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

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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
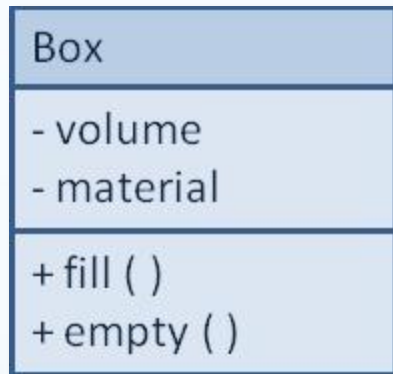 - Allows effective communication between analysts & users

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

Box

- volume
- material

+ fill ( )
+ empty ( )
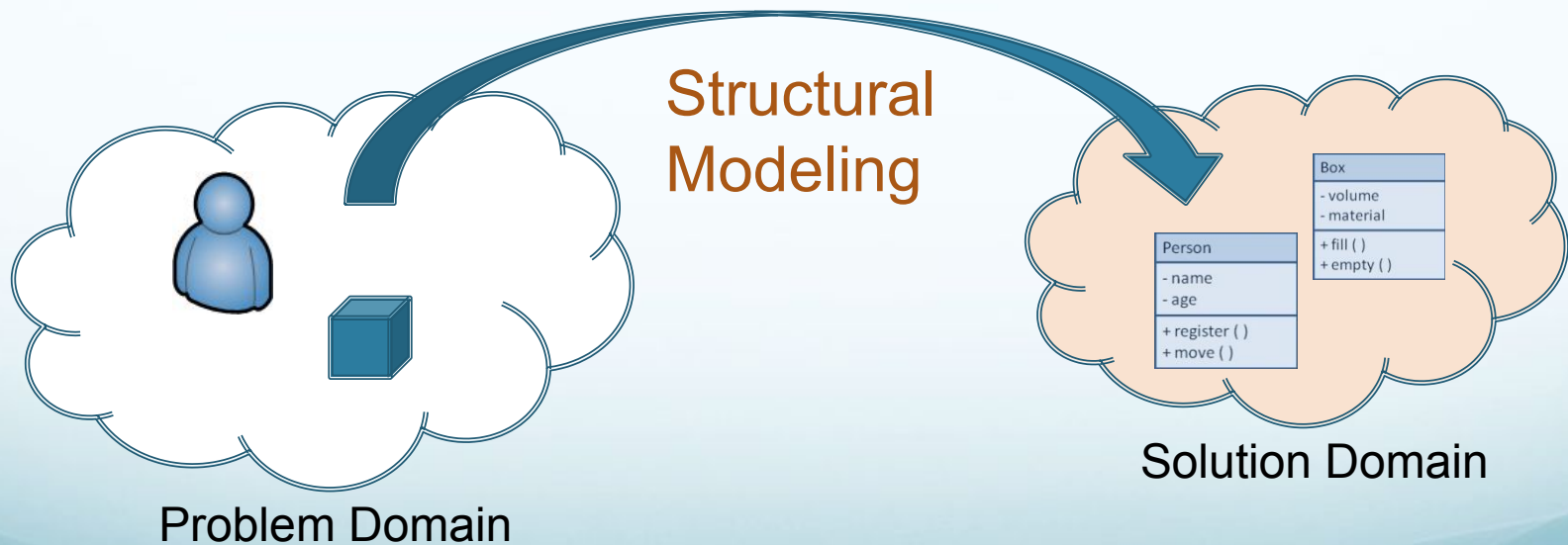
- Classes
  - Templates for instances of people, places, or things

- Attributes
  - Properties that describe the state of an instance of a class (an object)

- Operations
  - Actions or functions that a class can perform

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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

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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
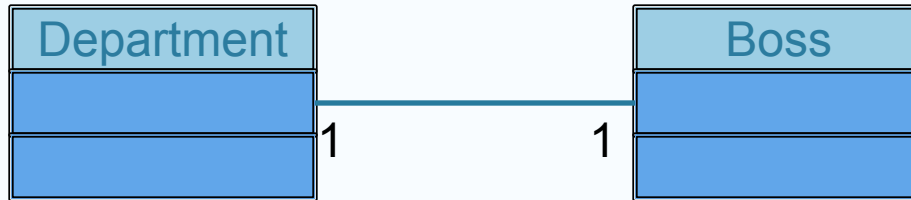
Department			Boss	
	1	1		

Exactly one:
A department has one and only one boss
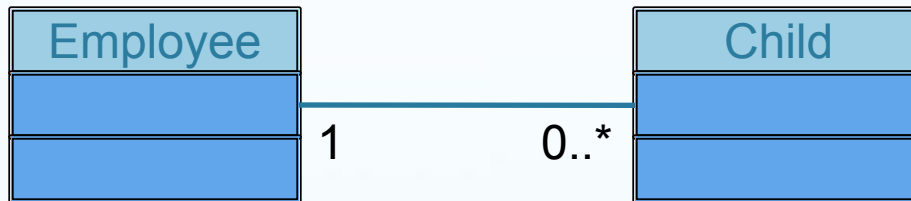
Employee			Child	
	1	0..*		

Zero or more:
An employee has zero to many children

Boss			Employee	
	1	1..*		

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

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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
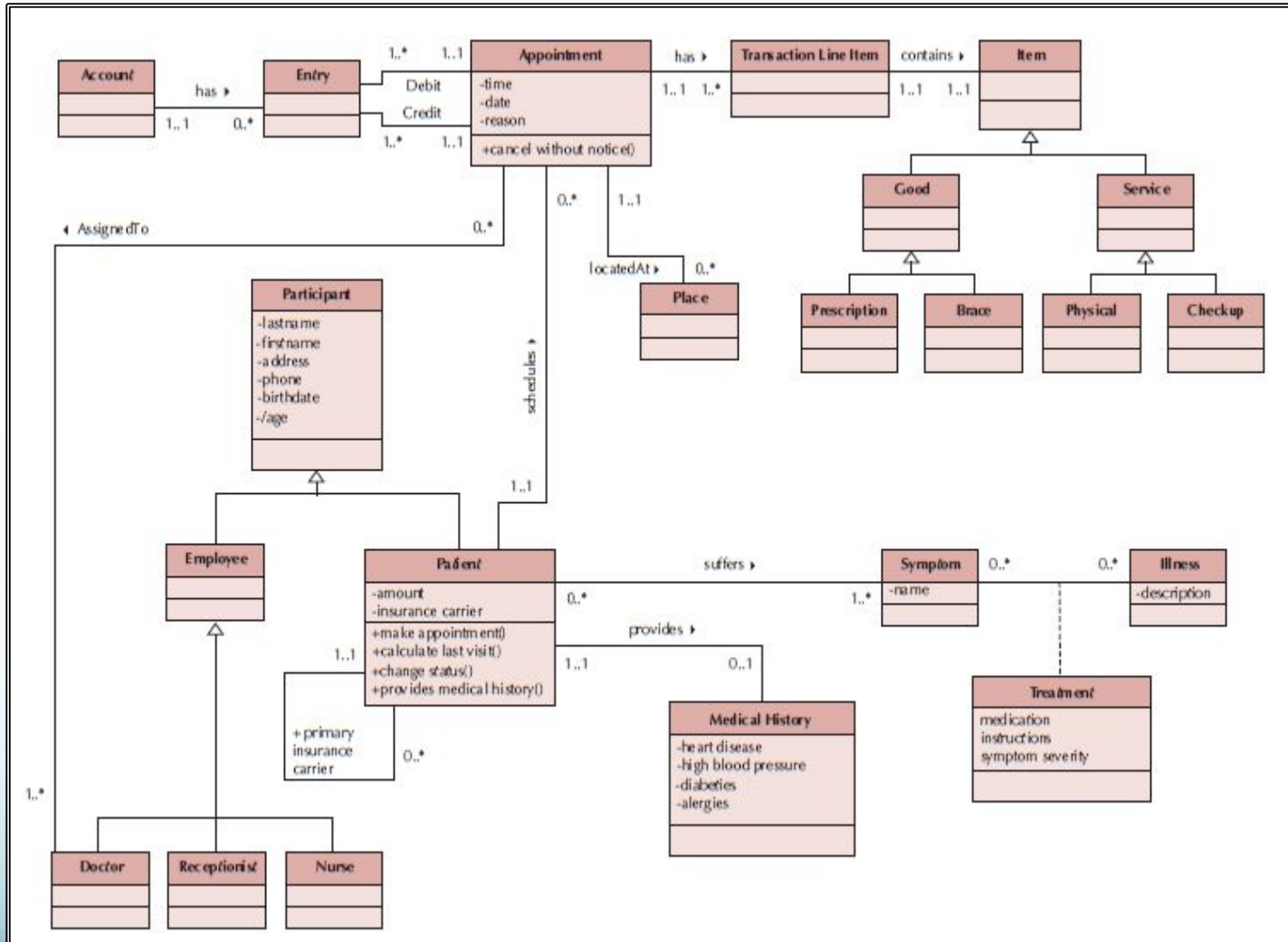
Simplifying Class Diagrams

- 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
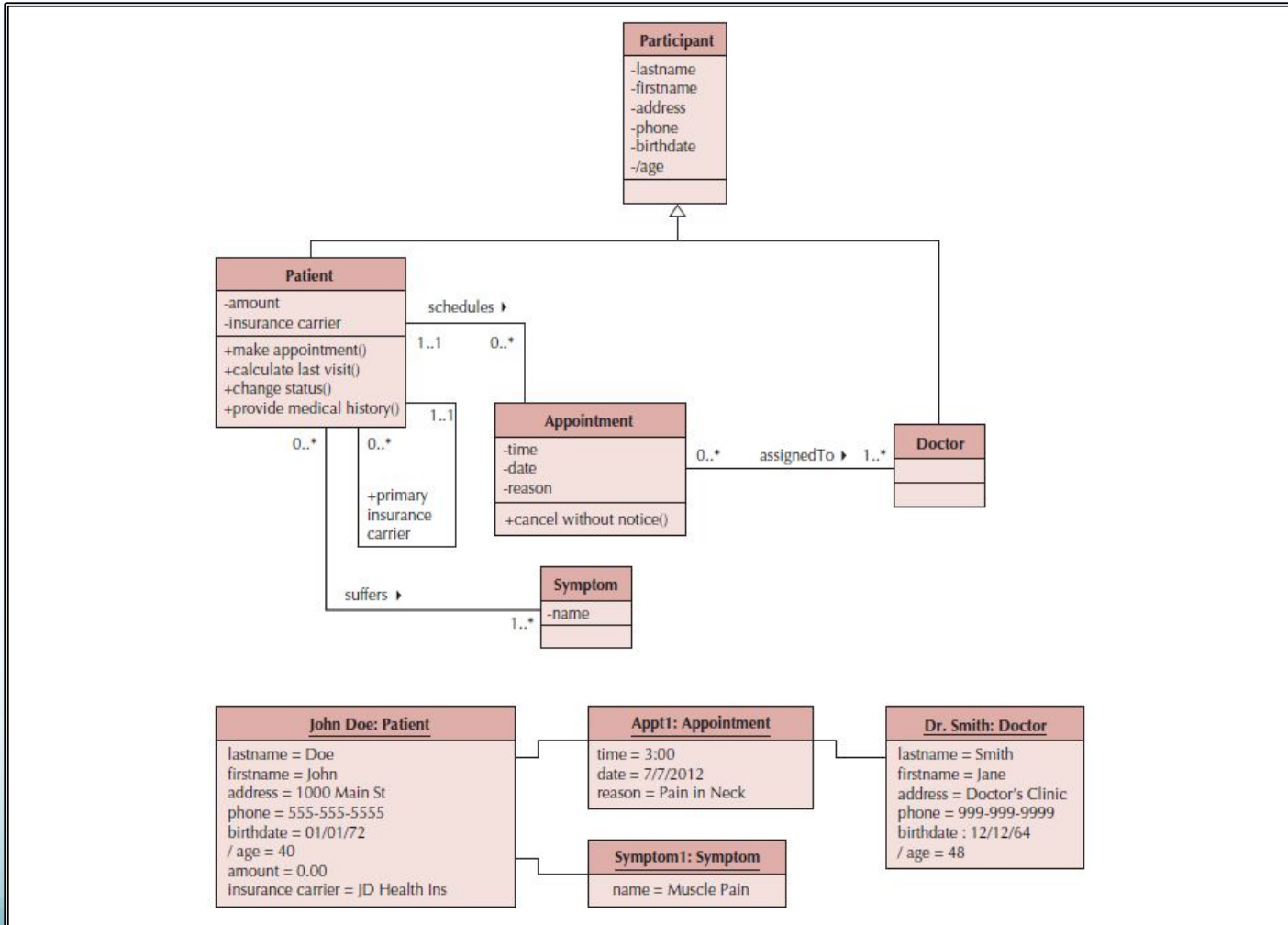
7 Steps to Structural Models

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