Chapter 5: Structural Modeling

Objectives

- Understand the rules and style guidelines for creating CRC cards, class diagrams, and object diagrams.
- Understand the processes used to create CRC cards, class diagrams, and object diagrams.
- Be able to create CRC cards, class diagrams, and object diagrams.
- Understand the relationship among structural models.
- Understand the relationship between structural and functional models.

Introduction

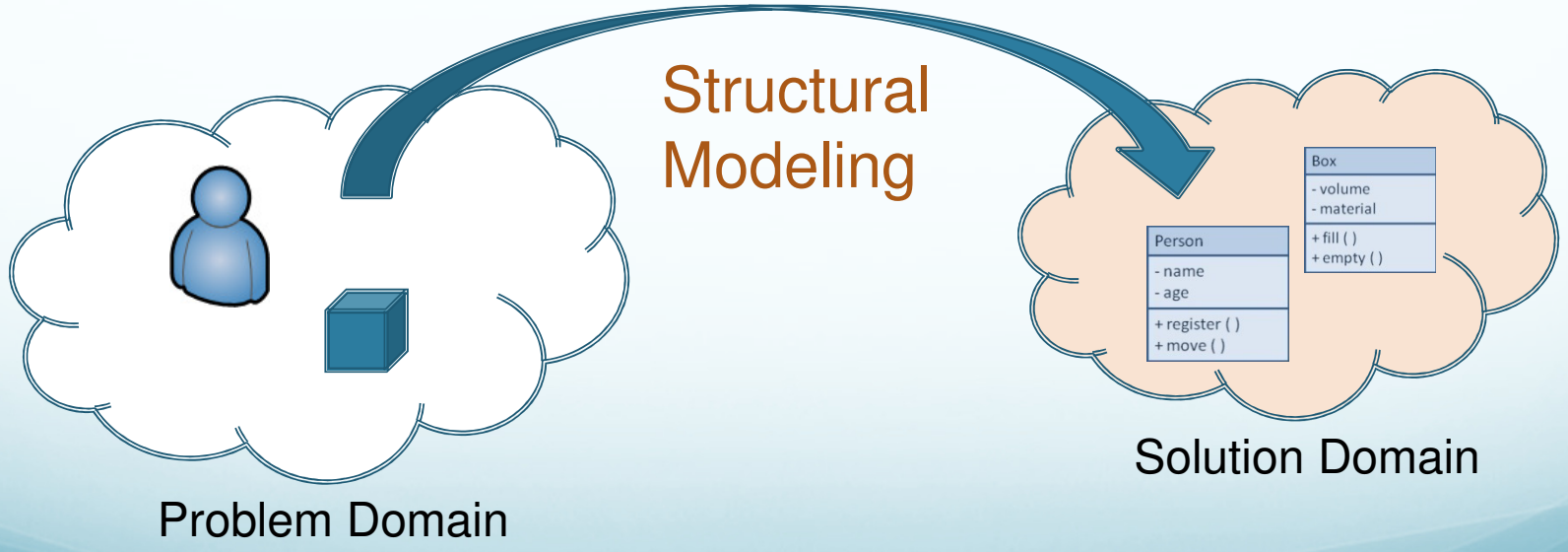
- Functional models represent system behavior
- Structural models represent system objects and their relationships:
  - People
  - Places
  - Things
- Create a conceptual model and evolve it into a design model using
  - CRC cards
  - Class diagrams
  - Object diagrams

Structural Models

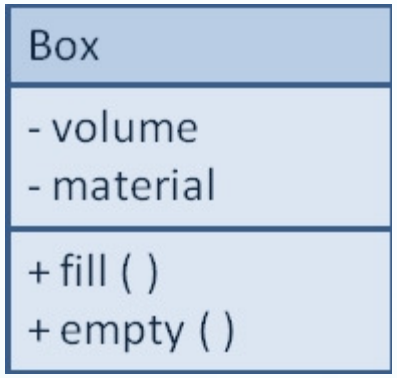
- Drawn using an iterative process
  - First drawn in a conceptual, business-centric way
  - Then refined in a technology-centric way describing the actual databases and files
  - More and more detail is added in each iteration
- Create a vocabulary for analysts & users
  - Allows effective communication between analysts & users

Structural Models

Main goal: to discover the key data contained in the problem domain and to build a structural model of the objects



Classes, Attributes, & Operations



- Classes
  - Templates for instances of people, places, or things
- Attributes
  - Properties that describe the state of an instance of a class (an object)
- Operations
  - Actions or functions that a class can perform

Relationships

- Describe how classes relate to one another
- Three basic types in UML
  - Generalization
    - Enables inheritance of attributes and operations
    - Represents relationships that are “a-kind-of”
  - Aggregation
    - Relates parts to wholes
    - Represents relationships that are “a-part-of”
  - Association
    - Miscellaneous relationships between classes
    - Usually a weaker form of aggregation

Object Identification

- Textual analysis of use-case information
  - Nouns suggest classes
  - Verbs suggest operations
  - Creates a rough first cut to provide an object list
- Brainstorming—people offering ideas
  - Initial list of classes (objects) is developed
  - Attributes, operations and relationships to other classes can be assigned in a second round

Object Identification (cont.)

- Common Object Lists
  - Physical things
  - Incidents
  - Roles
  - Interactions
- Patterns
  - Useful groupings of collaborating classes that provide solutions to common problems (are reusable)
  - Developed patterns provide a starting point for work in similar domains

CRC Cards

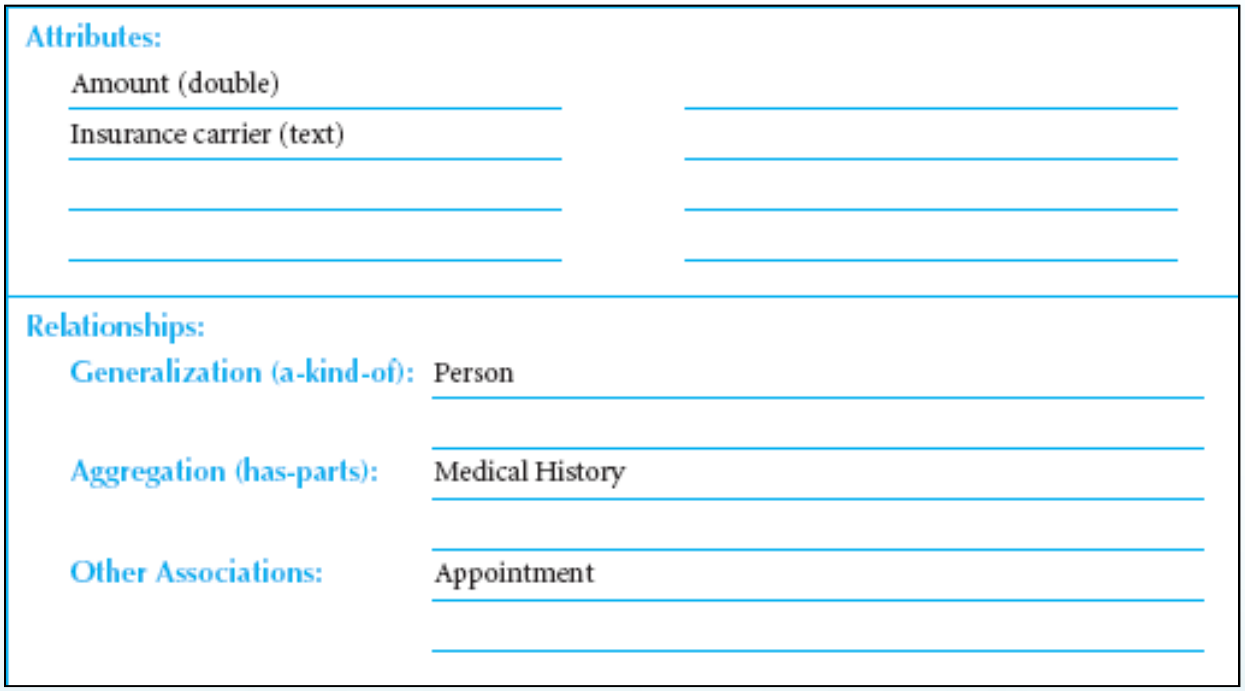
- Index cards used to document the responsibilities and collaborations of a class
- Responsibilities
  - Knowing—what a class must know manifested as attributes
  - Doing—what a class must do manifested later as operations
- Collaboration
  - Objects working together to service a request:
    - Requestor (client)
    - Responder (server)
  - Bound by a contract

Front-Side of a CRC Card

Class Name: Patient	ID: 3	Type: Concrete, Domain
Description: An individual that needs to receive or has received medical attention		Associated Use Cases: 2

Responsibilities	Collaborators
Make appointment	Appointment
Calculate last visit	
Change status	
Provide medical history	Medical history

Back-Side of a CRC Card



CRC Cards & Role-Playing

- An exercise to help discover additional objects, attributes, relationships & operations
- Team members perform roles associated with the actors and objects previously identified
- Utilize activity diagrams to run through the steps in a scenario
  - Identify an important use-case
  - Assign roles based on actors and objects
  - Team members perform each step in the scenario
  - Discover and fix problems until a successful conclusion is reached
  - Repeat for remaining use-cases

Class Diagrams

- A static model that shows classes and their relationships to one another
- Elements
  - Classes
    - Objects within the system (a person, place or thing)
    - Stores and manages information in the system and contains:
      - Attributes—characteristics of the class
      - Operations—activities the class can perform
  - Relationships—the associations between classes
    - Depicted as lines between classes
    - Multiplicity indicates how many of one object is/are associated with other objects

Attributes

- Properties of a class
  - Person: last name, first name, address, etc.
  - Attributes can be derived
    - Preceded with a slash (/)
    - e.g., age is derived from date of birth
- Visibility of an attribute:
  - Restricts access to attributes to ensure consistency
  - Public attributes (+): visible to all classes
  - Private attributes (-): visible only to an instance of the class in which they are defined
  - Protected attributes (#): visible only to an instance of the class in which they are defined and its descendants

Operations

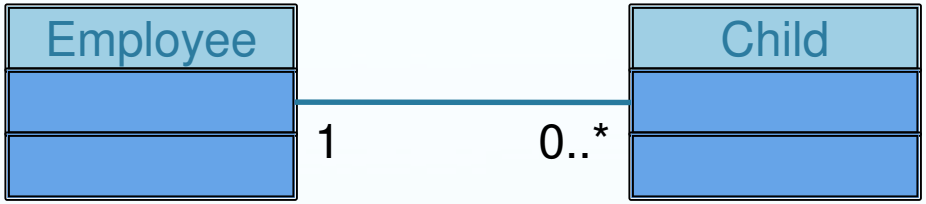
- Common operations are not shown
  - Create or delete an instance
  - Return or set a value
- Types of operations:
  - Constructor—creates an object
  - Query—makes information about the state of an object available
  - Update—changes values of some or all of an object's attributes
  - Destructor—deletes or removes an object

Relationships

- Denotes associations between classes
  - Depicted with a line labeled with the name of the relationship
  - May be directional (depicted with a triangle; e.g., a patient schedules an appointment)
- Classes may be related to themselves (e.g., employees and managers who may be members of the same class)
- Multiplicity indicates how many of one class are related to another class

Multiplicities

Exactly one:
A department has one and only one boss



Zero or more:
An employee has zero to many children

One or more:
A boss is responsible for one or more employees

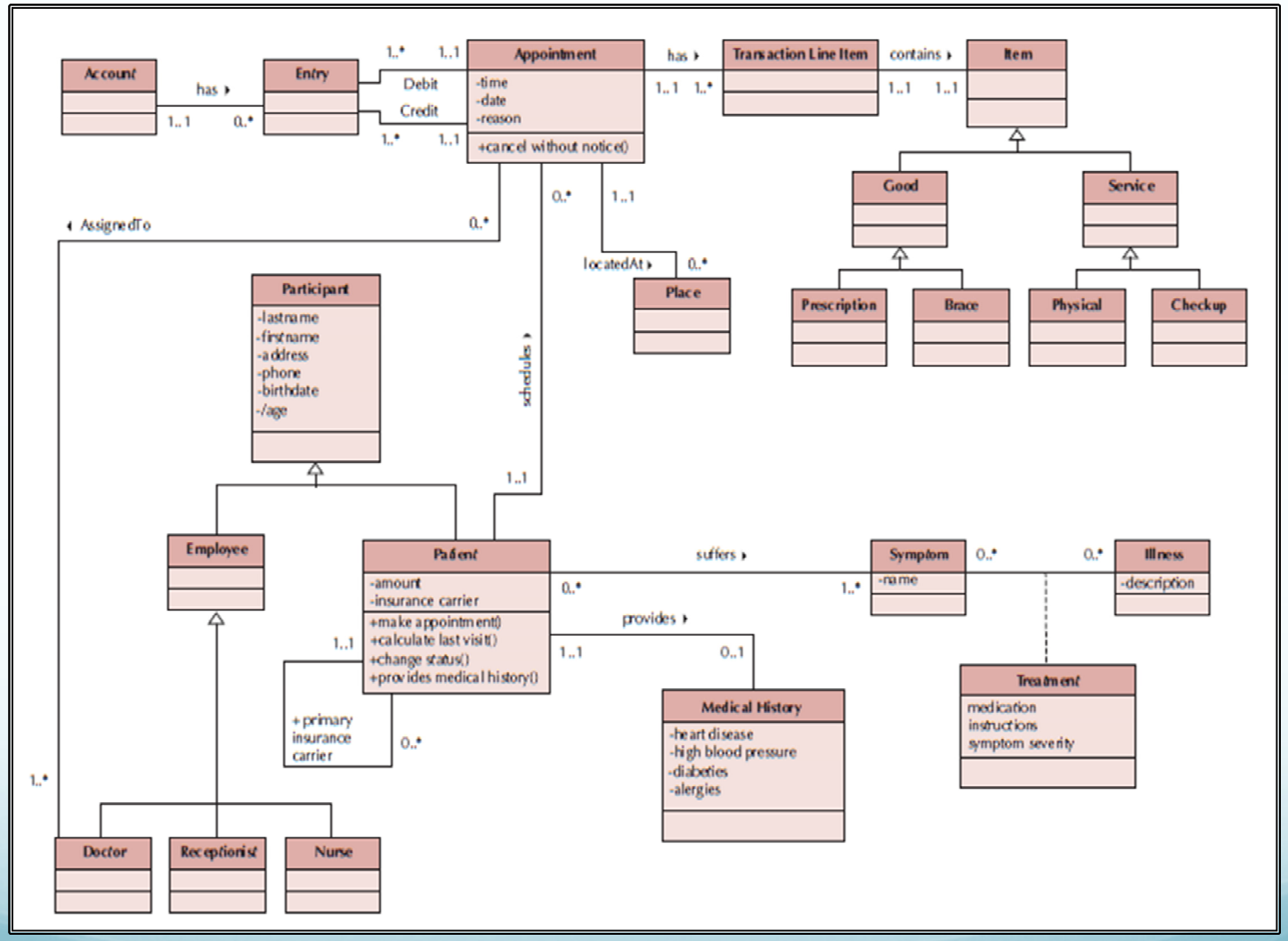
Association Classes

- Common in many-to-many relationships
- Used when attributes about the relationship between two classes needs to be recorded
  - Students are related to courses; a Grade class provides an attribute to describe this relationship
  - Illnesses are related to symptoms; a Treatment class provides an attribute to describe this relationship

Generalization & Aggregation Associations

- Generalization denotes inheritance
  - Properties and operations of the superclass are valid for the sub-class
  - Depicted as a solid line with a hollow arrow pointing at the superclass
- Aggregation denotes a logical “a-part-of” relationship
- Composition denotes a physical “a-part-of” relationship

Sample Class Diagram



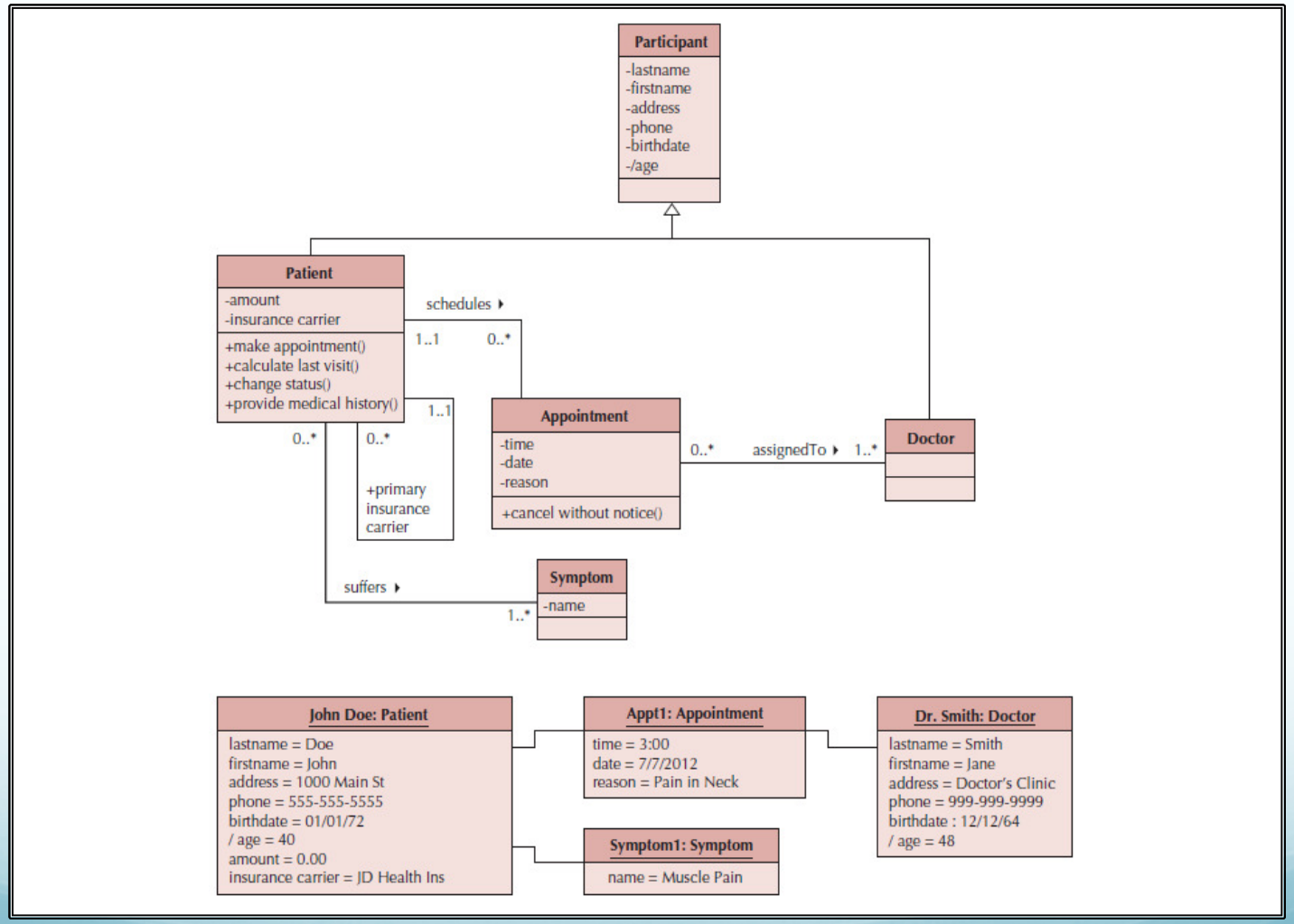
Simplifying Class Diagrams

- Fully populated class diagrams of real-world system can be difficult to understand
- Common ways of simplifying class diagrams:
  - Show only concrete classes
  - The view mechanism shows a subset of classes
  - Packages show aggregations of classes (or any elements in UML)

Object Diagrams

- Class diagrams with instantiated classes
  - Example: instead of a Doctor class, create an actual doctor, say Dr. Smith
  - Place values into each attribute
- Used to discover additional attributes, relationships and/or operations or those that are misplaced

Example Object Diagram



7 Steps to Structural Models

1. Create CRC Cards
2. Review CRC Cards & identify missing objects, attributes, operations and/or relationships
3. Role-play the CRC cards—look for breakdowns & correct; create new cards as necessary
4. Create the class diagram
5. Review the class diagram—remove unnecessary classes, attributes, operations and/or relationships
6. Incorporate patterns
7. Review and validate the model

Verifying & Validating the Model

- Analyst presents to developers & users
  - Walks through the model
  - Provides explanations & reasoning behind each class
- Rules
  1. Each CRC card is associated with a class
  2. Responsibilities on the front of the card are included as operations on the class diagram
  3. Collaborators on the front of the card imply a relationship on the back of the card
  4. Attributes on the back of the card are listed as attributes on the class diagram

Rules for Validating & Verifying the Model (cont.)

5. Attributes on the back of the CRC card each have a data type (e.g., salary implies a number format)
6. Relationships on the back of the card must be properly depicted on the class diagram
   a) Aggregation/Association
   b) Multiplicity
7. Association classes are used only to include attributes that describe a relationship

Summary

- Structural Models
- CRC Cards
- Class Diagrams
- Creating CRC Cards and Class Diagrams