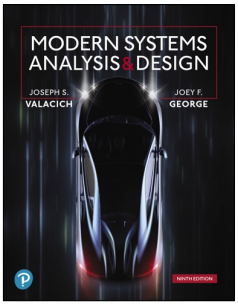
Modern Systems Analysis and Design

Ninth Edition



Chapter 8

Structuring System Data Requirements

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Learning Objectives

8.1 Explain the role of conceptual data modeling in the overall analysis and design of an information system

8.2 Describe the information gathering process for conceptual data modeling

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

8.5 Define supertypes and subtypes, showing how to represent these entity-relationship diagramming notation

8.6 Define four basic types of business rules in a conceptual data model

8.7 Explain the role of prepackaged database models (patterns) in data modeling

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Conceptual Data Modeling

8.1 Explain the role of conceptual data modeling in the overall analysis and design of an information system

- **Conceptual data model** – detailed model that captures the overall structure of organizational data and is independent of any database management system or other implementation considerations
  - Usually done in parallel with other requirements analysis
  - All team member work done and stored in a repository

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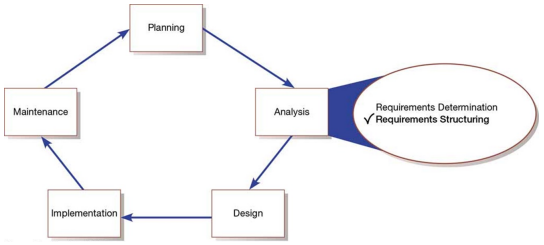
Figure 8-1: Systems Development Life Cycle with Analysis Phase Highlighted



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The Conceptual Data Modeling Process

8.1 Explain the role of conceptual data modeling in the overall analysis and design of an information system

- Develop a data model for the current system
- Develop (or purchase) a new conceptual data model that includes all requirements for the new system
- During design, final data model matched with systems inputs/outputs and translated into a physical design
- Project repository links all design and data modeling steps taken during the SDLC

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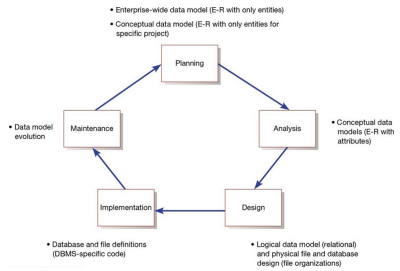
Figure 8-2: Relationship Between Data Modeling and the SDLC



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Deliverables and Outcomes

8.1 Explain the role of conceptual data modeling in the overall analysis and design of an information system

- Entity-relationship (E-R) diagraming includes:
  - Entities – categories of data, represented by rectangles
  - Relationships – between entities represented by lines drawn between entities
- Set of entities about data objects are stored in repository project dictionary, or data modeling software
  - Repository is the mechanism that links the data, processes, 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

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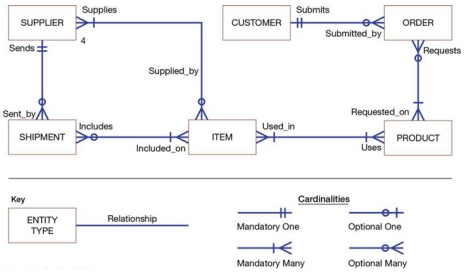
Figure 8-3: Sample Conceptual Data Model



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Gathering Information for Conceptual Data Modeling

8.2 Describe the information gathering process for conceptual data modeling

- Two perspectives on data modeling:
  - **Top-down approach** – derives the data model from an intimate understanding of the business
  - **Bottom up approach** – derives the data model by reviewing specific business documents (computer displays, reports, form)

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Table 8-1: Requirements Determination Questions for Data Modeling (1 of 2)

Requirements Determination Questions for Data Modeling	
1.	**What are the subjects/objects of the business?** What types of people, places, things, materials, events, etc. are used or interact in this business, about which data must be maintained? How many instances of each object might exist?—data entities and their descriptions
2.	**What unique characteristic (or characteristics) distinguishes each object from other objects of the same type?** Might this distinguishing feature change over time or is it permanent? Might this characteristic of an object be missing even though we know the object exists?—primary key
3.	**What characteristics describe each object?** On what basis are objects referenced, selected, qualified, sorted, and categorized? What must we know about each object in order to run the business?—attributes and secondary keys
4.	**How do you use these data?** That is, are you the source of the data for the organization, do you refer to the data, do you modify it, and do you destroy it? Who is not permitted to use these data? Who is responsible for establishing legitimate values for these data?—security controls and understanding who really knows the meaning of data
5.	**Over what period of time are you interested in these data?** Do you need historical trends, current "snapshot" values, and/or estimates or projections? If a characteristic of an object changes over time, must you know the obsolete values?—cardinality and time dimensions of data

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Table 8-1: Requirements Determination Questions for Data Modeling (2 of 2)

Requirements Determination Questions for Data Modeling	
6.	**Are all instances of each object the same?** That is, are there special kinds of each object that are described or handled differently by the organization? Are some objects summaries or combinations of more detailed objects?—supertypes, subtypes, and aggregations
7.	**What events occur that imply associations among various objects?** What natural activities or transactions of the business involve handling data about several objects of the same or a different type?—relationships and their cardinality and degree
8.	**Is each activity or event always handled the same way or are there special circumstances?** Can an event occur with only some of the associated objects, or must all objects be involved? Can the associations between objects change over time (for example, employees change departments)? Are values for data characteristics limited in any way?—integrity rules, minimum and maximum cardinality, time dimensions of data

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Introduction to E-R Modeling (1 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **Entity-relationship data modeling (E-R model)** – detailed, logical representation of the entities, associations, and data elements for an organization or business area
- **Entity-relationship diagram (E-R diagram)** – graphical representation of an E-R model
- The E-R model is expressed in terms of:
  - Entities in the business environment
  - Relationships among those entities
  - The attributes (properties) of both the entities and their relationships

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Introduction to E-R Modeling (2 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **Entity** – person, place, object about which the organization wishes to maintain data
- **Entity type** – collection of entities that share common properties or characteristics
- **Entity instance** – single occurrence of an entity type; also known as an instance

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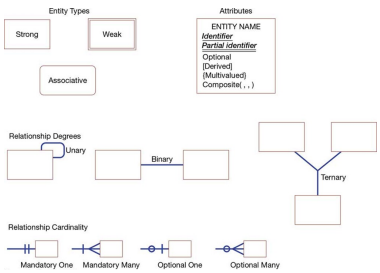
Figure 8-5: Basic E-R Notation



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Naming and Defining Entity Types (1 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- 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 (2 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- An entity type name should:
  - Include a statement of what the unique characteristic(s) is (are) for each instance
  - Make clear **what entity instances are included and not included** in the entity type
  - Include a description of **when an instance of the entity type is created or deleted**
- 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

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **Attribute** – named property or a characteristic of an entity that is of interest to the organization
  - Named using a capital letter followed by lower case letters such as 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 (1 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- 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 (2 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- 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**
- 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 (1 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **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 (2 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- Selection rules for identifiers include:
  - 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 (1 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **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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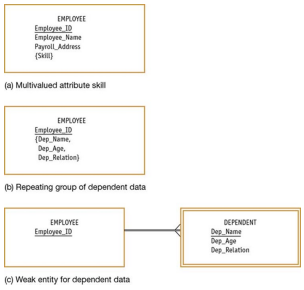
Figure 8-8: Multivalued Attributes and Repeating Groups



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Other Attribute Types (2 of 2)

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **Required attribute** – attribute that must have a value for every entity instance
- **Optional attribute** – attribute that may not have a value for every entity instance
- **Composite attribute** – attribute that has meaningful component parts
- **Derived attribute** – attribute whose value can be computed from related attribute values

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Relationships

8.3 Describe how to represent an entity-relationship model and be able to define the terms: **entity type, attribute, identifier, multivalued attribute, and relationship**

- **Relationship** – association between the instances of one or more entity types that is of interest to the organization
  - An association usually means an event has occurred
  - Relationships are labeled with verb phrases

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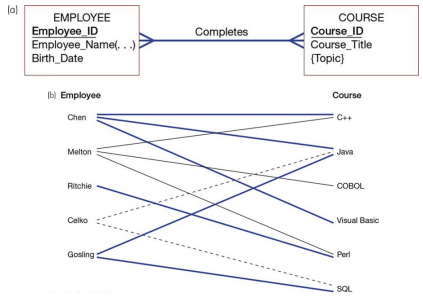
Figure 8-10: Relationship Type and Instances (a) Relationship Type (Completes) (b) Relationship Instances



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Degree of a Relationship

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

- **Degree** – number of entity types that participate in a relationship
- **Unary relationship** – relationship between one entity type; also called a recursive relationship
- **Binary relationship** – relationship between instances of two entity types. This is the most common type of relationship encountered in data modeling. (Also called a recursive relationship.)
- **Ternary relationship** – simultaneous relationship among instances of three entity types

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Figure 8-11: Example of Relationships of Different Degrees: (a) Unary

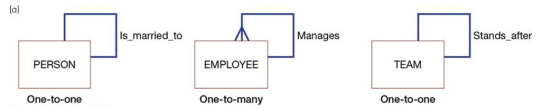

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Figure 8-11: Example of Relationships of Different Degrees: (b) Binary

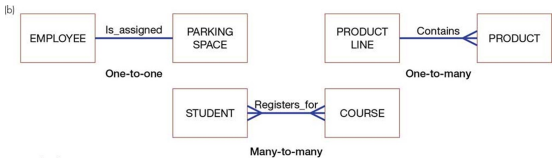

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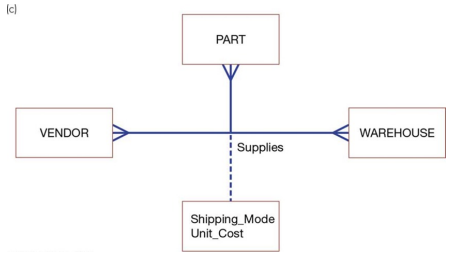
Figure 8-11: Example of Relationships of Different Degrees: (c) Ternary



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Cardinalities in Relationships

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

- **Cardinality** – number of instances of entity B that can (or must) be associated with each instance of entity A
  - **Minimum Cardinality** – minimum number of instances of entity B that may be associated with each instance of entity A
  - **Maximum Cardinality** – maximum number of instances of entity B that may be associated with each instance of entity A

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Figure 8-14: Examples of Cardinality Constraints: (a) Mandatory Cardinalities

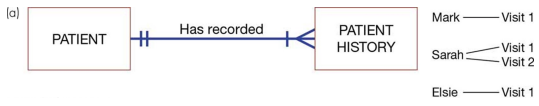

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Figure 8-14: Examples of Cardinality Constraints: (b) One Optional, One Mandatory Cardinality

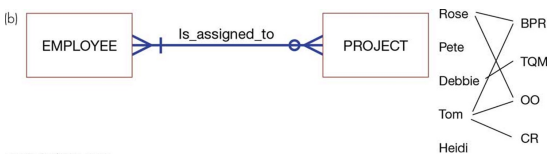

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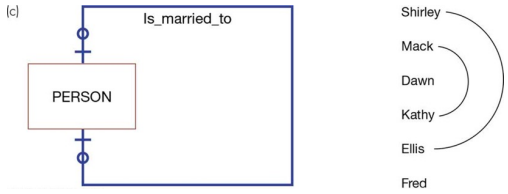
Figure 8-14: Examples of Cardinality Constraints: (c) Optional Cardinalities



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Naming and Defining Relationships

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

- A relationship name is a verb phrase in the present tense
- Relationship guidelines:
  - Explain importance and why it is important
  - Give examples to clarify action
  - Explain any optional participation
  - Explain reason for any explicit maximum cardinality other than many
  - Explain any reasons for participation restrictions
  - Explain the extend 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

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

- **Associative entity** – 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; also called a **gerund**

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Figure 8-15: An Associative Entity (a) Attribute on a Relationship

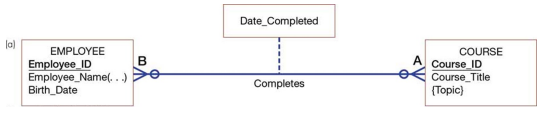

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Figure 8-15: An Associative Entity (b) An Associative Entity(Certificate)

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Figure 8-15: An Associative Entity (c) An Associative Entity Using Microsoft Visio

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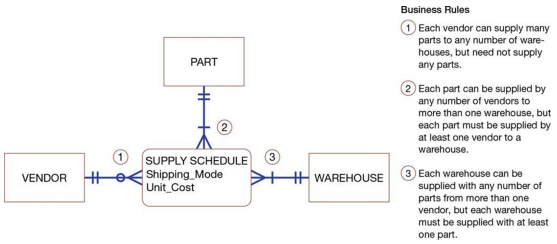
Figure 8-16: Cardinality Constraints in a Ternary Relationship



Business Rules

1. Each vendor can supply many parts to any number of warehouses, but need not supply any parts.
2. Each part can be supplied by any number of vendors to more than one warehouse, but each part must be supplied by at least one vendor to a warehouse.
3. Each warehouse can be supplied with any number of parts from more than one vendor, but each warehouse must be supplied with at least one part.

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Summary of Conceptual Data Modeling with E_R Diagrams

8.4 Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

- 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 (1 of 2)

8.5 Define supertypes and subtypes, showing how to represent these entity-relationship diagramming notation

- **Subtype** – subgrouping of the entities in an entity type that is meaningful to the organization and that shares common attributes or relationships distinct from other subgroupings
- **Supertype** – generic entity type that has a relationship with one or more subtypes

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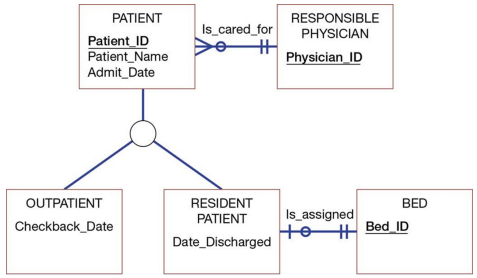
Figure 8-18: Supertype/Subtype Relationships in a Hospital



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Representing Supertypes and Subtypes (2 of 2)

8.5 Define supertypes and subtypes, showing how to represent these entity-relationship diagramming notation

- Business rules for supertype/subtype relationships:
  - **Total specialization rule** specifies that each entity instance of the supertype must be a member of some subtype in the relationship.
  - **Partial specialization rule** specifies that an entity instance of the supertype does not have to belong to any subtype
  - **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

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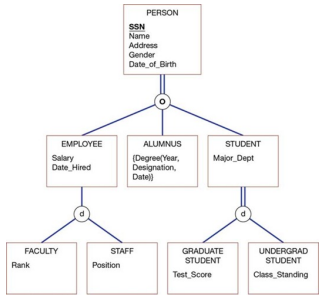
Figure 8-19: Example of Supertype/Subtype Hierarchy



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Business Rules

8.6 Define four basic types of business rules in a conceptual data model

- **Business rules** – specifications that preserve the integrity of the logical data model
- Four basic types of business rules:
  1. **Entity integrity**: unique, non-null identifiers
  2. **Referential integrity constraints**: rules governing relationships between entity types
  3. **Domains**: constraints on valid values for attributes
  4. **Triggering operations**: other business rules that protect the validity of attribute values

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Domains

8.6 Define four basic types of business rules in a conceptual data model

- **Domain** – set of all data types and values that an attribute can assume
- The use of domains offers 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

8.6 Define four basic types of business rules in a conceptual data model

- **Triggering operation (trigger)** – assertion or rule that governs the validity of data manipulation operations such as insert, update, and delete, also called a **trigger**
- A trigger includes the following components:
  1. **User rule:** concise statement of the business rule to be enforced by the triggering operation
  2. **Event:** data manipulation operation (insert, delete, or update) that initiates the operation
  3. **Entity name:** name of the entity being accessed and/or modified
  4. **Condition:** condition that causes the operation to be triggered
  5. **Action:** action taken when the operation is triggered

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Role of Package Conceptual Data Models – Database Patterns

8.7 Explain the role of prepackaged database models (patterns) in data modeling

- Packaged data models provide generic models that can be customized for a particular organization's business rules. Examples:
  - Universal data models are templates for core subject areas such as customers, products (etc.)
  - Industry-specific data models are generic and designed for specific industries (health care, telecommunications, etc.)

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Benefits of Using a Purchased Data Model

8.7 Explain the role of prepackaged database models (patterns) in data modeling

- Benefits include:
  - Validated
  - Cost reduction
  - Anticipate future requirements, not just initial requirements
  - Facilities system analysis
  - Consistent and complete

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Summary (1 of 2)

- In this chapter you learned 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, identifier, multivalued attribute, and relationship**
  - Distinguish among unary, binary, and ternary relationships as well as associative entities, providing an example of each

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Summary (2 of 2)

- In this chapter you learned to:
  - Define supertypes and subtypes, showing how to represent these entity-relationship 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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