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COMP6115

Object Oriented Analysis and Design

Session #6

Behavioral Modeling

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Learning Outcomes

LO1: Identify the basic concept of advance topic in Object Oriented Analysis and Design

LO2 : Use the knowledge to develop documentation for object oriented software analysis and design using Unified Modelling Language

LO3 : Analyze any problem in any software application and find out the alternative solutions using object oriented analysis and design approach

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Chapter 6:

Behavioral Modeling

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Learning Objectives

- Understand the rules and style guidelines for sequence and communication diagrams and behavioral state machines.
- Understand the processes used to create sequence and communication diagrams, behavioral state machines and CRUDE matrices.
- Be able to create sequence and communication diagrams, behavioral state machines and CRUDE matrices.
- Understand the relationship between the behavioral models and the structural and functional models.

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UML DIAGRAM TYPES

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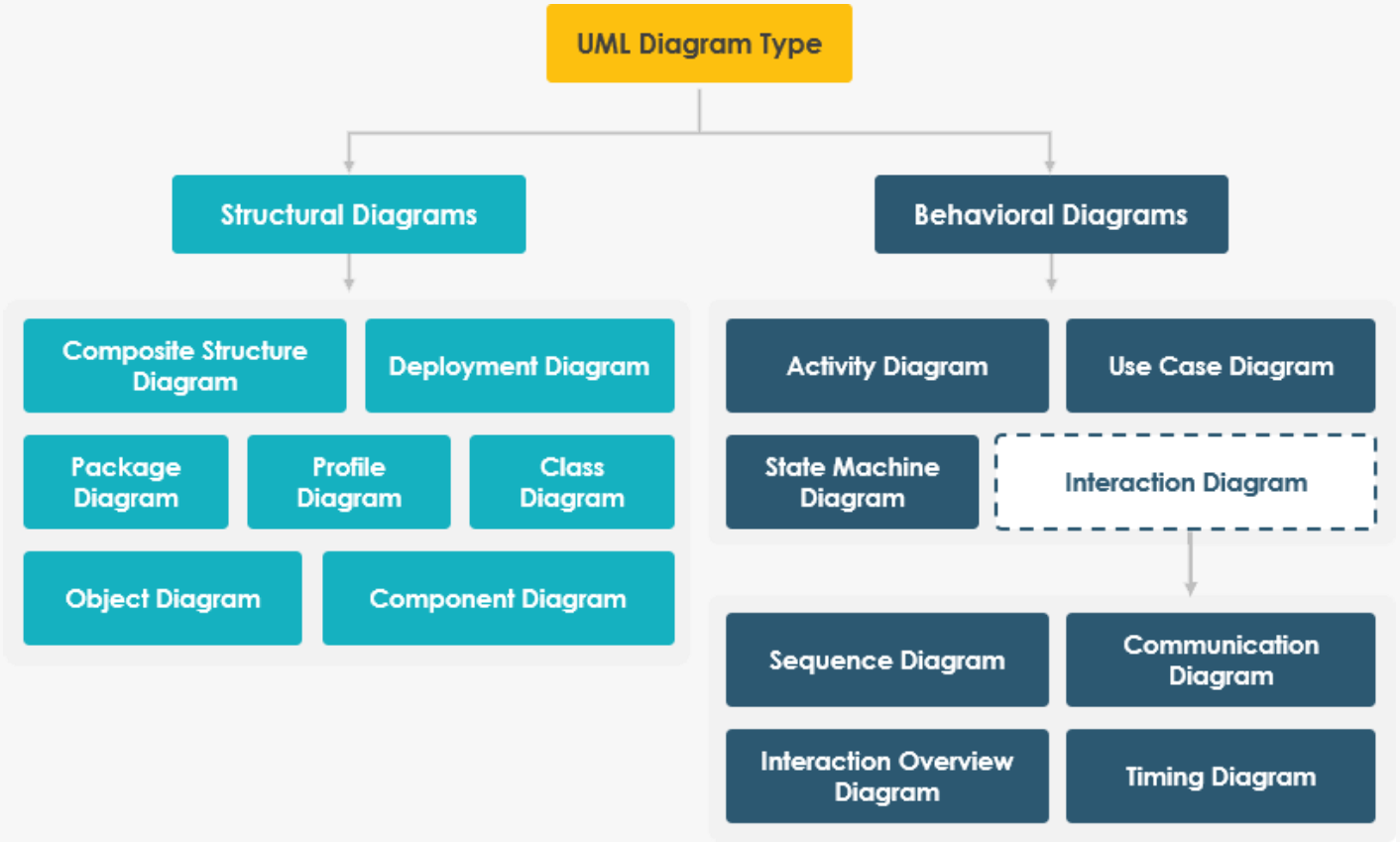
UML Diagram Types

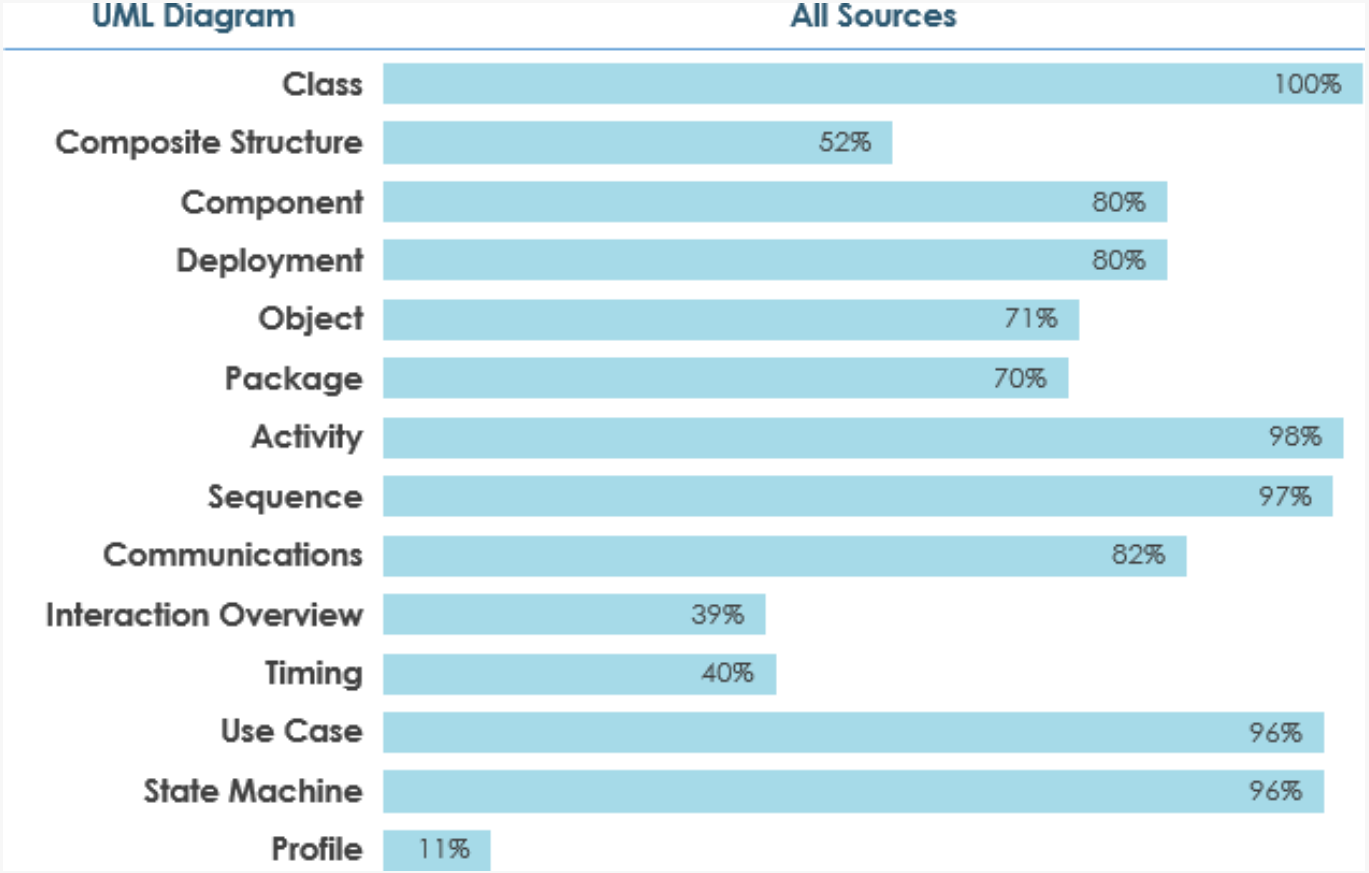


- **Structural diagrams** show the things in the modeled system. In a more technical term, they show different objects in a system.
- **Behavioral diagrams** describe the internal behavior of a system. They describe how the objects interact with each other to create a functioning system.

UML Diagram Types

We could interpret the results of the UML survey by assuming that, if a diagram is:

- Widely used, if it ≥ 60% of the sources
- Scarcely used if it is ≤ 40% of the sources



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BEHAVIORAL MODELS

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Introduction

- Behavioral models describe the internal behavior of a system
- Behavioral model types:
  - Representations of the details of a business process identified by use-cases
    - Interaction diagrams (Sequence & Communication)
    - Shows how objects collaborate to provide the functionality defined in the use cases.
  - Representations of changes in the data
    - Behavioral state machines
- Focus (for now) is on the dynamic view of the system, not on how it is implemented

Behavioral Models

- Analysts view the problem as a set of use cases supported by a set of collaborating objects
  - Aids in organizing and defining the software
  - Behavioral models depict this view of the business processes:
    - How the objects interact and form a collaboration to support the use cases
    - An internal view of the business process described by a use case
- Creating behavioral models is an iterative process which may induce changes in other models

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INTERACTION DIAGRAMS

Interaction Diagrams

- Objects: an instantiation of a class
  - Patient is a class
  - Mary Wilson is an instantiation of the patient class (object)
- Attributes: characteristics of a class
  - Patient class: name, address, phone, etc.
- Operations: the behaviors of a class, or an action that an object can perform
- Messages: information sent to objects to tell them to execute one of their behaviors
  - A function call from one object to another
- Types
  - Sequence Diagrams—emphasize message sequence
  - Communication Diagrams—emphasize message flow

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SEQUENCE DIAGRAMS

Sequence Diagrams

- Illustrate the objects that participate in a single use-case
- A dynamic model
  - Shows the sequence of messages that pass between objects
  - Aid in understanding real-time specifications and complex use-cases
- Generic diagram shows all scenarios for a use-case
- Instance diagrams show a single scenario

Sequence Diagram Syntax

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Term and Definition	Symbol
An actor: ■ Is a person or system that derives benefit from and is external to the system. ■ Participates in a sequence by sending and/or receiving messages. ■ Is placed across the top of the diagram. ■ Is depicted either as a stick figure (default) or, if a nonhuman actor is involved, as a rectangle with <<actor>> in it (alternative).	 anActor <<actor>> anActor
An object: ■ Participates in a sequence by sending and/or receiving messages. ■ Is placed across the top of the diagram.	anObject : aClass
A lifeline: ■ Denotes the life of an object during a sequence. ■ Contains an X at the point at which the class no longer interacts.	

More Sequence Diagram Syntax

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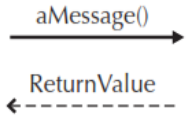
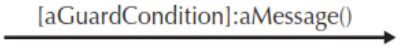
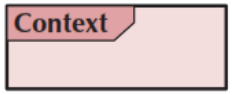
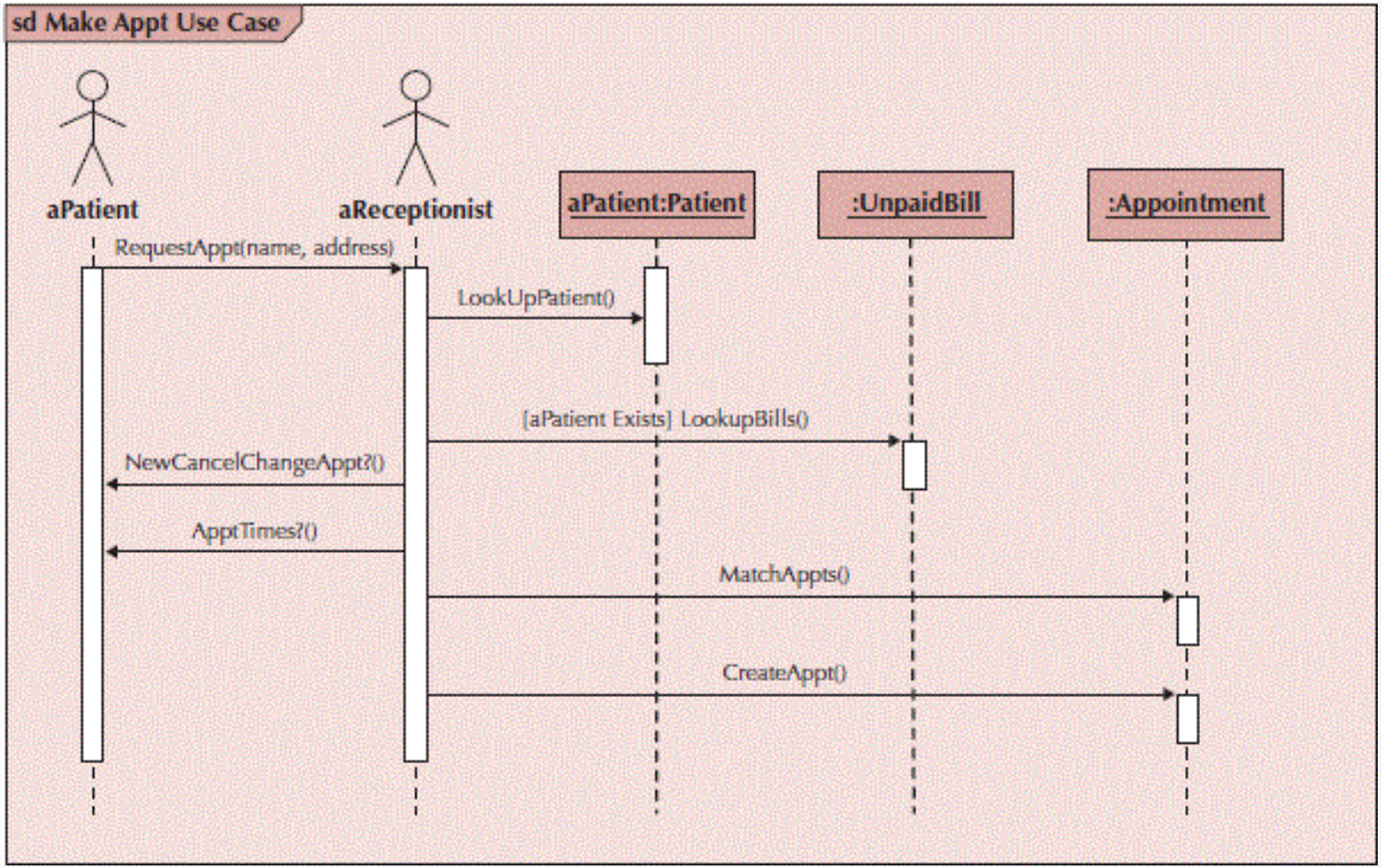
An execution occurrence: ■ Is a long narrow rectangle placed atop a lifeline. ■ Denotes when an object is sending or receiving messages.	
A message: ■ Conveys information from one object to another one. ■ A operation call is labeled with the message being sent and a solid arrow, whereas a return is labeled with the value being returned and shown as a dashed arrow.	
A guard condition: ■ Represents a test that must be met for the message to be sent.	
For object destruction: ■ An X is placed at the end of an object's lifeline to show that it is going out of existence.	X
A frame: ■ Indicates the context of the sequence diagram.	

Sample Sequence Diagram



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Building Sequence Diagrams

- Set the context
- Identify actors and objects that interact in the use-case scenario
- Set the lifeline for each object
- Add messages by drawing arrows
  - Shows how they are passed from one object to another
  - Include any parameters in parentheses
  - Obvious return values are excluded
- Add execution occurrence to each object's lifeline
- Validate the sequence diagram
  - Ensures that it depicts all of the steps in the process

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COMMUNICATION DIAGRAMS

Communication Diagrams

- Depict the dependencies among the objects
- An object diagram that shows message passing relationships
- Emphasize the flow through a set of objects

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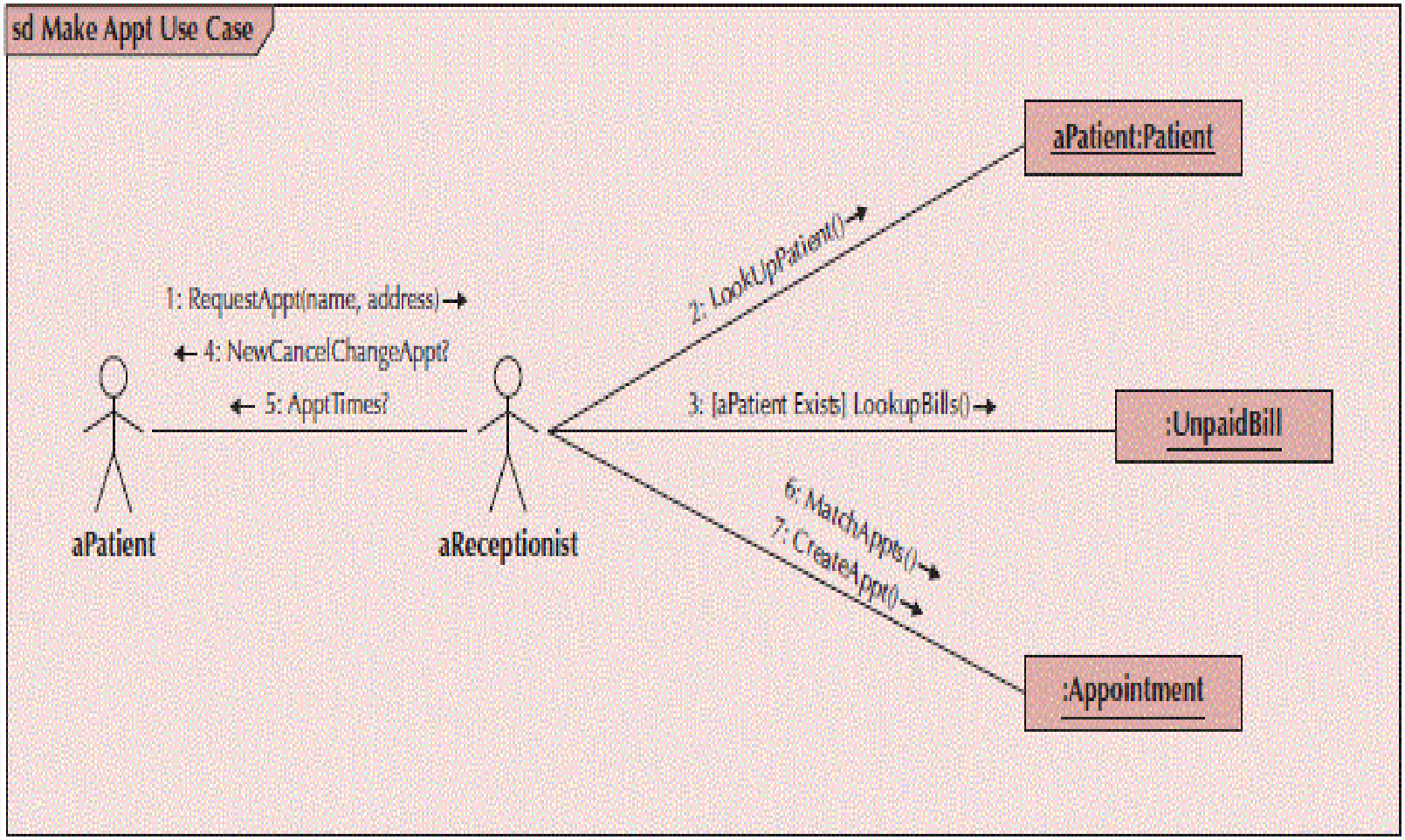
Communication Diagram Syntax

Term and Definition	Symbol
An actor: ■ Is a person or system that derives benefit from and is external to the system. ■ Participates in a collaboration by sending and/or receiving messages. ■ Is depicted either as a stick figure (default) or, if a nonhuman actor is involved, as a rectangle with <<actor>> in it (alternative).	 anActor <<actor>> anActor
An object: ■ Participates in a collaboration by sending and/or receiving messages.	anObject : aClass
An association: ■ Shows an association between actors and/or objects. ■ Is used to send messages.	
A message: ■ Conveys information from one object to another one. ■ Has direction shown using an arrowhead. ■ Has sequence shown by a sequence number.	SeqNumber: aMessage
A guard condition: ■ Represents a test that must be met for the message to be sent.	SeqNumber: [aGuardCondition]: aMessage
A frame: ■ Indicates the context of the communication diagram.	Context

Sample Communication Diagram



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Building Communication Diagrams

- Set the context
- Identify objects, actors and associations between them
- Lay out the diagram
- Add the messages
- Validate the model

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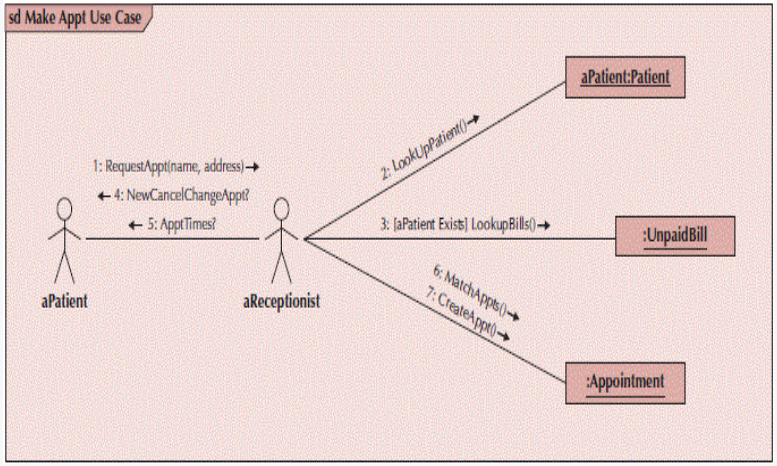
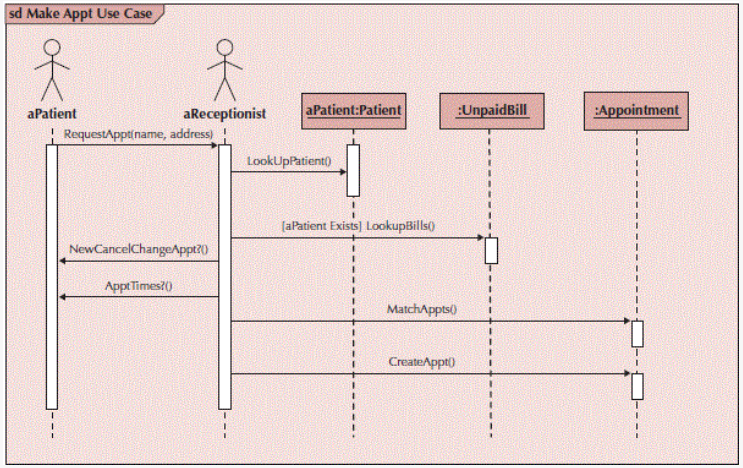
SEQUENCE DIAGRAMS VS COMMUNICATION DIAGRAMS

Sequence vs Communication





Communication Diagrams emphasize links between participants

Sequence Diagrams emphasize time ordering of messages

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Sequence vs Communication

Sequence diagrams	Communication diagrams
▪ Show the explicit sequence of messages ▪ Show execution occurrence ▪ Better for visualizing overall flow ▪ Better for real-time specifications and for complex scenarios	▪ Show relationships in addition to interactions ▪ Better for visualizing patterns of communication ▪ Better for visualizing all of the effects on a given object ▪ Easier to use for brainstorming sessions

Both are used to examine the behavior of objects within a single use case.

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BEHAVIORAL STATE MACHINES

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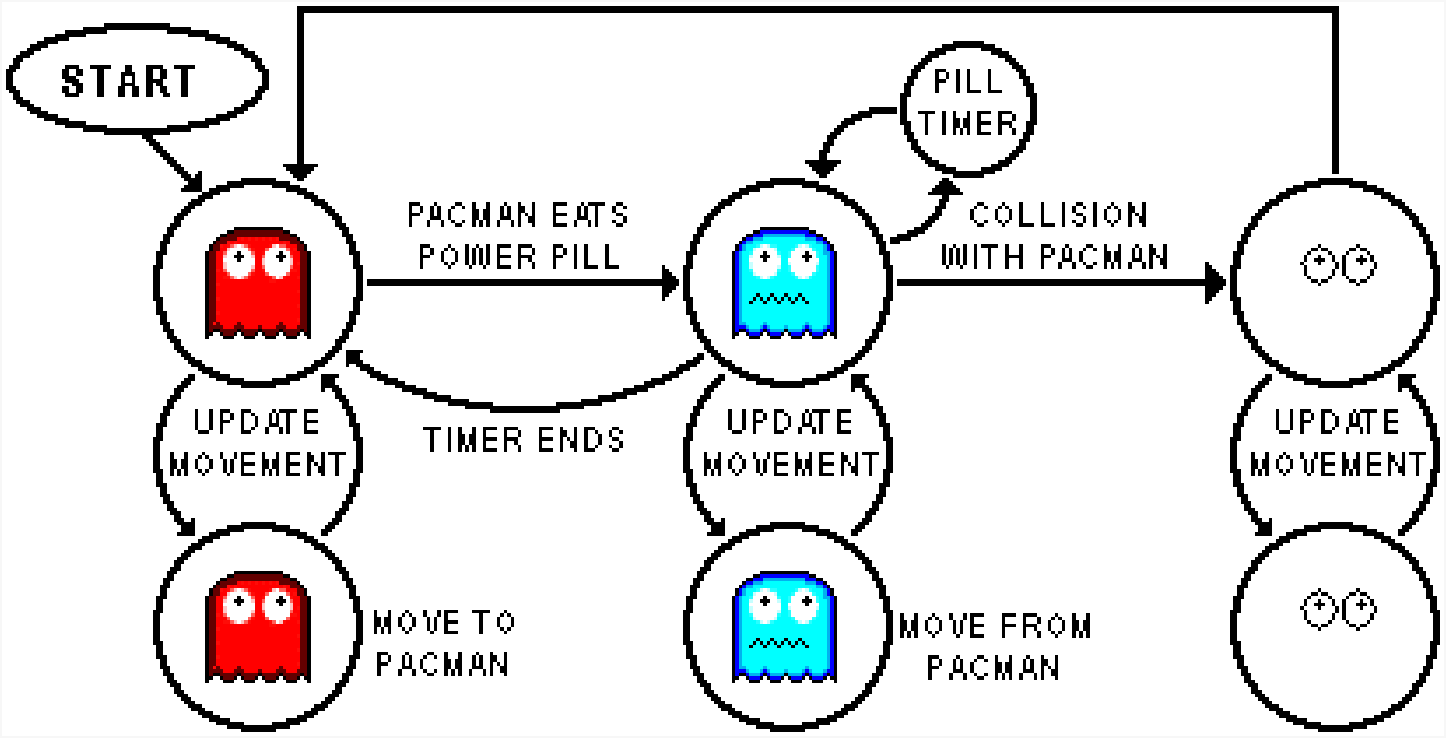
What is State?



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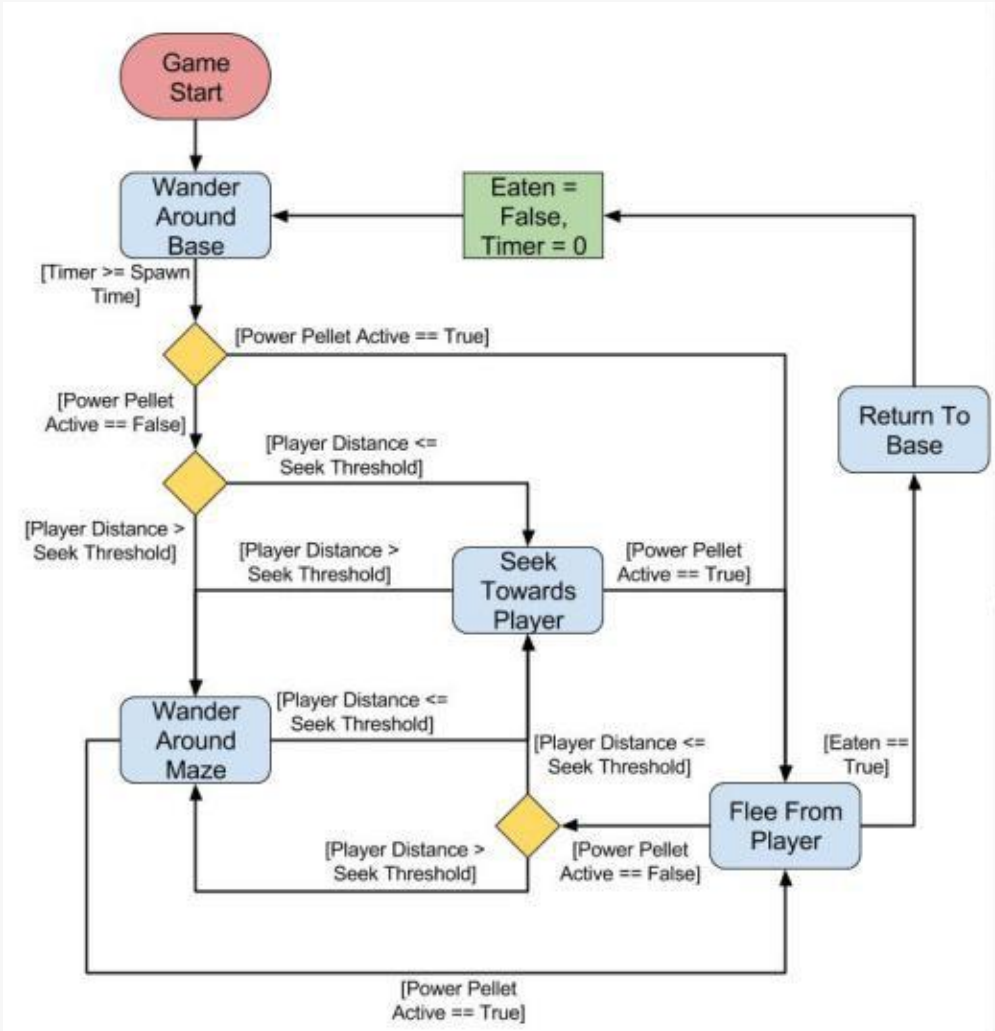
What is State?



Variable Name	Variable Definition
Spawn Time	The amount of time a ghost must wait before exiting the base
Timer	A timer on the ghost that is compared to Spawn Time
Power Pellet Active	Whether or not the player has just eaten a Power Pellet
Player Distance	The distance between the player and the current ghost
Seek Threshold	The maximum distance from the player the ghost can be to seek the player
Eaten	Whether or not a ghost has been eaten

Symbol	Definition
	Terminal
	State
	Decision
	Process
	Transition
[asdfx]	Condition

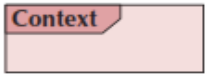
Behavioral State Machines

- Objects may change state in response to an event
- Different states are captured in this model
  - Shows the different states through which a single object passes during its life
  - May include the object's responses and actions
- Example: patient states
  - New patient—has not yet been seen
  - Current patient—is now receiving treatment
  - Former patient—no longer being seen or treated
- Typically used only for complex objects

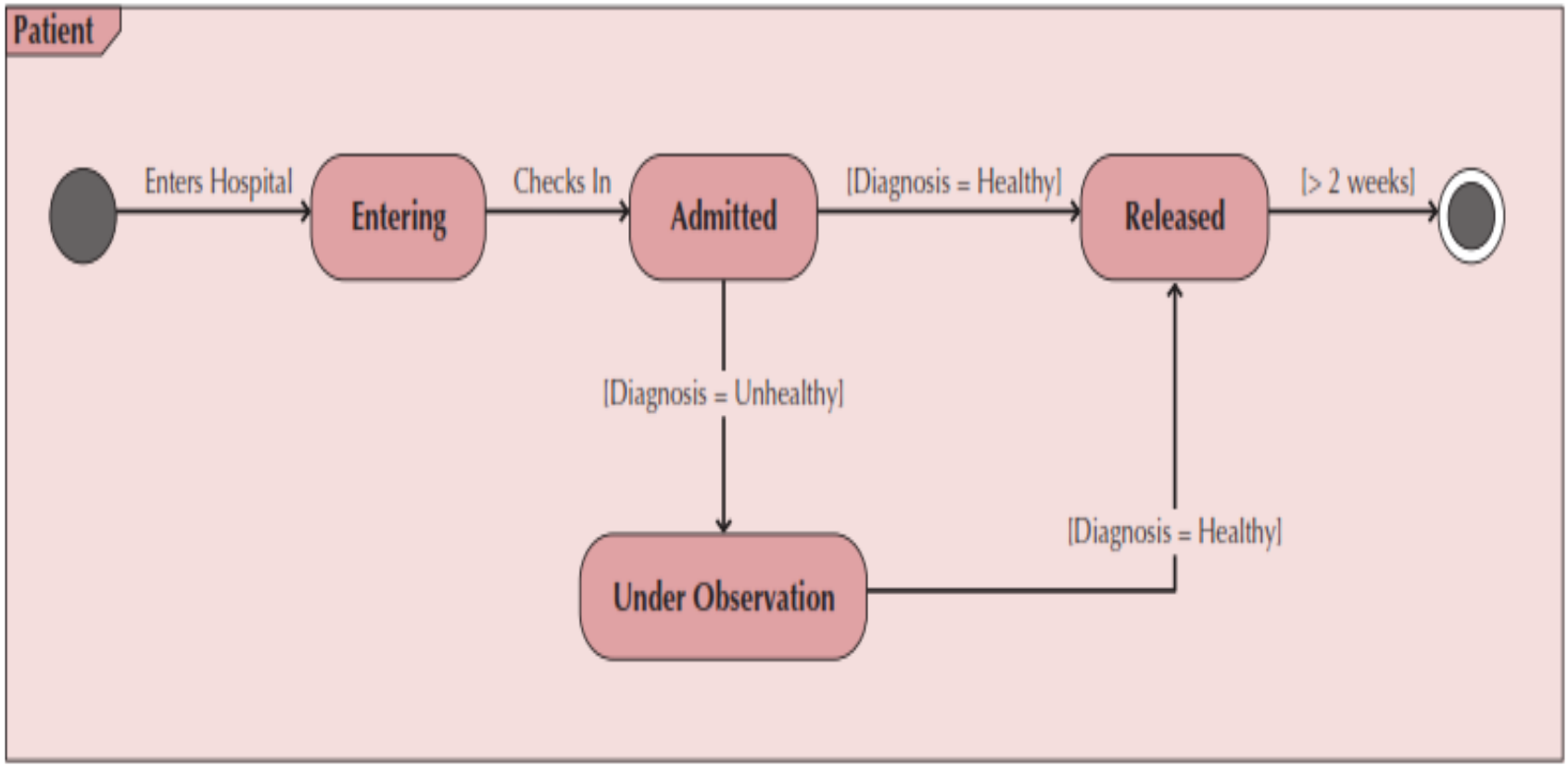
Components of State Machines

- States—values of an object's attributes at a point in time
- Events—the cause of the change in values of the object's attributes
- Transitions—movement of an object from one state to another
  - May include a guard condition to flag that a condition is true and allow the transition

State Machine Syntax

Term and Definition	Symbol
A state: ■ Is shown as a rectangle with rounded corners. ■ Has a name that represents the state of an object.	
An initial state: ■ Is shown as a small, filled-in circle. ■ Represents the point at which an object begins to exist.	
A final state: ■ Is shown as a circle surrounding a small, filled-in circle (bull's-eye). ■ Represents the completion of activity.	
An event: ■ Is a noteworthy occurrence that triggers a change in state. ■ Can be a designated condition becoming true, the receipt of an explicit signal from one object to another, or the passage of a designated period of time. ■ Is used to label a transition.	anEvent
A transition: ■ Indicates that an object in the first state will enter the second state. ■ Is triggered by the occurrence of the event labeling the transition. ■ Is shown as a solid arrow from one state to another, labeled by the event name.	
A frame: ■ Indicates the context of the behavioral state machine.	

Sample State Machine



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Guidelines for Creating Behavioral State Machines

- Use only for complex objects
- Draw the initial state in the upper left corner
- Draw the final state in the bottom right corner
- Use simple, but descriptive names for states
- Look out for “black holes” and “miracles”
- Ensure guard conditions are mutually exclusive
- Ensure transitions are associated with messages and operations

Building a Behavioral State Machine

- Set the context
- Identify the states of the object
  - Initial
  - Final
  - Stable states during its lifetime
- Lay out the diagram—use a left to right sequence
- Add the transitions
  - Identify the triggers (events that cause the transition)
  - Identify the actions which execute
  - Identify the guard conditions
- Validate the model—ensure all states are reachable

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CRUDE ANALYSIS

CRUDE Analysis

- Helps to identify object collaborations
- Labels object interaction in 5 possible ways:
  - Create—can one object create another?
  - Read—can one object read the attributes of another?
  - Update—can one object change values in another?
  - Delete—can one object delete another object?
  - Execute—can one object execute the operations of another?
- Utilizes a matrix to represent objects and their interactions
- Most useful as a system-wide representation

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Sample CRUDE Matrix

	Student Actor	Faculty/ Staff Actor	Guest Actor	Librarian Actor	Personnel Office Actor	Registrar's Office Actor	Book	Book Collection	Student Class	Faculty/ Staff Class	Guest Class	Interlibrary Loan System	Library	Storage
Student Actor				E			R,E	R				E		
Faculty/Staff Actor				E			R,E	R				E		
Guest Actor				E			R,E	R				E		
Librarian Actor	E	E	E		R,E	R,E	C,R,U,D,E	R,U,E	R,U	R,U	C,R,U,D,E	R,E		
Personnel Office Actor														
Registrar's Office Actor														
Book														
Book Collection														
Student Class														
Faculty/Staff Class														
Guest Class														
Interlibrary Loan System														
Library														
Storage														

Verifying & Validating Behavioral Models

- Actors must be consistent between models
- Messages on sequence diagrams must match associations on communication diagrams
- Every message on a sequence diagram must appear on an association in a communication diagram
- Guard conditions on a sequence diagram must appear on a communication diagram
- Sequence of messages must correspond to the top down ordering of messages being sent
- State transitions must be associated with a message on a sequence diagram
- Entries in a CRUDE matrix imply messages being sent

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SUMMARY

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Summary

- Behavioral Models—provide a detailed view of how object collaborations support use-cases
- Interaction Diagrams
  - Sequence diagrams
  - Communication diagrams
- Behavioral State Machines—depicts the states of complex objects during its lifetime
- CRUDE Analysis—helps to identify potential collaborations
- Verifying & Validating behavioral models—ensures the completeness and consistency of the models

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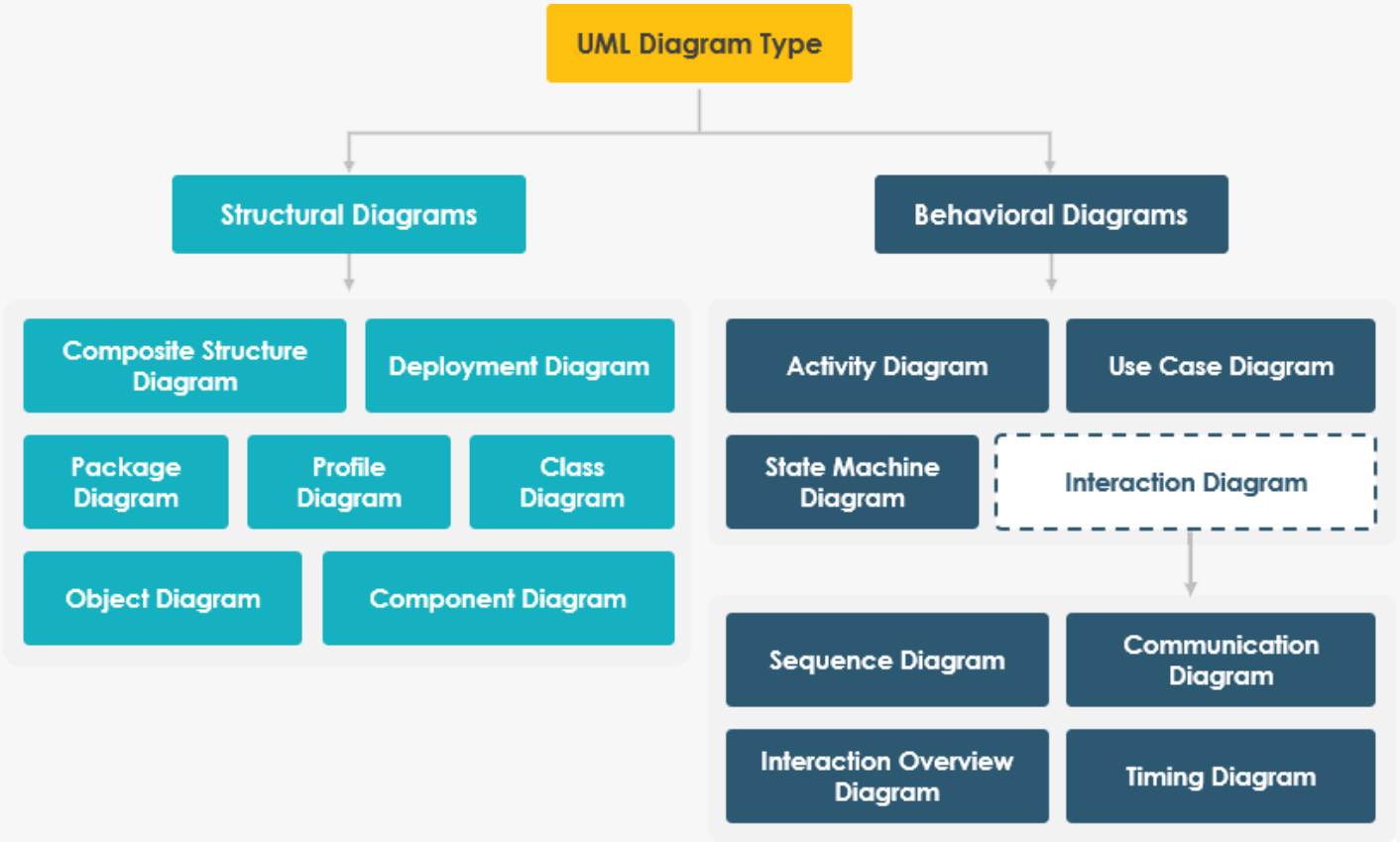
UML Diagram Types



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References

Denis, Wixom,Tegarden. (2015). Systems Analysis and Design: An Object-Oriented Approach with UML. 5th edition. ISBN: 978-1-118-80467-4, John Wiley & Sons, Inc, Denver (USA)