Chapter 8

Analysis Modeling

- Requirements analysis
- Flow-oriented modeling
- Scenario-based modeling
- Class-based modeling
- Behavioral modeling

(Source: Pressman, R. *Software Engineering: A Practitioner's Approach*. McGraw-Hill, 2005)

Goals of Analysis Modeling

- Provides the first technical representation of a system
- Is easy to understand and maintain
- Deals with the problem of size by partitioning the system
- Uses graphics whenever possible
- Differentiates between essential information versus implementation information
- Helps in the tracking and evaluation of interfaces
- Provides tools other than narrative text to describe software logic and policy

A Set of Models

- **Flow-oriented modeling** – provides an indication of how data objects are transformed by a set of processing functions
- **Scenario-based modeling** – represents the system from the user's point of view
- **Class-based modeling** – defines objects, attributes, and relationships
- **Behavioral modeling** – depicts the states of the classes and the impact of events on these states

Requirements Analysis

Purpose

- Specifies the software's operational characteristics
- Indicates the software's interfaces with other system elements
- Establishes constraints that the software must meet
- Provides the software designer with a representation of information, function, and behavior
  - This is later translated into architectural, interface, class/data and component-level designs
- Provides the developer and customer with the means to assess quality once the software is built

Overall Objectives

- Three primary objectives
  - To describe what the customer requires
  - To establish a basis for the creation of a software design
  - To define a set of requirements that can be validated once the software is built
- All elements of an analysis model are directly traceable to parts of the design model, and some parts overlap

Analysis Rules of Thumb

- The analysis model should focus on requirements that are visible within the problem or business domain
  - The level of abstraction should be relatively high
- Each element of the analysis model should add to an overall understanding of software requirements and provide insight into the following
  - Information domain, function, and behavior of the system
- The model should delay the consideration of infrastructure and other non-functional models until the design phase
  - First complete the analysis of the problem domain
- The model should minimize coupling throughout the system
  - Reduce the level of interconnectedness among functions and classes
- The model should provide value to all stakeholders
- The model should be kept as simple as can be

Domain Analysis

- Definition
  - The identification, analysis, and specification of common, reusable capabilities within a specific application domain
  - Do this in terms of common objects, classes, and frameworks
- Sources of domain knowledge
  - Technical literature
  - Existing applications
  - Customer surveys and expert advice
  - Current/future requirements
- Outcome of domain analysis
  - Class taxonomies
  - Reuse standards
  - Functional and behavioral models
  - Domain languages

Analysis Modeling Approaches

- Structured analysis
  - Considers data and the processes that transform the data as separate entities
  - Data is modeled in terms of only attributes and relationships (but no operations)
  - Processes are modeled to show the 1) input data, 2) the transformation that occurs on that data, and 3) the resulting output data
- Object-oriented analysis
  - Focuses on the definition of classes and the manner in which they collaborate with one another to fulfill customer requirements

Elements of the Analysis Model

Object-oriented Analysis

Scenario-based modeling

Use case text
Use case diagrams
Activity diagrams
Swim lane diagrams

Class-based modeling

Class diagrams
Analysis packages
CRC models
Collaboration diagrams

Structured Analysis

Flow-oriented modeling

Data structure diagrams
Data flow diagrams
Control-flow diagrams
Processing narratives

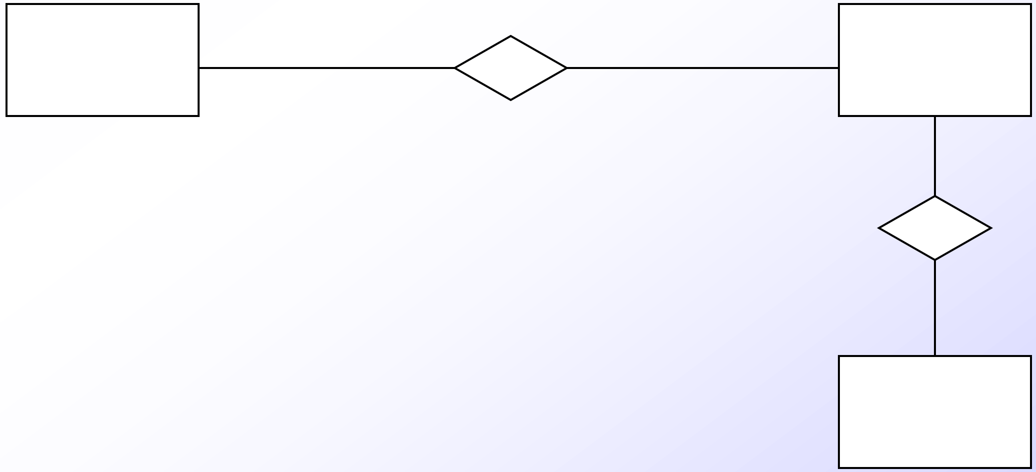
Behavioral modeling

State diagrams
Sequence diagrams

Flow-oriented Modeling

Data Modeling

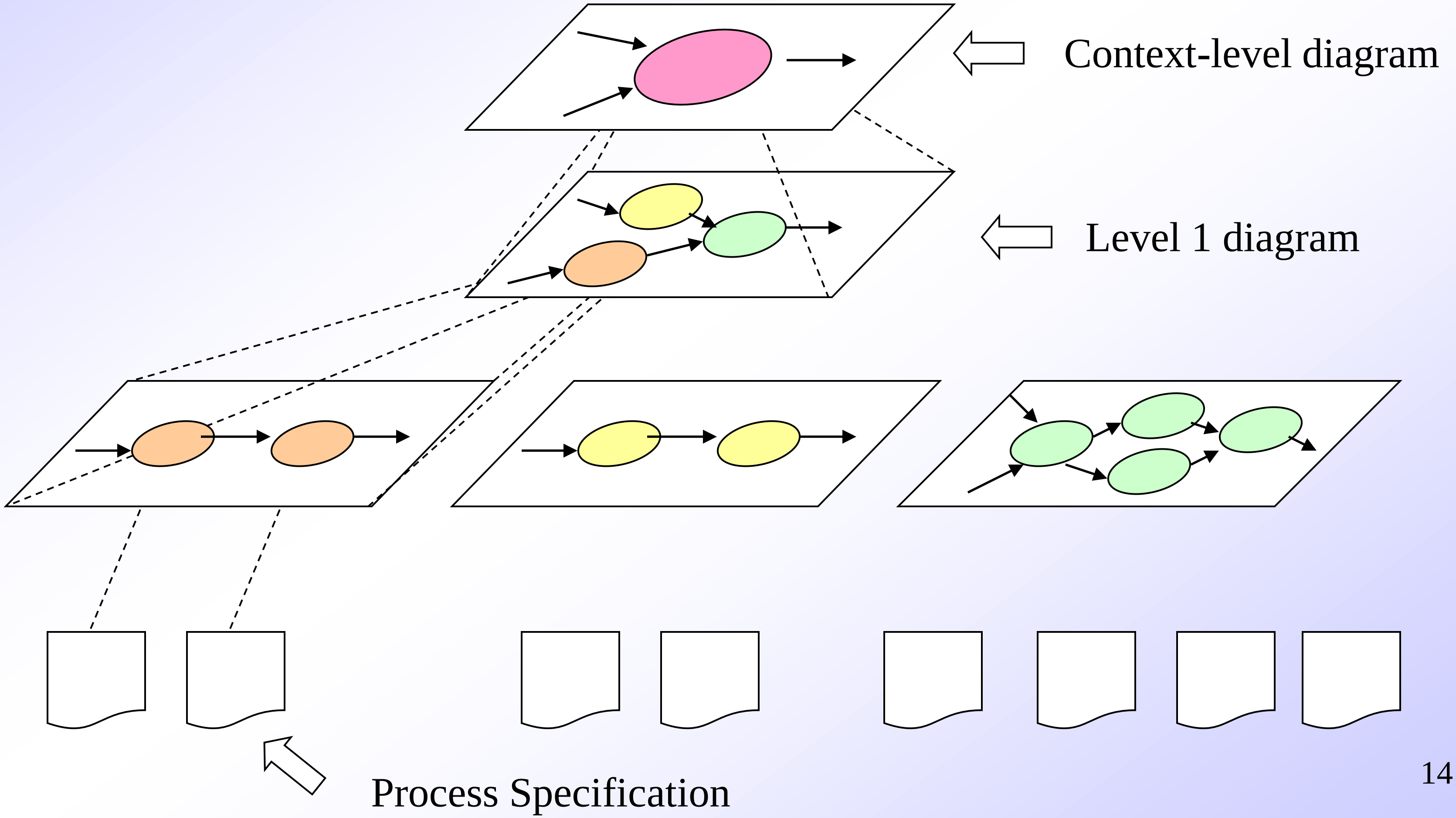
- Identify the following items
  - Data objects (Entities)
  - Data attributes
  - Relationships
  - Cardinality (number of occurrences)



Data Flow and Control Flow

- Data Flow Diagram
  - Depicts how input is transformed into output as data objects move through a system
- Process Specification
  - Describes data flow processing at the lowest level of refinement in the data flow diagrams
- Control Flow Diagram
  - Illustrates how events affect the behavior of a system through the use of state diagrams

Diagram Layering and Process Refinement



Scenario-based Modeling

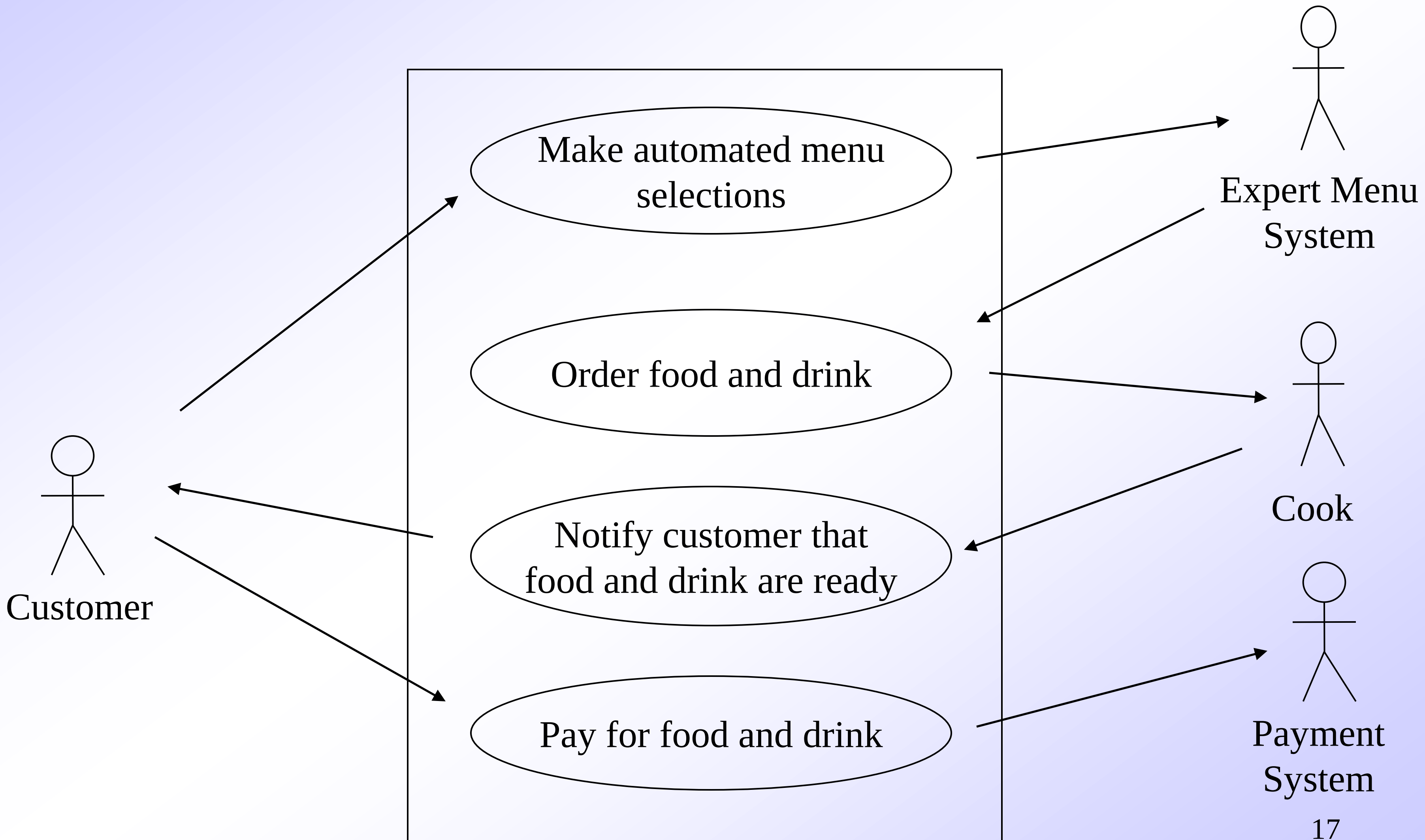
Writing Use Cases

- Writing of use cases was previously described in Chapter 7 – Requirements Engineering
- It is effective to use the first person "I" to describe how the actor interacts with the software
- Format of the text part of a use case

Use-case title: Actor: Description: I …

(See examples in Pressman textbook on pp. 188-189)

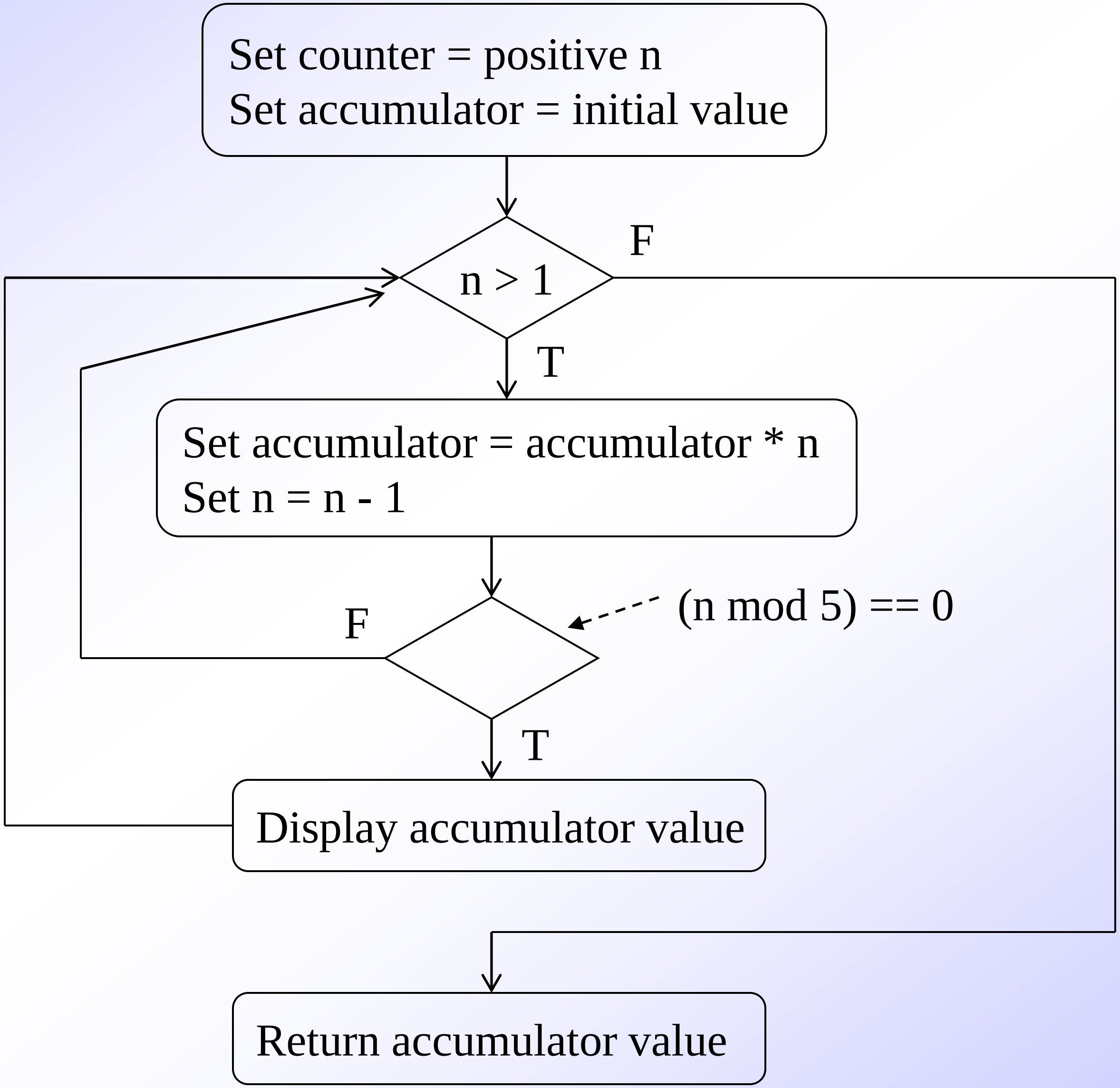
Example Use Case Diagram



Activity Diagrams

- Creation of activity diagrams was previously described in Chapter 7 – Requirements Engineering
- Supplements the use case by providing a graphical representation of the flow of interaction within a specific scenario
- Uses flowchart-like symbols
  - **Rounded rectangle -** represent a specific system function/action
  - **Arrow -** represents the flow of control from one function/action to another
  - **Diamond -** represents a branching decision
  - **Solid bar** – represents the fork and join of parallel activities

Example Activity Diagram



Class-based Modeling

Identifying Analysis Classes

1) Perform a grammatical parse of the problem statement or use cases
2) Classes are determined by underlining each noun or noun clause
3) A class required to implement a solution is part of the solution space
4) A class necessary only to describe a solution is part of the problem space
5) A class should NOT have an imperative procedural name (i.e., a verb)
6) List the potential class names in a table and "classify" each class according to some taxonomy and class selection characteristics
7) A potential class should satisfy nearly all (or all) of the selection characteristics to be considered a legitimate problem domain class

Potential classes	General classification	Selection Characteristics

(More on next slide)

Identifying Analysis Classes (continued)

- General classifications for a potential class
  - External entity (e.g., another system, a device, a person)
  - Thing (e.g., report, screen display)
  - Occurrence or event (e.g., movement, completion)
  - Role (e.g., manager, engineer, salesperson)
  - Organizational unit (e.g., division, group, team)
  - Place (e.g., manufacturing floor, loading dock)
  - Structure (e.g., sensor, vehicle, computer)

(More on next slide)

Identifying Analysis Classes (continued)

- Six class selection characteristics
  1) Retained information
     - Information must be remembered about the system over time
  2) Needed services
     - Set of operations that can change the attributes of a class
  3) Multiple attributes
     - Whereas, a <u>single</u> attribute may denote an atomic variable rather than a class
  4) Common attributes
     - A set of attributes apply to all instances of a class
  5) Common operations
     - A set of operations apply to all instances of a class
  6) Essential requirements
     - Entities that produce or consume information

Defining Attributes of a Class

- Attributes of a class are those nouns from the grammatical parse that reasonably belong to a class
- Attributes hold the values that describe the current properties or state of a class
- An attribute may also appear initially as a potential class that is later rejected because of the class selection criteria
- In identifying attributes, the following question should be answered
  - What data items (composite and/or elementary) will fully define a specific class in the context of the problem at hand?
- Usually an item is not an attribute if <u>more than one</u> of them is to be associated with a class

Defining Operations of a Class

- Operations define the behavior of an object
- Four categories of operations
  - Operations that manipulate data in some way to change the state of an object (e.g., add, delete, modify)
  - Operations that perform a computation
  - Operations that inquire about the state of an object
  - Operations that monitor an object for the occurrence of a controlling event
- An operation has knowledge about the state of a class and the nature of its associations
- The action performed by an operation is based on the current values of the attributes of a class
- Using a grammatical parse again, circle the verbs; then select the verbs that relate to the problem domain classes that were previously identified

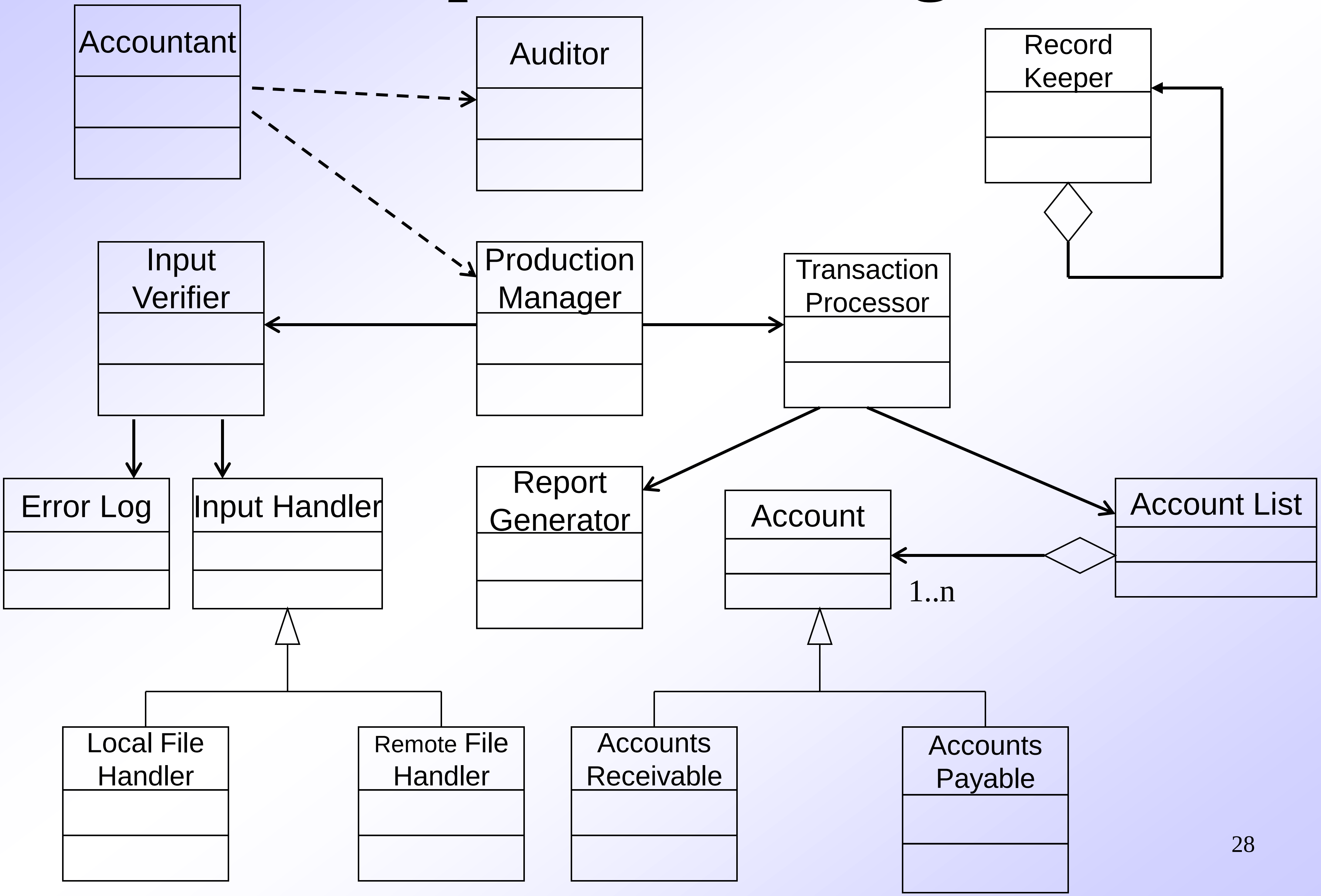
Example Class Box

Class Name	Component
Attributes	+ componentID - telephoneNumber - componentStatus - delayTime - masterPassword - numberOfTries
Operations	+ program() + display() + reset() + query() - modify() + call()

Association, Generalization and Dependency (Ref: Fowler)

- Association
  - Represented by a solid line between two classes directed from the source class to the target class
  - Used for representing (i.e., pointing to) object types for attributes
  - May also be a <u>part-of</u> relationship (i.e., <u>aggregation)</u>, which is represented by a diamond-arrow
- Generalization
  - Portrays inheritance between a super class and a subclass
  - Is represented by a line with a triangle at the target end
- Dependency
  - A dependency exists between two elements if changes to the definition of one element (i.e., the source or supplier) may cause changes to the other element (i.e., the client)
  - Examples
    - One class calls a method of another class
    - One class utilizes another class as a parameter of a method

Example Class Diagram



Behavioral Modeling

Creating a Behavioral Model

1) Identify events found within the use cases and implied by the attributes in the class diagrams
2) Build a state diagram for each class, and if useful, for the whole software system

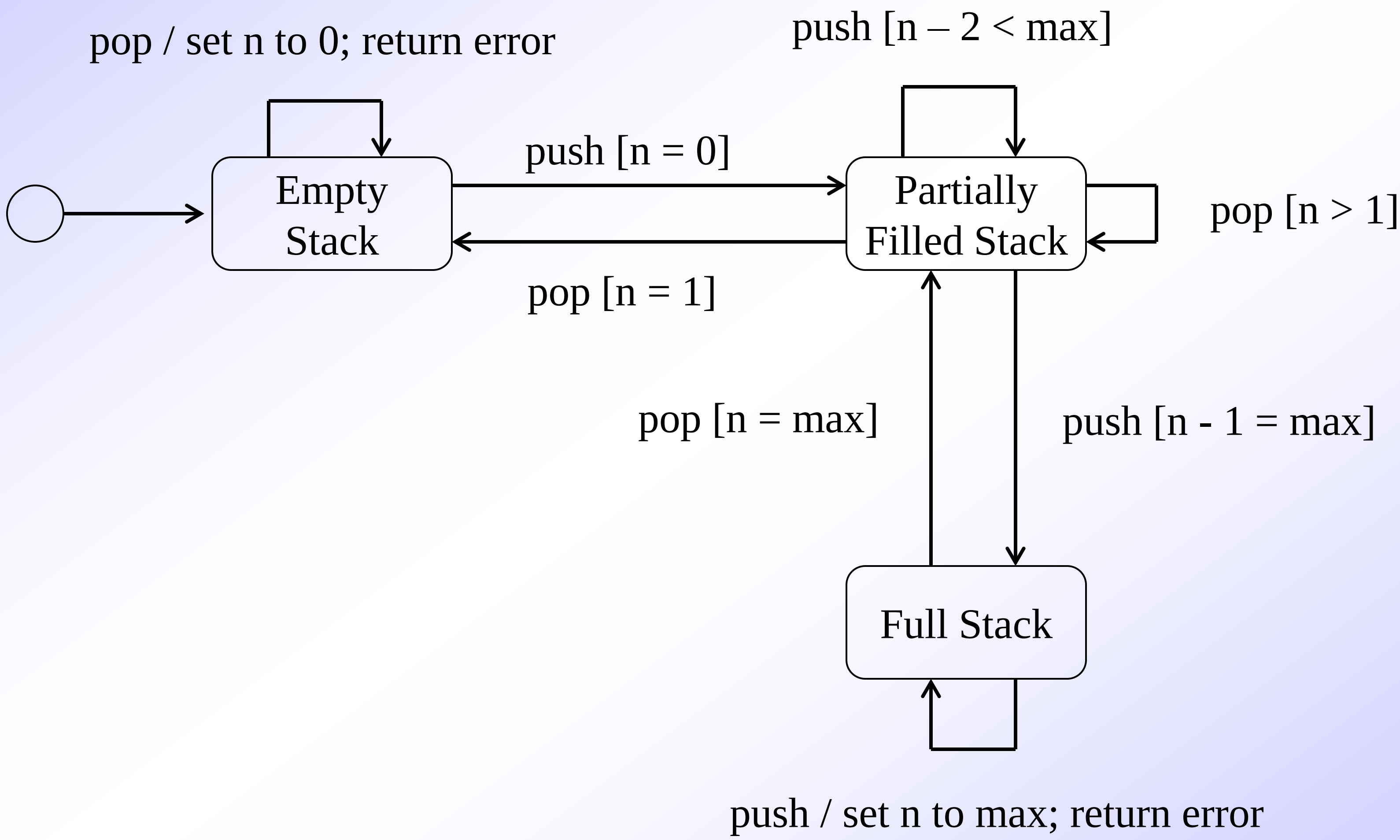
Identifying Events in Use Cases

- An event occurs whenever an actor and the system exchange information
- An event is NOT the information that is exchanged, but rather the fact that information has been exchanged
- Some events have an explicit impact on the flow of control, while others do not
  - An example is the reading of a data item from the user versus comparing the data item to some possible value

Building a State Diagram

- A state is represented by a rounded rectangle
- A transition (i.e., event) is represented by a labeled arrow leading from one state to another
  - `Syntax: trigger-signature [guard]/activity`
- The <u>active state</u> of an object indicates the current overall status of the object as is goes through transformation or processing
  - A state name represents one of the possible active states of an object
- The <u>passive state</u> of an object is the current value of all of an object's attributes
  - A guard in a transition may contain the checking of the passive state of an object

Example State Diagram



Summary: Elements of the Analysis Model

Object-oriented Analysis

Scenario-based modeling

- *Use case text*
- *Use case diagrams*
- Activity diagrams
- Swim lane diagrams

Class-based modeling

- *Class diagrams*
- Analysis packages
- CRC models
- Collaboration diagrams

Structured Analysis

Flow-oriented modeling

- Data flow diagrams
- Control-flow diagrams
- Processing narratives

Behavioral modeling

- *State diagrams*
- Sequence diagrams