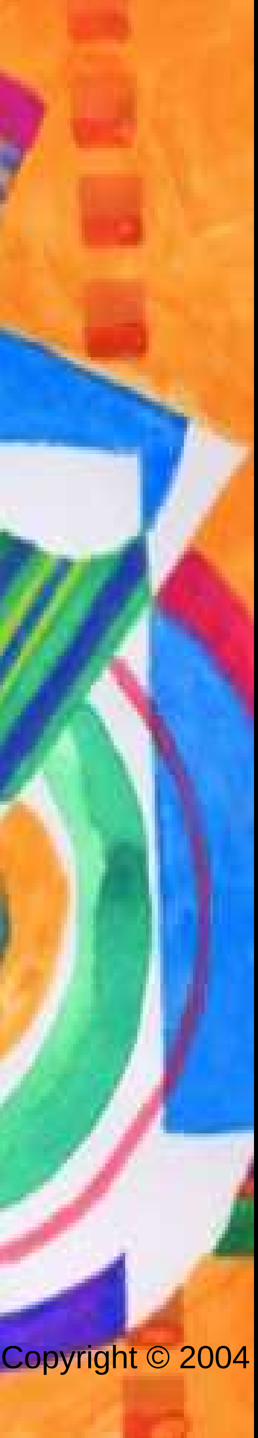
Chapter 2
Entity-Relationship Data Modeling: Tools and Techniques

DATABASE PROCESSING

Fundamentals, Design,
and Implementation, 9/e

Three Schema Model

- ANSI/SPARC introduced the three schema model in 1975
- It provides a framework describing the role and purpose of data modeling



Three Schema Model (cont.)

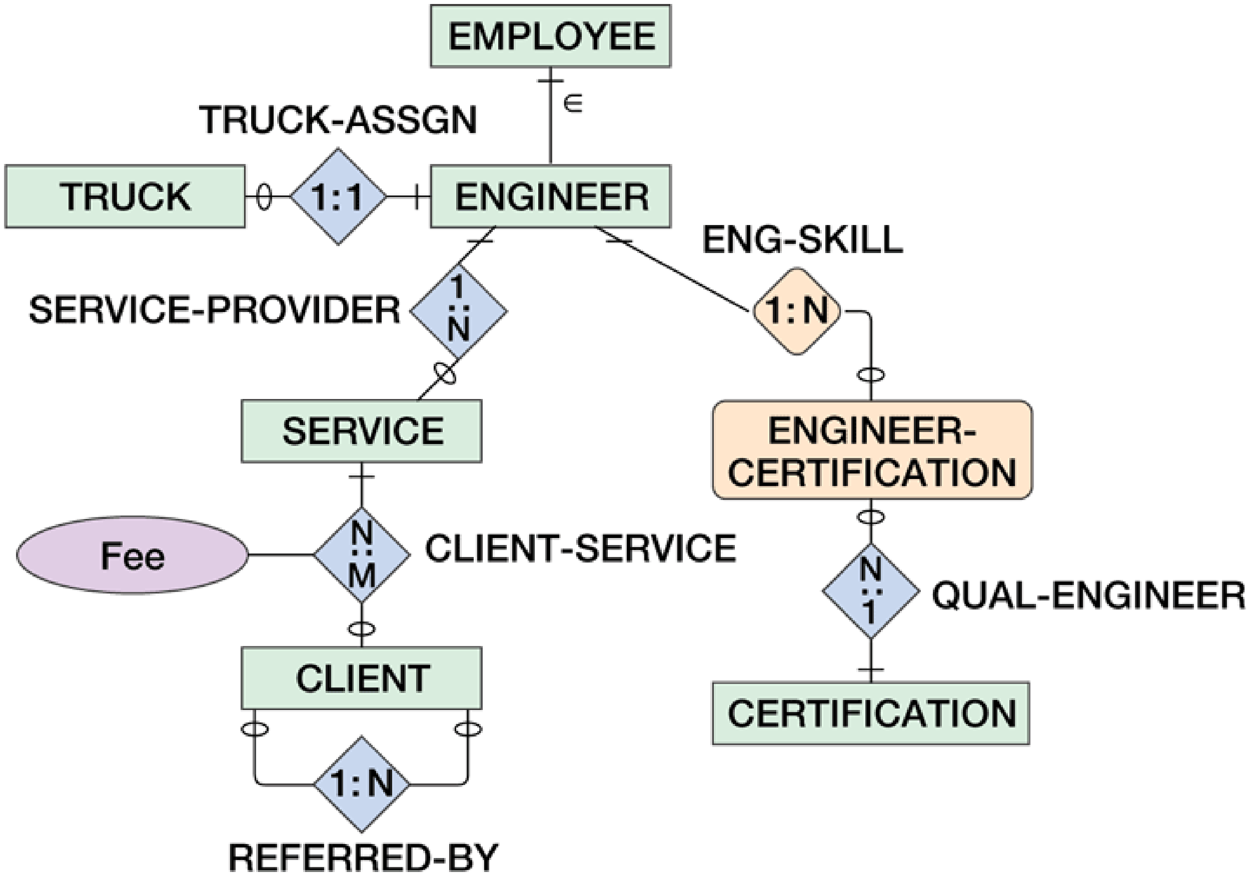
- External schema or user view
  - Representation of how users view the database
- Conceptual schema
  - A logical view of the database containing a description of all the data and relationships
  - Independent of any particular means of storing the data
  - One conceptual schema usually contains many different external schemas
- Internal schema
  - A representation of a conceptual schema as physically stored on a particular product
  - A conceptual schema can be represented by many different internal schemas

E-R Model

- Entity-Relationship model is a set of concepts and graphical symbols that can be used to create conceptual schemas
- Four versions
  - Original E-R model by Peter Chen (1976)
  - Extended E-R model: the most widely used model
  - Information Engineering (IE) by James Martin (1990)
  - IDEF1X national standard by the National Institute of Standards and Technology
  - Unified Modeling Language (UML) supporting object-oriented methodology

The Extended E-R Model

Figure 2.15 Example Entity-Relationship Diagram



Example: E-R Diagram

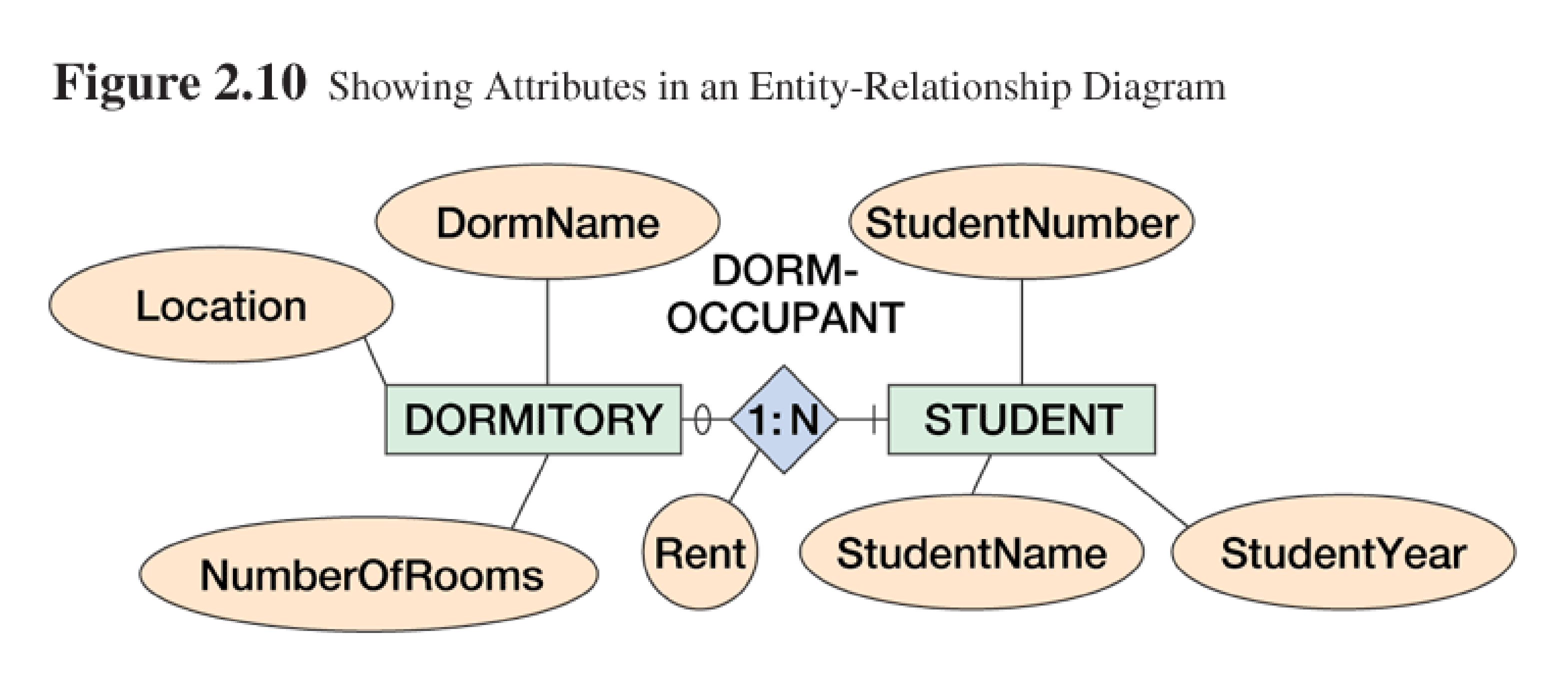


Figure 2.10 Showing Attributes in an Entity-Relationship Diagram

Entities

- Something that can be identified and the users want to track
  - Entity class is a collection of entities described by the entity format in that class
  - Entity instance is the representation of a particular entity
- There are usually many instances of an entity in an entity class

Example: Entity

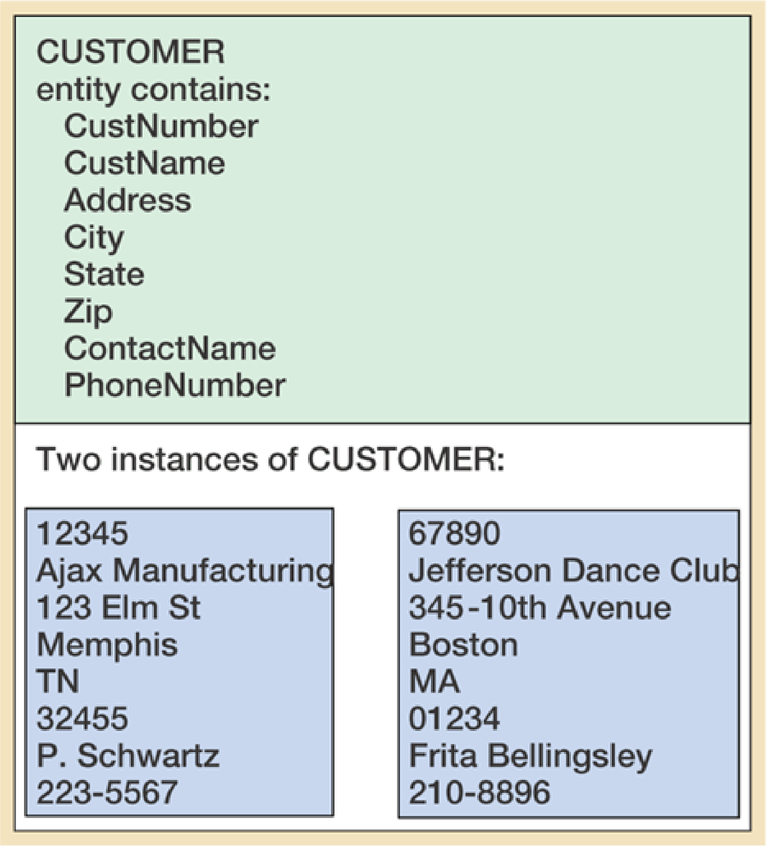


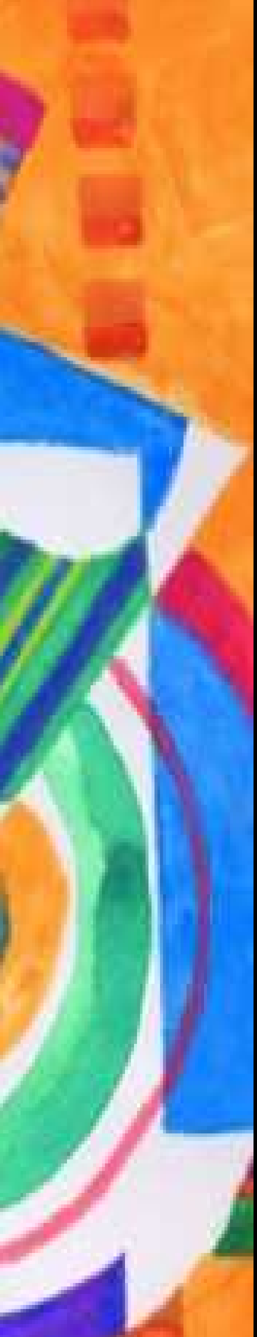
Figure 2.5 CUSTOMER: An Example of an Entity

CUSTOMER
entity contains:
  CustNumber
  CustName
  Address
  City
  State
  Zip
  ContactName
  PhoneNumber

Two instances of CUSTOMER:

12345
Ajax Manufacturing
123 Elm St
Memphis
TN
32455
P. Schwartz
223-5567

67890
Jefferson Dance Club
345-10th Avenue
Boston
MA
01234
Frita Bellingsley
210-8896



Attributes

- Description of the entity's characteristics
- All instances of a given entity class have the same attributes
  - Composite attribute: attribute consisting of the group of attributes
  - Multi-value attributes: attribute with more than one possible value

Identifiers

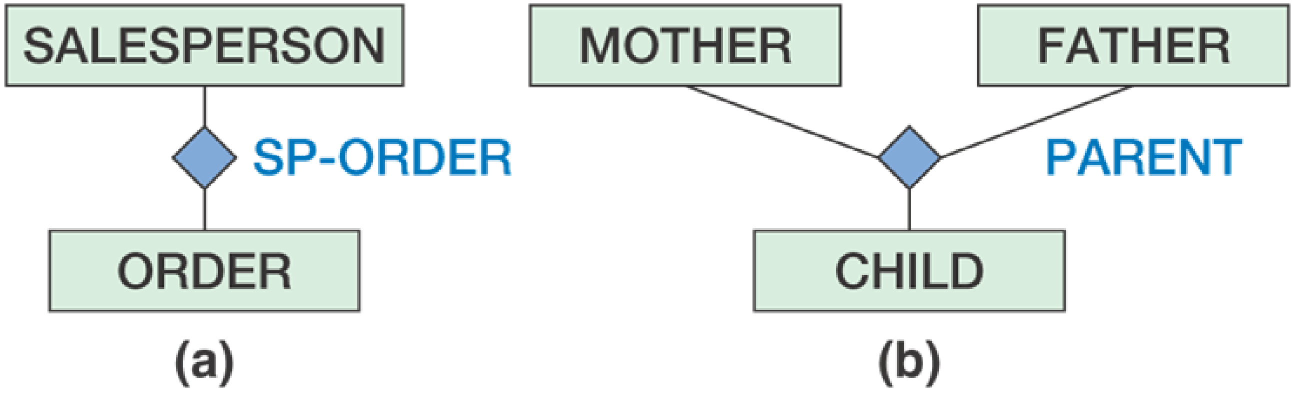
- Identifiers are attributes that name, or identify, entity instances
- The identifier of an entity instance consists of one or more of the entity’s attributes
- An identifier may be either unique or non-unique
  - Unique identifier: the value identifies one and only one entity instance
  - Non-unique identifier: the value identifies a set of instances
- Composite identifiers: Identifiers that consist of two or more attributes

Relationships

- Entities can be associated with one another in relationships
  - Relationship classes: associations among entity classes
  - Relationship instances: associations among entity instances
- Relationships can have attributes
- A relationship class can involve many entity classes
- Degree of the relationship is the number of entity classes in the relationship

Example:
Degree of the relationship

Figure 2.6 Relationships of Different Degrees (a) Example Relationship of Degree 2 and (b) Example Relationship of Degree 3

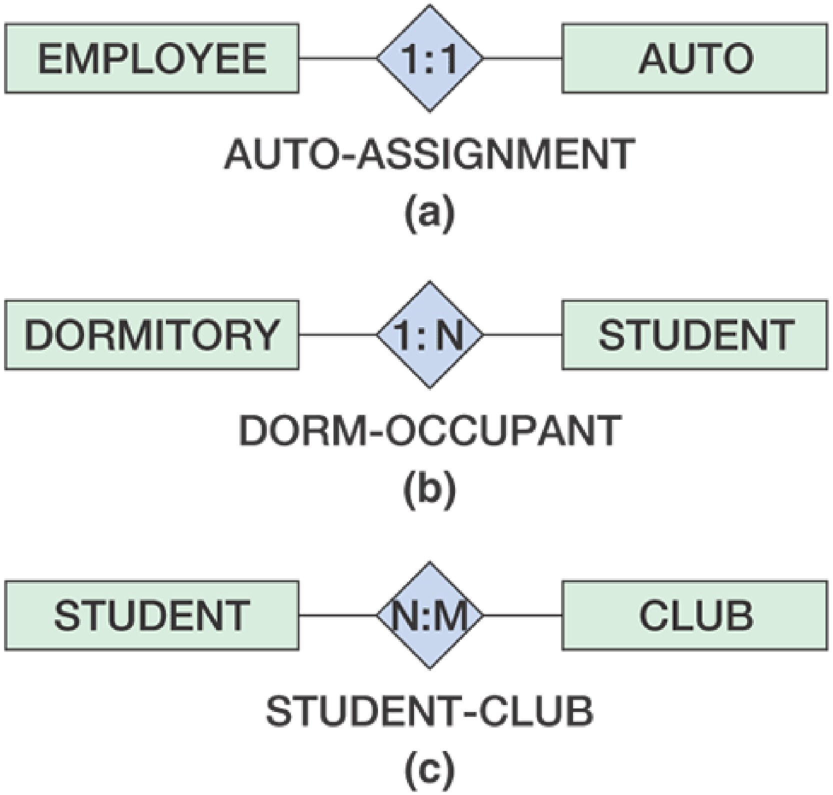


- Relationships of degree 2 are very common and are often referred to by the term binary relationships

Binary Relationships

- 1:1
- 1:N
- N:M

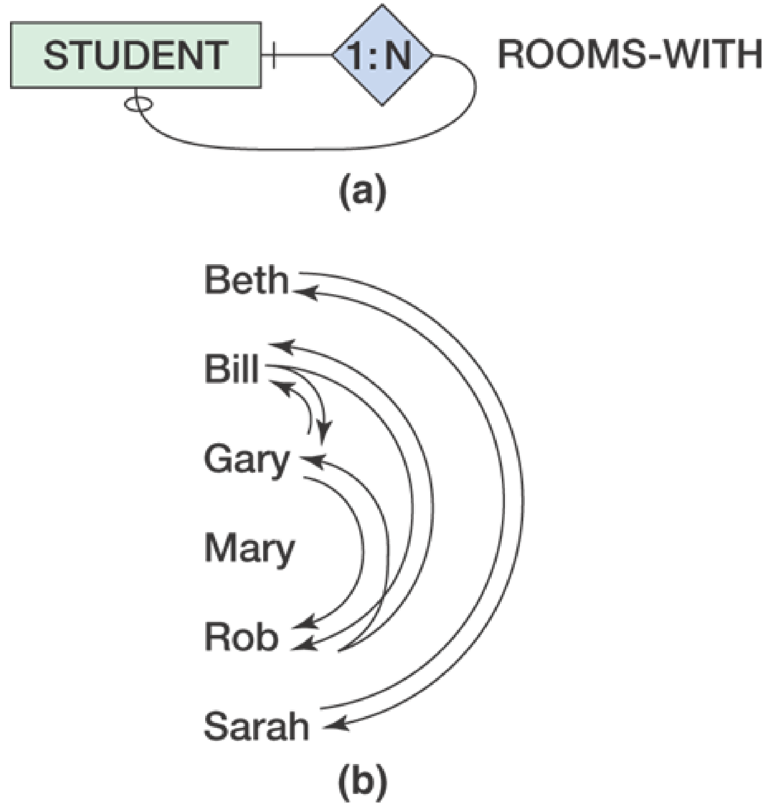
Figure 2.7 Three Types of Binary Relationships (a) 1:1 Binary Relationship; (b) 1:N Binary Relationship and (c) N:M Binary Relationship



Recursive Relationship

- Recursive relationships are relationships among entities of a single class

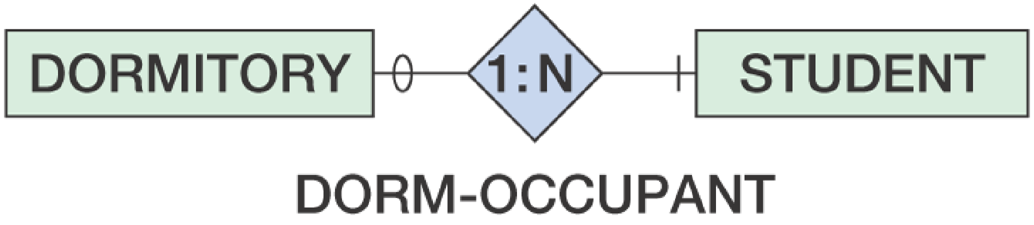
Figure 2.9 Recursive Relationship (a) E-R Diagram and (b) Sample Data



Cardinality

- Maximum cardinality indicates the maximum number of entities that can be involved in a relationship
- Minimum cardinality indicate that there may or may not be an entity in a relationship

Figure 2.8 Relationship with Minimum Cardinality Shown

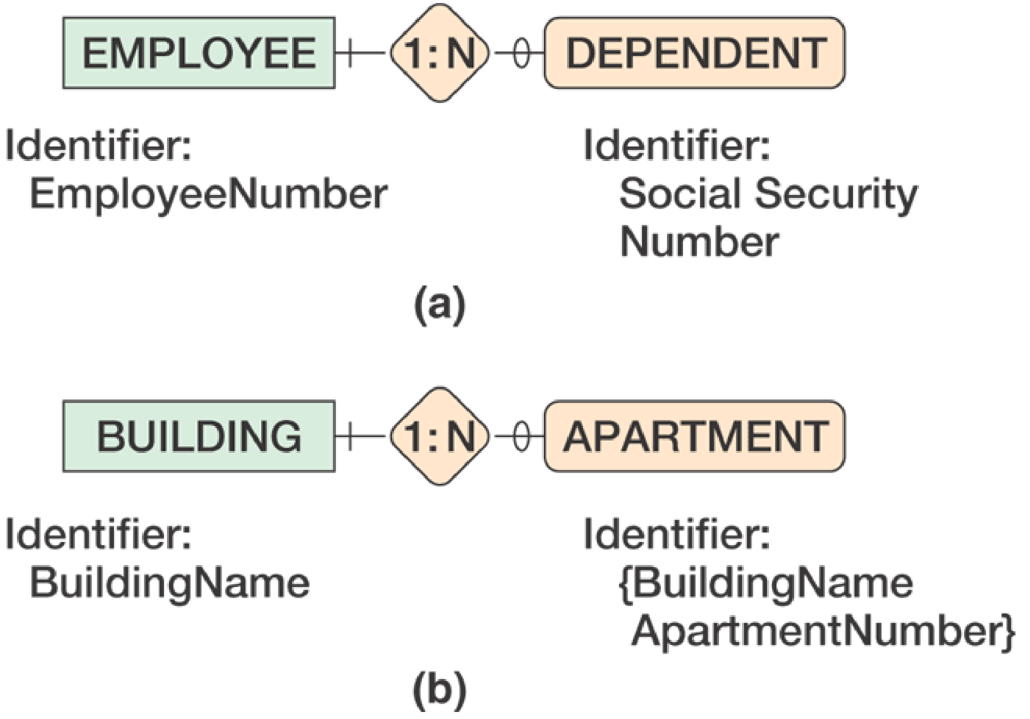


Weak Entities

- Weak entities are those that must logically depend on another entity
- Weak entities cannot exist in the database unless another type of entity (strong entity) also exists in the database
  - ID-dependent entity: the identifier of one entity includes the identifier of another entity

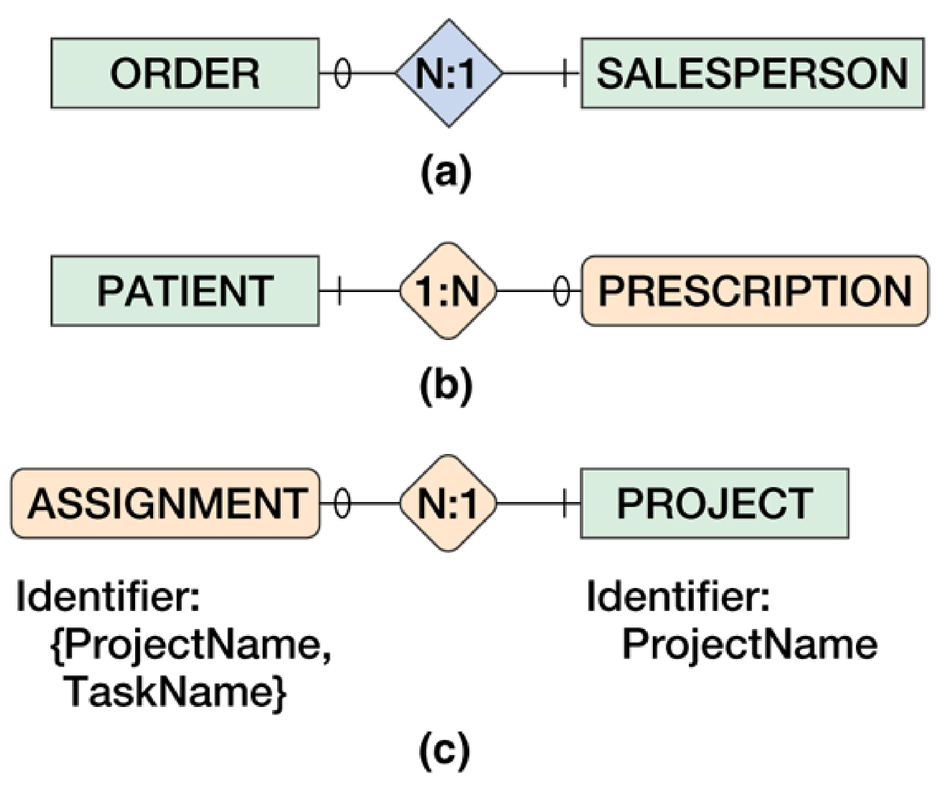
Example: Weak Entities

Figure 2.11 Weak Entities (a) Weak, but Not ID-Dependent and (b) ID-Dependent



Example: Weak Entities

Figure 2.12 Examples of Required Entities



Subtype Entities

- Subtype entity is an entity that represents a special case of another entity, called supertype
- Sometimes called an IS-A relationship
- Entities with an IS-A relationship should have the same identifier

Example: Subtype Entities

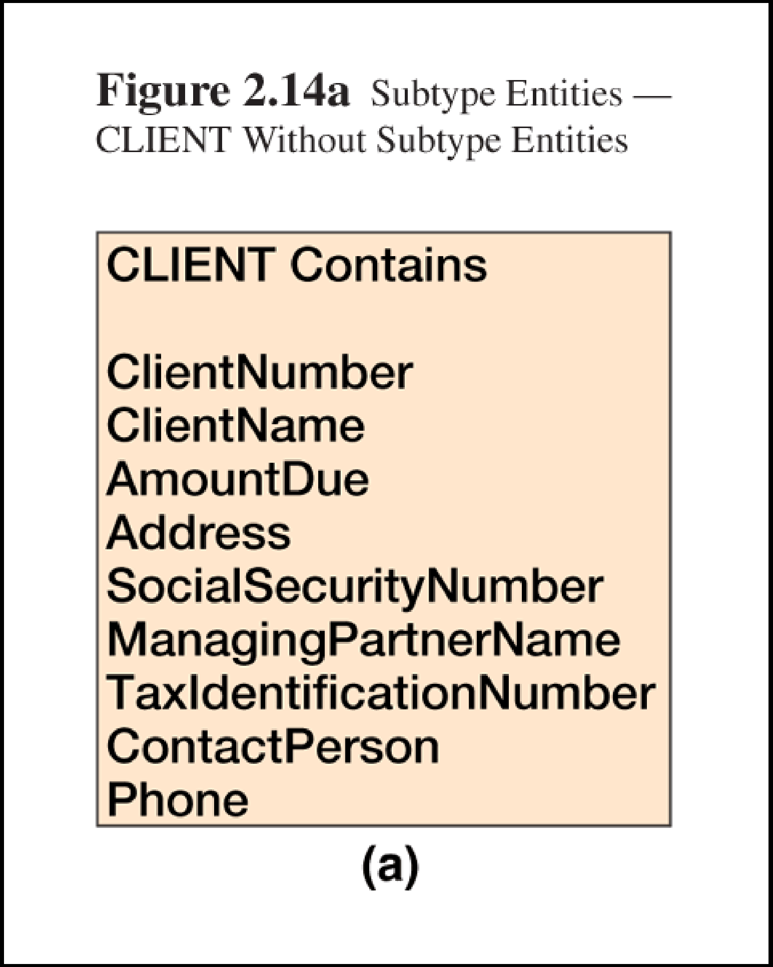


Figure 2.14a Subtype Entities — CLIENT Without Subtype Entities

CLIENT Contains

ClientNumber
ClientName
AmountDue
Address
SocialSecurityNumber
ManagingPartnerName
TaxIdentificationNumber
ContactPerson
Phone

(a)

Example: Subtype Entities

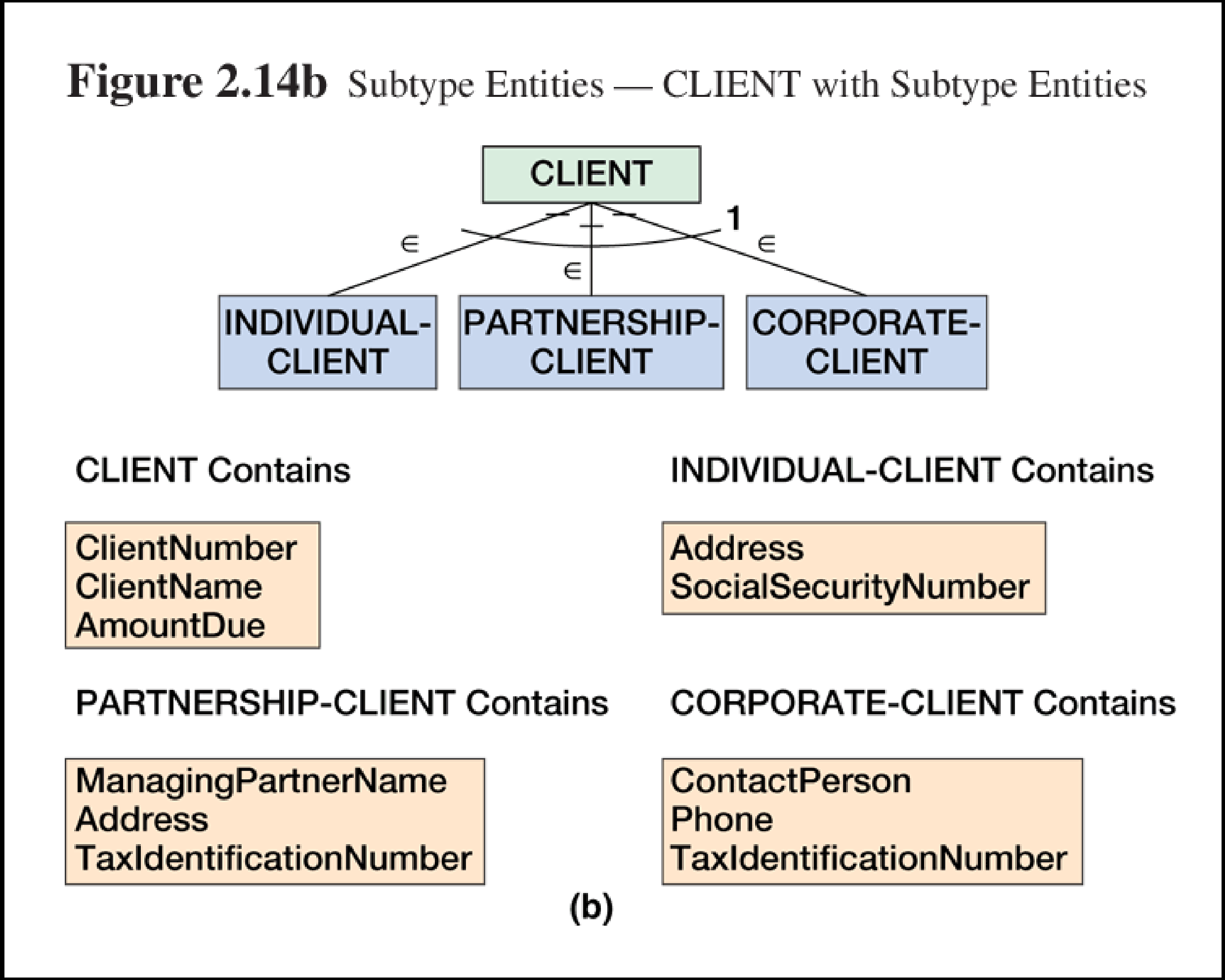


Figure 2.14b Subtype Entities — CLIENT with Subtype Entities

CLIENT Contains

ClientNumber
ClientName
AmountDue

INDIVIDUAL-CLIENT Contains

Address
SocialSecurityNumber

PARTNERSHIP-CLIENT Contains

ManagingPartnerName
Address
TaxIdentificationNumber

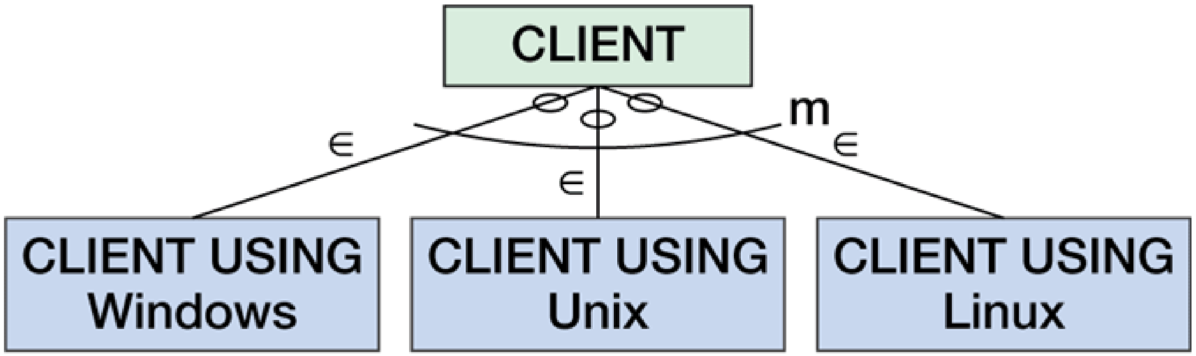
CORPORATE-CLIENT Contains

ContactPerson
Phone
TaxIdentificationNumber

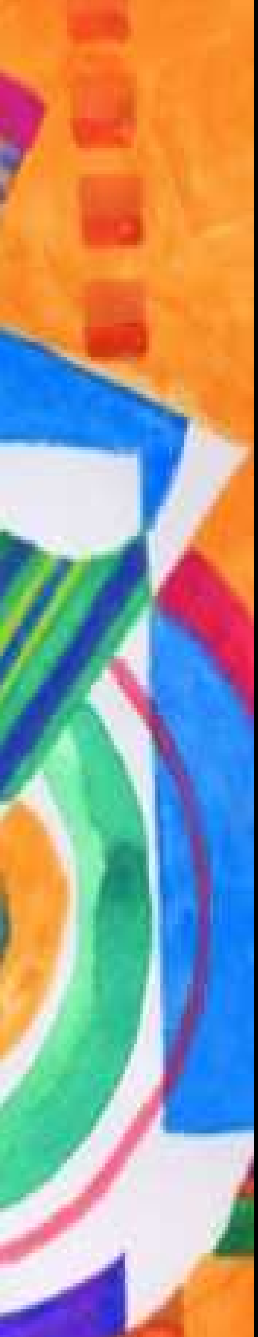
(b)

Example: Subtype Entities

Figure 2.14c Subtype Entities — Non-Exclusive Subtypes with Optional Supertype



(c)

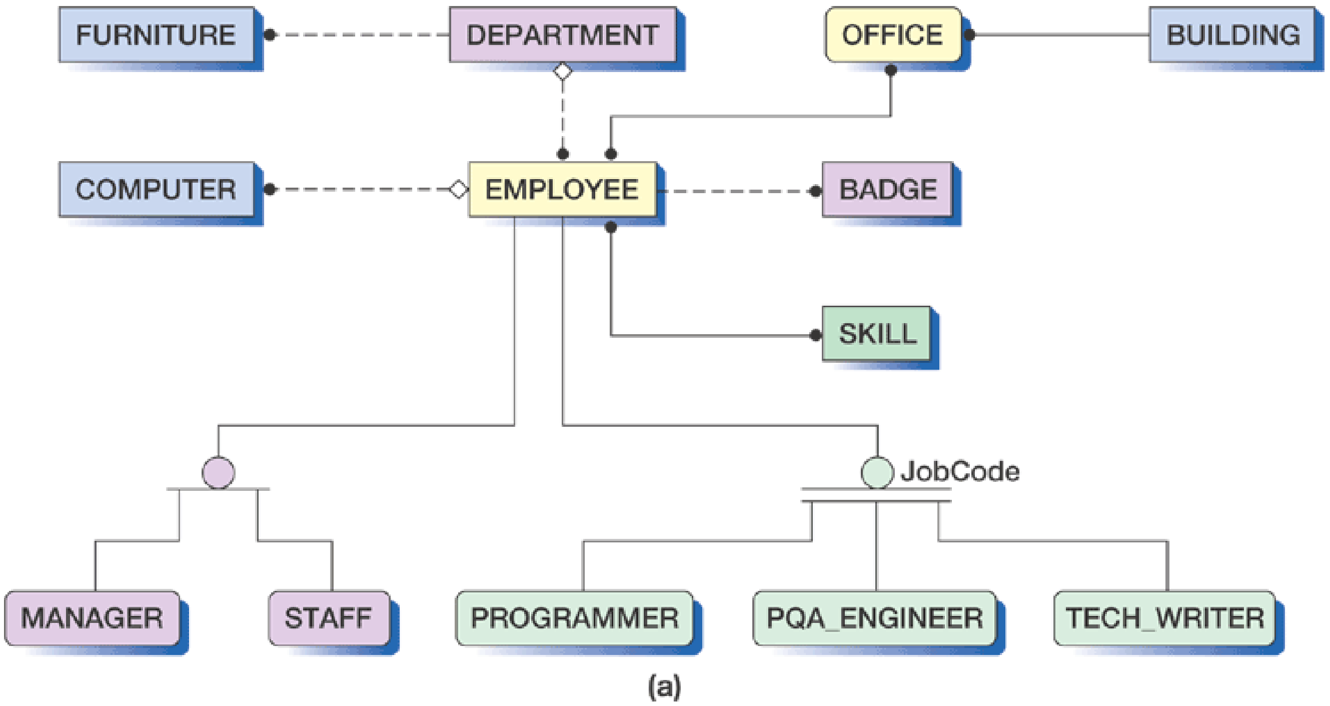


IDEF1X Standard

- IDEF1X (Integrated Definition 1, Extended) was announced as a national standard in 1993
- It defines entities, relationships, and attributes in more specific meanings
- It changed some of the E-R graphical symbols
- It includes definition of domains, a component not present in the extended E-R model
- Four Relationship Types
  - Non-Identifying Connection Relationships
  - Identifying Connection Relationships
  - Non-Specific Relationships
  - Categorization Relationships
- Products supporting IDEF1X: ERWin, Visio, Design/2000

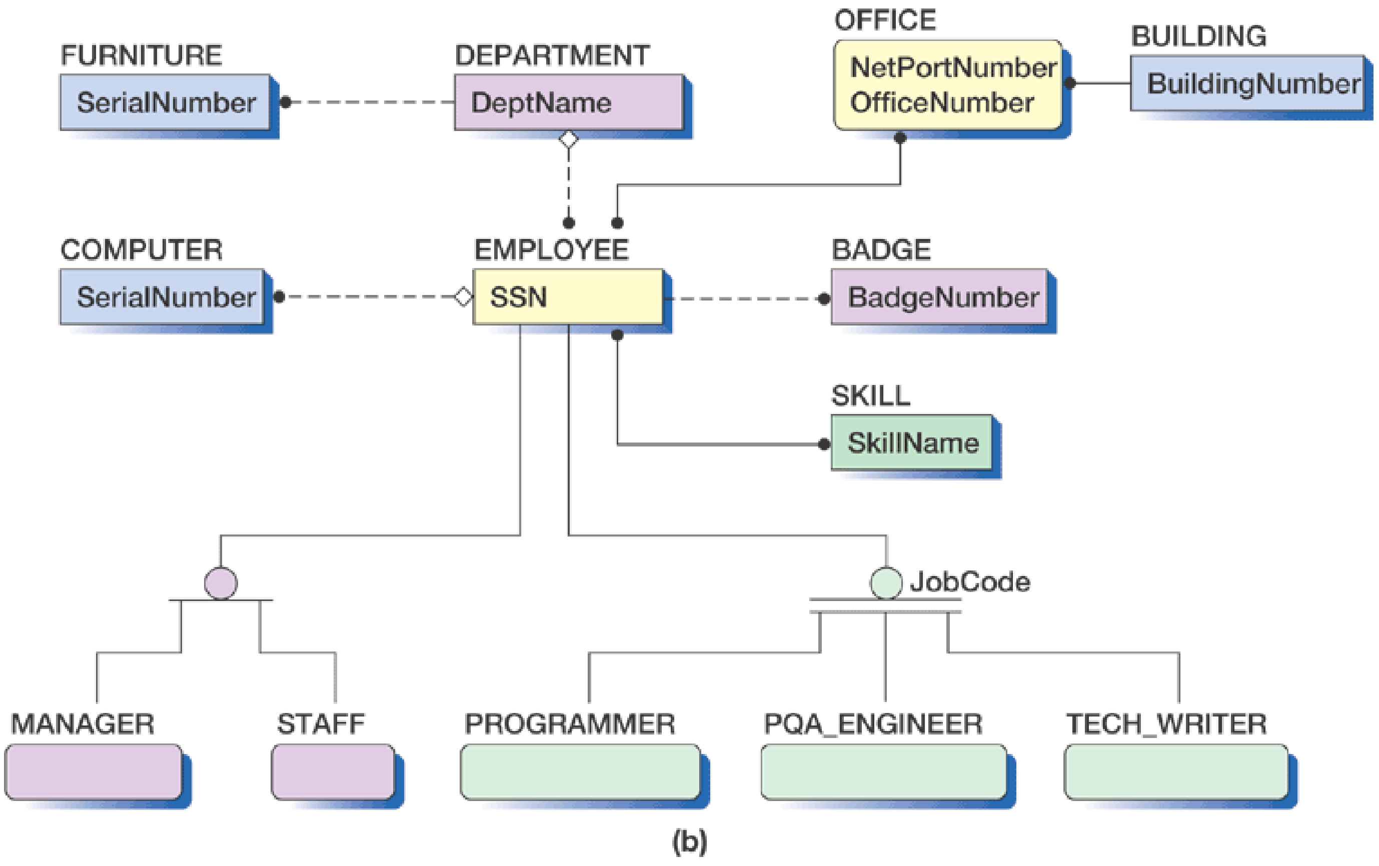
Example: IDEF1X

Figure 2.17a Levels of Detail in IDEF1X Models — Entities Only



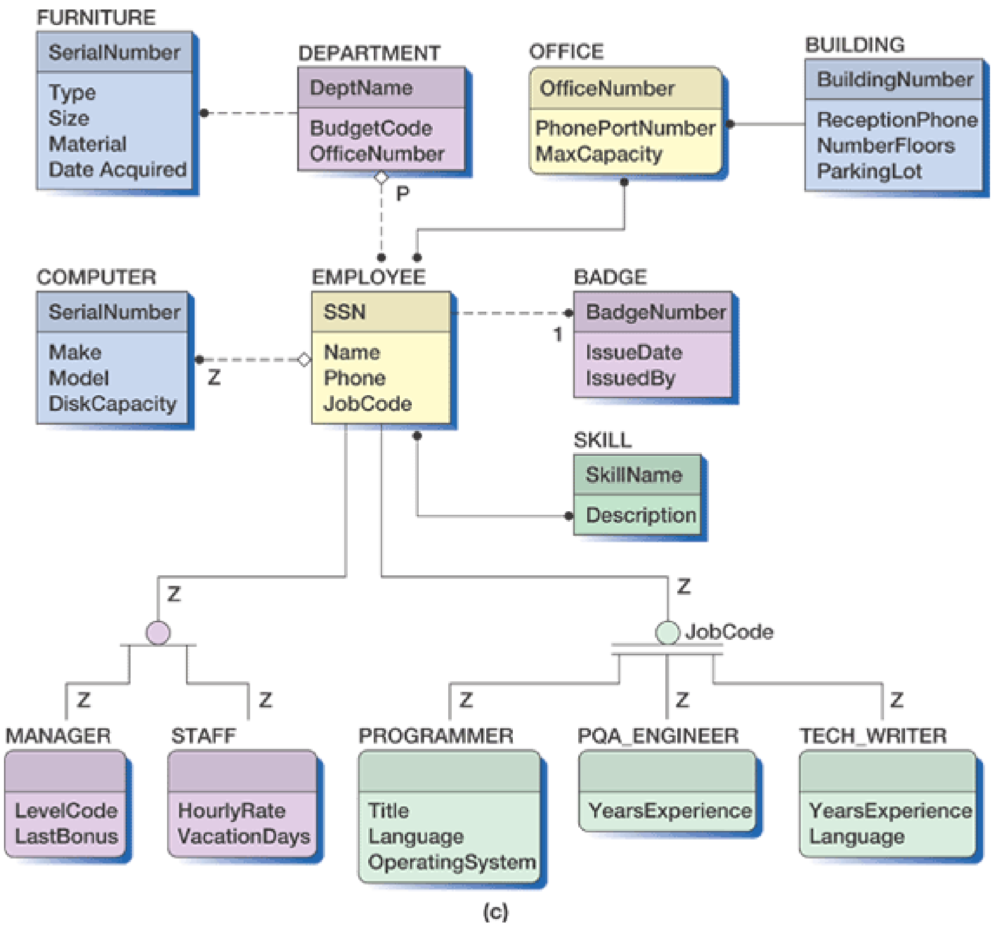
Example: IDEF1X

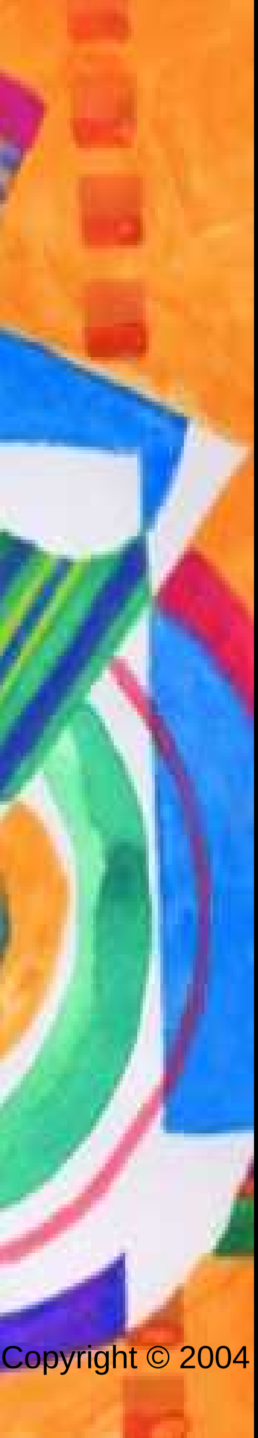
Figure 2.17b Levels of Detail in IDEF1X Models — Entities and Primary Keys



Example: IDEF1X

Figure 2.17c Levels of Detail in IDEF1X Models — Entities and Attributes



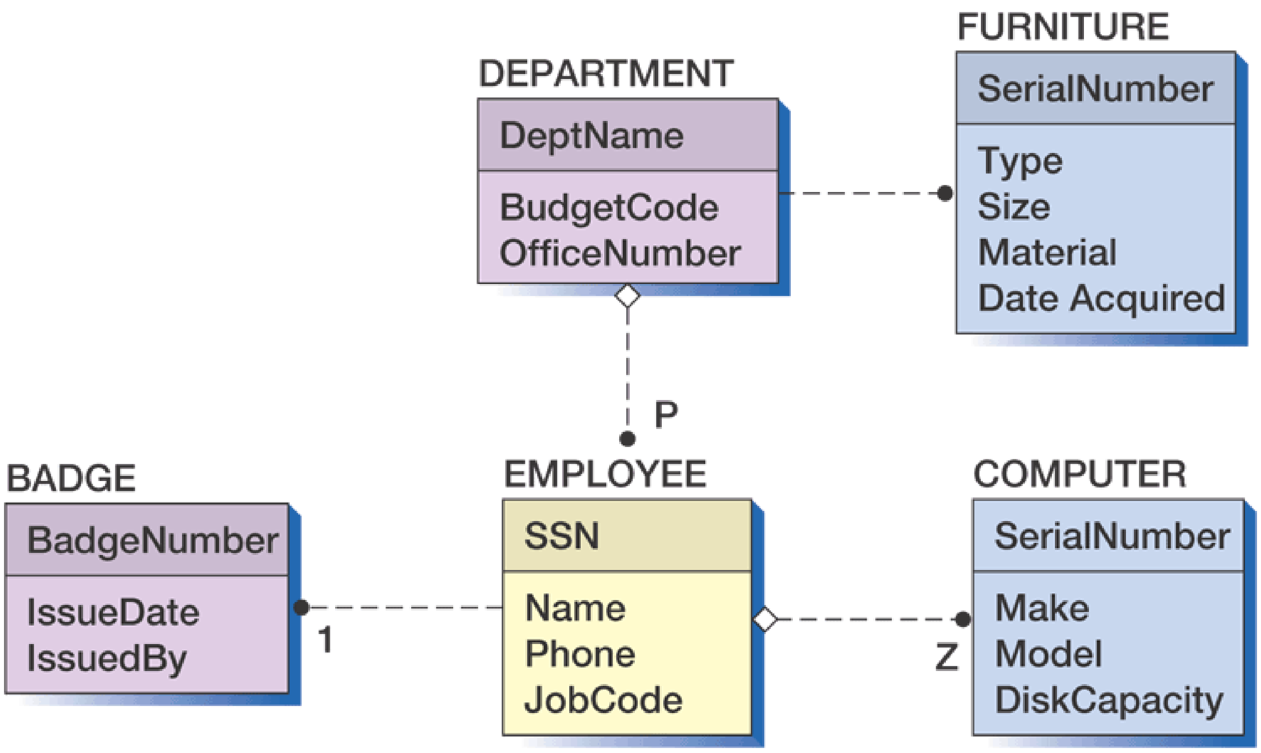


Non-Identifying Connection Relationships

- Represent relationship with a dashed line from a parent to a child entity
- Default cardinality is 1:N with a mandatory parent and an optional child
  - 1 indicates exactly one child is required
  - Z indicates zero or one children

Non-Identifying Connection Relationships

Figure 2.19 Non-Identifying Connection Relationships



Identifying Connection Relationships

- Same as ID-dependent relationships in the extended E-R model
- Parent’s identifier is always part of the child’s identifier
- Relationship are indicated with solid lines, child entities are shown with rounded corners (ID-dependent entities only)

Identifying Connection Relationships

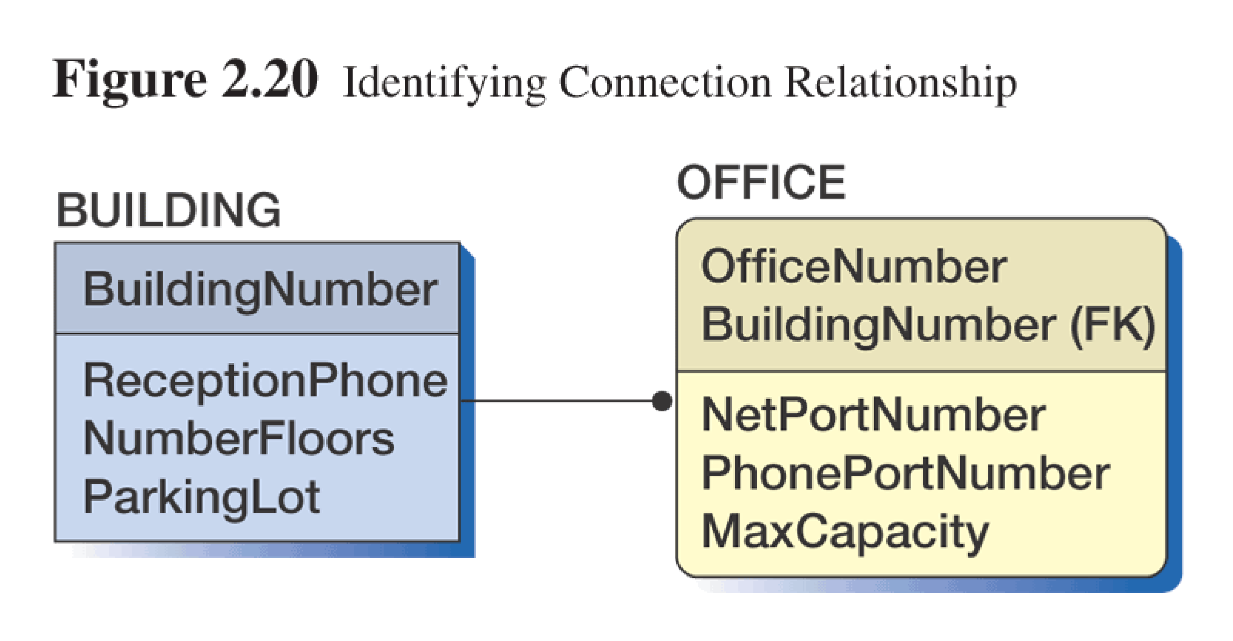
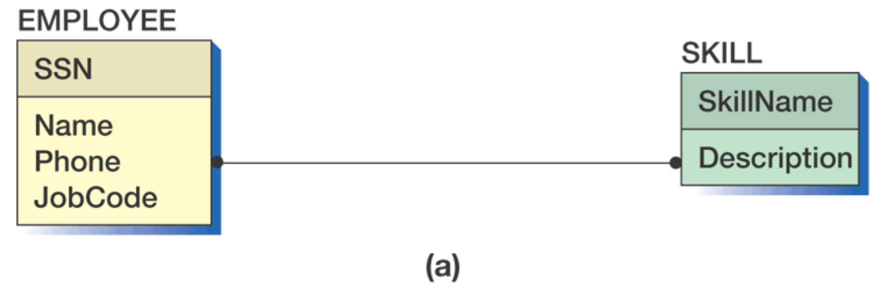


Figure 2.20 Identifying Connection Relationship

Non-Specific Relationships

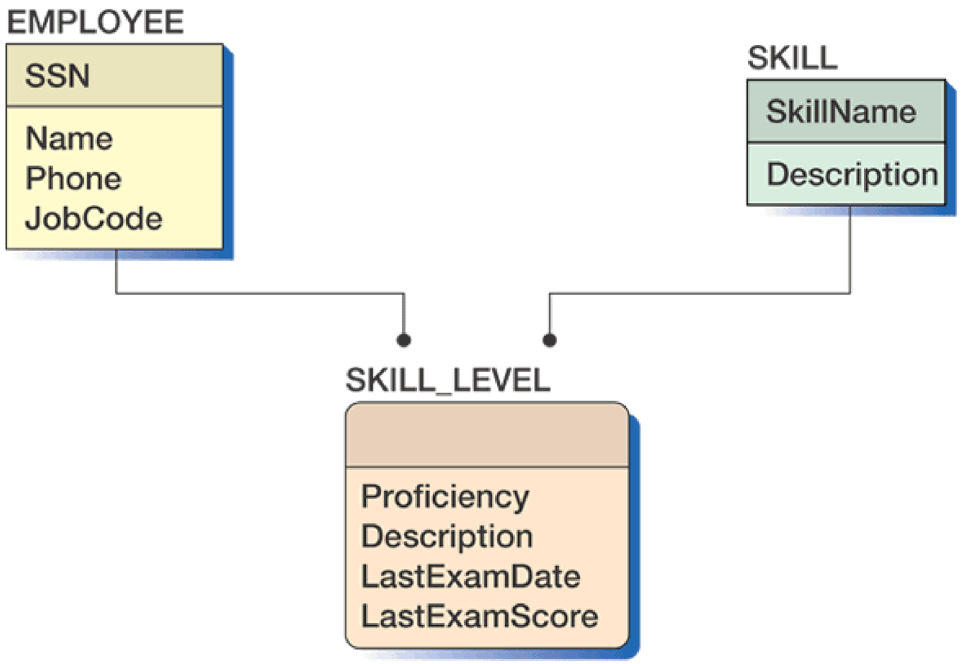
- Simply a many-to-many relationship
- Relationships are shown with a filled-in circle on each end of the solid relationship line
- Cannot set minimum cardinalities of a non-specific relationship

Figure 2.21a Non-Specific Relationships — Model with N:M Relationship



Non-Specific Relationships

Figure 2.21b Non-Specific Relationships — Model Showing Missing Entity



EMPLOYEE

SSN

Name
Phone
JobCode

SKILL

SkillName

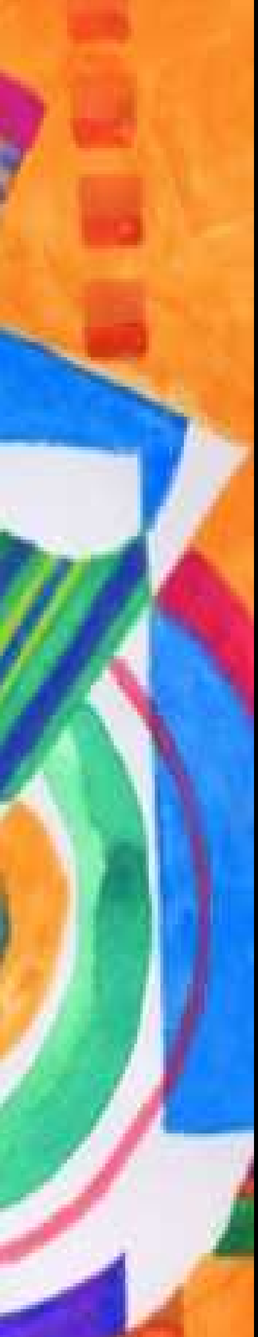
Description

SKILL_LEVEL

Proficiency
Description
LastExamDate
LastExamScore

Note: Identifier of SKILL_LEVEL
is (SSN, SkillName)

(b)

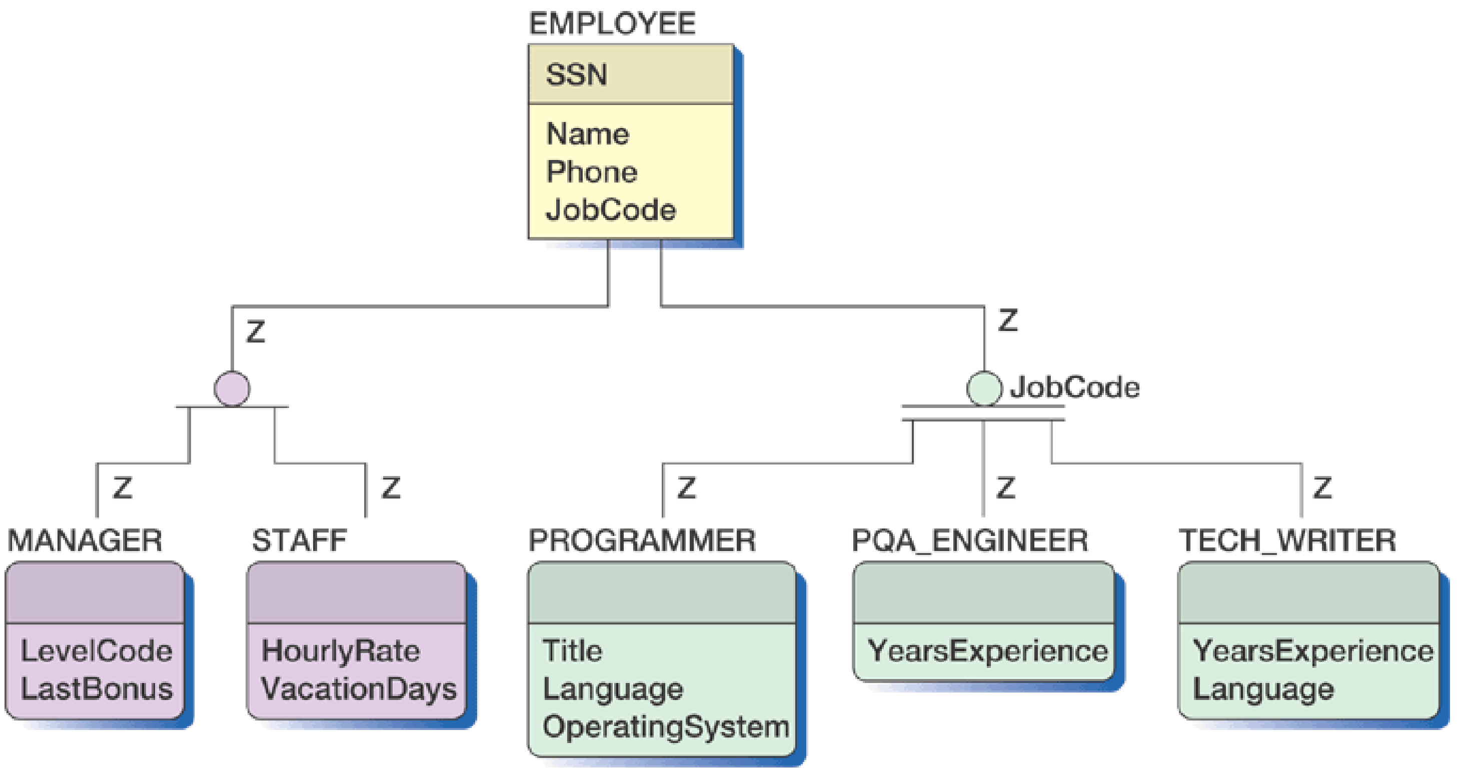


Categorization Relationships

- A relationship between a generic entity and another entity called a category entity
- Called specialization of generalization/subtype relationships (IS-A relationships) in the extended E-R model
- Within category clusters, category entities are mutually exclusive
- Two types of category clusters:
  - Complete: every possible type of category for the cluster is shown (denoted by two horizontal lines with a gap in-between)
  - Incomplete: at least one category is missing (denoted by placing the category cluster circle on top of a single line, no gap between horizontal lines)

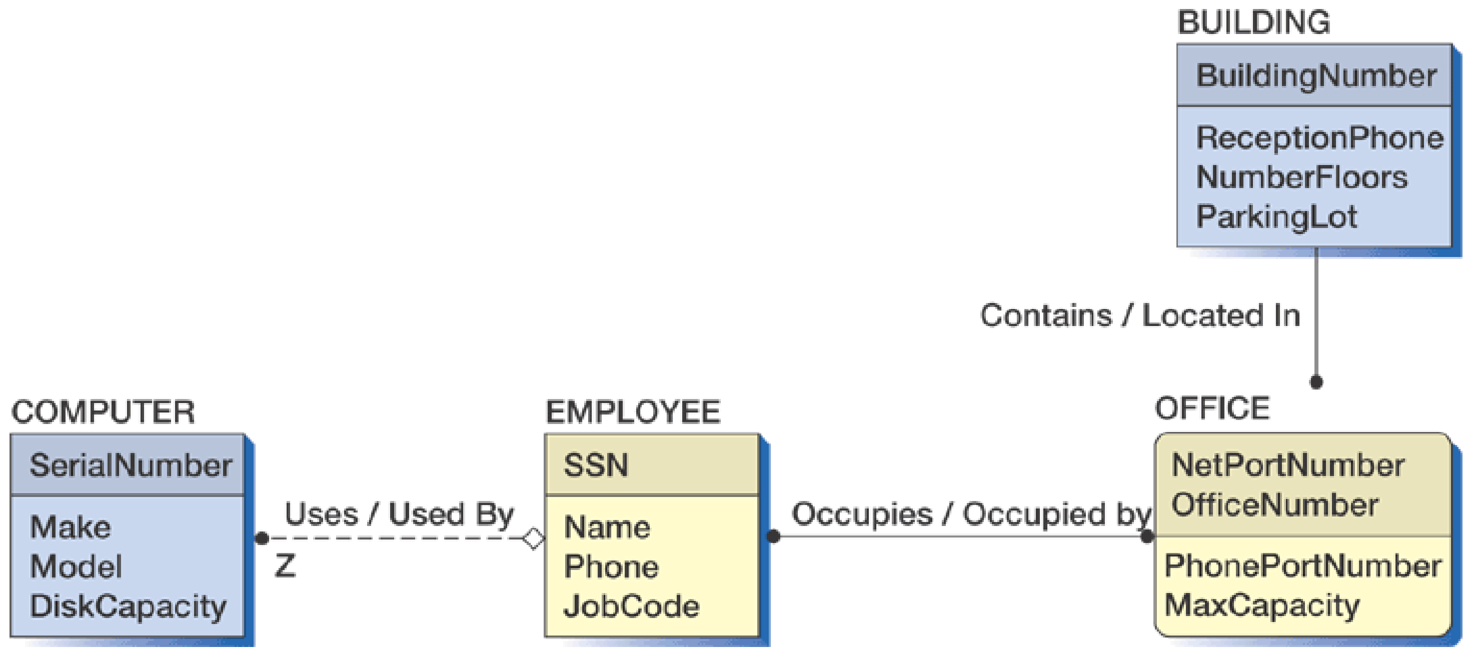
Example: Categorization Relationships

Figure 2.23 Incomplete and Complete Category Clusters



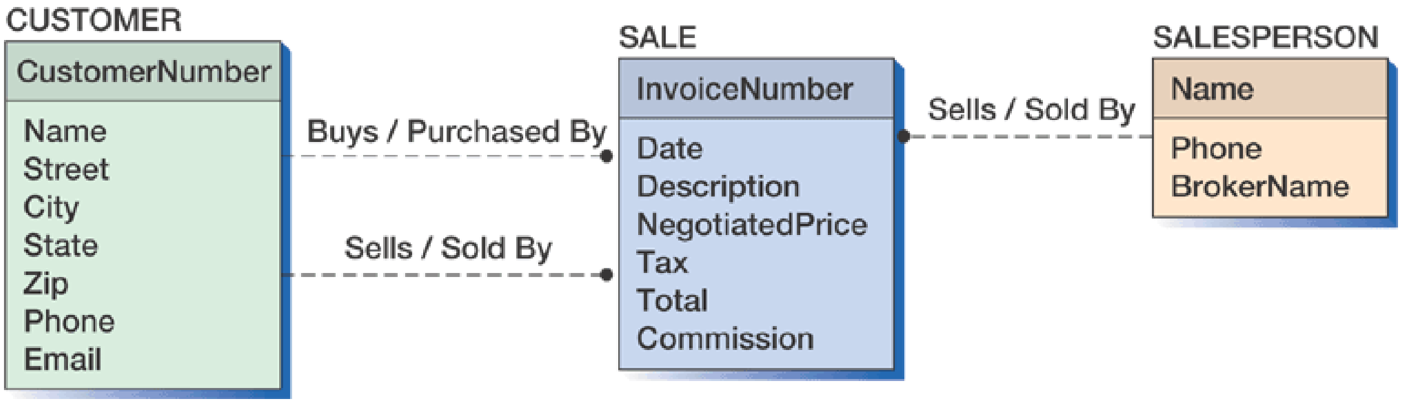
Example: IDEF1X Model With Relationship Names

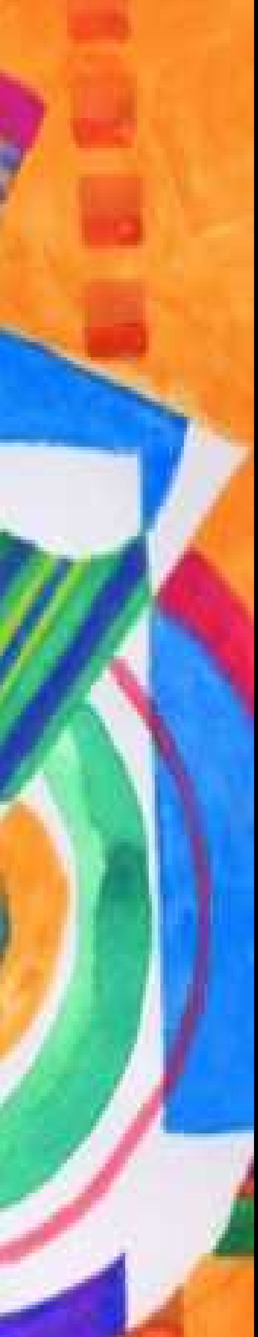
Figure 2.24 IDEF1X Model Showing Relationship Names



Example: IDEF1X Model With Relationship Names

Figure 2.25 Using Names for Multiple Relationships between the Two Entities





Domains

- A domain is a named set of values that an attribute can have
- It can be a specific list of values or a pre-defined data characteristic, e.g. character string of length less than 75
- Domains reduce ambiguity in data modeling and are practically useful
- Two types of domains
  - Base domain: have a data type and possibly a value list or range definition
  - Type domain: a subset of a base domain or a subset of another type domain

Example: Domain Hierarchy

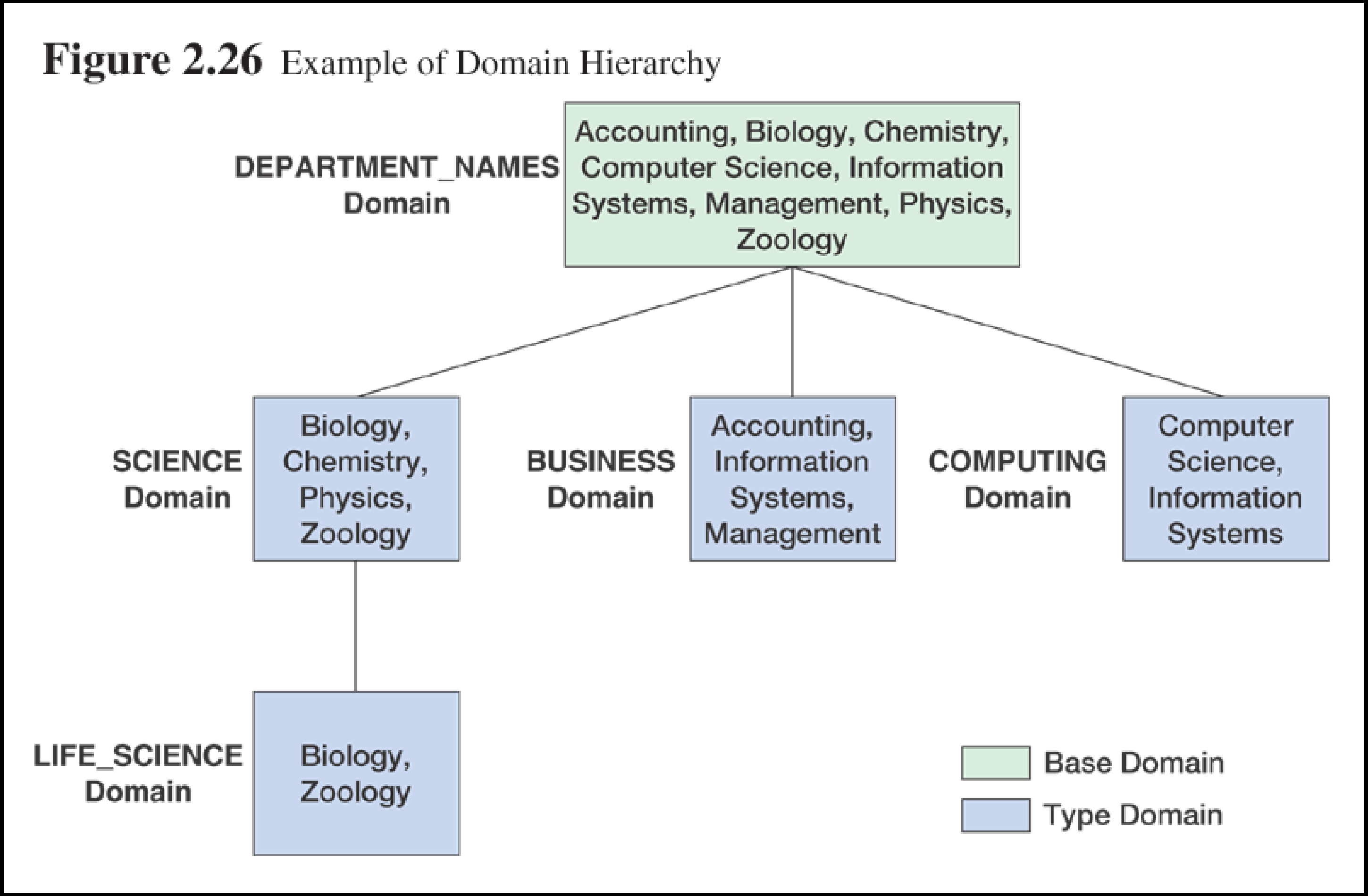
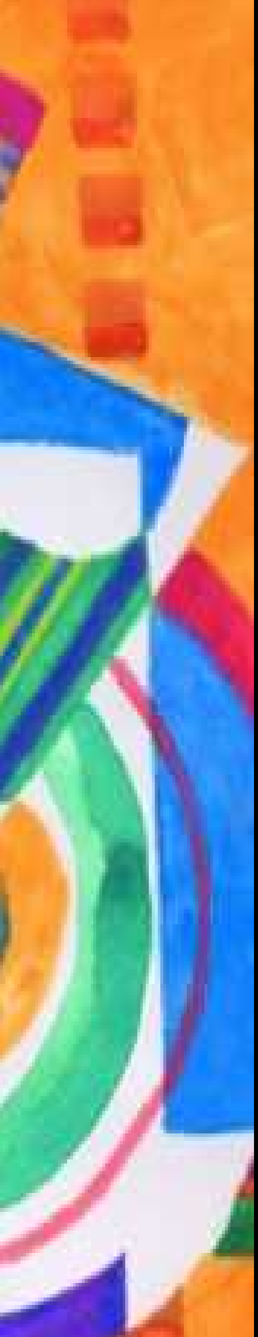


Figure 2.26 Example of Domain Hierarchy

DEPARTMENT_NAMES Domain
Accounting, Biology, Chemistry, Computer Science, Information Systems, Management, Physics, Zoology
SCIENCE Domain
Biology, Chemistry, Physics, Zoology
BUSINESS Domain
Accounting, Information Systems, Management
COMPUTING Domain
Computer Science, Information Systems
LIFE_SCIENCE Domain
Biology, Zoology
Base Domain
Type Domain

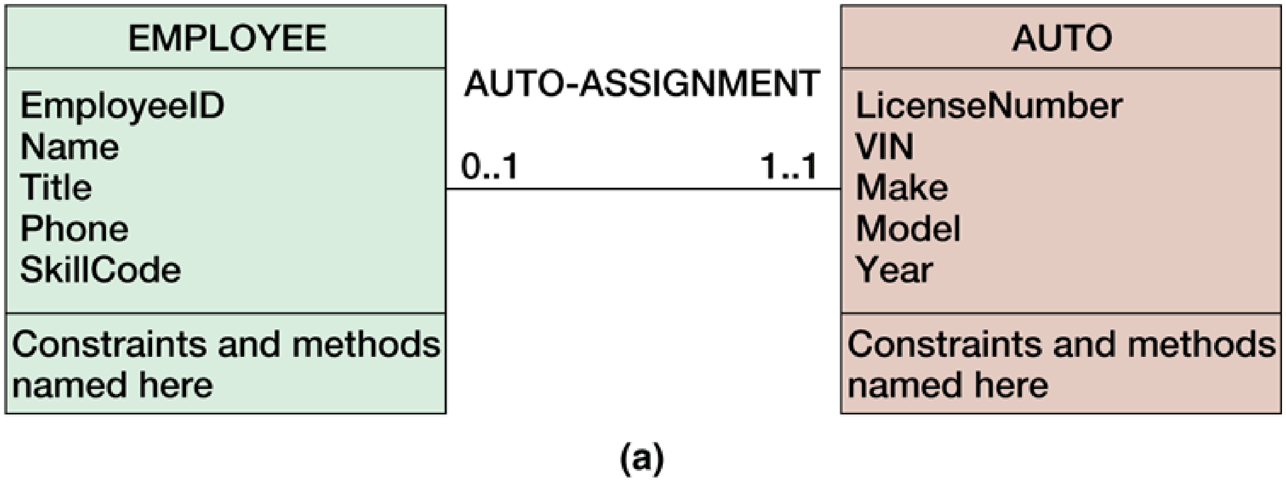


UML-style E-R Diagrams

- The Unified Modeling Language (UML) is a set of structures and techniques for modeling and designing object-oriented programs (OOP) and applications
- The concept of UML entities, relationships, and attributes are very similar to those of the extended E-R model
- Several OOP constructs are added:
  - <Persistent> indicates that the entity class exist in the database
  - UML allows entity class attributes
  - UML supports visibility of attributes and methods
  - UML entities specify constraints and methods in the third segment of the entity classes
- Currently, the object-oriented notation is of limited practical value

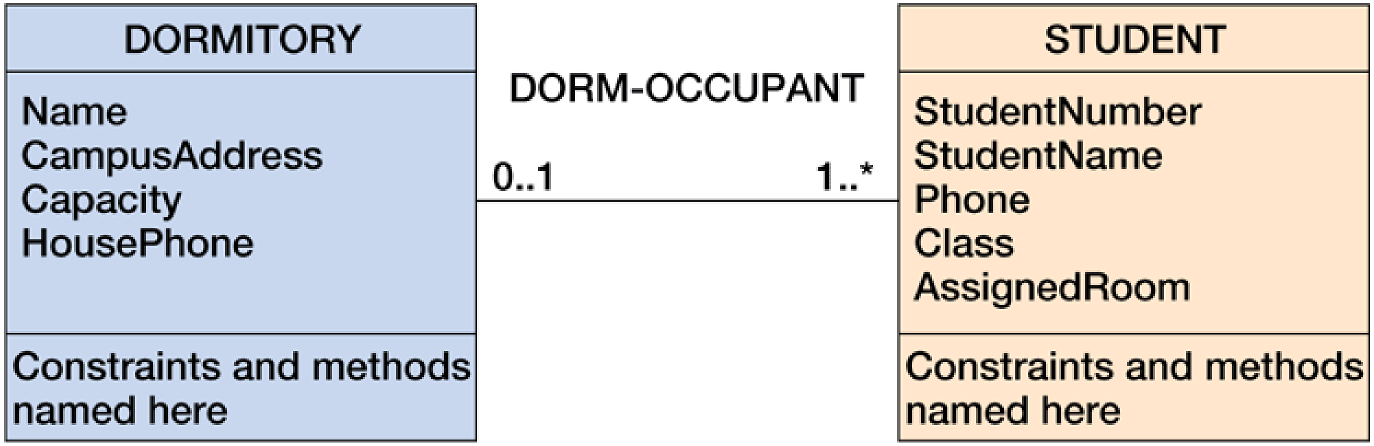
Example: UML

Figure 2.27a UML Representation of a 1:1 Relationship



Example: UML

Figure 2.27b UML Representation of a 1:N Relationship



DORMITORY

Name
CampusAddress
Capacity
HousePhone

Constraints and methods named here

DORM-OCCUPANT

0..1

1..*

STUDENT

StudentNumber
StudentName
Phone
Class
AssignedRoom

Constraints and methods named here

(b)

Example: UML

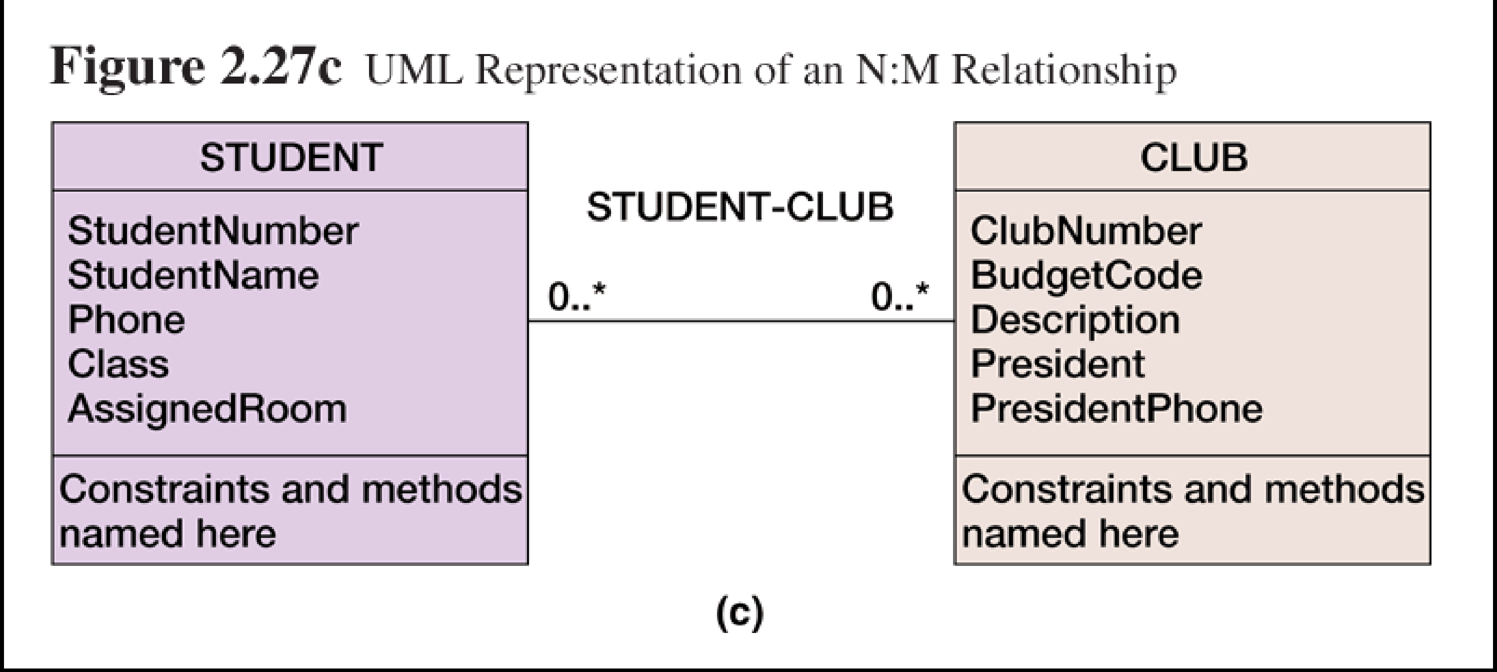


Figure 2.27c UML Representation of an N:M Relationship

UML: Weak Entities

Figure 2.28a UML Representation of Weak Entities — Non-ID-Dependent Weak Entity

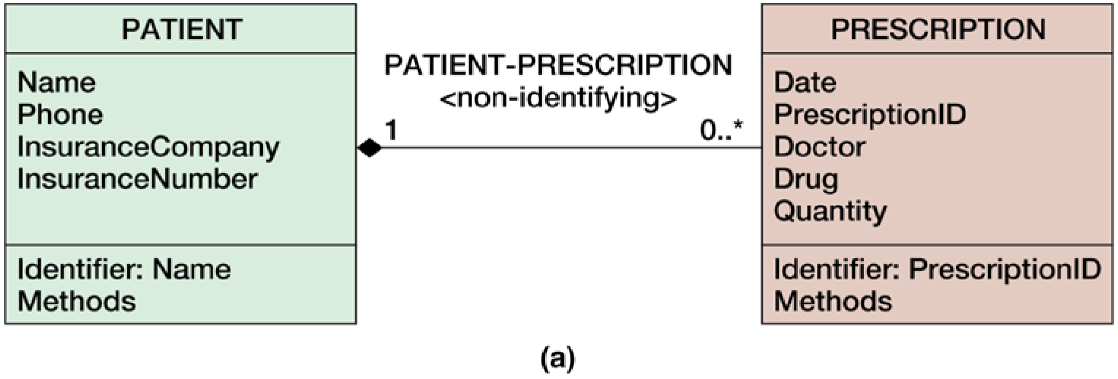
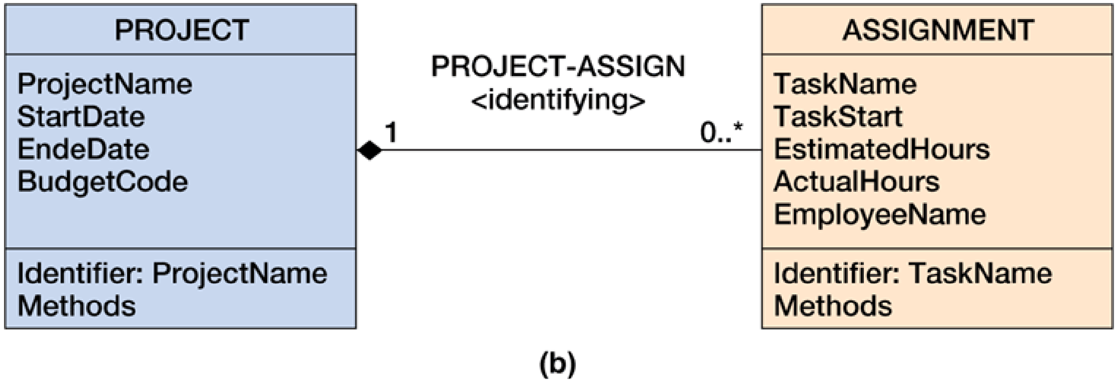
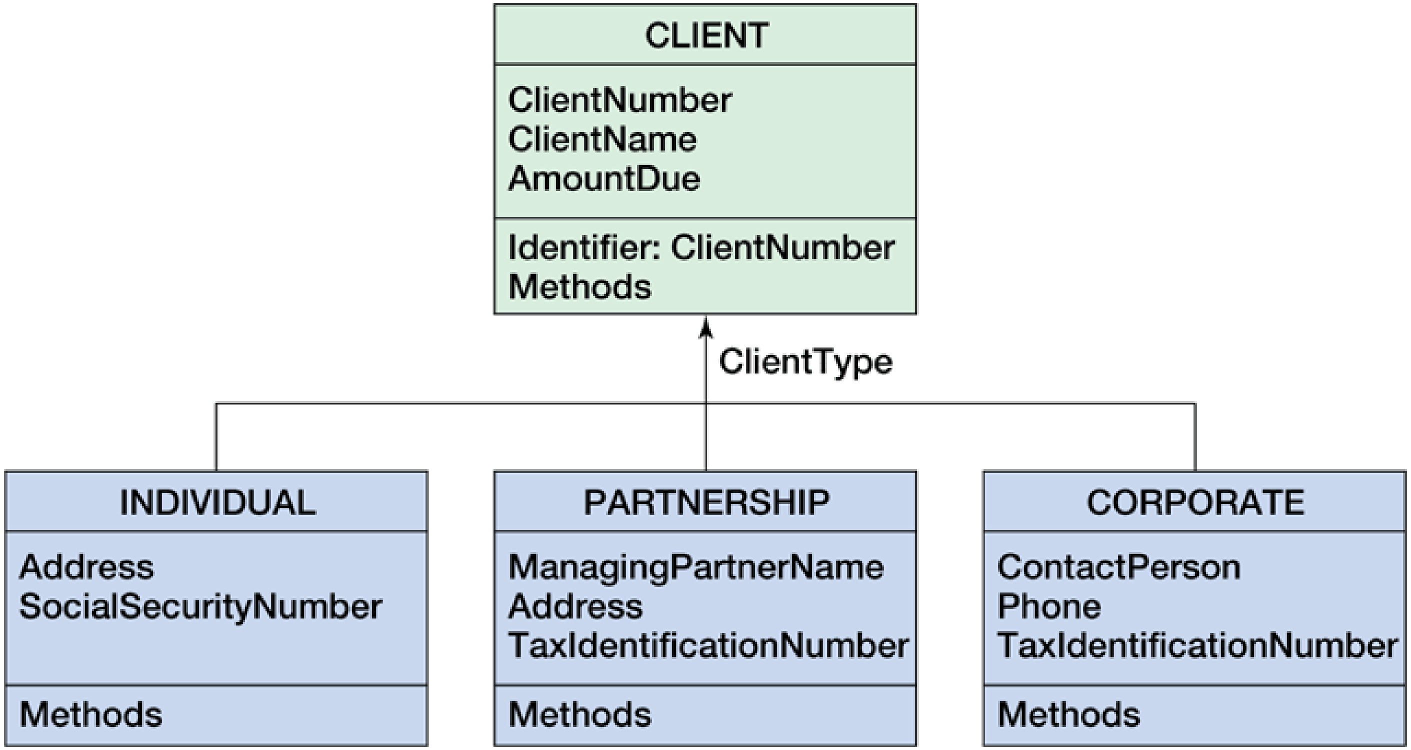


Figure 2.28b UML Representation of Weak Entities — ID-Dependent Weak Entity



UML: Subtypes

Figure 2.29 UML Representation of Subtypes



CLIENT

ClientNumber
ClientName
AmountDue

Identifier: ClientNumber
Methods

ClientType

INDIVIDUAL

Address
SocialSecurityNumber

Methods

PARTNERSHIP

ManagingPartnerName
Address
TaxIdentificationNumber

Methods

CORPORATE

ContactPerson
Phone
TaxIdentificationNumber

Methods

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