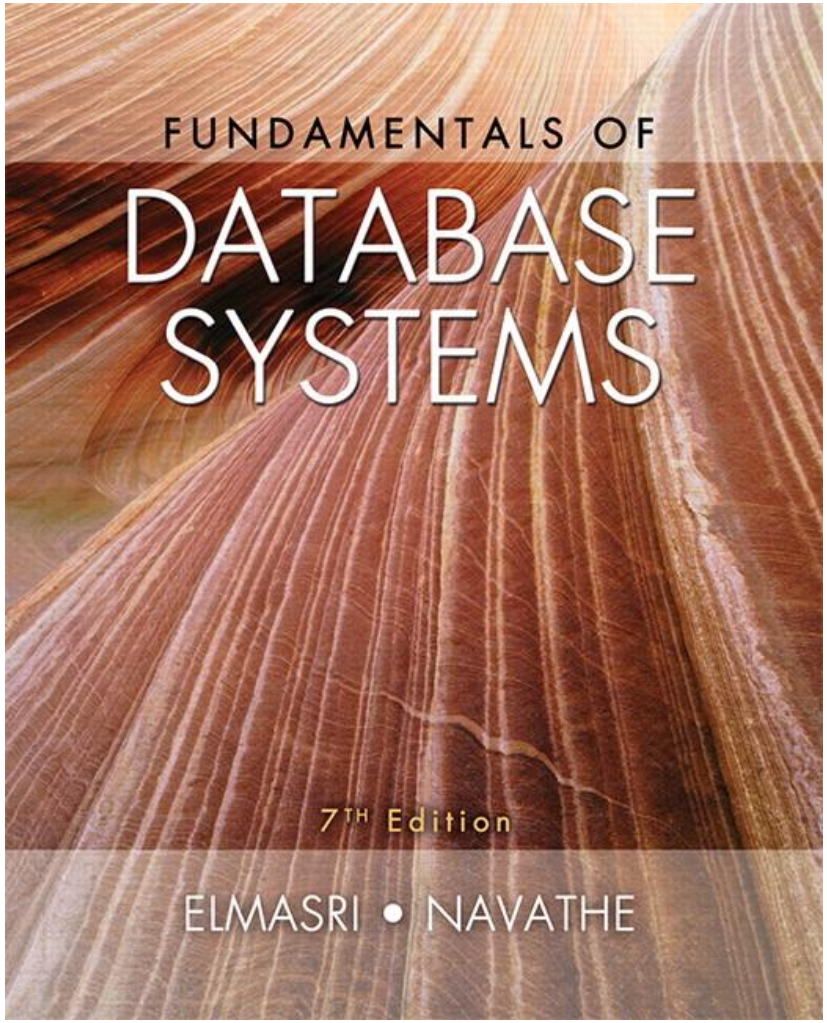


CHAPTER 9

Relational Database Design
ER-to-Relational Mapping

Chapter Outline

- **ER-to-Relational Mapping Algorithm**
  - Step 1: Mapping of Regular Entity Types
  - Step 2: Mapping of Weak Entity Types
  - Step 3: Mapping of Binary 1:1 Relation Types
  - Step 4: Mapping of Binary 1:N Relationship Types.
  - Step 5: Mapping of Binary M:N Relationship Types.
  - Step 6: Mapping of Multivalued attributes.
  - Step 7: Mapping of N-ary Relationship Types.

- **Mapping EER Model Constructs to Relations (to be covered later when we discuss Enhanced ER)**
  - Step 8: Options for Mapping Specialization or Generalization

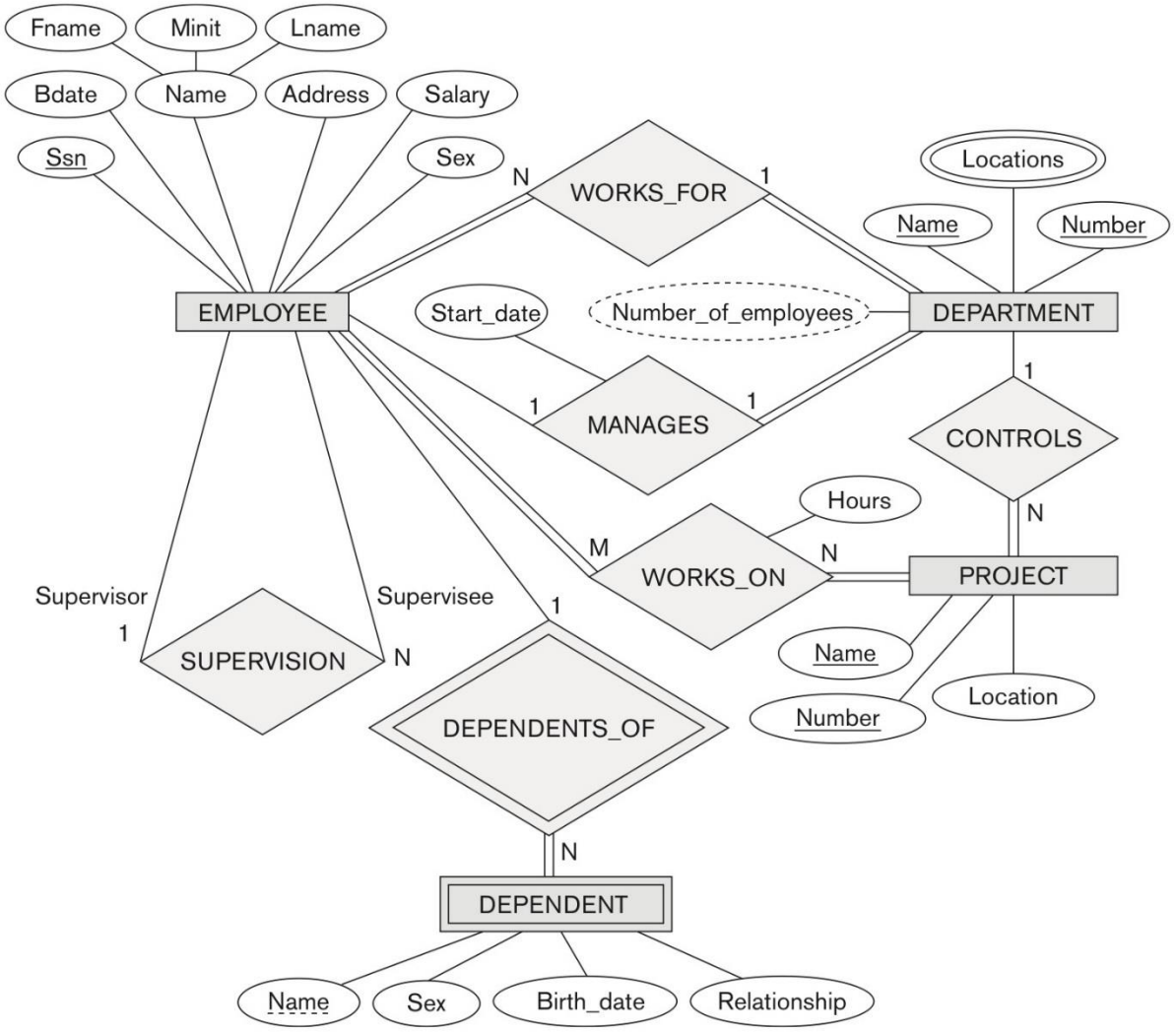
OMIT FOR NOW: Section 9.2 of this Chapter.

GOALS during Mapping

- Preserve all information (that includes all attributes belonging to entity types, all relationships among entity types)
- Maintain the constraints to the extent possible (Relational Model cannot preserve all constraints: e.g., max cardinality ratio such as 1:10 in ER; exhaustive classification into subtypes, e.g., STUDENTS are specialized into Domestic and Foreign subclasses only)
- Minimize null values

The mapping procedure described here has been implemented in many commercial tools.

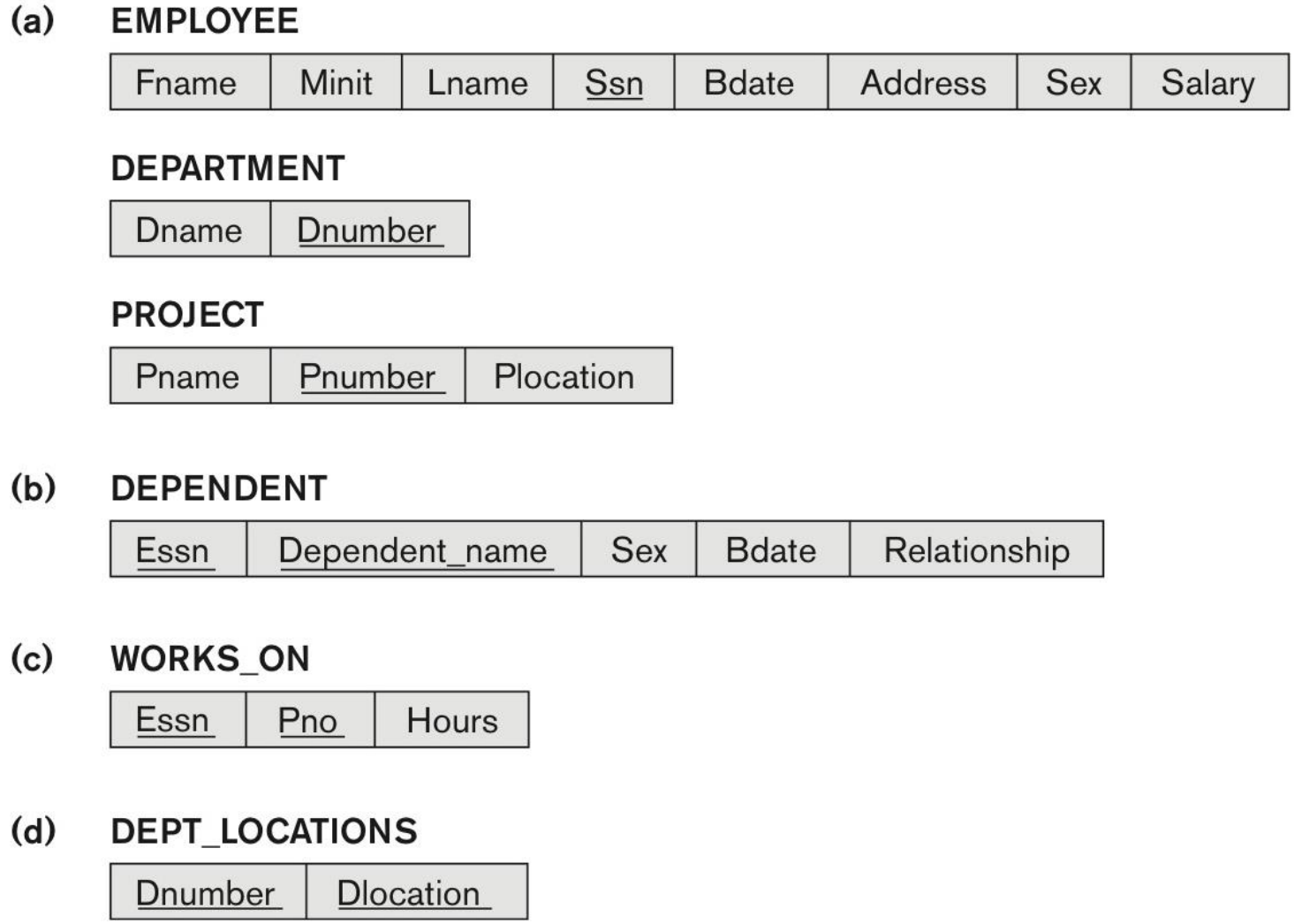
The ER conceptual schema diagram for the COMPANY database.



ER-to-Relational Mapping Algorithm

- Step 1: Mapping of Regular Entity Types.
  - For each regular (strong) entity type E in the ER schema, create a relation R that includes all the simple attributes of E.
  - Choose one of the key attributes of E as the primary key for R.
  - If the chosen key of E is composite, the set of simple attributes that form it will together form the primary key of R.
- Example: We create the relations EMPLOYEE, DEPARTMENT, and PROJECT in the relational schema corresponding to the regular entities in the ER diagram.
  - SSN, DNUMBER, and PNUMBER are the primary keys for the relations EMPLOYEE, DEPARTMENT, and PROJECT as shown.

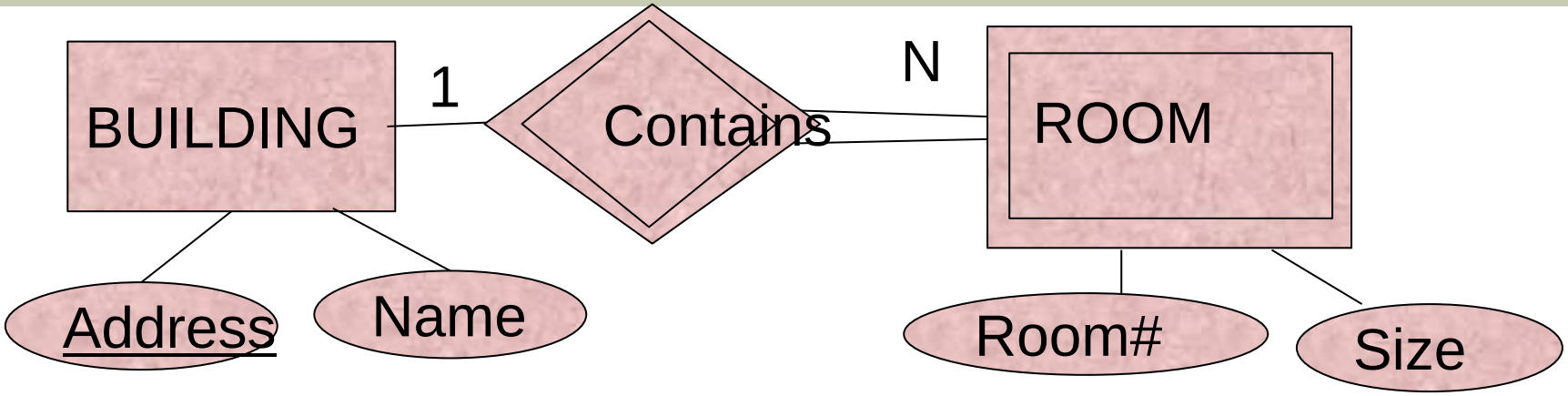
Figure 9.3 Illustration of some mapping steps. (a) *Entity* relations after step 1. (b) Additional *weak entity* relation after step 2. (c) *Relationship* relations after step 5. (d) Relation representing multivalued attribute after step 6.



Mapping of Weak Entity Types

- **Step 2: Mapping of Weak Entity Types**
  - For each weak entity type W in the ER schema with owner entity type E, create a relation R & include all simple attributes (or simple components of composite attributes) of W as attributes of R.
  - Also, include as foreign key attributes of R the primary key attribute(s) of the relation(s) that correspond to the owner entity type(s).
  - The primary key of R is the *combination of* the primary key(s) of the owner(s) and the partial key of the weak entity type W, if any.
- **Example:** Create the relation DEPENDENT in this step to correspond to the weak entity type DEPENDENT.
  - Include the primary key SSN of the EMPLOYEE relation as a foreign key attribute of DEPENDENT (renamed to ESSN).
  - The primary key of the DEPENDENT relation is the combination {ESSN, DEPENDENT_NAME} because DEPENDENT_NAME is the partial key of DEPENDENT.

Weak Entity Mapping



Note: ROOM is a weak entity type.

(1) Room# is a local identifier (should be underlined with a dotted line)

(2) Entity ROOM is existence dependent as well as identification dependent on entity BUILDING

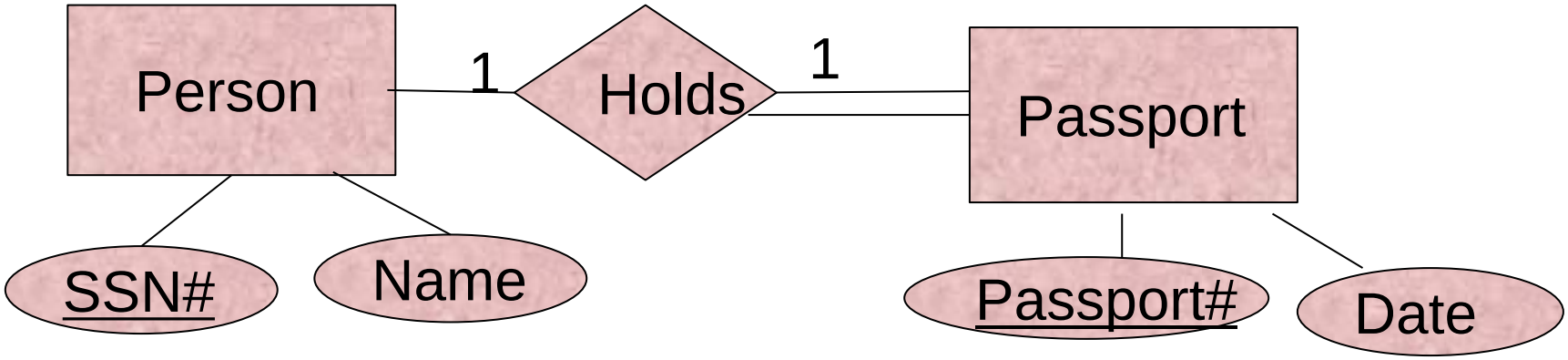
(3) The complete identifier for ROOM is (Room#, Building-Address). Hence the mapping to relation is:

ROOM (Room#, Building_address, Size)

Mapping Binary 1:1 Relationship Types

- **Step 3: Mapping of Binary 1:1 Relation Types**
  - For each binary 1:1 relationship type R in the ER schema, identify the relations S and T that correspond to the entity types participating in R.
- There are three possible approaches:
  1. **Foreign Key (2 relations) approach:** Choose one of the relations-say S-and include a foreign key in S the primary key of T. It is better to choose an entity type with total participation in R in the role of S.
     - Example: 1:1 relation MANAGES is mapped by choosing the participating entity type DEPARTMENT to serve in the role of S, because its participation in the MANAGES relationship type is total.
  2. **Merged relation (1 relation) option:** An alternate mapping of a 1:1 relationship type is possible by merging the two entity types and the relationship into a single relation. This may be appropriate when both participations are total.
  3. **Cross-reference or relationship relation (3 relations) option:** The third alternative is to set up a third relation R for the purpose of cross-referencing the primary keys of the two relations S and T representing the entity types.

One to One Relationship Mapping



(1) TWO RELATIONS APPROACH:

Person (SSN#, Name, Passport#)

Passport (Passport#, Date, SSN#)

Possible null values in first relation

Not every person holds a passport

Better: Person (SSN#, Name, …….)

Passport (Passport#, Date, SSN#). WHY?

However, every passport has a person identified by their SSN

(2) **ONE RELATION** (MERGED) Approach:

Person-Passport(SSN#, Name, …Passport#, Date, …)

When is this reasonable?

One:One Relationship Mapping (contd.)

- **Three relations** approach:

Person (SSN, Name, …., …., …….,….)

Passport (Passport# , Date, …., …., ….)

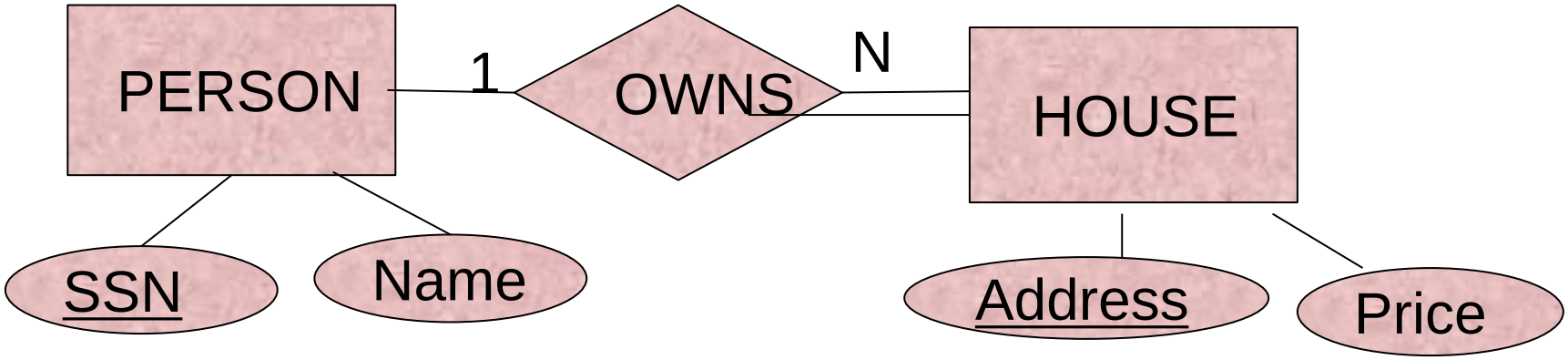
Lookup_Table (Passport#, SSN#)

Preferred when quick look-up is desired such as owner of passport, owner of vehicle, etc.in surveillance/policing/emergency type applications

Mapping Binary 1:N Relationship Types

- Step 4: Mapping of Binary 1:N Relationship Types.
  - For each regular binary 1:N relationship type R, identify the relation S that represent the participating entity type at the N-side of the relationship type.
  - Include as foreign key in S the primary key of the relation T that represents the other entity type participating in R.
  - Include any simple attributes of the 1:N relation type as attributes of S.
- Example: 1:N relationship types WORKS_FOR, CONTROLS, and SUPERVISION in the figure.
  - For WORKS_FOR we include the primary key DNUMBER of the DEPARTMENT relation as foreign key in the EMPLOYEE relation and call it DNO.
- An alternative approach is to use a Relationship relation (cross referencing relation) – this is rarely done.

One to Many Relationship Mapping



Each HOUSE is OWNed by some PERSON

Hence, SSN of owner is like a mandatory attribute of each HOUSE.

Hence, it becomes a foreign key attribute in the relation HOUSE.

Mapping Rule: Transfer the primary key from the “one side” of the relationship type to the “many-side” of the relationship type.

PERSON (SSN, Name)

HOUSE (Address, Price, ……., Owner_SSN)

Foreign Key

The ER conceptual schema diagram for the COMPANY database.

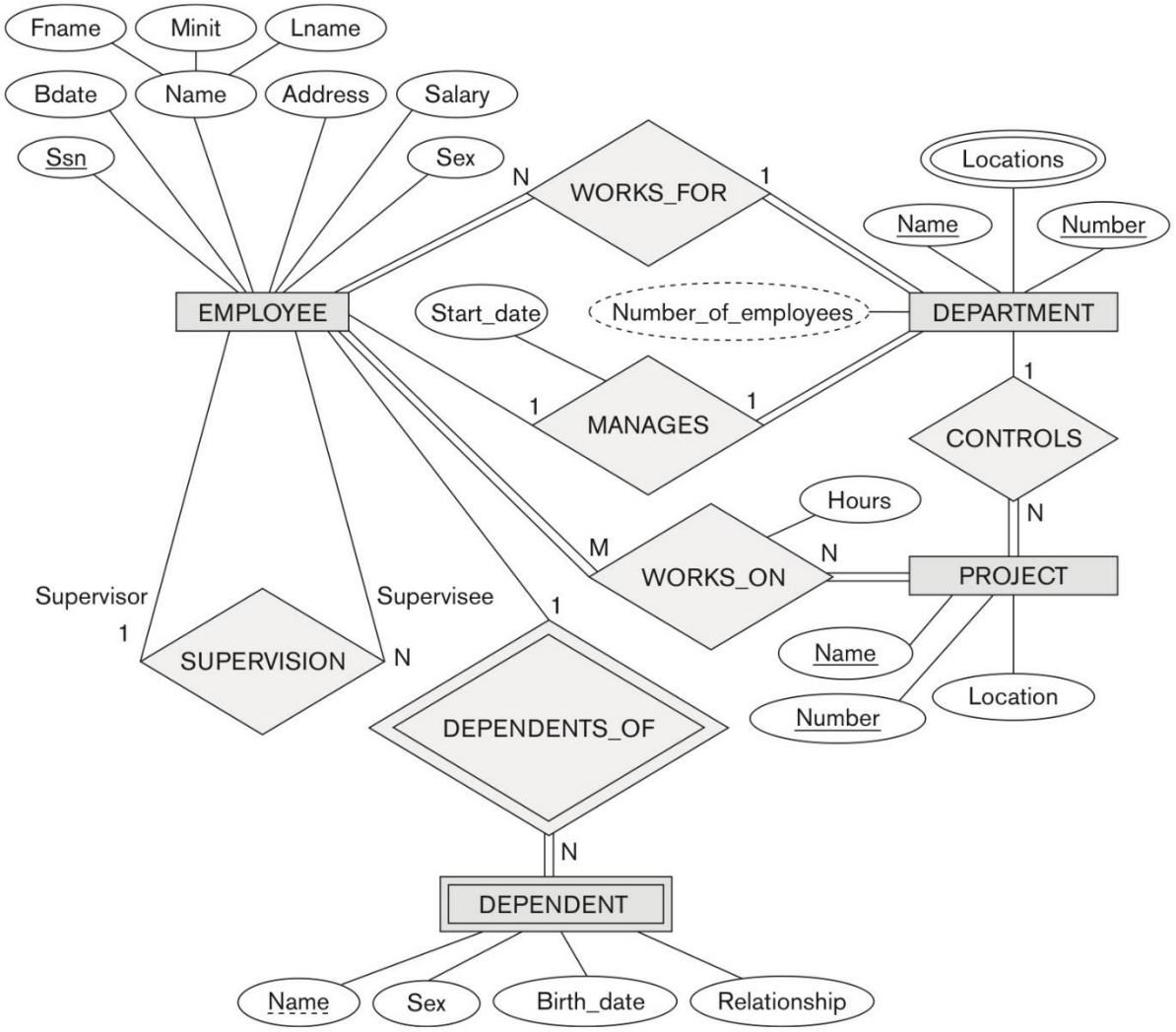
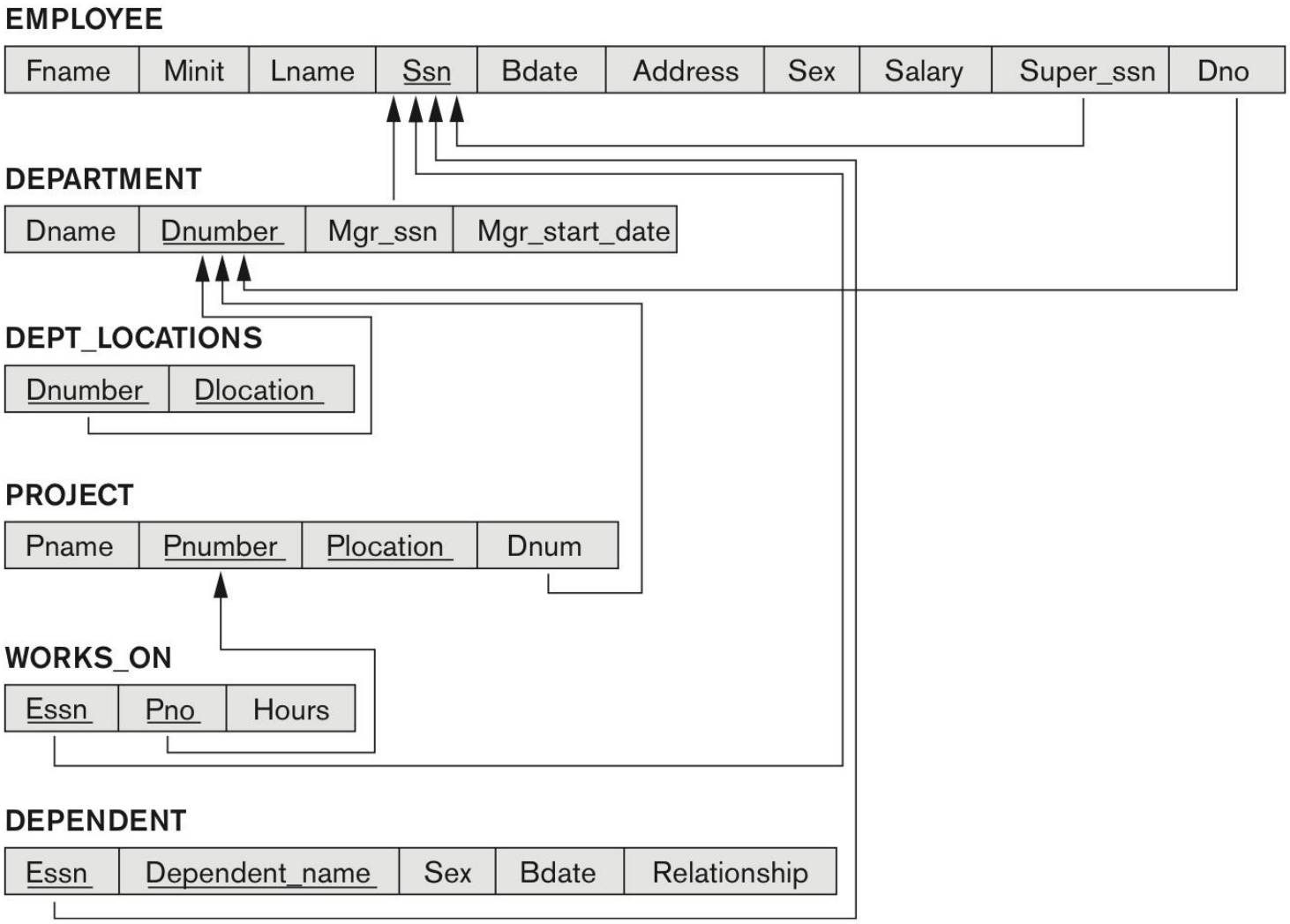


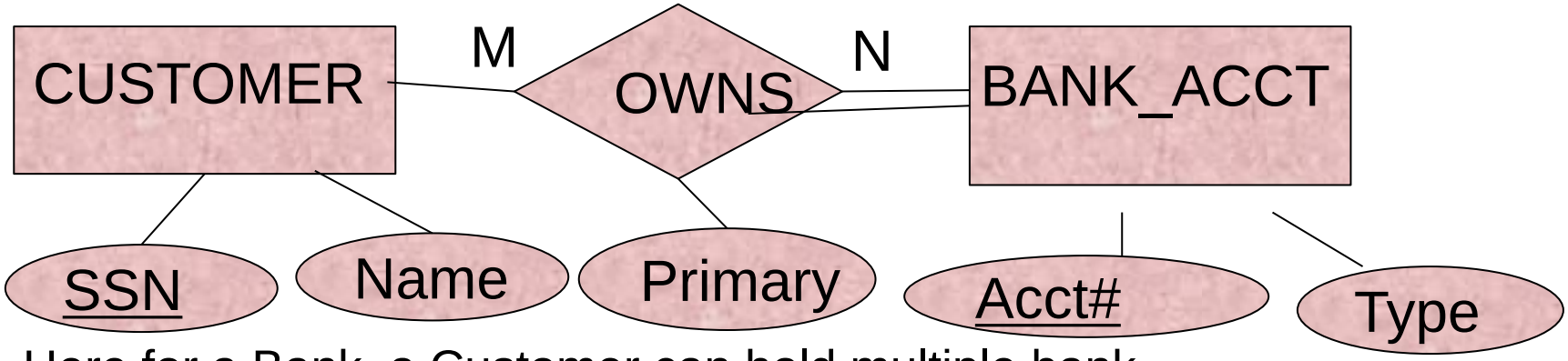
Figure 9.2 Result of mapping the COMPANY ER schema into a relational database schema.



Mapping Binary M:N Relationship Types

- **Step 5: Mapping of Binary M:N Relationship Types.**
  - For each regular binary M:N relationship type R, *create a new relation* S to represent R. This is a *relationship relation.*
  - Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types; *their combination will form the primary key* of S.
  - Also include any simple attributes of the M:N relationship type (or simple components of composite attributes) as attributes of S.
- Example: The M:N relationship type WORKS_ON from the ER diagram is mapped by creating a relation WORKS_ON in the relational database schema.
  - The primary keys of the PROJECT and EMPLOYEE relations are included as foreign keys in WORKS_ON and renamed PNO and ESSN, respectively.
  - Attribute HOURS in WORKS_ON represents the HOURS attribute of the relation type. The primary key of the WORKS_ON relation is the combination of the foreign key attributes {ESSN, PNO}.

One to Many Relationship Mapping

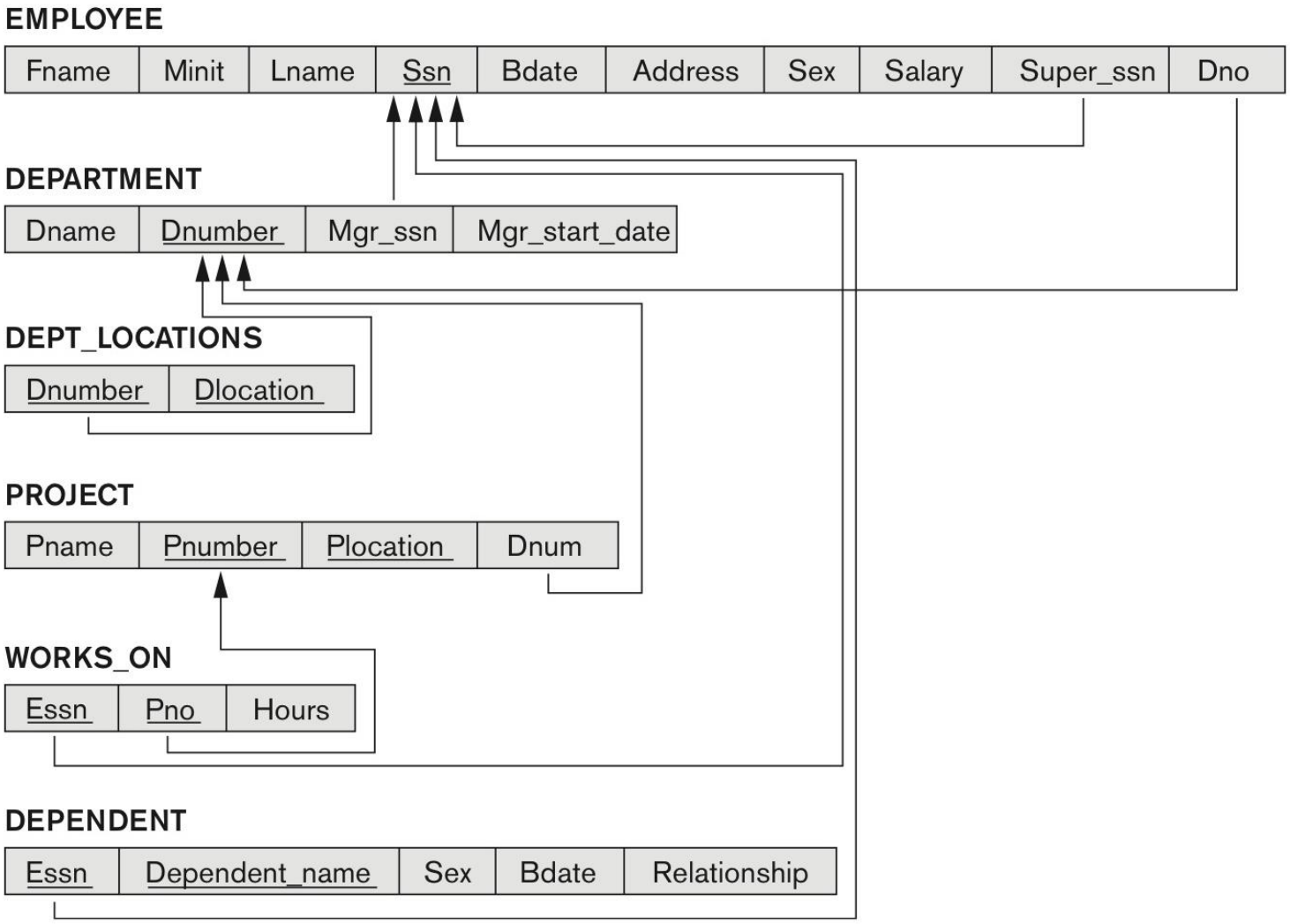


Here for a Bank, a Customer can hold multiple bank accounts.
Similarly, an account may be jointly held by multiple customers.
A foreign-key attribute SSN of owner in BANK_ACCT or a foreign key ACCT# in CUSTOMER cannot be used.
Hence a separate relation is needed. The relationship attribute "Primary" which is a Boolean designating the primary owner of account belongs to this relation.:
Cust-account (SSN, Acct#, Primary)

Mapping of Multi-valued Attributes

- **Step 6: Mapping of Multivalued attributes.**
  - For each multivalued attribute A, create a new relation R.
  - This relation R will include an attribute corresponding to A, plus the primary key attribute K-as a foreign key in R-of the relation that represents the entity type of relationship type that has A as an attribute.
  - The primary key of R is the combination of A and K. If the multivalued attribute is composite, we include its simple components.
- **Example:** The relation DEPT_LOCATIONS is created.
  - The attribute DLOCATION represents the multivalued attribute LOCATIONS of DEPARTMENT, while DNUMBER-as foreign key-represents the primary key of the DEPARTMENT relation.
  - The primary key of R is the combination of {DNUMBER, DLOCATION}.

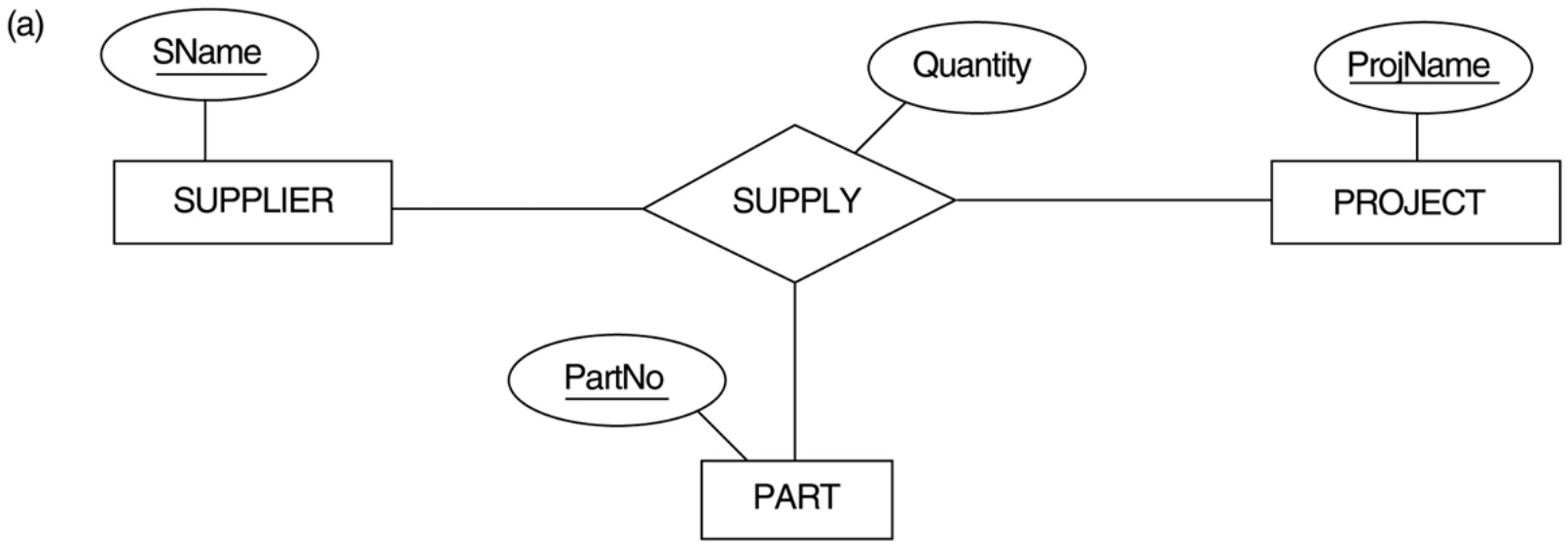
Figure 9.2 Result of mapping the COMPANY ER schema into a relational database schema.



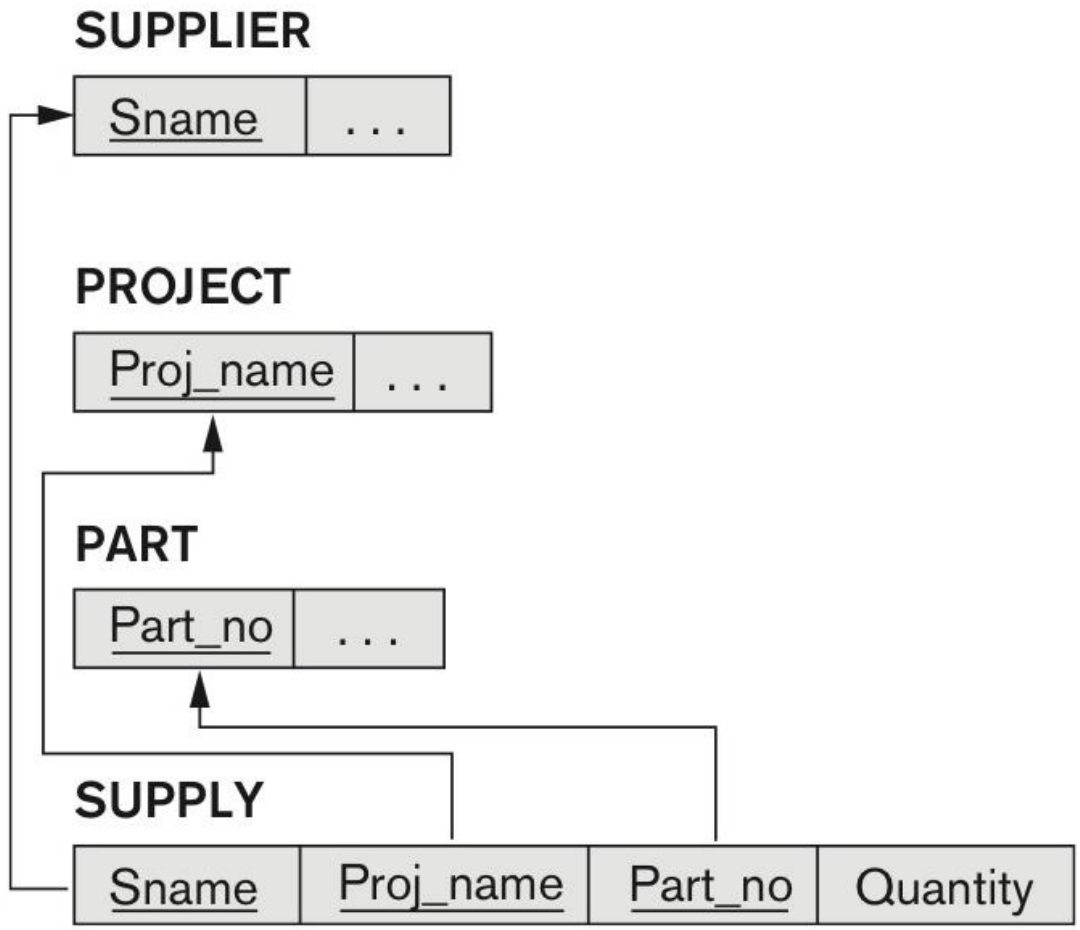
Mapping of N-ary relationship types

- **Step 7: Mapping of N-ary Relationship Types.**
  - For each n-ary relationship type R, where n>2, create a new relationship S to represent R.
  - Include as foreign key attributes in S the primary keys of the relations that represent the participating entity types.
  - Also include any simple attributes of the n-ary relationship type (or simple components of composite attributes) as attributes of S.
- **Example:** The relationship type SUPPY in the ER on the next slide.
  - This can be mapped to the relation SUPPLY shown in the relational schema, whose primary key is the combination of the three foreign keys {SNAME, PARTNO, PROJNAME}

FIGURE 3.17
TERNARY RELATIONSHIP: SUPPLY



Mapping the ternary relationship type SUPPLY



Summary of Mapping constructs and constraints

Table 9.1 Correspondence between ER and Relational Models

ER MODEL	RELATIONAL MODEL
Entity type	*Entity* relation
1:1 or 1:N relationship type	Foreign key (or *relationship* relation)
M:N relationship type	*Relationship* relation and *two* foreign keys
n-ary relationship type	*Relationship* relation and *n* foreign keys
Simple attribute	Attribute
Composite attribute	Set of simple component attributes
Multivalued attribute	Relation and foreign key
Value set	Domain
Key attribute	Primary (or secondary) key

Chapter 9 Summary

ER-to-Relational Mapping Algorithm

- Step 1: Mapping of Regular Entity Types
- Step 2: Mapping of Weak Entity Types
- Step 3: Mapping of Binary 1:1 Relation Types
- Step 4: Mapping of Binary 1:N Relationship Types.
- Step 5: Mapping of Binary M:N Relationship Types.
- Step 6: Mapping of Multivalued attributes.
- Step 7: Mapping of N-ary Relationship Types.

NOTE**: IGNORE SECTION 9.2** OF THE CHAPTER FOR NOW THAT DISCUSSES MAPPING OF EER (ENHANCED ER SCHEMAS INVOLVING SET-SUBSET AND SPECIALIZATION HIERARCHY RELATIONSHIPS AMONG ENTITY TYPES0.