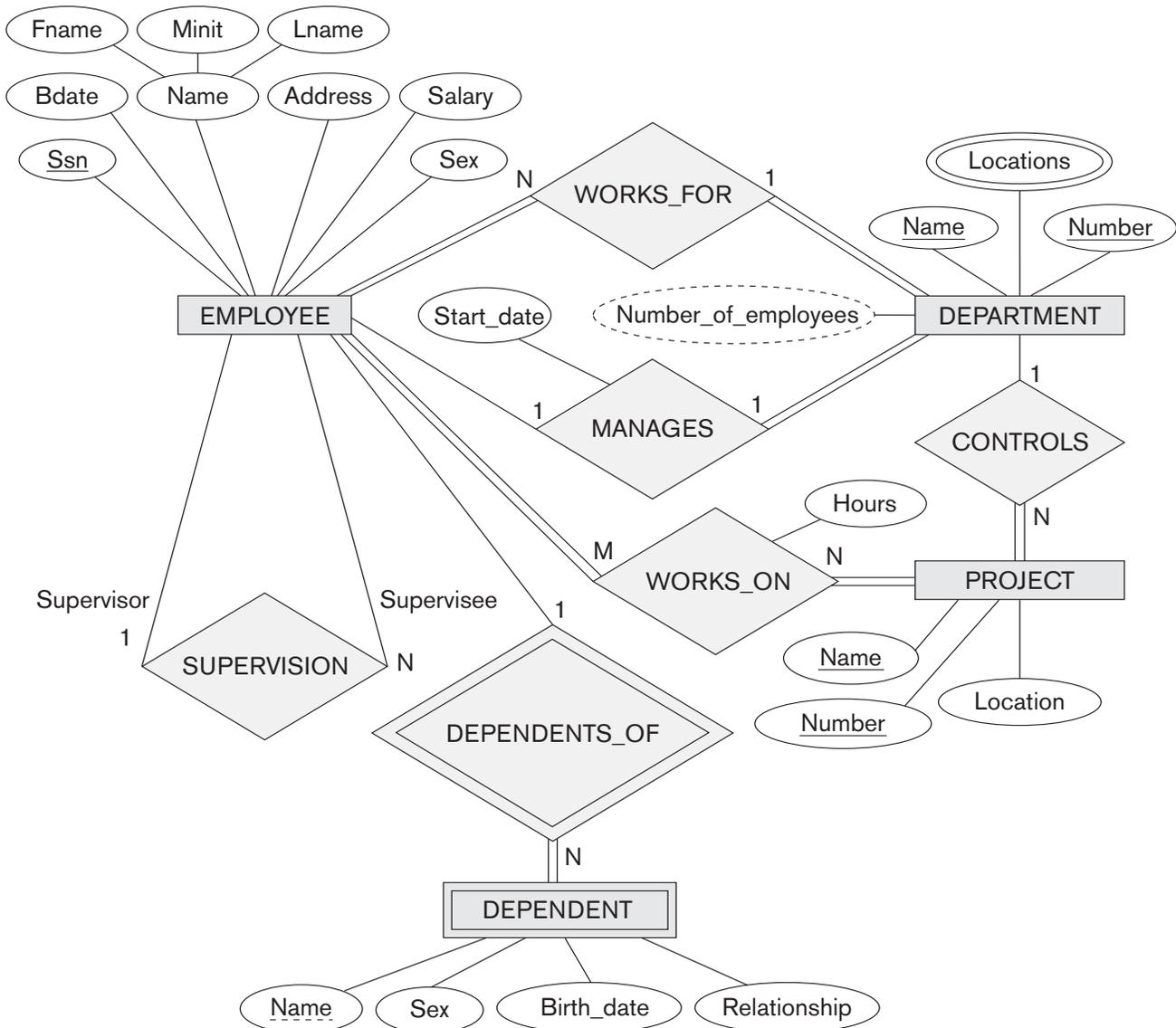


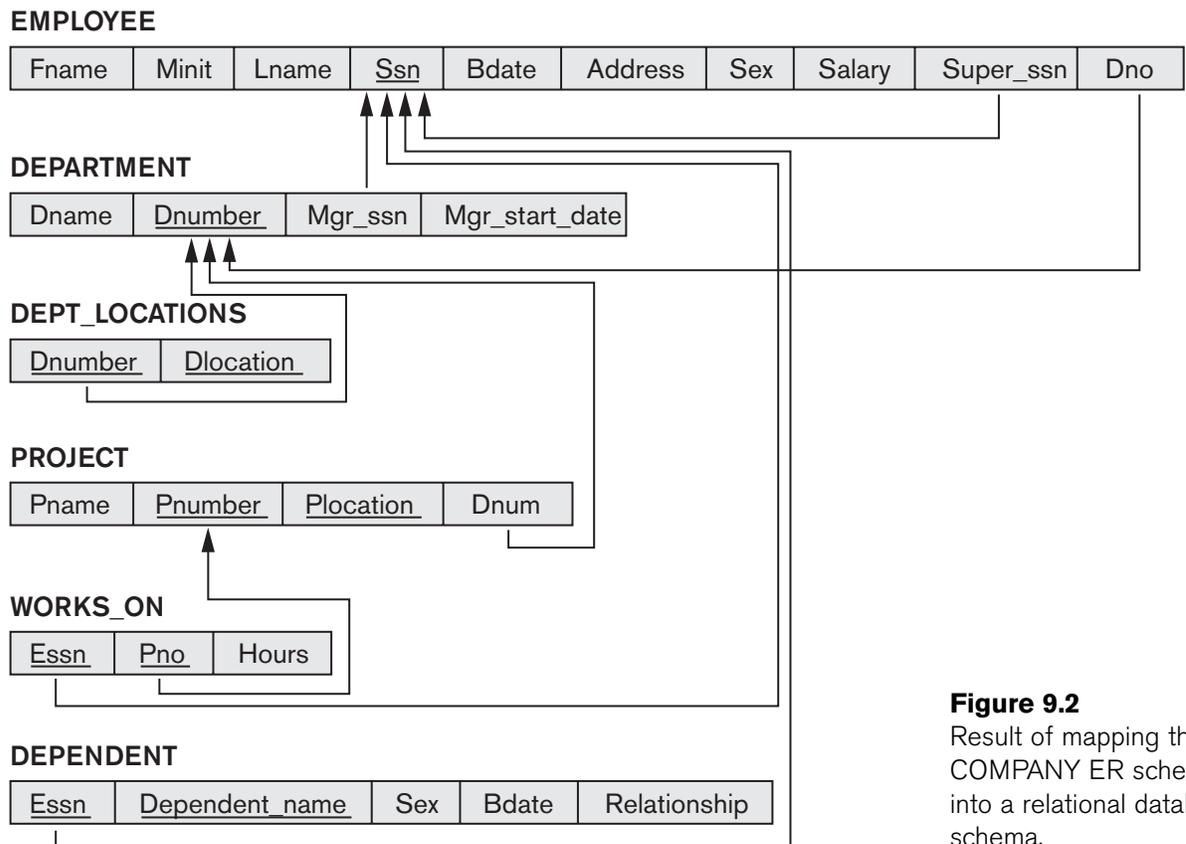
## 9.1 Relational Database Design Using ER-to-Relational Mapping

### 9.1.1 ER-to-Relational Mapping Algorithm

In this section we describe the steps of an algorithm for ER-to-relational mapping. We use the COMPANY database example to illustrate the mapping procedure. The COMPANY ER schema is shown again in Figure 9.1, and the corresponding COMPANY relational database schema is shown in Figure 9.2 to illustrate the map-

**Figure 9.1**  
The ER conceptual schema diagram for the COMPANY database.





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

ping steps. We assume that the mapping will create tables with simple single-valued attributes. The relational model constraints defined in Chapter 3, which include primary keys, unique keys (if any), and referential integrity constraints on the relations, will also be specified in the mapping results.

**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*. Include only the simple component attributes of a composite attribute. Choose one of the key attributes of *E* as the primary key for *R*. If the chosen key of *E* is a composite, then the set of simple attributes that form it will together form the primary key of *R*.

If multiple keys were identified for *E* during the conceptual design, the information describing the attributes that form each additional key is kept in order to specify secondary (unique) keys of relation *R*. Knowledge about keys is also kept for indexing purposes and other types of analyses.

In our example, we create the relations EMPLOYEE, DEPARTMENT, and PROJECT in Figure 9.2 to correspond to the regular entity types EMPLOYEE, DEPARTMENT, and PROJECT in Figure 9.1. The foreign key and relationship attributes, if any, are not included yet; they will be added during subsequent steps. These include the

The basic relational algebra does not have a NEST or COMPRESS operation that would produce a set of tuples of the form  $\{ \langle '1', 'Houston' \rangle, \langle '4', 'Stafford' \rangle, \langle '5', 'Bellaire', 'Sugarland', 'Houston' \rangle \}$  from the DEPT\_LOCATIONS relation in Figure 3.6. This is a serious drawback of the basic normalized or *flat* version of the relational model. The object data model and object-relational systems (see Chapter 11) do allow multivalued attributes.

## 9.2 Mapping EER Model Constructs to Relations

Next, we discuss the mapping of EER model constructs to relations by extending the ER-to-relational mapping algorithm that was presented in Section 9.1.1.

### 9.2.1 Mapping of Specialization or Generalization

There are several options for mapping a number of subclasses that together form a specialization (or alternatively, that are generalized into a superclass), such as the {SECRETARY, TECHNICIAN, ENGINEER} subclasses of EMPLOYEE in Figure 8.4. We can add a further step to our ER-to-relational mapping algorithm from Section 9.1.1, which has seven steps, to handle the mapping of specialization. Step 8, which follows, gives the most common options; other mappings are also possible. We discuss the conditions under which each option should be used. We use  $\text{Attrs}(R)$  to denote *the attributes of relation R*, and  $\text{PK}(R)$  to denote *the primary key of R*. First we describe the mapping formally, then we illustrate it with examples.

**Step 8: Options for Mapping Specialization or Generalization.** Convert each specialization with  $m$  subclasses  $\{S_1, S_2, \dots, S_m\}$  and (generalized) superclass  $C$ , where the attributes of  $C$  are  $\{k, a_1, \dots, a_n\}$  and  $k$  is the (primary) key, into relation schemas using one of the following options:

- **Option 8A: Multiple relations—superclass and subclasses.** Create a relation  $L$  for  $C$  with attributes  $\text{Attrs}(L) = \{k, a_1, \dots, a_n\}$  and  $\text{PK}(L) = k$ . Create a relation  $L_i$  for each subclass  $S_i$ ,  $1 \leq i \leq m$ , with the attributes  $\text{Attrs}(L_i) = \{k\} \cup \{\text{attributes of } S_i\}$  and  $\text{PK}(L_i) = k$ . This option works for any specialization (total or partial, disjoint or overlapping).
- **Option 8B: Multiple relations—subclass relations only.** Create a relation  $L_i$  for each subclass  $S_i$ ,  $1 \leq i \leq m$ , with the attributes  $\text{Attrs}(L_i) = \{\text{attributes of } S_i\} \cup \{k, a_1, \dots, a_n\}$  and  $\text{PK}(L_i) = k$ . This option only works for a specialization whose subclasses are *total* (every entity in the superclass must belong to (at least) one of the subclasses). Additionally, it is only recommended if the specialization has the *disjointness constraint* (see Section 8.3.1). If the specialization is *overlapping*, the same entity may be duplicated in several relations.
- **Option 8C: Single relation with one type attribute.** Create a single relation  $L$  with attributes  $\text{Attrs}(L) = \{k, a_1, \dots, a_n\} \cup \{\text{attributes of } S_1\} \cup \dots \cup \{\text{attributes of } S_m\} \cup \{t\}$  and  $\text{PK}(L) = k$ . The attribute  $t$  is called a **type** (or