Fox School of Business
TEMPLE UNIVERSITY®

Information Technology Audit & Cyber Security

Structured Data Requirements

Systems & Infrastructure Lifecycle Management

Introduction

Conceptual Data Modeling

Gathering Information

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LEARNING OBJECTIVES

- ✓Explain the role of conceptual data modeling in the overall analysis and design of an information system.
- ✓Describe the information gathering process for conceptual data modeling.
- ✓Describe how to represent an entity-relationship model and be able to define the terms: *entity type, attribute, multivalued attribute,* and *relationship*.
- ✓Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each.
- ✓Define supertypes and subtypes, showing how to represent these entity types with ER diagramming notation.
- ✓Define four basic types of business rules in a conceptual data model.
- ✓Explain the role of prepackaged database models (patterns) in data modeling.

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CONCEPTUAL DATA MODELING

Conceptual data modeling: a detailed model that captures the overall structure of data in an organization

- Independent of any database management system (DBMS) or other implementation considerations

CONCEPTUAL DATA MODELING (CONT.)

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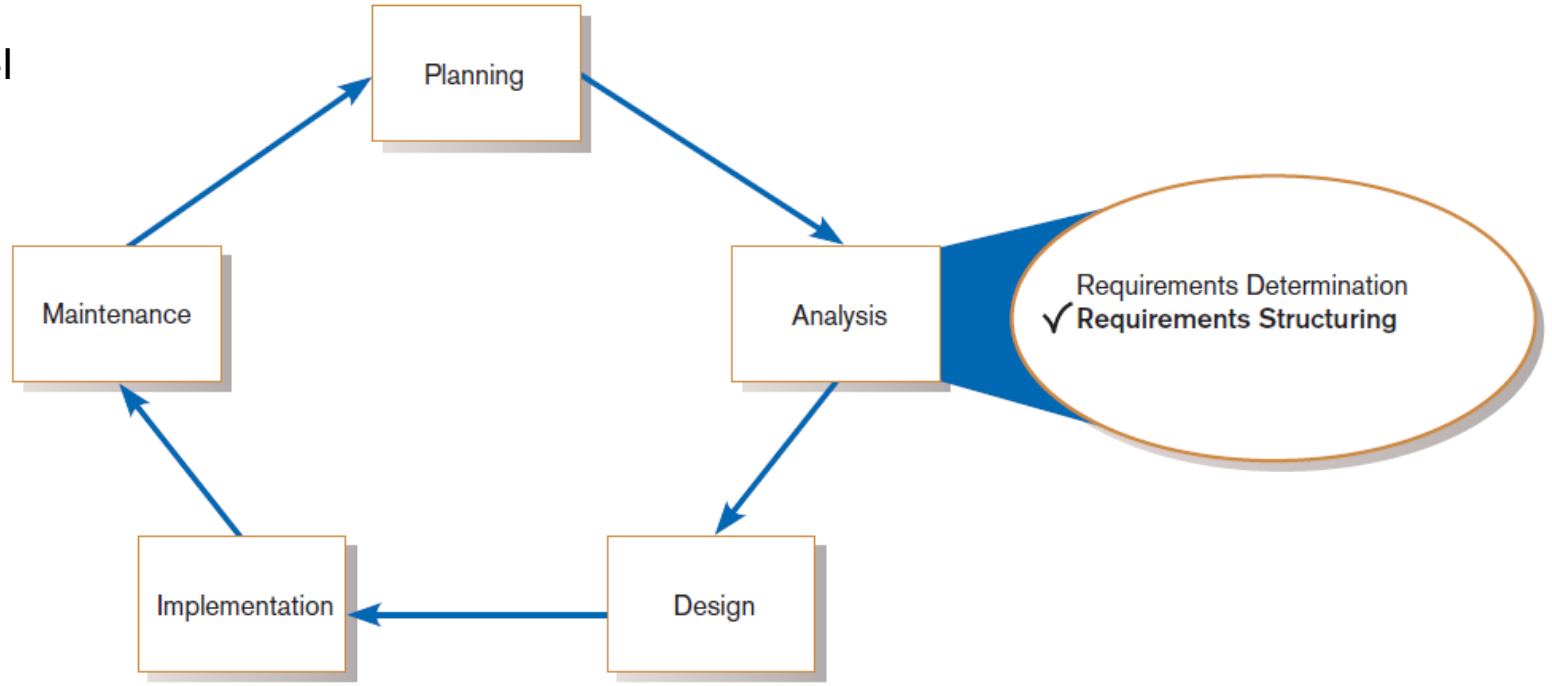

FIGURE 8-1
Systems development life cycle with analysis phase highlighted

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THE CONCEPTUAL DATA MODELING PROCESS

Develop a data model for the current system.

Develop (or purchase) a new conceptual data model that includes all requirements of the new system.

In the design stage, the conceptual data model is translated into a physical design.

Project repository links all design and data modeling steps performed during SDLC.

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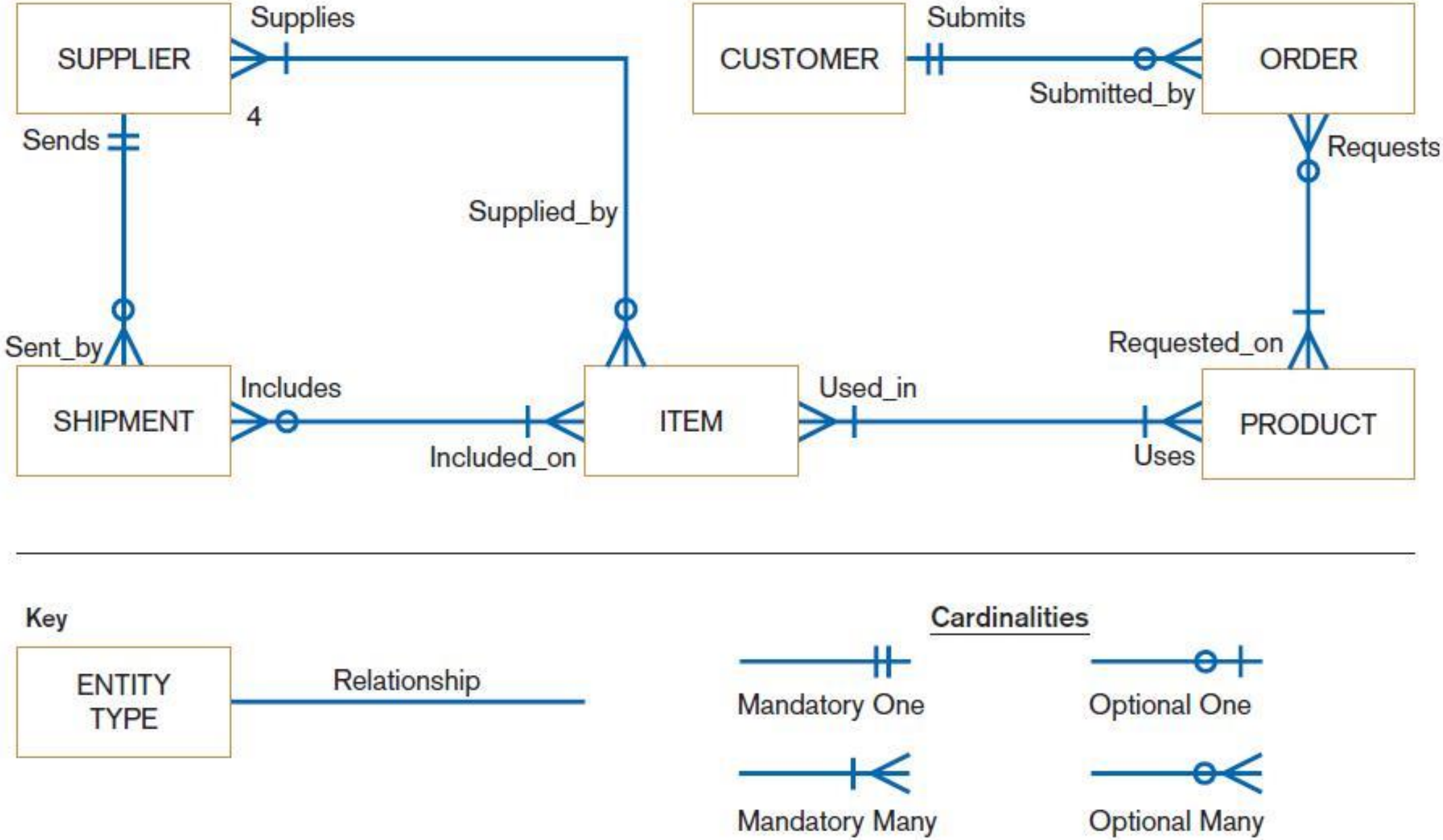
DELIVERABLES AND OUTCOME

Entity-relationship (E-R) diagram or UML class diagram

- Entities (or classes) – categories of data, represented as rectangles
- Relationships (or associations) – lines between the entities

Set of entries about data objects to be stored in repository project dictionary, or data modeling software

- Repository links data, process, and logic models of an information system.
- Data elements included in the data flow diagram (DFD) must appear in the data model and vice versa.
- Each data store in a process model must relate to business objects represented in the data model.



Sample conceptual data model

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GATHERING INFORMATION FOR CONCEPTUAL DATA MODELING

Two perspectives on data modeling:

- *Top-down approach* for a data model is derived from an intimate understanding of the business.
- *Bottom-up approach* for a data model is derived by reviewing specifications and business documents.

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GATHERING INFORMATION FOR CONCEPTUAL DATA MODELING (CONT.)

Requirements Determination Questions for Data Modeling:

- What are subjects/objects of the business?
  - Data entities and descriptions
- What unique characteristics distinguish between subjects/objects of the same type?
  - Primary keys

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GATHERING INFORMATION FOR CONCEPTUAL DATA MODELING (CONT.)

- What characteristics describe each subject/object?
  - Attributes and secondary keys
- How do you use the data?
  - Security controls and user access privileges
  - Who knows the meaning of the data?
- Over what period of time are you interested in the data?
  - Cardinality and time dimensions

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GATHERING INFORMATION FOR CONCEPTUAL DATA MODELING (CONT.)

- Are all instances of each object the same?
  - Supertypes, subtypes, and aggregations
- What events occur that imply associations between objects?
  - Relationships and cardinalities
- Are there special circumstances that affect the way events are handled?
  - Integrity rules, minimum and maximum cardinalities, time dimensions

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INTRODUCTION TO ENTITY-RELATIONSHIP (E-R) MODELING

Entity-Relationship data model (E-R model): a detailed, logical representation of the entities, associations and data elements for an organization or business area

Entity-relationship diagram (E-R diagram): a graphical representation of an E-R model

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INTRODUCTION TO ENTITY-RELATIONSHIP (E-R) MODELING

The E-R model is expressed in terms of:

- Data entities in the business environment.
- Relationships or associations among those entities.
- Attributes or properties of both the entities and their relationships.

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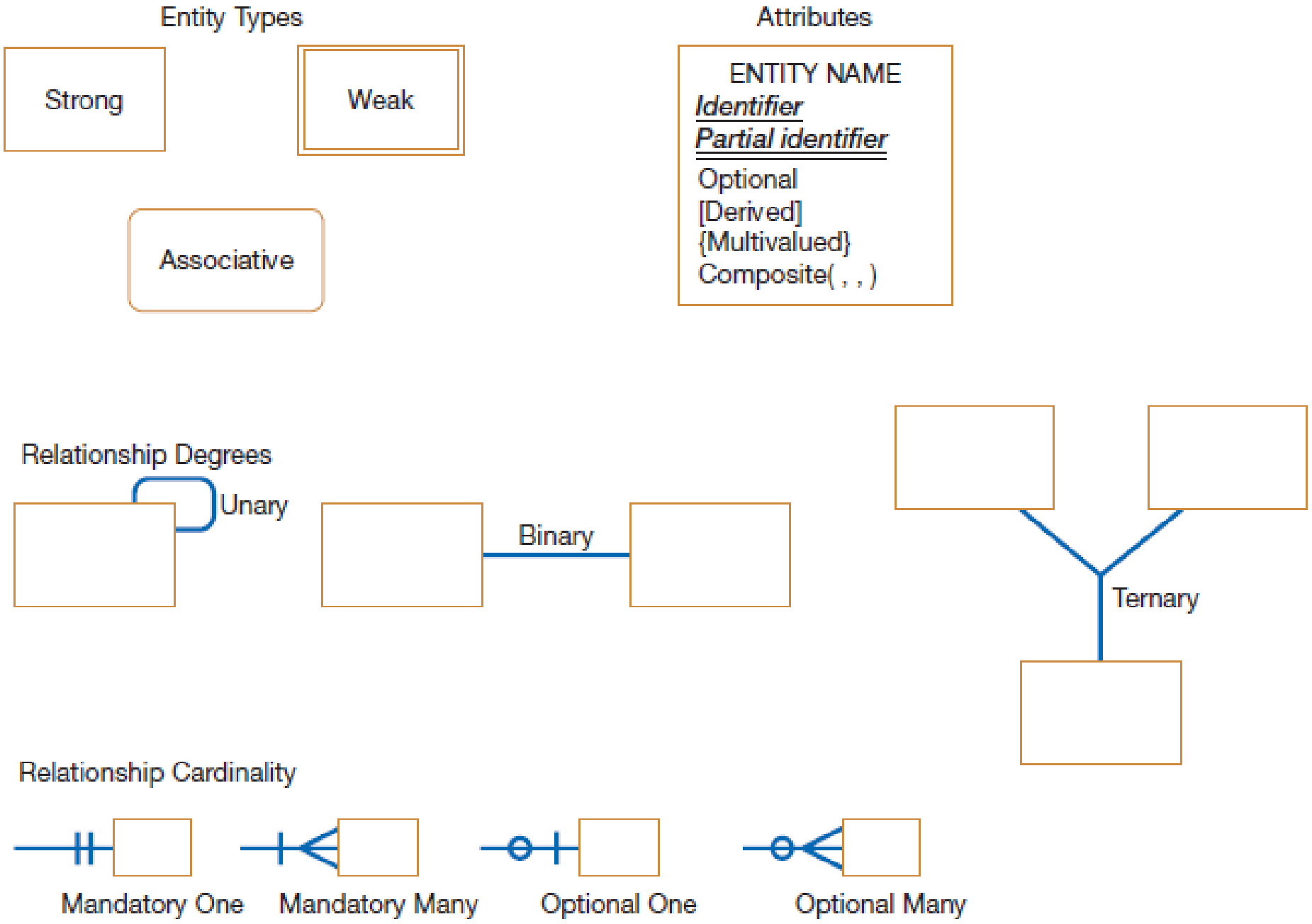
INTRODUCTION TO E-R MODELING (CONT.)

Entity: a person, place, object, event or concept in the user environment about which data is to be maintained

Entity type: collection of entities that share common properties or characteristics

Entity instance: single occurrence of an entity type



Basic E-R notation

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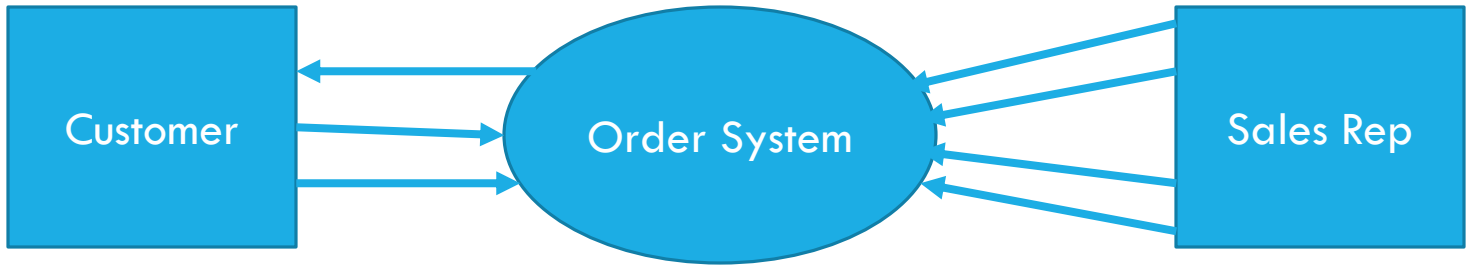

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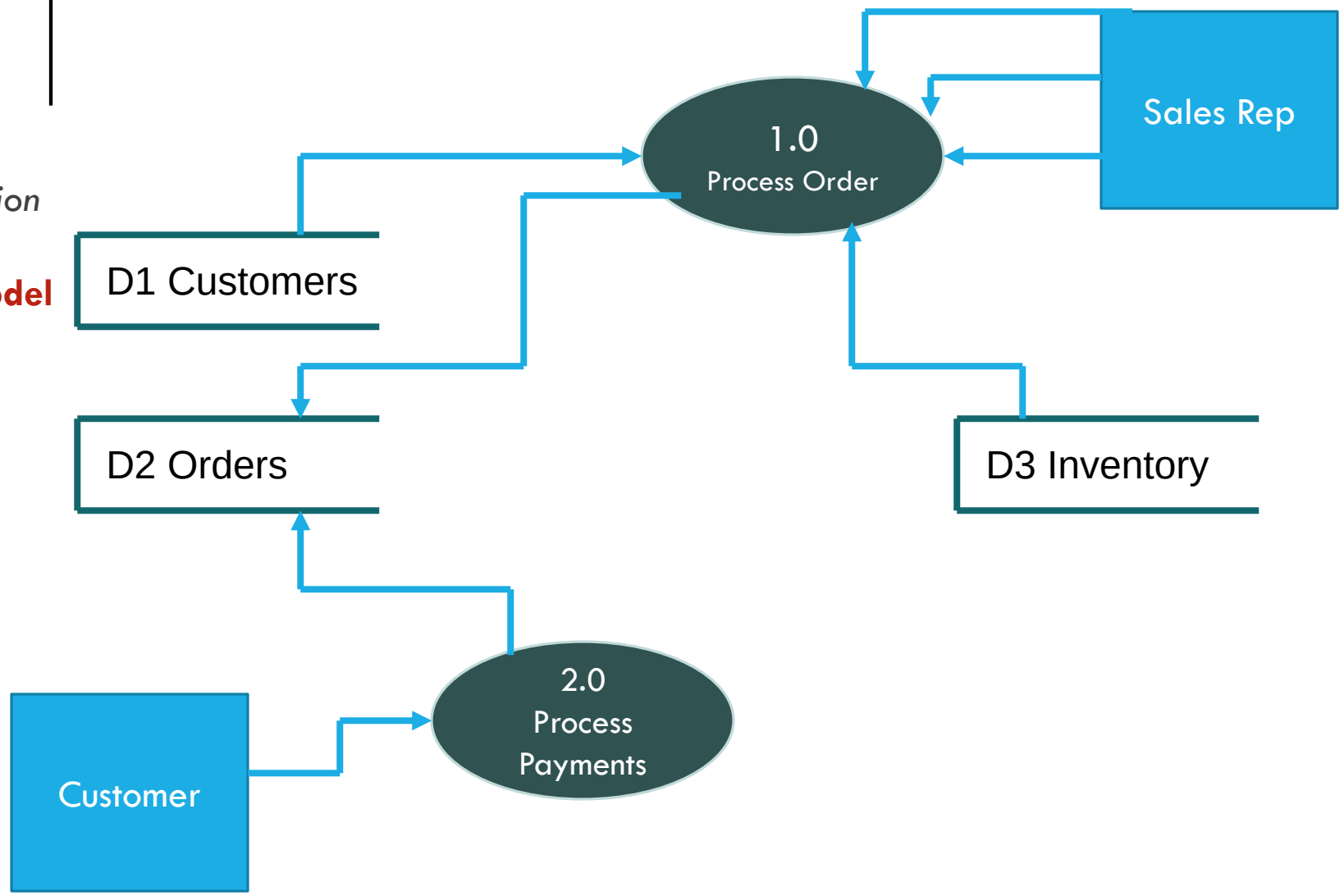

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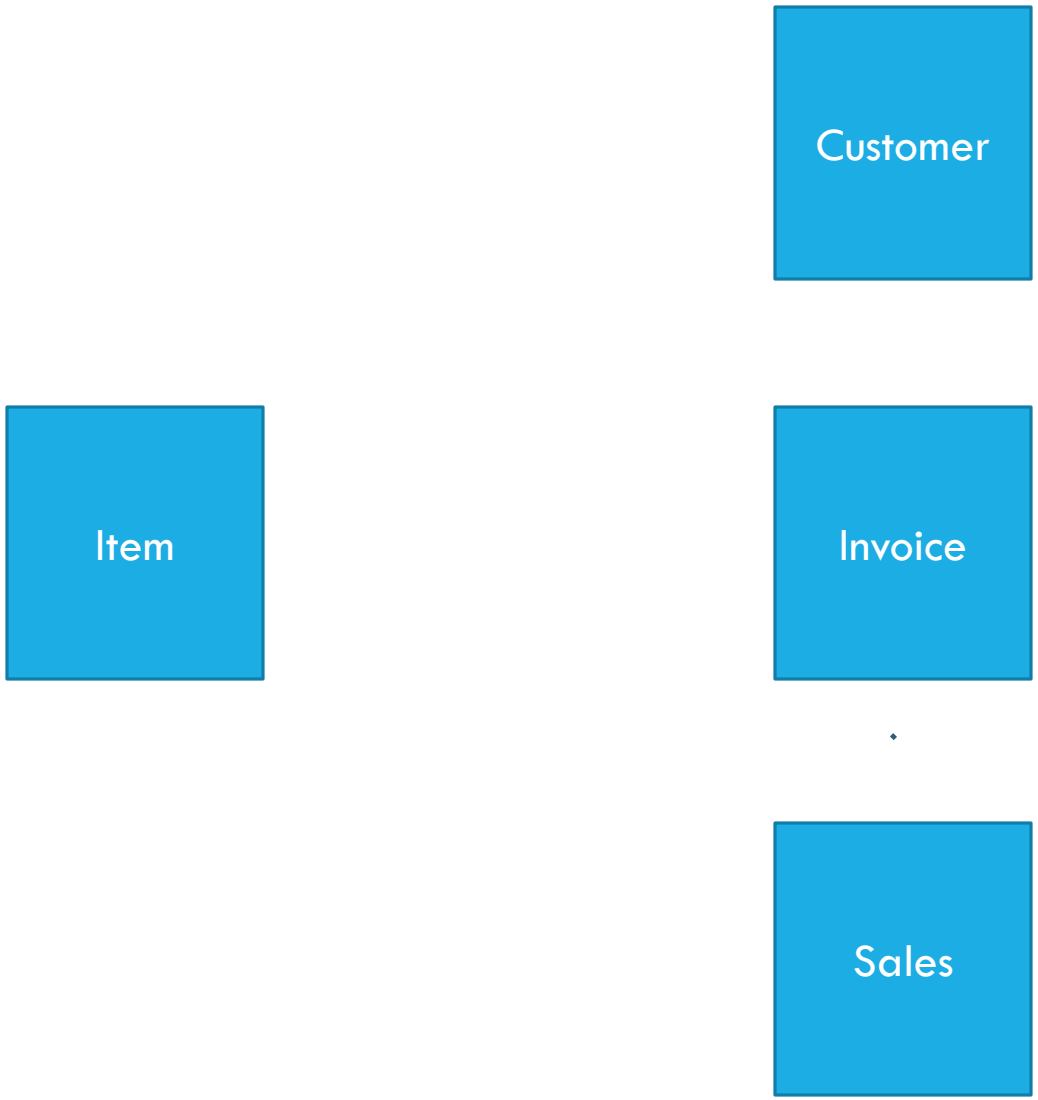

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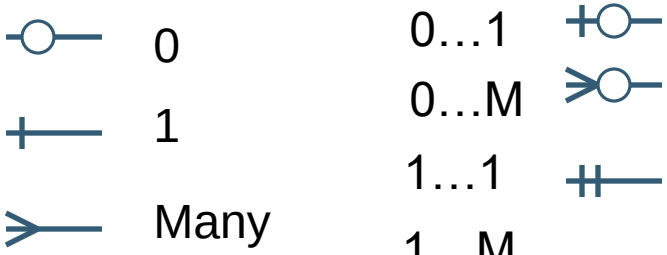

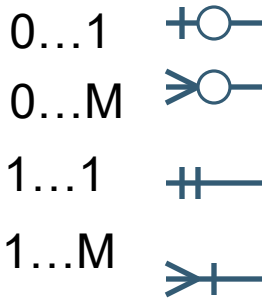

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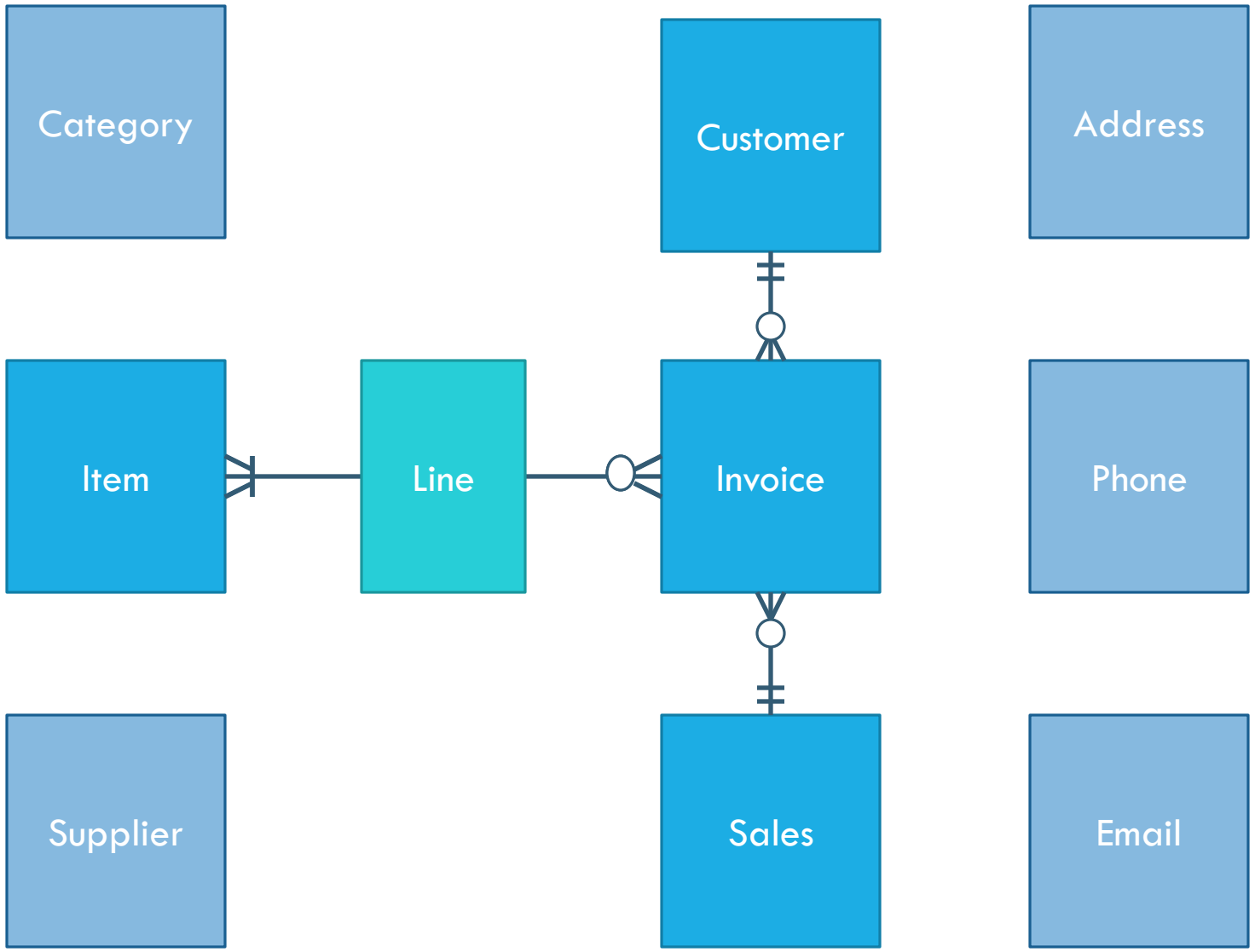

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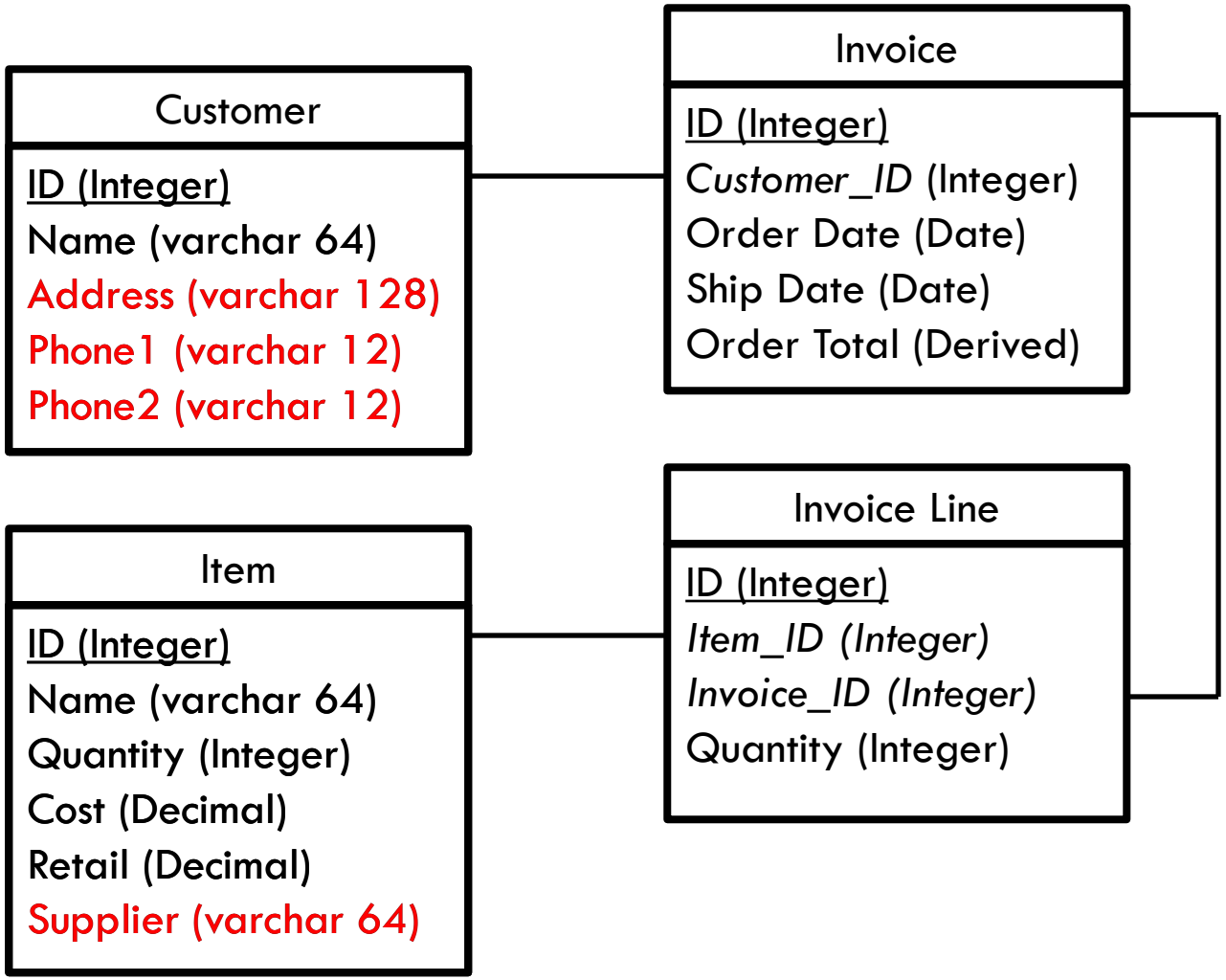

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NAMING AND DEFINING ENTITY TYPES

An entity type name should be:

- *A singular noun.*
- *Descriptive and specific to the organization.*
- *Concise.*

Event entity type should be named for the *result of the event*, not the activity or process of the event.

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NAMING AND DEFINING ENTITY TYPES (CONT.)

An entity type definition:

- Includes a statement of *what the unique characteristic(s) is (are) for each instance.*
- Makes clear *what entity instances are included and not included* in the entity type.
- Often includes a description of *when an instance of the entity type is created or deleted.*

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NAMING AND DEFINING ENTITY TYPES (CONT.)

For some entity types the definition must specify:

- *When an instance might change into an instance of another entity type.*
- *What history is to be kept about entity instances.*

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ATTRIBUTES

Attribute: a named property or characteristic of an entity that is of interest to the organization

- Naming an attribute: i.e. Vehicle_ID
- Place its name inside the rectangle for the associated entity in the E-R diagram.

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NAMING AND DEFINING ATTRIBUTES

An attribute name is a *noun* and should be *unique.*

To make an attribute name unique and for clarity, *each attribute name should follow a standard format.*

Similar attributes of different entity types should use similar but distinguishing names.

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NAMING AND DEFINING ATTRIBUTES (CONT.)

An attribute definition:

- *States what the attribute is and possibly why it is important.*
- Should make it clear *what is included and what is not included.*
- Contains any *aliases* or alternative names.
- States *the source of values for the attribute.*

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NAMING AND DEFINING ATTRIBUTES (CONT.)

An attribute definition should indicate:

- *If a value for the attribute is required or optional.*
- *If a value for the attribute may change.*
- Any *relationships that attribute has with other attributes.*

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CANDIDATE KEYS AND IDENTIFIERS.

Candidate key: an attribute (or combination of attributes) that uniquely identifies each instance of an entity type

Identifier: a candidate key that has been selected as the unique, identifying characteristic for an entity type

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CANDIDATE KEYS AND IDENTIFIERS (CONT.)

Selection rules for an identifier

- Choose a candidate key that will not change its value.
- Choose a candidate key that will never be null.
- Avoid using intelligent keys.
- Consider substituting single value surrogate keys for large composite keys.

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OTHER ATTRIBUTE TYPES

Multivalued attribute: an attribute that may take on more than one value for each entity instance

Repeating group: a set of two or more multivalued attributes that are logically related

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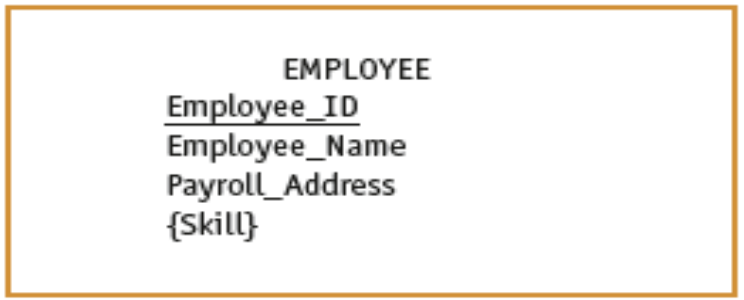
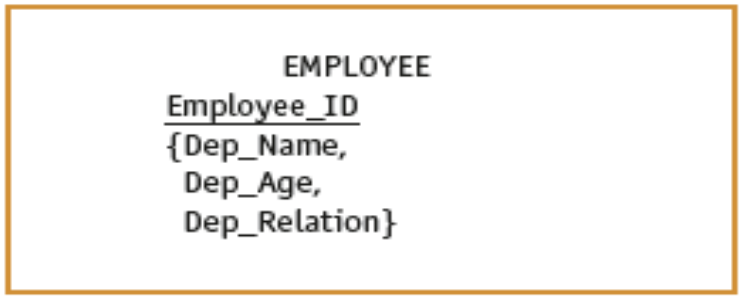
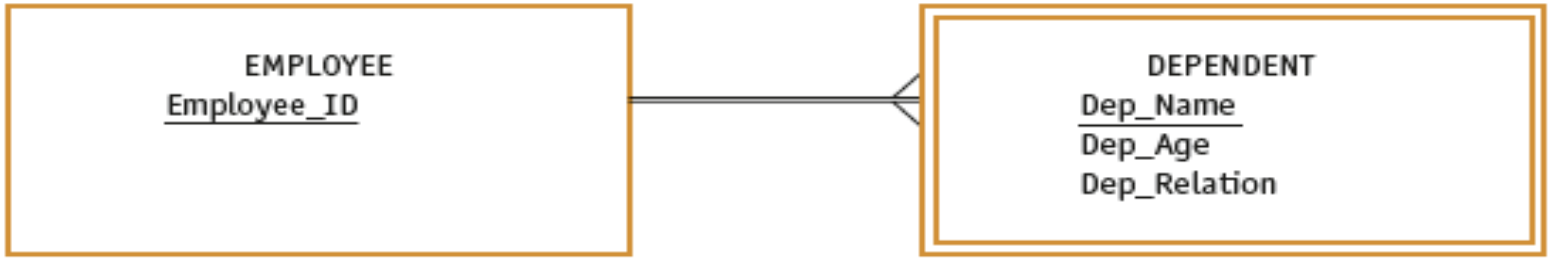


(a) Multivalued attribute skill

Multivalued attributes and repeating groups



(b) Repeating group of dependent data



(c) Weak entity for dependent data

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OTHER ATTRIBUTE TYPES

Required attribute: an attribute that must have a value for every entity instance

Optional attribute: an attribute that may not have a value for every entity instance

Composite attribute: an attribute that has meaningful component parts

Derived attribute: an attribute whose value can be computed from related attribute values

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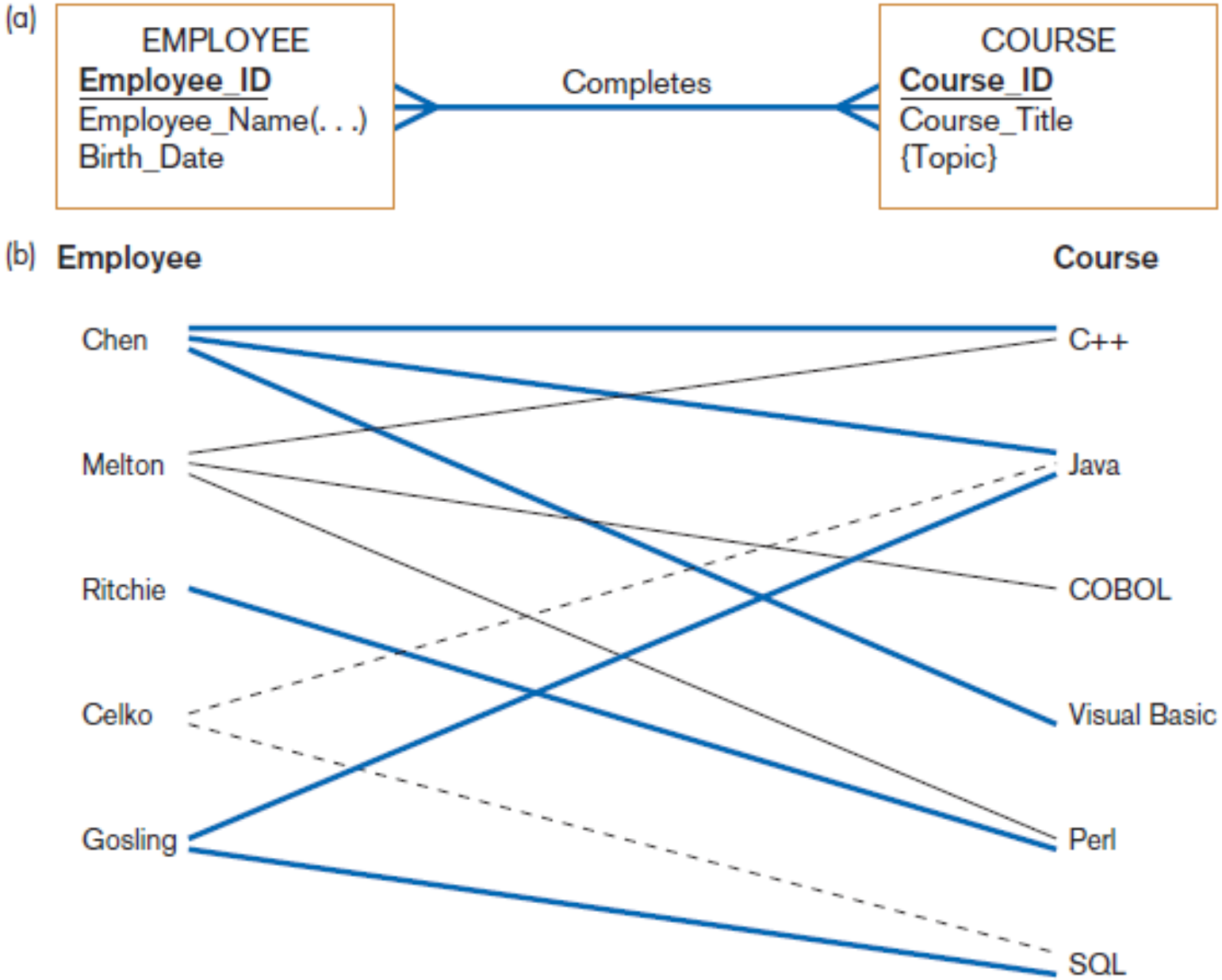
RELATIONSHIPS

Relationship: an association between the instances of one or more entity types that is of interest to the organization

Degree: the number of entity types that participate in a relationship



Relationship type and instances
(a) Relationship type (Completes)
(b) Relationship instances

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CONCEPTUAL DATA MODELING AND THE E-R MODEL

Unary relationship: a relationship between the instances of one entity type

- Also called a *recursive relationship*

Binary relationship: a relationship between instances of two entity types

- Most common type of relationship encountered in data modeling

Ternary relationship: a simultaneous relationship among instances of three entity types

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CARDINALITIES IN RELATIONSHIPS

Cardinality: the number of instances of entity B that can (or must) be associated with each instance of entity A

Minimum Cardinality

- The minimum number of instances of entity B that may be associated with each instance of entity A

Maximum Cardinality

- The maximum number of instances of entity B that may be associated with each instance of entity A

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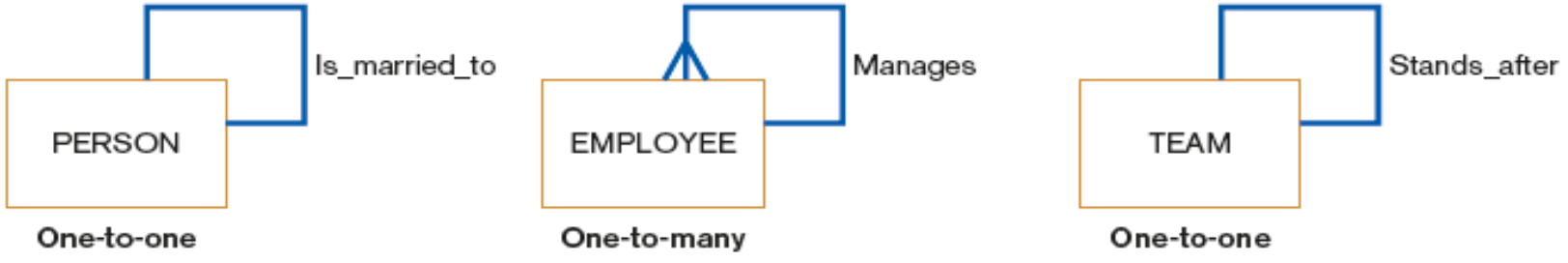
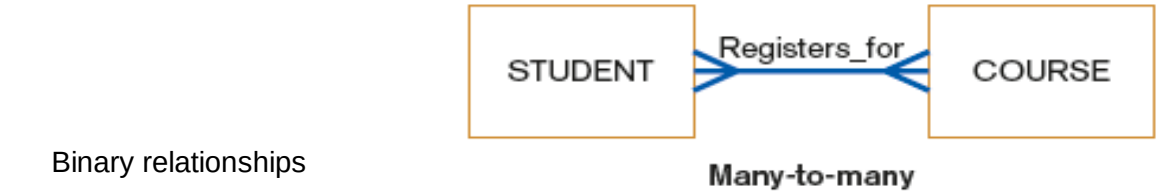
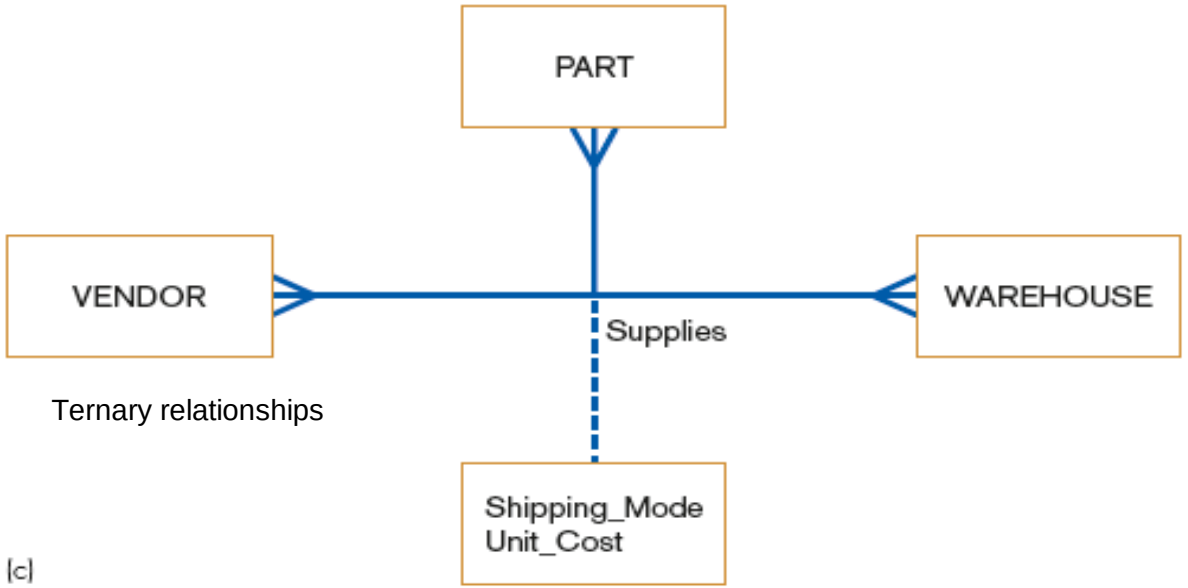


(a) Unary relationships



(b) Binary relationships



(c) Ternary relationships

Examples of relationships of different degrees

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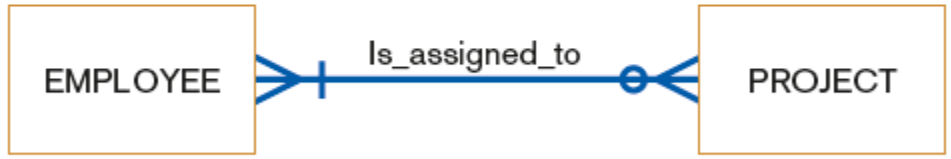
CARDINALITIES IN RELATIONSHIPS (CONT.)

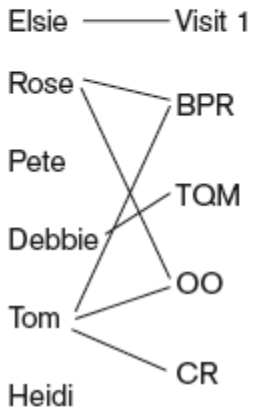
Mandatory vs. Optional Cardinalities

- Specifies whether an instance must exist or can be absent in the relationship

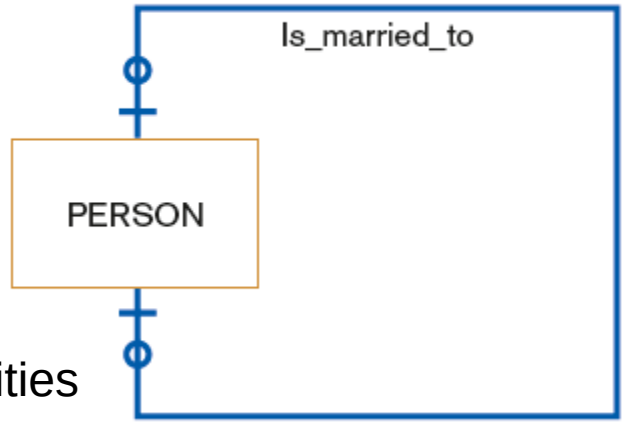
Examples of cardinality constraints

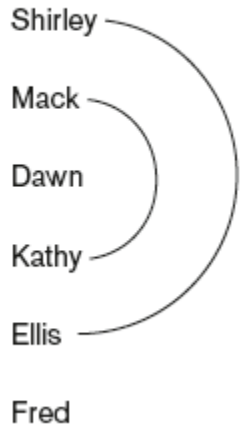
(a) Mandatory cardinalities





(b) One optional, one mandatory cardinality





(c) Optional cardinalities

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NAMING AND DEFINING RELATIONSHIPS

A relationship name is a verb phrase; avoid vague names.

A relationship definition:

- Explains what action is to be taken and possibly why it is important.
- Gives examples to clarify the action.

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NAMING AND DEFINING RELATIONSHIPS (CONT.)

A relationship definition should:

- Explain any optional participation.
- Explain the reason for any explicit maximum cardinality other than many.
- Explain any restrictions on participation in the relationship.
- Explain the extent of history that is kept in the relationship.
- Explain whether an entity instance involved in a relationship instance can transfer participation to another relationship instance.

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ASSOCIATIVE ENTITIES

Associative Entity: an entity type that associates the instances of one or more entity types and contains attributes that are peculiar to the relationship between those entity instances

The data modeler chooses to model the relationship as an entity type.

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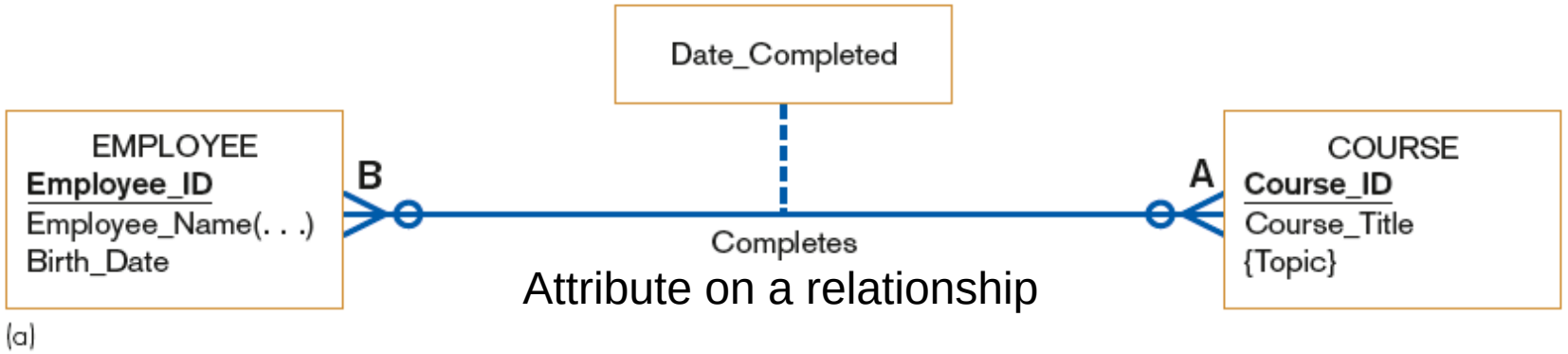
An associative entity



Attribute on a relationship

(a)

An associative entity (CERTIFICATE)

(b)

An associative entity using Microsoft Visio®

(c)

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SUMMARY OF CONCEPTUAL DATA MODELING WITH E-R DIAGRAMS

The purpose of E-R diagramming is to capture the richest possible understanding of the meaning of the data necessary for an information system or organization.

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REPRESENTING SUPERTYPES AND SUBTYPES

Subtype: a subgrouping of the entities in an entity type

- Is meaningful to the organization
- Shares common attributes or relationships distinct from other subgroupings

Supertype: a generic entity type that has a relationship with one or more subtypes

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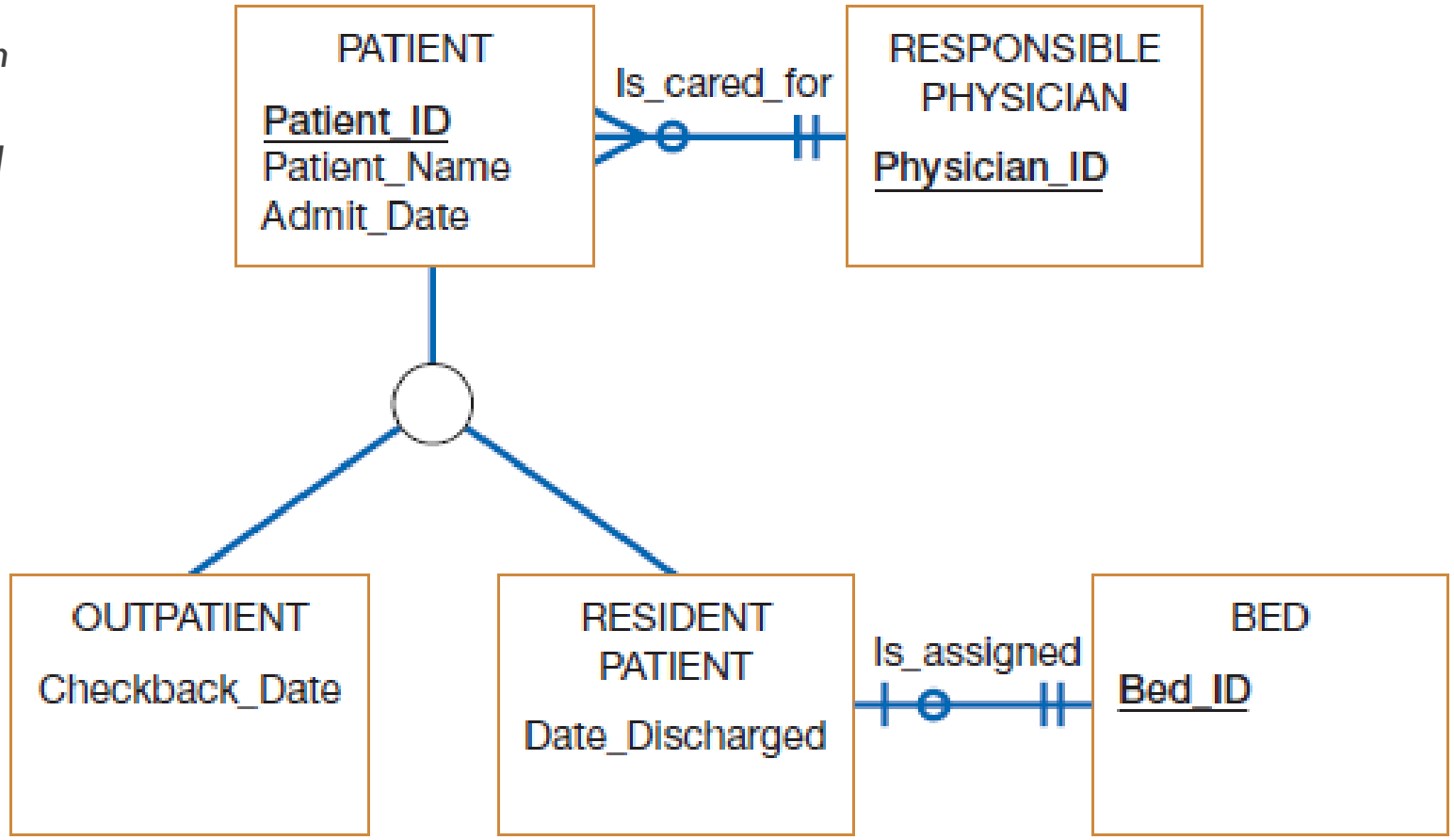
Supertype/subtype relationships in a hospital



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REPRESENTING SUPERTYPES AND SUBTYPES (CONT.)

Business Rules for Supertype/subtype Relationships:

- **Total specialization** specifies that each entity instance of the supertype must be a member of some subtype in the relationship.
- **Partial specialization** specifies that an entity instance of the supertype does not have to belong to any subtype, and may or may not be an instance of one of the subtypes.

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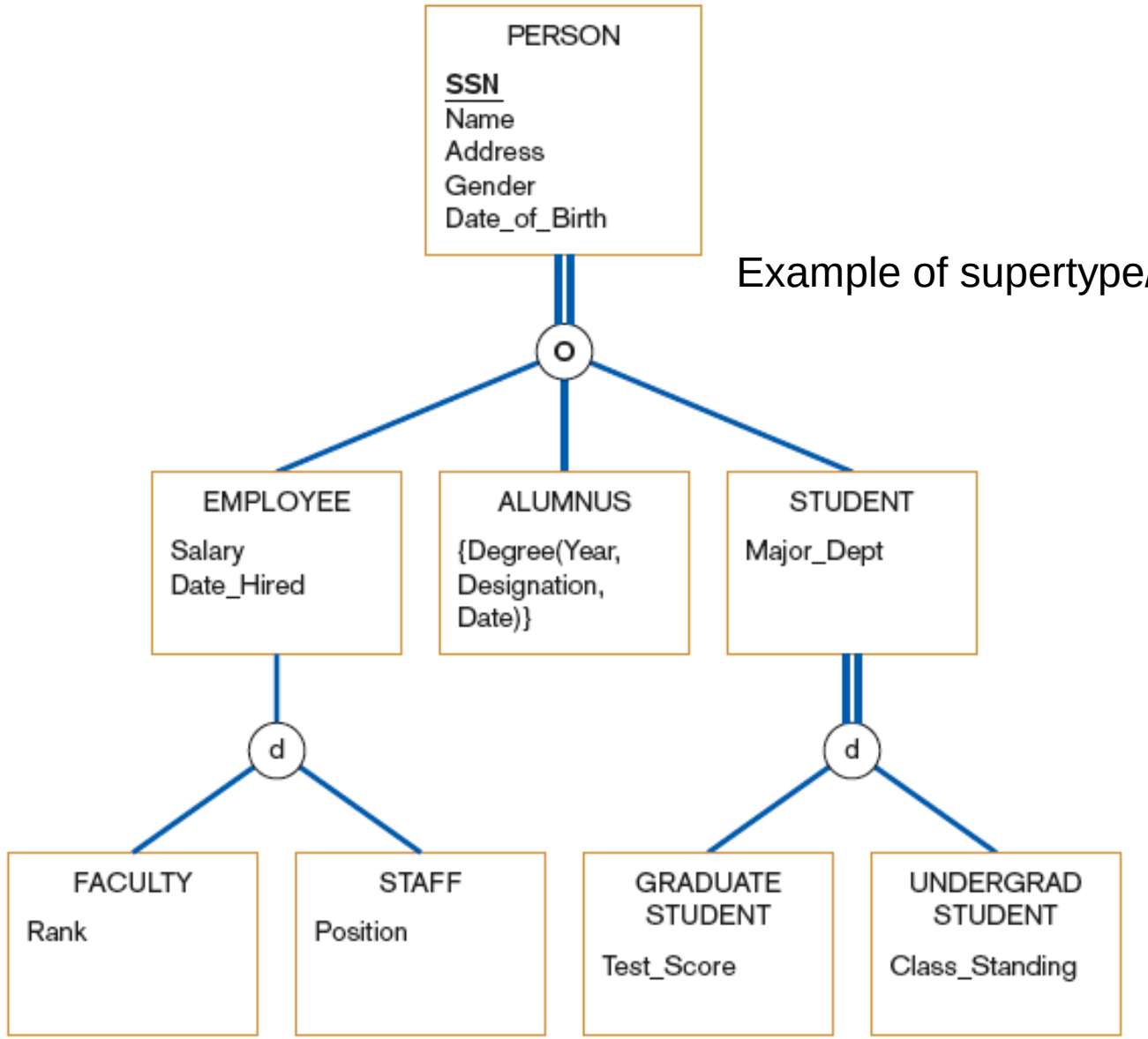
REPRESENTING SUPERTYPES AND SUBTYPES (CONT.)

- **Disjoint rule** specifies that if an entity instance of the supertype is a member of one subtype, it cannot simultaneously be a member of any other subtype.
- **Overlap rule** specifies that an entity instance can simultaneously be a member of two (or more) subtypes.



Example of supertype/subtype hierarchy

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BUSINESS RULES

Business rules: specifications that preserve the integrity of the logical data model

- Captured during requirements determination
- Stored in CASE repository as they are documented

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BUSINESS RULES (CONT.)

Four basic types of business rules are:

- *Entity integrity*: unique, non-null identifiers
- *Referential integrity constraints*: rules governing relationships between entity types
- *Domains*: constraints on valid values for attributes
- *Triggering operations*: other business rules that protect the validity of attribute values

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DOMAINS

Domain: the set of all data types and values that an attribute can assume

Several advantages

- Verify that the values for an attribute are valid
- Ensure that various data manipulation operations are logical
- Help conserve effort in describing attribute characteristics

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TRIGGERING OPERATIONS

Trigger: an assertion or rule that governs the validity of data manipulation operations such as insert, update and delete

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TRIGGERING OPERATIONS

Includes the following components:

- *User rule*: statement of the business rule to be enforced by the trigger
- *Event*: data manipulation operation that initiates the operation
- *Entity Name*: name of entity being accessed or modified
- *Condition*: condition that causes the operation to be triggered
- *Action*: action taken when the operation is triggered

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ROLE OF PACKAGED CONCEPTUAL DATA MODELS – DATABASE PATTERNS

Packaged data models provide generic models that can be customized for a particular organization's business rules.

Universal data models are templates for

- one or more core subject areas such as:
  - Customers, products, accounts, documents
- and/or core business functions such as:
  - Purchasing, accounting, receiving, etc.

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ROLE OF PACKAGED CONCEPTUAL DATA MODELS – DATABASE PATTERNS (CONT.)

Industry-specific data models are designed to be used by organizations within specific industries.

These models are based on the premise that data model patterns for organizations are similar within a particular industry.

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BENEFITS OF DATABASE PATTERNS AND PACKAGED DATA MODELS

Dramatically reduced implementation times and costs

- Provides a starting point for asking requirements questions

Higher-quality models

- Represent "best practice" data modeling techniques and data model components whose quality often exceeds that which can be achieved by internal development teams, given typical organizational pressures

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SUMMARY

In this unit you learned how to:

- ✓Explain the role of conceptual data modeling in the overall analysis and design of an information system.
- ✓Describe the information gathering process for conceptual data modeling.
- ✓Describe how to represent an entity-relationship model and be able to define the terms: *entity type, attribute, multivalued attribute,* and *relationship*.
- ✓Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each.
- ✓Define supertypes and subtypes, showing how to represent these entity types with ER diagramming notation.
- ✓Define four basic types of business rules in a conceptual data model.
- ✓Explain the role of prepackaged database models (patterns) in data modeling.