Requirements Modeling and Use Case Diagrams

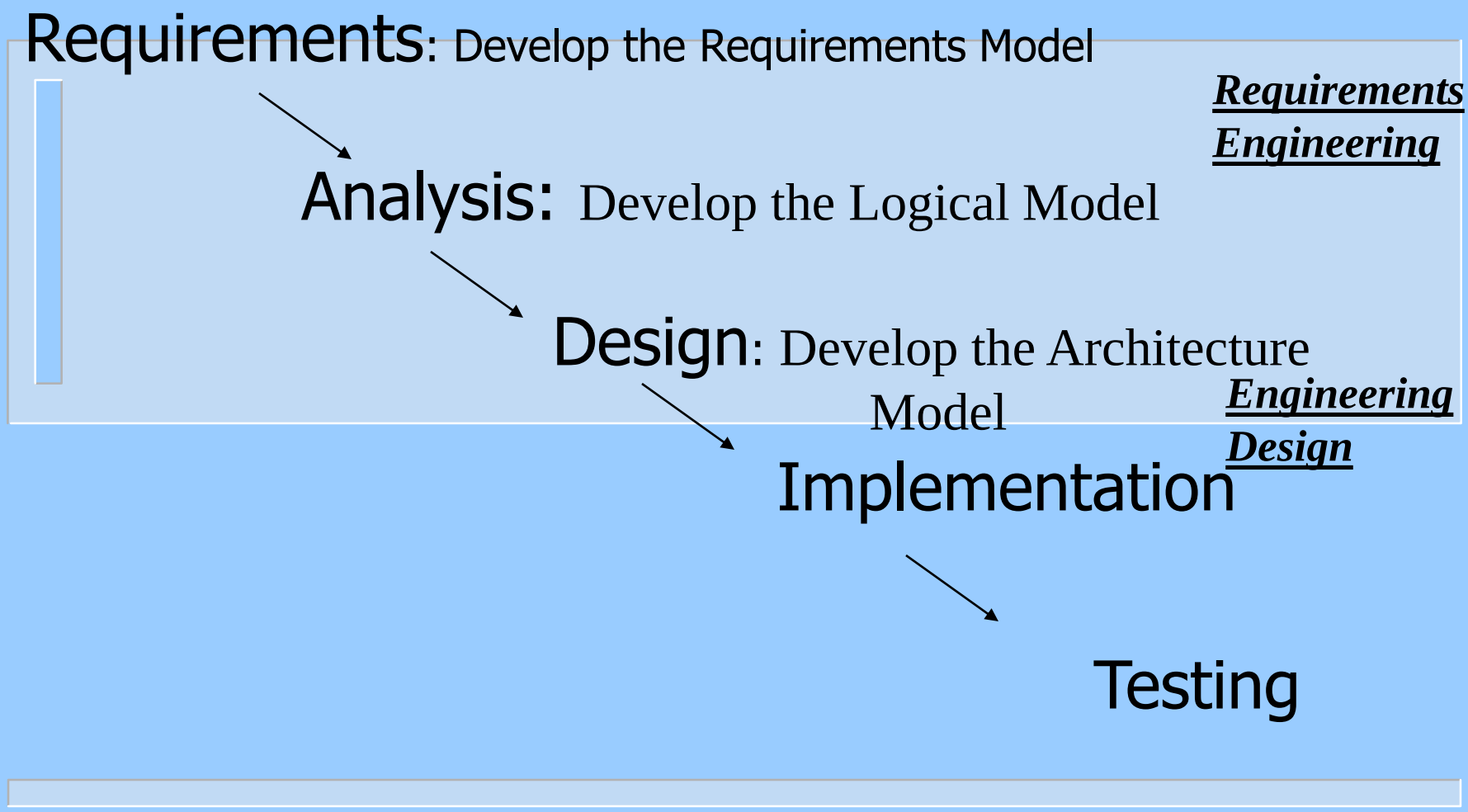
Instructor: Dr. Hany H. Ammar

Dept. of Computer Science and Electrical Engineering, WVU

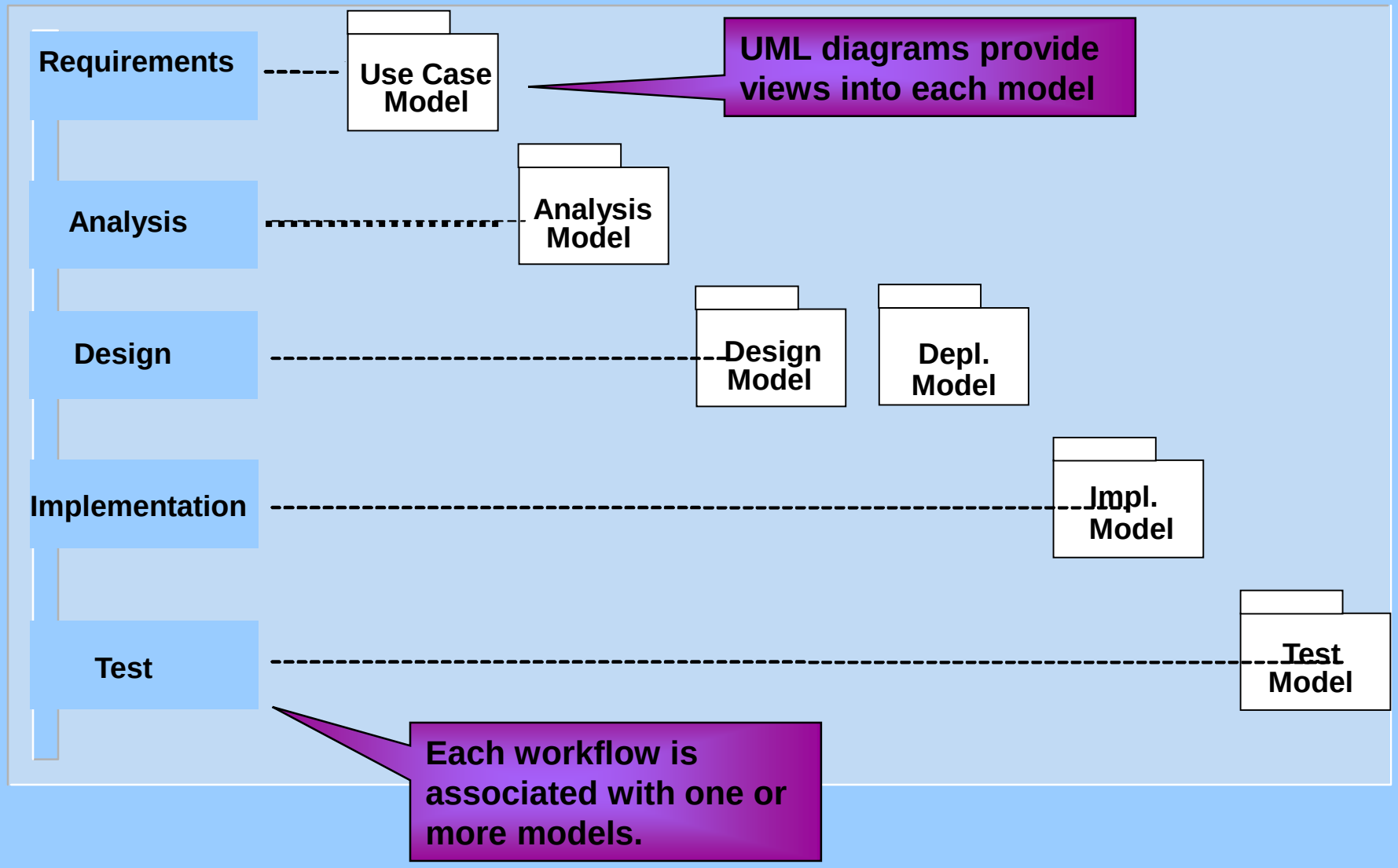
outline

- Review of development phases and UML Development – Overview
- Requirements Engineering and the Requirements model
- Introduction and importance of Use Case Diagrams
- Use Case Diagram Rules
- Examples of Use Case diagrams
- Requirements Elicitation Process
    1. Identify Actors
    2. Identify Scenarios
    3. Identify Use Cases
    4. Refine Use Cases
    5. Identify Relationships between actors and Use Cases
    6. Identify Initial Analysis Objects
    7. Identify Non-functional requirements

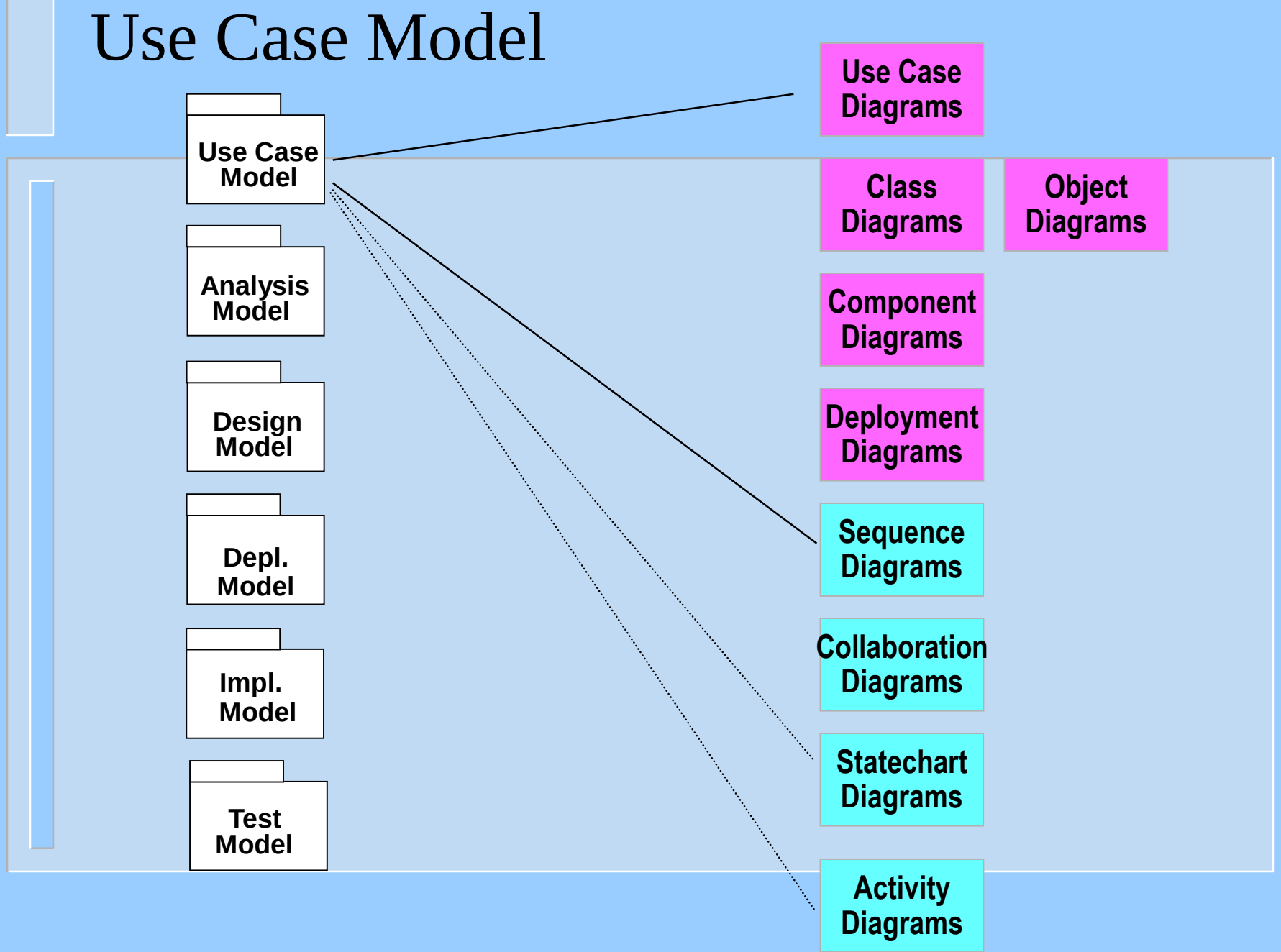
Review: Phases of System Development



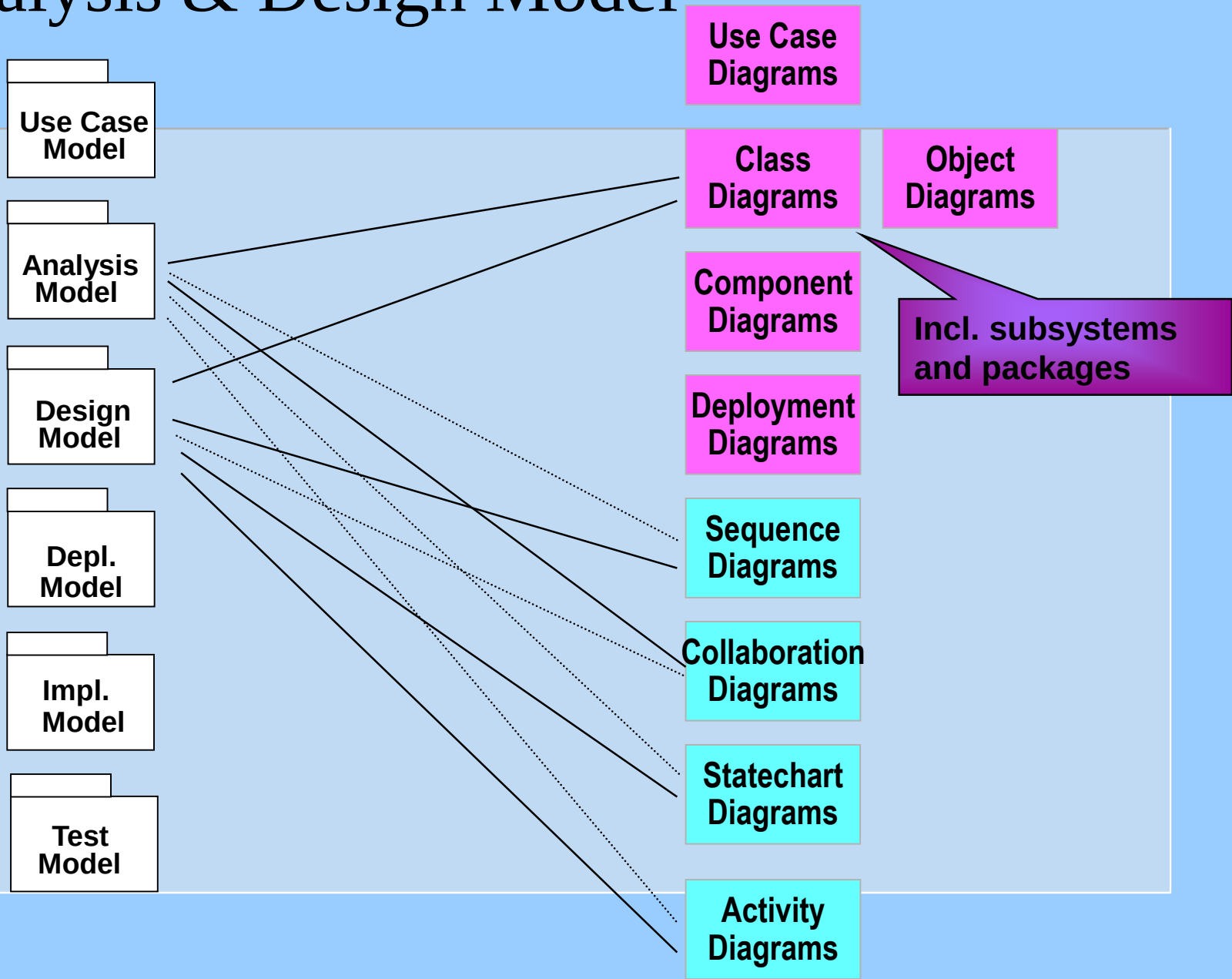
Workflows and Models



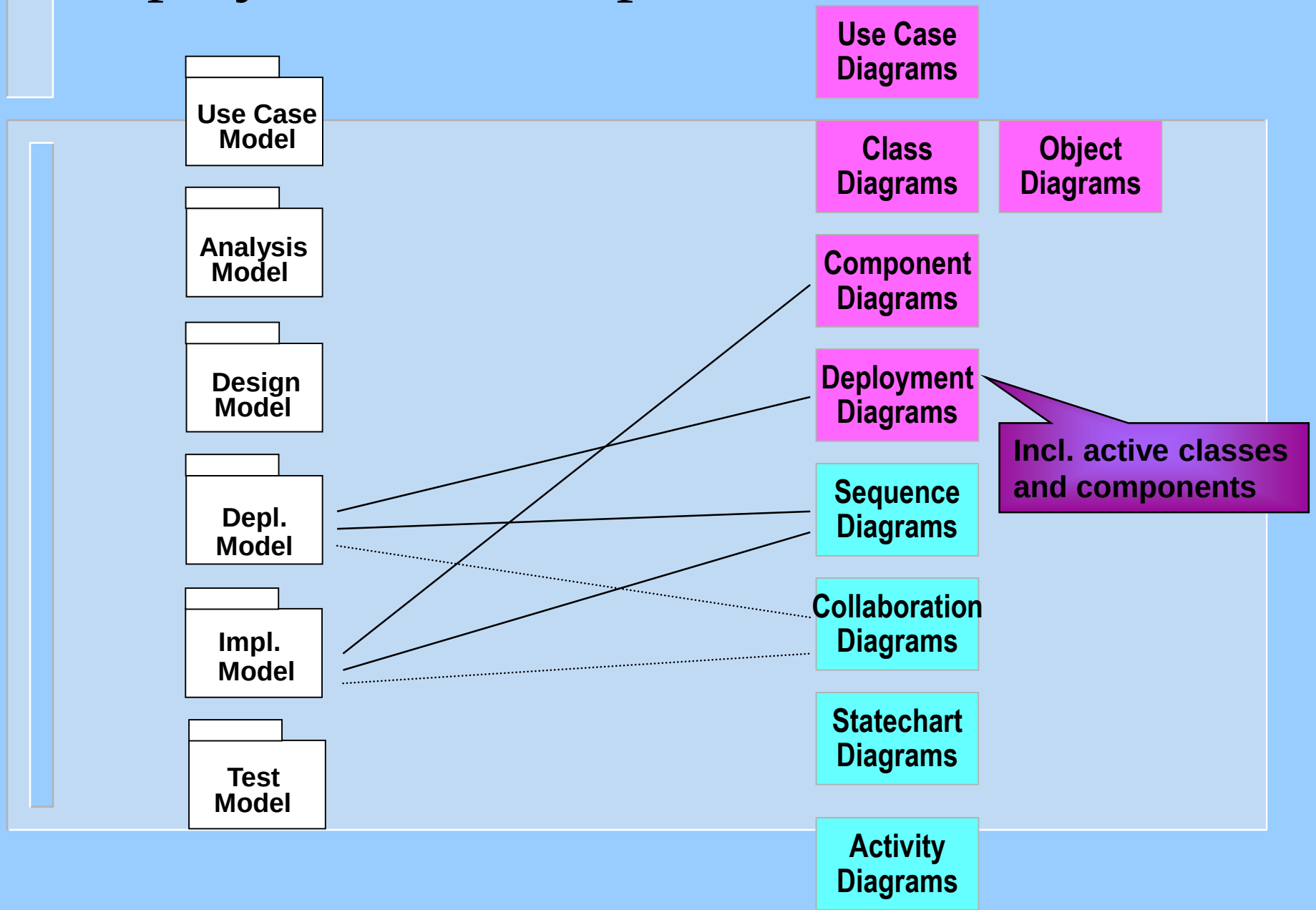
Use Case Model



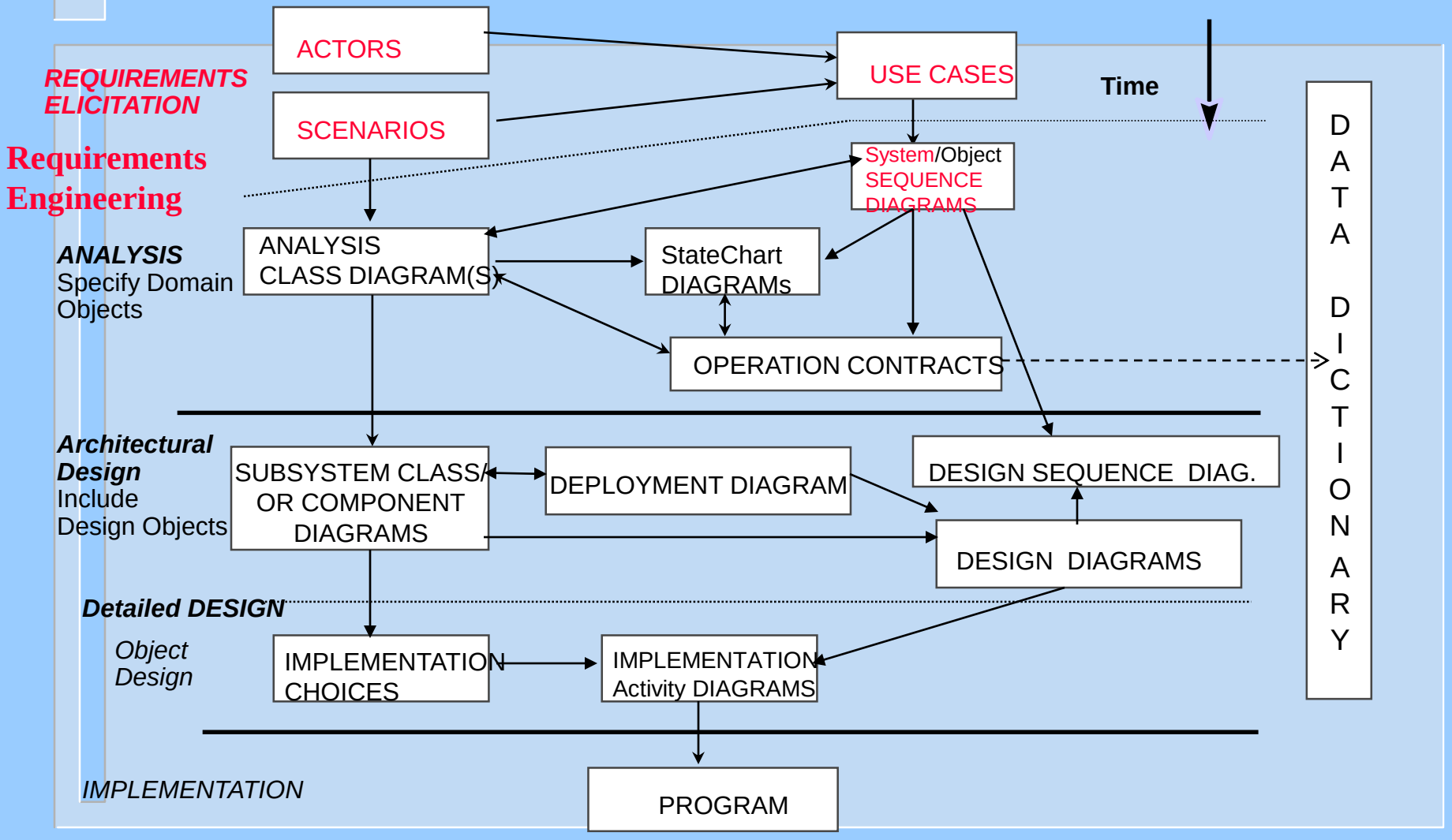
Analysis & Design Model



Deployment and Implementation Model



UML Development - Overview



outline

- Review of development phases and UML Development – Overview
- **Requirements Engineering and the Requirements model**
- Introduction and importance of Use Case Diagrams
- Use Case Diagram Rules
- Examples of Use Case diagrams
- Requirements Elicitation Process
    1. Identify Actors
    2. Identify Scenarios
    3. Identify Use Cases
    4. Refine Use Cases
    5. Identify Relationships between actors and Use Cases
    6. Identify Initial Analysis Objects
    7. Identify Non-functional requirements

What is Requirements Engineering ?

- Requirements Engineering

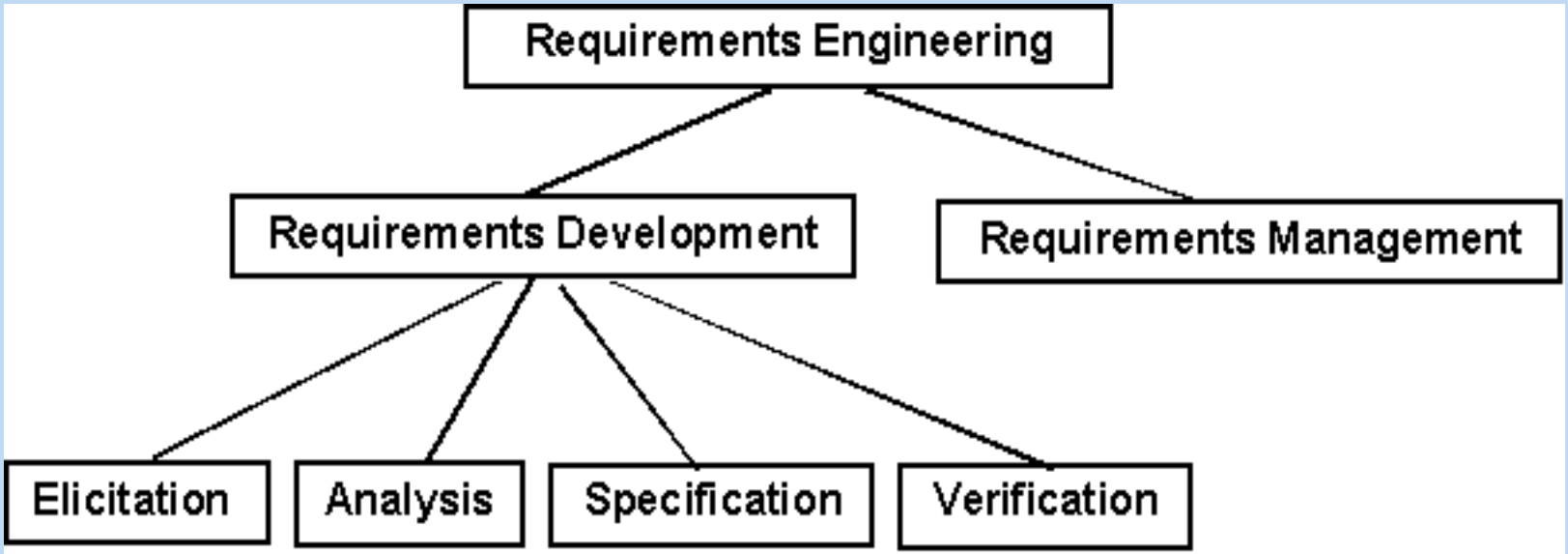


Figure 2. Subdisciplines of requirements engineering.

What is Requirements Engineering?

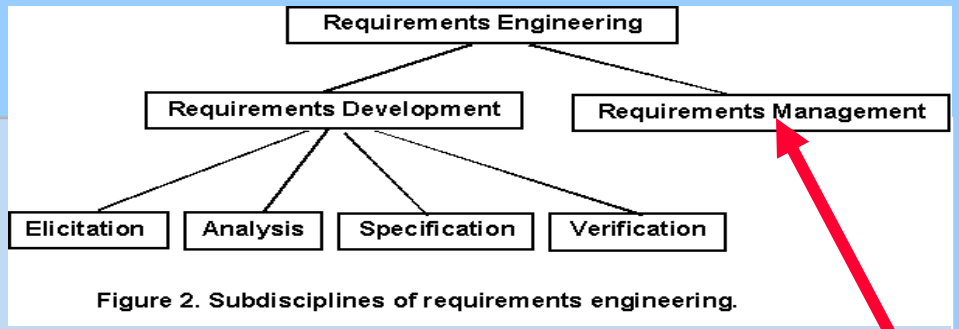


Figure 2. Subdisciplines of requirements engineering.

- Requirements Management:

  Requirements management activities include evaluating the impact of proposed changes, tracing individual requirements to downstream work products, and tracking requirements status during development
- Several Requirements management tools are available in industry

What is Requirements Engineering?

- Major Requirements Management Tools:

http://www.capterra.com/requirements-management-software

1. Caliber-RM by Technology Builders, Inc.; www.tbi.com
2. RequisitePro by Rational Software Corporation; www.rational.com
3. RTM Workshop by Integrated Chipware, Inc.; www.chipware.com

What is Requirements Engineering?

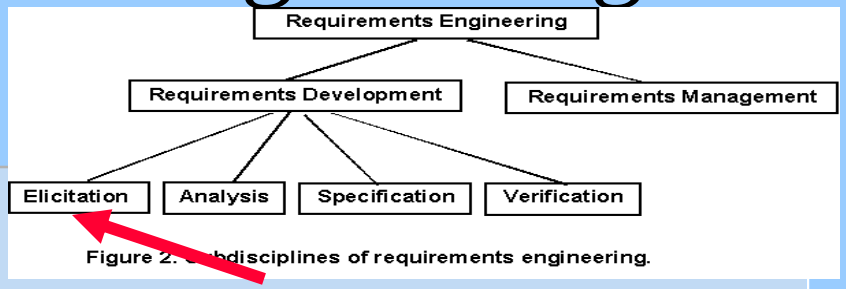


Figure 2. Subdisciplines of requirements engineering.

Requirements Elicitation

- is the process of gathering the different types of requirements from suitable stakeholders.
  - **Business requirements** describe why the product is being built and identify the benefits for both the customers and the business.
  - **User requirements**, describe the tasks or business processes a user will be able to perform with the product. (Developing use-cases)
  - **Functional requirements** describe the specific system behaviors that must be implemented (Developing usage scenarios)
  - **Non-functional requirements,** describe the non-functional features such as quality attributes of Reliability, Performance, availability, and maintainability.

What is Requirements Engineering?

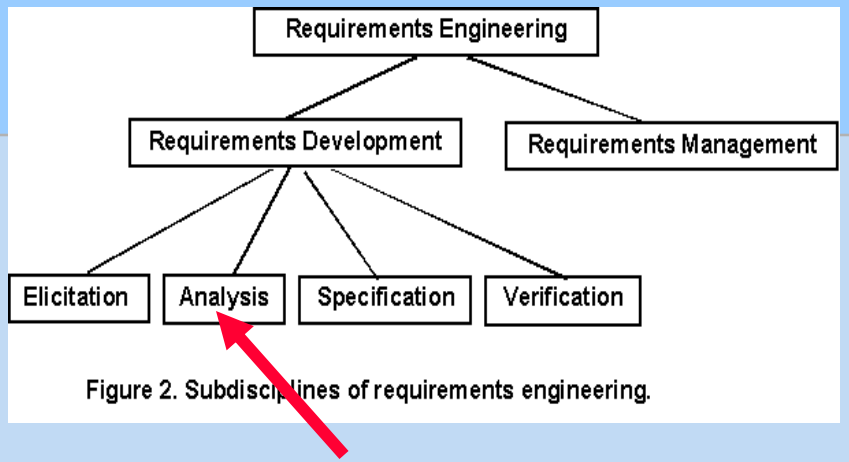


Figure 2. Subdisciplines of requirements engineering.

- Requirements analysis:

  Requirements analysis includes decomposing high-level requirements into detailed functional requirements, constructing graphical requirements models or ***logical models*** (structured Analysis models, or Object-Oriented Analysis models) (for developers), and building prototypes.

- Analysis models and prototypes provide alternative views of the requirements, which often reveal errors and conflicts that are hard to spot in a textual SRS.

What is Requirements Engineering?

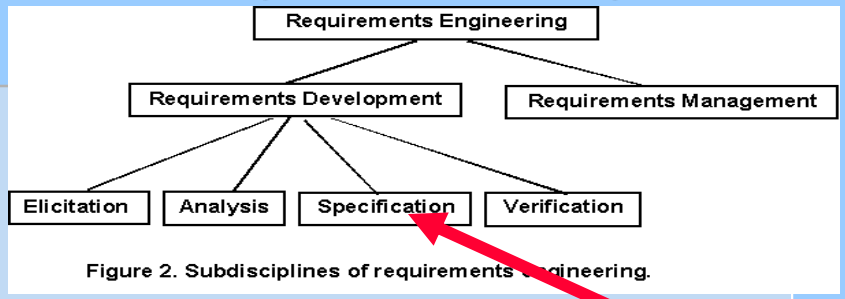


Figure 2. Subdisciplines of requirements engineering.

Requirements Specification

- Specification key practice is to write down the requirements in some accepted, structured format as you gather and analyze them.
- The objective of requirements development is to communicate a shared understanding of the new product among all project stakeholders.
- Historically, this understanding is captured in the form of a textual SRS document written in natural language, augmented by appropriate analysis models. (to be discussed in detail)

What is Requirements Engineering?

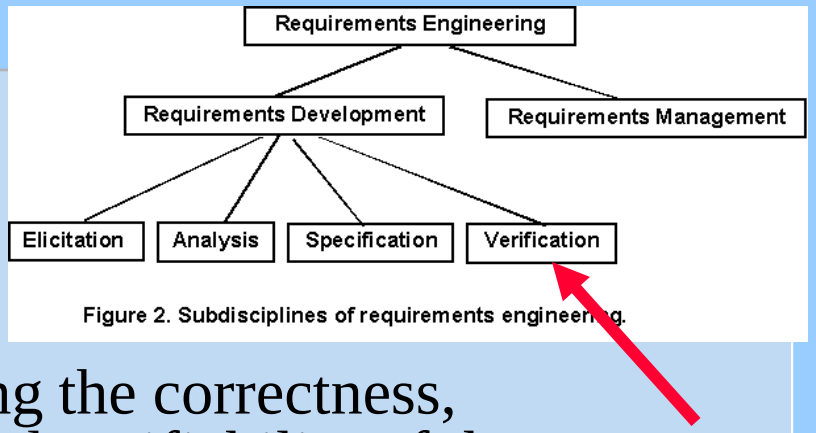
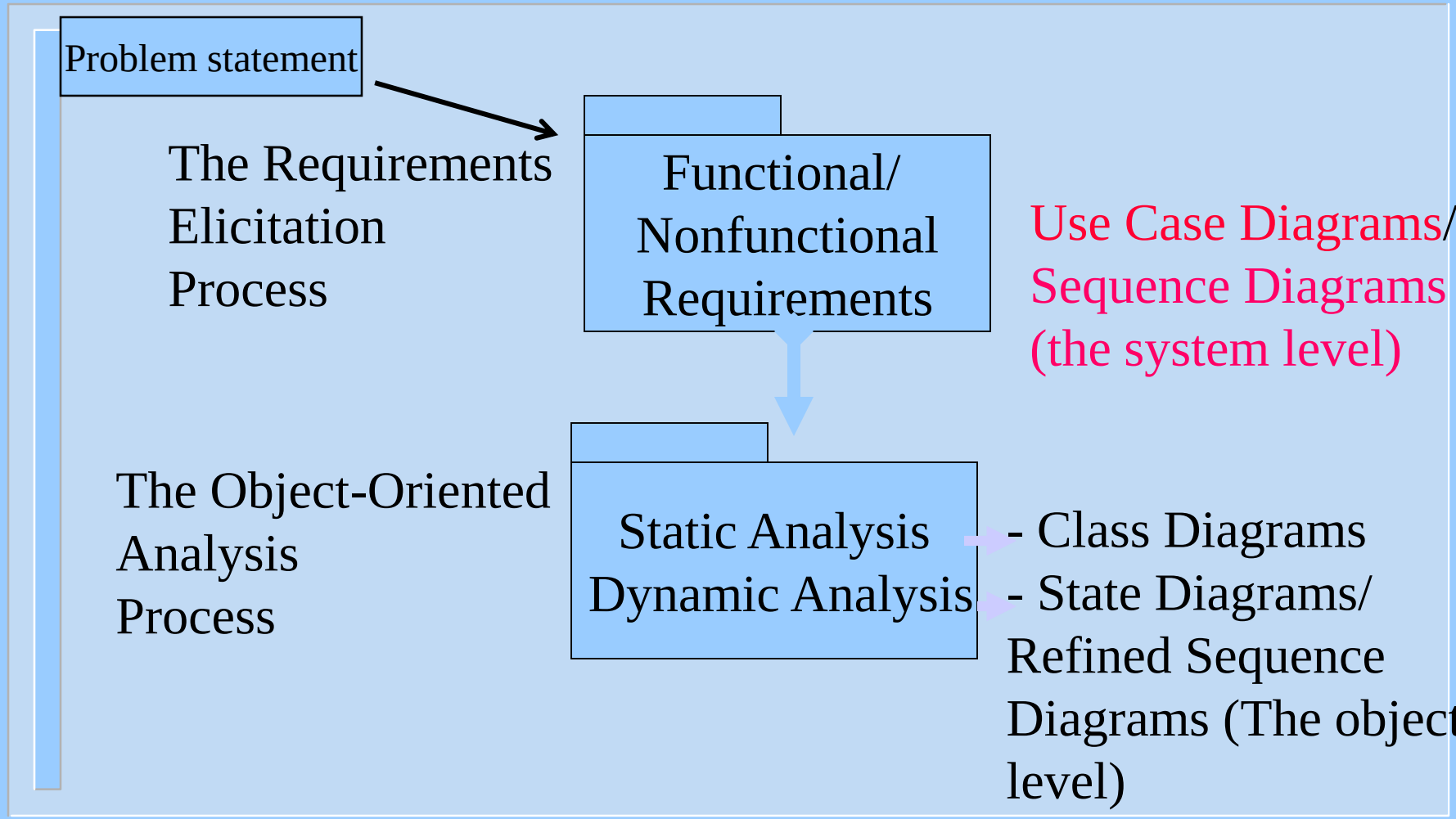


Figure 2. Subdisciplines of requirements engineering.

- Requirements Verification

  Verification involves evaluating the correctness, completeness, unambiguity, and verifiability of the requirements, to ensure that a system built to those requirements will satisfy the users' needs and expectations. The goal of verification is to ensure that the requirements provide an adequate basis to proceed with design
- Prototyping (or executable specifications) is a major technique used in verification. Examples include GUI development for user requirements verification, and Formal requirements specification environments

Requirements Engineering: The Requirements Model



outline

- Review of development phases and UML Development – Overview
- Requirements Engineering and the Requirements model
- **Introduction and importance of Use Case Diagrams**
- Use Case Diagram Rules
- Examples of Use Case diagrams
- Requirements Elicitation Process
    1. Identify Actors
    2. Identify Scenarios
    3. Identify Use Cases
    4. Refine Use Cases
    5. Identify Relationships between actors and Use Cases
    6. Identify Initial Analysis Objects
    7. Identify Non-functional requirements

Use Case Diagrams
Introduction and importance

- Use cases are widely regarded as one of the important artifacts needed to successfully develop complex software systems
- Use cases define the scope of the system and clarify the behavioral system requirements

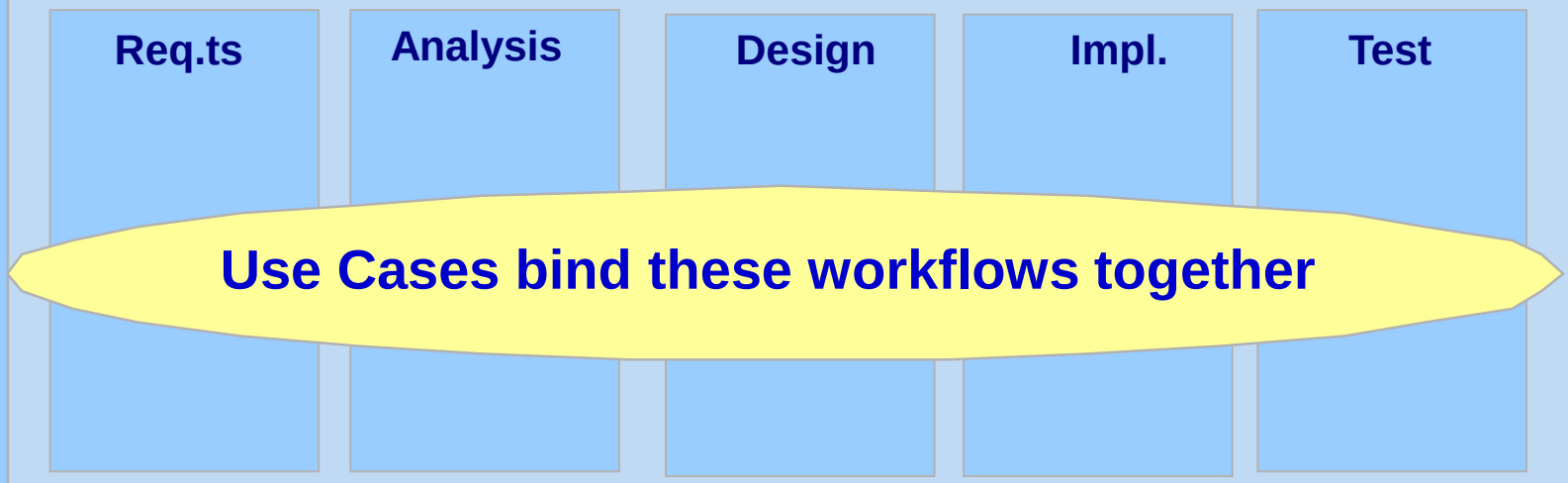
Use Case Diagrams
Introduction and importance

- Provide a basis for a coherent conceptual understanding of the system under consideration without requiring knowledge of software design or implementation technology
- Used as organized means of capturing domain expertise

Use Case Diagrams
Introduction and importance

- Can be used to track the progress of the system development effort
- Provide means to trace requirements to the design
- Provide the basis for developing system acceptance tests

Use Case Driven



Use Cases Drive Iterations

- Drive a number of development activities
  - Creation and validation of the system's architecture
  - Definition of test cases and procedures
  - Planning of iterations
  - Creation of user documentation
  - Deployment of system
- Synchronize the content of different models

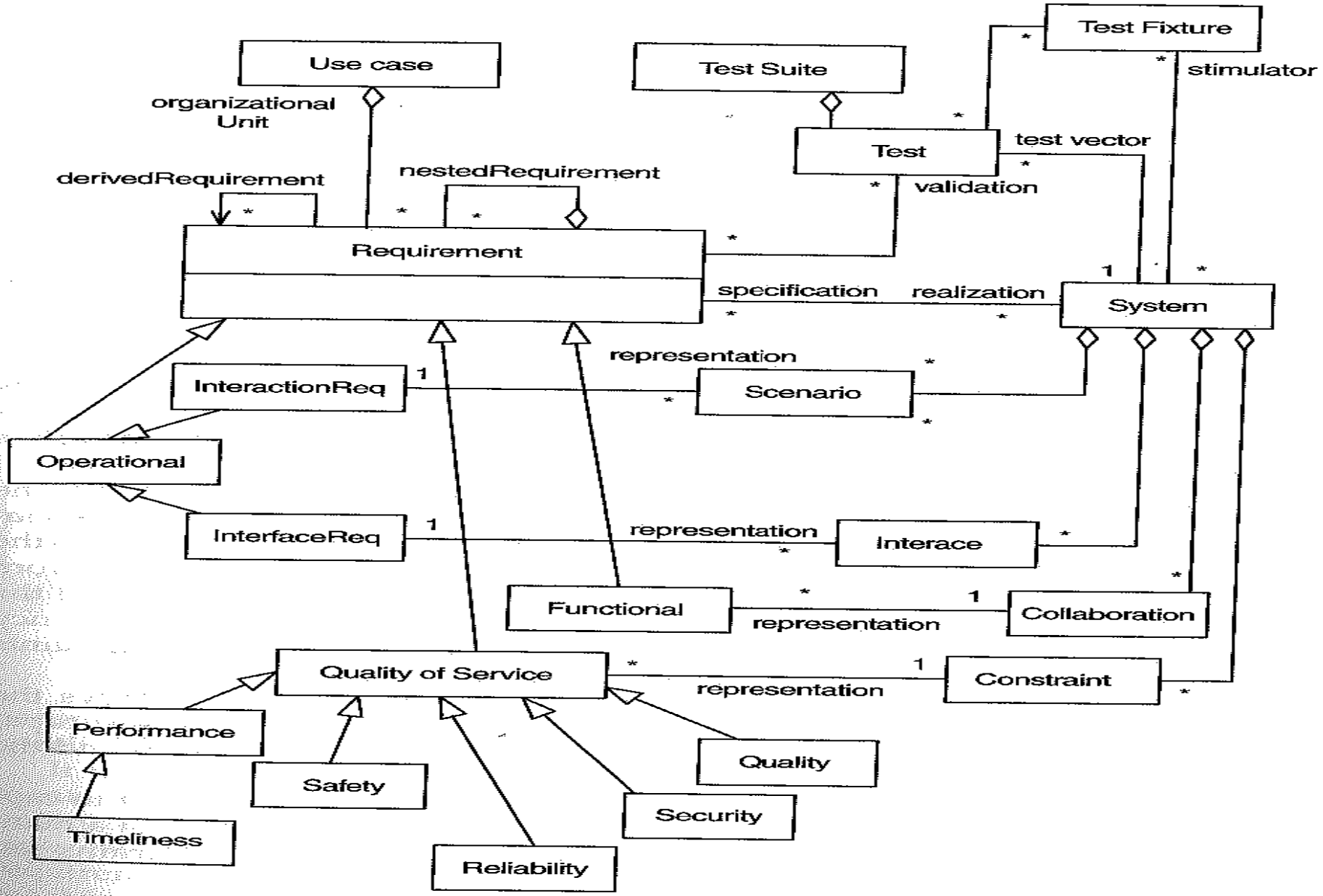


Figure 5-1: *Requirements Taxonomy*

Use Case Diagrams
Introduction and importance

- The identification of use cases and actors occurs during the initial requirements analysis phase of a project
- The use cases most essential to the system are selected, analyzed, and specified.

Use Case Diagrams
Introduction and importance

- These essential use cases eventually become the basis for defining the architecture of the system during the first iterations of system development
- The use cases are then allocated to iterative releases, which are planned and eventually executed

Use Case Diagrams
Introduction and importance

- In the requirements phase of each delivery, the use cases allocated to that delivery are analyzed and completely specified
- the use cases would then be realized by domain level analysis/design using class and interaction diagrams

Use Case Diagrams
Introduction and importance

- The domain level realization is further refined into a detailed design that typically employs class and interaction diagrams and often includes state transition diagrams and/or decision tables.

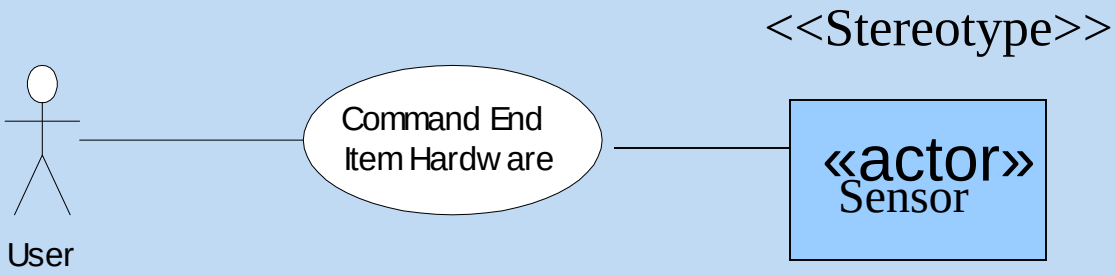
outline

- Review of development phases and UML Development – Overview
- Requirements Engineering and the Requirements model
- Introduction and importance of Use Case Diagrams
- **Use Case Diagram Rules**
- Examples of Use Case diagrams
- Requirements Elicitation Process
    1. Identify Actors
    2. Identify Scenarios
    3. Identify Use Cases
    4. Refine Use Cases
    5. Identify Relationships between actors and Use Cases
    6. Identify Initial Analysis Objects
    7. Identify Non-functional requirements

Use Case Diagrams

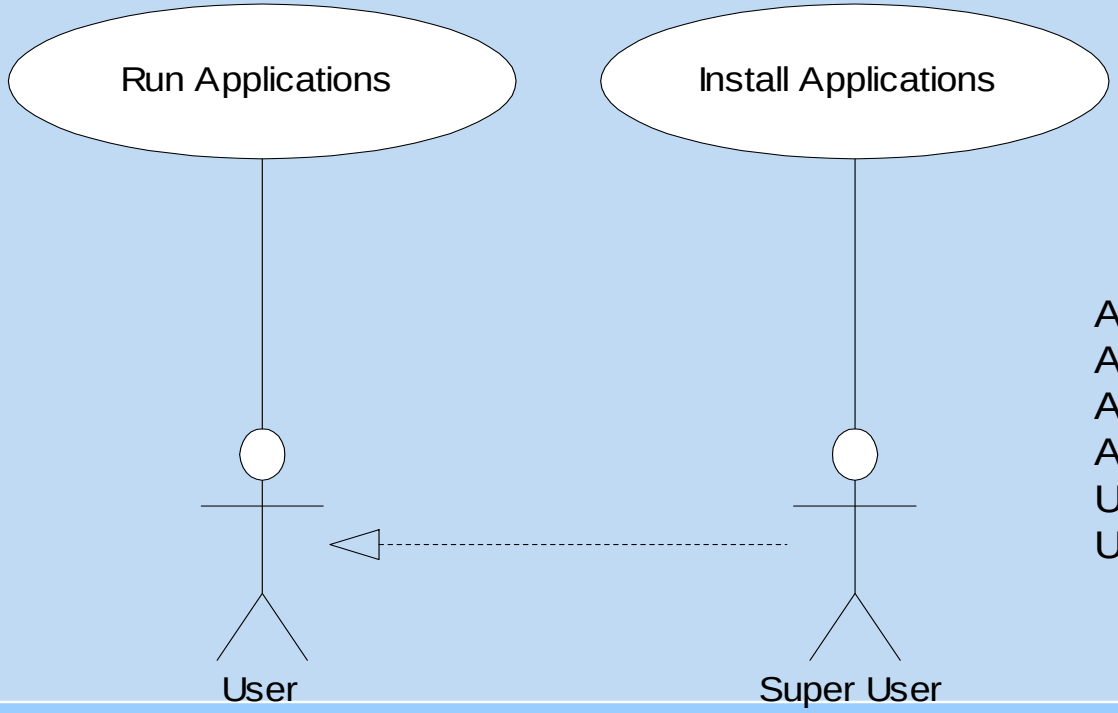
Use Case Diagram Rules

- Use a “stick man” figure for an actor, and show the actor’s name below the stick man
- The UML standard allows for the option of using a class rectangle with the stereotype «actor»



Use Case Diagram Rules

- The only valid relationship between an actor and another actor is *generalization*



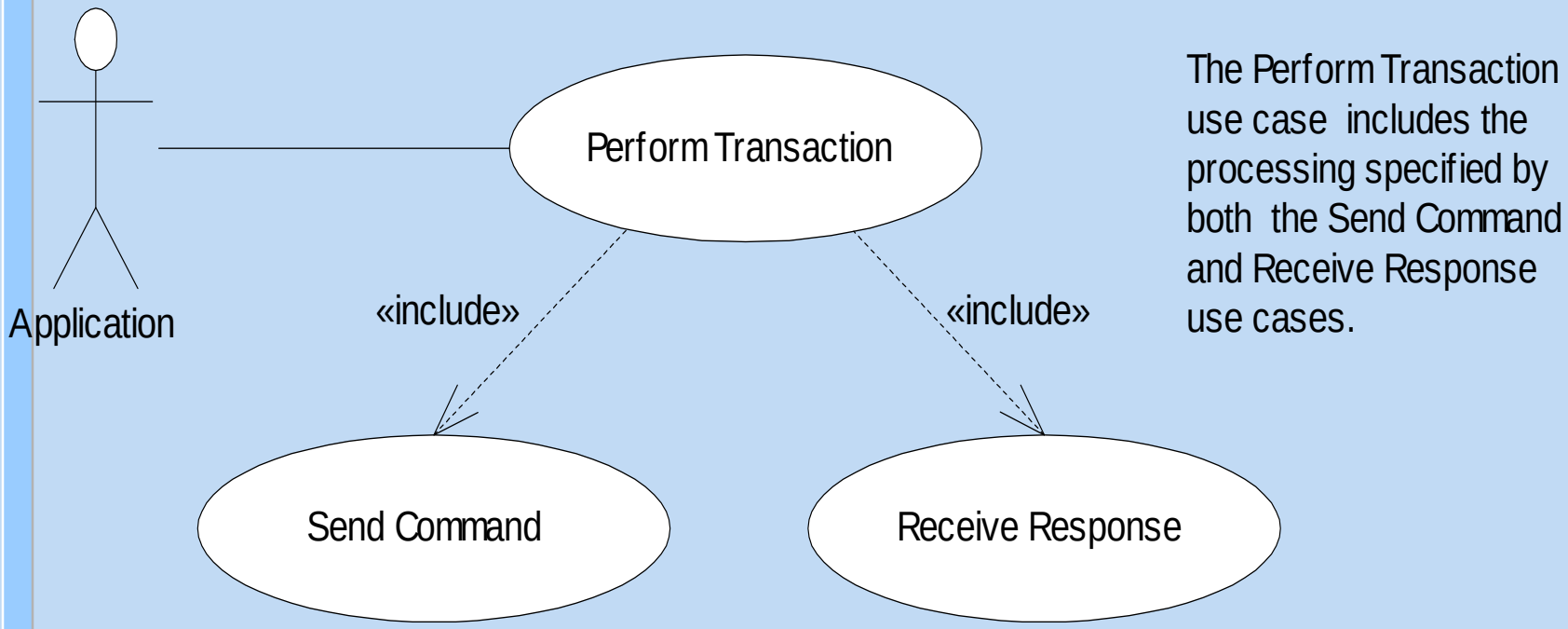
A User can Run Applications. A Super User can Install Applications and Run Applications, since a Super User is a specialization of User.

Use Case Diagram Rules

- Use only the following relationships between use cases
  - Use the *include* relationship to show that the behavior of one use case is wholly and unconditionally used in another use case
  - Use the *generalization* relationship to show that a use case is a specialization of another use case

Use Case Diagram Rules

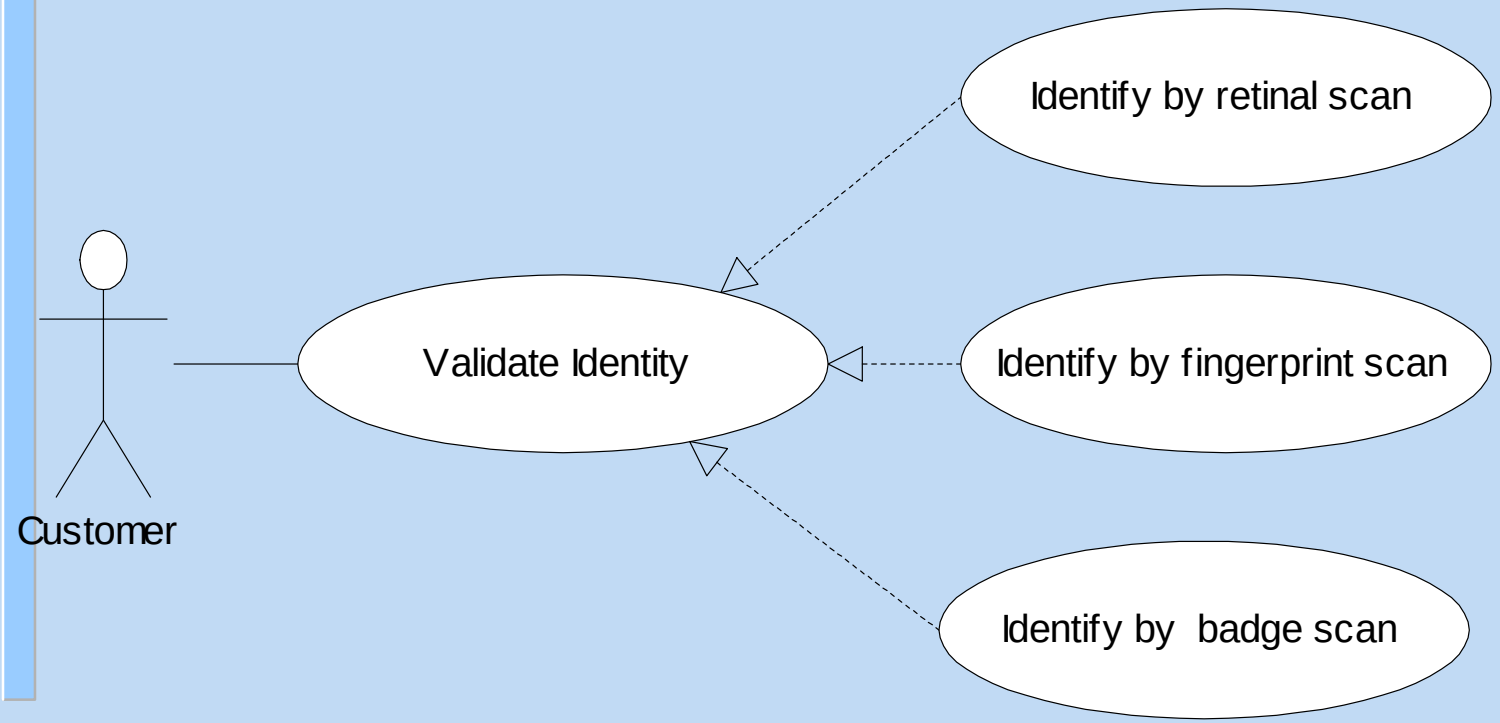
- the *include* relationship



The Perform Transaction use case includes the processing specified by both the Send Command and Receive Response use cases.

Use Case Diagram Rules

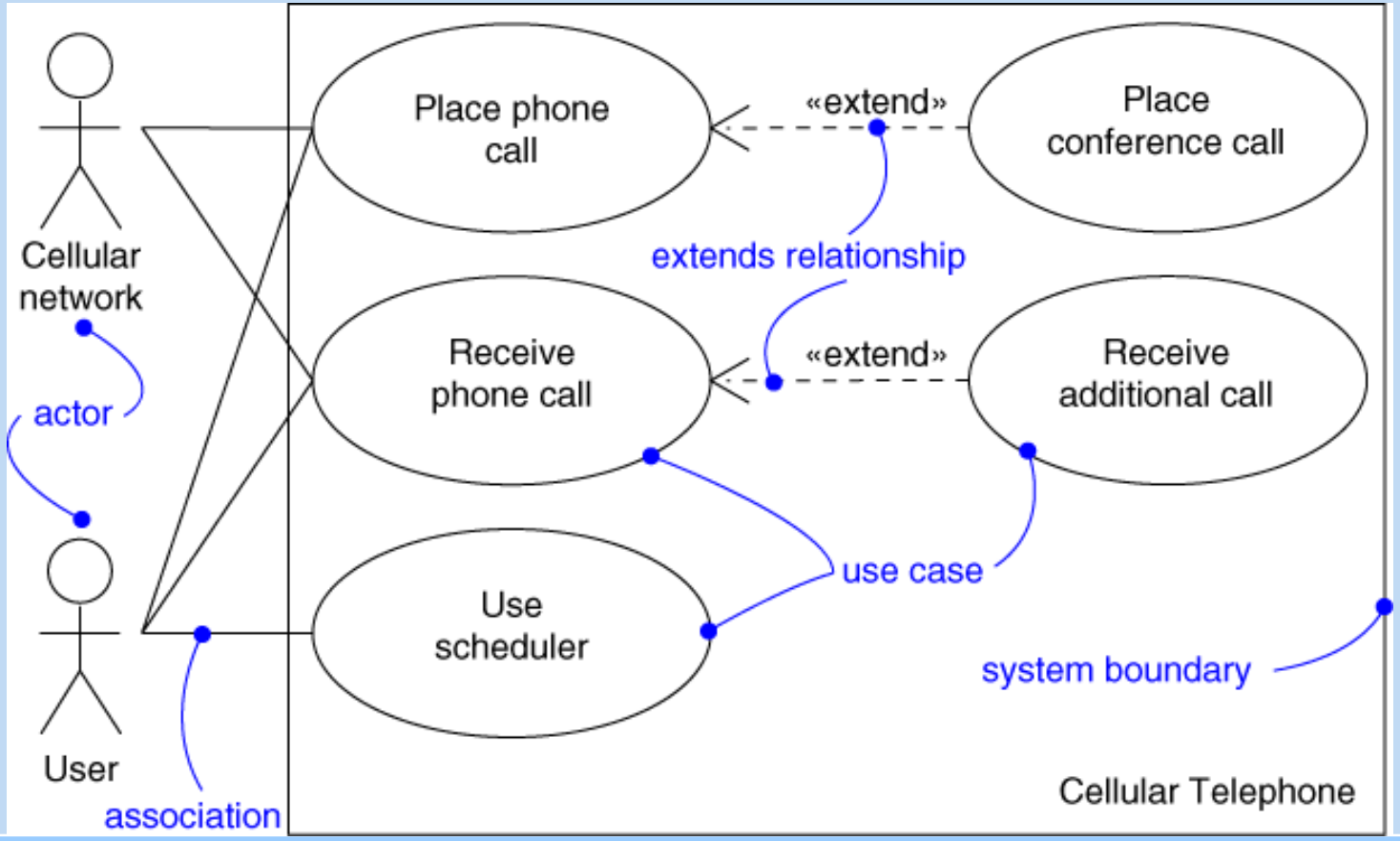
- the *generalization* relationship



Use Case Diagram Rules

- Use the *extend* relationship to show that one use case conditionally augment (or extend) the behavior of another use case.

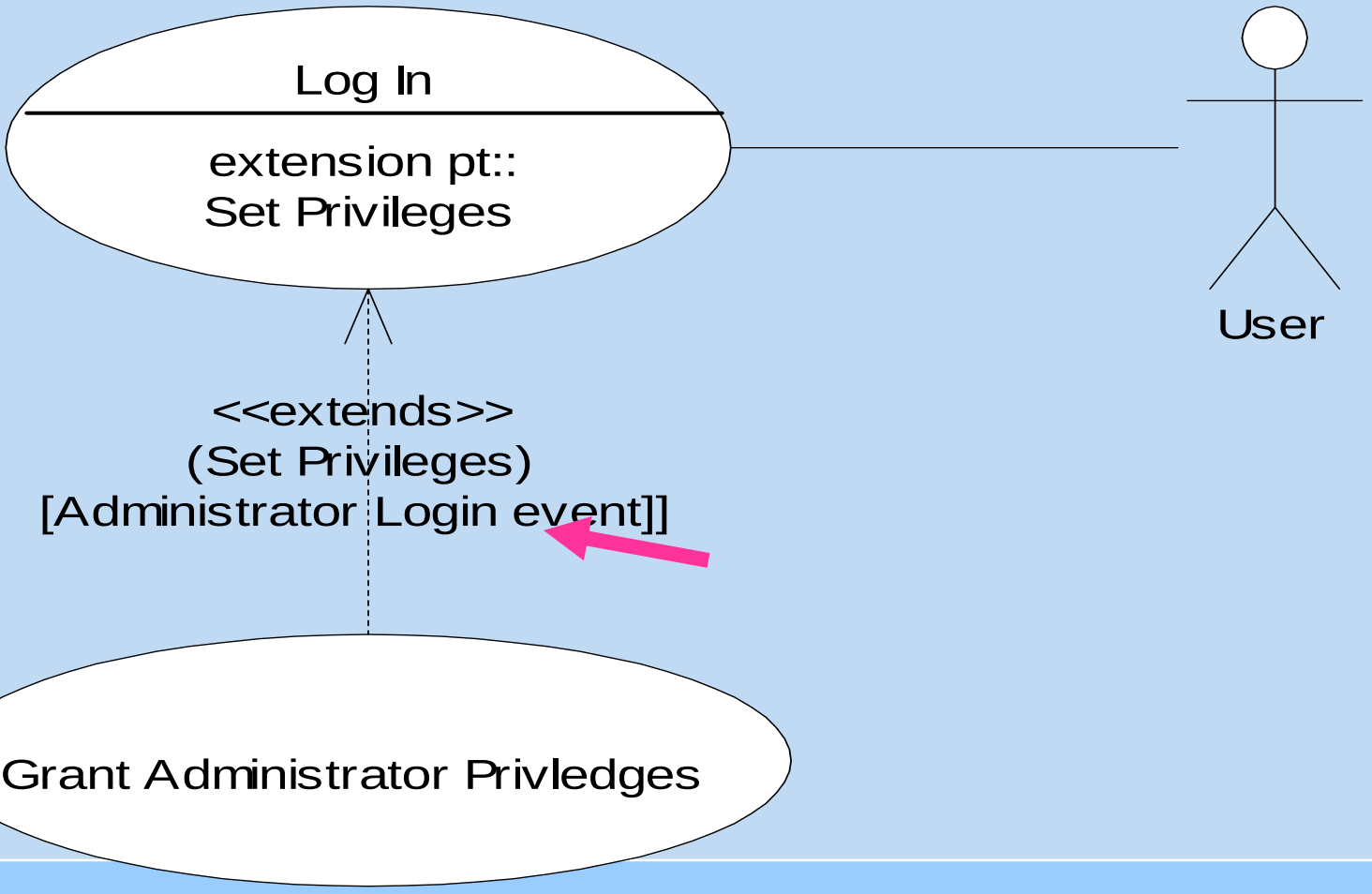
Example of Extends relationship



Use Case Diagram Rules

- Extension points for a base use case are identified within the specification of that base use case
- These are the locations where another use case may *extend* the base use case. These extension points are optionally shown in a diagram by listing them in a compartment of the base use case bubble under the heading “extension points
- The extending *relationship* identifies, within parenthesis, the extension point(s) in the use case being extended

Identify, within brackets, the condition under which the extension is executed



Example of Extends, includes, and generalization relationships

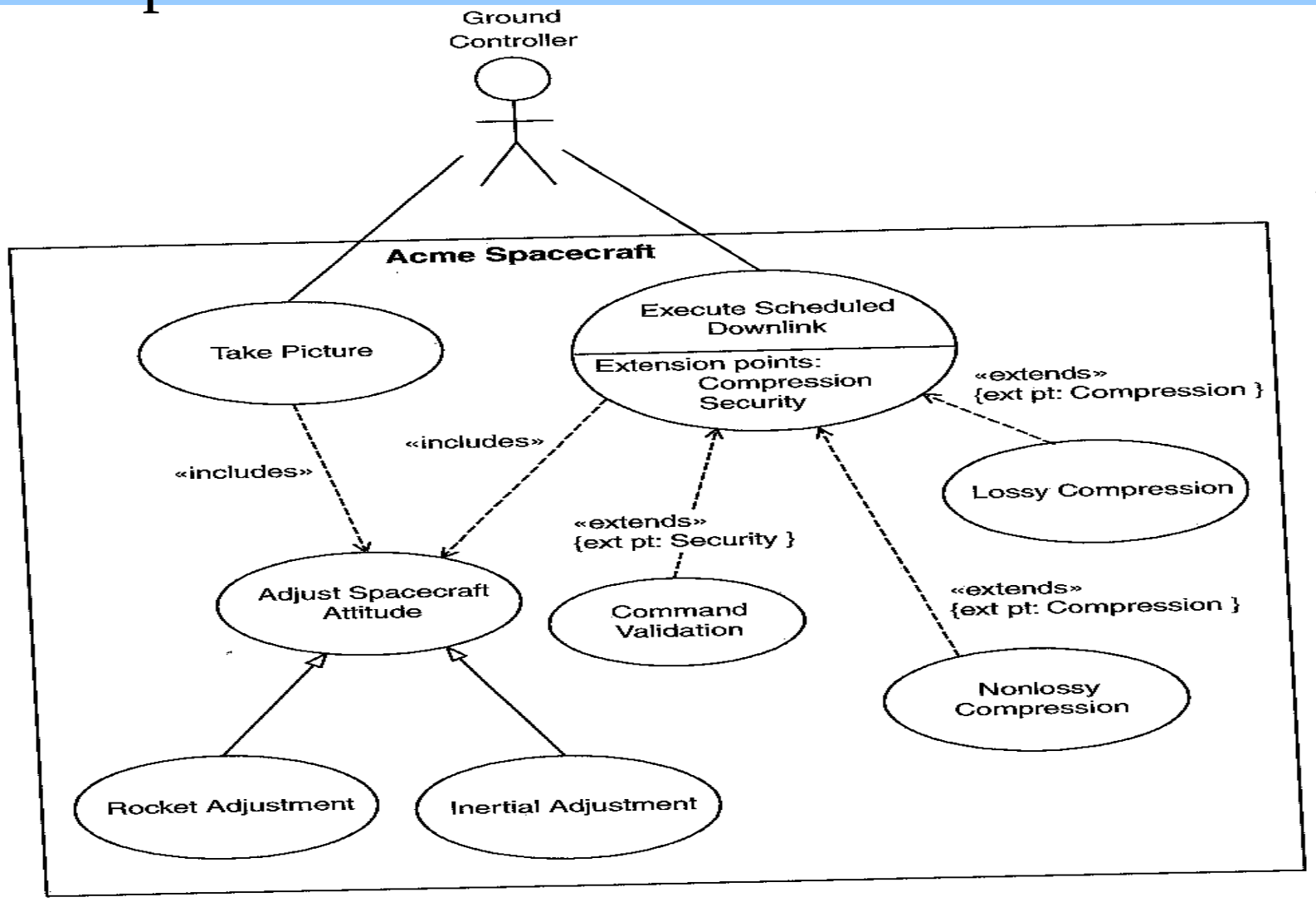


Figure 2-7: *Use Case Relations*

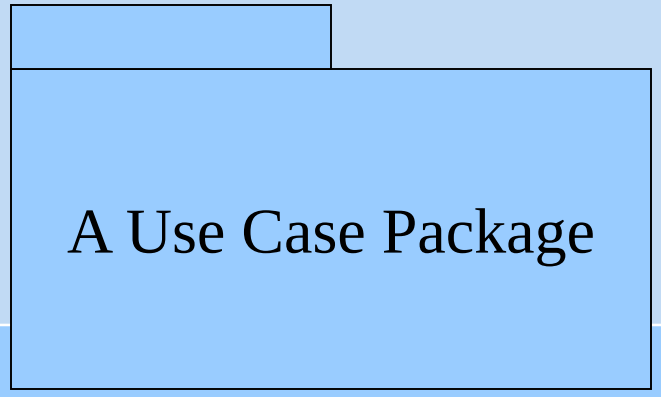
Use Case Diagram Rules

- There must be one extension point listed for each segment identified in the extension use case
- Although considered optional, it is recommended that the extending relationship also identify, within brackets, the condition under which the extension is executed

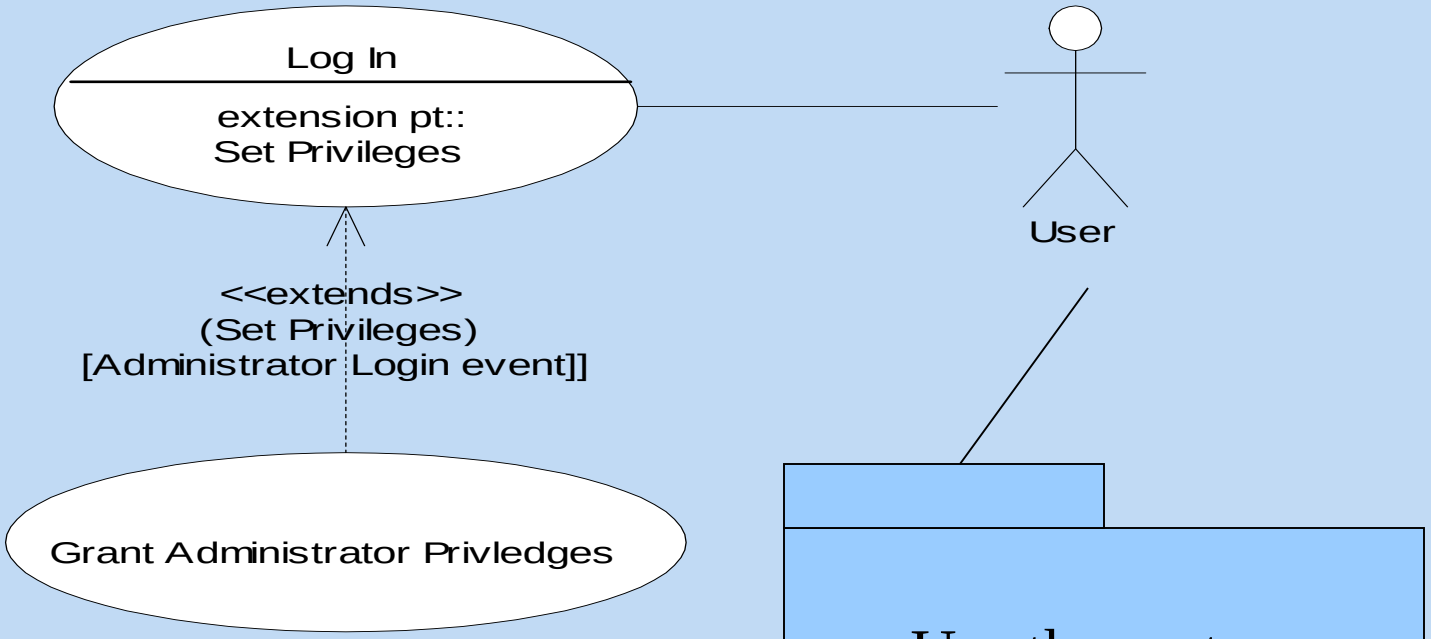
Use Case Diagram Rules

Use Case Packages

- Use cases are often written and organized in layers of abstractions using Use Case Packages
- A use case package contains a number of actors, use cases, their relationships, and perhaps other packages



Use Case Diagrams and Packages

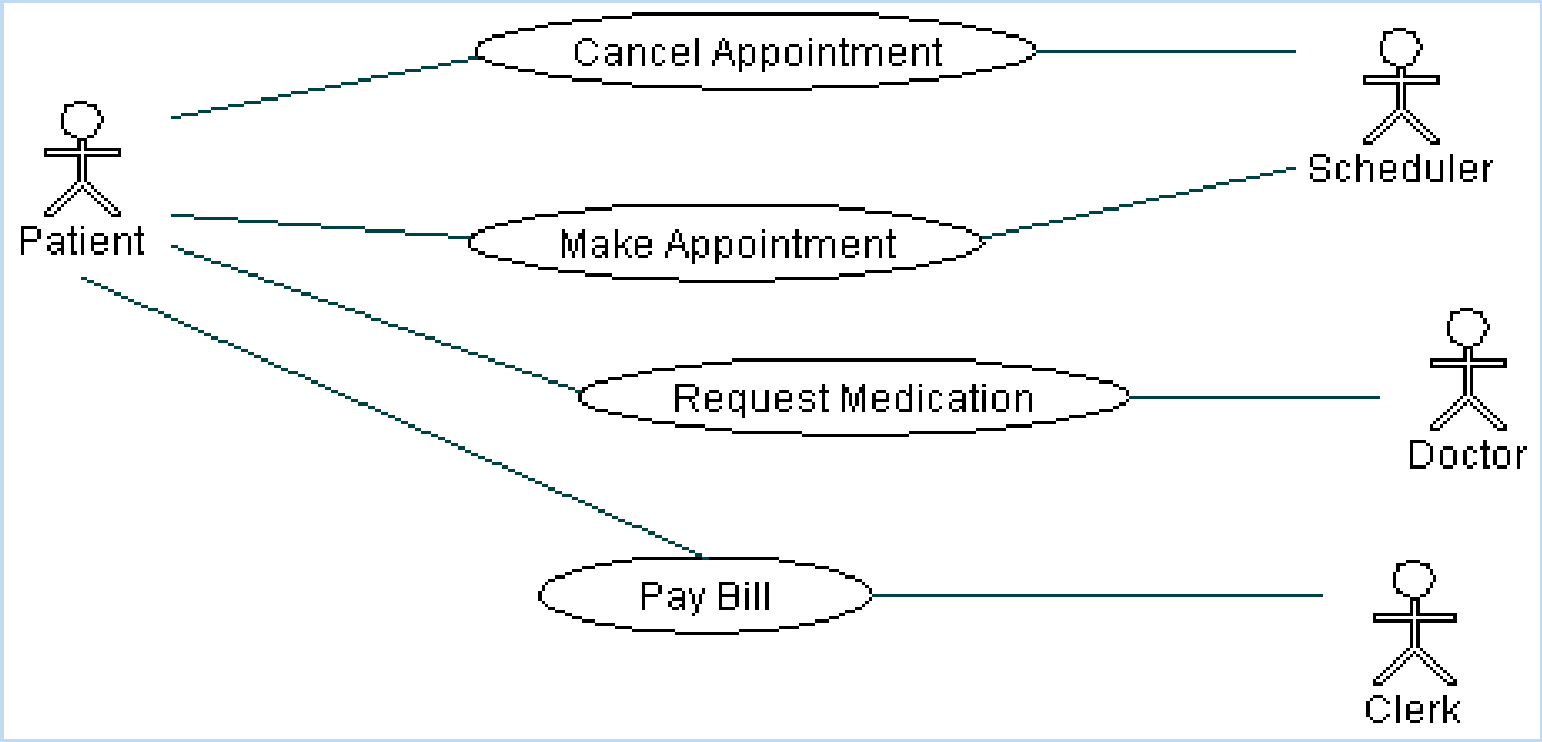


outline

- Review of development phases and UML Development – Overview
- Requirements Engineering and the Requirements model
- Introduction and importance of Use Case Diagrams
- Use Case Diagram Rules
- **Examples of Use Case diagrams**
- Requirements Elicitation Process
    1. Identify Actors
    2. Identify Scenarios
    3. Identify Use Cases
    4. Refine Use Cases
    5. Identify Relationships between actors and Use Cases
    6. Identify Initial Analysis Objects
    7. Identify Non-functional requirements

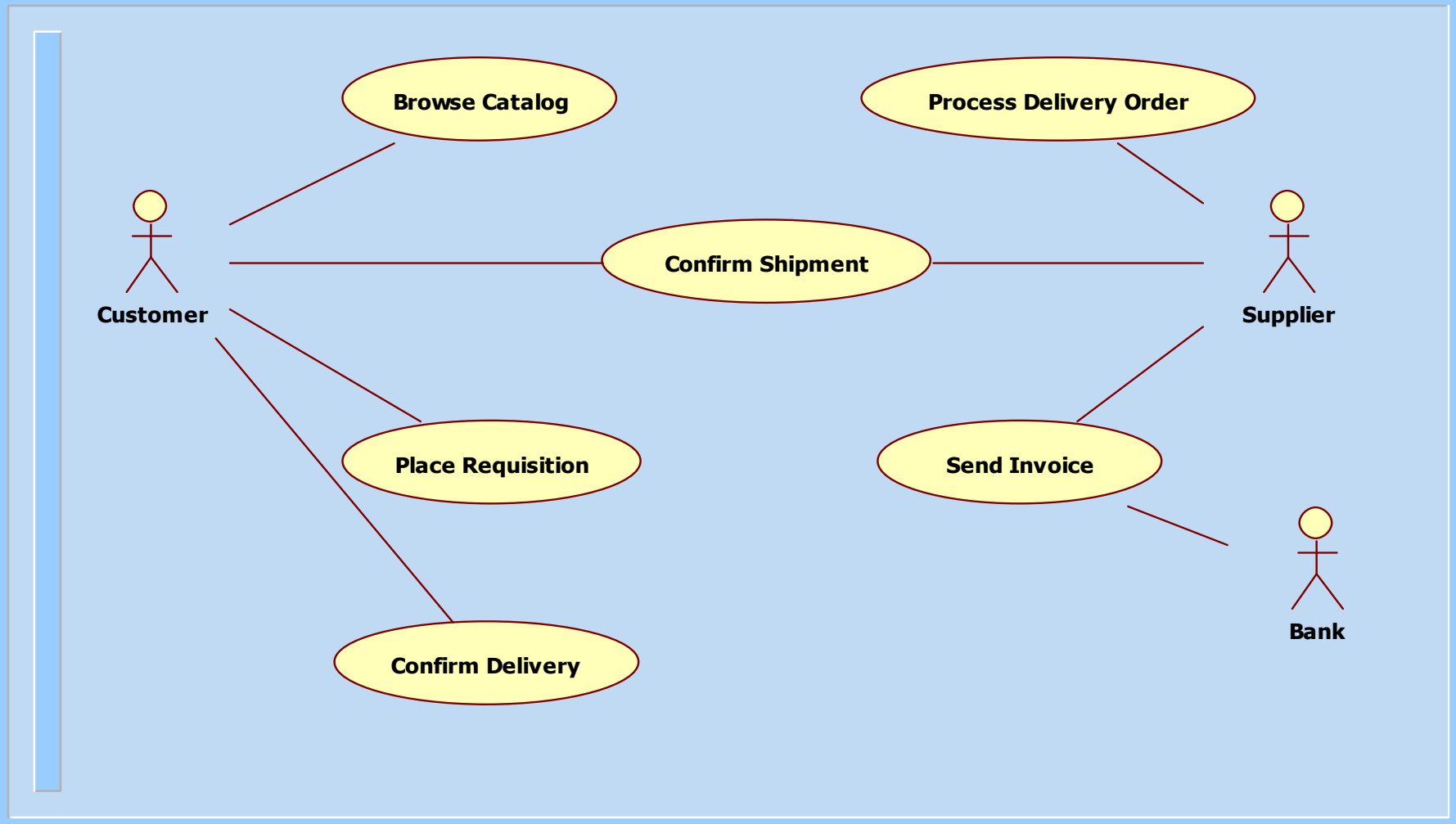
Examples of Use Case Diagrams

Example 1: Medical Clinic Software, could be missing use case relations

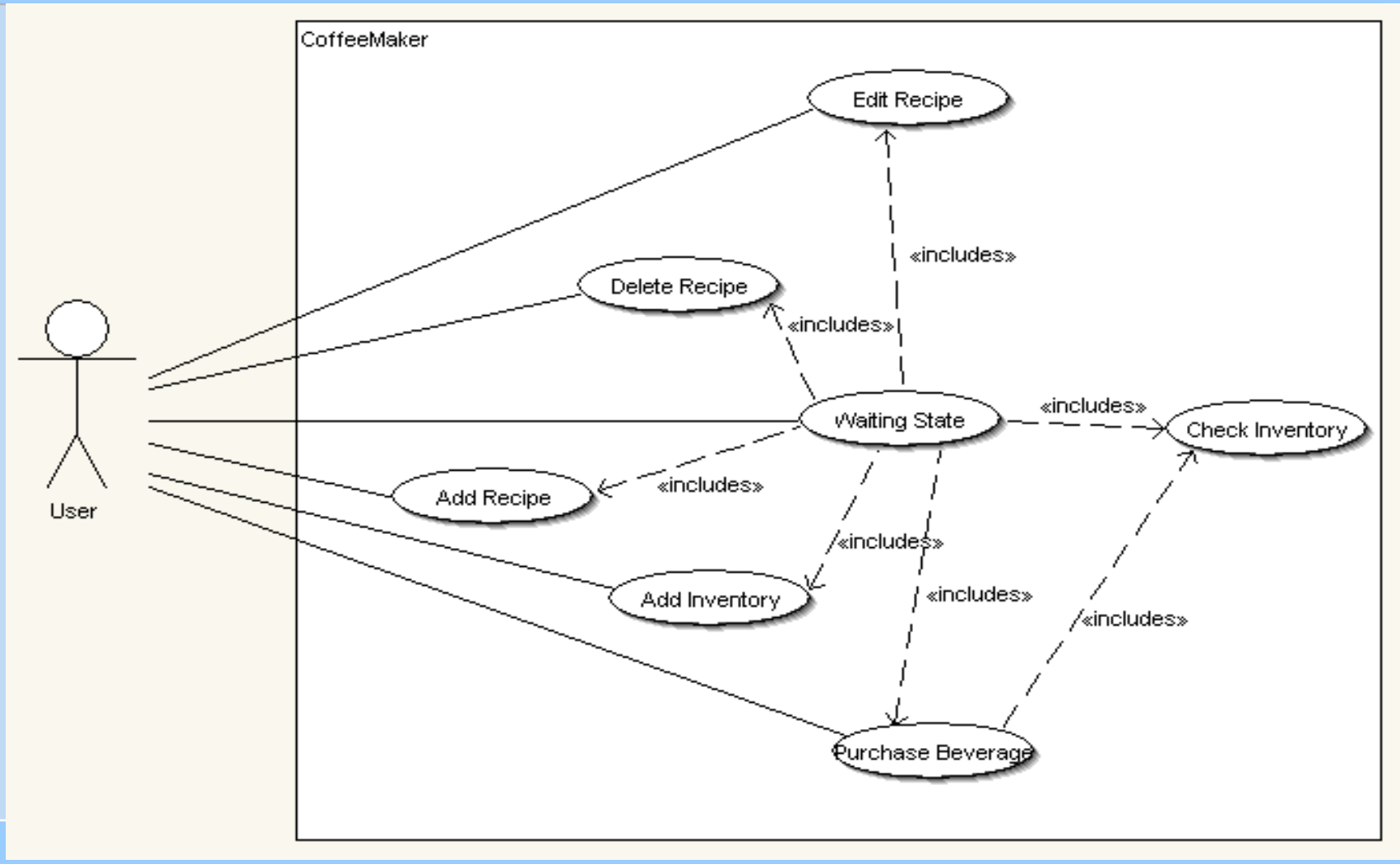


Each use-case is described further by textual document and by Scenarios developed using UML sequence diagrams

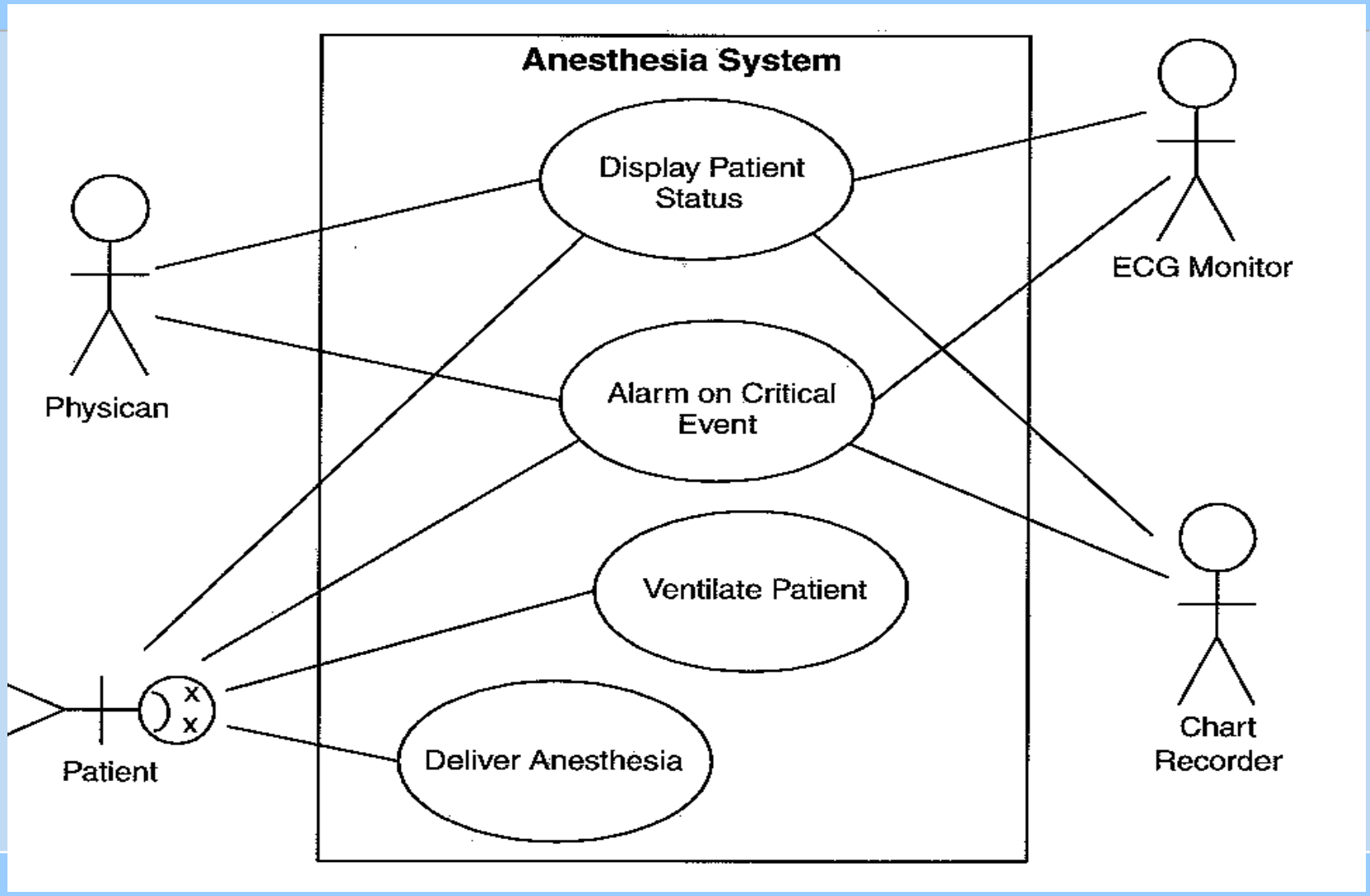
Example 2: E-Commerce Application (Incomplete)
Missing a link between “Place Requisition” and “Supplier” and missing use case relationships



Example 3: Coffee Maker, "waiting state" Not a good name for a use-case (bad example)



Example 4: Anesthesia System (Incomplete)



Example 5: Automated Air Traffic Control System (AATCS)

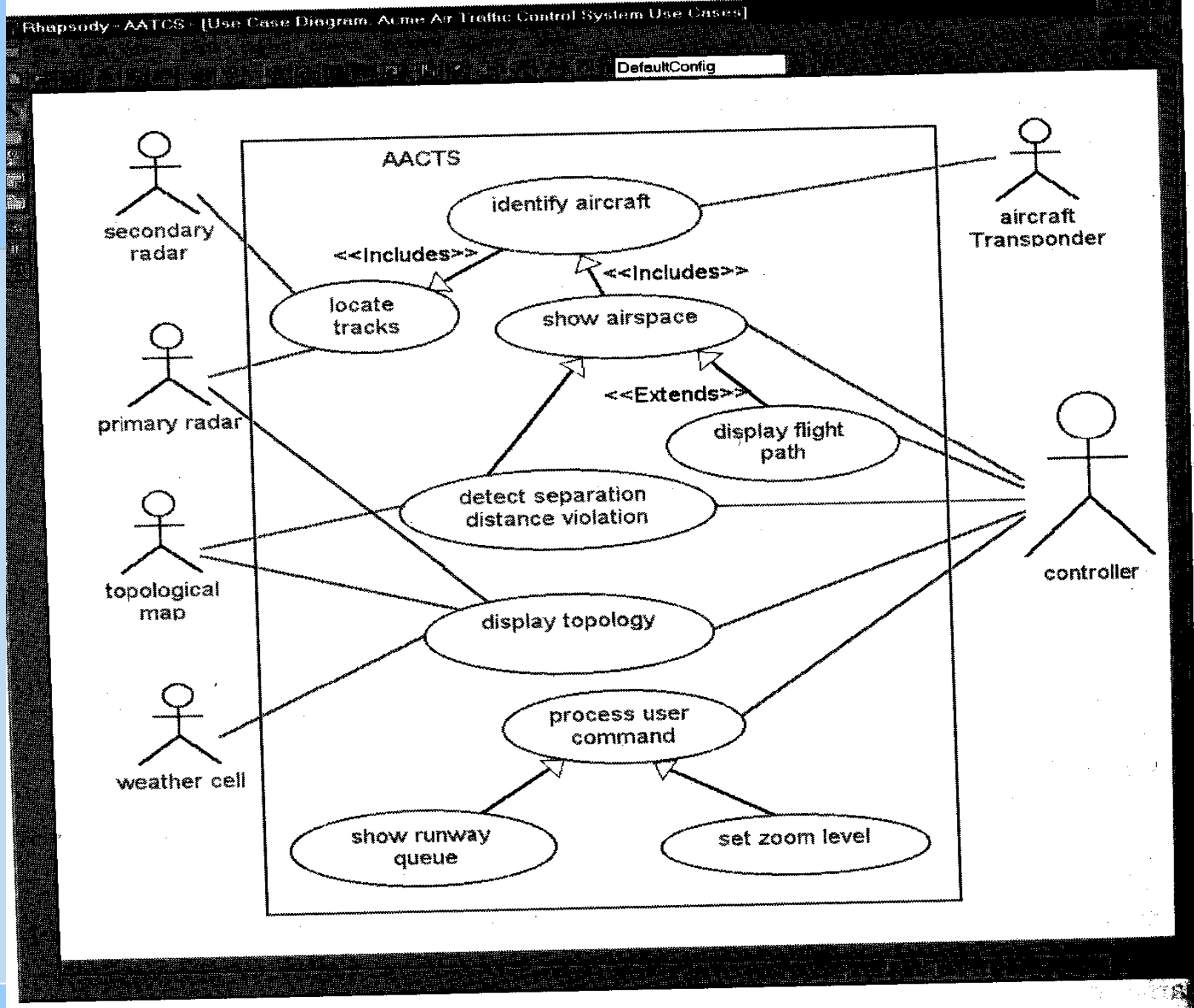
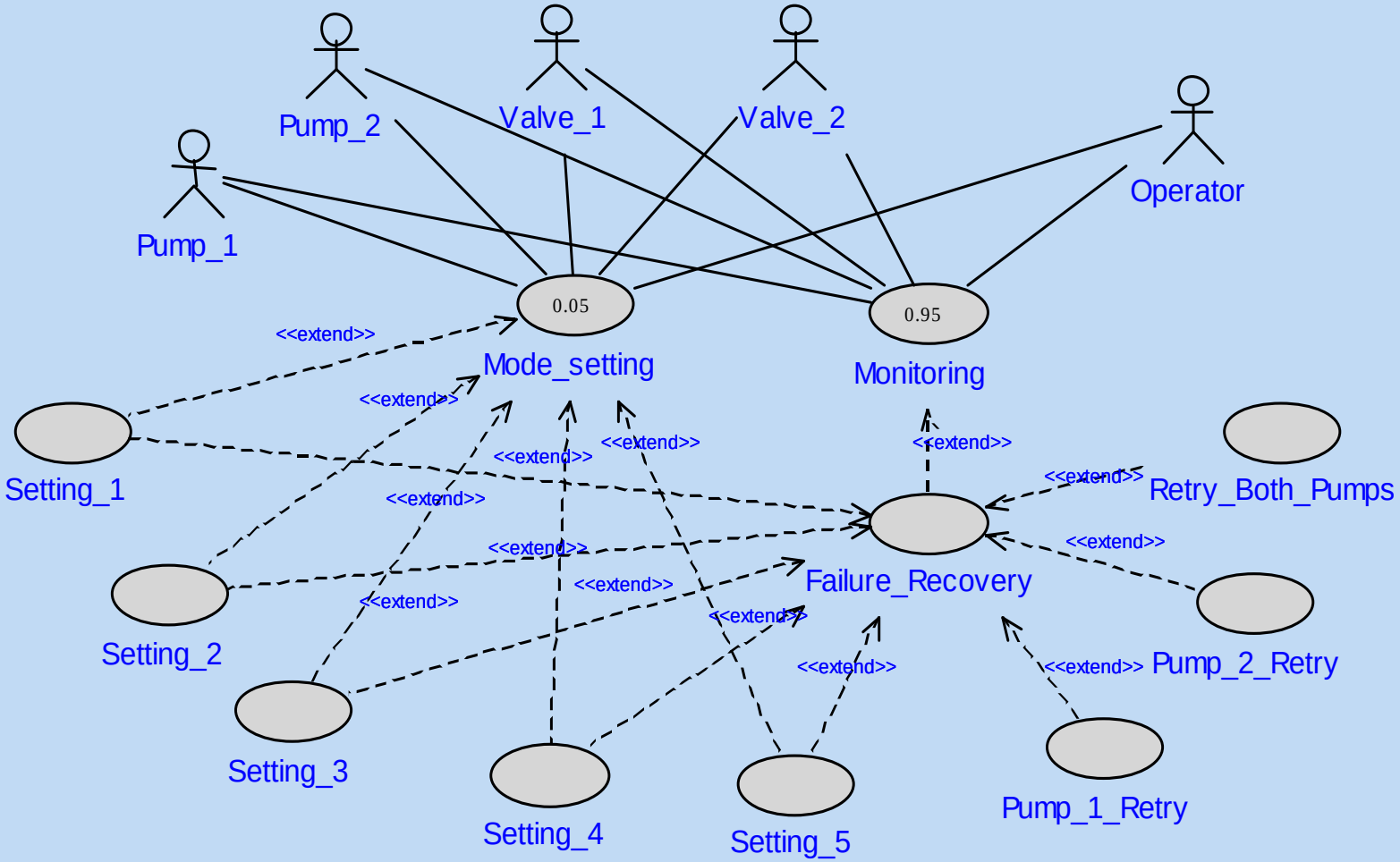


Figure 5-4: *AATCS Use Case Diagram*

Example 6: Use case diagram of the Internal Thermal Control subsystem (NASA-ISS project) Showing probabilities of use cases



Example 7: Showing QoS Reqrs. Using UML notes

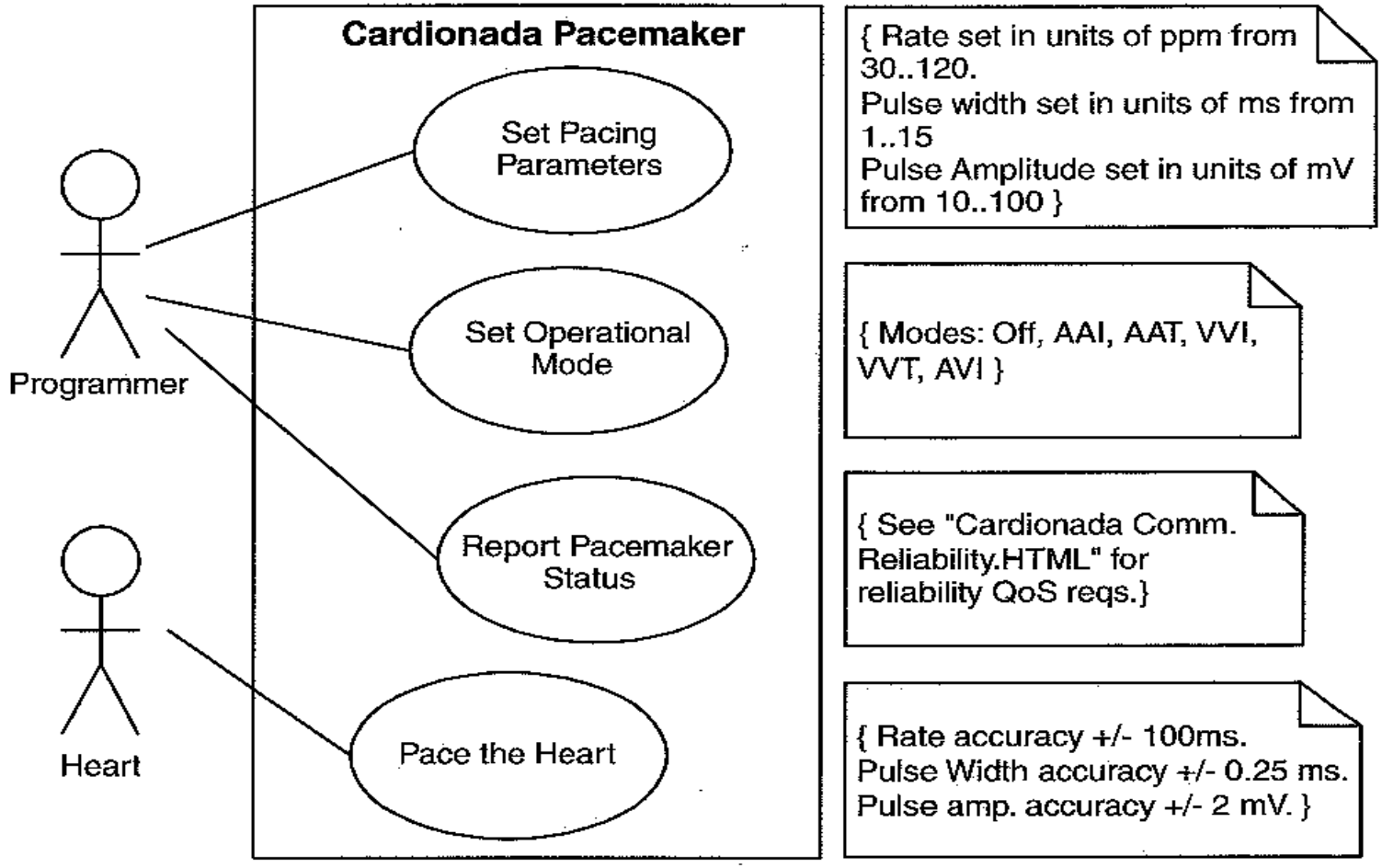
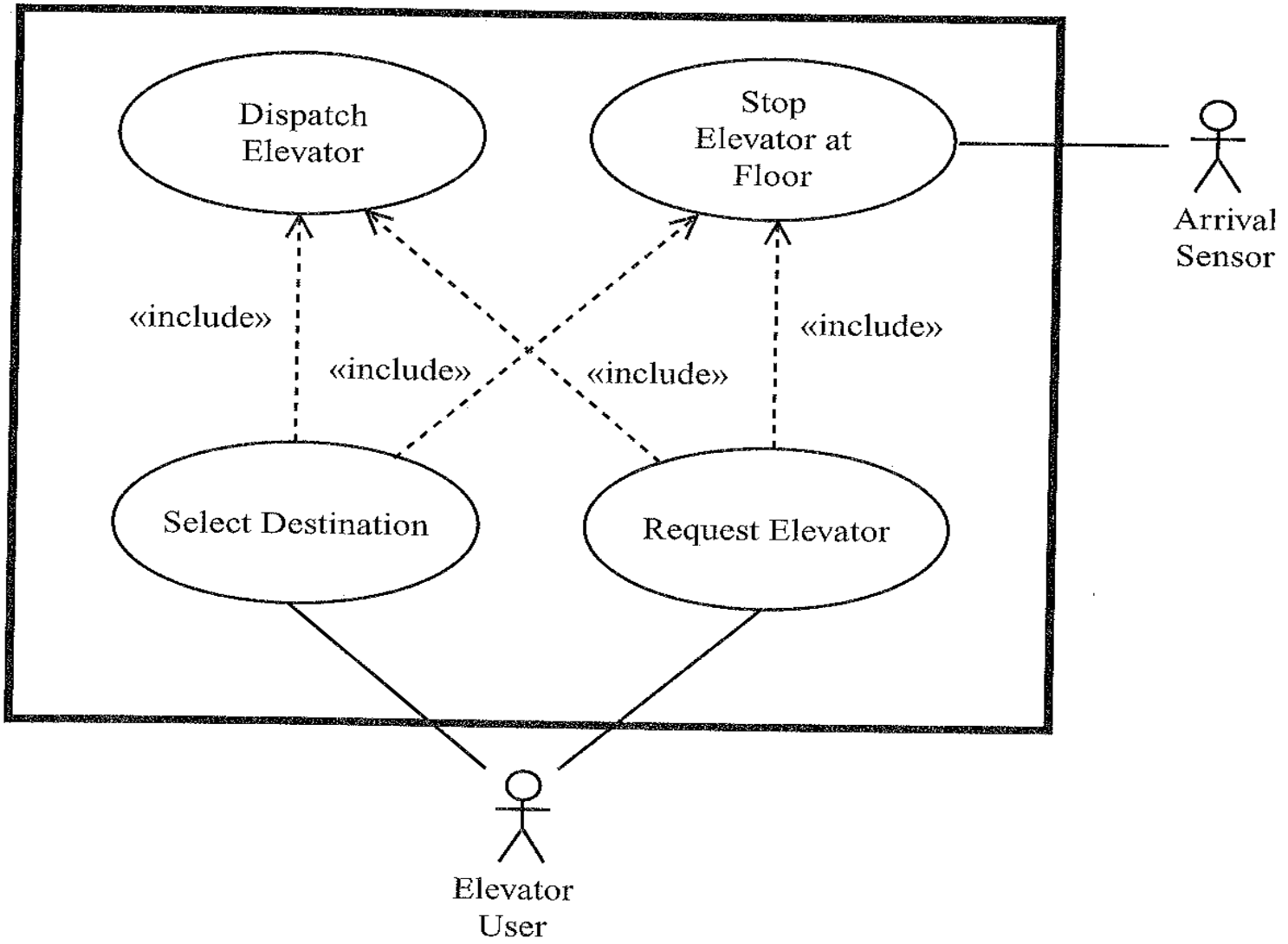


Figure 2-6: *Capturing QoS Requirements*

Example 8: Elevator Control System



Example 9: Factory Control System, consists of several packages of use cases

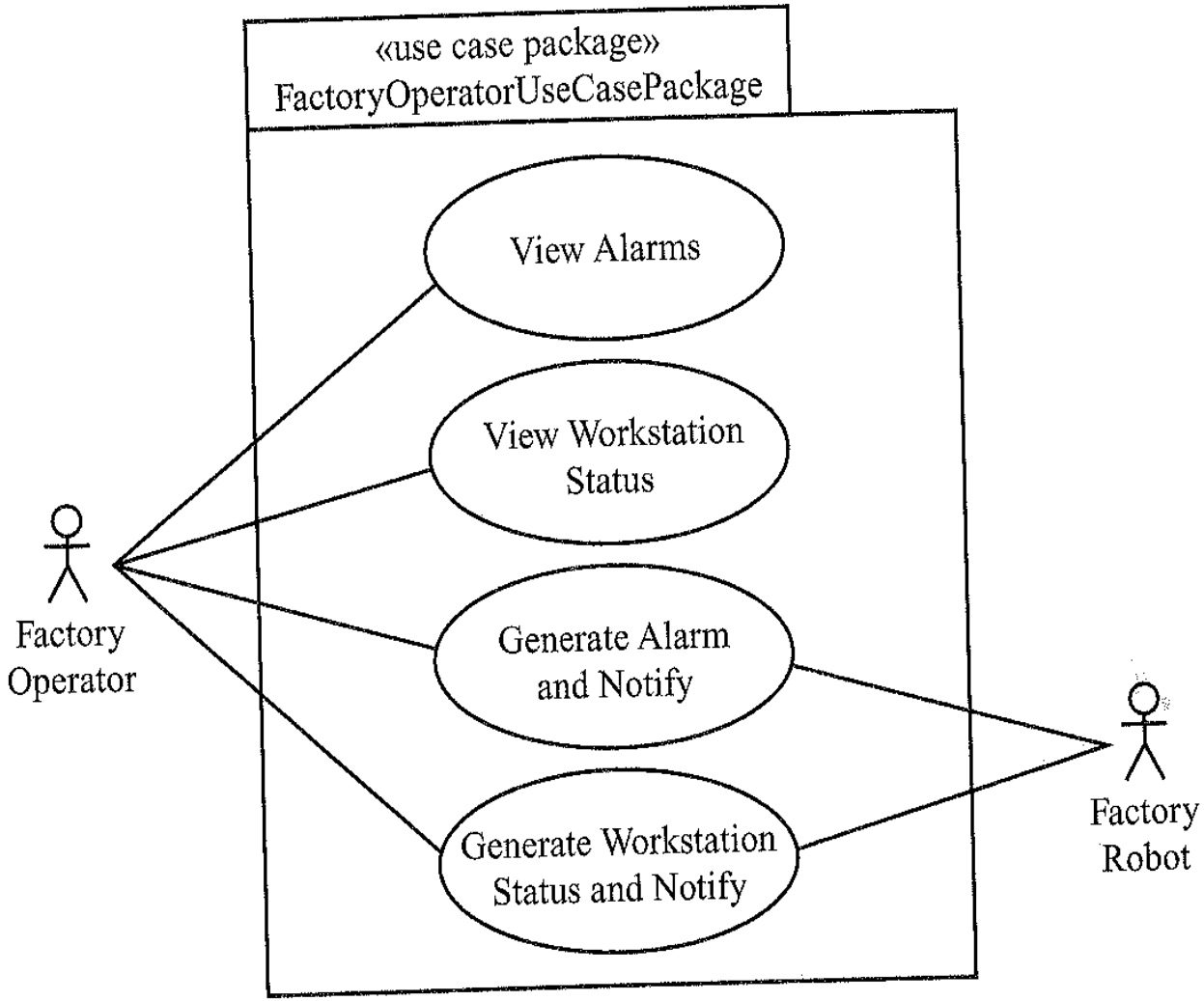


Figure 21.2 *Factory Operator use cases*

Example 9: Factory Control System (cont.)

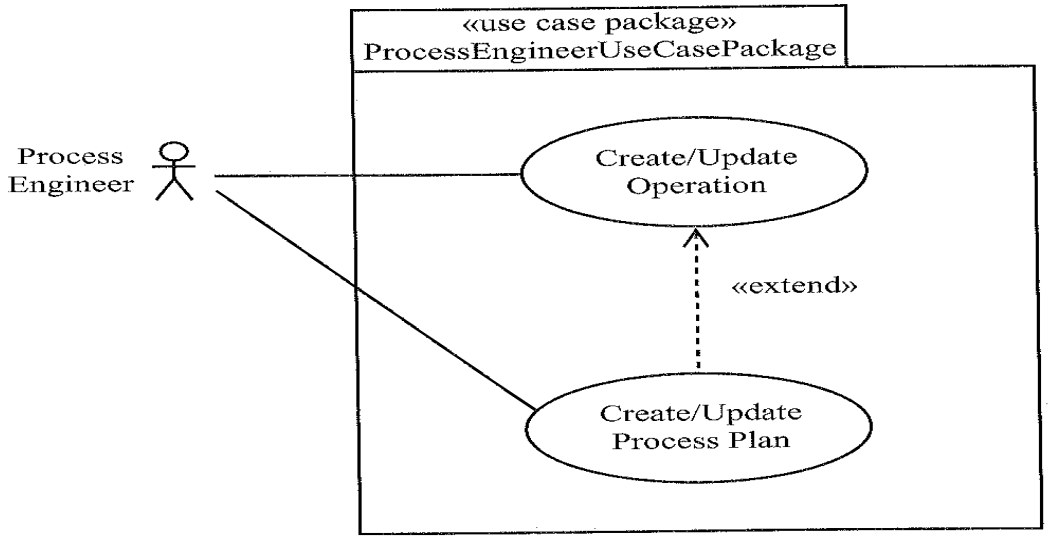


Figure 21.3 *Process Engineer use cases*

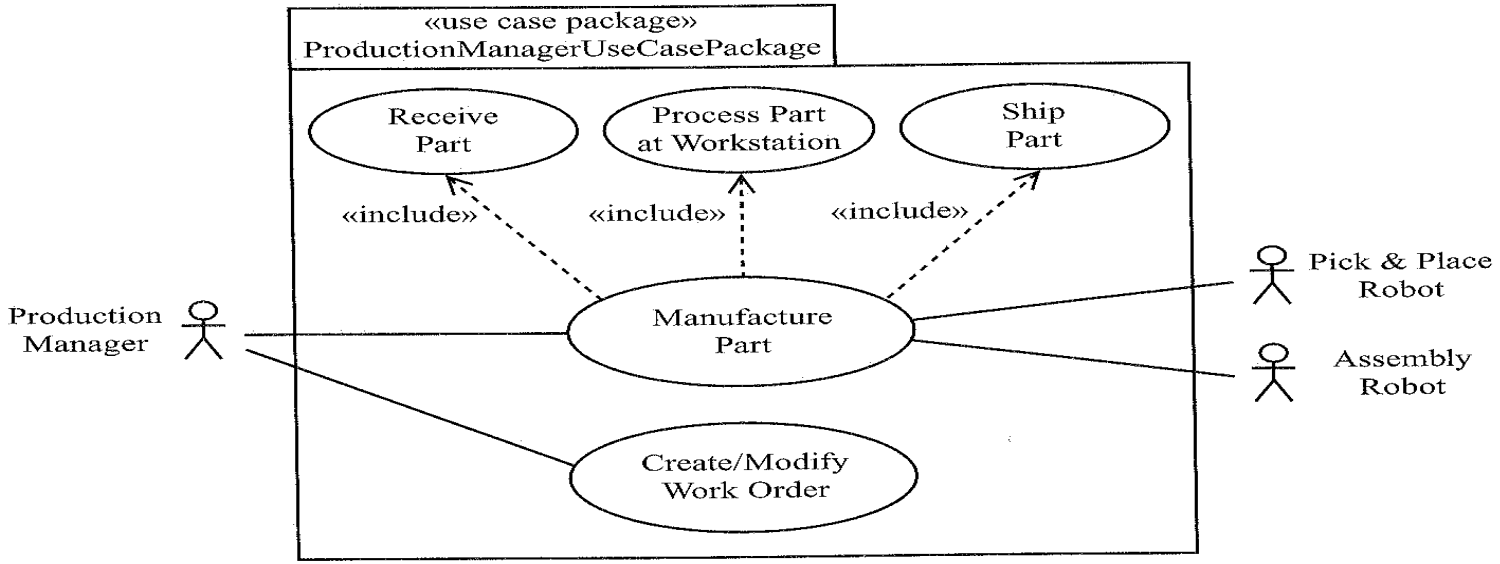


Figure 21.4 *Production Manager use cases*

Example 10: Cruise Control and Monitoring System: Cruise Control Package

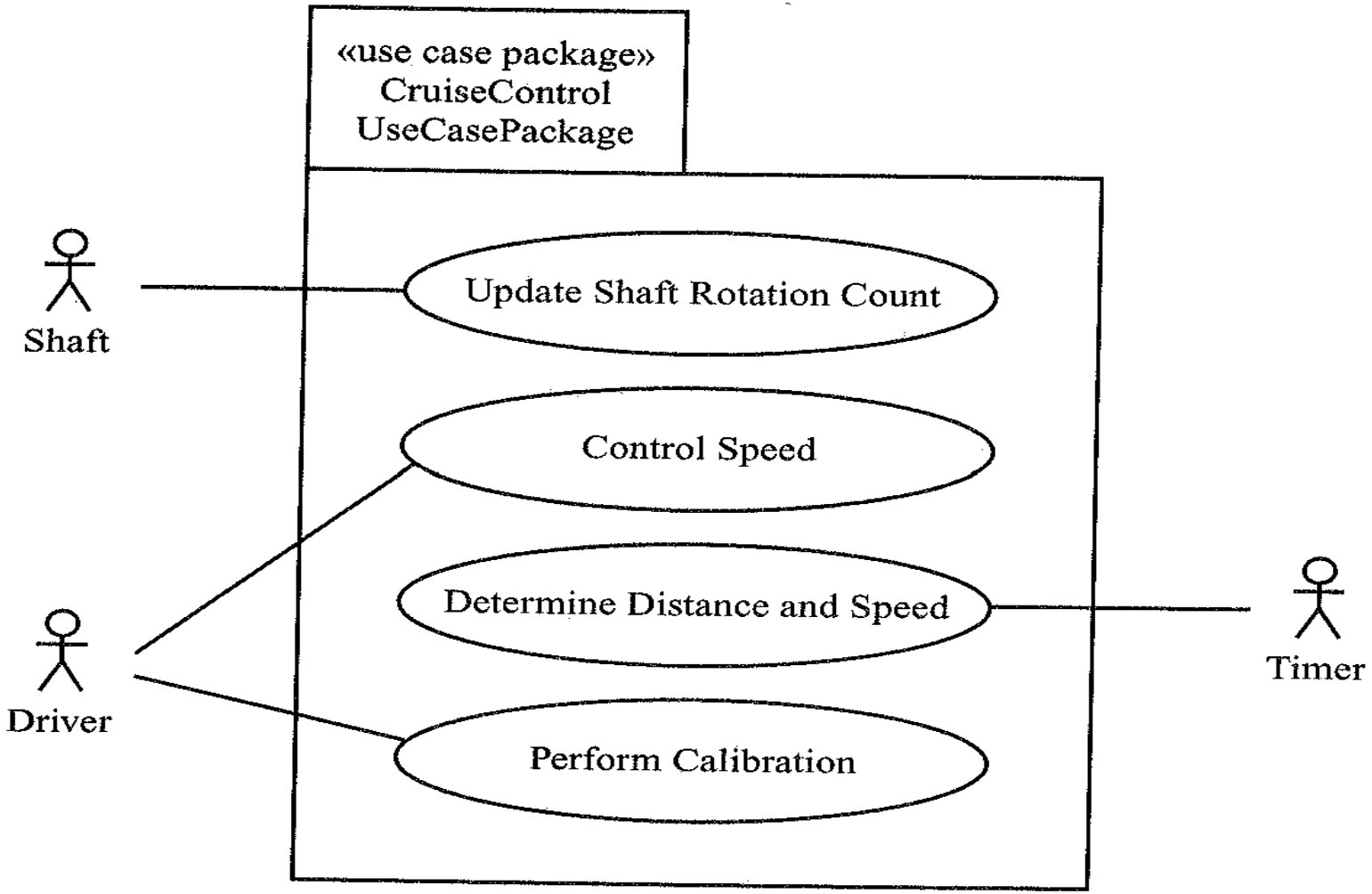


Figure 20.2 *Use case model: Cruise Control Use Case Package*

Example 10: Cruise Control and Monitoring System (cont.): Monitoring Package

Not Good
Too many use cases, try to aggregate

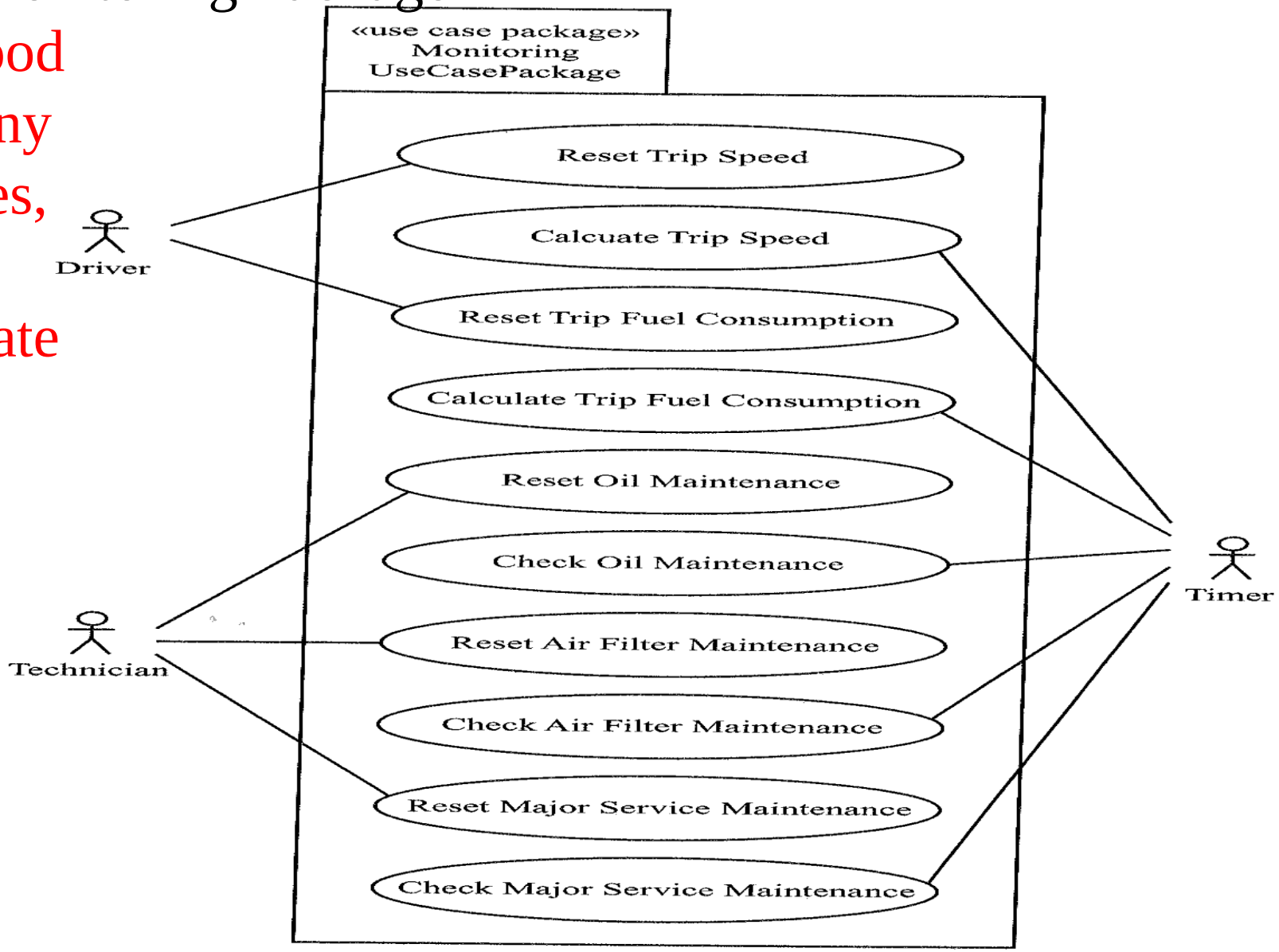
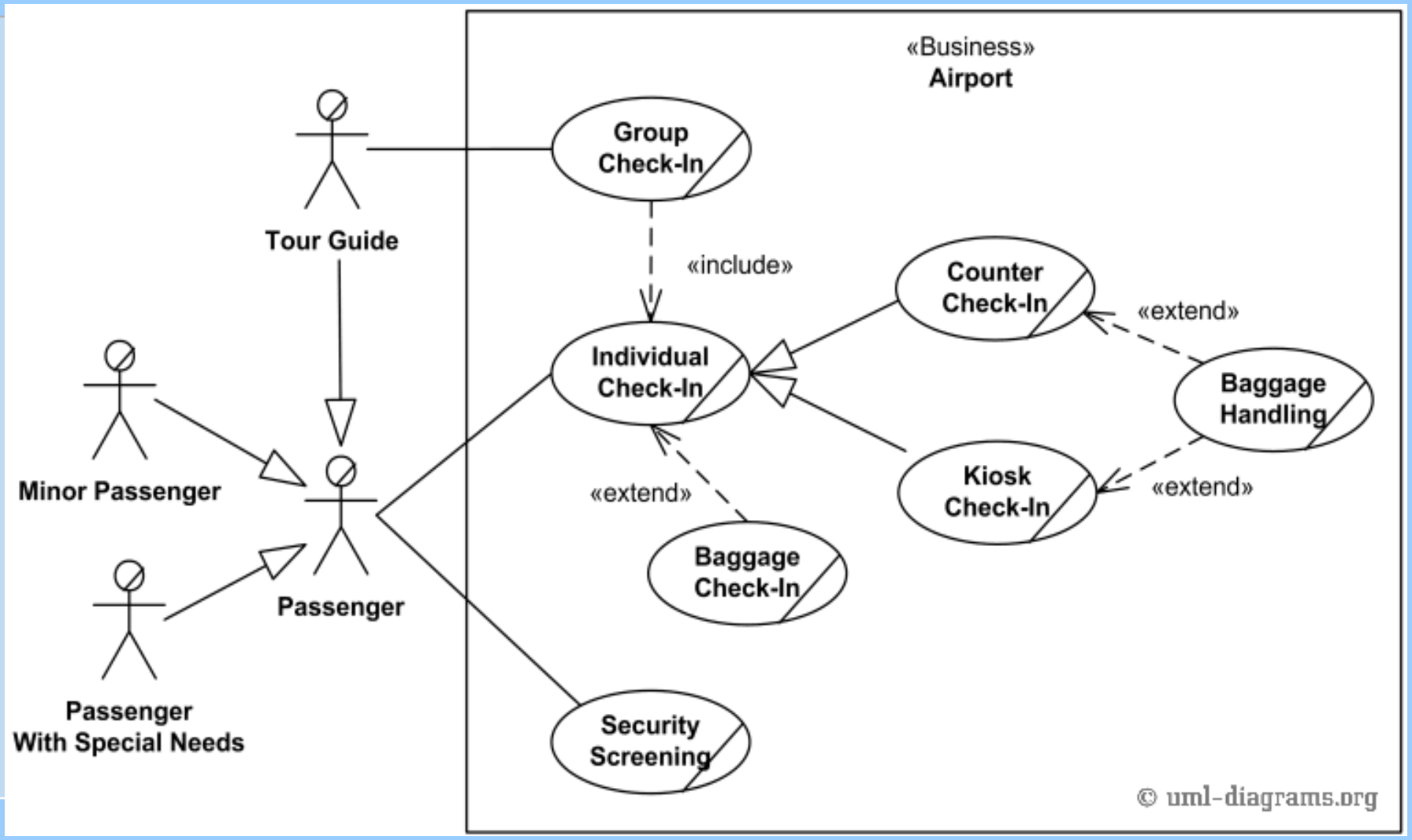


Figure 20.3 *Use case model: Monitoring Use Case Package*

Example 11: Airport Check-in



outline

- Review of development phases and UML Development – Overview
- Requirements Engineering and the Requirements model
- Introduction and importance of Use Case Diagrams
- Use Case Diagram Rules
- Examples of Use Case diagrams
- **Requirements Elicitation Process**
  1. Identify Actors
  2. Identify Scenarios
  3. Identify Use Cases
  4. Refine Use Cases
  5. Identify Relationships between actors and Use Cases
  6. Identify Initial Analysis Objects
  7. Identify Non-functional requirements

Requirements Elicitation Process

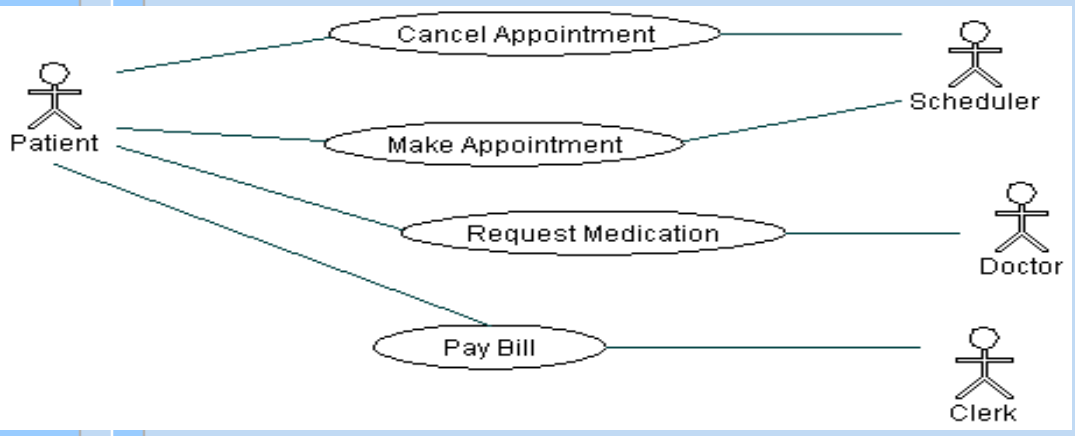
- The process of requirements elicitation consists of the following steps
  1. Identify Actors
  2. Identify Scenarios
  3. Identify Use Cases
  4. Refine Use Cases
  5. Identify Relationships between actors and Use Cases
  6. Identify Initial Analysis Objects
  7. Identify Non-functional requirements

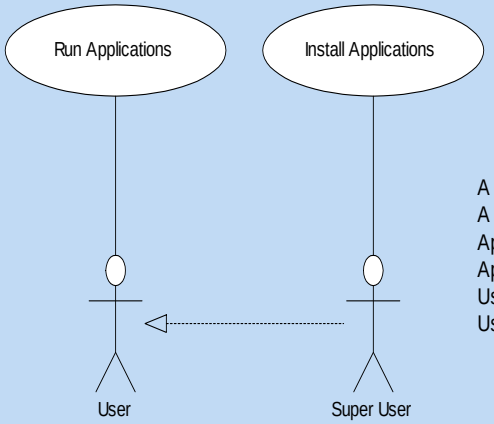
Requirements Elicitation Process

1. **Identifying Actors**: Identify the users or external entities the system will interact with or support.

   Examples: Medical Clinic Software: Patient, Doctor, Scheduler, and the Clerk

   Actors may have a generalization relationship



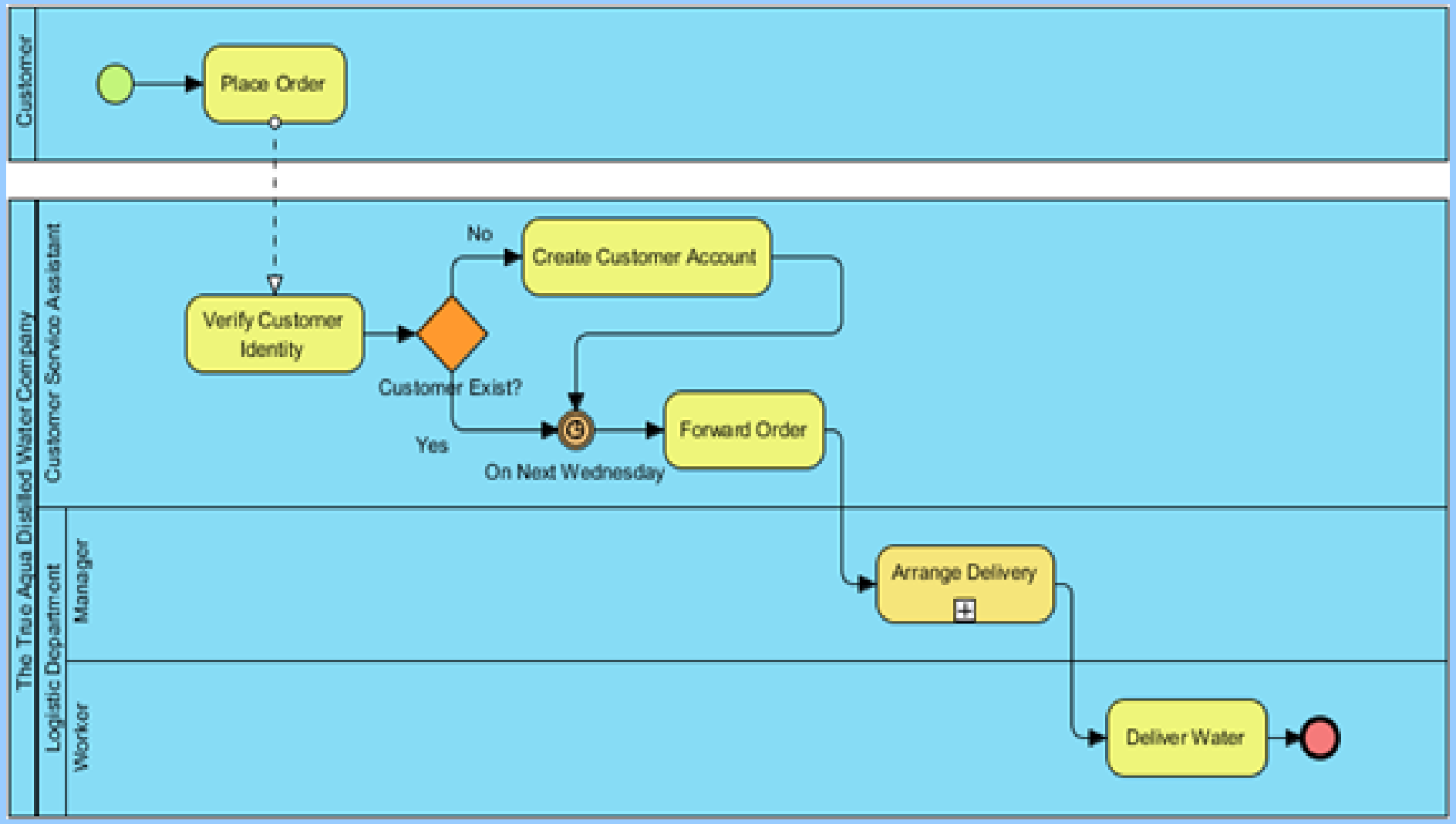


A User can Run Applications. A Super User can Install Applications and Run Applications, since a Super User is a specialization of User.

Requirements Elicitation Process

Identifying Actors from Business process models

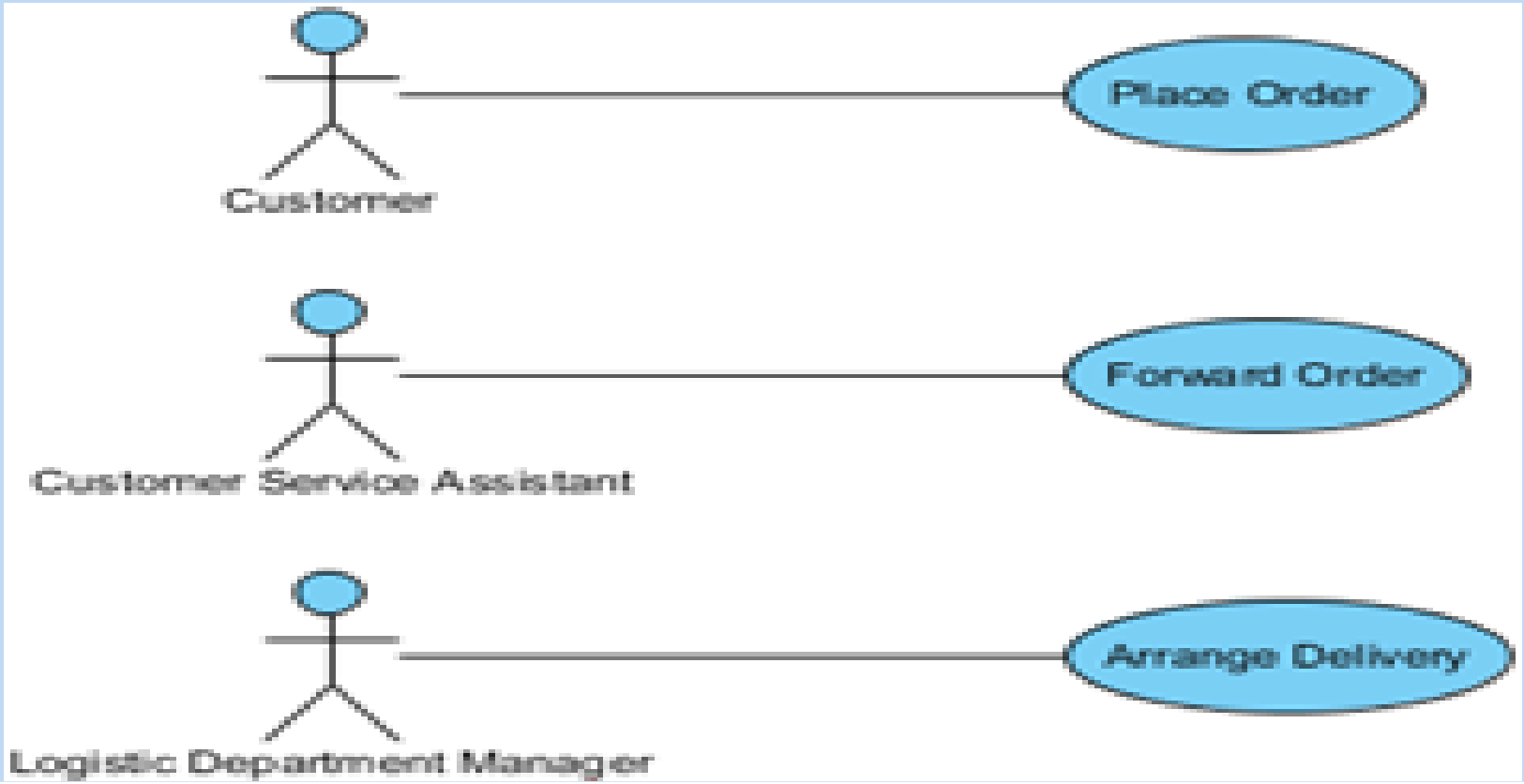
http://www.visual-paradigm.com/product/ag/tutorials/frombptouc.jsp



Requirements Elicitation Process

Identifying Actors from Business process models

http://www.youtube.com/watch?v=d4_yvQwC66o



Requirements Elicitation Process

2. **Identify Scenarios of usage** (user/actor stories): these are examples of typical user or actor interactions with the system. The are defined by a flow of events

   Example 1: Medical Clinic Software: in one scenario, the patient will contact the scheduler to make an appointment he finds an answer that office is closed, in another scenario he will contact the doctor to request medication, the doctor responds to him with the name of the medication

Requirements Elicitation Process
2. Identify Scenarios of usage (cont.)

Example 3: The Coffee Maker waits for user input. There are six options to chose from: 1) add recipe, 2) delete a recipe, 3) edit a recipe, 4) add inventory, 5) check inventory, and 6) purchase beverage, the user chooses to delete a recipe which does not exist.

Recall that the scenarios are user driven and not system driven (user perspective)

Requirements Elicitation Process

3. **Identify Use Cases**: Once scenarios of usage are identified, use cases are defined to model the main user-based processes of the system.

   Example: identify the “Make an Appointment” use case from one scenario and the “Request Medication” from another scenario

Requirements Elicitation Process

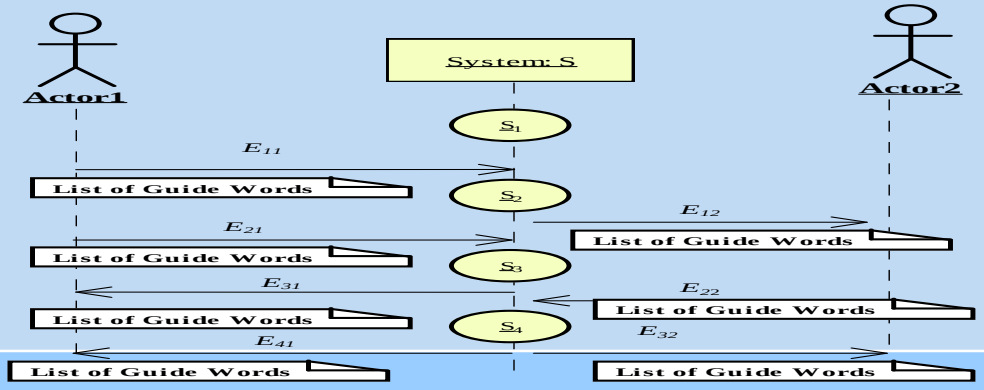
- The process of requirements elicitation consists of the following steps
  1. Identify Actors
  2. Identify Scenarios
  3. Identify Use Cases
  4. **Refine Use Cases**
  5. Identify Relationships between actors and Use Cases
  6. Identify Initial Analysis Objects
  7. Identify Non-functional requirements

Requirements Elicitation Process

4. **Refine Use Cases**: describe the details of each use case. A Textual template is used as well as UML interaction diagrams (UML sequence diagrams or object collaboration diagrams).

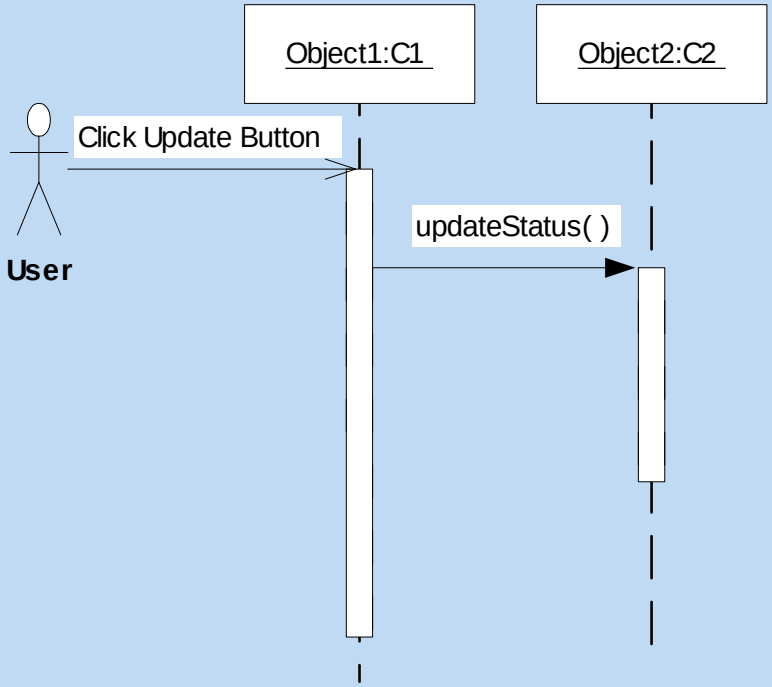
Textual: Brief Description, Actors, Preconditions, Basic Flow of Events, Alternate flow of events,

System Sequence Diagram



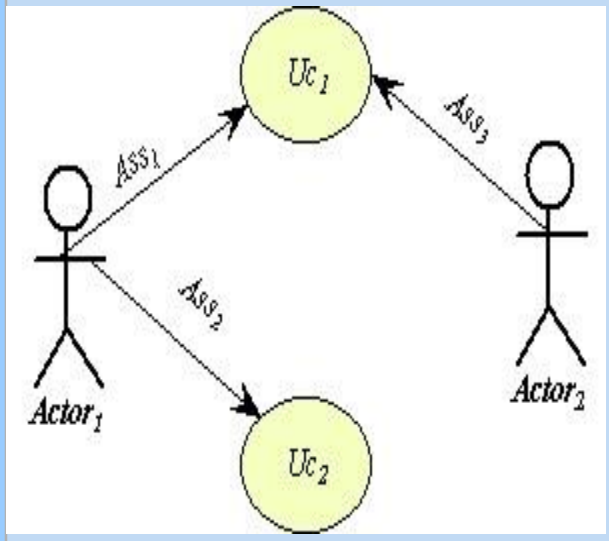
Requirements Elicitation Process
4. Refining Use Cases (cont.)

Sequence Diagrams capture scenarios
(to be discussed later in slides 4)

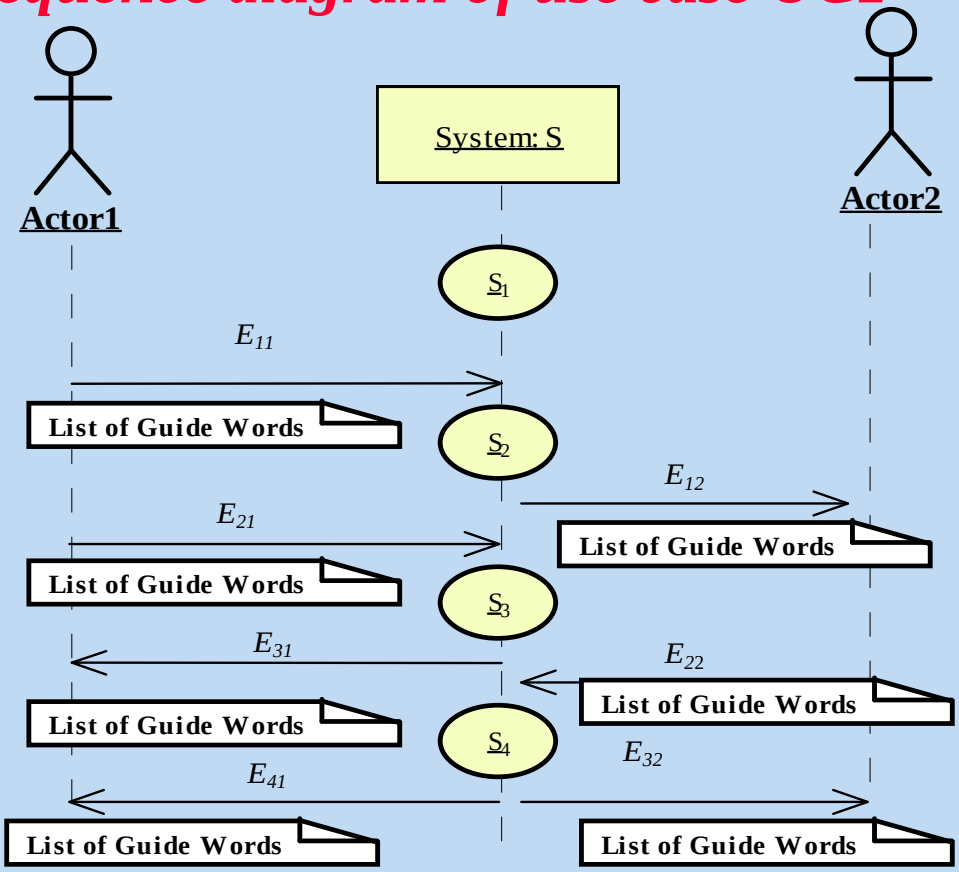


Requirements Elicitation Process
4. Refining Use Cases (cont.)
System Sequence Diagram

System S Use-case diagram



The sequence diagram of use case UC1



Requirements Elicitation Process
4. Refining Use Cases (cont.)

A Template for textual description of Use Cases

Use Case name: Name of Use Case, which should be related to the result, purpose or the event of the Use Case.

Purpose: The main purpose of the Use Case and what the participants expect of the transaction.

Description: A paragraph(s) describing the goal(s) and the scenario(s) illustrated by this Use Case.

Requirements Elicitation Process
4. Refining Use Cases (cont.)

A Template for textual description of Use Cases (cont.)

Actors: Who or what participates in the Use Case. That includes what individuals, organizations, job functions, software applications, software functions or machines collaborate in the Use Case.

Data Content: What data are in scope of this Use Case. What information is exchanged in the transactions that implement the Use Case.

Preconditions: What conditions are expected to exist prior to the start of the Use Case.

Begins When: What starts or triggers the performance of this Use Case.

Requirements Elicitation Process
4. Refining Use Cases (cont.)

A Template for textual description of Use Cases (cont.)

Ends When: When is the Use Case finished.

Exceptions: What exceptional outcomes are there besides the normal one expected for a successful performance of the Use Case.

Post Conditions: What is the state of "the system" after the Use Case has been completed

References: If this Use Case references other works or documents, or other Use Cases the references to these sources are placed here

Requirements Elicitation Process
4. Refining Use Cases (cont.)

- A simplified example of some sections: The Coffee Maker

UC3: Flow of Events for the *Delete Recipe* Use Case

3.1 **Preconditions:** recipes exist in the system

3.2 **Main Flow**: The user will be shown a list of all recipes in the system, and asked to choose the recipe, by number, that they wish to delete. [S1][E1][E2]

3.3 **Subflows**:

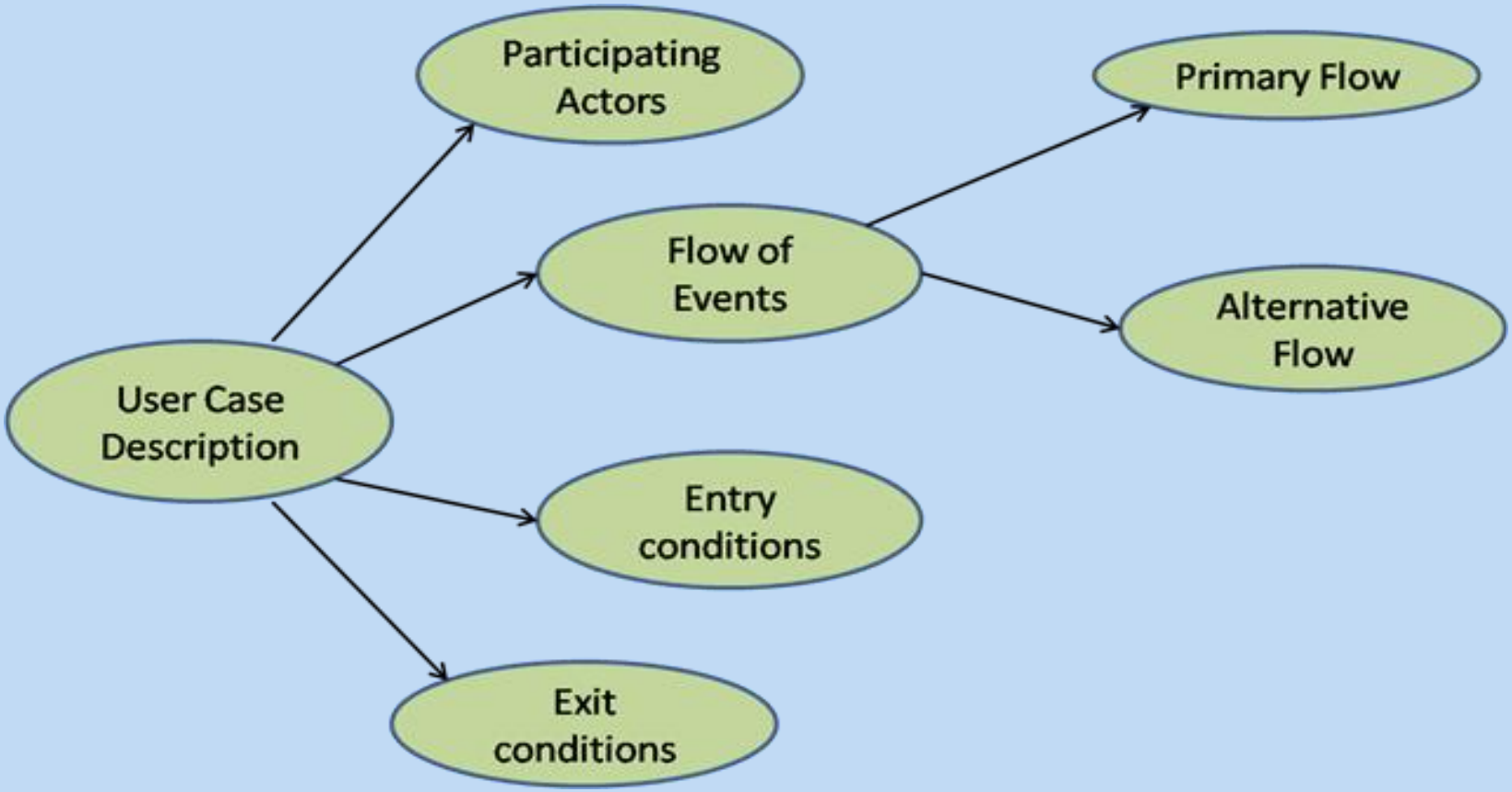
[S1] If the user selects an empty recipe to delete, the user is returned to the main menu.

3.4 **Alternative Flows**:

[E1] If the user selects a number that is out of bounds of the number of recipes, the user is returned to the main menu.

[E2] If the user enters a alphabetic character, the user is returned to the main menu. .

The components of Use case description template



Requirements Elicitation Process

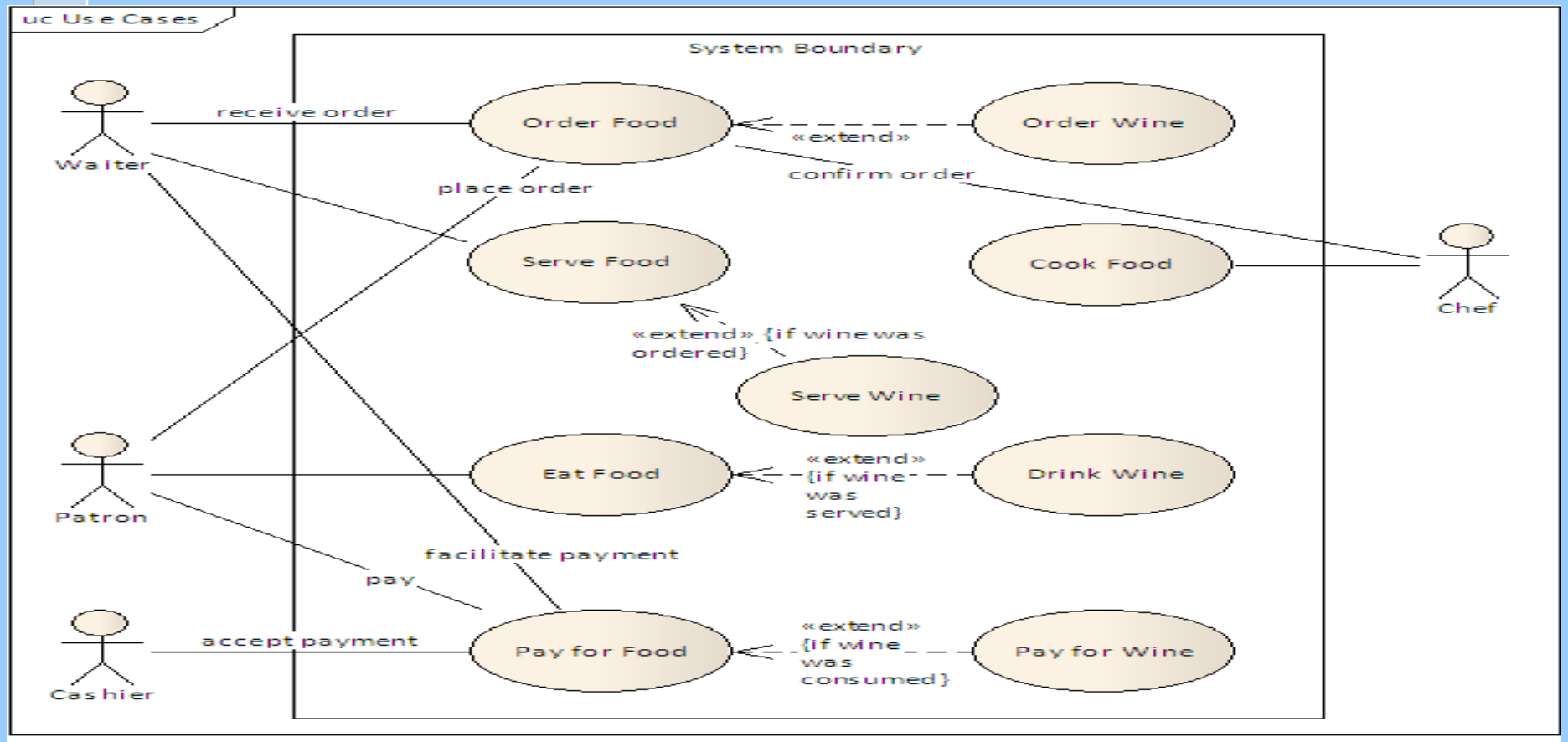
- The process of requirements elicitation consists of the following steps
  1. Identify Actors
  2. Identify Scenarios
  3. Identify Use Cases
  4. Refine Use Cases
  5. **Identify Relationships between actors and Use Cases**
  6. **Identify Initial Analysis Objects**
  7. **Identify Non-functional requirements**

Requirements Elicitation Process

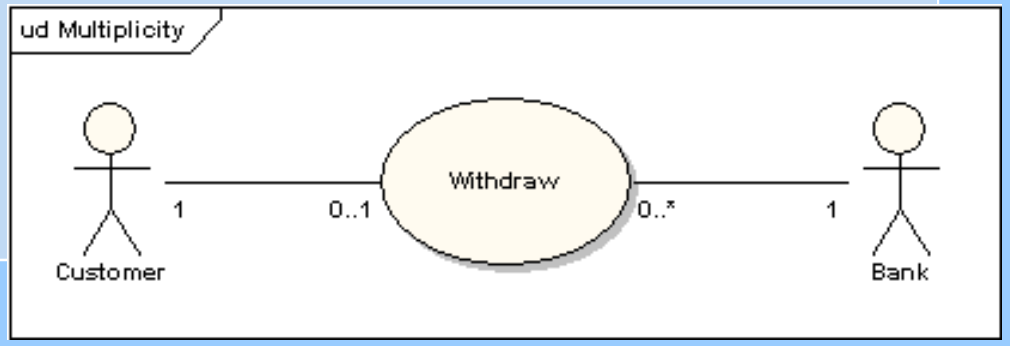
5. Identify Relationship among Actors and Use Cases:

- Establish and Label (initiate, set, or get) the association or communication relationship between actors and use cases
- Establish *include*, *extend* or *generalization* relationships between use cases
  - Use include to factor out redundancies for "common" use cases (or utility Use Cases) used by other use cases
  - Use extend to show use cases having added functionality to other use cases
  - Use generalization to add abstraction or subtype cases between use cases

Label Associatons,e.g. Receive order, and accept payment,



Identify Multiplicity of associations



Requirements Elicitation Process

6. Identify Initial Analysis Objects

These can be nouns or processes in the textual requirements (also called Domain objects)

Types of objects may include:

- Interfaces to External Entities: Sensors, actuators, control panel, devices
- Information Items : Displays, Commands, etc.
- Entities which establishes the context of the system (to support Use case functionality): Controller, monitors, schedulers, handlers, servers, agents, wrappers

Requirements Elicitation Process

7. Identify Non-functional requirements

Includes the following types:

1. Usability: e.g. determined by the level of user expertise to determine user interface look and feel
2. Reliability: determined by the risk of Failures (e.g. safety critical systems must have high level of reliability
3. Performance: e.g. response time of usage scenarios, throughput (no of transactions processed per unit time)
4. Maintainability (Supportability): the level of adaptive, perfective, and corrective maintenance
5. Implementation/operation constraints