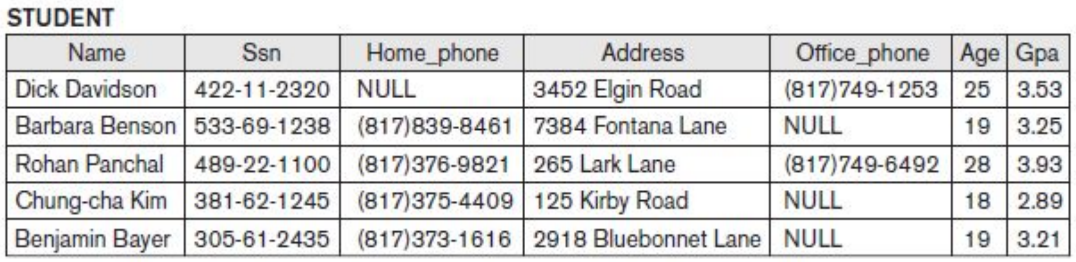
- **Characteristics of Relations**
- ***Ordering of Tuples in a Relation***
- Relation - a set of tuples
- **Elements of a set have no order among them;** hence, tuples in a relation do not have any particular order.
- In a **file**, records are physically stored on disk (or in memory), so there always **is an order among the records.** This ordering indicates first, second, ith, and last records in the file.
- Similarly, when we display a relation as a table, the rows are displayed in a certain order.
- For example, tuples in the STUDENT relation in Figure 5.1 could be ordered by values of Name, Ssn, Age, or some other attribute. The definition of a relation does not specify any order: There is no preference for one ordering over another.
- Hence, the relation displayed in Figure 5.2 is considered identical to the one shown in Figure 5.1.



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

Figure 5.1
The attributes and tuples of a relation STUDENT.

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

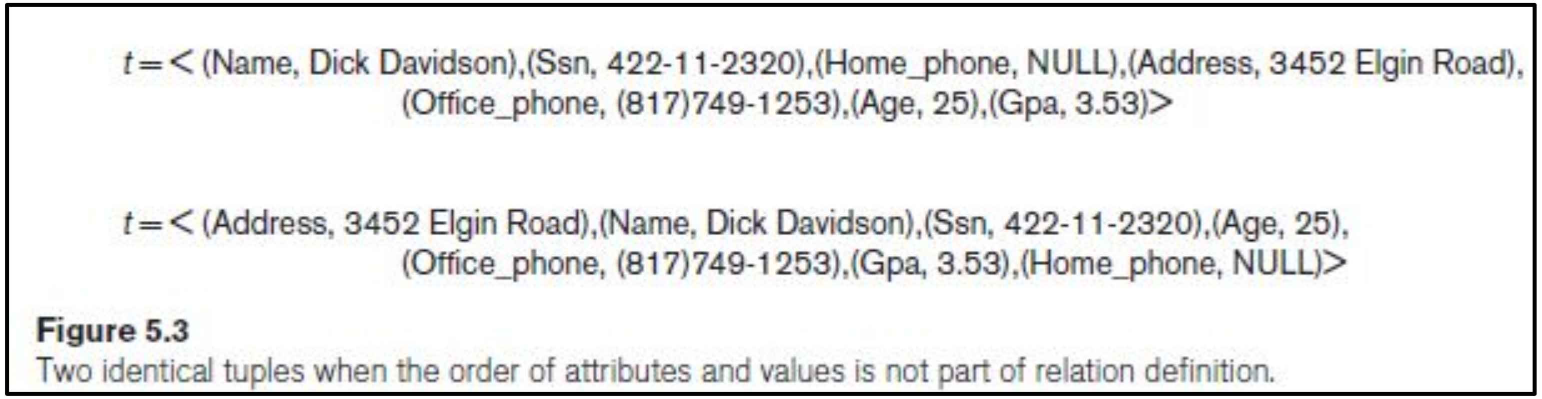


STUDENT

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

Relational Model Concepts

- **Characteristics of Relations**
- ***Ordering of Values within a Tuple***
- Ordering of values in tuple matters if it doesn’t mention the attribute along with values.
- A tuple can be considered as a set of **(<attribute>, <value>)** pairs, where each pair gives the value of the mapping from an attribute Ai to a value vi from dom(Ai).
- **In that case, The ordering of attributes is not important, because the attribute name appears with its value.**
- This makes sense at an abstract level, since there really is no reason to prefer having one attribute value appear before another in a tuple.



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)>

Figure 5.3
Two identical tuples when the order of attributes and values is not part of relation definition.

Self describing data

Relational Model Concepts

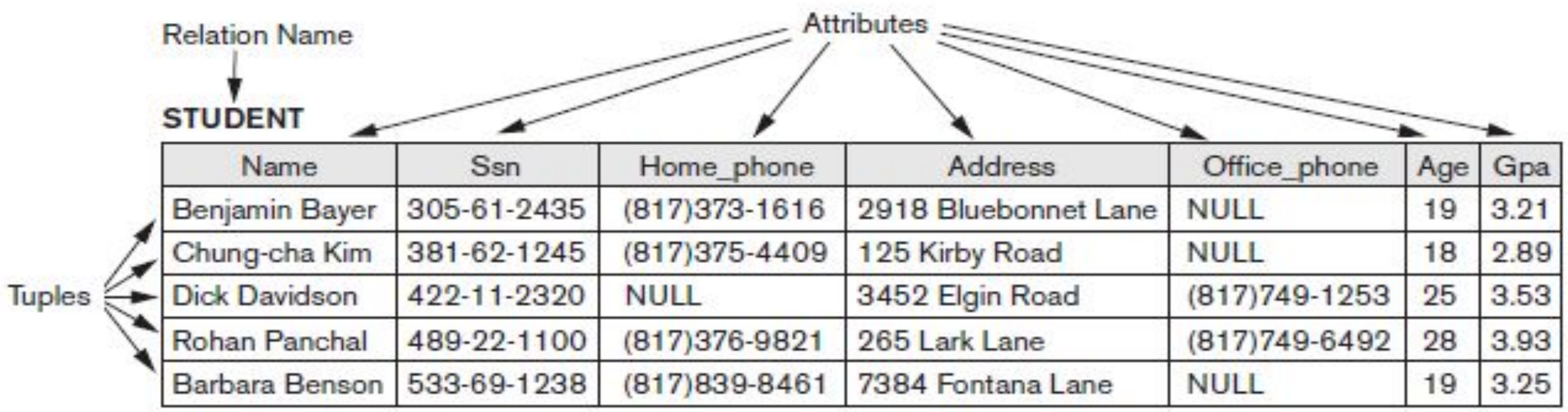
- **Characteristics of Relations**
- ***Values and NULLs in the Tuples.***
- Each attribute have an atomic value , no multivalued attributes are allowed.

Id	Name	Enrolled Courses
1	James Moriarty	Cl1002,Cl1003,CL1004

- An important concept is that of NULL values, which are used to represent the values of attributes that may be **unknown** or **may not apply to a tuple**. A special value, called **NULL**, is used in these cases.
- E.g., Some STUDENT tuples have NULL for their office phones because they do not have an office.
- E.g., Another student has a NULL for home phone, presumably because either he does not have a home phone or he has one but we do not know it (value is unknown).
- In general, we can have several meanings for NULL values, such as **value unknown**, **value exists but is not available**, or **attribute does not apply to this tuple** (also known as value undefined).
- Null values lead to ambiguities , so its best to remove null values in db. As two students having NULL as address doesn’t mean they reside on the same address.

Relational Model Concepts

- **Characteristics of Relations**
- ***Interpretation (Meaning) of a Relation***
- The relation schema can be interpreted as a declaration or a type of assertion.
- For example, the schema of the STUDENT relation of Figure 5.1 asserts that, in general, a student entity has a Name, Ssn, Home_phone, Address, Office_phone, Age, and Gpa.
- Each tuple in the relation can then be interpreted as a **fact** or a particular instance of the assertion.
  - For example, the first tuple in Figure 5.1 asserts the fact that there is a STUDENT whose Name is Benjamin Bayer, Ssn is 305-61-2435, Age is 19, and so on.



STUDENT

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

Figure 5.1
The attributes and tuples of a relation STUDENT.

Relational Model Concepts

- **Relational Model Notation**
- A relation schema R of degree n is denoted by R(A1, A2, … , An).
- The uppercase letters Q, R, S denote relation names.
- The lowercase letters q, r, s denote relation states.
- The letters t, u, v denote tuples.
- In general, the name of a relation such as STUDENT also indicates the current set of tuples in that relation—the current relation state—whereas STUDENT(Name, Ssn, …) refers only to the relation schema.
- An n-tuple t in a relation r(R) is denoted by t = <v1, v2, … , vn>, where vi is the value corresponding to attribute Ai. The following notation refers to component values of tuples:
- Both t[Ai] and t.Ai (and sometimes t[i]) refer to the value vi in t for attribute Ai.
- As an example, consider the tuple t = <'Barbara Benson', '533-69-1238', '(817)839-8461', '7384 Fontana Lane', NULL, 19, 3.25> from the STUDENT relation in Figure 5.1; we have t[Name] = <'Barbara Benson'>, and t[Ssn, Gpa, Age] = <'533-69-1238', 3.25, 19>.

Relational Model Constraints and Relational Database Schemas

- Relational constraints are the constraints on actual values in db
- Constraints on databases can generally be divided into three main categories:
- 1. Constraints that are inherent in the data model. We call these **inherent model-based constraints or implicit constraints**. (A relation cannot have duplicate tuples is an inherent constraint)
- 2. Constraints that can be directly expressed in the schemas of the data model, typically by specifying them in the DDL .We call these **schema-based constraints or explicit constraints**. (e.g., films have only one director)
- 3.Constraints that cannot be directly expressed in the schemas of the data model, and hence must be expressed and enforced by the application programs or in some other way. We call these **application-based or semantic constraints** or business rules. (e.g., this year’s salary increase can be no more than last year’s)
- 4. Another important category is data dependencies. That consists of functional dependence and multivalued dependence. Will discussed in normalization.

Relational Model Constraints and Relational Database Schemas

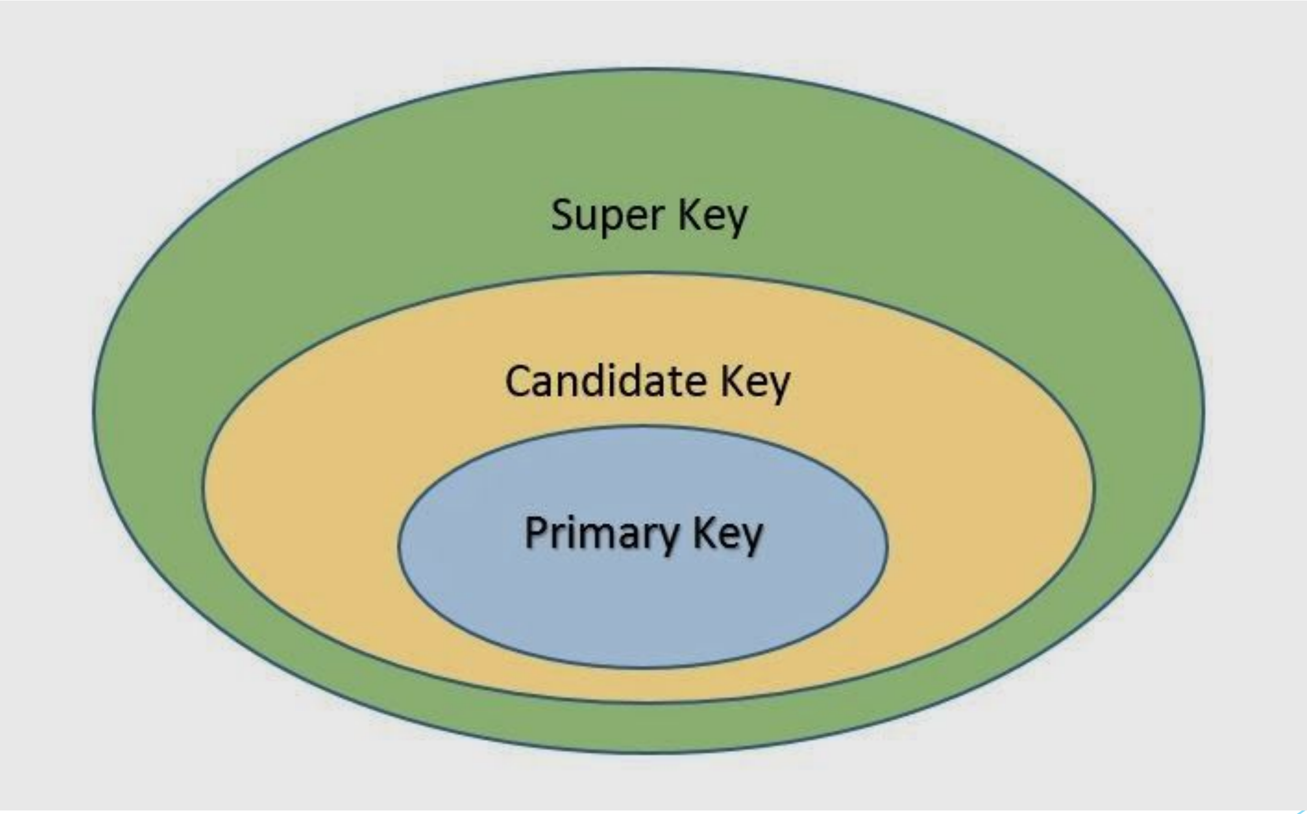
- The characteristics of relations discussed earlier belongs to inherent constraints.
- Schema based constraints include domain constraints, key constraints , null value constrains, entity integrity constraints & referential integrity constraints.

Relational Model Constraints and Relational Database Schemas

- **Domain Constraints**
- Domain constraints specify that within each tuple, the value of each attribute A must be an atomic value from the domain dom(A).
- The data types associated with domains typically include:
  - standard numeric data types for integers (such as short integer, integer and long integer)
  - real numbers (float and double-precision float)
- Characters, Booleans, fixed-length strings, and variable-length strings are also available, as are date, time, timestamp, and other special data types.

Relational Model Constraints and Relational Database Schemas

- **Key Constraints and Constraints on NULL Values**



Relational Model Constraints and Relational Database Schemas

- **Key Constraints and Constraints on NULL Values**

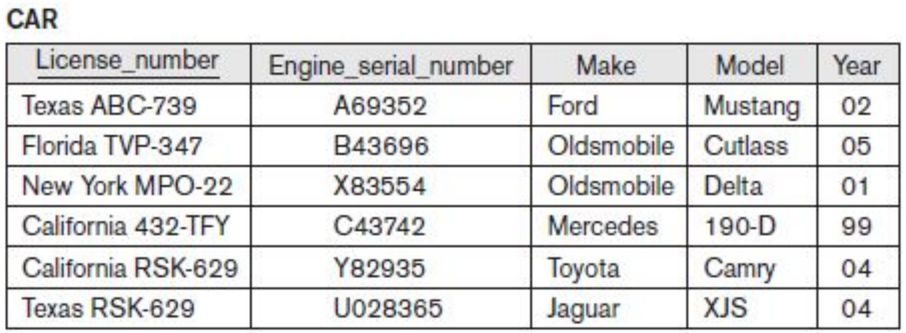
- A superkey SK specifies a uniqueness constraint that no two distinct tuples in any state r of R can have the same value for SK(here SK is 1 subset of attributes in a domain).
- Every relation has at least one default superkey— the set of all its attributes.
- Suppose that we denote one such subset of attributes by SK; then for any two distinct tuples t1 and t2 in a relation state r of R, we have the constraint that: $t1[SK] \neq t2[SK]$

Relational Model Constraints and Relational Database Schemas

- **Key Constraints and Constraints on NULL Values**
- A super key can have redundant attributes, however, so a more useful concept is that of a key, which has no redundancy.
- Hence, a key satisfies two properties:
  - 1. Two distinct tuples in any state of the relation cannot have identical values for (all) the attributes in the key. This uniqueness property also applies to a super key.
  - 2. It is a minimal super key—that is, a super key from which we cannot remove any attributes and still have the uniqueness constraint hold. This minimality property is required for a key but is optional for a super key.

Relational Model Constraints and Relational Database Schemas

- **Key Constraints and Constraints on NULL Values**
- A key is a super key but not vice versa.
- Consider the STUDENT relation. The attribute set {Ssn} is a key of STUDENT because no two student tuples can have the same value for Ssn. Any set of attributes that includes Ssn—for example, {Ssn, Name, Age}—is a superkey.
- In general, a relation schema may have more than one key. In this case, each of the keys is called a candidate key. For example, the CAR relation in Figure 5.4 has two candidate keys: License_number and Engine_serial_number.
- It is common to designate one of the candidate keys as the primary key of the relation. This is the candidate key whose values are used to identify tuples in the relation.



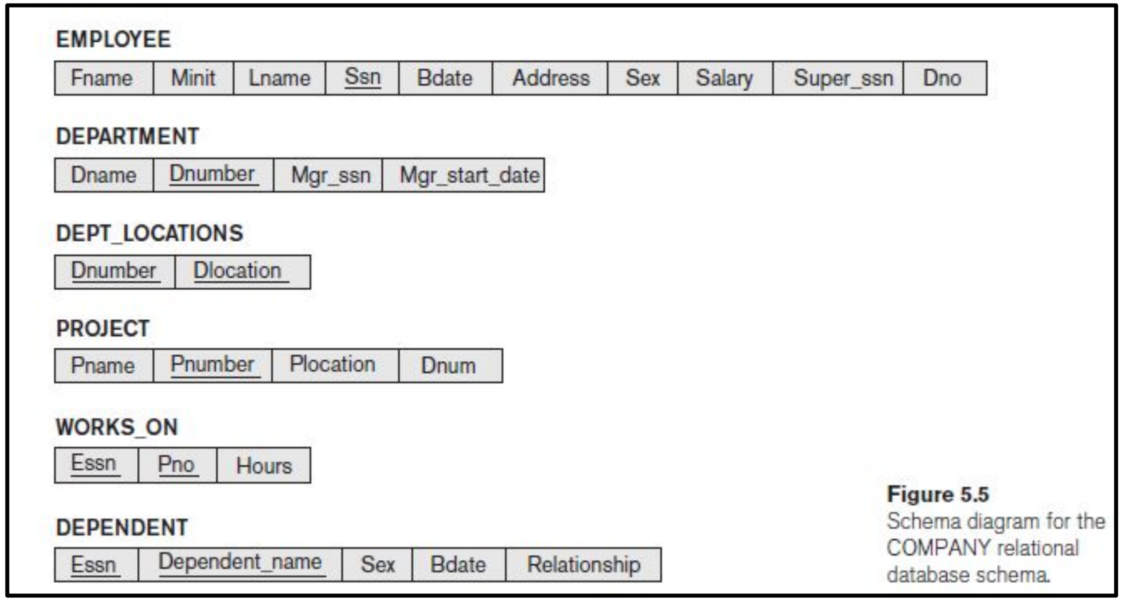
CAR

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

Figure 5.4
The CAR relation, with two candidate keys: License_number and Engine_serial_number.

Relational Model Constraints and Relational Database Schemas

- Relational Databases and Relational Database Schemas
- A relational database schema S is a set of relation schemas S = {R1, R2, … , Rm} and a set of integrity constraints.
- Figure 5.5 shows a relational database schema that we call COMPANY = {EMPLOYEE, DEPARTMENT, DEPT_LOCATIONS, PROJECT, WORKS_ON, DEPENDENT}. In each relation schema, the underlined attribute represents the primary key.



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.

Relational Model Constraints and Relational Database Schemas

- **Relational Databases and Relational Database Schemas**
- A relational database state DB of S is a set of relation states DB = {r1, r2, ..., rm} such that each ri is a state of Ri and such that the ri relation states satisfy the integrity constraints specified in IC.
- A relational database state is sometimes called a relational database snapshot or instance.
- A database state that does not meet the constraints is an invalid state.
- Each relation will have many tuples in its current relation state
- The relational database state is a union of all the individual relation states

Relational Model Constraints and Relational Database Schemas

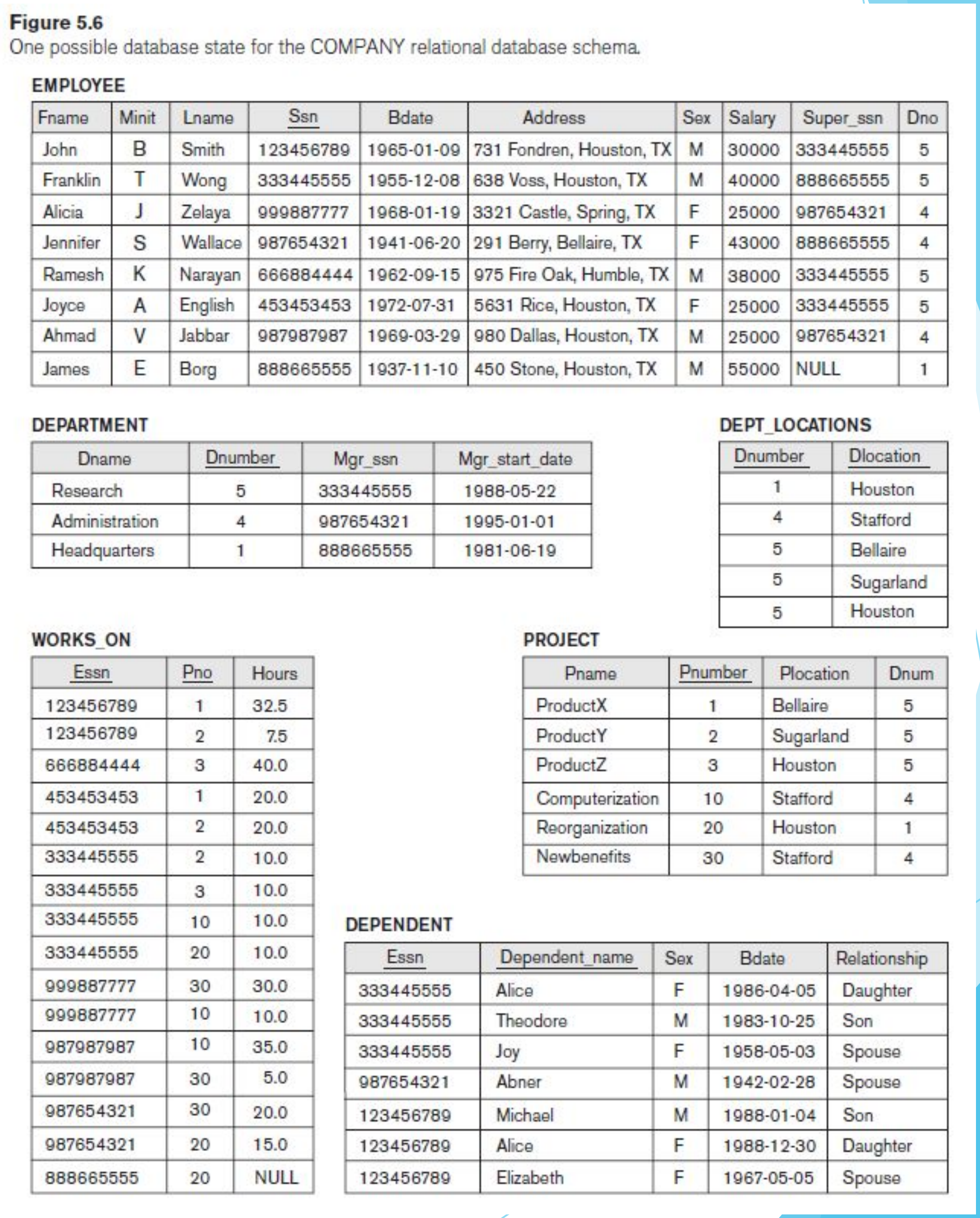


Figure 5.6
One possible database state for the COMPANY relational database schema.

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

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

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

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Entity integrity constraint***
- The **entity integrity constraint** states that no primary key value can be **NULL**. This is because the primary key value is used to identify individual tuples in a relation.
- Having NULL values for the primary key implies that we cannot identify some tuples.
  - For example, if two or more tuples had NULL for their primary keys, we may not be able to distinguish them if we try to reference them from other relations.

Relational Model Constraints and Relational Database Schemas

- Entity Integrity, Referential Integrity, and Foreign Keys
- *Referential integrity constraint*
- Key constraints and entity integrity constraints are specified on individual relations.
- The referential integrity constraint is specified between two relations and is used to maintain the consistency among tuples in the two relations.
- Referential integrity constraint states that a tuple in one relation that refers to another relation must refer to an existing tuple in that relation.
  - For example, in Figure 5.6, the attribute Dno of EMPLOYEE gives the department number for which each employee works; hence, its value in every EMPLOYEE tuple must match the Dnumber value of some tuple in the DEPARTMENT relation.

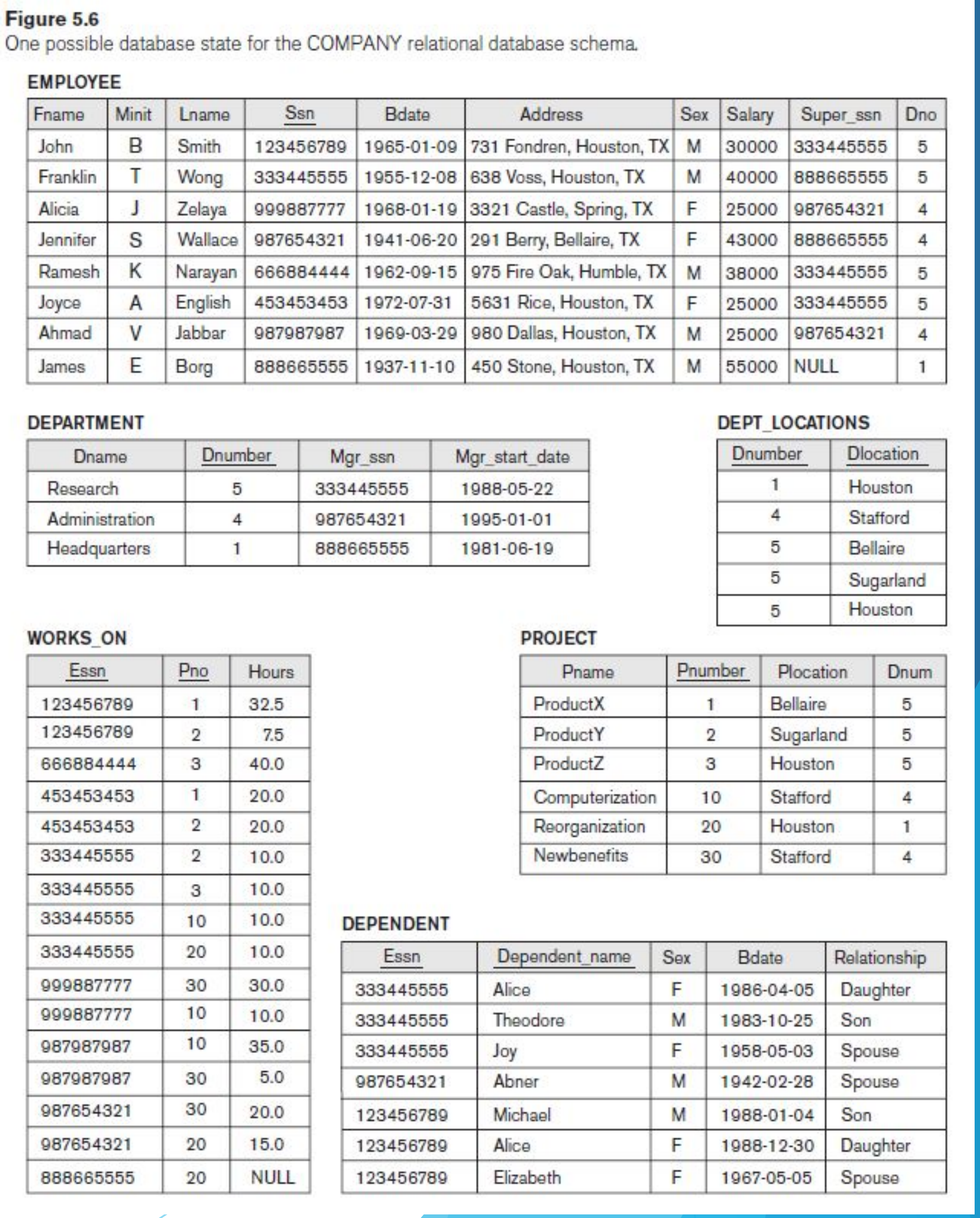


Figure 5.6
One possible database state for the COMPANY relational database schema.

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

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

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

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Referential integrity constraint***
- A set of attributes FK in relation schema R1 is a foreign key of R1 that references relation R2 if it satisfies the following rules:
- 1. The attributes in FK have the same domain(s) as the primary key attributes PK of R2.
- 2. A value of FK in a tuple t1 of the current state r1(R1) either occurs as a value of PK for some tuple t2 in the current state r2(R2) or is NULL.
- In the former case, we have t1[FK] = t2[PK], and we say that the tuple t1 refers to the tuple t2.
- In this definition, R1 is called the **referencing relation** and R2 is the **referenced relation**.

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Referential integrity constraint***
- In the EMPLOYEE relation, the attribute Dno refers to the department for which an employee works; hence, we designate Dno to be a foreign key of EMPLOYEE referencing the DEPARTMENT relation.
- This means that a value of Dno in any tuple t1 of the EMPLOYEE relation must match a value of the primary key of DEPARTMENT—the Dnumber attribute—in some tuple t2 of the DEPARTMENT relation,
- or
- the value of Dno can be NULL if the employee does not belong to a department or will be assigned to a department later.

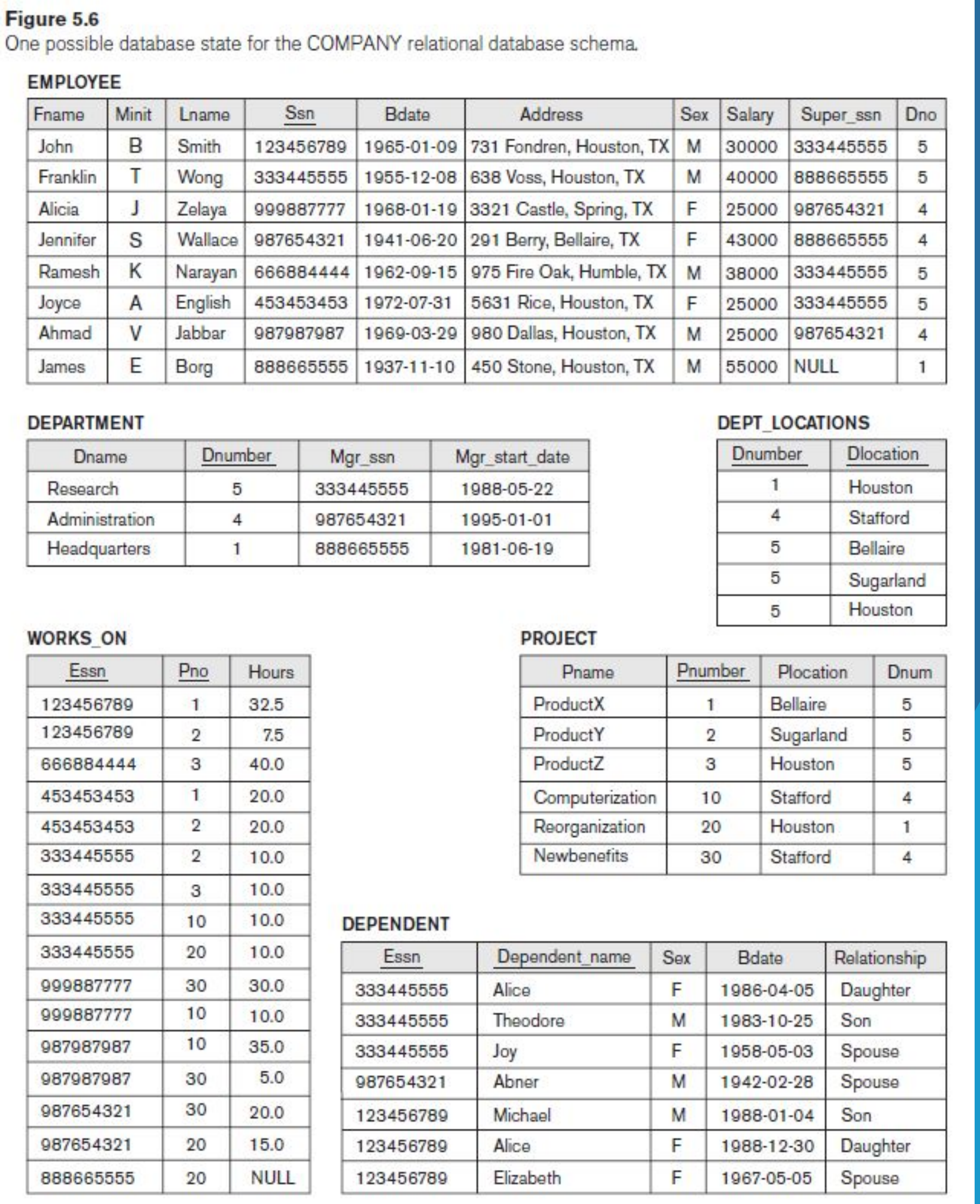


Figure 5.6
One possible database state for the COMPANY relational database schema.

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

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

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

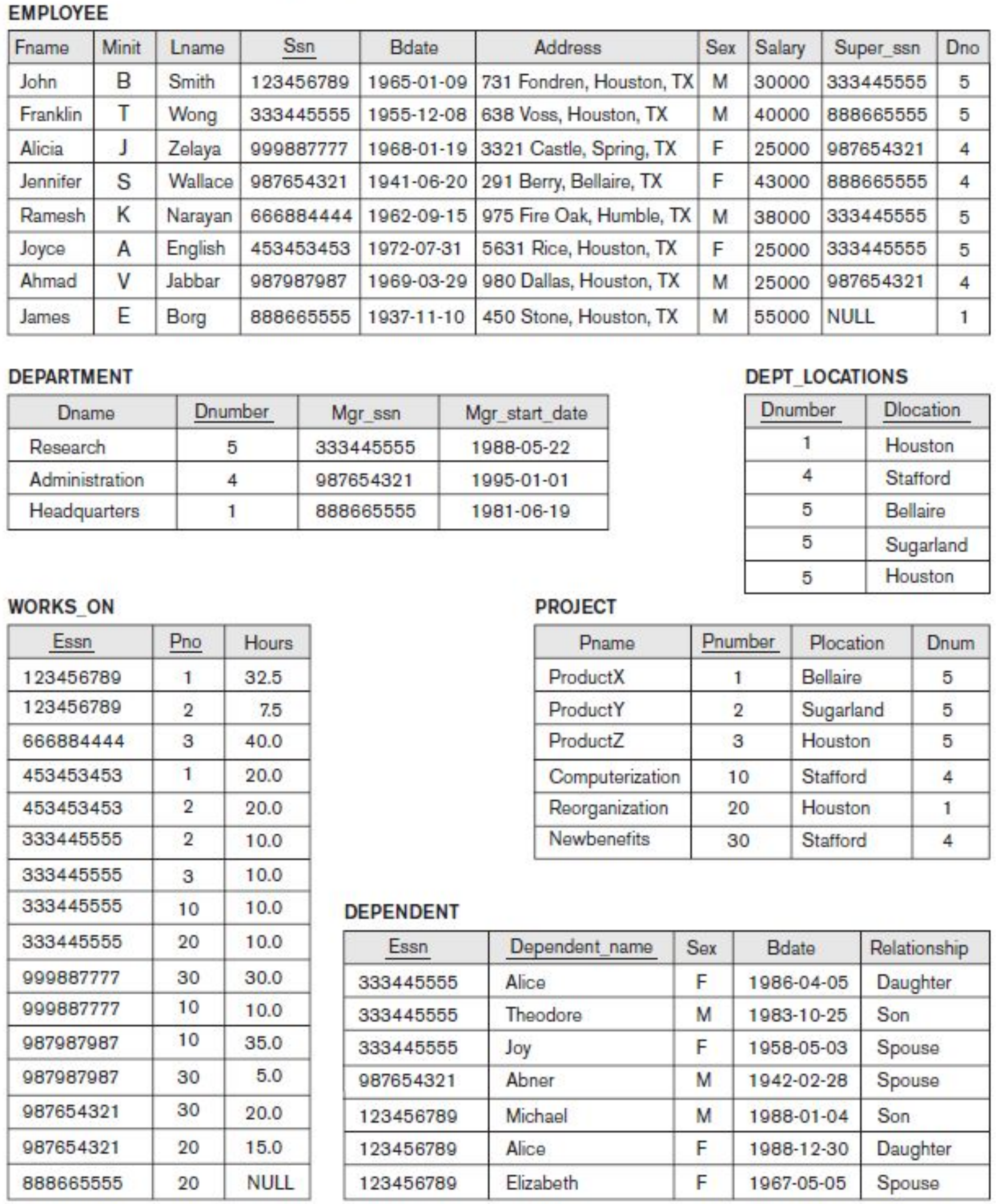
DEPENDENT

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

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Referential integrity constraint***
- Notice that a foreign key can refer to its own relation.
  - For example, the attribute Super_ssn in EMPLOYEE refers to the supervisor of an employee; this is another employee, represented by a tuple in the EMPLOYEE relation. Hence, Super_ssn is a foreign key that references the EMPLOYEE relation itself.
- In Figure 5.6 the tuple for employee ‘John Smith’ references the tuple for employee ‘Franklin Wong,’ indicating that ‘Franklin Wong’ is the supervisor of ‘John Smith’.

Figure 5.6
One possible database state 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

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

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

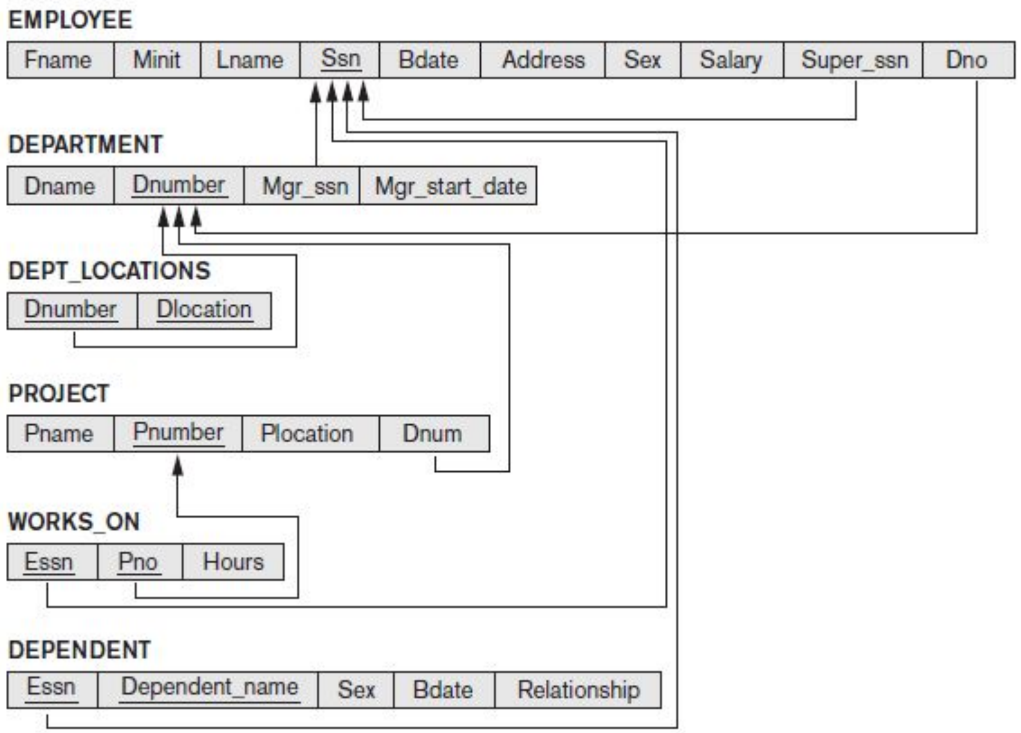
DEPENDENT

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

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Referential integrity constraint***

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

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

Relational Model Constraints and Relational Database Schemas

- **Entity Integrity, Referential Integrity, and Foreign Keys**
- ***Other Types of Constraints***
- General constraints, sometimes called semantic integrity constraints, are not part of the DDL and have to be specified and enforced in a different way. Examples of such constraints are the salary of an employee should not exceed the salary of the employee's supervisor and the maximum number of hours an employee can work on all projects per week is 56.
- Mechanisms called triggers and assertions can be used in SQL, through the CREATE ASSERTION and CREATE TRIGGER statements, to specify some of these constraints.
- The types of constraints we discussed so far may be called state constraints because they define the constraints that a valid state of the database must satisfy.
- Another type of constraint, called transition constraints, can be defined to deal with state changes in the database. An example of a transition constraint is: "the salary of an employee can only increase."

Update Operations, Transactions, and Dealing with Constraint Violations

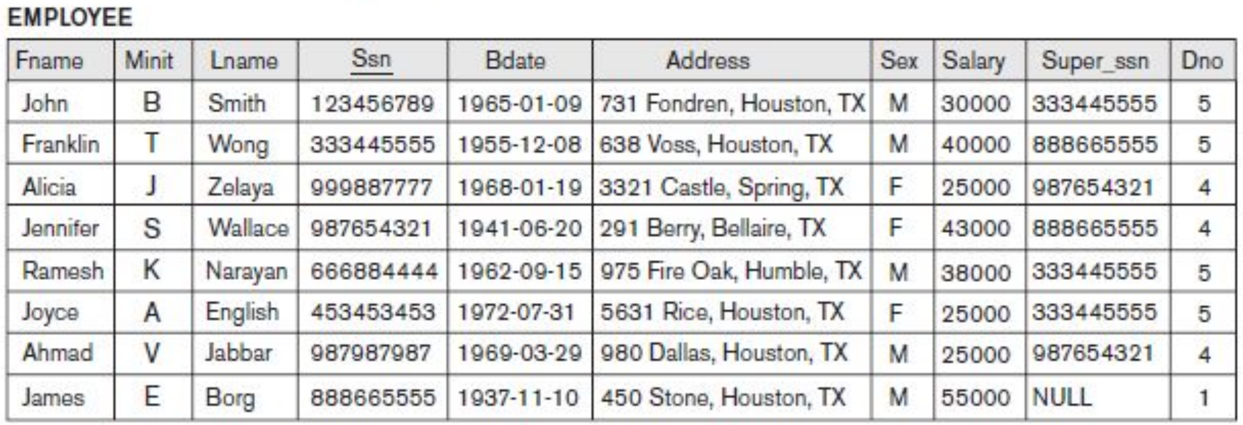
- There are three basic operations that can change the states of relations in the database:
- Insert, Delete, and Update (or Modify).
  - Insert is used to insert one or more new tuples in a relation
  - Delete is used to delete tuples
  - Update (or Modify) is used to change the values of some attributes in existing tuples.
- Whenever these operations are applied, the integrity constraints specified on the relational database schema should not be violated.

Update Operations, Transactions, and Dealing with Constraint Violations

- The Insert Operation
- The Insert operation provides a list of attribute values for a new tuple t that is to be inserted into a relation R. Insert can violate any of the four types of constraints.
  - **Domain constraints** can be violated if an attribute value is given that does not appear in the corresponding domain or is not of the appropriate data type.
  - **Key constraints** can be violated if a key value in the new tuple t already exists in another tuple in the relation r(R).
  - **Entity integrity** can be violated if any part of the primary key of the new tuple t is NULL.
  - **Referential integrity** can be violated if the value of any foreign key in t refers to a tuple that does not exist in the referenced relation.

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Insert Operation**
- Here are some examples to illustrate this discussion.
- ■ Operation:
- Insert <'Cecilia', 'F', 'Kolonsky', NULL, '1960-04-05', '6357 Windy Lane, Katy, TX', F, 28000, NULL, 4> into EMPLOYEE.



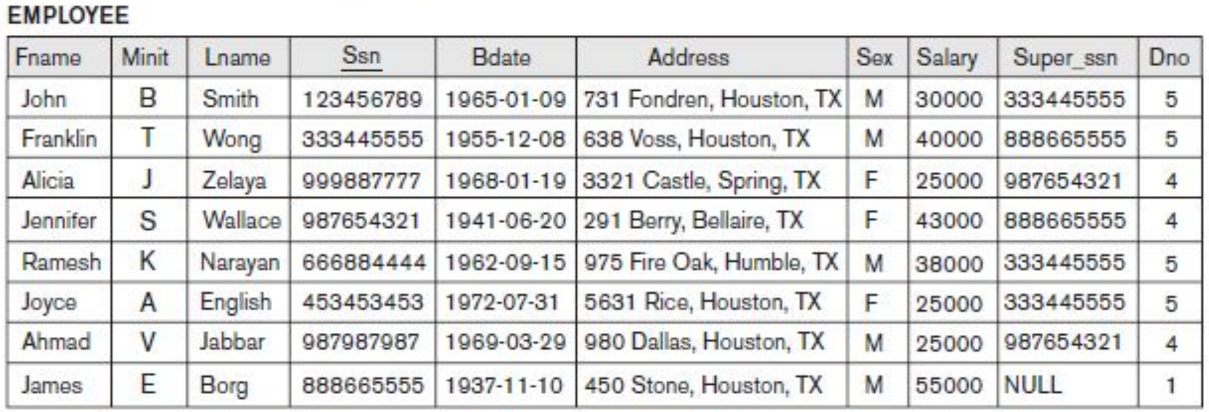
EMPLOYEE

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

- Result: This insertion violates the **entity integrity constraint (NULL for the primary key Ssn),** so it is rejected.

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Insert Operation**
- Here are some examples to illustrate this discussion.
- ■ Operation:
- Insert <‘Alicia’, ‘J’, ‘Zelaya’, ‘999887777’, ‘1960-04-05’, ‘6357 Windy Lane, Katy, TX’, F, 28000, ‘987654321’, 4> into EMPLOYEE.



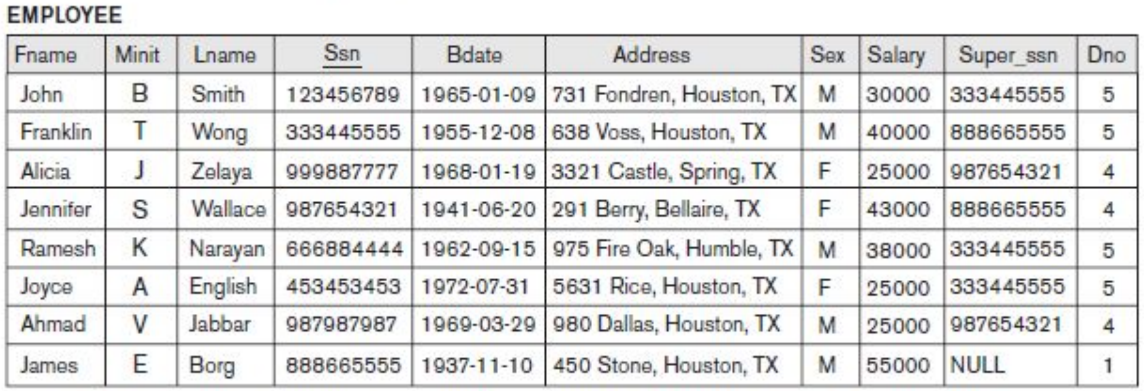
EMPLOYEE

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

- Result: This insertion violates the **key constraint** because another tuple with the same Ssn value already exists in the EMPLOYEE relation, and so it is rejected.

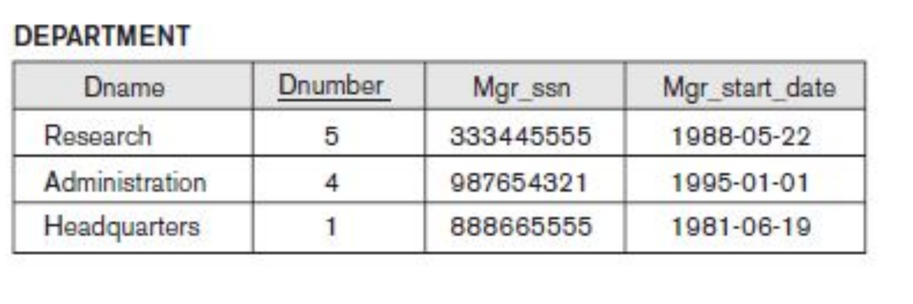
Update Operations, Transactions, and Dealing with Constraint Violations

- **The Insert Operation**
- Here are some examples to illustrate this discussion.
- ■ Operation:
- Insert <‘Cecilia’, ‘F’, ‘Kolonsky’, ‘677678989’, ‘1960-04-05’, ‘6357 Windswept, Katy, TX’, F, 28000, ‘987654321’, 7> into EMPLOYEE.



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



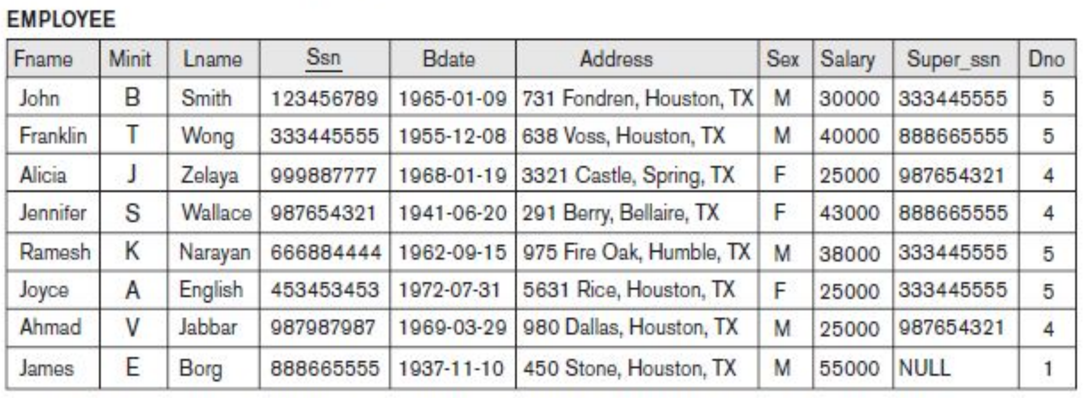
DEPARTMENT

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

- Result: This insertion violates the **referential integrity constraint** specified on Dno in EMPLOYEE because no corresponding referenced tuple exists inDEPARTMENT with Dnumber = 7.

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Insert Operation**
- Operation:
- Insert <'Cecilia', 'F', 'Kolonsky', '677678989', '1960-04-05', '6357 Windy Lane, Katy, TX', F, 28000, NULL, 4> into EMPLOYEE.
- Result: This insertion **satisfies all constraints**, so it is acceptable.
- Reject: If an insertion violates one or more constraints, the default option is to reject the insertion.



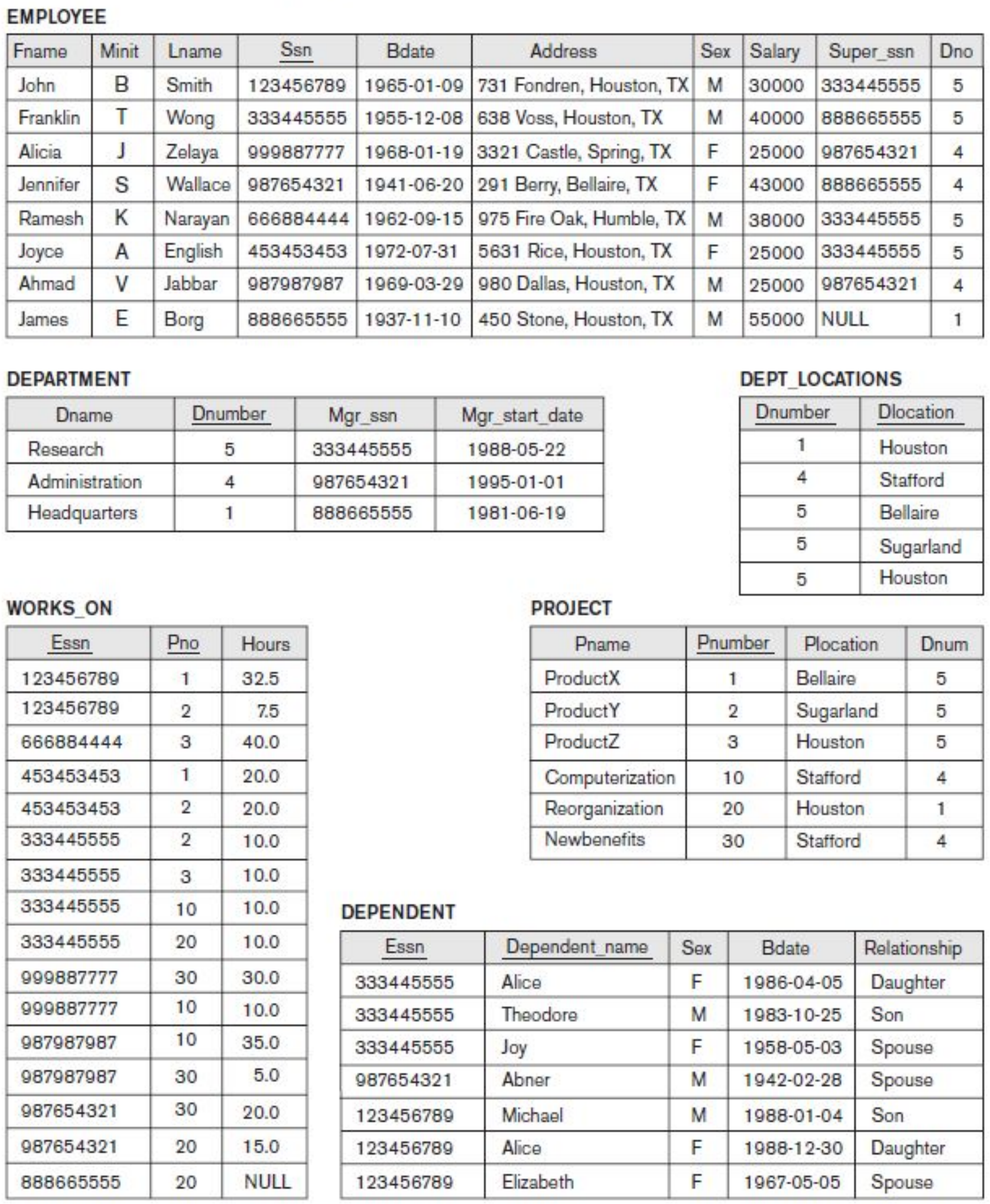
EMPLOYEE

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

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Delete Operation**
- The Delete operation can **violate only referential integrity**. This occurs if the tuple being deleted is referenced by foreign keys from other tuples in the database.
- Here are some examples.
- ■ Operation:
- Delete the WORKS_ON tuple with Essn = '999887777' and Pno = 10.
- Result: This deletion is acceptable and deletes exactly one tuple.

Figure 5.6
One possible database state 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

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

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

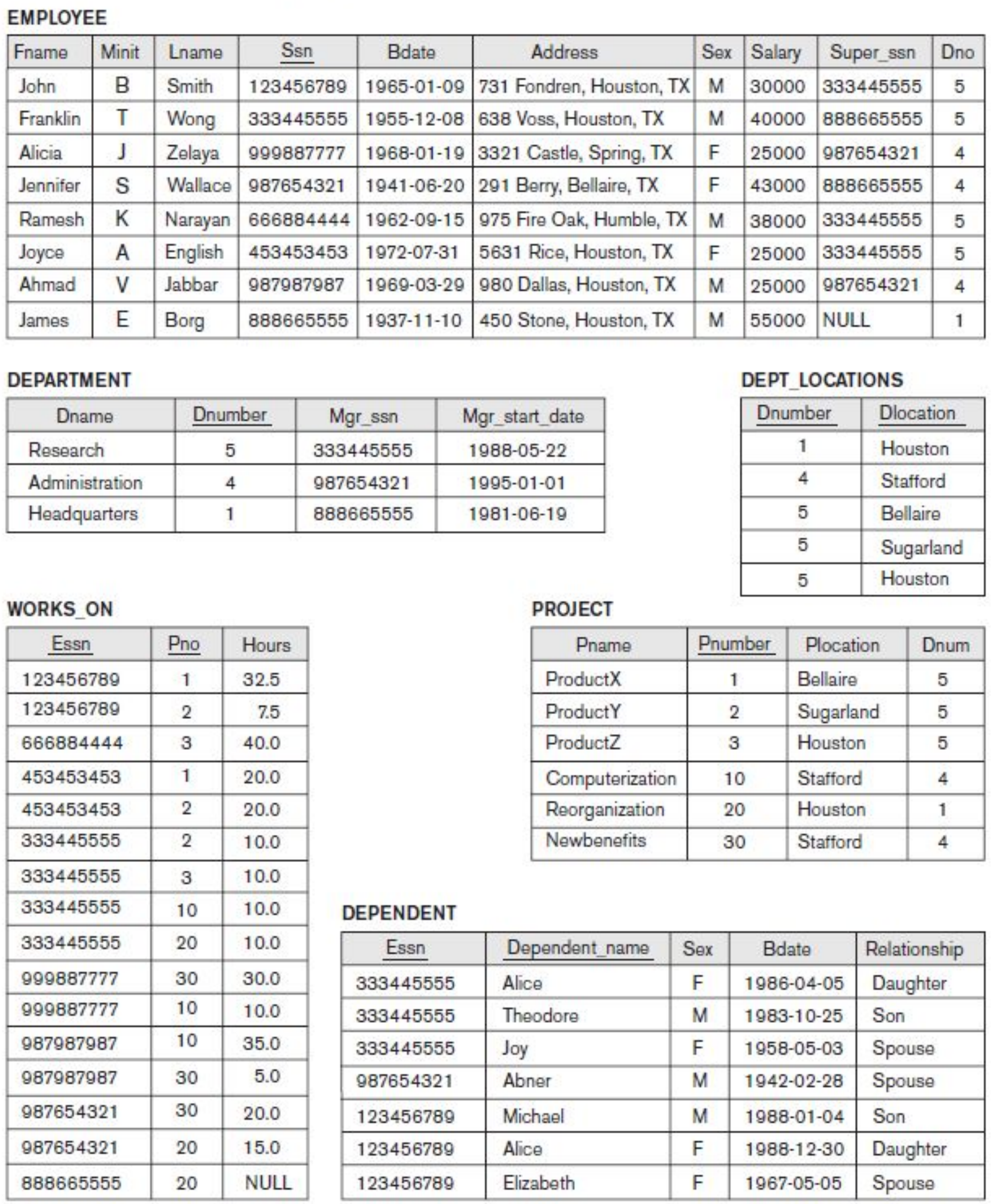
DEPENDENT

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

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Delete Operation**
- ■ Operation:
- Delete the EMPLOYEE tuple with Ssn = ‘999887777’.
- Result: This deletion is not acceptable, because there are tuples in WORKS_ON that refer to this tuple. Hence, if the tuple in EMPLOYEE is deleted, referential integrity violations will result.
- ■ Operation:
- Delete the EMPLOYEE tuple with Ssn = ‘333445555’.
- Result: This deletion will result in even worse referential integrity violations, because the tuple involved is referenced by tuples from the EMPLOYEE, DEPARTMENT, WORKS_ON, and DEPENDENT relations.

Figure 5.6
One possible database state 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

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

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

Update Operations, Transactions, and Dealing with Constraint Violations

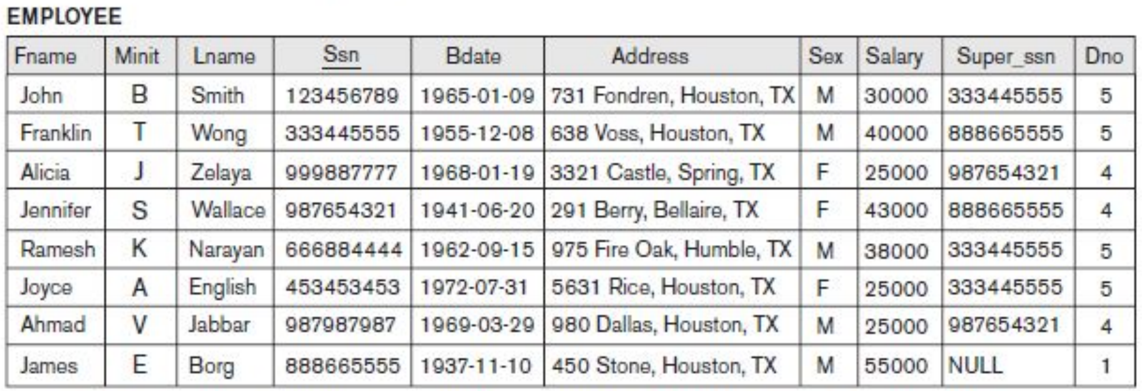
- **The Delete Operation**
- Several options are available if a deletion operation causes a violation.
- **Restrict**: to reject the deletion**(DEFAULT).**
- **Cascade**: attempt to cascade (or propagate) the deletion by deleting tuples that reference the tuple that is being deleted. For example, in operation 2, the DBMS could automatically delete the offending tuples from WORKS_ON with Essn = ‘999887777’.
- **Set null or set default**: modify the referencing attribute values that cause the violation; each such value is either set to NULL or changed to reference another default valid tuple**(to be done on Foreign Keys).**

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Update Operation**
- Updating an attribute that is neither part of a **primary key nor part of a foreign key usually causes no problems**; the DBMS need only check to confirm that the new value is of the correct data type and domain.
- **Modifying** a primary key value is similar to deleting one tuple and inserting another in its place because we use the primary key to identify tuples.
- If a **foreign key attribute is modified**, the DBMS must make sure that the new value refers to an existing tuple in the referenced relation (or is set to NULL).

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Update Operation**
- The Update (or Modify) operation is used to change the values of one or more attributes in a tuple (or tuples) of some relation R. Here are some examples.
- ■ Operation:
- Update the salary of the EMPLOYEE tuple with Ssn = ‘999887777’ to 28000.
- Result: Acceptable.
- ■ Operation:
- 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
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 Operations, Transactions, and Dealing with Constraint Violations

- **The Update Operation**
- ■ Operation:
- Update the Dno of the EMPLOYEE tuple with Ssn = ‘999887777’ to 7.
- Result: Unacceptable, because it violates referential integrity.
- ■ Operation:
- Update the Ssn of the EMPLOYEE tuple with Ssn = ‘999887777’ to ‘987654321’.
- Result: Unacceptable, because it violates primary key constraint by repeating a value that already exists as a primary key in another tuple; it violates referential integrity constraints because there are other relations that refer to the existing value of Ssn.

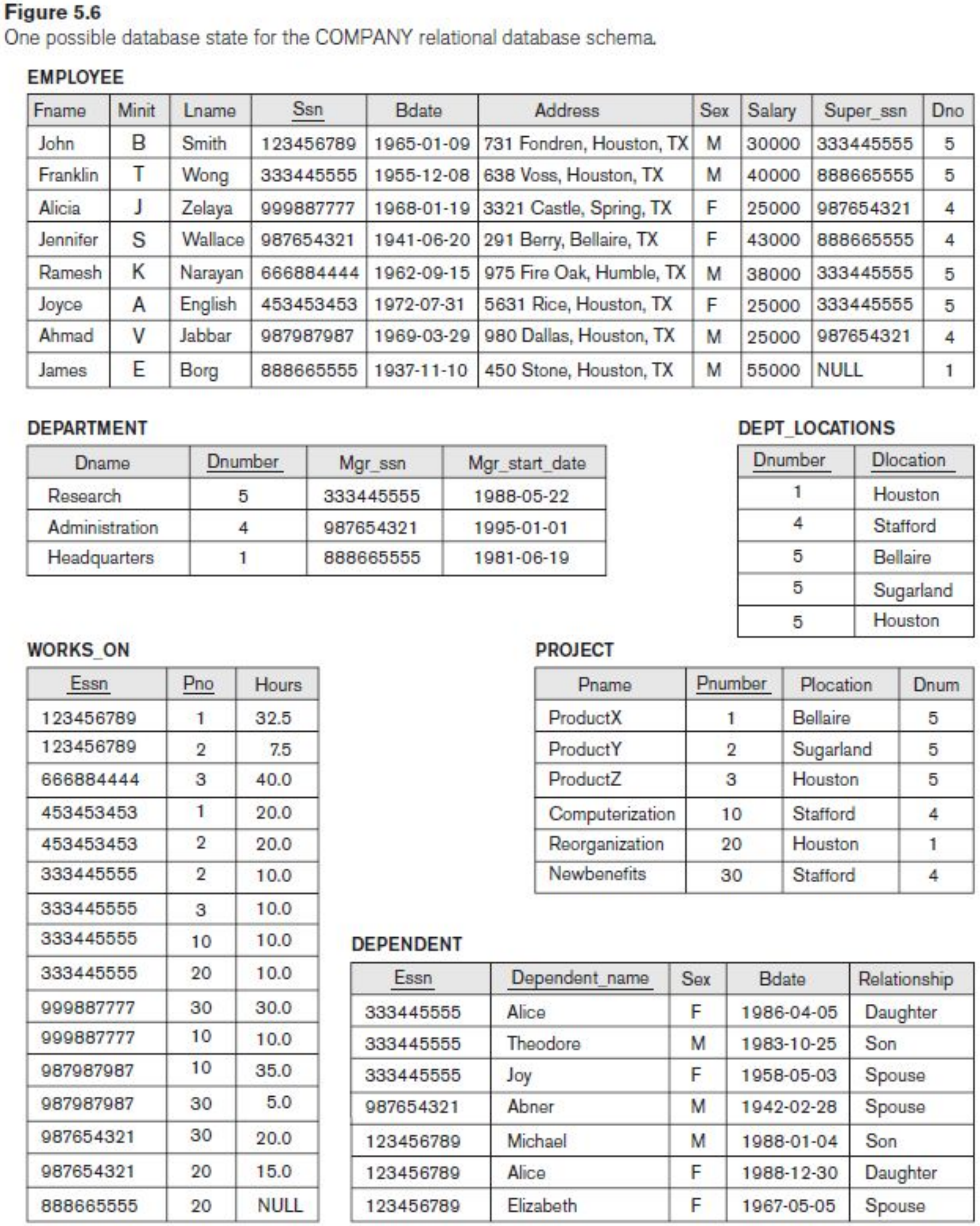


Figure 5.6
One possible database state for the COMPANY relational database schema.

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

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

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

Update Operations, Transactions, and Dealing with Constraint Violations

- **The Transaction Concept**
- A transaction is an executing program that includes some database operations, such as reading from the database, or applying insertions, deletions, or updates to the database. At the end of the transaction, it must leave the database in a valid or consistent state that satisfies all the constraints specified on the database schema.
- A single transaction may involve any number of retrieval operations and any number of update operations.
- For example, a transaction to apply a bank withdrawal will typically read the user account record, check if there is a sufficient balance, and then update the record by the withdrawal amount.
- A large number of commercial applications running against relational databases in online transaction processing (OLTP) systems are executing transactions at rates that reach several hundred per second.