Data Modeling Using the Entity-Relationship (ER) Model

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Outline

- Using High-Level Conceptual Data Models for Database Design
- A Sample Database Application
- Entity Types, Entity Sets, Attributes, and Keys
- Relationship Types, Relationship Sets, Roles, and Structural Constraints
- Weak Entity Types
- Refining the ER Design for the COMPANY Database
- ER Diagrams, Naming Conventions, and Design Issues
- Relationship Types of Degree Higher than Two

Data Modeling Using the Entity-Relationship (ER) Model

- **Entity-Relationship (ER) model**
  - Popular high-level conceptual data model
- **ER diagrams**
  - Diagrammatic notation associated with the ER model
- **Unified Modeling Language (UML)**

Using High-Level Conceptual Data Models for Database Design

- **Requirements collection and analysis**
  - Database designers interview prospective database users to understand and document data requirements
  - Result: **data requirements**
  - **Functional requirements** of the application

Using High-Level Conceptual Data Models (cont'd.)

- **Conceptual schema**
  - Conceptual design
  - Description of data requirements
  - Includes detailed descriptions of the entity types, relationships, and constraints
  - Transformed from high-level data model into implementation data model

Using High-Level Conceptual Data Models (cont'd.)

- **Logical design** or **data model mapping**
  - Result is a database schema in implementation data model of DBMS
- **Physical design phase**
  - Internal storage structures, file organizations, indexes, access paths, and physical design parameters for the database files specified

ER Diagrams, Naming Conventions, and Design Issues

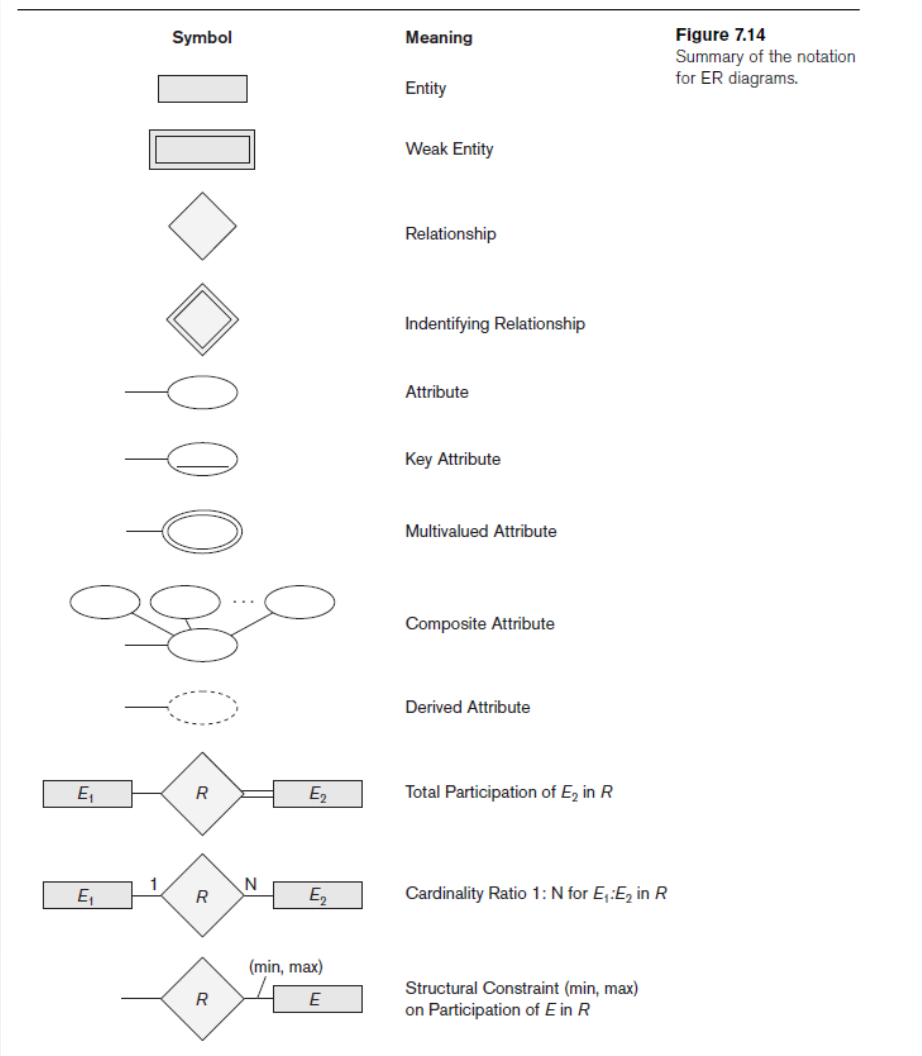


Figure 7.14
Summary of the notation for ER diagrams.

A Sample Database Application

- COMPANY
  - Employees, departments, and projects
  - Company is organized into departments
  - Department controls a number of projects
  - Employee: store each employee's name, Social Security number, address, salary, gender, and birth date
  - Keep track of the dependents of each employee

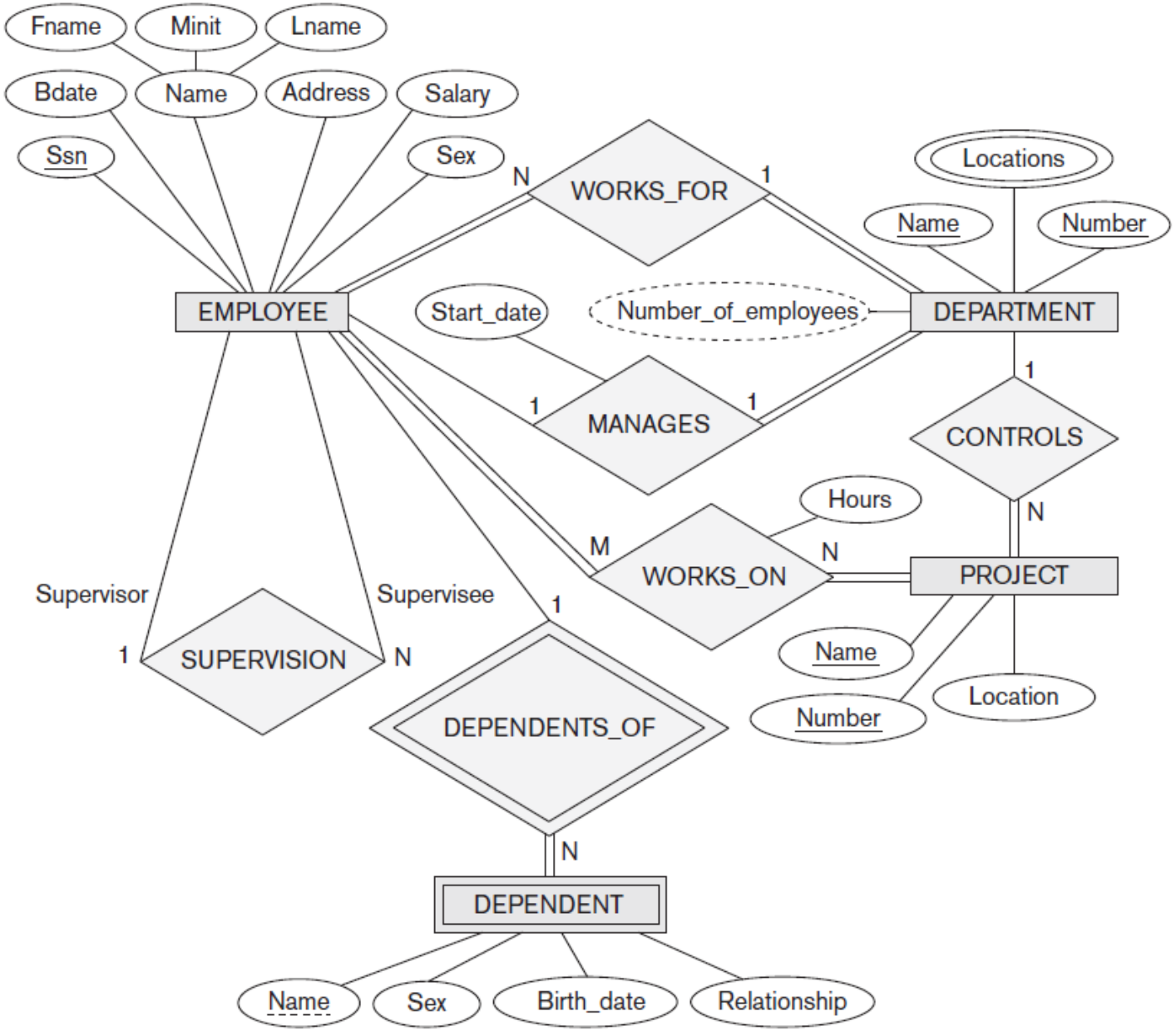


Figure 7.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter and is summarized in Figure 7.14.

Entity Types, Entity Sets, Attributes, and Keys

- ER model describes data as:
  - Entities
  - Relationships
  - Attributes

Entities and Attributes

- **Entity**
  - Thing in real world with independent existence
- **Attributes**
  - Particular properties that describe entity
  - Types of attributes:
    - *Composite* versus *simple* (atomic) *attributes*
    - **Single-valued** versus **multivalued** attributes
    - **Stored** versus **derived** attributes
    - **NULL** values
    - **Complex** attributes

Attributes

- **Simple Attribute**
  - **Attribute composed of a single component with an independent existence.**
- **Composite Attribute**
  - **Attribute composed of multiple components, each with an independent existence.**

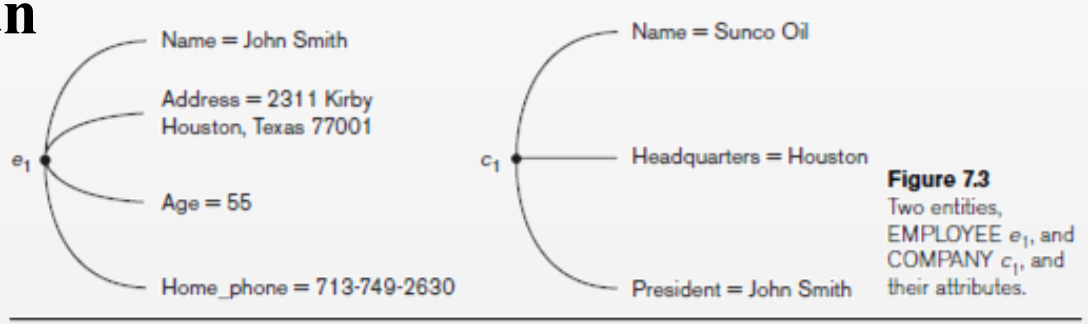


Figure 7.3
Two entities, EMPLOYEE e_1, and COMPANY c_1, and their attributes.

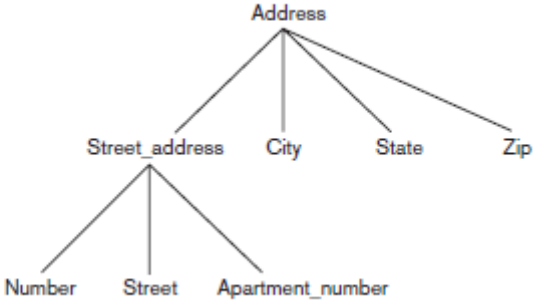


Figure 7.4
A hierarchy of composite attributes.

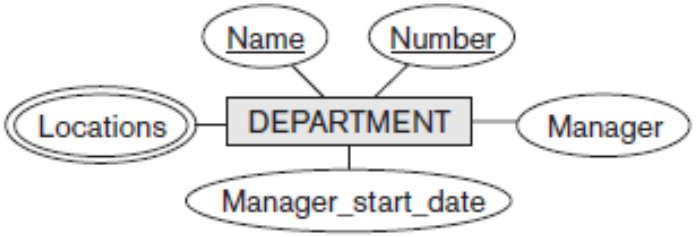
Attributes

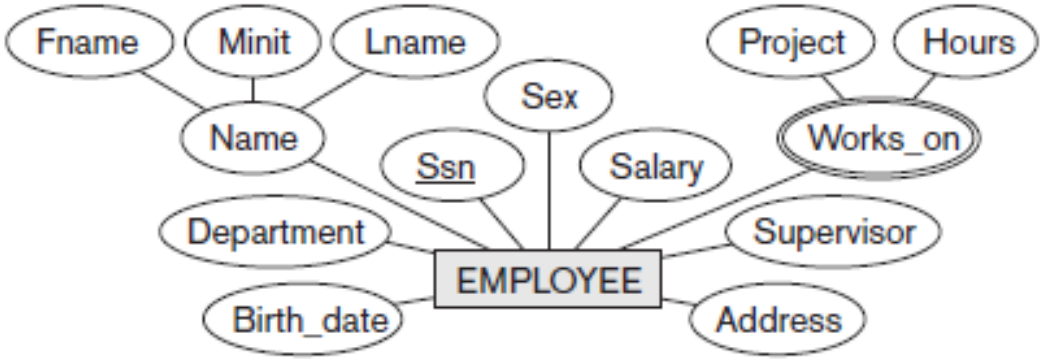
- **Single-valued Attribute**
  - **Attribute that holds a single value for each occurrence of an entity type.**
- **Multi-valued Attribute**
  - **Attribute that holds multiple values for each occurrence of an entity type.**
- **Derived Attribute vs. Stored**
  - **Attribute that represents a value that is derivable from value of a related attribute, or set of attributes, not necessarily in the same entity type.**
- **NULL**
- **Complex Attributes**

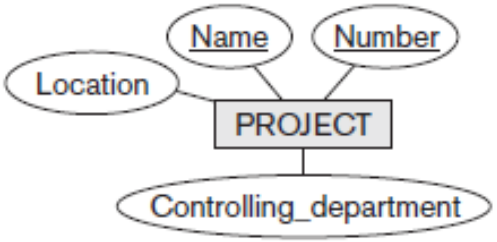
{Address_phone({Phone(Area_code,Phone_number)},Address(Street_address (Number,Street,Apartment_number),City,State,Zip))}

Figure 7.5
A complex attribute: Address_phone.

Initial Conceptual Design of the COMPANY Database







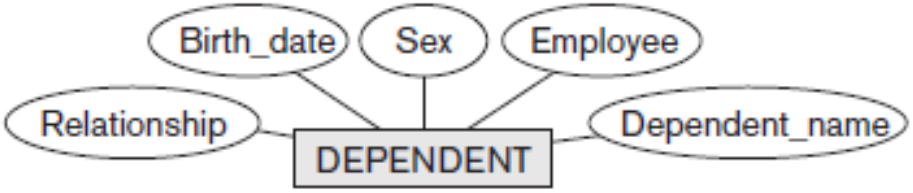


Figure 7.8
Preliminary design of entity types for the COMPANY database. Some of the shown attributes will be refined into relationships.

Relationship Types, Relationship Sets, Roles, and Structural Constraints

- **Relationship**
  - When an attribute of one entity type refers to another entity type
  - Represent references as relationships not attributes

Relationship Degree

- **Degree** of a relationship type
  - Number of participating entity types
  - **Binary**, **ternary**
- Relationships as attributes
  - Think of a binary relationship type in terms of attributes

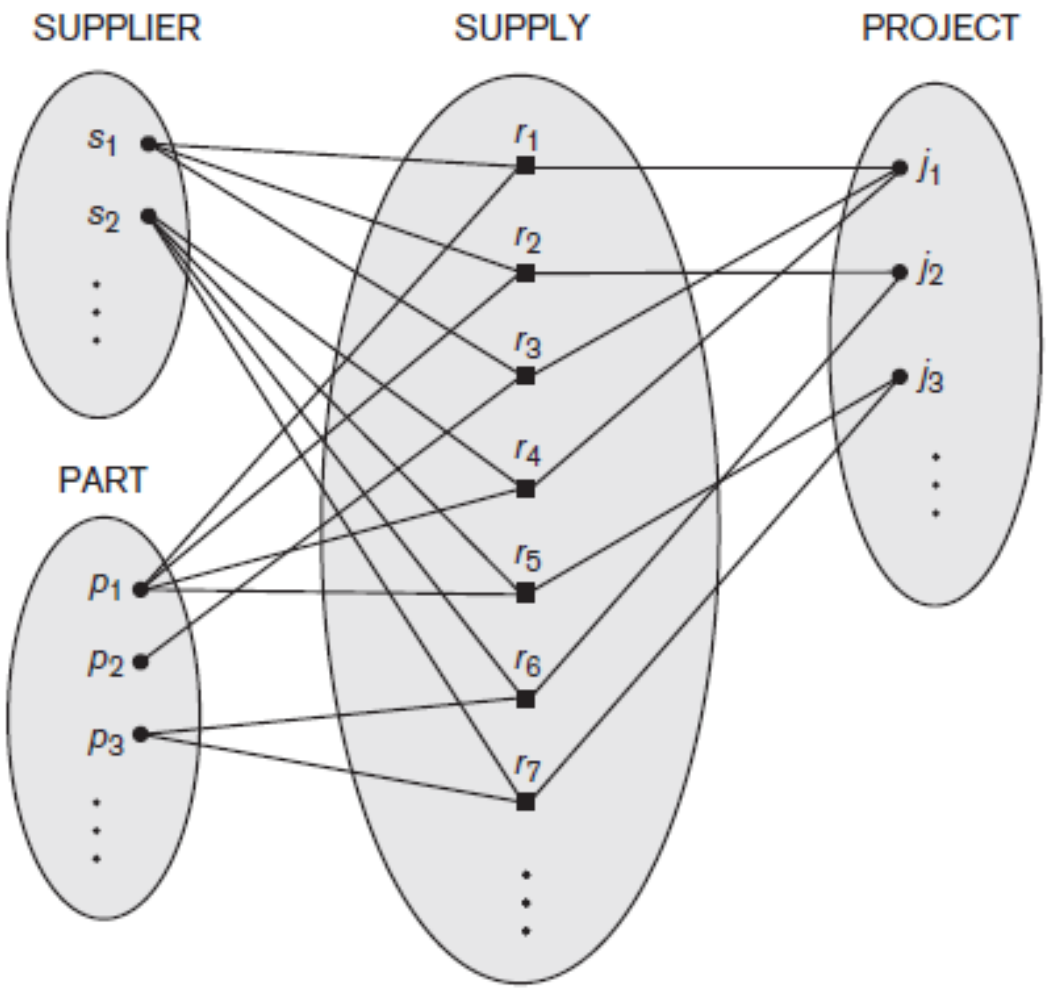


Figure 7.10
Some relationship instances in the SUPPLY ternary relationship set.

Role Names and Recursive Relationships

- **Role names** and recursive relationships
  - Role name signifies role that a participating entity plays in each relationship instance
- **Recursive** relationships
  - Same entity type participates more than once in a relationship type in different roles
  - Must specify role name

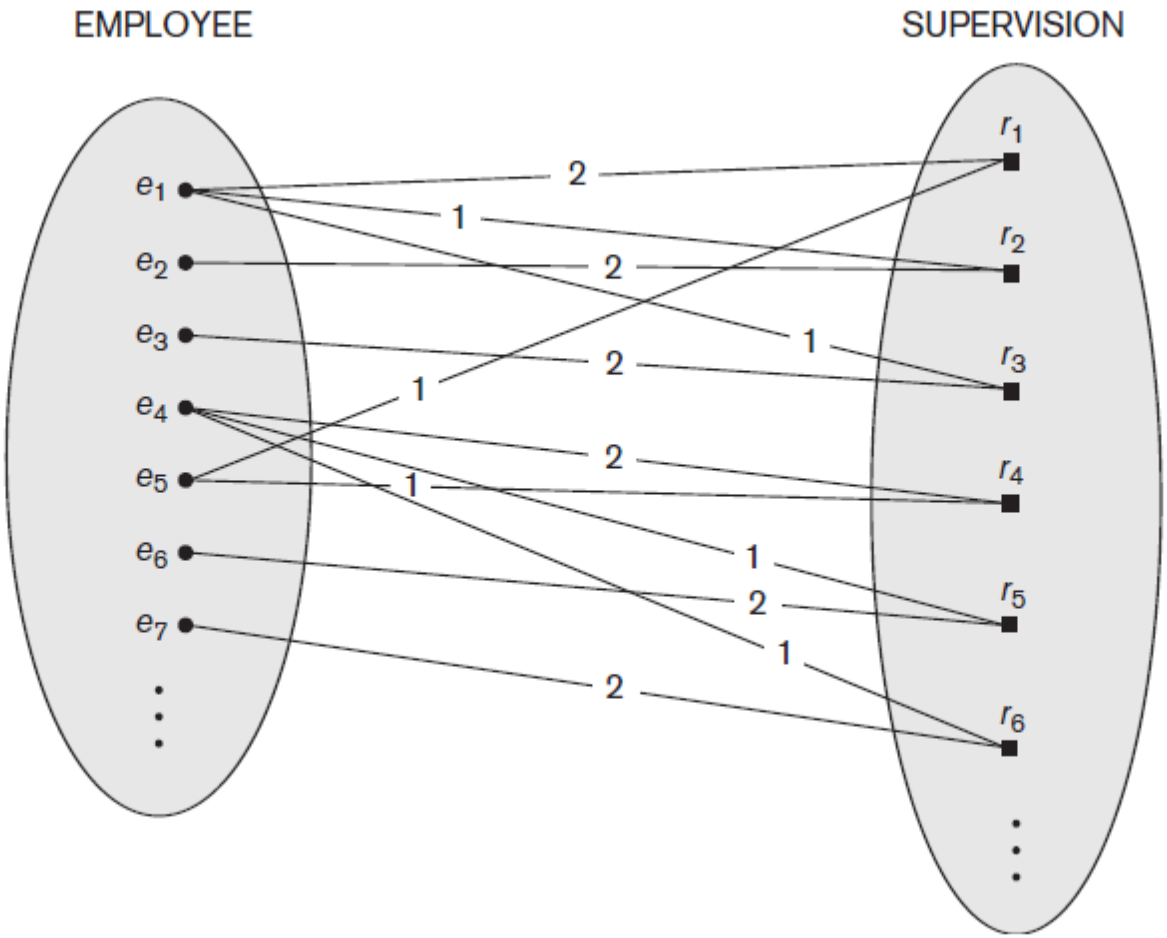


Figure 7.11
A recursive relationship SUPERVISION between EMPLOYEE in the *supervisor* role (1) and EMPLOYEE in the *subordinate* role (2).

Constraints on Binary Relationship Types

- **Cardinality ratio** for a binary relationship
  - Specifies maximum number of relationship instances that entity can participate in
- **Participation constraint**
  - Specifies whether existence of entity depends on its being related to another entity
  - Types: **total** and **partial**

Attributes of Relationship Types

- Attributes of 1:1 or 1:N relationship types can be migrated to one entity type
- For a 1:N relationship type
  - Relationship attribute can be migrated only to entity type on N-side of relationship
- For M:N relationship types
  - Some attributes may be determined by combination of participating entities
  - Must be specified as relationship attributes

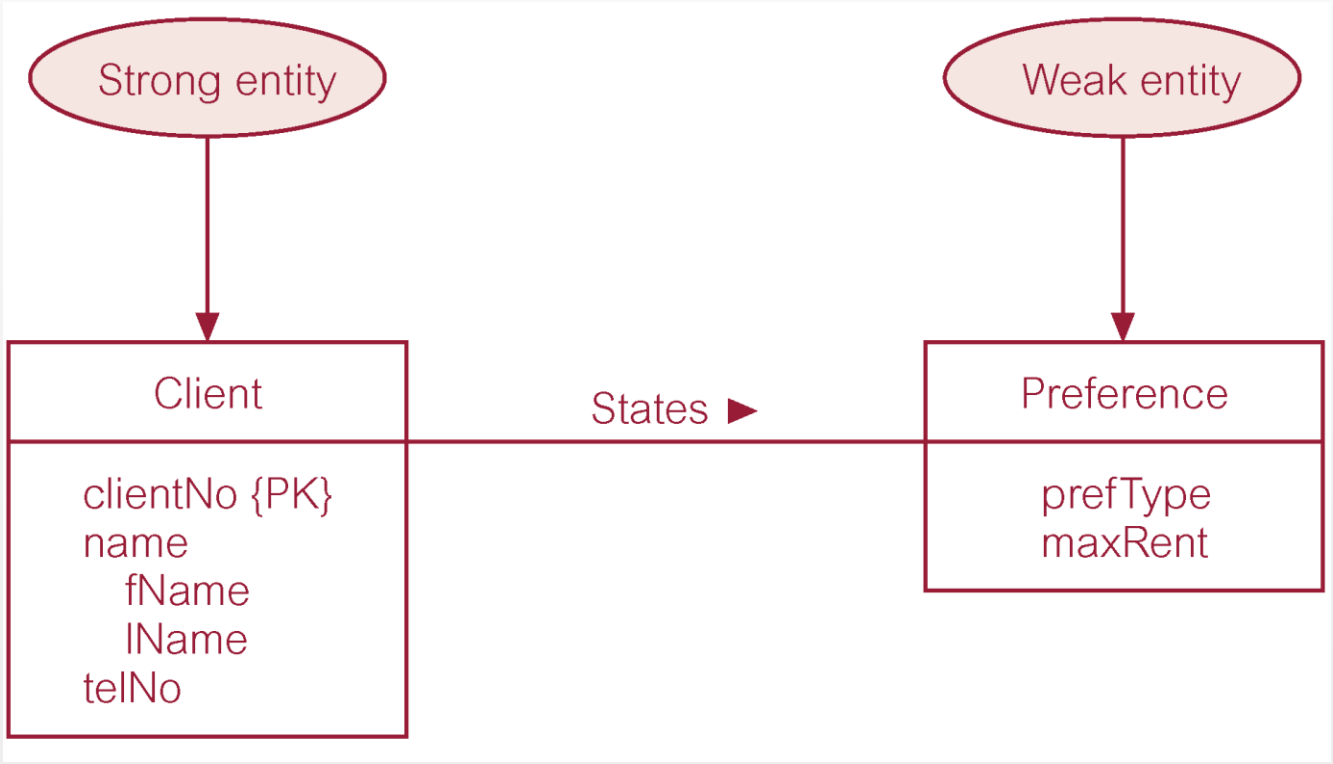
Weak Entity Types

- Do not have key attributes of their own
  - Identified by being related to specific entities from another entity type
- **Identifying relationship**
  - Relates a weak entity type to its owner
- Always has a total participation constraint

Entity Type

- **Strong Entity Type**
  - **Entity type that is *not* existence-dependent on some other entity type.**
- **Weak Entity Type**
  - **Entity type that is existence-dependent on some other entity type.**

Strong entity type called Client and weak entity type called Preference



Refining the ER Design for the COMPANY Database

- Change attributes that represent relationships into relationship types
- Determine cardinality ratio and participation constraint of each relationship type

Proper Naming of Schema Constructs

- Choose names that convey meanings attached to different constructs in schema
- Nouns give rise to entity type names
- Verbs indicate names of relationship types
- Choose binary relationship names to make ER diagram readable from left to right and from top to bottom

Design Choices for ER Conceptual Design

- Model concept first as an attribute
  - Refined into a relationship if attribute is a reference to another entity type
- Attribute that exists in several entity types may be elevated to an independent entity type
  - Can also be applied in the inverse

Alternative Notations for ER Diagrams

- Specify structural constraints on relationships
  - Replaces cardinality ratio (1:1, 1:N, M:N) and single/double line notation for participation constraints
  - Associate a pair of integer numbers (min, max) with each participation of an entity type *E* in a relationship type *R*, where $0 \leq \min \leq \max$ and $\max \geq 1$

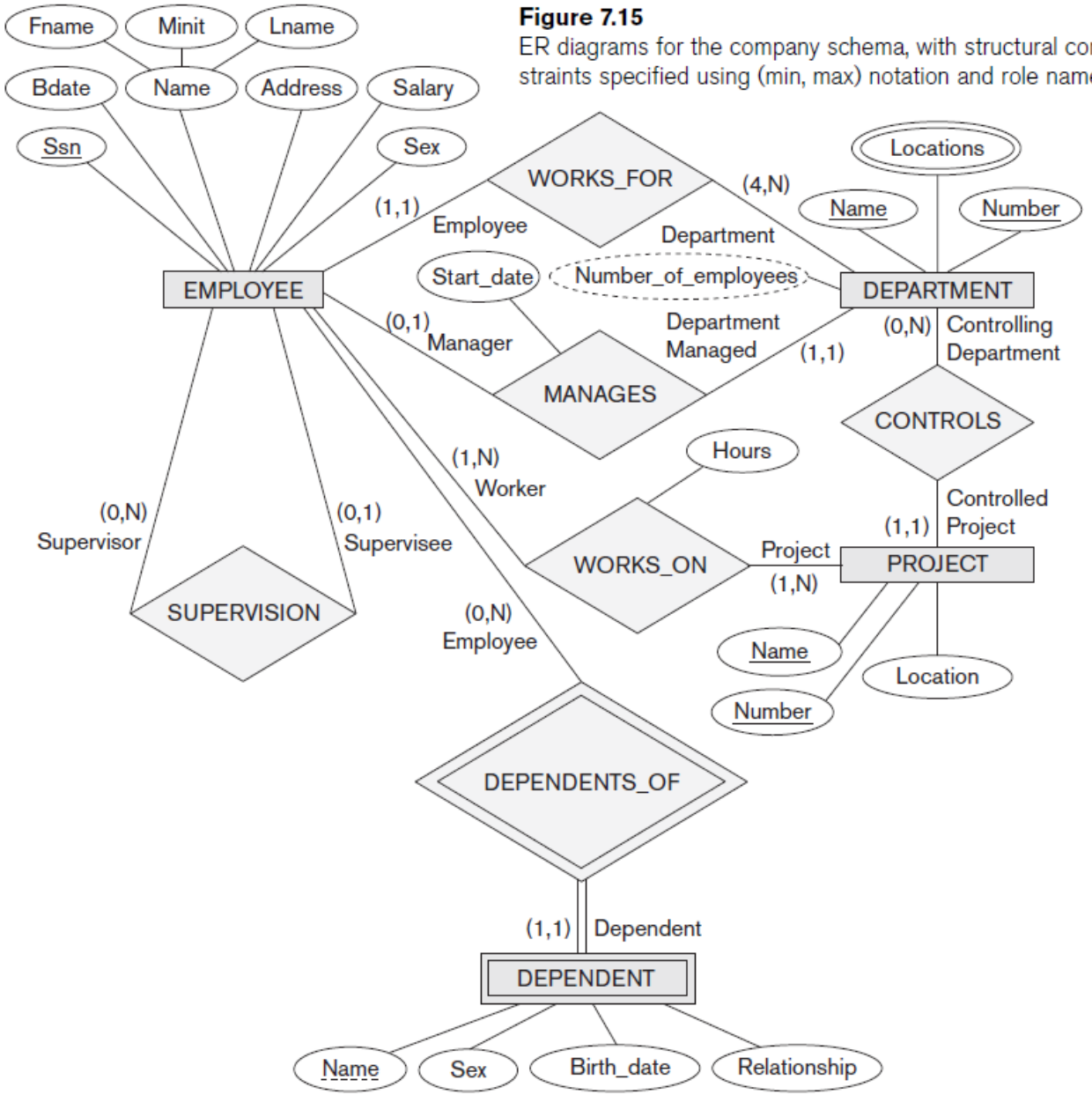


Figure 7.15
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

Relationship Types of Degree Higher than Two

- **Degree** of a relationship type
  - Number of participating entity types
- *Binary*
  - Relationship type of degree two
- *Ternary*
  - Relationship type of degree three

Choosing between Binary and Ternary (or Higher-Degree) Relationships

- Some database design tools permit only binary relationships
  - Ternary relationship must be represented as a weak entity type
  - No partial key and three identifying relationships
- Represent ternary relationship as a regular entity type
  - By introducing an artificial or surrogate key

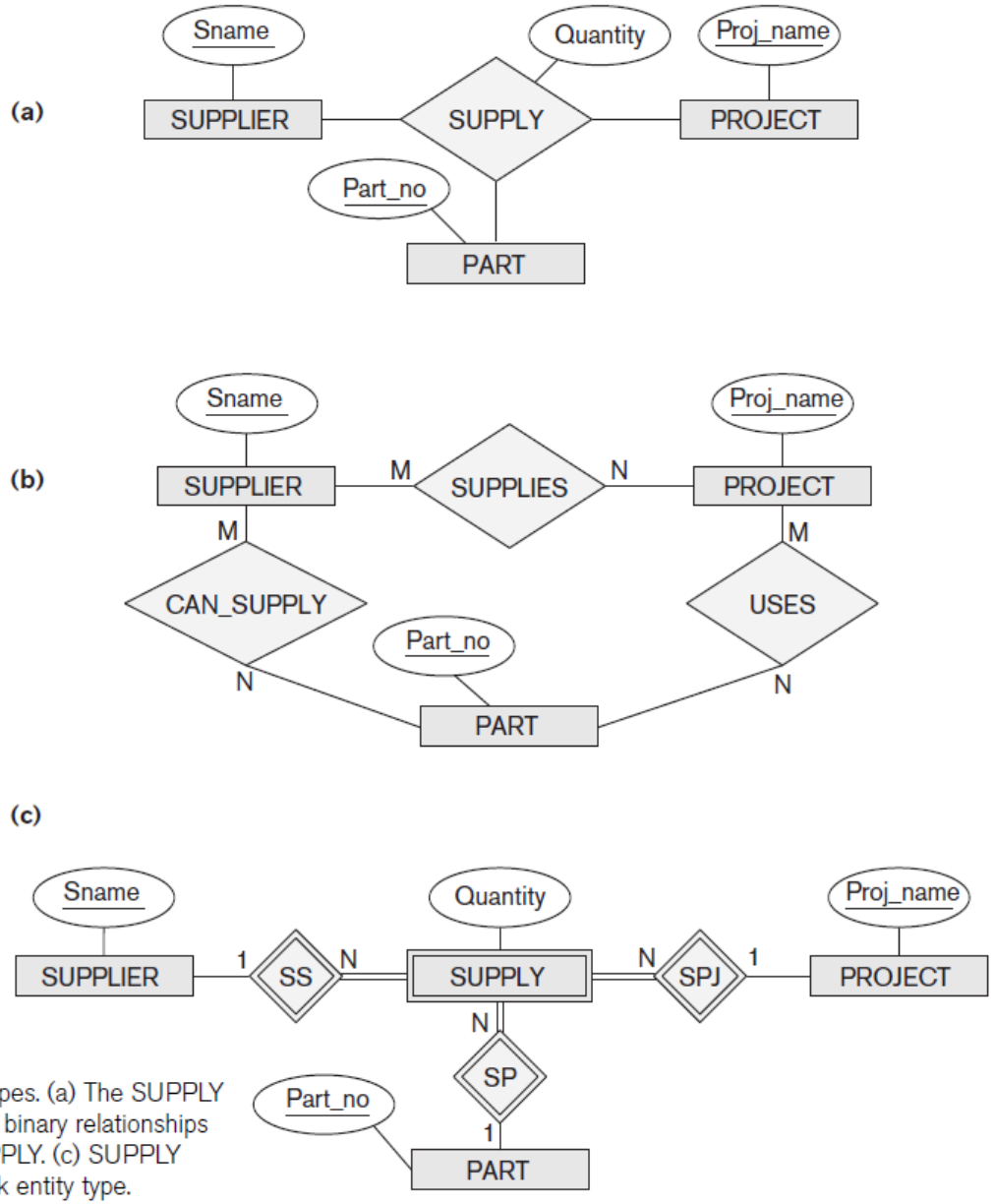


Figure 7.17
Ternary relationship types. (a) The SUPPLY relationship. (b) Three binary relationships not equivalent to SUPPLY. (c) SUPPLY represented as a weak entity type.

Constraints on Ternary (or Higher-Degree) Relationships

- Notations for specifying structural constraints on *n*-ary relationships
  - Should both be used if it is important to fully specify structural constraints

Summary

- Basic ER model concepts of entities and their attributes
  - Different types of attributes
  - Structural constraints on relationships
- ER diagrams represent E-R schemas
- UML class diagrams relate to ER modeling concepts

Exercise

- Review Questions [Chapter 02]
- Reading **Assignment** of Exercise Question
- Expected **Quiz** from Reading Assignment