THE ENTITY-RELATIONSHIP (ER) MODEL

CHAPTER 7 (6/E)

CHAPTER 3 (5/E)

LECTURE OUTLINE

- Using High-Level, Conceptual Data Models for Database Design
- **Entity-Relationship (ER) model**
  - Popular high-level conceptual data model
- **ER diagrams**
  - Diagrammatic notation associated with the ER model

STEPS IN DATABASE DESIGN

- **Requirements collection and analysis**
  - DB designers interview prospective DB users to understand and document data requirements
    - Data requirements
    - Functional requirements of the principal applications
- **Conceptual** or **logical DB design**
  - Description of data requirements
    - Detailed descriptions of components and constraints
    - Transformed into implementation data model
  - Result: DB schema in implementation data model of DBMS
- **Physical DB design**
  - Internal storage structures, file organizations, indexes, access paths, and physical design parameters for the DB files
- **External** or **view design**

A SAMPLE DATABASE APPLICATION

- Requirements gathered for COMPANY
  - Employees, departments, and projects
  - Company is organized into departments
  - Department controls several projects
  - Employee: require each employee's name, Social Security number, address, salary, sex (gender), and birth date
  - Keep track of the dependents of each employee

ER MODEL OVERVIEW

- ER model describes data in terms of:
  - **Entities** and **entity sets**
    - Objects
  - **Relationships** and **relationship sets**
    - Connections between objects
  - **Attributes**
    - Properties that characterize or describe entities or relationships

ENTITIES AND ATTRIBUTES EXAMPLE

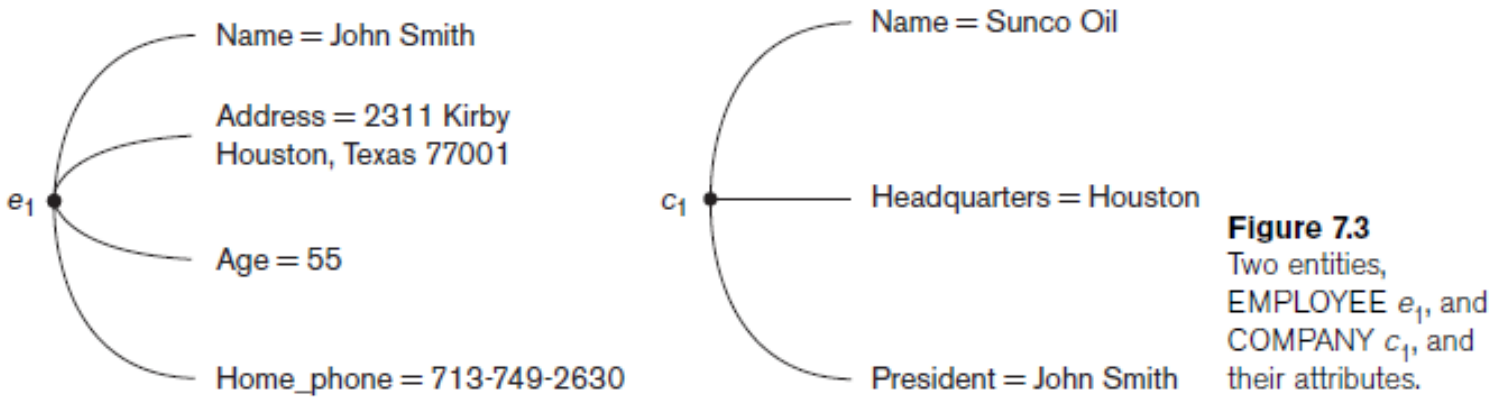


Figure 7.3
Two entities, EMPLOYEE e_1, and COMPANY c_1, and their attributes.

ENTITY SETS

- **Entity type** or **set**
  - Collection (or set) of similar entities that have the same attributes

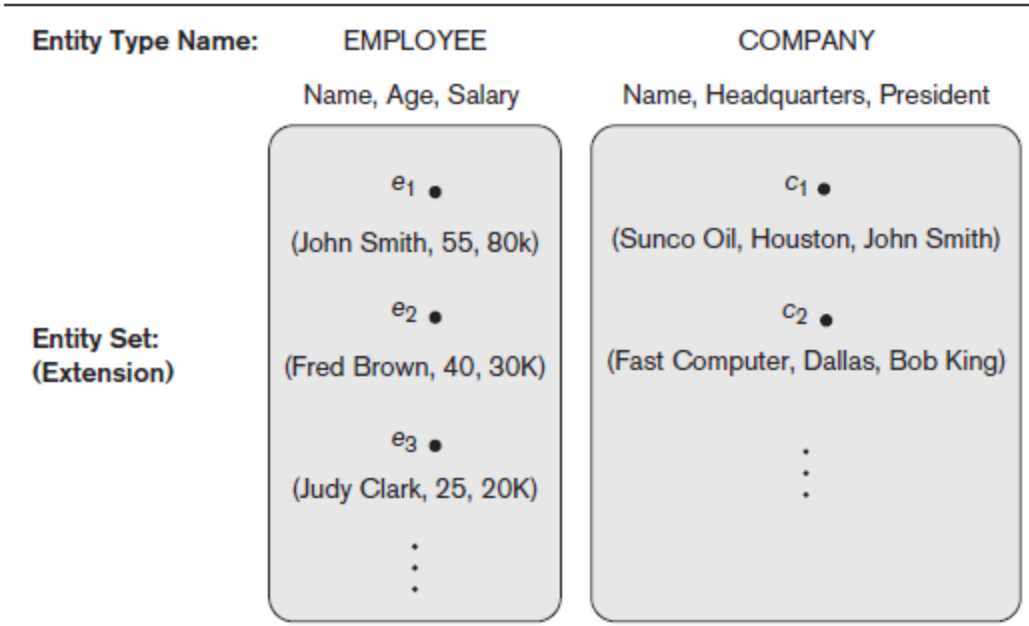


Figure 7.6
Two entity types, EMPLOYEE and COMPANY, and some member entities of each.

- ER model defines *entity sets,* not individual entities
- But entity sets described in terms of their attributes

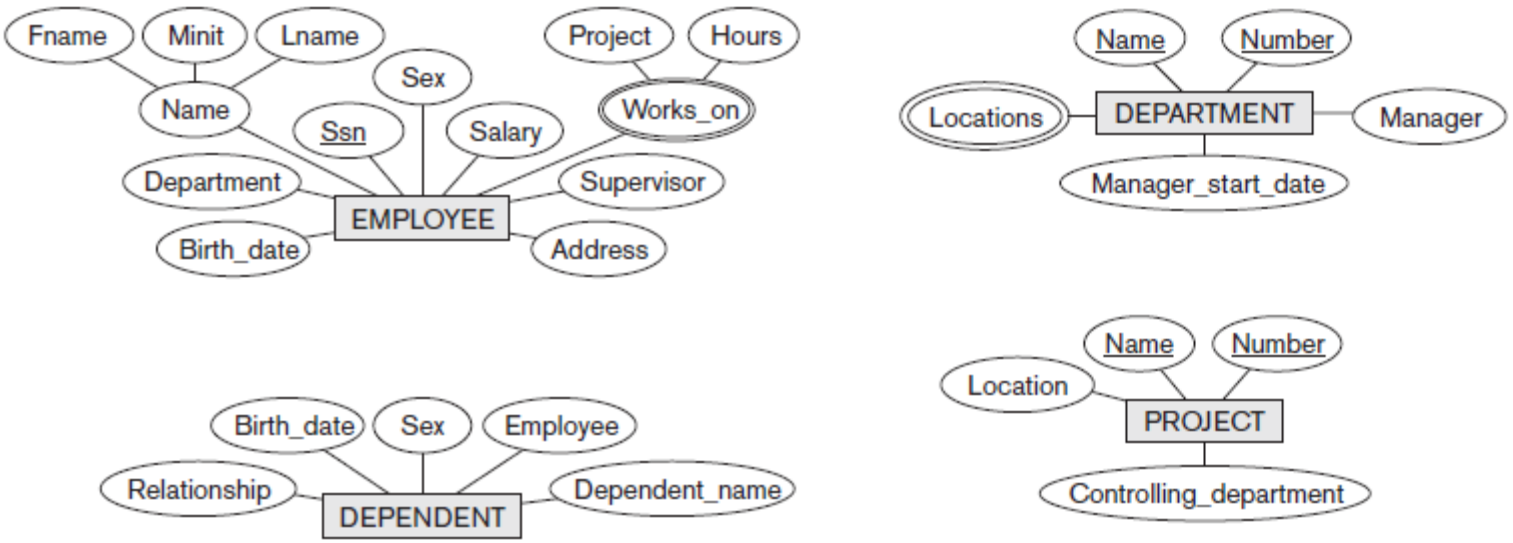
CATEGORIES OF ATTRIBUTES

- **Simple** (atomic) vs. **composite** attributes
- **Single-valued** vs. **multivalued** attributes
- **Stored** vs. **derived** attributes

- **Key** or **unique** attributes
  - Attribute values constrained to be distinct for individual entities in entity set

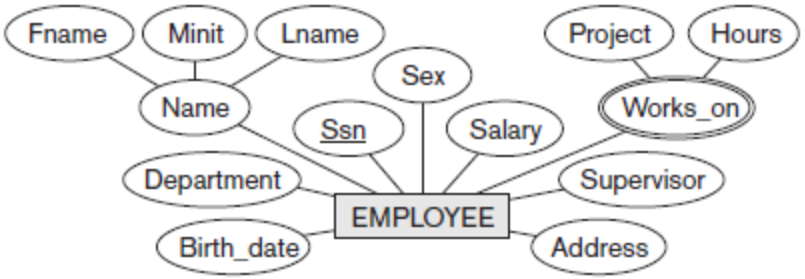
INITIAL ER DIAGRAM FOR COMPANY

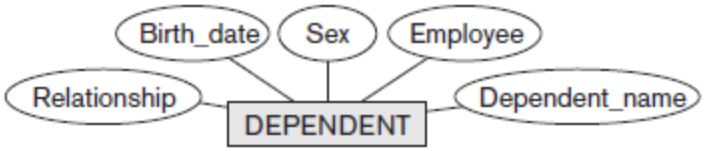
- Four entity types
- Most attributes are simple, single-valued, and stored
  - Works_on and Locations are multivalued
  - Employee's Name is composite
- Employee has one key, department and project have two keys, dependent has none



WEAK ENTITY TYPES

- Entity types that do not have key attributes of their own
  - Identified by their relationship to specific entities from another entity type



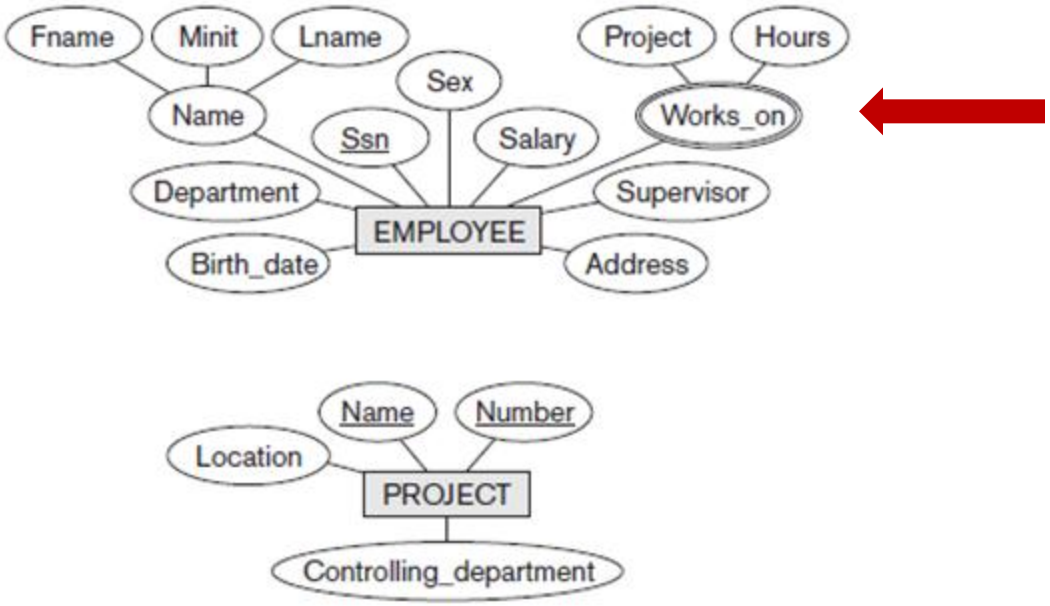


- Dependent is meaningless in COMPANY DB independently of Employee
- Identified by relationship to Employee
- Dependent_name distinguishes one dependent from other dependents for the same employee: ***partial* key**

- **Identifying relationship**
  - Relates a weak entity type to the **identifying entity**, which has the rest of the key

RELATIONSHIPS IN GENERAL

- **Relationship**
  - Interaction between entities
  - Indicator: an attribute of one entity refers to another entity
    - Represent such references as relationships not attributes



RELATIONSHIPS

- **Relationship**
  - Interaction between entities
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- **Relationship type** *R* among *n* entity types E_1, E_2, ..., E_n
  - Defines a set of associations among entities from these entity types
- **Relationship instance** r_i
  - Each r_i associates *n* individual entities (e_1, e_2, ..., e_n)
  - Each entity e_j in r_i is a member of entity set E_j
  - Relationships uniquely identified by keys of participating entities
- **Degree** of a relationship type
  - Number of participating entity types
  - e.g., binary, ternary

RELATIONSHIPS & RELATIONSHIP SETS

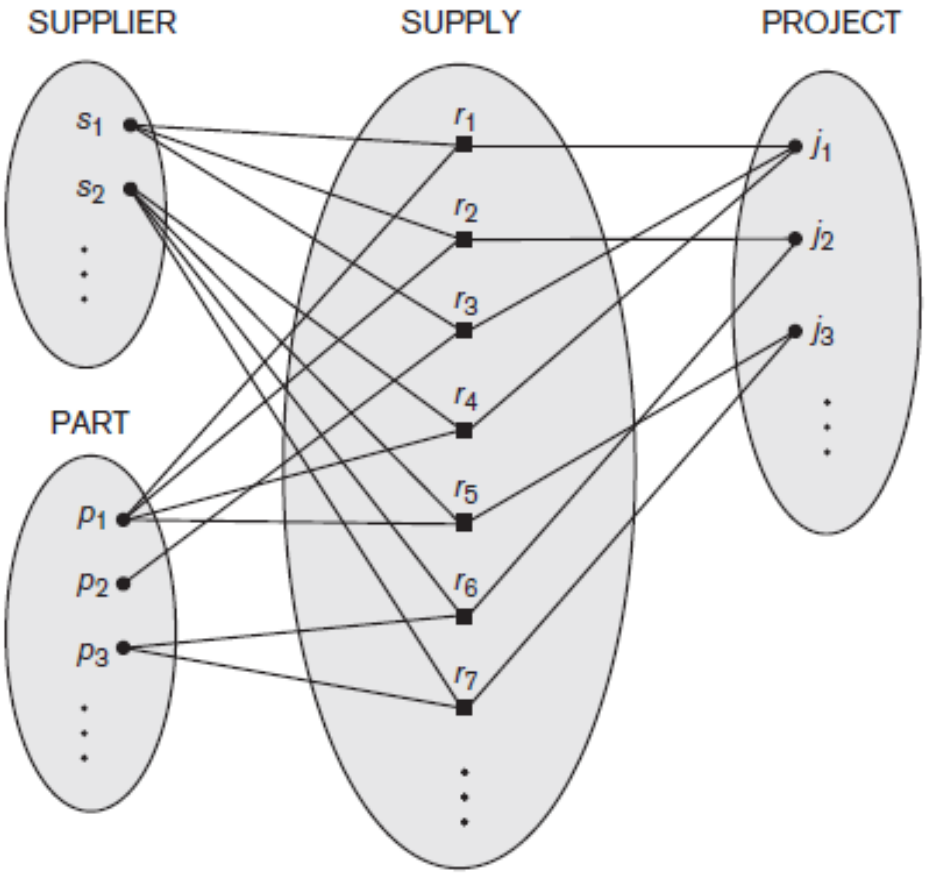
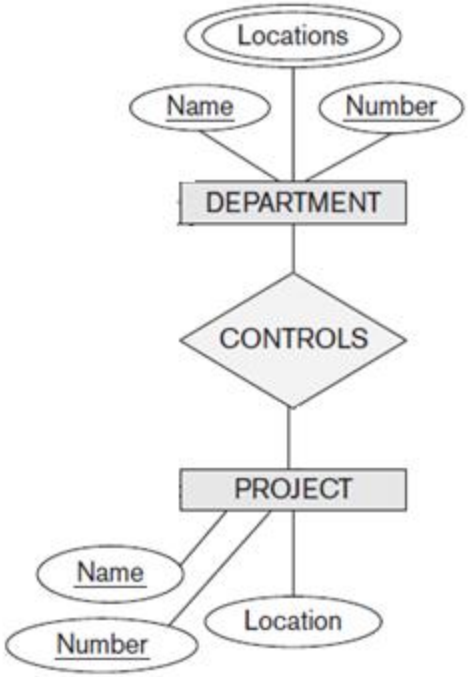


Figure 7.10
Some relationship instances in the SUPPLY ternary relationship set.

DIAGRAMMING RELATIONSHIP TYPE

- Diamond for relationship type
- Connected to each participating entity type
  - Could be binary, ternary, or higher degree
- *Remember*:
  - Represents a *set* of entities of each type, some of which are related to entities of the other type(s)
  - Some entities might participate in several relationships
  - Some entities might not participate in the relationship at all



RELATIONSHIPS WITH REPEATED ENTITY SETS

- Some relationships involve multiple entities from the same entity set
  - e.g., spouse (two persons), games (two teams)
  - e.g., recursive relationships, such as supervises (two employees)
- **Role name**
  - Signifies role that participating entity plays in relationship instance
  - Required when entity type participates multiple times in a relationship

USING ROLE NAMES

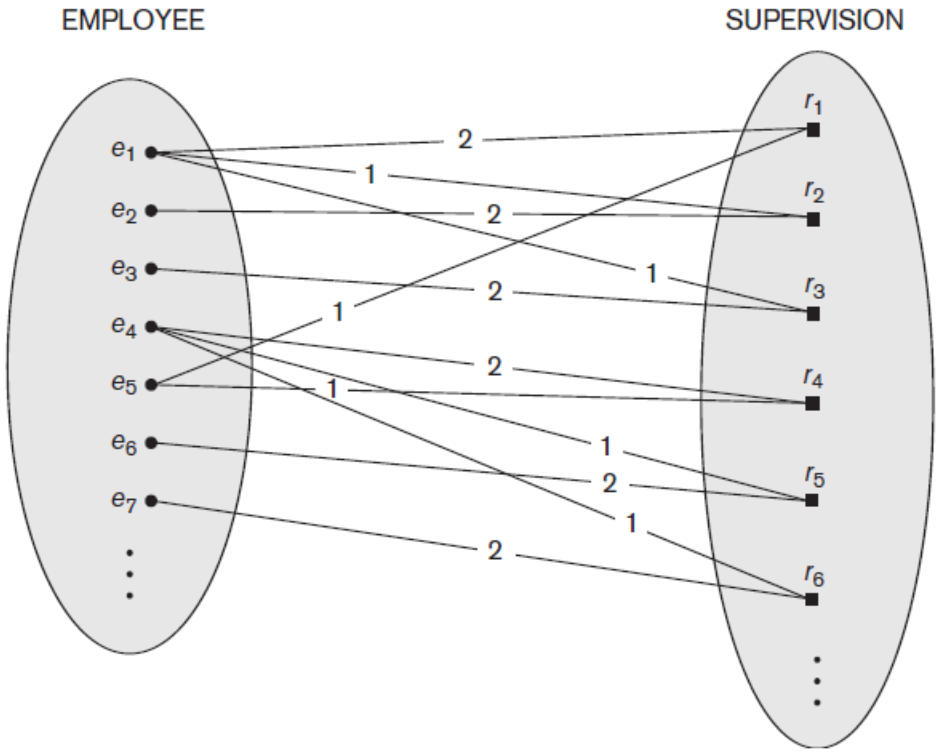
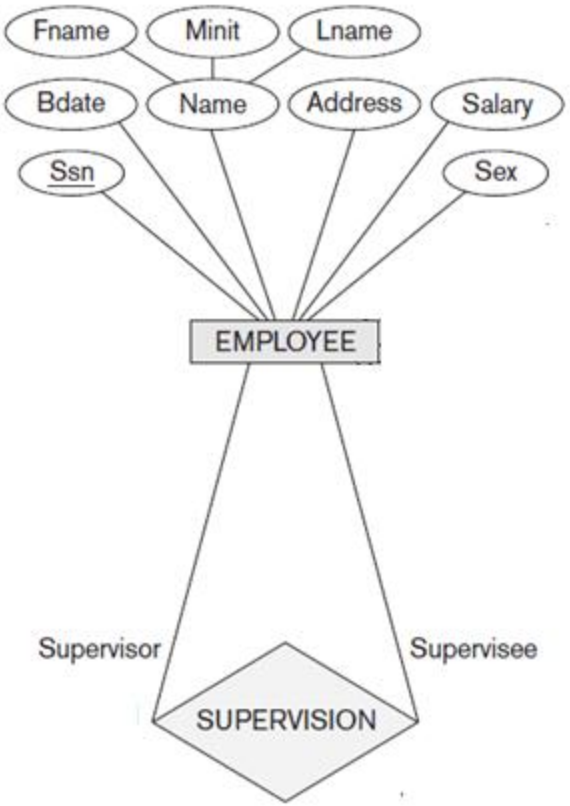


Figure 7.11
A recursive relationship SUPERVISION between EMPLOYEE in the *supervisor* role (1) and EMPLOYEE in the *subordinate* role (2).



RELATIONSHIP CONSTRAINTS

- **Cardinality ratio**
  - Specifies maximum number of relationship instances in which each entity can participate
  - Types 1:1, 1:N, or M:N
- **Participation constraint**
  - Specifies whether existence of entity depends on its being related to another entity
  - Types: **total** and **partial**
  - Thus minimum number of relationship instances in which entities can participate: thus1 for total participation, 0 for partial
  - Diagrammatically, use a double line from relationship type to entity type

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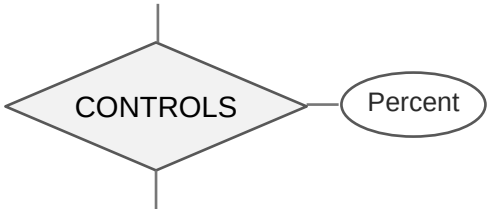
- **Alternative: Structural constraint**
  - Generalization: specifying any min and max participation
    - Replaces cardinality ratio numerals and single/double line notation
  - Associate a pair of integer numbers (min, max) with each participation of an entity type *E* in a relationship type *R*, where $0 \leq \text{min} \leq \text{max}$ and $\text{max} \geq 1$
  - max=N $\Rightarrow$ finite, but unbounded

RELATIONSHIP ATTRIBUTES

- Relationship types can also have attributes
  - Property that depends on both/all participating entities
  - Example: Percentage of control that department has on a project



- Attributes of 1:1 or 1:N relationship types can be migrated to one of the participating entity types
  - For a 1:N relationship type, relationship attribute can be migrated only to entity type on N-side of relationship
  - Attributes on M:N relationship types must be specified as relationship attributes

SUMMARY OF ER DIAGRAM SYMBOLS

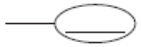
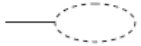
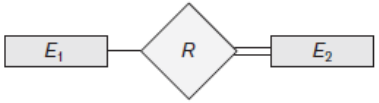
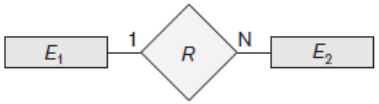
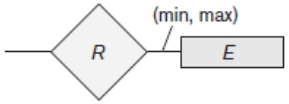
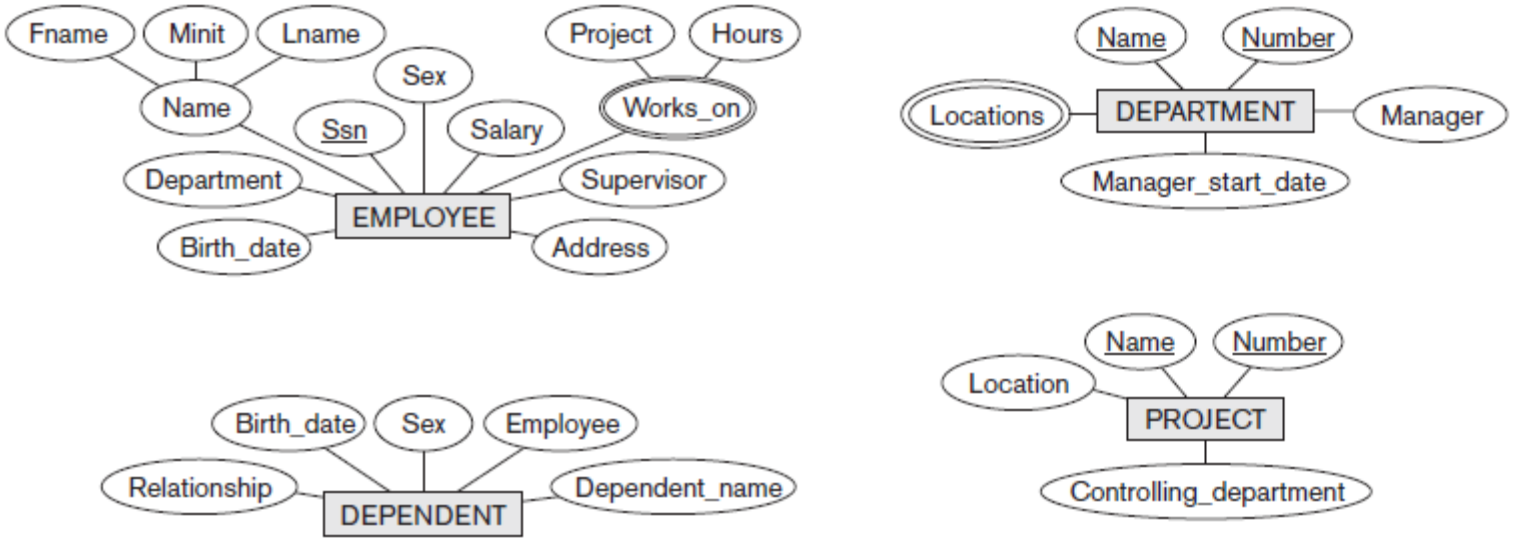
Symbol	Meaning
	Entity
	Weak Entity
	Relationship
	Indentifying Relationship
	Attribute
	Key Attribute
	Multivalued Attribute
	Composite Attribute
	Derived Attribute
	Total Participation of E_2 in R
	Cardinality Ratio 1: N ⟹ 1 E_1 entity can be related to N E_2 entities
	Structural Constraint (min, max) on Participation of E in R

Figure 7.14
Summary of the notation for ER diagrams.

REFINING EXAMPLE ER DESIGN

- Recall preliminary ER design



- Change attributes that reference entity types into relationship types
  - Weak entities use **identifying relationship**
- Determine cardinality ratio and participation constraints for each relationship type
  - Weak entity type always has structural constraint of (1,1) participation in identifying relationship

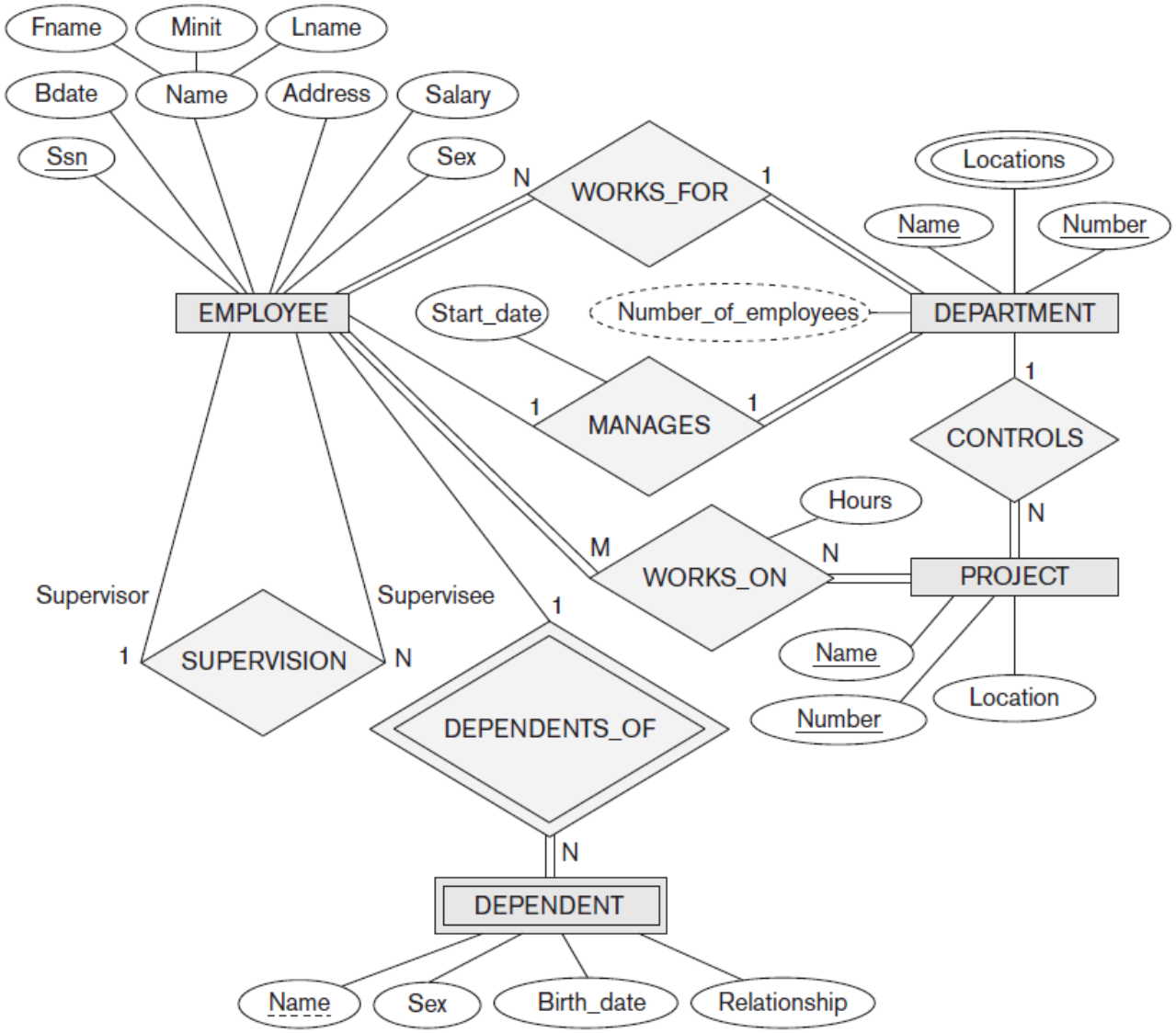


Figure 7.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter and is summarized in Figure 7.14.

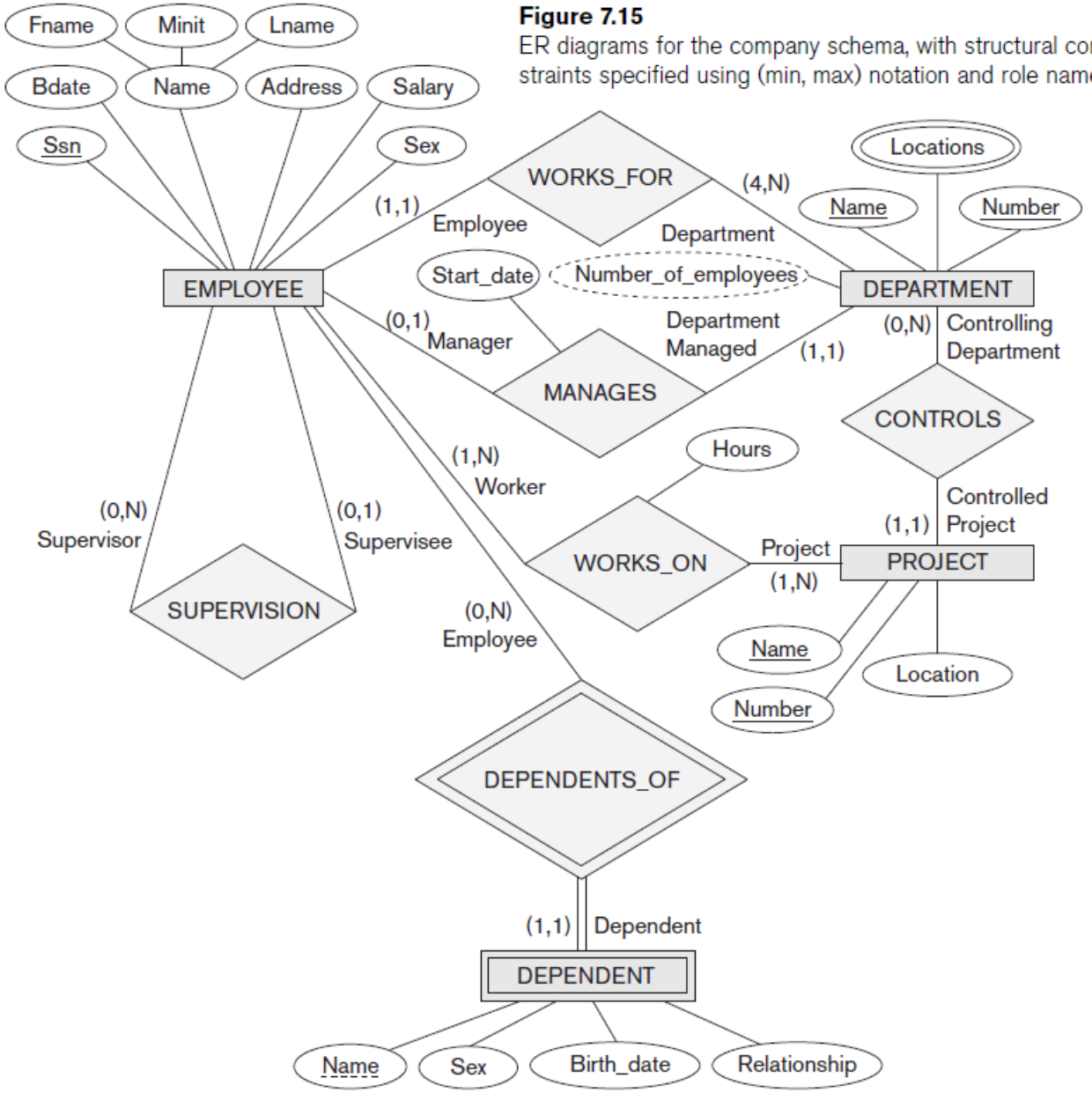


Figure 7.15
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

APPROPRIATE ER MODEL DESIGN

- Choose names that convey meanings attached to various constructs.
- 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
- Review all attributes
  - Refine into a relationship if attribute references an entity type
  - Attribute that exists in several entity types may be better modelled as an independent entity type
- Entities that *must* participate in a relationship with another entity type and with cardinality constraint of 1 might be better modelled as weak entity

REVIEW HIGH-DEGREE RELATIONSHIPS

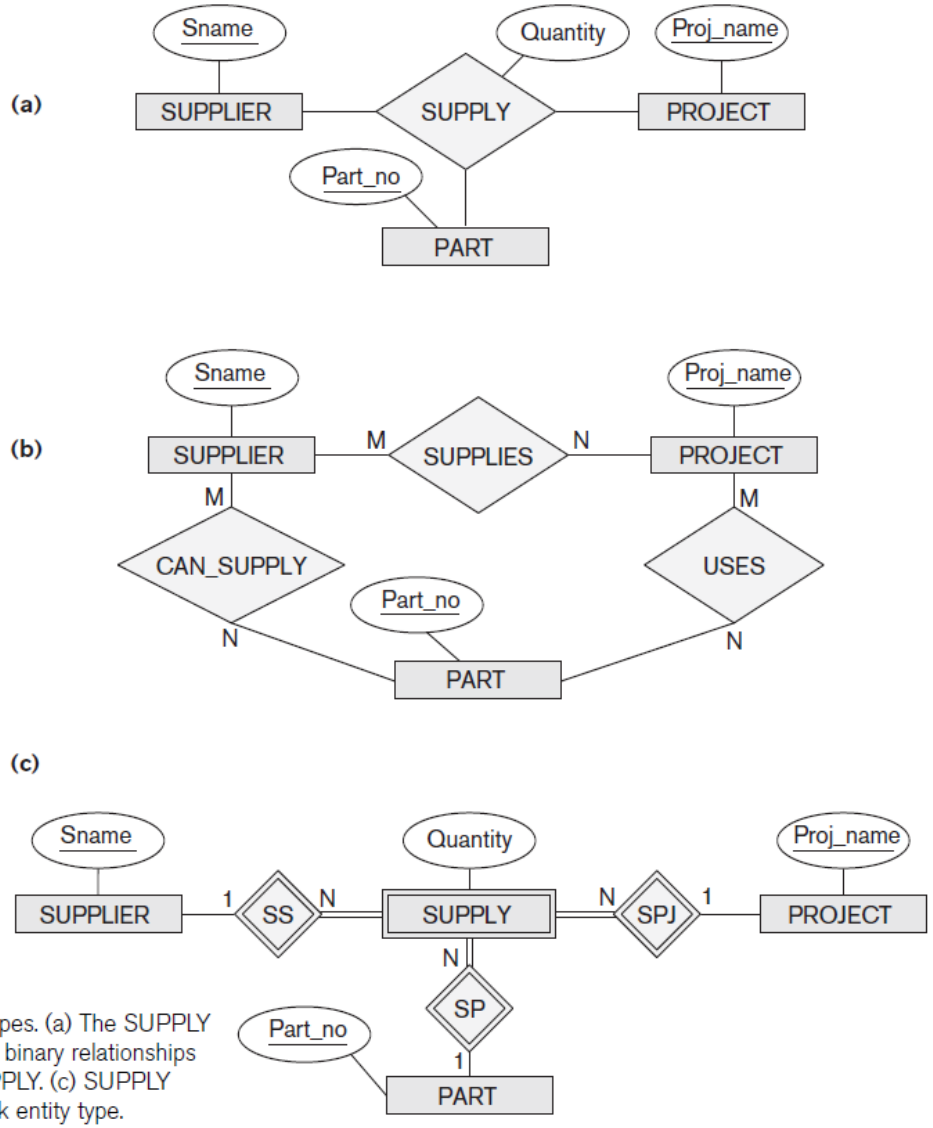


Figure 7.17
Ternary relationship types. (a) The SUPPLY relationship. (b) Three binary relationships not equivalent to SUPPLY. (c) SUPPLY represented as a weak entity type.

LECTURE SUMMARY

- Components of the Entity-Relationship Model
  - Entity Types, Entity Sets
  - Weak Entity Types
  - Relationship Types, Relationship Sets, Roles
  - Attributes, Attribute Classification, Keys
  - Structural Constraints
- ER diagrams represent ER models
- Appropriate ER design