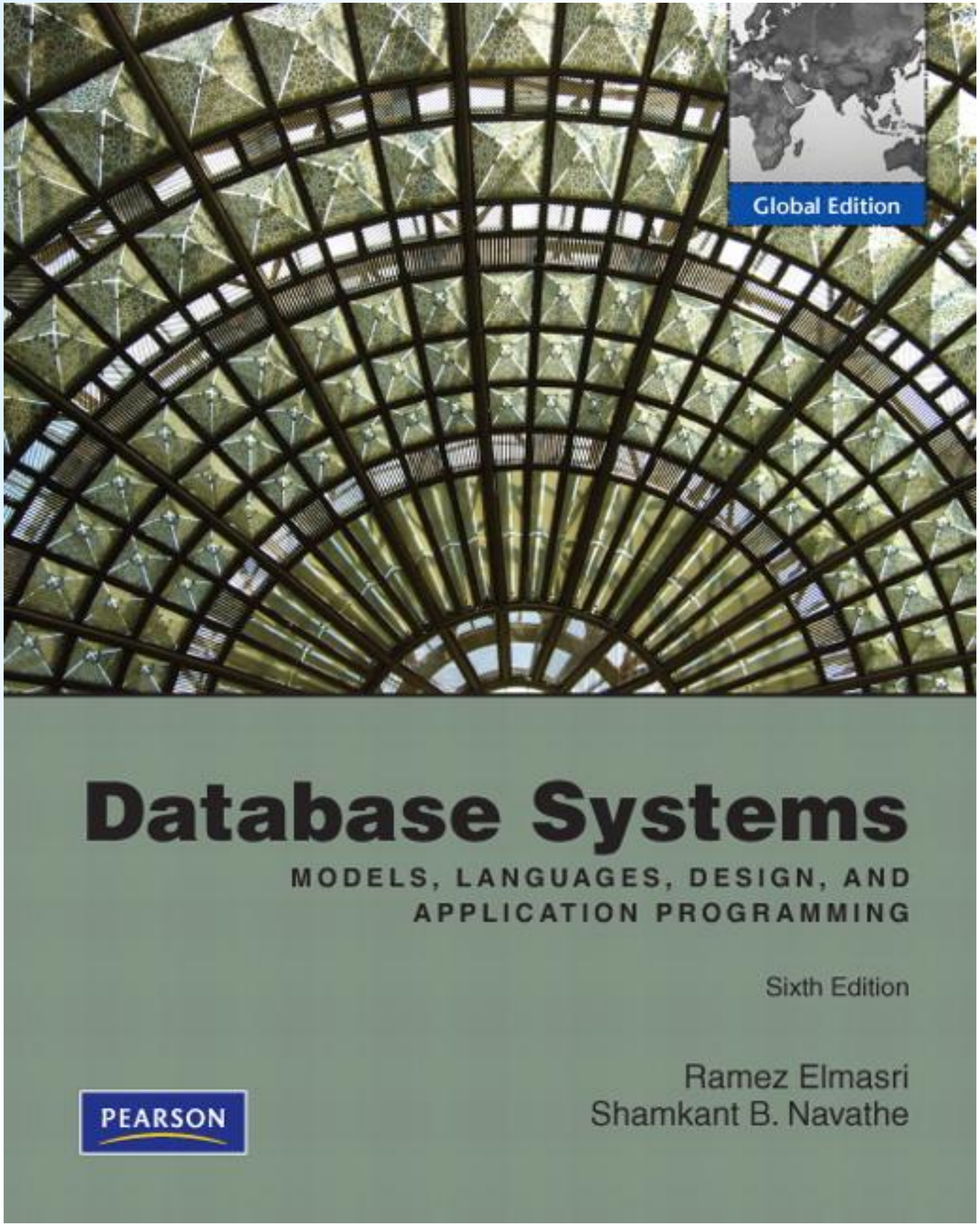
Chapter 3

The Basic (Flat) Relational Model



Addison-Wesley
is an imprint of
PEARSON

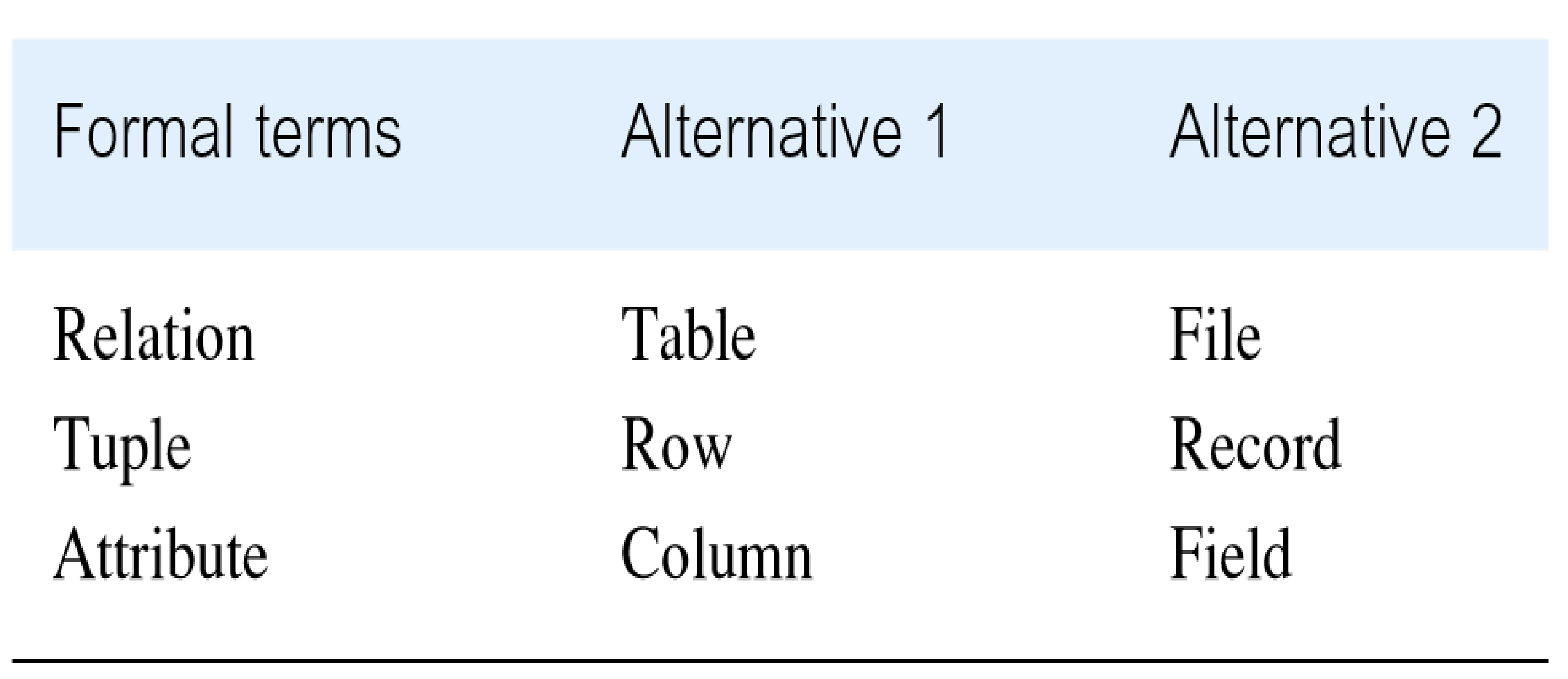
Chapter 3 Outline

- The Relational Data Model and Relational Database Constraints
- Relational Database Schemas
- Update Operations, Transactions, and Dealing with Constraint Violations

Relational Model Terminology

- Relational Database is a collection of normalized relations each with a distinct name
- A relation is a table with columns and rows.
  - Only applies to logical structure of the database, not the physical structure

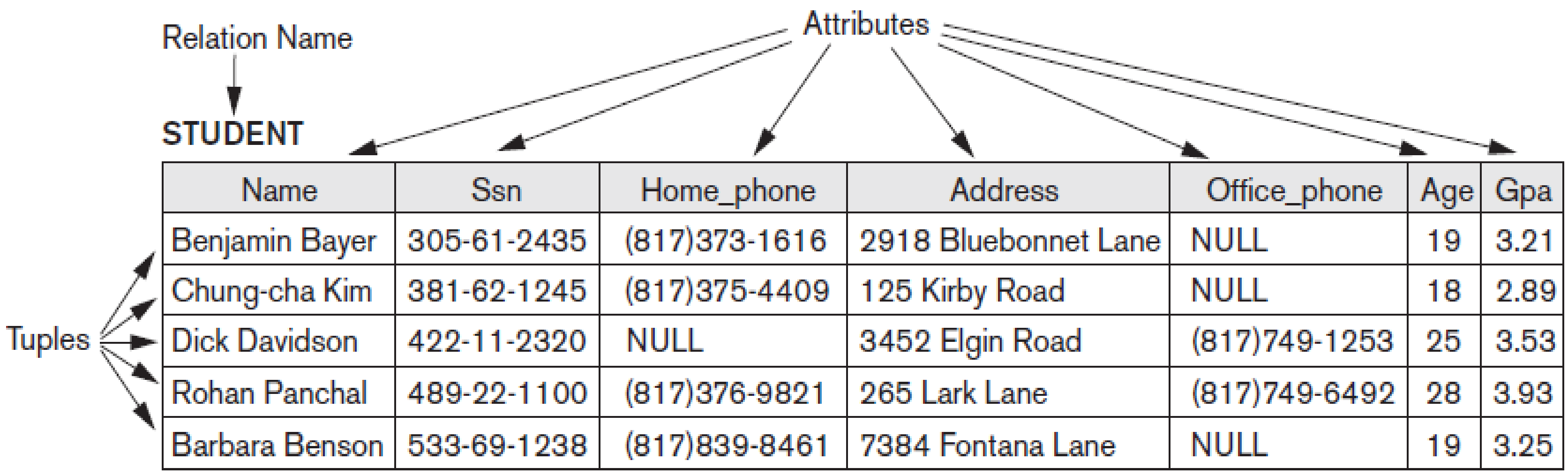
Alternative Terminology for Relational Model



Formal terms	Alternative 1	Alternative 2
Relation	Table	File
Tuple	Row	Record
Attribute	Column	Field

Relational Model Concepts

Represents data as a collection of relations


Relation Name
Attributes
Tuples

STUDENT

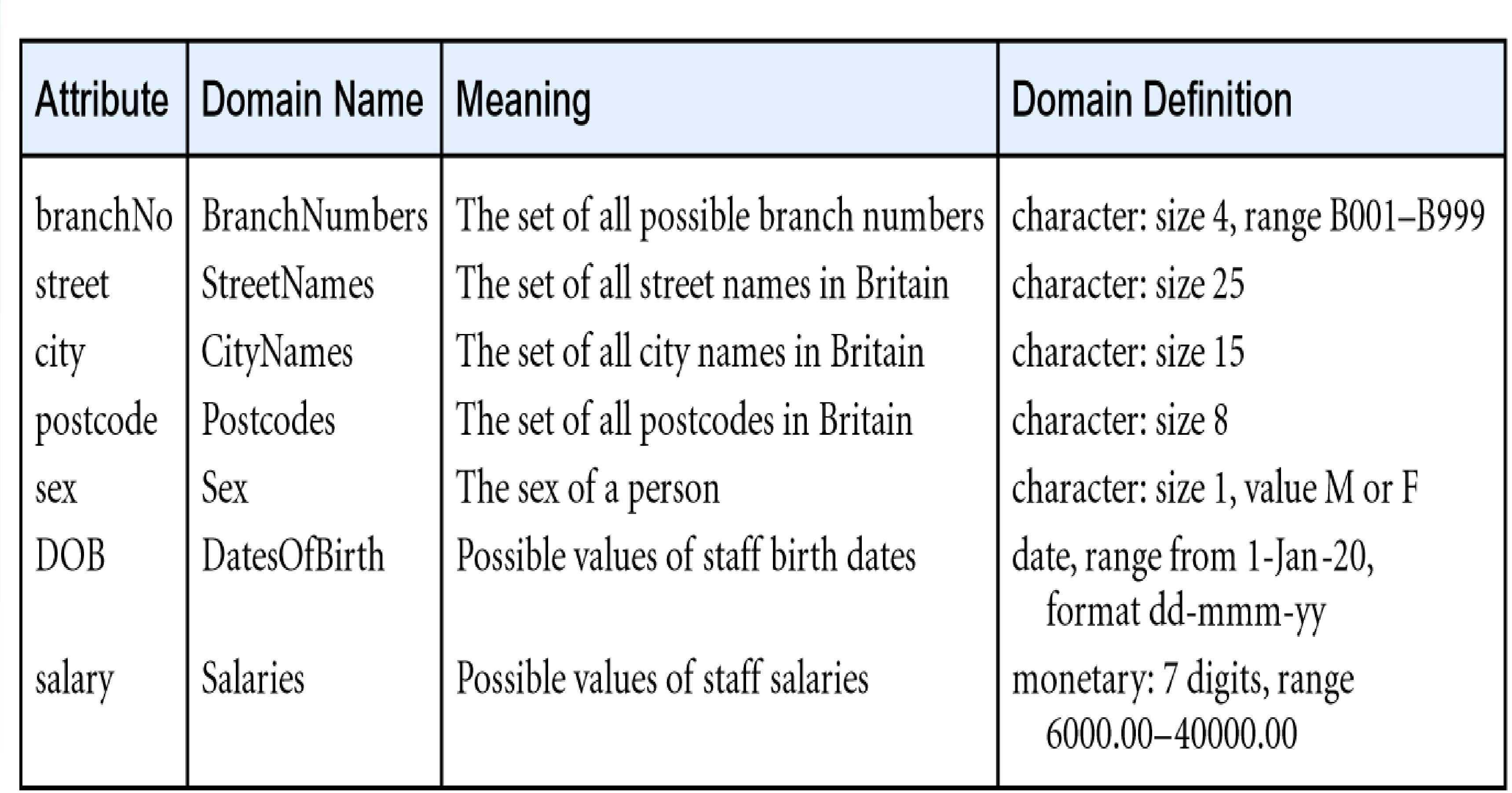
Name	Ssn	Home_phone	Address	Office_phone	Age	Gpa
Benjamin Bayer	305-61-2435	(817)373-1616	2918 Bluebonnet Lane	NULL	19	3.21
Chung-cha Kim	381-62-1245	(817)375-4409	125 Kirby Road	NULL	18	2.89
Dick Davidson	422-11-2320	NULL	3452 Elgin Road	(817)749-1253	25	3.53
Rohan Panchal	489-22-1100	(817)376-9821	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 3.1
The attributes and tuples of a relation STUDENT.

Domains and Relations

- **Domain** D
  - Is the set of allowable values for one or more attributes.
  - Set of atomic values
- **Atomic**
  - Each value is indivisible
- Specifying a domain
  - **Data type** specified for each domain

Examples of Attribute Domains



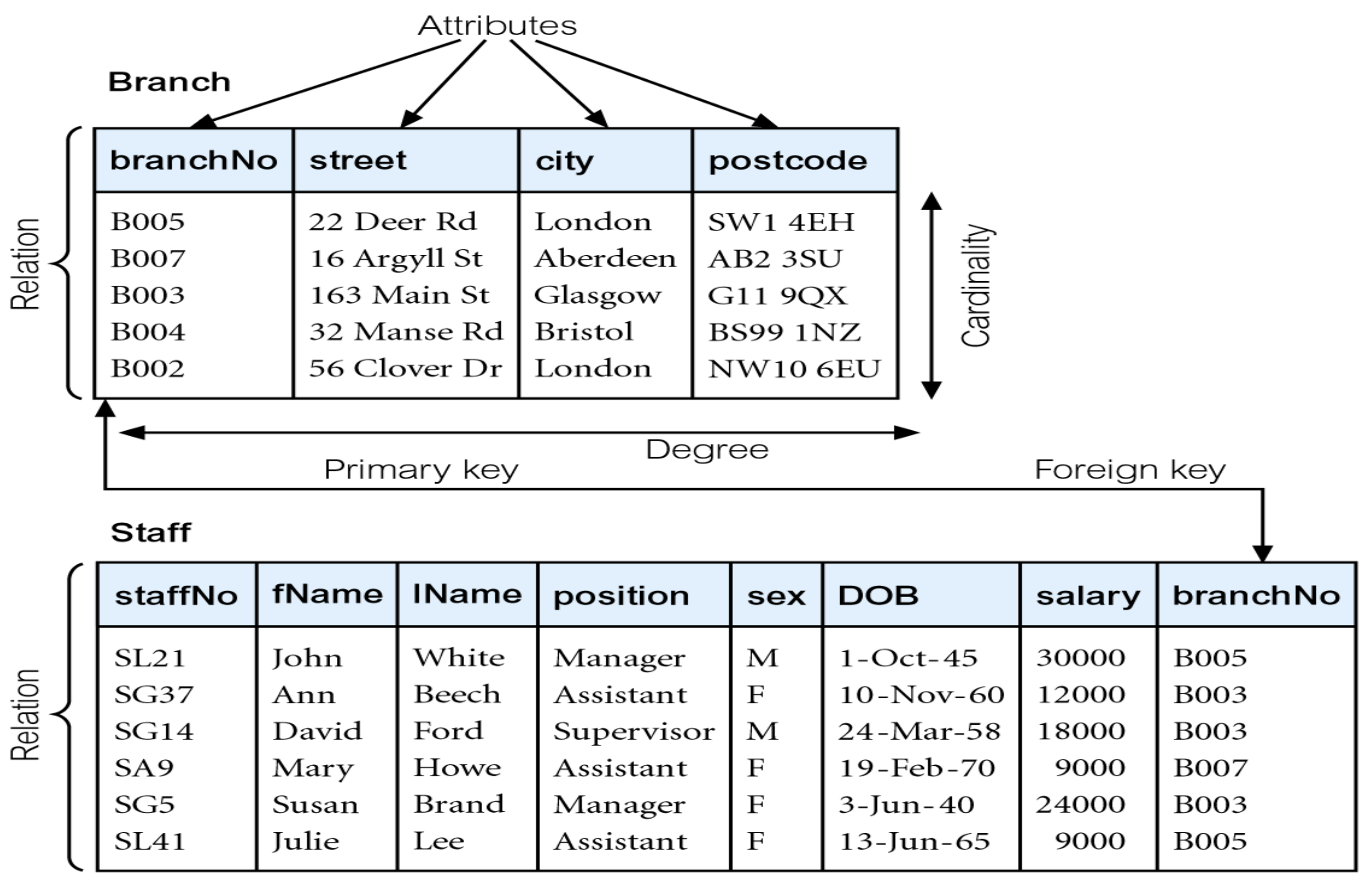
Attribute	Domain Name	Meaning	Domain Definition
branchNo	BranchNumbers	The set of all possible branch numbers	character: size 4, range B001–B999
street	StreetNames	The set of all street names in Britain	character: size 25
city	CityNames	The set of all city names in Britain	character: size 15
postcode	Postcodes	The set of all postcodes in Britain	character: size 8
sex	Sex	The sex of a person	character: size 1, value M or F
DOB	DatesOfBirth	Possible values of staff birth dates	date, range from 1-Jan-20, format dd-mmm-yy
salary	Salaries	Possible values of staff salaries	monetary: 7 digits, range 6000.00–40000.00

Addison-Wesley
is an imprint of
PEARSON

Attributes, Tuples and Relations

- **Relation schema** *R*
  - Denoted by $R(A_1, A_2, ..., A_n)$
  - Made up of a relation name *R* and a list of attributes, $A_1, A_2, ..., A_n$
- **Attribute** A_i
  - Name of a role played by some domain *D* in the relation schema *R*
- **Cardinality**
  - Total number of tuples in a relation
- **Degree** of a relation
  - Number of attributes *n* of its relation schema

Cardinality & Degree of Relations



Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

Relational Database Schemas

- **Relational database schema S**
  - Set of relation schemas $S = \{R_1, R_2, ..., R_m\}$
  - Set of integrity constraints IC
- **Relational database state**
  - Reflects only the valid tuples that represent a particular state of the real world
  - Set of relation states $DB = \{r_1, r_2, ..., r_m\}$
  - Each r_i is a state of R_i and such that the r_i relation states satisfy integrity constraints specified in IC

Addison-Wesley
is an imprint of
PEARSON

Relational Schemas States

- **Invalid state**
  - Does not obey all the integrity constraints
- **Valid state**
  - Satisfies all the constraints in the defined set of integrity constraints IC

Example of a Database State

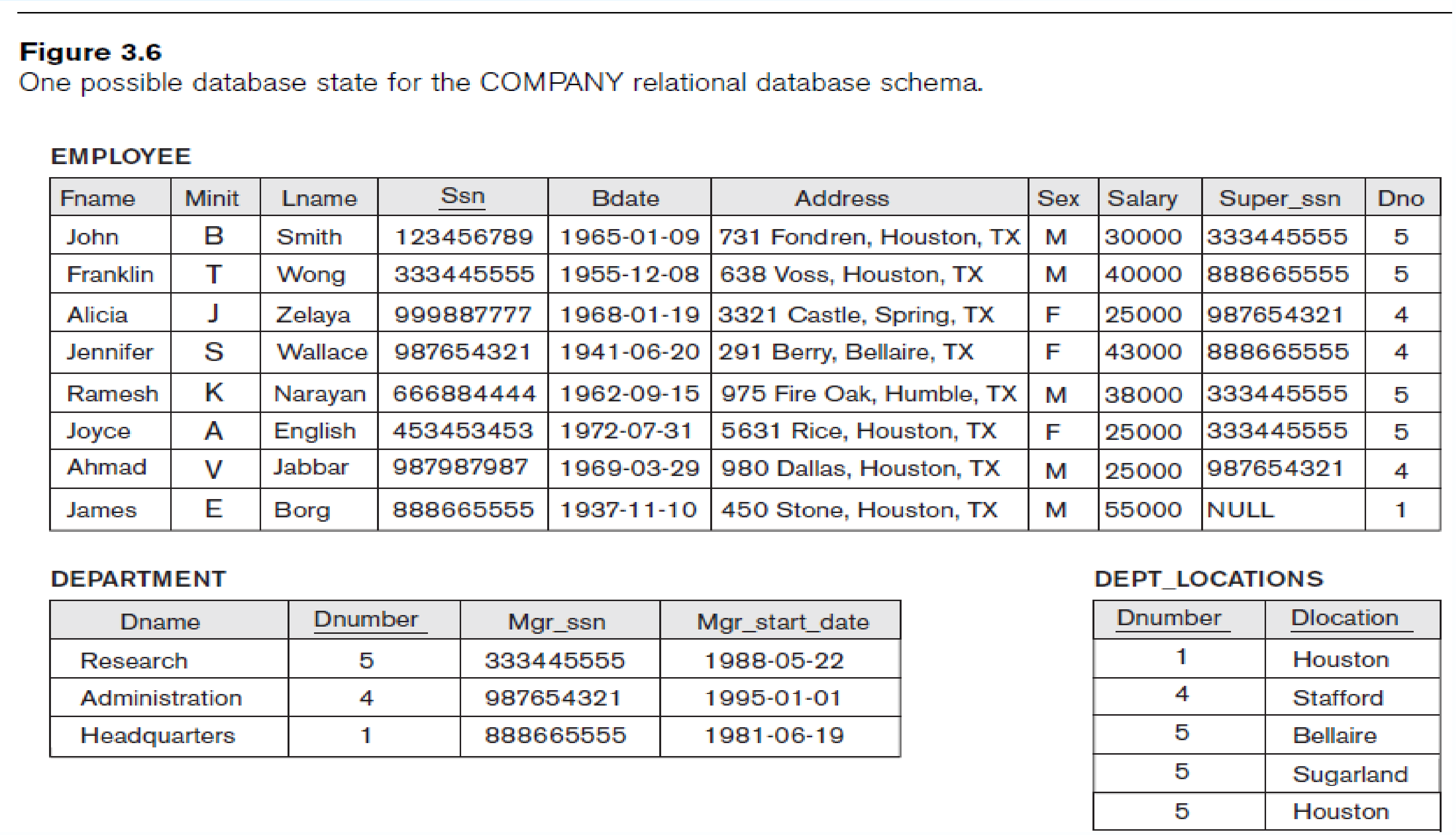


Figure 3.6
One possible database state for the COMPANY relational database schema.

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

Addison-Wesley
is an imprint of
PEARSON

Characteristics of Relations

- Each cell of relation contains exactly one atomic (single) value.
  - **Flat relational model**
    - Composite and multivalued attributes not allowed
  - **First normal form** assumption
    - **Multivalued attributes**
      - Must be represented by separate relations
    - **Composite attributes**
      - Represented only by simple component attributes in basic relational model

Addison-Wesley
is an imprint of
PEARSON

Characteristics of Relations

- Each tuple is distinct; there are no duplicate tuples.
- Each attribute has a distinct name
- Values of an attribute are all from the same domain
- Order of attributes has no significance.
- Order of tuples has no significance, theoretically

NULL Values

- NULL values
  - Represent the values of attributes that may be:
    - *Unknown*
    - *Exists but is not available*
    - *Not applicable to this tuple (also known as value undefined)*
    - *Is not the same as zero or spaces, which are values*

Addison-Wesley
is an imprint of
PEARSON

Relational Model Constraints

- **Constraints**
  - Restrictions on the actual values in a database state
  - Derived from the rules in the miniworld that the database represents
- **Categories of Constraints**
  - **Inherent model-based constraints** or **implicit constraints**
  - Inherent in the data model

Addison-Wesley
is an imprint of
PEARSON

Relational Model Constraints

- **Schema-based constraints** or **explicit constraints**
- Can be directly expressed in schemas of the data model
- **Application-based** or **semantic constraints** or **business rules**
- Cannot be directly expressed in schemas
- Expressed and enforced by application program

Domain Constraints

- The value of each attribute must be atomic
- Typically include:
  - Numeric data types for integers and real numbers
  - Characters
  - Booleans
  - Fixed-length strings
  - Variable-length strings
  - Date, time, timestamp
  - Money

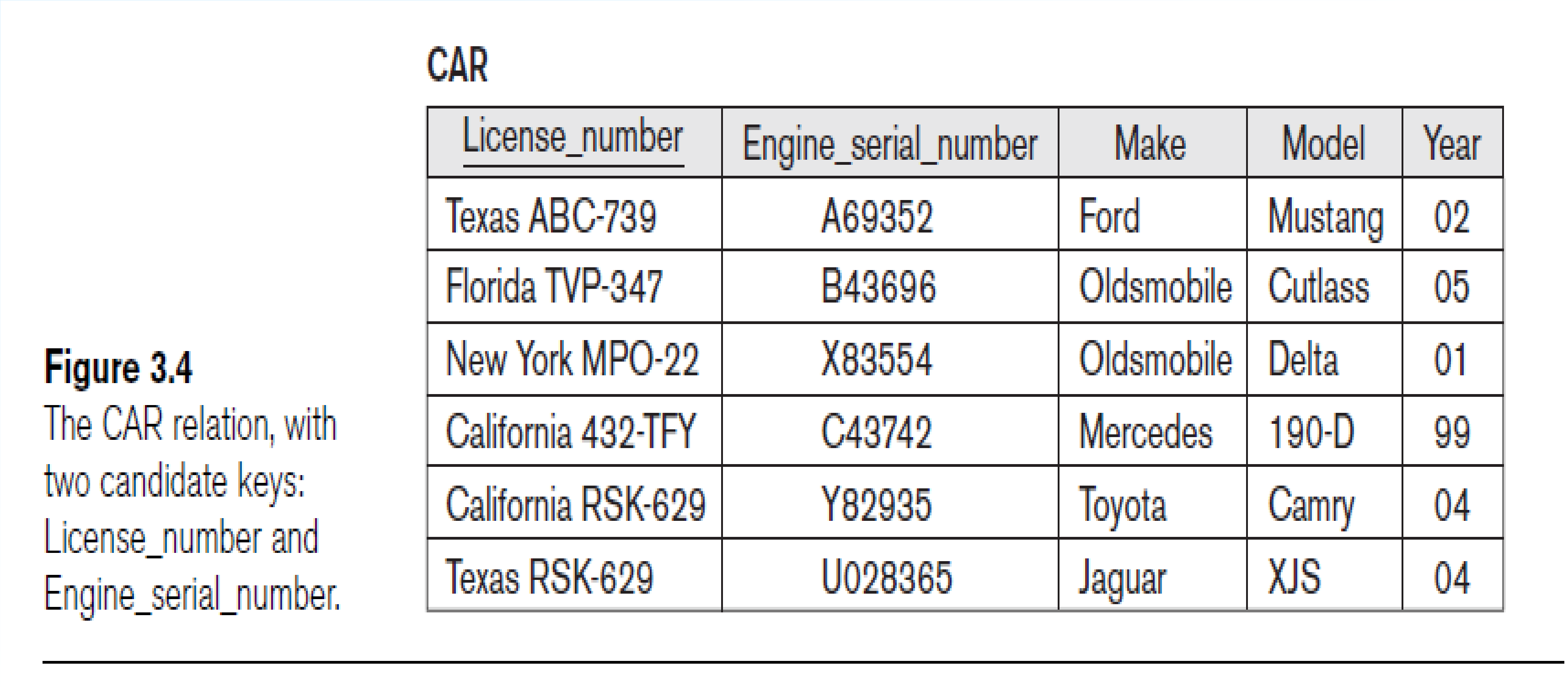
Key Constraints and Constraints on NULL Values

- **Superkey** satisfies two properties:
  - Two distinct tuples in any state of relation cannot have identical values for (all) attributes in key
  - Minimal superkey
    - Cannot remove any attributes and still have uniqueness constraint in above condition hold

Key Constraints and Constraints on NULL Values (cont'd.)

- **Candidate key**
  - Relation schema may have more than one key
- **Primary key** of the relation
  - Designated among candidate keys
  - Underline attribute
- Other candidate keys are designated as **unique keys**

A Relation With Two Candidate Keys



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 3.4
The CAR relation, with two candidate keys: License_number and Engine_serial_number.

Integrity and Foreign Keys

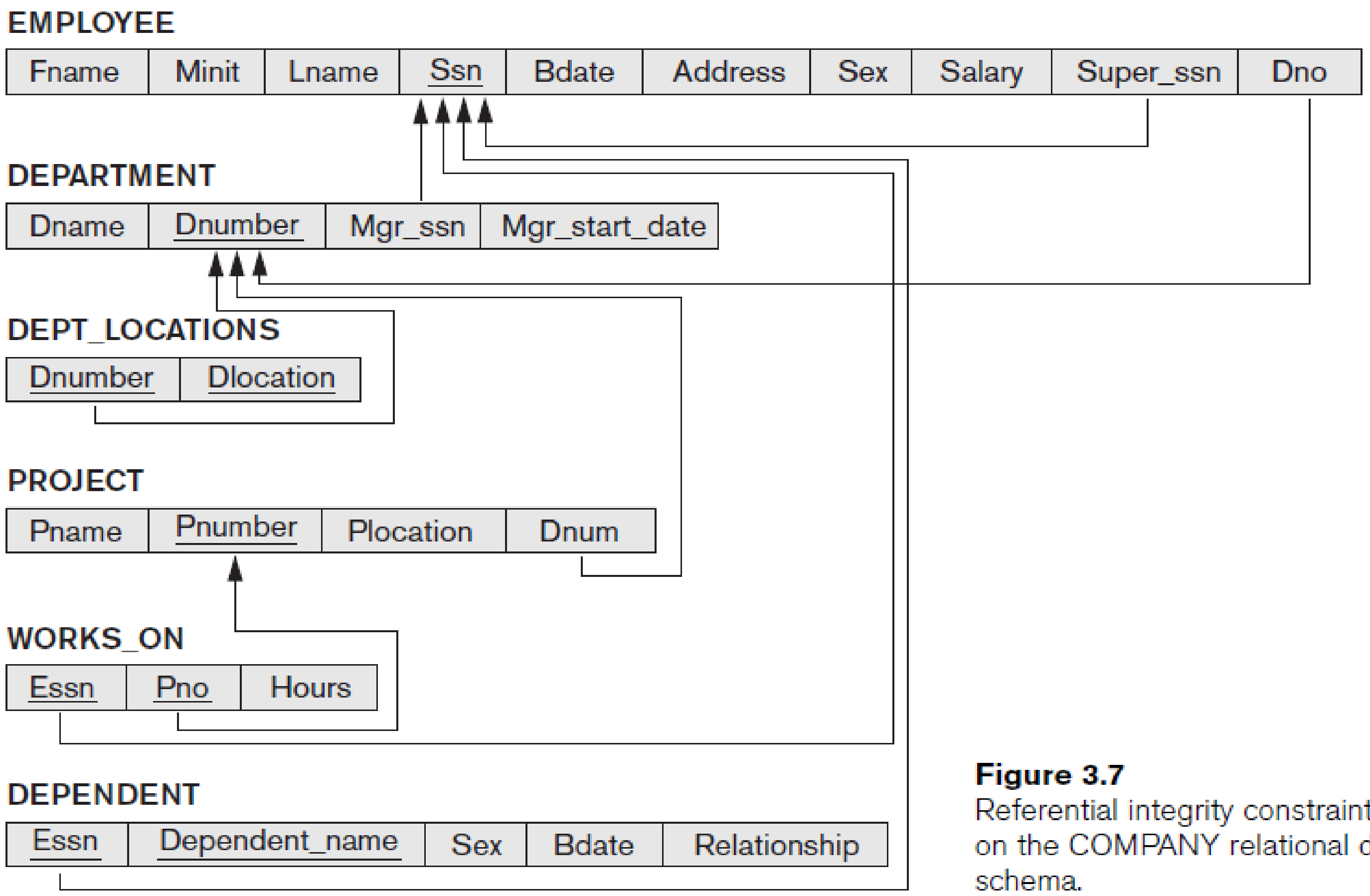
- **Entity integrity constraint**
  - No primary key value can be NULL
- **Referential integrity constraint**
  - Specified between two relations
  - Maintains consistency among tuples in two relations

Addison-Wesley
is an imprint of
PEARSON

Foreign Key Rules

- **Foreign key** rules:
  - The attributes in FK have the same domain(s) as the primary key attributes PK
  - Value of FK in a tuple t_1 of the current state $r_1(R_1)$ either occurs as a value of PK for some tuple t_2 in the current state $r_2(R_2)$ or is NULL
  - A tuple in one relation that refers to another relation must refer to an existing tuple

Example of Referential Integrity Constraints



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 3.7
Referential integrity constraints displayed on the COMPANY relational database schema.

Addison-Wesley
is an imprint of
PEARSON

Other Types of Constraints

- **Semantic integrity constraints**
  - May have to be specified and enforced on a relational database
  - Use **triggers** and **assertions**
  - More common to check for these types of constraints within the application programs

Update Operations and Dealing with Constraint Violations

- Operations of the relational model can be categorized into retrievals and updates
- Basic operations that change the states of relations in the database:
  - Insert
  - Delete
  - Update (or Modify)

The Insert Operation

- Provides a list of attribute values for a new tuple t that is to be inserted into a relation R
- Can violate any of the four types of constraints
- If an insertion violates one or more constraints
    - Default option is to reject the insertion

The Delete Operation

- Can violate only referential integrity
  - If tuple being deleted is referenced by foreign keys from other tuples
  - **Restrict**
    - Reject the deletion
  - **Cascade**
    - Propagate the deletion by deleting tuples that reference the tuple that is being deleted
  - **Set null** or **set default**
    - Modify the referencing attribute values that cause the violation

Addison-Wesley
is an imprint of
PEARSON

The Update Operation

- Necessary to specify a condition on attributes of relation
  - Select the tuple (or tuples) to be modified
- If attribute not part of a primary key nor of a foreign key
  - Usually causes no problems
- Updating a primary/foreign key
  - Similar issues as with Insert/Delete