CHAPTER 9

Relational Database Design by ER-to-Relational Mapping

Note: Slides, content, web links and end chapter questions are prepared from Pearson textbook (Elmasri & Navathe), and other Internet resources.

Topic of Discussion

A. ER-to-Relational Mapping Algorithm

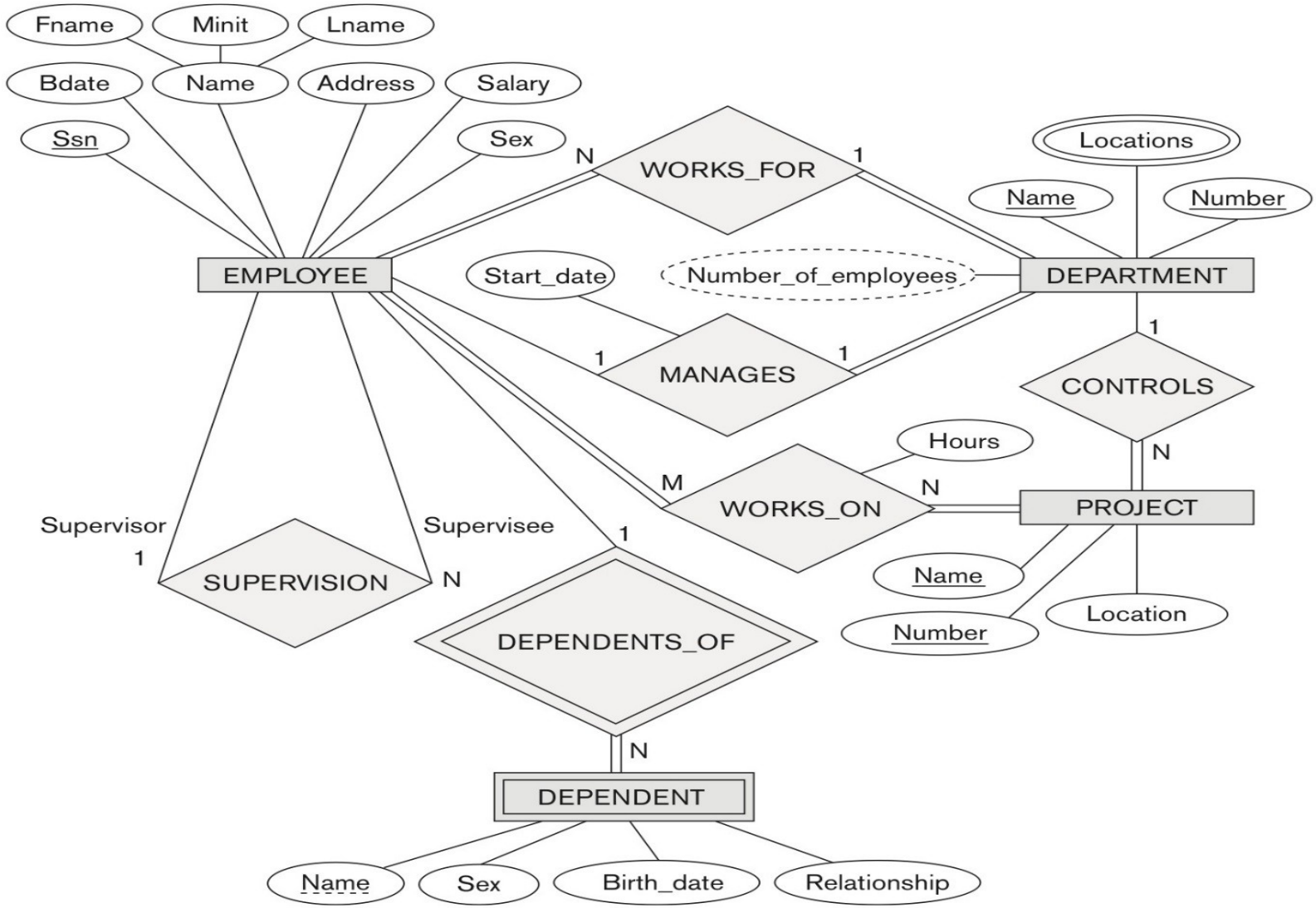
- Step 1: Mapping of Regular Entity Types
- Step 2: Mapping of Weak Entity Types
- Step 3: Mapping of Binary 1:1 Relation Types
- Step 4: Mapping of Binary 1:N Relationship Types.
- Step 5: Mapping of Binary M:N Relationship Types.
- Step 6: Mapping of Multivalued attributes.
- Step 7: Mapping of N-ary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

GOALS during Mapping

- Preserve all information (that includes all attributes)
- Maintain the constraints to the extent possible (Relational Model cannot preserve all constraints- e.g., max cardinality ratio in ER; exhaustive classification into subtypes, e.g., STUDENTS are specialized into Domestic and Foreign)
- Minimize null values.

- The mapping procedure described has been implemented in many commercial tools.
- Now, we are implementing our COMPANY database conceptual schema into MS SQL server 2017, (A Commercial Relational Database System), in next slides.

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 (table) 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.

ER-to-Relational Mapping Algorithm

- In our example: We create 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 (tables) EMPLOYEE, DEPARTMENT, and PROJECT as shown figure (a).

(a)

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

ER-to-Relational Mapping Algorithm(contd.)

- **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.

ER-to-Relational Mapping Algorithm(contd.)

- In our 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. See at figure (b).

(b) **DEPENDENT**

Essn	Dependent_name	Sex	Bdate	Relationship

ER-to-Relational Mapping Algorithm (contd.)

- **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.
     - In our 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.

ER-to-Relational Mapping Algorithm (contd.)

- **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.
- In our 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.

ER-to-Relational Mapping Algorithm (contd.)

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Dno	Super_ssn

DEPARTMENT

Dname	Dnumber	Mgr_ssn

PROJECT

Pname	Pnumber	Plocation	Dnum

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

ER-to-Relational Mapping Algorithm (contd.)

- **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.

ER-to-Relational Mapping Algorithm (contd.)

- In our 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}. See in figure (c).

WORKS_ON

Essn	Pno	Hours

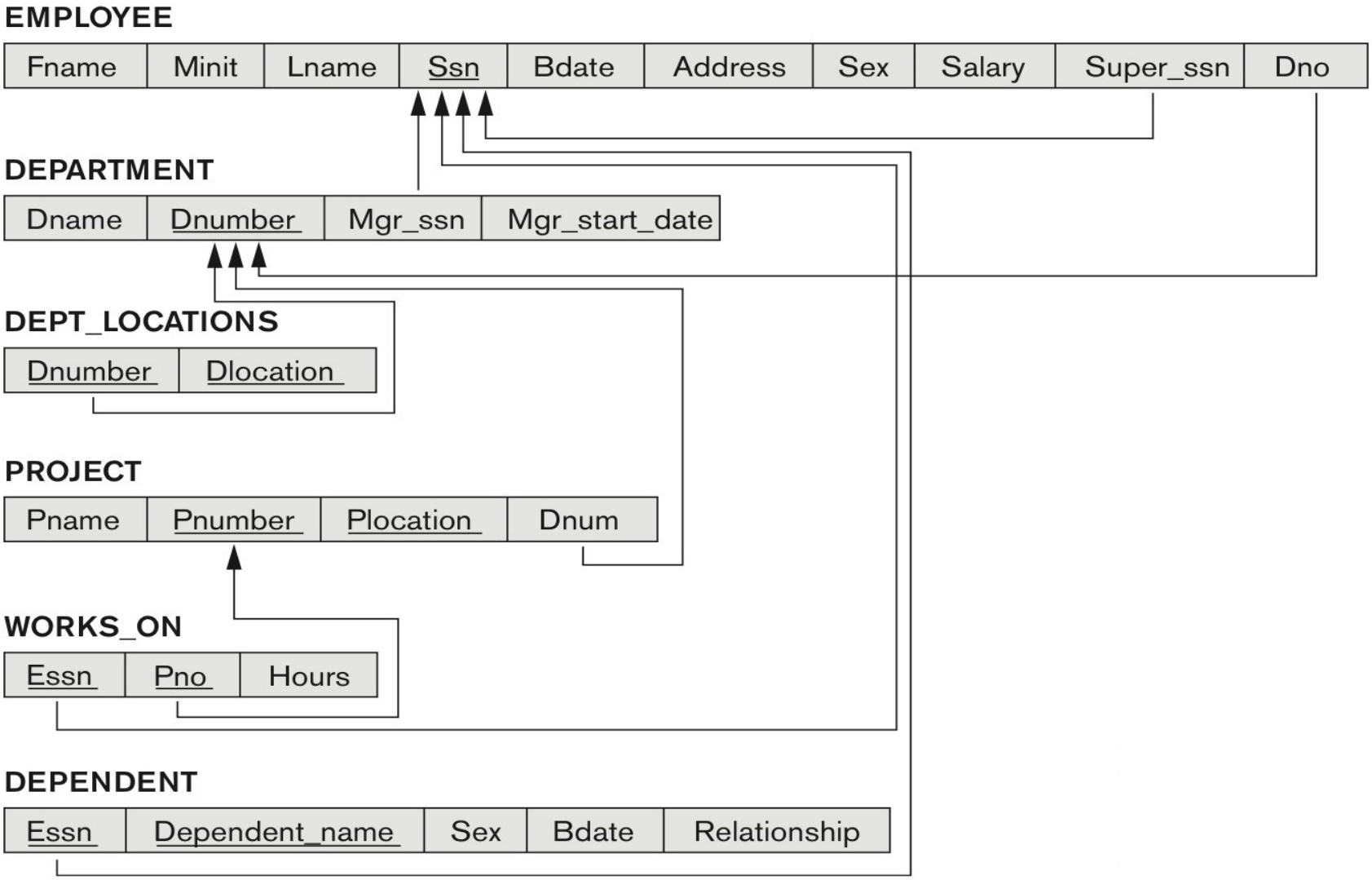
ER-to-Relational Mapping Algorithm (contd.)

- **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.

ER-to-Relational Mapping Algorithm (contd.)

- In our 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}. See at figure (d).

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

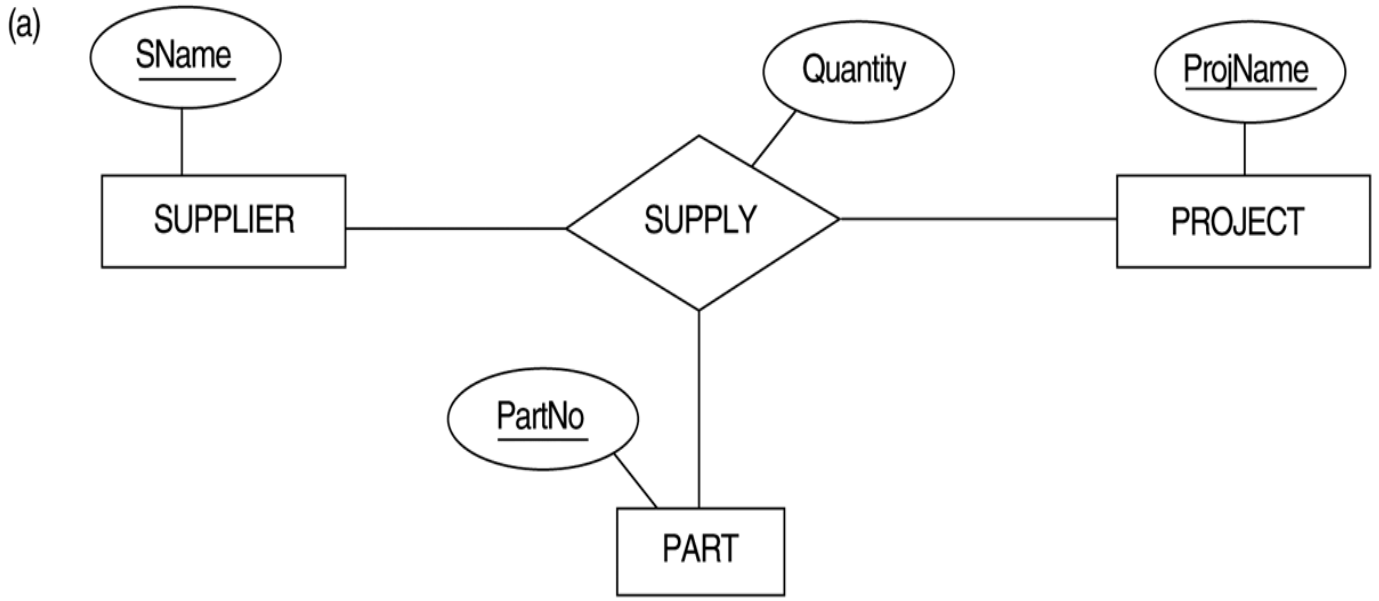


ER-to-Relational Mapping Algorithm (contd.)

- **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.

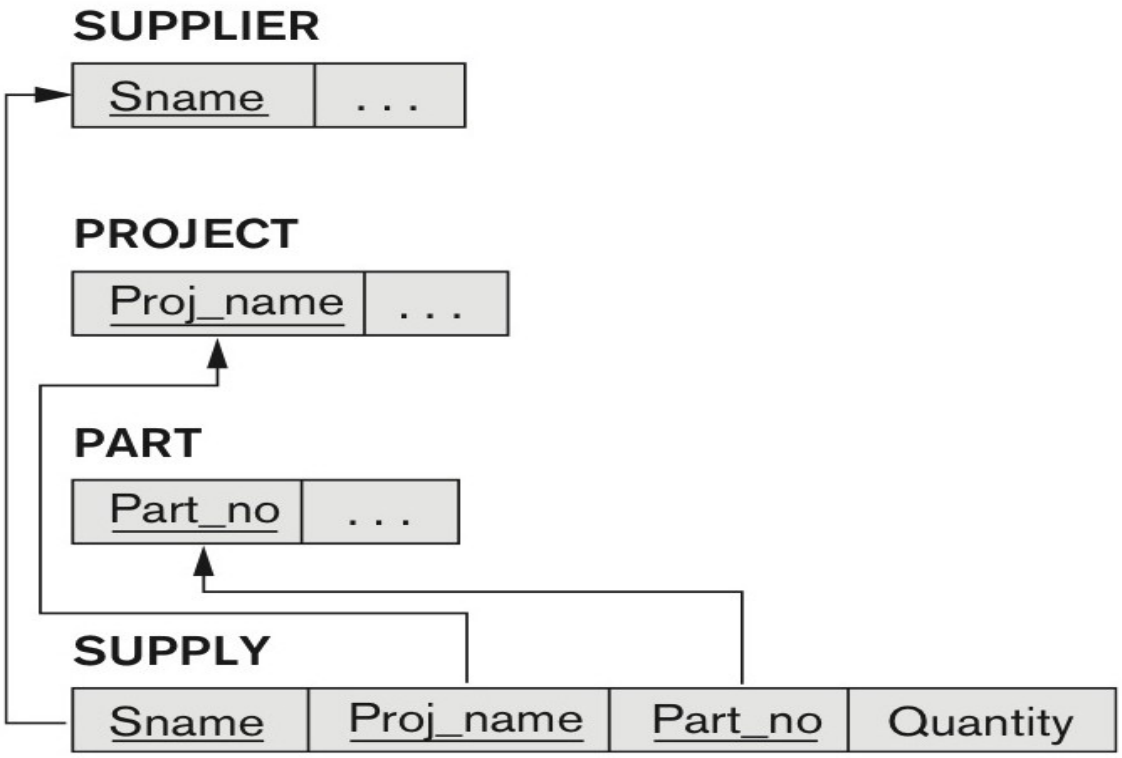
ER-to-Relational Mapping Algorithm (contd.)

- **Example:** The relationship type SUPPY in the ER at below figure, suppose.



ER-to-Relational Mapping Algorithm (contd.)

- 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}, in below figure.



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

End Chapter Questions

- 9.1. Discuss the correspondences between the ER model constructs and the relational model constructs. Show how each ER model construct can be mapped to the relational model and discuss any alternative mappings.
- 9.2. Map the UNIVERSITY database schema shown in Figure 3.20 (Ch3 slide no 56) into a relational database schema. (Forward engineering)
- 9.4. Figure 9.8 shows (next slide) an ER schema for a database that can be used to keep track of transport ships and their locations for maritime authorities. Map this schema into a relational schema and specify all primary keys and foreign keys.

End Chapter Questions

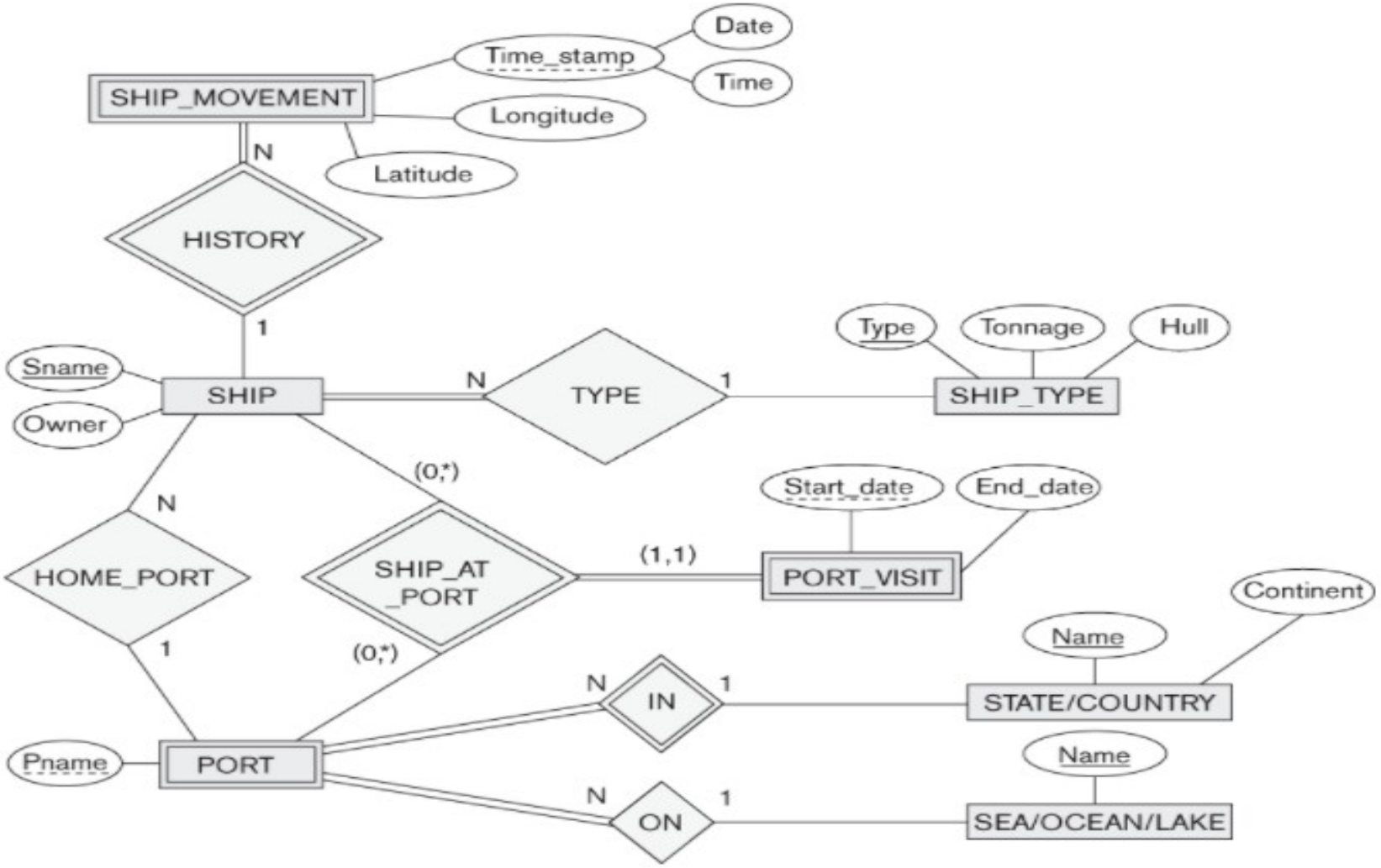


Figure 9.8 An ER schema for a SHIP_TRACKING database.