UNIT-1

Introduction to Object Oriented Analysis and Design

WHAT IS OBJECT?

- An "object" is anything to which a concept applies, in our awareness.
- Things drawn from the problem domain or solution space.
  E.g., a living person in the problem domain, a software component in the solution space

WHAT IS OBJECT-ORIENTATION?

➔ If any application was developed based on the following concepts then that application will comes under object orientation:

  - Class and Object
  - Message
  - Operation and Method
  - Encapsulation
  - Abstraction
  - Inheritance
  - Polymorphism

Class and Object in UML

UML class is a classifier which describes a set of objects that share the same

- ✓ features,
- ✓ constraints,
- ✓ semantics (meaning).

An object is an individual [thing] with a state and relationships to other objects. The state of an object identifies the values for that object of properties of the classifier of the object.

Message in UML

A message defines a specific kind of communication between lifelines of an interaction. A communication can be, for example, invoking an operation, replying back, creating or destroying an instance, raising a signal. It also specifies the sender and the receiver of the message.

Operation and Method in UML

An operation has a signature, which may restrict the actual parameters that are possible. Method is defined as the implementation of an operation. It specifies the algorithm or procedure associated with an operation.

Encapsulation in UML

Object is defined as an entity with a well-defined boundary and identity that encapsulates state (attributes and relationships) and behavior (operations, methods, and state machines).

Abstraction in UML

Abstraction in UML corresponds to the concept of abstraction in OOD. UML provides different types (subclasses) of abstraction, including realizations (i.e. implementations).

Abstraction is a dependency relationship that relates two elements or sets of elements (called client and supplier) representing the same concept but at different levels of abstraction or from different viewpoints.

Inheritance in UML

Inheritance supplements generalization relationship.

Generalization is defined as a taxonomic relationship between a more general element and a more specific element. The more specific element is fully consistent with the more general element and contains some additional information. An instance of the more specific element may be used where the more general element is allowed.

Polymorphism in UML

There is no definition of polymorphism in UML specifications but there are some differences in how this term is used in different versions of UML.

- In UML 1.4.2 operation declares whether or not it may be realized by a different method in a subclass. Methods realizing polymorphic operation have the same signature as the operation and have a body implementing the specification of the operation. Methods in descendants override and replace methods inherited from ancestors.
- The UML 2.4.1 specification had one obscure statement mentioning polymorphism that is Operations are specified in the model and can be dynamically selected only through polymorphism.

WHY OBJECT ORIENTATION:

Reduced Maintenance: The primary goal of object-oriented development is the assurance that the system will enjoy a longer life while having far smaller maintenance costs. Because most of the processes within the system are encapsulated, the behaviors may be reused and incorporated into new behaviors.

Real-World Modeling: Object-oriented system tend to model the real world in a more complete fashion than do traditional methods. Objects are organized into classes of objects, and objects are associated with behaviors. The model is based on objects, rather than on data and processing.

Improved Reliability and Flexibility: Object-oriented system promise to be far more reliable than traditional systems, primarily because new behaviors can be "built" from existing objects.

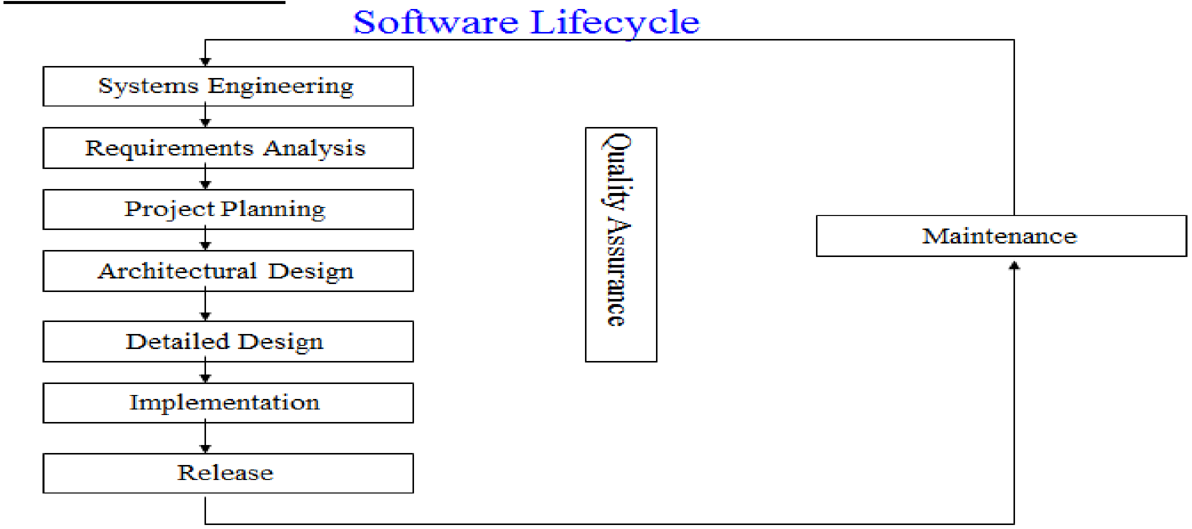
High Code Reusability: When a new object is created, it will automatically inherit the data attributes and characteristics of the class from which it was spawned.

WHAT IS OOAD?

Analysis: Emphasizes an investigation of the problem and requirements rather than a solution. (Understanding, finding and describing concepts in the problem domain.)

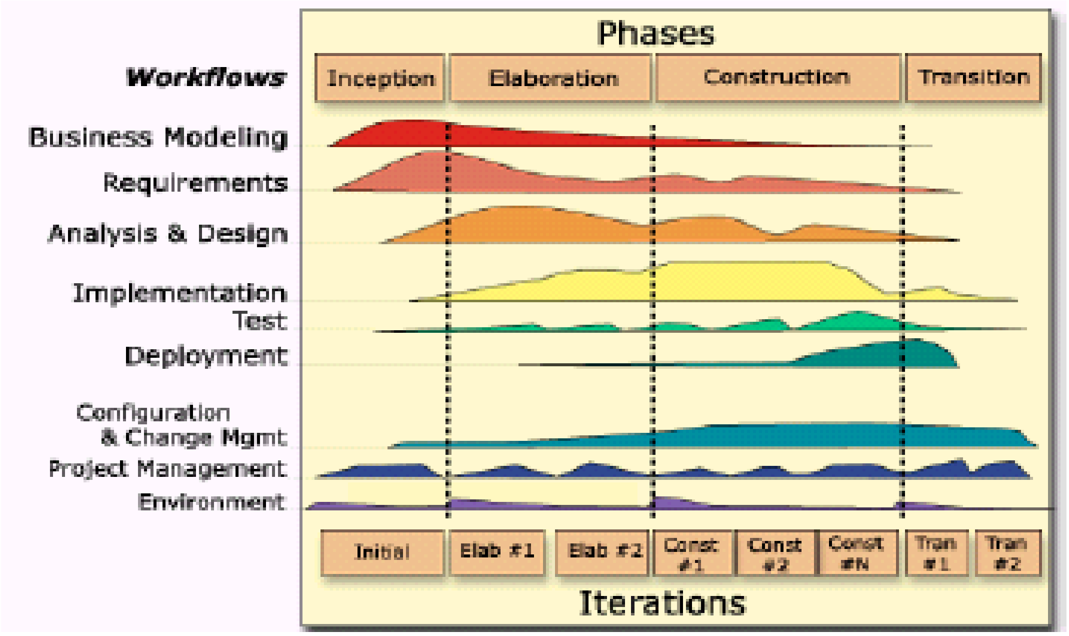
Design: Emphasizes a conceptual solution that fulfills the requirements rather than it's implementation.(Understanding and defining software solution/objects that represent the analysis concepts and will eventually be implemented in code.)
OOAD: Analysis is object-oriented and design is object-oriented. A software development approach that emphasizes a logical solution based on objects.

HOW TO DO OOAD:



Typical activities / workflows / disciplines in OOAD

WORKFLOWS IN OOAD:



RUP Overview Diagram

The Four Phases

The life of a software system can be represented as a series of cycles. A cycle ends with the release of a version of the system to customers.

Within the Unified Process, each cycle contains four phases. A phase is simply the span of time between two major milestones, points at which managers make important decisions about whether to proceed with development and, if so, what's required concerning project scope, budget, and schedule.

Inception

The primary goal of the Inception phase is to establish the case for the viability of the proposed system. The tasks that a project team performs during Inception include the following:

1. Defining the scope of the system (that is, what's in and what's out)
2. Outlining a candidate architecture, which is made up of initial versions of six different models
3. Identifying critical risks and determining when and how the project will address them
4. Starting to make the business case that the project is worth doing, based on initial estimates of cost, effort, schedule, and product quality

Elaboration

The primary goal of the Elaboration phase is to establish the ability to build the new system given the financial constraints, schedule constraints, and other kinds of constraints that the development project faces. The tasks that a project team performs during Elaboration include the following:

1. Capturing a healthy majority of the remaining functional requirements
2. Expanding the candidate architecture into a full architectural baseline, which is an internal release of the system focused on describing the architecture
3. Addressing significant risks on an ongoing basis
4. Finalizing the business case for the project and preparing a project plan that contains sufficient detail to guide the next phase of the project (Construction)

Construction

1. The primary goal of the Construction phase is to build a system capable of operating successfully in beta customer environments.
2. During Construction, the project team performs tasks that involve building the system iteratively and incrementally (see "Iterations and Increments" later in this chapter), making sure that the viability of the system is always evident in executable form.
3. The major milestone associated with the Construction phase is called Initial Operational Capability. The project has reached this milestone if a set of beta customers has a more or less fully operational system in their hands.

Transition

1. The primary goal of the Transition phase is to roll out the fully functional system to customers.
2. During Transition, the project team focuses on correcting defects and modifying the system to correct previously unidentified problems.
3. The major milestone associated with the Transition phase is called Product Release.

The Workflows

Within the Unified Process, five workflows cut across the set of four phases: Requirements, Analysis, Design, Implementation, and Test. Each workflow is a set of activities that various project workers perform.

Business Modeling: The purpose of the Business Modeling discipline is to:
_ Understand the structure and the dynamics of the organization in which a system is to be deployed (the target organization)
_ Understand current problems in the target organization and identify improvement potential
_ Ensure that customers, end users, and developers have a common understanding of the target organization
_ Derive the system requirements needed to support the target organization
Requirements: The purpose of the Requirements discipline is to:
_ Establish and maintain agreement with the customers and other stakeholders on what the system should do
_ Provide system developers with a better understanding of the system requirements
_ Define the boundaries of (delimit) the system
_ Provide a basis for planning the technical contents of iterations
_ Provide a basis for estimating the cost and time to develop the system
Analysis and Design: The purpose of the Analysis and Design discipline is to:
_ Transform the requirements into a design of the system-to-be
_ Evolve a robust architecture for the system
_ Adapt the design to match the implementation environment

Implementation: The purpose of the Implementation discipline is to:
_ Define the organization of the implementation
_ Implement the design elements
_ Unit test the implementation
_ Integrate the results produced by individual implementers (or teams), resulting in an executable system
Test: The purpose of the Test discipline is to:
_ Find and document defects in software quality
_ Provide general advice about perceived software quality
_ Prove the validity of the assumptions made in design and requirement specifications through concrete demonstration
_ Validate that the software product functions as designed

_ Validate that the software product functions as required (that is, the requirements have been implemented appropriately)

Deployment: The purpose of the Deployment discipline is to:

_ Ensure that the software product is available for its end users

Configuration and Change Management: The purpose of the Configuration and Change Management discipline is to:

_ Identify configuration items5

_ Restrict changes to those items

_ Audit changes made to those items

_ Define and manage configurations6 of those items

Project Management: The purpose of the Project Management discipline is to:

_ Manage a software-intensive project

_ Plan, staff, execute, and monitor a project

_ Manage risk

Environment: The purpose of the Environment discipline is to:

_ Provide the software development organization with the software development environment—both processes and tools—that will support the development team. This includes configuring the process for a particular project, as well as developing guidelines in support of the project.

Introduction to iterative development and the Unified Process

Unified Process: The Rational Unified Process is a software development process framework that provides a disciplined approach to assigning tasks and responsibilities within a development organization. Its goal is to ensure the production of high quality software that meets the needs of its end users within a predictable schedule and budget ("better software faster").

RUP was explicitly designed to support the implementation of six best practices.

■ **Develop iteratively.** Deliver the functionality of the system in a successive series of releases of increasing completeness, where each release is the result of an iteration. The selection of which requirements are addressed within each iteration is driven by the mitigation of project risks, with the most critical risks being addressed first.

■ **Manage requirements.** Use a systematic approach to elicit and document the system requirements, and then manage changes to those requirements, including assessing the impact of those changes on the rest of the system. Effective requirements management involves maintaining a clear statement of the requirements, as well as maintaining traceability from these requirements to the other project artifacts.

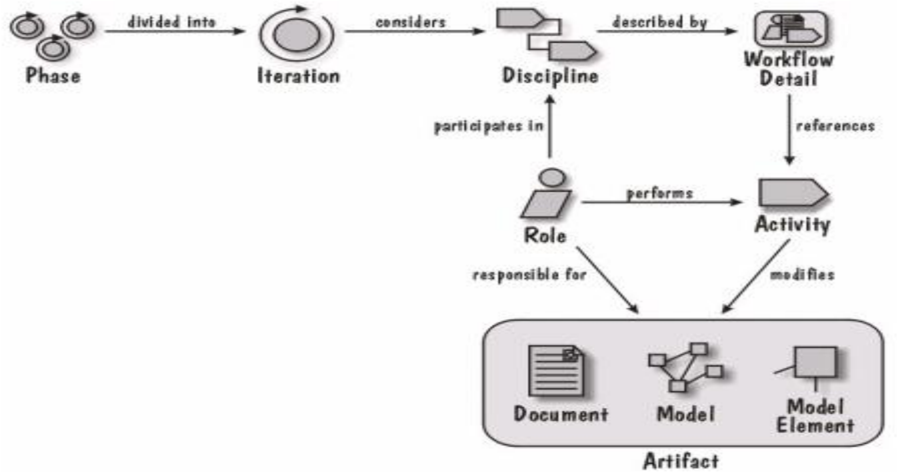
■ **Use component architectures**. Structure the software architecture using components2. A component-based development approach to architecture tends to reduce the complexity of the solution, and results in an architecture that is more robust and resilient, and which enables more effective reuse.

■ **Model visually**. Produce a set of visual models of the system, each of which emphasizes specific details, and "ignores"(abstracts, filters away) others. These models promote a better understanding of the system being developed and provide a mechanism for unambiguous communication among team members ("a picture is worth a thousand words").

■ **Continuously verify quality**. Continuously assess the quality of the system with respect to its functional and nonfunctional requirements. Perform testing as part of every iteration. It is a lot less expensive to correct defects found early in the software development life cycle than it is to fix defects found later.

■ **Manage change.** Establish a disciplined and controlled approach for managing change (changing requirements, technology, resources, products, platforms, and so on).

RUP key concepts:



An effective software development process should describe who does what, how, and when. RUP does exactly that in terms of the following key concepts:

Roles: The who
Artifacts: The what
Activities: The how
Phases, iterations, disciplines and workflow details

Artifacts

An artifact is a piece of information that is produced and/or used during the execution of the process. Artifacts are the tangible by-products of the process. The deliverables that end up in the hands of the customers and end users are only a subset of the artifacts that are produced on a project.
Artifacts are the responsibility of a single role. Roles use artifacts as input to activities, and roles produce or modify artifacts in the course of performing activities.

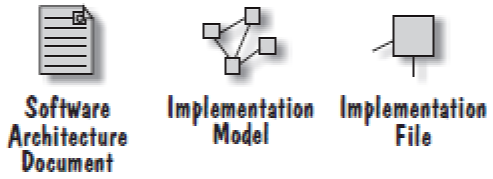


Figure 3.3 Examples of RUP Artifacts

Roles

A role defines the behavior and responsibilities of an individual, or a set of individuals working together as a team, within the context of a software development organization. A role is responsible for one or more artifacts and performs a set of activities.

Software Architect
Designer
Implementer

Figure 3.4 Examples of RUP Roles

Activities

An activity is a unit of work that provides a meaningful result in the context of the project. It has a clear purpose, which usually involves creating or updating artifacts. Every activity is assigned to a specific role. Activities may be repeated several times, especially when executed in different iterations.

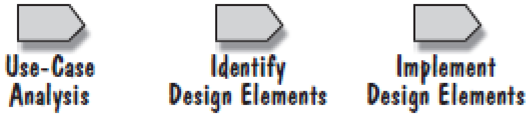


Figure 3.5 Examples of Activities

Iterative Development:

- The following list provides some important characteristics of a successful iteration.
- The iteration has clear evaluation criteria.
- The iteration has a planned capability that is demonstrable.
- The iteration is concluded by a minor milestone, where the result of the iteration is assessed relative to the objective success criteria of that particular iteration.

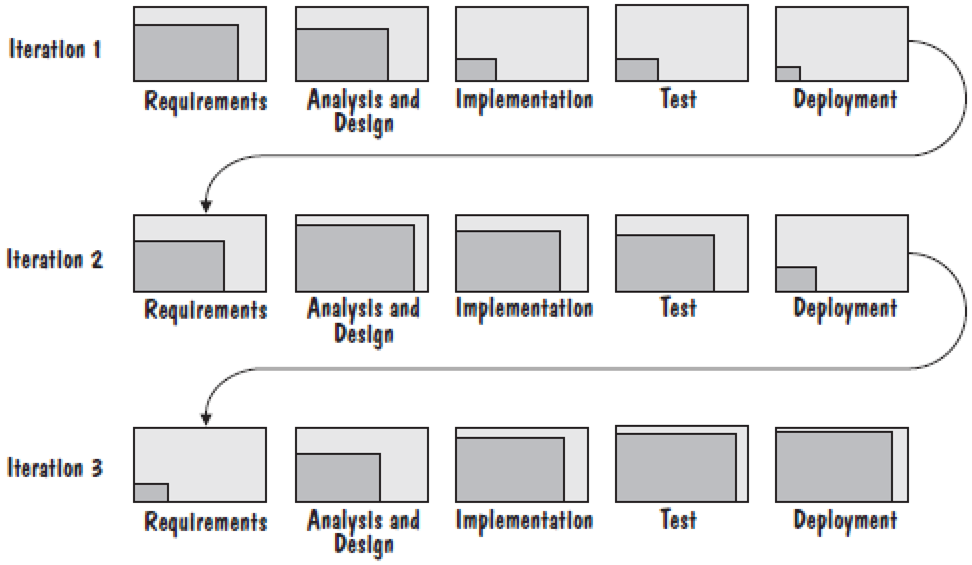


Fig: Iterative life cycle

INTRODUCTION TO UML

WHAT IS A MODEL AND WHY?

- A model is a simplification of reality.
  E.g., a miniature bridge for a real bridge to be built
- A model is our simplification of our perception of reality
- A model is an abstraction of something for the purpose of understanding, be it the problem or a solution.

What is UML?

The UML is a common diagrammatic language developed by Rational with the support of all the big computer companies. It is now maintained by the Object Management Group.

The Unified Modeling Language (UML) is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems. The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects. Using the UML helps project teams communicate, explore potential designs, and validate the architectural design of the software.

Why use the UML

Many people think in pictures and a picture can express a lot of ideas in a quick way. UML is a standard way to draw various views of a piece of software: the user's view, the architecture, the internal structure of the software, the source code, and the hardware involved.

Goals of UML :

1. Provide users with a ready-to-use, expressive visual modeling language so they can develop and exchange meaningful models.

2. Provide extensibility and specialization mechanisms to extend the core concepts.

3. Be independent of particular programming languages and development processes.
4. Provide a formal basis for understanding the modeling language.

5. Encourage the growth of the OO tools market.

6. Support higher-level development concepts such as collaborations, frameworks, patterns and components.

7. Integrate best practices.

Benefits of UML:

1. Your software system is professionally designed and documented before it is coded. You will know exactly what you are getting, in advance.

2. Since system design comes first, reusable code is easily spotted and coded with the highest efficiency. You will have lower development costs.

3. Logic 'holes' can be spotted in the design drawings. Your software will behave as you expect it to. There are fewer surprises.

4. The overall system design will dictate the way the software is developed. The right decisions are made before you are married to poorly written code. Again, your overall costs will be less.

5. UML lets us see the big picture. We can develop more memory and processor efficient systems.

6. When we come back to make modifications to your system, it is much easier to work on a system that has UML documentation. Much less 'relearning' takes place. Your system maintenance costs will be lower.

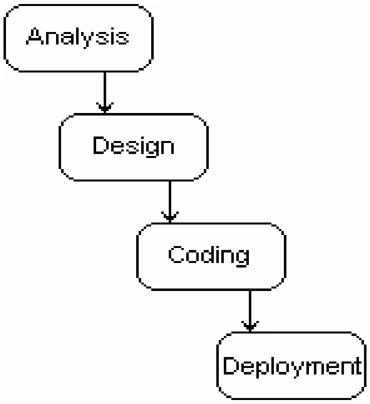
7. If you should find the need to work with another developer, the UML diagrams will allow them to get up to speed quickly in your custom system. Think of it as a schematic to a radio. How could a tech fix it without it?

8. If we need to communicate with outside contractors or even your own programmers, it is much more efficient.

Modeling of systems, old way vs. new way:

System is a combination of software and hardware that provides a solution for a business problem.

Process of developing that system involves a lot of people. First of all is the client, the person who has the problem to be solved. An analyst documents the client's problem and relays it to developers, programmers who build the software that solves the problem, test it and deploy it on computer hardware.



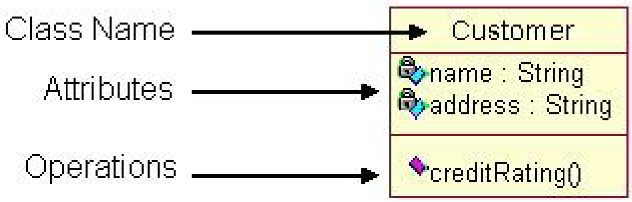
The waterfall method for modeling of systems

- The old way of system modeling, known as the waterfall method, specifies that analysis, design, coding and deployment follow one another. Only when one is complete can the next one begin. If an analyst hands off analysis to a designer, who hands off a design to a developer, chances are that the three team members will rarely work together and share important insights. Usually the adherents of the waterfall method give coding a big amount of project time; it takes a valuable time away from analysis and design.
- In the new way, contemporary software engineering stress continuing interplay among the stages of development. Analysts and designers, for example, go back and forth to evolve a solid foundation for the programmers. Programmers, in turn, interact with analysts and designers to share their insights, modify designs, and strengthen their code. The advantage is that as understanding grows, the team incorporates new ideas and builds a stronger system.

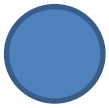
UML Diagram Symbols:

Structural Elements:

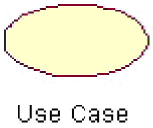
Class: Classes are composed of three things: a name, attributes, and operations. Below is an example of a class.



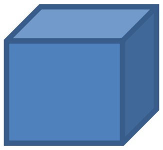
Interface: The symbol of interface is



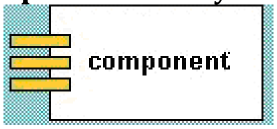
Use case: A use case is a set of scenarios that describing an interaction between a user and a system. The following is the symbol for use case.



Node: The symbol for the node is as shown below.

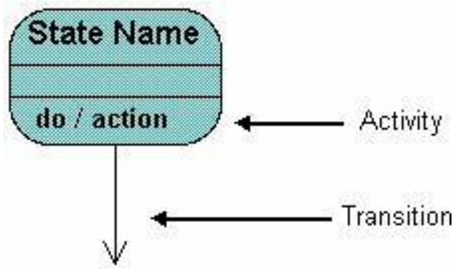


Component: The symbol for the component is as shown below.

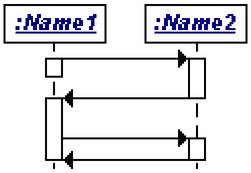


Behavioral Elements:

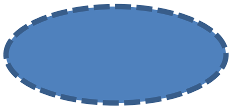
State: The basic elements are rounded boxes representing the state of the object and arrows indicting the transition to the next state. The activity section of the state symbol depicts what activities the object will be doing while it is in that state.



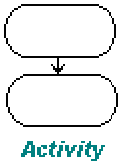
Sequence: The following diagram is a sequence.



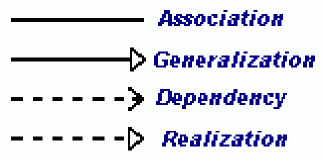
Collaboration: The following notation is collaboration.



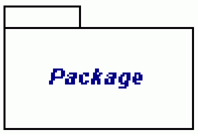
Activity: The following notation is an activity.



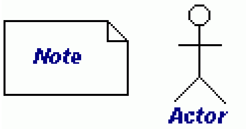
Relationships:



Grouping:



Annotion and Actor:



<u>MAPPING DISCIPLINES TO UML ARTIFACTS</u>

→An artifact is a classifier that represents some physical entity, a piece of information that is used or is produced by a software development process, or by deployment and operation of a system. Artifact is a source of a deployment to a node. A particular instance (or "copy") of an artifact is deployed to a node instance.

→Some real life examples of UML artifacts are:

- ✓ text document
- ✓ source file
- ✓ script
- ✓ binary executable file
- ✓ archive file
- ✓ database table

Introduction to Design Patterns

- A *pattern* is a recurring solution to a standard problem
- A pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.

Patterns in engineering

- Mature engineering disciplines have handbooks describing successful solutions to known problems
- Automobile designers don't design cars from scratch using the laws of physics
- Instead, they reuse standard designs with successful track records, learning from experience

- ➢ Design patterns have 4 essential elements:
  - Pattern name: increases vocabulary of designers
  - Problem: intent, context, when to apply
  - Solution: UML-like structure, abstract code
  - Consequences: results and tradeoffs

Types of Patterns

Creational patterns:

- Deal with initializing and configuring classes and objects
- Creational patterns are associated with control mechanisms of creating objects. The basic mode of forming an object may be problematic in some projects and may lead to unnecessary complexity in some areas. Creational patterns are supposed to prevent from occurring problems and introduce more control over creating objects. Their task is to separate the processes of creation, completion and representation of an object.
- There are five well-known design patterns possible to implement in a wide scope of programming languages:

- ✓ Abstract Factory Pattern
- ✓ Builder Pattern
- ✓ Factory Method Pattern
- ✓ Prototype Pattern
- ✓ Singleton Pattern

Structural patterns:

- o Deal with decoupling interface and implementation of classes and objects
- o Composition of classes or objects

Behavioral patterns:

- o Deal with dynamic interactions among societies of classes and objects
- o How they distribute responsibility

Benefits of Design Patterns

- Design patterns enable large-scale reuse of software architectures and also help document systems
- Patterns explicitly capture expert knowledge and design tradeoffs and make it more widely available
- Patterns help improve developer communication
- Pattern names form a common vocabulary

Goals of design patterns:

1. Help designer focus on solution.
2. Provide a common language for design discussion.
3. Provide solution to real-world problem.
4. Document decision that lead to the solution.
5. Reuse is very useful.
6. Quick to solve problem and development process.

Good design leads to software that is:

1. Correct – does what it should
2. Robust – tolerant of misuse, e.g. faulty data
3. Flexible – adaptable to shifting requirements
4. Reusable – cut production costs for code
5. Efficient – good use of processor and memory

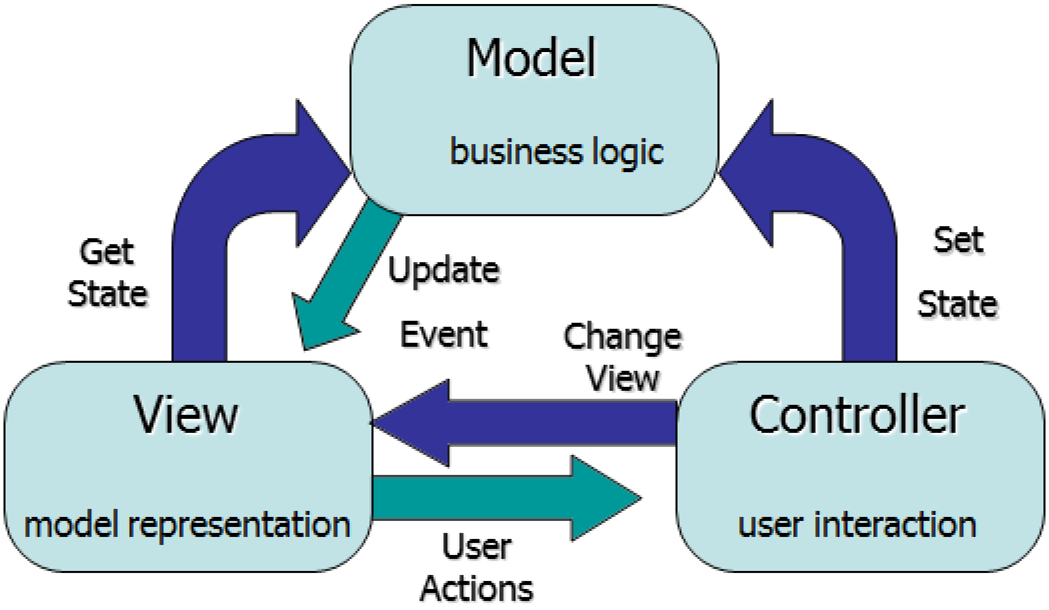
MVC Architecture

Model: The model represents data and the rules that govern access to and updates of this data. In enterprise software, a model often serves as a software approximation of a real-world process.

View: The view renders the contents of a model. It specifies exactly how the model data should be presented. If the model data changes, the view must update its presentation as needed.
Controller: The controller translates the user's interactions with the view into actions that the model will perform.

In a typical application you will find these three fundamental parts:

- Data (Model)
- An interface to view and modify the data (View)
- Operations that can be performed on the data (Controller)



The MVC pattern, in a nutshell, is this:

1. The **model** represents the data, and does nothing else. The model does NOT depend on the controller or the view.

2. The **view** displays the model data, and sends user actions (e.g. button clicks) to the controller. The view can:

   - be independent of both the model and the controller; or

   - actually **be** the controller, and therefore depend on the model.

3. The **controller** provides model data to the view, and interprets user actions such as button clicks. The controller depends on the view and the model. In some cases, the controller and the view are the same object.

<u>Case study:--------------></u>
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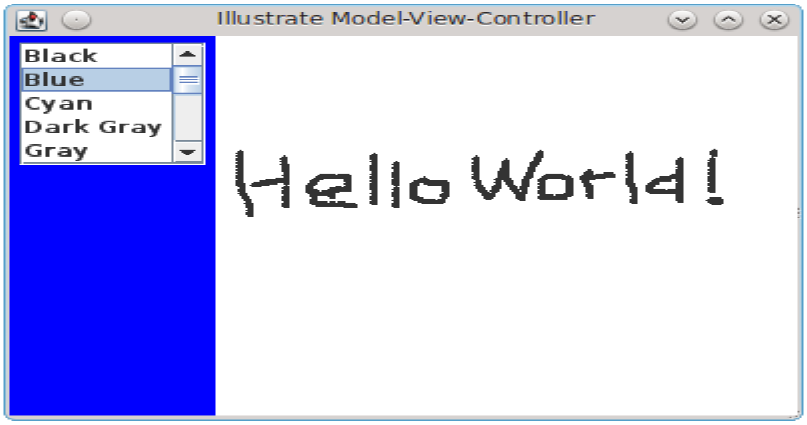


UNIT-2

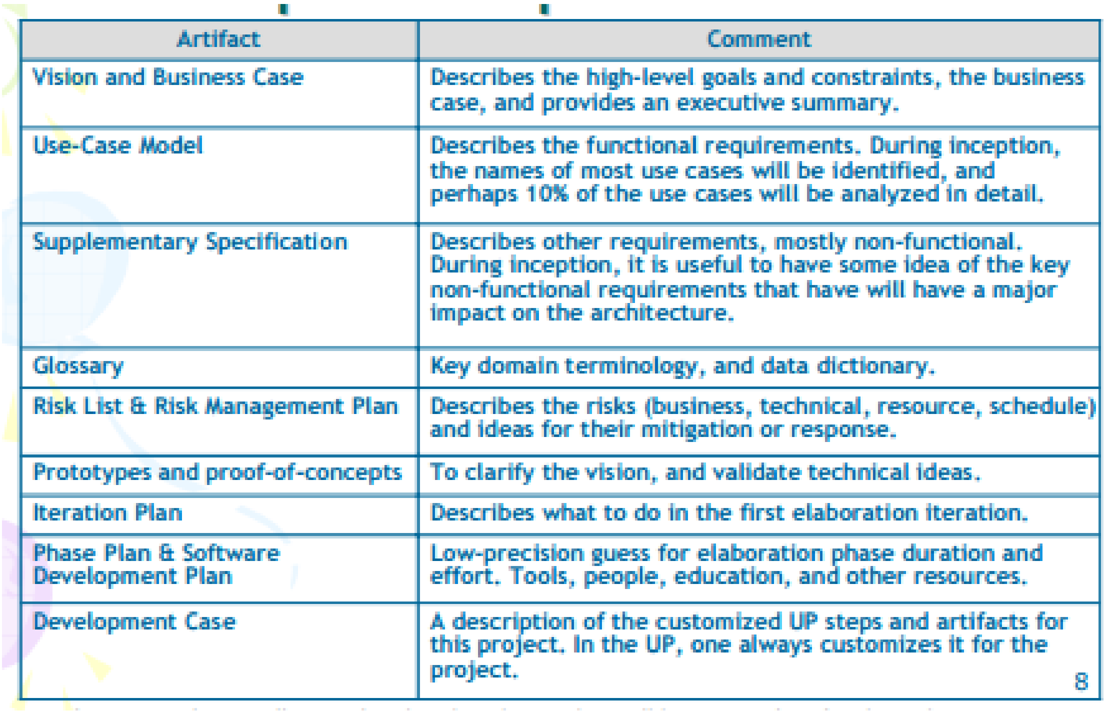
INCEPTION:

The aim of the inception phase is to determine whether the proposed software product is economically viable(Capable of living-anukulamina)

- ◎ Inception phase of the UP has (5) objectives
    - ⦿ Identify the business need for the project
    - ⦿ Establish the vision for the solution
    - ⦿ Identify scope of the new system and the project
    - ⦿ Develop preliminary schedules and cost estimates
    - ⦿ Develop the business case for the project
- ◎ Inception phase may be completed in one iteration

Artifacts:

- ✓ Vision
- ✓ Use Case Model
- ✓ Supplementary Specification
- ✓ Glossary
- ✓ Risk Plan
- ✓ Prototypes
- ✓ Iteration Plan



Artifact	Comment
Vision and Business Case	Describes the high-level goals and constraints, the business case, and provides an executive summary.
Use-Case Model	Describes the functional requirements. During inception, the names of most use cases will be identified, and perhaps 10% of the use cases will be analyzed in detail.
Supplementary Specification	Describes other requirements, mostly non-functional. During inception, it is useful to have some idea of the key non-functional requirements that have will have a major impact on the architecture.
Glossary	Key domain terminology, and data dictionary.
Risk List & Risk Management Plan	Describes the risks (business, technical, resource, schedule) and ideas for their mitigation or response.
Prototypes and proof-of-concepts	To clarify the vision, and validate technical ideas.
Iteration Plan	Describes what to do in the first elaboration iteration.
Phase Plan & Software Development Plan	Low-precision guess for elaboration phase duration and effort. Tools, people, education, and other resources.
Development Case	A description of the customized UP steps and artifacts for this project. In the UP, one always customizes it for the project.

8

Vision: Describes the high level goals and constraints from stakeholder's point of view, focusing on key stakeholder needs Order of magnitude estimate of costs and benefits Required to end Inception Phase.

Use Case Model: Describes the functional requirements Functional requirements. During inception, the names of use cases will be identified, perhaps 10% of use cases will be analyzed in detail.

Supplementary Specification Describes non-functional requirements , During inception it is useful to have some idea of the key non-functional requirements that will have a major impact on the architecture.

Glossary: Defines key domain terms and data dictionary.

Risk Plan: List of known and expected risks(Business, Technical, Resource, Schedule) and Ideas for mitigation or response to each risk.

Prototypes: Develop prototypes to clarify vision and validate the technical ideas.

Development case: A description of customized UP steps and artifacts to this project.

Understanding requirements – the FURPS model

Requirements: are capabilities and conditions to which the system—and more broadly, the project—must conform . A prime challenge of requirements work is to find, communicate, and remember what is really needed, in a form that clearly speaks to the client and development team members.

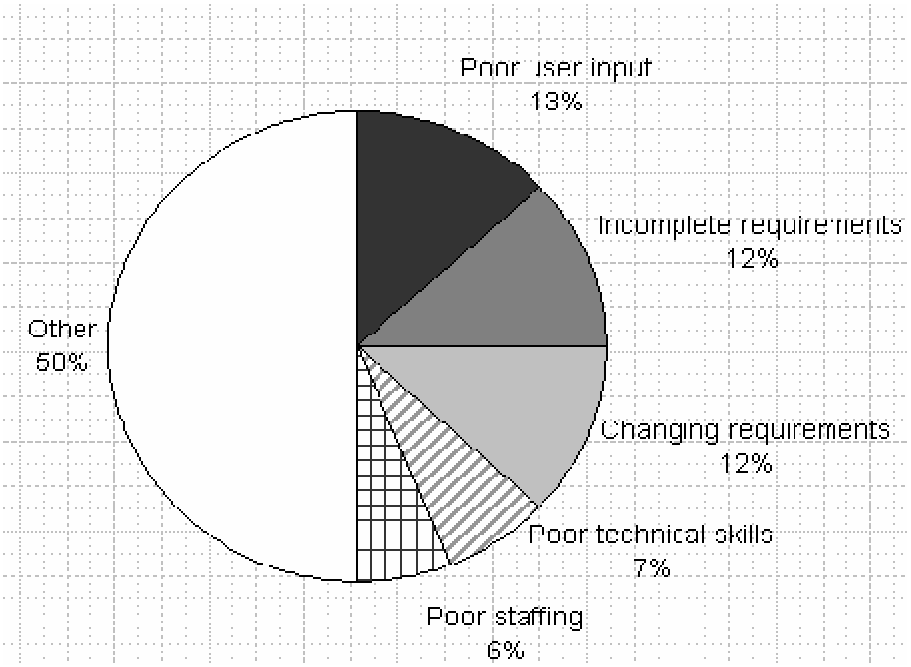


Fig:factors on challenged software projects

Types of Requirements

In the UP, requirements are categorized according to the FURPS model a useful mnemonic with the following meaning:

- ◎ **Functional**—features, capabilities, security.
- ◎ **Usability**—human factors, help, documentation.
- ◎ **Reliability**—frequency of failure, recoverability, predictability
- ◎ **Performance—**response times, throughput, accuracy, availability, resource usage.
- ◎ **Supportability**—adaptability, maintainability, internationalization, configurability.

The "+" in FURPS+ indicates ancillary and sub-factors, such as:

- **Implementation**—resource limitations, languages and tools, hardware, ...
- **Interface—**constraints imposed by interfacing with external systems.
- **Operations**—system management in its operational setting.
- **Packaging**
- **Legal—**licensing and so forth.

Understanding Use case model:

Use case is a list of actions or event steps, typically defining the interactions between a role and a system, to achieve a goal. The actor can be a human or other external system.

A **use case diagram** is a graphic depiction of the interactions among the elements of a system. A use case is a methodology used in system analysis to identify, clarify, and organize system requirements. ... The use cases, which are the specific roles played by the actors within and around the system.

How do we identify the usecases:

To identify use cases we will take the following steps:

Step 1: Identify candidate system actors.

Step 2: Identify the goals of the actors.

Step 3: Identify the candidate use cases.

Step 4: Identify the start point for each use case.

Step 5: Identify the end point for each use case.

Use case description: A use case is a written description of how users will perform tasks on your website. It outlines, from a user's point of view, a system's behavior as it responds to a request.

Types of Use Cases:

There are three types of use cases: Essential, Concrete and Abstract.

Essential Use Cases ... are expressed in an ideal form that remains relatively free of technology and implementation details; design decisions are deferred and abstracted, especially those related to the user interface.

Concrete or Real Use Case concretely describes the process in terms of its real current design, committed to specific input and output technologies and so on. When a user interface is involved, they often show screen shots and discuss interaction with the widgets.

Abstract Use Case is not complete and has no actor that initiates it but is used by another use cases.

Case Study - Answering System:
The Answering System is system foe answering phone calls and recording messages from callers. It is intended as a personal answering system for a single owner. It will support:
Modes for announce only and accepting caller messages

- Ability to review caller messages
- Personalized greetings
- Local management of modes, greetings, and caller messages

Answering System Domain Use Case Model
Let us analyze the requirement document to identify the potential actors and use cases of the system. First, let's list the potential actors. A quick look at requirement document shows the following terms and entities specific to the system:
The caller is the person who is answered and their messages are taken

- The owner is person who records the greetings, set the answer mode and reviews the caller me

Identifying Actor

There are certain terms and entities in the list that identify that they perform certain roles or business processes. From the preceding list, we can see that there are some entities that perform an action and some that form the target for the action. The entities that perform action will be the actor for Answering System. In the above list, the actor that we can identify are:

- owner
- caller

Identifying Use Cases

Next, let's identify the potential business processes in the Answering System. The primary business flows in the system are:

- Review Caller Messages
- Answer Caller
- Set Answer Mode
- Record Greetings

As we analyze the requirement document further, we can determine some discrete processes within these primary business flows. To review caller messages, the owner needs to have ability to delete caller message. So, within the "Review Caller Messages" use case, we can identify following use case:

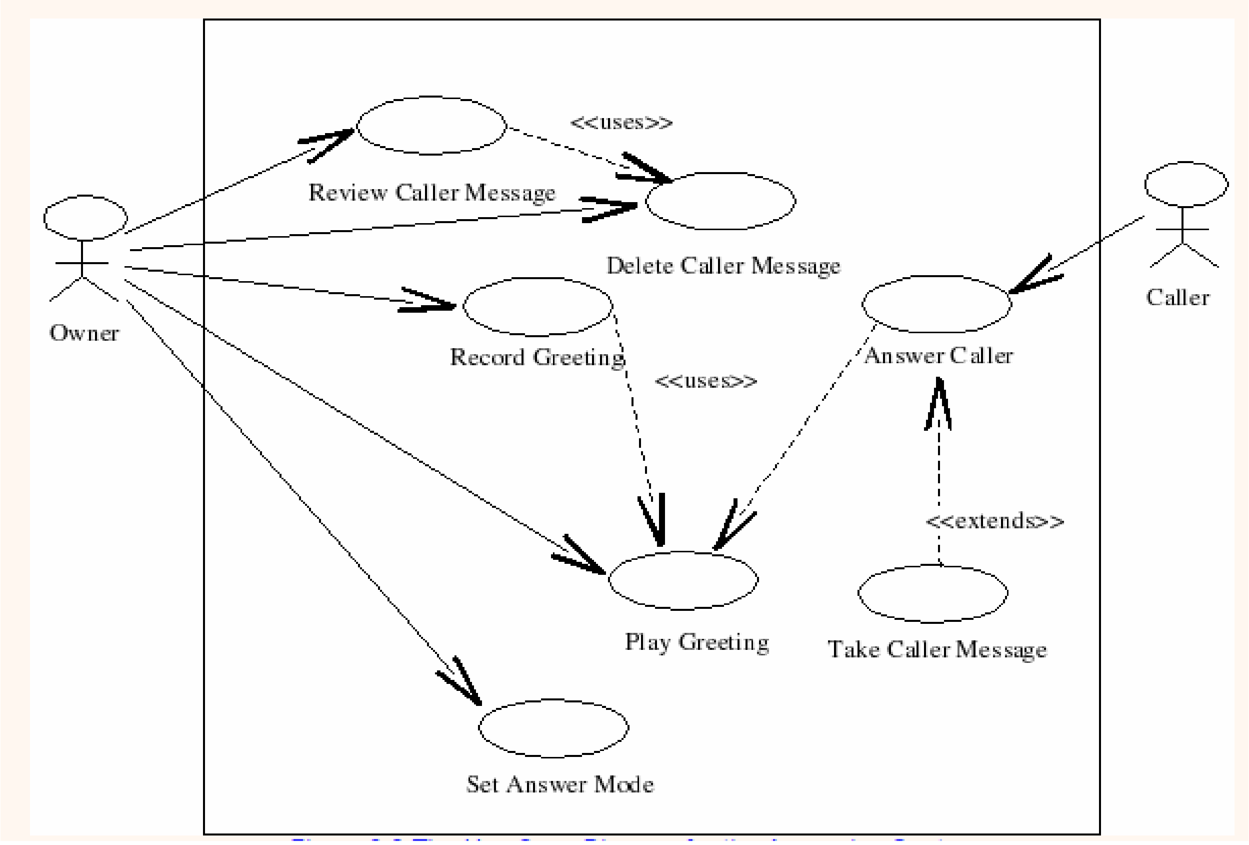
- Delete Caller Message

The "Answer Caller" use case can be refined into smaller discrete processes such as play greeting, take caller message. Now, the use cases that we identified within the "Answer Caller" are:

- Play Greeting
- Take Caller Message

And similarly, "Record Greeting" use case uses the discrete process - play greeting.
Our final list of use cases for Answering System will be:

- Review Caller Messages
- Answer Caller
- Set Answer Mode
- Record Greetings
- Delete Caller Message
- Play Greeting
- Take Caller Message



Usecase formats:

- **Use-case model overview:** A format for understanding the “big-picture”
- **Use-case brief descriptions:** A format for writing summary use cases
- **Step-by-step outlines:** A format for writing less formal, low-ceremony use cases
- **Fully detailed:** A format for writing more formal, high-ceremony use cases

Use-Case Model Overview

Create a use-case model overview, which captures actors and associated use cases.

- Start by identifying the list of actors who will use the system, and then identify at least one goal for each. Actors without goals indicate that you haven’t adequately defined the system. The actor is beyond the system’s scope, doesn’t belong in the system, or is part of another actor.
- Likewise, leftover goals can indicate that the system is too complex and you're trying to accomplish too much, or that you haven’t adequately defined all of the necessary actors. Carefully evaluate the leftovers to see if you are just overlooking some detail, or whether they don’t belong in the system.
- Remove unassociated actors and goals from the model.

Sometimes, this overview may provide enough information to serve as the use-case model for very small, high-communicating, low-ceremony project teams. Usually, the use-case model overview is the first step of identifying use cases and system boundaries.

Use-Case brief descriptions

Write two to four sentences per use case, capturing key activities and key-extension handling.

- Expand the high priority use-cases by writing a two- to four-sentence use cases for each entry in the list.
- Briefly describe each use case's main scenario and most important extensions.
- Include enough information to eliminate ambiguity for at least the main scenario.

Step-by-step outlines

Write the step-by-step outline which describes the interaction between the actor(s) and the system.

- Key scenarios are detailed to describe the interaction
- Triggering events are specified
- Information exchanged is described

Fully Detailed

Complete all sections of the Use-Case Specification template.

- The main scenario is detailed
- All alternative flows are identified and detailed
- Special requirements are complete and un-ambiguous
- Pre- and Post-conditions are specified.

Goals and scope of a use case:

1. Provide users with a ready-to-use, expressive visual modeling language to develop and exchange meaningful models.

2. Furnish extensibility and specialization mechanisms to extend the core concepts.

3. Support specifications that are independent of particular programming languages and development processes.

4. Provide a formal basis for understanding the modeling language.

5. Encourage the growth of the object tools market.

6. Support higher-level development concepts such as components, collaborations, frameworks and patterns.

7. Integrate best practices.

→ The design scope is not a specific property of a use case but something you should consider carefully to make sure you understand what is inside and what is outside the boundary of the use case.

Elements of usecase:

Shape	Element	Description and Main Properties
1	**Actor**	Represents a user, organization, or external system that interacts with your application or system. An actor is a kind of type. - **Image Path** - the file path of an image that should be used instead of the default actor icon. The icon should be a resource file within the Visual Studio project.
2	**Use Case**	Represents the actions performed by one or more actors in the pursuit of a particular goal. A use case is a kind of type. - **Subjects** - the Subsystem in which the use case appears.
3	**Association**	Indicates that an actor takes part in a use case.
4	**Subsystem or component**	The system or application that you are working on, or a part of it. Can be anything from a large network to a single class in an application. The use cases that a system or component supports appear inside its rectangle. It can be useful to show some use cases outside the rectangle, to clarify the scope of your system.

Shape	Element	Description and Main Properties
		A subsystem in a use case diagram has basically the same type as a component in a component diagram. - **Is Indirectly Instantiated** - If false, your executing system has one or more objects that directly correspond to this subsystem. If true, the subsystem is a construct in your design that appears in the executing system only through the instantiation of its constituent parts.

Three Kinds of Actors

Primary actor: has user goals fulfilled through using services of the system under Discussion drives the use cases**.**

Supporting actor: provides a service to the system under discussion e.g., payment authorization service implies: clarification of external interfaces and protocols needed

Offstage actor: has an interest in the behavior of the use case, but is not primary or Supporting e.g., a government tax agency

Relationships in Use Case Diagram:

Use cases share different kinds of relationships. A relationship between two use cases is basically a dependency between the two use cases. Defining the relationship between two use cases is the decision of the modeler of the use case diagram. This use of an existing use case using different types of relationships reduces the overall effort required in defining use cases in a system. Use case relationships can be one of the following:

- *Communicates:* The participation of an actor in a use case is shown by connecting the actor symbol to use case symbol by a solid path. The actor is said to 'communicates' with the use case. This is only relation between an actor and use cases. See figure 3.4.

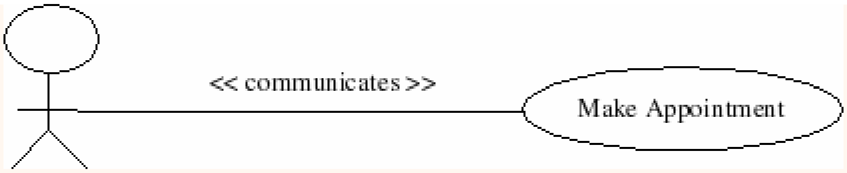


Figure 3.4 Communicates relationship

- *Extends:* An extends shows the relationships between use cases. Relationship between use case A and use case B indicates that an instance of use case B may include (subject to specified in the extension) the behavior specified by A. An 'extends' relationship between use cases is depicted with a directed arrow having a dotted shaft. The tip of arrowhead points to the parent use case and the child usecase is connected at the base of the arrow.

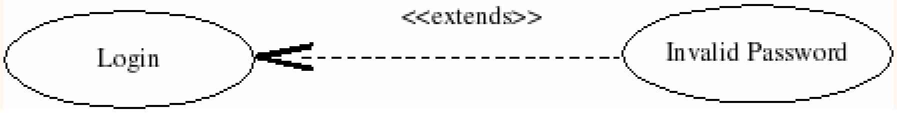


Figure 3.5 An example of an extend relationship

For example, validating the user for a system. A invalid password is extension of validating password use case as shown in figure 3.5.

- *Include or uses:* When a use case is depicted as using functionality of another functionality of another use case, this relationship between the use cases is named as an include or uses relationship. In other words, in an include relationship, a use case includes the functionality described in the another use case as a part of its business process flow.

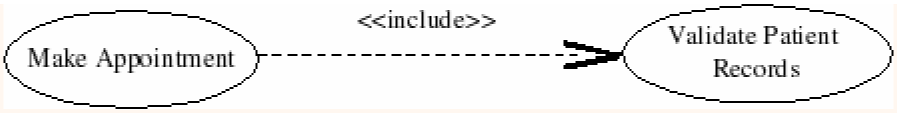
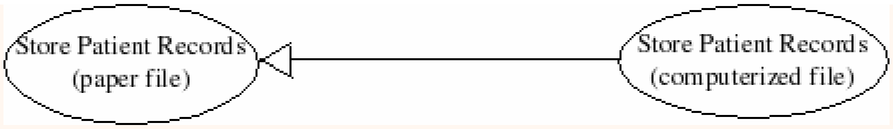


Figure 3.6 An example of an include relationship

The system boundary is potentially the entire system as defined in the requirements document. For large and complex systems, each modules may be the system boundary. For example, for an ERP system for an organization, each of the modules such as personal, payroll, accounting, etc. can form a system boundary for use cases specific to each of these business functions. The entire system can span all of these modules depicting the overall system boundary.

- *Generalization:* A generalization relationship is also a parent-child relationship between use cases. The child use case in the generalization relationship has the underlying business process meaning, but is an enhancement of the parent use case. In a use case diagram, generalization is shown as a directed arrow with a triangle arrowhead. The child use case is connected at the base of the arrow. The tip of the arrow is connected to the parent use case.



Store Patient Records (paper file)
Store Patient Records (computerized file)

Figure 3.7 An example of generalization relationship

How to Create a Use Case Diagram

→Identifying Actors

Actors are external entities that interact with your system. It can be a person, another system or an organization. In a banking system the most obvious actor is the customer. Other actors can be bank employee or cashier depending on the role your trying to show in the use case.

→Identifying Use Cases

Now it's time to identify the use cases. A good way to do this is to identify what the actors needs from the system. In a banking system a customer will need to open accounts, deposit and withdraw funds, request check books and similar functions. So all of these can be considered as use cases.

→Look for Common Functionality to use Include

Look for common functionality that can be reused across the system. If you find two or more use cases that share common functionality you can extract the common functions and add it to a separate use case.

→Is it Possible to Generalize Actors and Use Cases

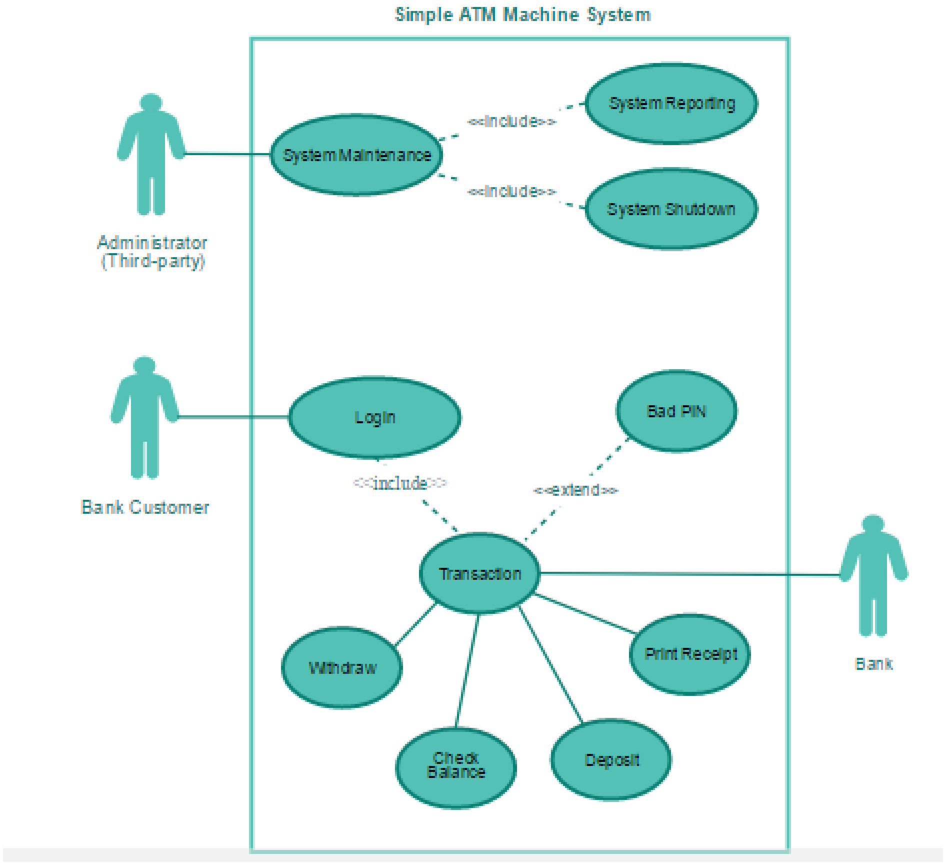
There may be instances where actors are associated with similar use cases while triggering few use cases unique only to them.

One of the best examples of this is "Make Payment" use case in a payment system. You can further generalize it to "Pay by Credit Card", "Pay by Cash", "Pay by Check" etc. All of them have the attributes and the functionality of a payment with special scenarios unique to them.

→Optional Functions or Additional Functions

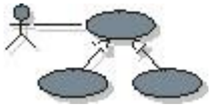
There are some functions that are triggered optionally. In such cases you can use the extend relationship and attach and extension rule to it. Extend doesn't always mean its optional. Sometimes the use case connected by extend can supplement the base use case. Thing to remember is that the base use case should be able to perform a function on its own even if the extending use case is not called.

Example:



Use cases in the UP context and UP artifacts:

Artifact: Use-Case Model

 **Use-Case Model**	The use-case model is a model of the system's intended functions and its environment, and serves as a contract between the customer and the developers. The use-case model is used as an essential input to activities in analysis, design, and test.
UML representation:	Model, stereotyped as «use-case model».
Role:	Analyst
More information:	• Guidelines:Use-Case Model

<table>
<tr><td></td><td>• Guidelines:Use-Case Diagram
• Checkpoints:Use-Case Model</td></tr>
<tr><td colspan="2">• Templates, Case-Study, Report..
• Purpose
• Properties
• Timing
• Responsibility
• Tailoring</td></tr>
<tr><td><b>Input to Activities:</b>
• Architectural Analysis
• Review Requirements
• Structure the Use-Case Model
• Use-Case Analysis</td><td><b>Output from Activities:</b>
• Elicit Stakeholders Requests
• Find Actors and Use Cases
• Structure the Use-Case Model</td></tr>
</table>

UNIT-3

System sequence diagrams for use case model

→A **sequence diagram** is an interaction **diagram** that shows how objects operate with one another and in what order. It is a construct of a message **sequence** chart. A **sequence diagram** shows object interactions arranged in time **sequence**. ...**Sequence diagrams** are sometimes called event **diagrams** or event scenarios.

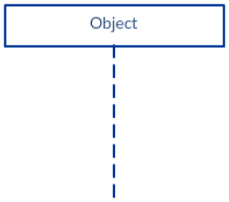
→**System behavior** is a description *of what* a system does, without explaining how it does it. One part of that description is a system sequence diagram. Other parts include the use cases, and system contracts.

→The UML includes **sequence diagrams** as a notation that can illustrate actor interactions and the operations initiated by them.
→**A system sequence diagram** (SSD) is a picture that shows, for a particular scenario of a use case, the events that external actors generate, their order, and inter-system events. An SSD should be done for the main success scenario of the use case, and frequent or complex alternative scenarios.
→Sequence diagrams, commonly used by developers, model the interactions between objects in a single use case.

Sequence Diagram Notations

→A sequence diagram is structured in such a way that it represents a timeline which begins at the top and descends gradually to mark the sequence of interactions. Each object has a column and the messages exchanged between them are represented by arrows.

1. Lifeline Notation



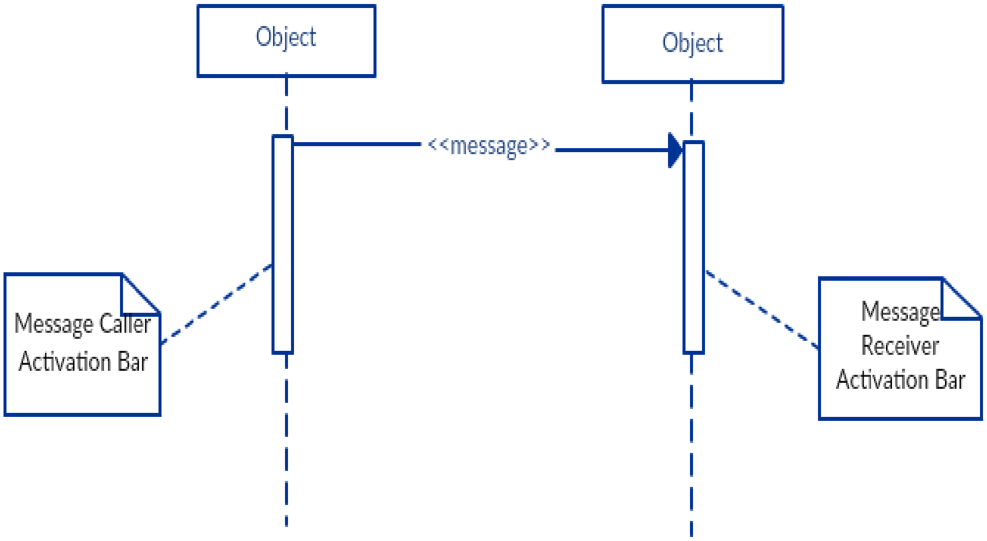
A sequence diagram is made up of several of these lifeline notations that should be arranged horizontally across the top of the diagram. No two lifeline notations should overlap each other. They represent the different objects or parts that interact with each other in the system during the sequence.

→A lifeline notation with an actor element symbol is used when the particular sequence diagram is owned by a use case.

2. Activation Bars

→Activation bar is the box placed on the lifeline. It is used to indicate that an object is active (or instantiated) during an interaction between two objects. The length of the rectangle indicates the duration of the objects staying active.

→In a sequence diagram, an interaction between two objects occurs when one object sends a message to another. The use of the activation bar on the lifelines of the Message Caller (the object that sends the message) and the Message Receiver (the object that receives the message) indicates that both are active/is instantiated during the exchange of the message.


Object
Object
<<message>>
Message Caller Activation Bar
Message Receiver Activation Bar

3. Message Arrows

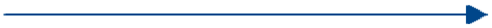
→An arrow from the Message Caller to the Message Receiver specifies a message in a sequence diagram. A message can flow in any direction; from left to right, right to left or back to the Message Caller itself. While you can describe the message being sent from one object to the other on the arrow, with different arrowheads you can indicate the type of message being sent or received.

→The message arrow comes with a description, which is known as a message signature, on it. The format for this message signature is below. All parts except the message_name is optional.

attribute = message_name (arguments): return_type

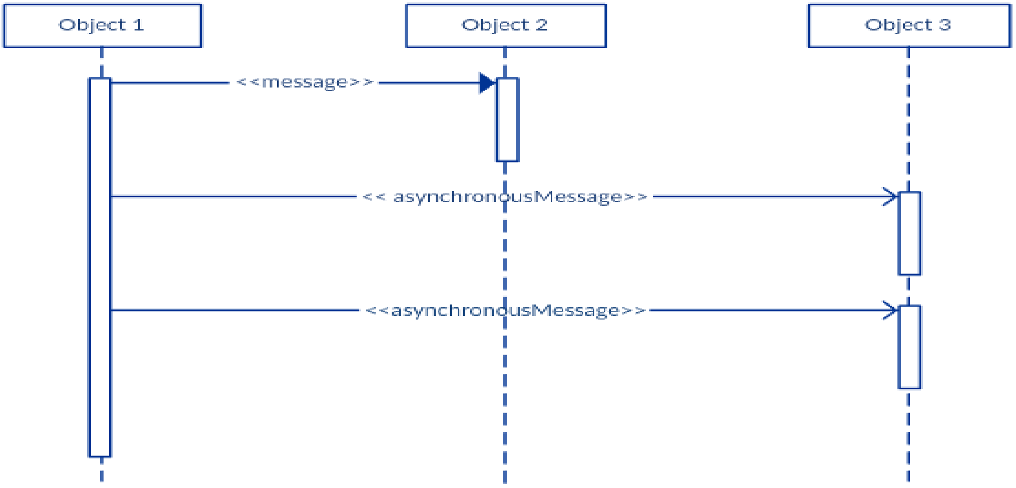
4. Synchronous message

→As shown in the activation bars example, a synchronous message is used when the sender waits for the receiver to process the message and return before carrying on with another message. The arrow head used to indicate this type of message is a solid one, like the one below.



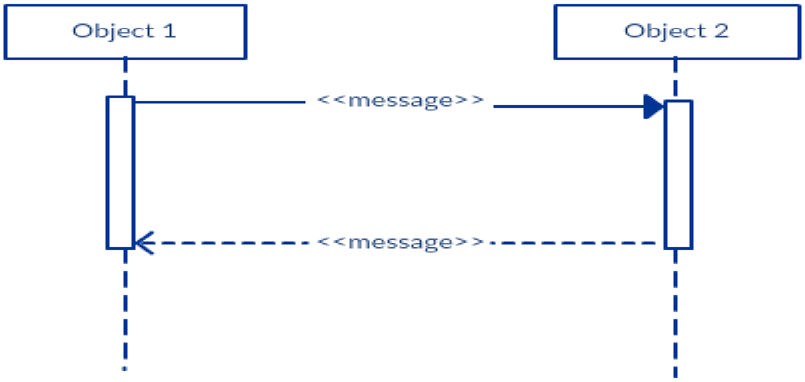
5. Asynchronous message

→An asynchronous message is used when the message caller does not wait for the receiver to process the message and return before sending other messages to other objects within the system. The arrow head used to show this type of message is a line arrow like shown in the example below.



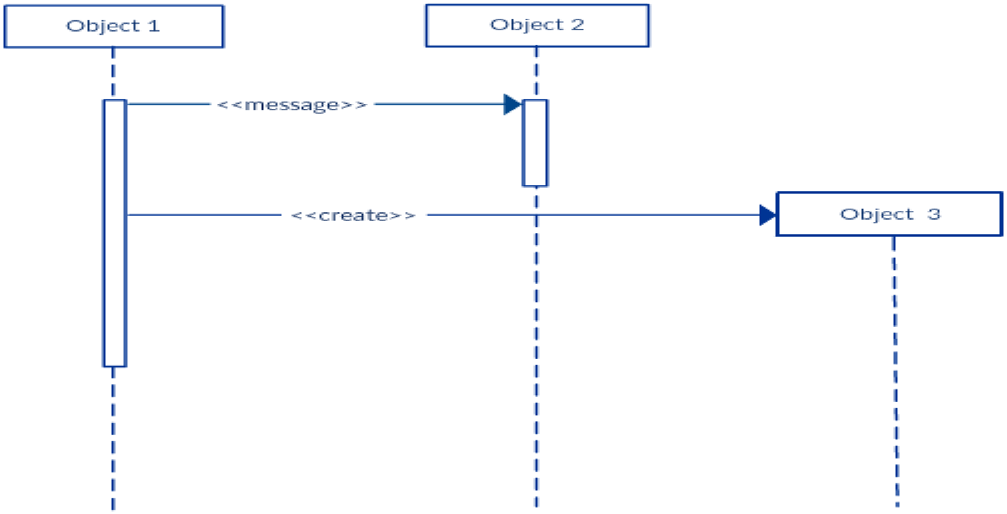
6. Return message

→A return message is used to indicate that the message receiver is done processing the message and is returning control over to the message caller. Return messages are optional notation pieces, for an activation bar that is triggered by a synchronous message always implies a return message.



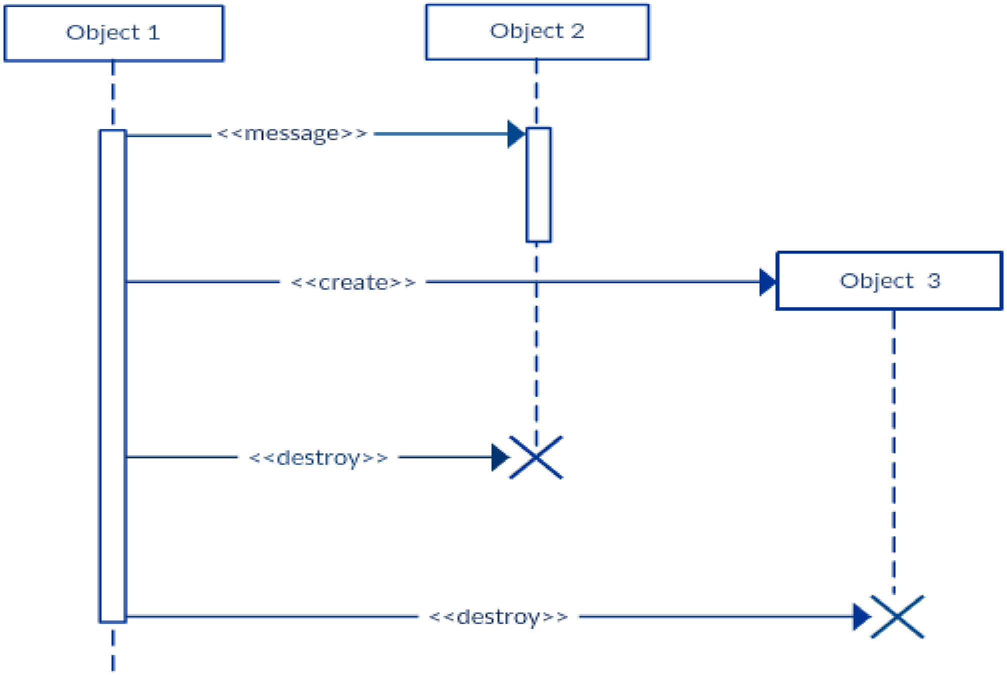
7. Participant creation message

→Objects do not necessarily live for the entire duration of the sequence of events. Objects or participants can be created according to the message that is being sent. The dropped participant box notation can be used when you need to show that the particular participant did not exist until the create call was sent. If the created participant does something immediately after its creation, you should add an activation box right below the participant box.



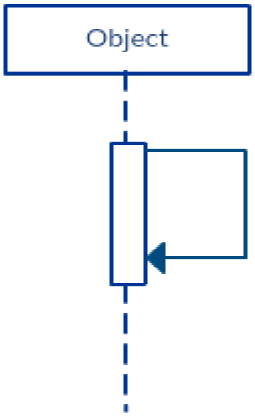
8. Participant destruction message

Likewise, participants when no longer needed can also be deleted from a sequence diagram. This is done by adding an ‘X’ at the end of the lifeline of the said participant.



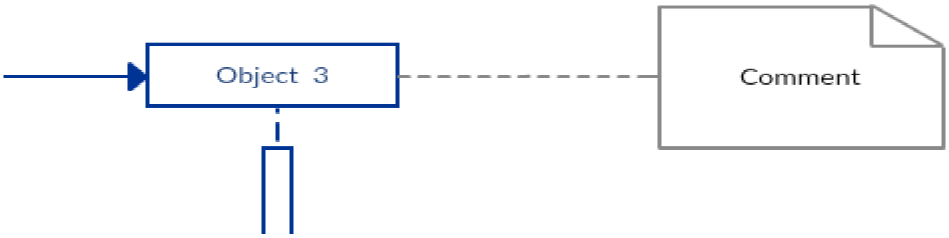
9. Reflexive message

→ When an object sends a message to itself, it is called a reflexive message. It is indicated with a message arrow that starts and ends at the same lifeline like shown in the example below.



10. Comment

→UML diagrams generally permit the annotation of comments in all UML diagram types. The comment object is a rectangle with a folded-over corner as shown below. The comment can be linked to the related object with a dashed line.



Example:

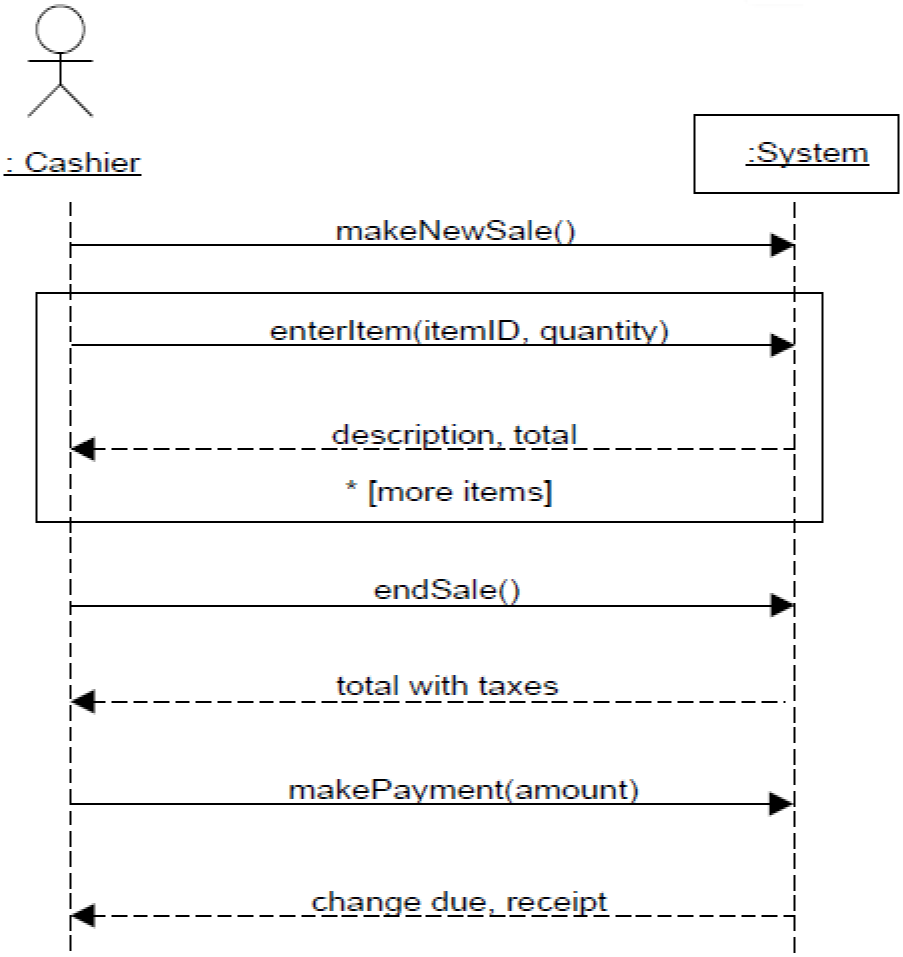


Fig: SSD for a Process Sale scenario

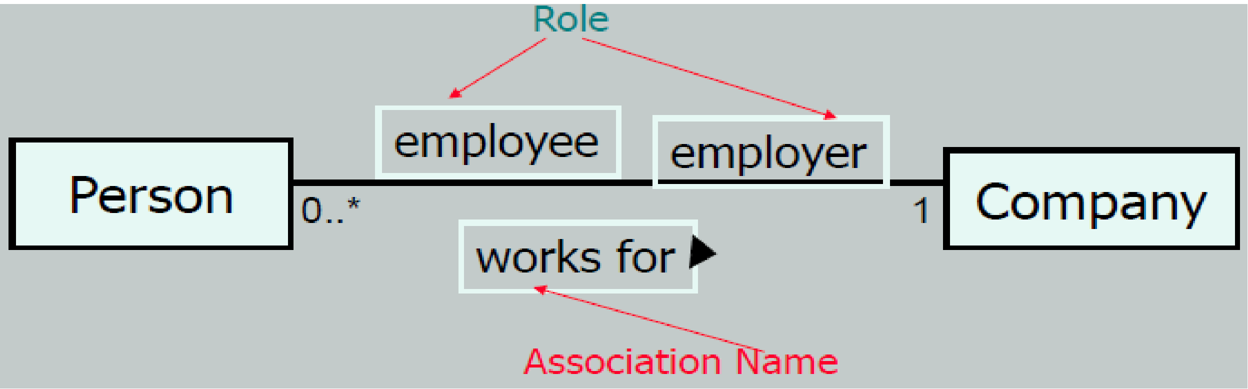
Domain model:

A domain model is widely used as a source of inspiration for designing software objects, and will be a required input to several subsequent artifacts
A domain model illustrates meaningful (to the modelers) conceptual classes in a problem domain; it is the most important artifact to create during object-oriented analysis.
A **domain model** is a *visual* representation of conceptual classes or real-world objects in a domain of interest
They have also been called **conceptual models**, **domain object models, and analysis object models.**
Why do a domain model?
Gives a conceptual framework of the things in the problem space.
Features of a domain model
• Domain classes – each domain class denotes a type of object.
• Attributes – an attribute is the description of a named slot of a specified type in a domain class; each instance of the class separately holds a value.
• Associations – an association is a relationship between two (or more) domain classes that describes links between their object instances. Associations can have roles, describing the multiplicity and participation of a class in the relationship.
• Additional rules – complex rules that cannot be shown with symbolically can be shown with attached notes.
Domain classes?
• Each domain class denotes a type of object. It is a descriptor for a set of things that share common features.
Classes can be:-
• Business objects - represent things that are manipulated in the business e.g. Order.
• Real world objects – things that the business keeps track of e.g. Contact, Site.
• Events that transpire - e.g. sale and payment.

Associations
•A link between two classes ("has a")

- Typically modeled as a member reference
- Notation from Extended Entity Relation (EER) models

•A Person works for a Company



- Role names and multiplicity at association ends

- Direction arrow to aid reading of association name

Adding Association

•An association is a relationship between classes that indicates some meaningful and interesting connection.

•In the UML, associations are defined as "the semantic relationship between two or more classifiers that involve connections among their instances."

Adding Attributes

•An attribute is a logical data value of an object.

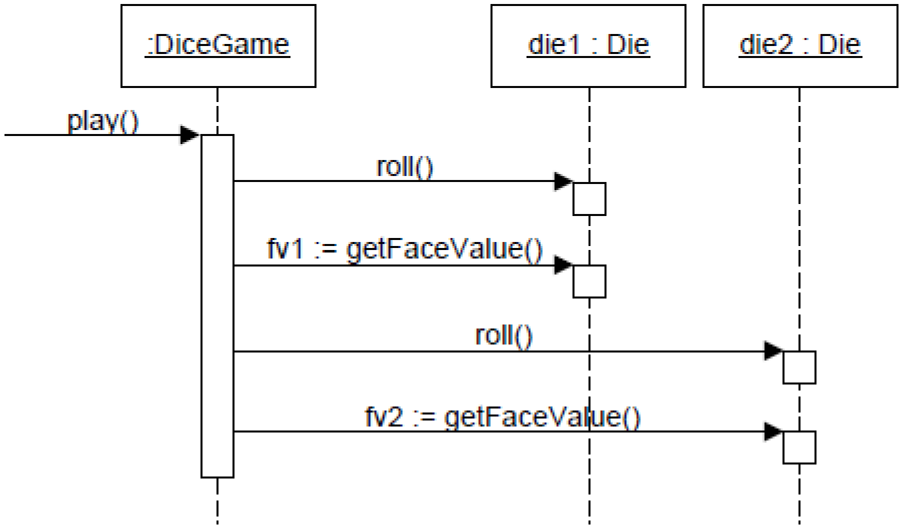
•Include the following attributes in a domain model: Those for which the requirements suggest a need to remember information.

•An attribute can be a more complex type whose structure is unimportant to the problem, so we treat it like a simple type

•UML Attributes Notation: Attributes are shown in the second compartment of the class box

Interaction Diagrams:

- Interaction Diagrams provide a thoughtful, cohesive, common starting point for inspiration during programming
- Patterns, principles, and idioms can be applied to improve the quality of the Interaction Diagrams
- ➔ The main differences between sequence and collaboration diagrams: sequence diagrams show time-based object interaction while collaboration diagrams show how objects associate with each other.



GRASP Design patterns:

→Stands for General Responsibility Assignment Software Patterns

A Design Model may have

- hundreds or even thousands of software classes and
- hundreds or thousands of responsibilities to be assigned.

During object design, when interactions between objects are defined; we make choices about the assignment of responsibilities to software classes

Responsibilities and Methods

The UML defines a **responsibility** as "a contract or obligation of a classifier". Responsibilities are related to the obligations of an object in terms of its behavior. Basically, these responsibilities are of the following two types: knowing, doing

Doing responsibilities of an object include:

- ✓ doing something itself, such as creating an object or
- ✓ doing a calculation
- ✓ initiating action in other objects
- ✓ controlling and coordinating activities in other objects

Knowing responsibilities of an object include:

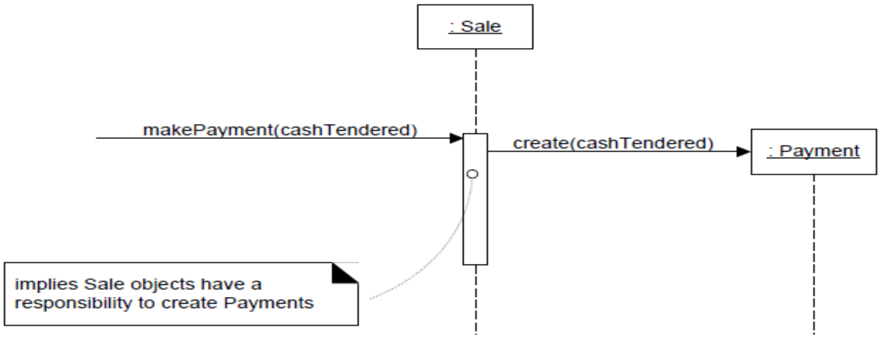
- ✓ knowing about private encapsulated data
- ✓ knowing about related objects
- ✓ knowing about things it can derive or calculate

How to Apply the GRASP Patterns

The following sections present the first five GRASP patterns:

- ✓ Information Expert
- ✓ Creator
- ✓ High Cohesion
- ✓ Low Coupling
- ✓ Controller

A responsibility is not the same thing as a method, but methods are implemented to fulfill responsibilities. Responsibilities are implemented using methods that either act alone or collaborate with other methods and objects. For example, the Sale class might define one or more methods to know its total; say, a method named getTotal. To fulfill that responsibility, the Sale may collaborate with other objects, such as sending agetSubtotal message to each SalesLineltem object asking for its subtotal


: Sale
makePayment(cashTendered)
create(cashTendered)
: Payment
implies Sale objects have a responsibility to create Payments

→Indicates that Sale objects have been given a responsibility to create Payments, which is invoked with a makePayment message and handled with a corresponding makePayment method. Furthermore, the fulfillment of this responsibility requires collaboration to create the SalesLineltem object and invoke its constructor.

- a pattern is a named problem/solution pair that can be applied in new context, with advice on how to apply it in novel situations and discussion of its trade-offs.
- "One person’s pattern is another person’s primitive building block" is an object technology adage illustrating the vagueness of what can be called a pattern

Repeating Patterns

- New pattern could be considered an oxymoron, if it describes a new idea. The very term "pattern" is meant to suggest a repeating thing. The point of patterns is not to express new design ideas.
  - **GRASP: Patterns of General Principles in Assigning** Responsibilities
  - To summarize the preceding introduction:
  - The skillful assignment of responsibilities is extremely important in object design. Determining the assignment of responsibilities often occurs during The creation of interaction diagrams, and certainly during programming.
  - patterns are named problem/solution pairs that codify good advice and principles often related to the assignment of responsibilities.
    <u>How to Apply the GRASP Patterns</u>
  - The following sections present the first five GRASP patterns:
  - • Information Expert
  - • Creator
  - • High Cohesion
  - • Low Coupling
  - • Controller

<u>Information Expert (or Expert)</u>

Solution Assign a responsibility to the information expert.the class that has the *information* necessary to fulfill the responsibility.

Problem What is a general principle of assigning responsibilities to objects?

A Design Model may define hundreds or thousands of software classes, and an application may require hundreds or thousands of responsibilities to be fulfilled. During object design, when the interactions between objects are defined, we make choices about the assignment of responsibilities to software classes.

<u>Creator</u>

Solution Assign class B the responsibility to create an instance of class A if one or more of the following is true:

. B *aggregates* A objects.

. B *contains* A objects.

. B *records* instances of A objects.

. B *closely uses* A objects.

. B *has the initializing data* that will be passed to A when it is created (thus B is an Expert with respect to creating A).

B is a *creator* of A objects.

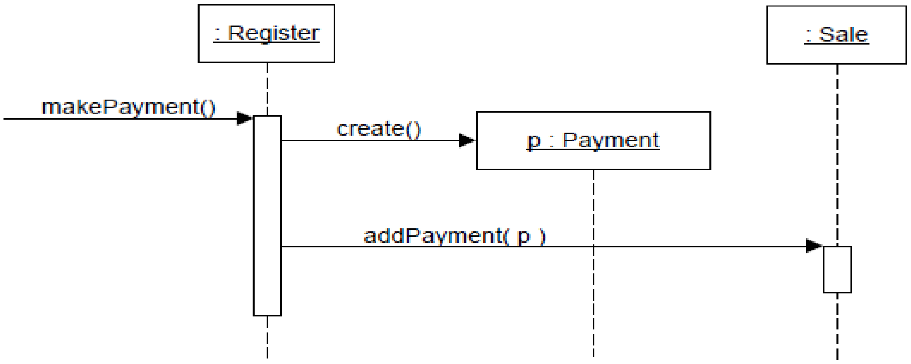
If more than one option applies, prefer a class B which *aggregates* or *contains* class A.
Problem Who should be responsible for creating a new instance of some class?
The creation of objects is one of the most common activities in an object-oriented system. Consequently, it is useful to have a general principle for the assignment of creation responsibilities. Assigned well, the design can support low coupling, increased clarity, encapsulation, and reusability.

Low Coupling

Solution Assign a responsibility so that coupling remains low.
Problem How to support low dependency, low change impact, and increased reuse?
Coupling is a measure of how strongly one element is connected to, has knowledge of, or relies on other elements. An element with low (or weak) coupling is not dependent on too many other elements; "too many" is context-dependent, but will be examined. These elements include classes, subsystems, systems, and so on.
A class with high (or strong) coupling relies on many other classes. Such classes may be undesirable; some suffer from the following problems:
. Changes in related classes force local changes.
. Harder to understand in isolation.
. Harder to reuse because its use requires the additional presence of the classes on which it is dependent.

High cohesion:

Solution Assign a responsibility so that cohesion remains high.
Problem How to keep complexity manageable?
In terms of object design, **cohesion** (or more specifically, functional cohesion) is a measure of how strongly related and focused the responsibilities of an element are. An element with highly related responsibilities, and which does not do a tremendous amount of work, has high cohesion. These elements include classes, subsystems, and so on.
A class with low cohesion does many unrelated things, or does too much work. Such classes are undesirable; they suffer from the following problems:
. hard to comprehend
. hard to reuse
. hard to maintain
. delicate; constantly effected by change
Low cohesion classes often represent a very "large grain" of abstraction, or have taken on responsibilities that should have been delegated to other objects.
Example The same example problem used in the Low Coupling pattern can be analyzed for High Cohesion.



Controller

Solution Assign the responsibility for receiving or handling a system event message to a class representing one of the following choices:

. Represents the overall system, device, or subsystem *(facade controller).*

. Represents a use case scenario within which the system event occurs, often named <UseCaseName>Handler, <UseCaseName>Coordinator, or <Use-CaseName>Session *(use-case or session controller).*

o Use the same controller class for all system events in the same use case scenario.

o Informally, a session is an instance of a conversation with an actor. Sessions can be of any length, but are often organized in terms of use cases

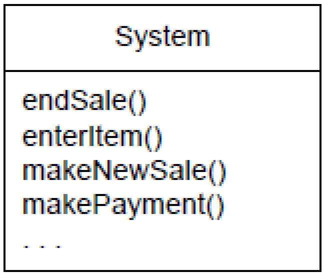
Problem Who should be responsible for handling an input system event?

An input system event is an event generated by an external actor. They are associated with system operations operations of the system in response to system events, just as messages and methods are related.

For example, when a cashier using a POS terminal presses the "End Sale" button, he is generating a system event indicating "the sale has ended." Similarly, when a writer using a word processor presses the "spell check" button, he is generating a system event indicating "perform a spell check."

A Controller is a non-user interface object responsible for receiving or handling a system event. A Controller defines the method for the system operation.

Example In the NextGen application, there are several system operations, as illustrated in the following figure:



Design Model: Use case realizations with GRASP patterns:

"A use-case realization describes how a particular use case is realized within the design model, in terms of collaborating objects" UML interaction diagrams are a common language to illustrate use-case realizations.

There are principles and patterns of object design, such as Information Expert and Low Coupling, that can be applied during this design work.

UP artifacts:

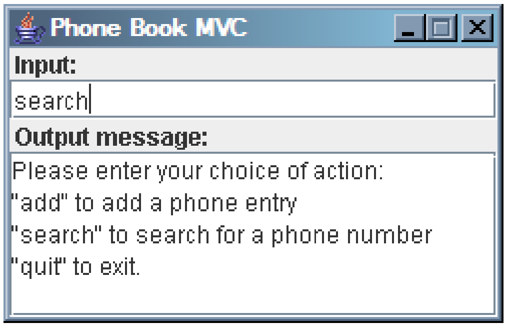
- The use case suggests the system events that are explicitly shown in system sequence diagrams.
- Details of the effect of the system events in terms of changes to domain objects may optionally be described in system operation contracts.
- The system events represent messages that initiate interaction diagrams, which illustrate how objects interact to fulfill the required tasks—the use case realization.

• The interaction diagrams involve message interaction between software objects whose names are sometimes inspired by the names of conceptual classes in the Domain Model, plus other classes of objects.

Design Class diagrams in each MVC layer Mapping Design to Code:

CASE STUDY: The Phone Book MVC

→It includes a text-based interface that allows the user to add name/phone pairs and search for phone by name.



Input:

search

Output message:

Please enter your choice of action:
"add" to add a phone entry
"search" to search for a phone number
"quit" to exit.

The application's architecture is based on the popular Model-View-Controller (MVC) architectural design pattern; the Model is responsible for data processing and persistence, the View is responsible for the user interface (presentation and collection of user input), and the Controller is responsible for executing actions according to user input and current state of the application.

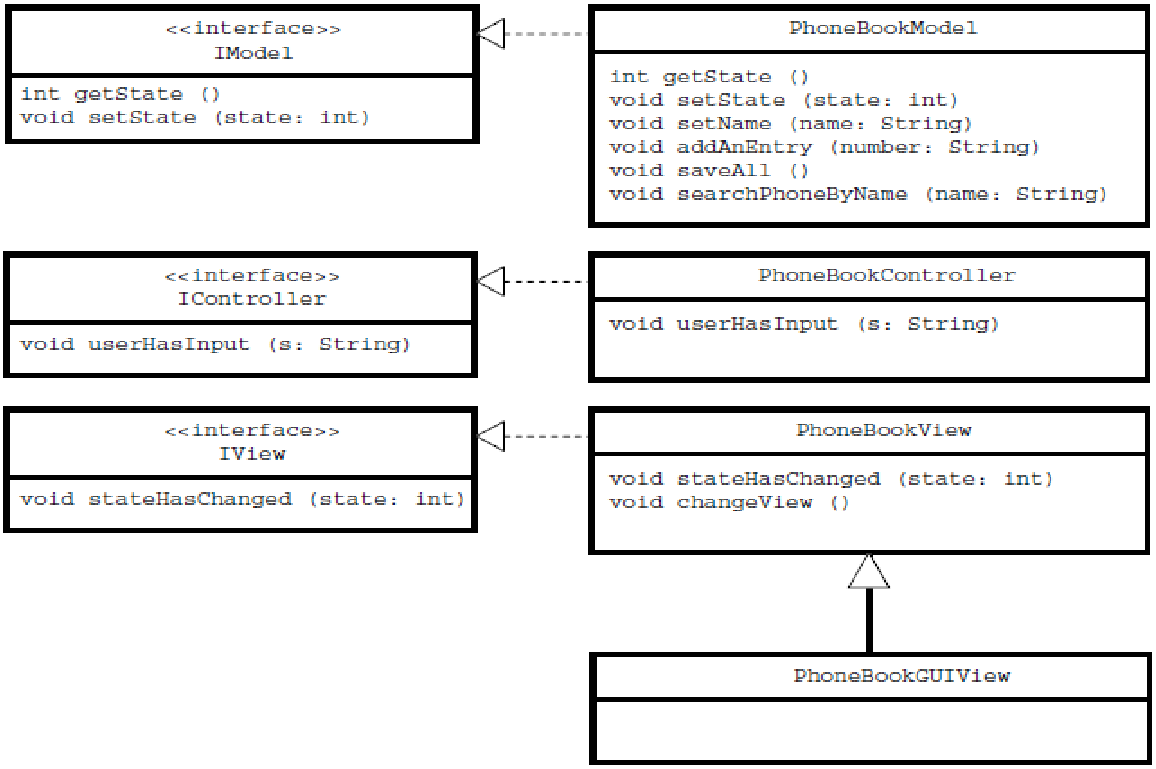

<<interface>>
IModel
int getState ()
void setState (state: int)
PhoneBookModel
int getState ()
void setState (state: int)
void setName (name: String)
void addAnEntry (number: String)
void saveAll ()
void searchPhoneByName (name: String)
<<interface>>
IController
void userHasInput (s: String)
PhoneBookController
void userHasInput (s: String)
<<interface>>
IView
void stateHasChanged (state: int)
PhoneBookView
void stateHasChanged (state: int)
void changeView ()
PhoneBookGUIView

Fig: The phone book application's class diagram

➔ Above figure shows the Phone Book application UML class diagram; it includes three interfaces and three concrete classes that implement them, plus another class, PhoneBookGUIView, which extends PhoneBookView.

Case Study - Answering System:

An initial reading of requirements documents and use cases as shown in figure 3.... suggests that the following will be part of the system:

- A controller object representing the Answering Machine itself.
- Boundary objects representing the individual components parts of Answering Machine:
  - Owner Console consists of display, keyboard, etc.
  - Microphone
  - Speaker
  - Phone Line
- An entity object representing the message storage – Message Box
- An entity object representing the greeting storage – Greeting Box

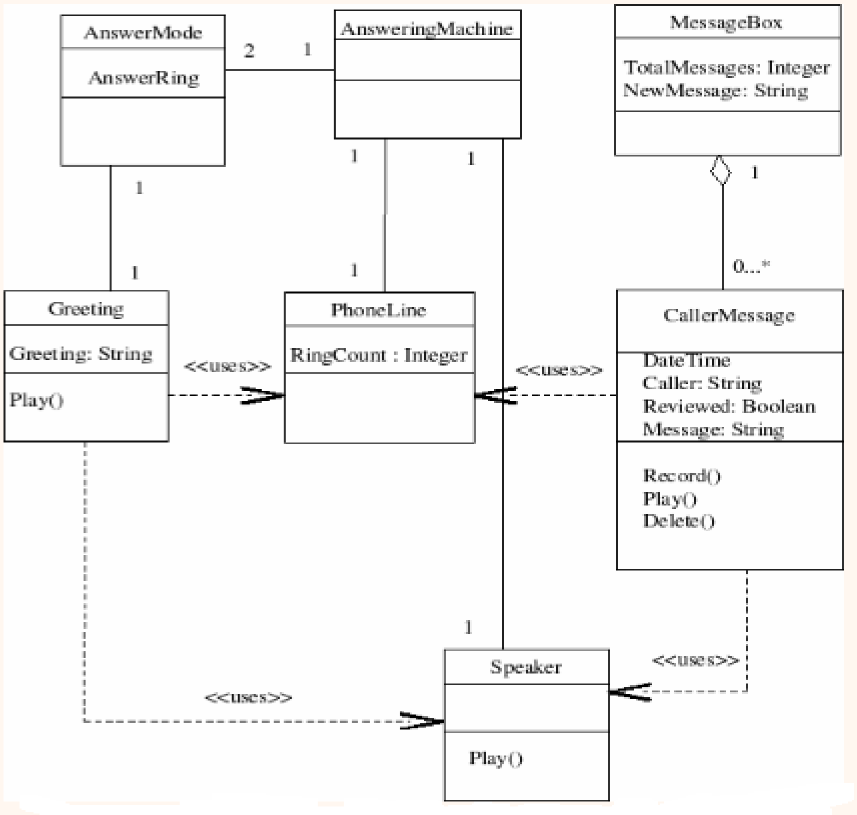
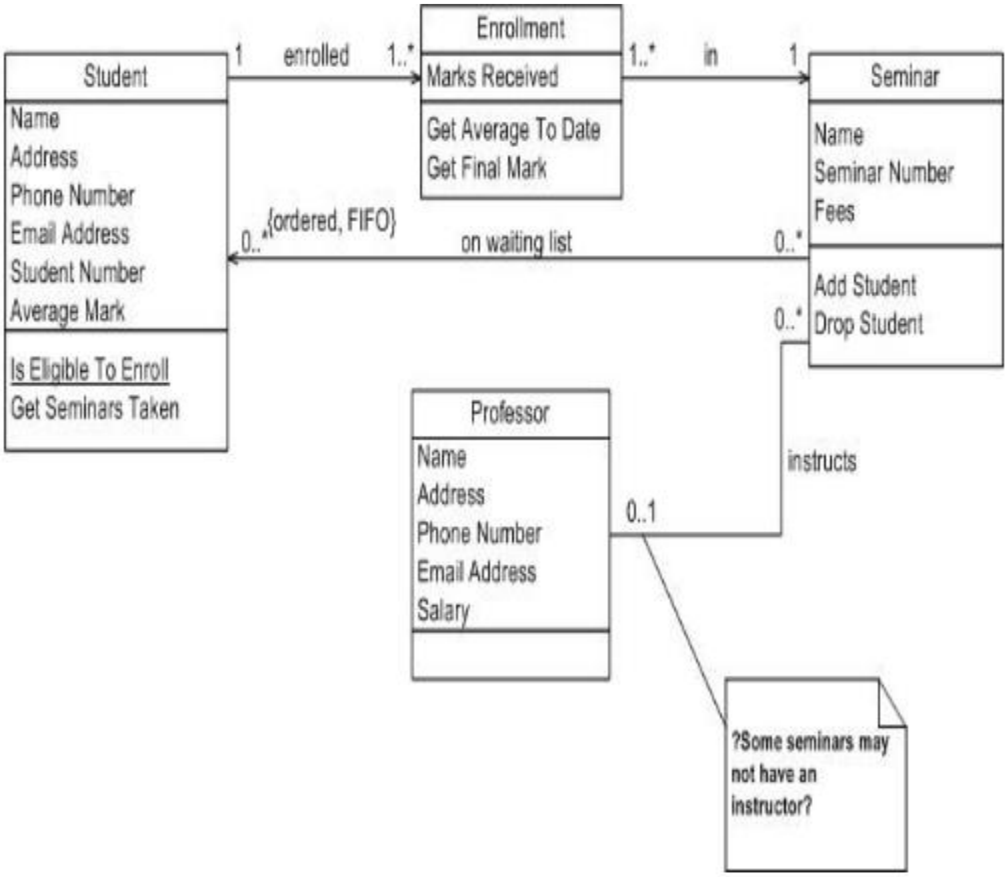


Fig: class diagram for answering system

<u>Design a class diagram for skeleton code:</u>



UNIT-4

Fabrication

We have explored what are patterns and GRASP (in part I), Information Expert in part II and Creator in part II, Controller in Part IV, "Low Coupling" in part V and "High Cohesion" in part VI and Polymorphism in Part VII. In this part VIII, we would focus on next GRASP pattern named "Pure Fabrication". Generally working on existing system, everybody fumbles on a dilemma about changing the existing design. Imagine scenario where the existing classes have low cohesion and high coupling rather it violates the High cohesion and low coupling. It would be overkill to change the existing classes in entirety or even it could be unviable from the perspective of budget(and time). The principle behind this pattern is to resolve such a dilemma by deciding on ***"Whom to assign responsibilities when assigning to existing domain classes violates High cohesion and Low coupling?"*** These domain classes are generally the Information Expert classes.

Problem: Who should be responsible when an expert violates high cohesion and low coupling?

Solution: Assign the responsibility for handling a system event message to a class which is new fictitious (artificial) and doesn't represent a concept in domain.

Assign the cohesive set of responsibilities to such class in order to support high cohesion, low coupling and reuse.

As this class is fictitious hence it can be called as its outcome of imagination or pure fabrication.

Approach:

Step I: Closely look at domain/ design model and locate the classes with low cohesion and high coupling. **e.**g. "Sale" class doing all the database operation related to "Sale"

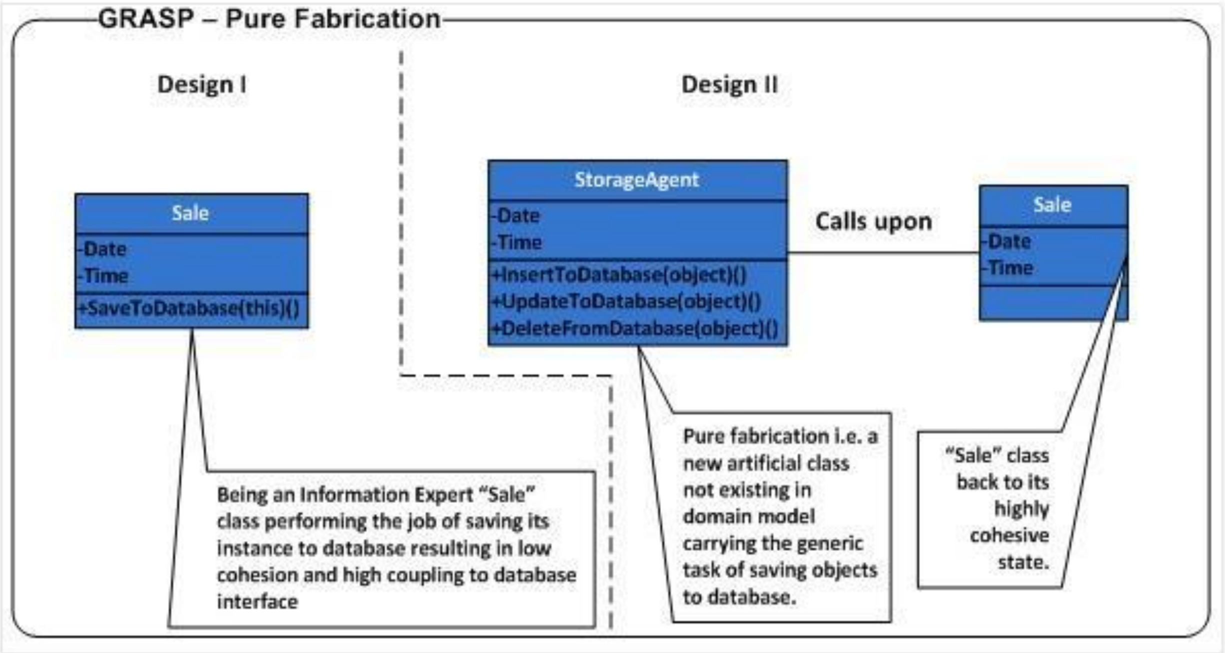
Step II: Create a new class to take the responsibility of functionality causing low cohesion and high coupling.

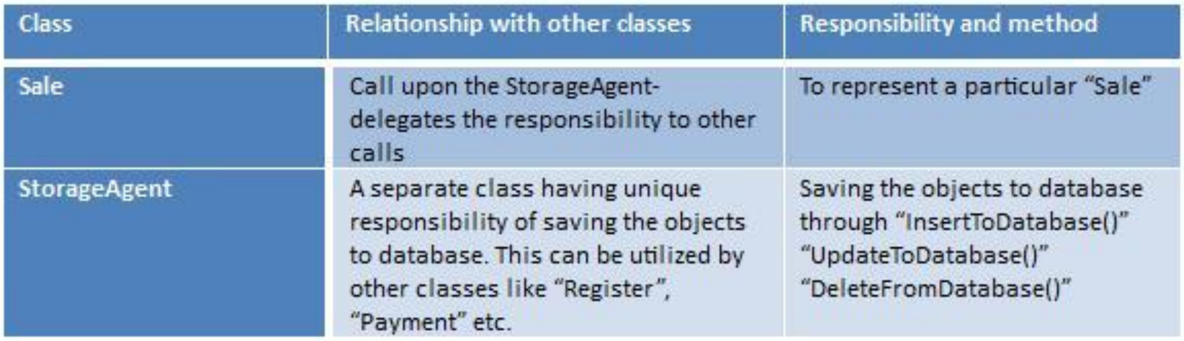
Description

Let's extend an example of POS (Point Of Sale) systems explained in previous part. We are fairly aware of "Sale" class by now. By principle of "Information Expert", the responsibility of saving the instance of "Sale" is with the "Sale" class. (Left part of Fig no.1 i.e. "Design I")

This results in large number of database oriented operations which actually has nothing to do with "Sales". Also there could be additional overhead of transaction related stuff. This leads the "Sale" class towards the low cohesion (remember the definition, "A Class responsible for many things in related areas") i.e. the database operations are related but it ends up doing many things.

Also while performing such database operations; it would need to employ the database interface culminating into low coupling. In fact, such database operations are generic in nature and have potential for reuse.The solution is to create a new class say “StorageAgent“which would interact with database interface and saves the instance of “Sale” class. As “Sale” would be spared from saving its own instance into database thus giving rise to high cohesion and low coupling. In this fashion the “StorageAgent” is also highly cohesive by performing the sole responsibility of saving the instance / object. (Right part of Fig no.1 i.e. “Design II”).


GRASP – Pure Fabrication
Design I
Design II
Sale
-Date
-Time
+SaveToDatabase(this)()
StorageAgent
-Date
-Time
+InsertToDatabase(object)()
+UpdateToDatabase(object)()
+DeleteFromDatabase(object)()
Calls upon
Sale
-Date
-Time
Being an Information Expert “Sale” class performing the job of saving its instance to database resulting in low cohesion and high coupling to database interface
Pure fabrication i.e. a new artificial class not existing in domain model carrying the generic task of saving objects to database.
“Sale” class back to its highly cohesive state.



Class	Relationship with other classes	Responsibility and method
Sale	Call upon the StorageAgent- delegates the responsibility to other calls	To represent a particular “Sale”
StorageAgent	A separate class having unique responsibility of saving the objects to database. This can be utilized by other classes like “Register”, “Payment” etc.	Saving the objects to database through “InsertToDatabase()” “UpdateToDatabase()” “DeleteFromDatabase()”

As demonstrated, the “StorageAgent” is a generic and reusable class. All such classes i.e. pure fabrication (rather purely fabricated) classes are function centric. Other good examples are the adapters, observers and one would find many examples in a service layer.As per Larman, there are 2 approaches of designing which the pure fabrication is the behavioural way. Representation decomposition: Designing the objects the way they represent in the domain

- Behavioural decomposition: Designing the objects the way they do. These are function centric or encapsulate algorithm

Commonly, the pure fabrication is used to place / encapsulate the algorithm or function which doesn’t fit well in other classes.

Benefits:

- Supports Low Coupling
- Results in high cohesion
- Promotes reusability

Liabilities /Contradictions:

- Sometimes such design may result into bunch of classes having a single method which is a kind of overkill.

Singleton:

Intent

- Ensure a class has only one instance, and provide a global point of access to it.
- Encapsulated "just-in-time initialization" or "initialization on first use".

Problem

Application needs one, and only one, instance of an object. Additionally, lazy initialization and global access are necessary.

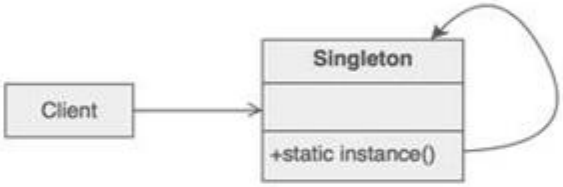
Discussion

Make the class of the single instance object responsible for creation, initialization, access, and enforcement. Declare the instance as a private static data member. Provide a public static ember function that encapsulates all initialization code, and provides access to the instance.The client calls the accessor function (using the class name and scope resolution operator) whenever a reference to the single instance is required. Singleton should be considered only if all three of the following criteria are satisfied:

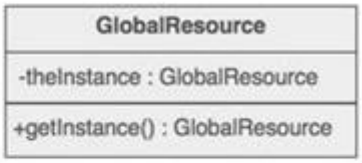
- Ownership of the single instance cannot be reasonably assigned
- Lazy initialization is desirable
- Global access is not otherwise provided for

If ownership of the single instance, when and how initialization occurs, and global access are not issues, Singleton is not sufficiently interesting. The Singleton pattern can be extended to support access to an application-specific number of instances. The "static member function accessor" approach will not support sub classing of the Singleton class.

Structure

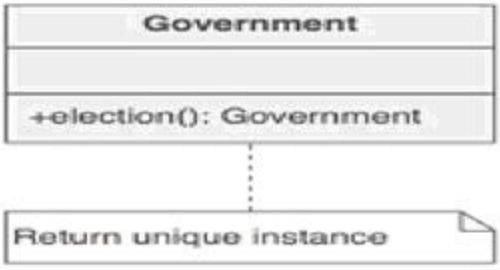


Make the class of the single instance responsible for access and "initialization on first use". The single instance is a private static attribute. The accessor function is a public static method.


GlobalResource
-theInstance : GlobalResource
+getInstance() : GlobalResource

Example

The Singleton pattern ensures that a class has only one instance and provides a global point of access to that instance. It is named after the singleton set, which is defined to be a set containing one element. The office of the President of the United States is a Singleton. The United States Constitution specifies the means by which a president is elected, limits the term of office, and defines the order of succession. As a result, there can be at most one active president at any given time. Regardless of the personal identity of the active president, the title, "The President of the United States" is a global point of access that identifies the person in the office.



Check list

1. Define a private static attribute in the "single instance" class.
2. Define a public staticaccessor function in the class.
3. Do "lazy initialization" (creation on first use) in the accessor function.
4. Define all constructors to be protected or private.
5. Clients may only use the accessor function to manipulate the Singleton.

Rules of thumb

- Abstract Factory, Builder, and Prototype can use Singleton in their implementation.
- Facade objects are often Singletons because only one Facade object is required.
- State objects are often Singletons.
- The advantage of Singleton over global variables is that you are absolutely sure of the number of instances when you use Singleton, and, you can change your mind and manage any number of instances.
- The Singleton design pattern is one of the most inappropriately used patterns. Singletons are intended to be used when a class must have exactly one instance, no more, no less. Designers frequently use Singletons in a misguided attempt to replace global variables. A Singleton is, for intents and purposes, a global variable. The Singleton does not do away with the global; it merely renames it.
- When is Singleton unnecessary? Short answer: most of the time. Long answer: when it's simpler to pass an object resource as a reference to the objects that need it, rather than letting objects access the resource globally. The real problem with Singletons is that they give you such a good excuse not to think carefully about the appropriate visibility of an object. Finding the right balance of exposure and protection for an object is critical for maintaining flexibility.
- Our group had a bad habit of using global data, so I did a study group on Singleton. The next thing I know Singletons appeared everywhere and none of the problems related to global data went away. The answer to the global data question is not, "Make it a Singleton." The answer is, "Why in the hell are you using global data?" Changing the name doesn't change the problem. In fact, it may make it worse because it gives you the opportunity to say, "Well I'm not doing that, I'm doing this" – even though this and that are the same thing.

Factory

Intent

- ✓ Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory Method lets a class defer instantiation to subclasses.
- ✓ Defining a "virtual" constructor.
- ✓ The new operator considered harmful.

Problem

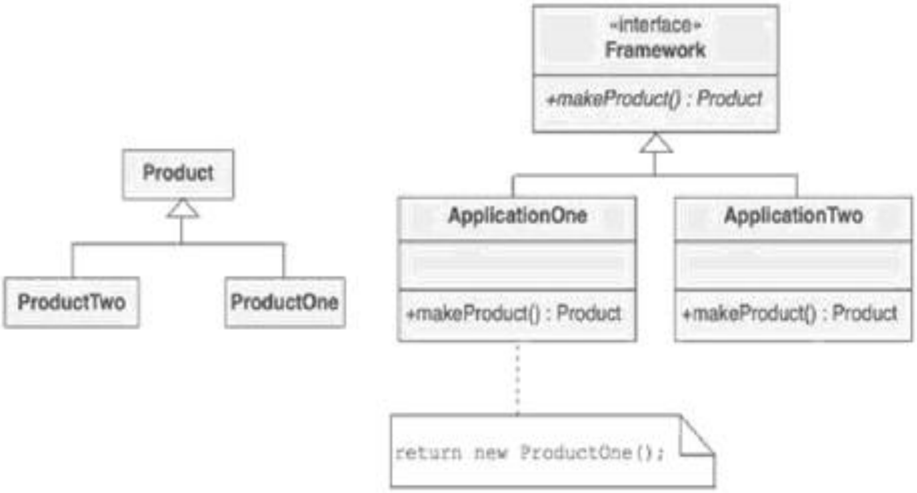
A framework needs to standardize the architectural model for a range of applications, but allow for individual applications to define their own domain objects and provide for their instantiation.

Discussion

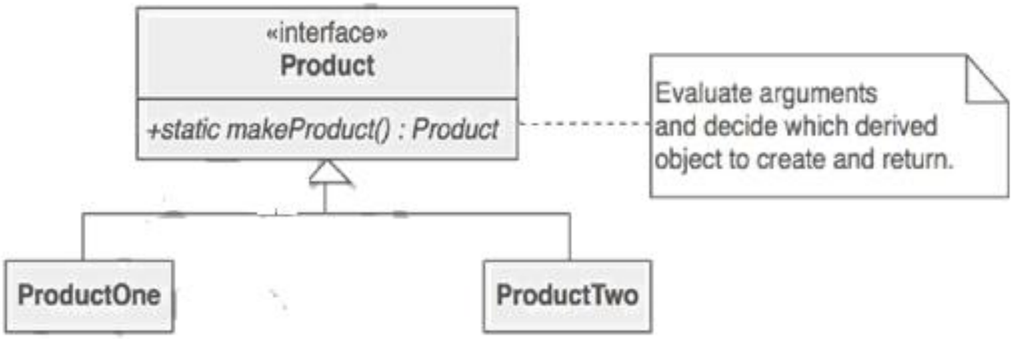
Factory Method is to creating objects as Template Method is to implementing an algorithm. A superclass specifies all standard and generic behavior (using pure virtual "placeholders" for creation steps), and then delegates the creation details to subclasses that are supplied by the client. Factory Method makes a design more customizable and only a little more complicated. Other design patterns require new classes, whereas Factory Method only requires a new operation. People often use Factory Method as the standard way to create objects; but it isn't necessary if: the class that's instantiated never changes, or instantiation takes place in an operation that subclasses can easily override (such as an initialization operation).Factory Method is similar to Abstract Factory but without the emphasis on families. Factory Methods are routinely specified by an architectural framework, and then implemented by the user of the framework.

Structure

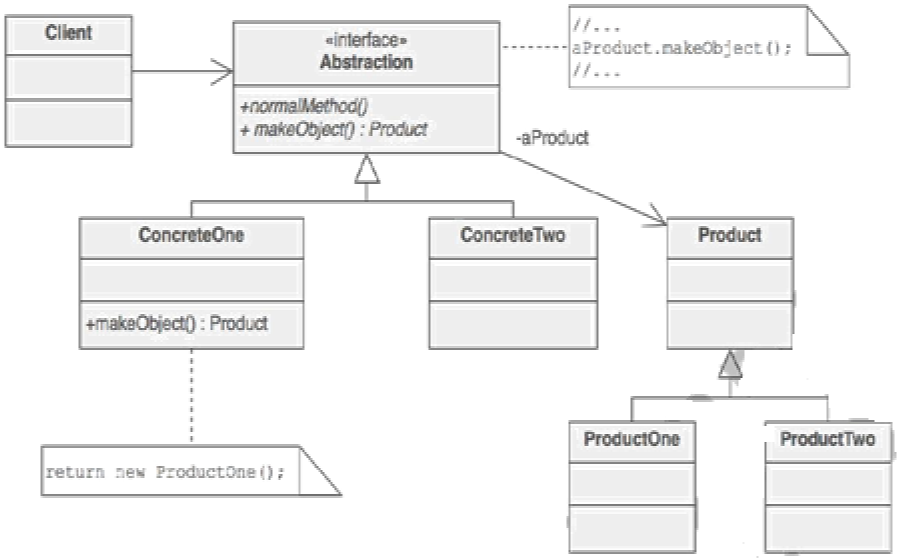
The implementation of Factory Method discussed in the Gang of Four (below) largely overlaps with that of Abstract Factory. For that reason, the presentation in this chapter focuses on the approach that has become popular since.



An increasingly popular definition of factory method is: a static method of a class that returns an object of that class' type. But unlike a constructor, the actual object it returns might be an instance of a subclass. Unlike a constructor, an existing object might be reused, instead of a new object created. Unlike a constructor, factory methods can have different and more descriptive names (e.g. Color.make_RGB_color(float red, float green, float blue) and Color.make_HSB_color(float hue, float saturation, float brightness)

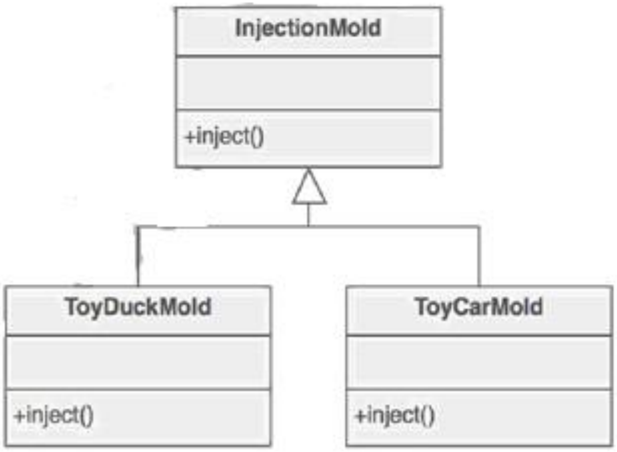


The client is totally decoupled from the implementation details of derived classes. Polymorphic creation is now possible.



Example

The Factory Method defines an interface for creating objects, but lets subclasses decide which classes to instantiate. Injection molding presses demonstrate this pattern. Manufacturers of plastic toys process plastic molding powder, and inject the plastic into molds of the desired shapes. The class of toy (car, action figure, etc.) is determined by the mold.



Check list

1. If you have an inheritance hierarchy that exercises polymorphism, consider adding a polymorphic creation capability by defining a static factory method in the base class.
2. Design the arguments to the factory method. What qualities or characteristics are necessary and sufficient to identify the correct derived class to instantiate?
3. Consider designing an internal "object pool" that will allow objects to be reused instead of created from scratch.
4. Consider making all constructors private or protected.

Rules of thumb

- ✓ Abstract Factory classes are often implemented with Factory Methods, but they can be implemented using Prototype.
- ✓ Factory Methods are usually called within Template Methods.
- ✓ Factory Method: creation through inheritance. Prototype: creation through delegation.
- ✓ Often, designs start out using Factory Method (less complicated, more customizable, subclasses proliferate) and evolve toward Abstract Factory, Prototype, or Builder (more flexible, more complex) as the designer discovers where more flexibility is needed.
- ✓ Prototype doesn't require sub classing, but it does require an Initialize operation. Factory Method requires subclassing, but doesn't require Initialize.
- ✓ The advantage of a Factory Method is that it can return the same instance multiple times, or can return a subclass rather than an object of that exact type.
- ✓ Some Factory Method advocates recommend that as a matter of language design (or failing that, as a matter of style) absolutely all constructors should be private or protected. It's no one else's business whether a class manufactures a new object or recycles an old one.
- ✓ The new operator considered harmful. There is a difference between requesting an object and creating one. The new operator always creates an object, and fails to encapsulate object creation. A Factory Method enforces that encapsulation, and allows an object to be requested without inextricable coupling to the act of creation.

Façade:

Intent

- ✓ Provide a unified interface to a set of interfaces in a subsystem. Facade defines a higher-level interface that makes the subsystem easier to use.
- ✓ Wrap a complicated subsystem with a simpler interface.

Problem

A segment of the client community needs a simplified interface to the overall functionality of a complex subsystem.

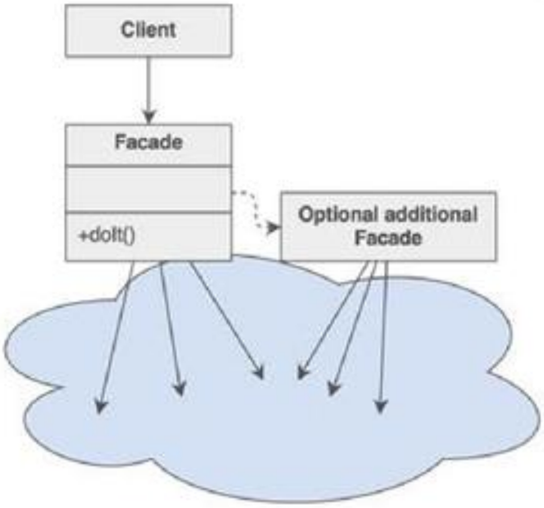
Discussion

Facade discusses encapsulating a complex subsystem within a single interface object. This reduces the learning curve necessary to successfully leverage the subsystem. It also promotes decoupling the subsystem from its potentially many clients. On the other hand, if the Facade is the only access point for the subsystem, it will limit the features and flexibility that "power users" may need.

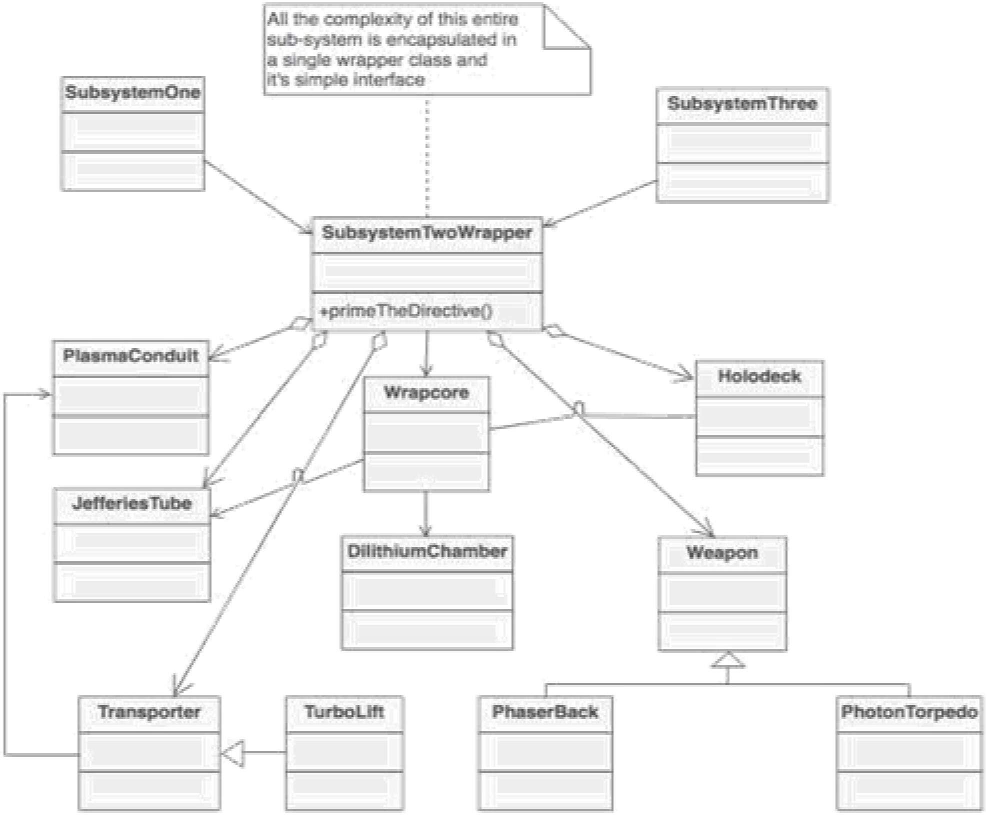
The Facade object should be a fairly simple advocate or facilitator. It should not become an all-knowing oracle or "god" object.

Structure

Facade takes a "riddle wrapped in an enigma shrouded in mystery", and interjects a wrapper that tames the amorphous and inscrutable mass of software.

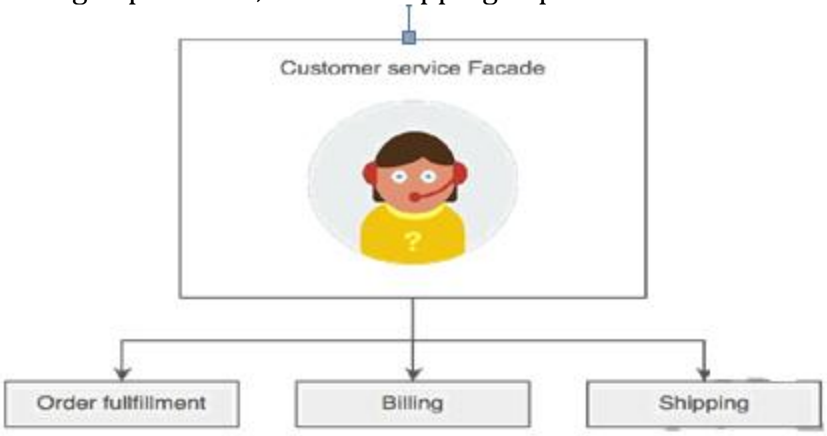


SubsystemOne and SubsystemThree do not interact with the internal components of SubsystemTwo. They use the SubsystemTwoWrapper "facade" (i.e. the higher level abstraction).



Example

The Facade defines a unified, higher level interface to a subsystem that makes it easier to use. Consumers encounter a Facade when ordering from a catalog. The consumer calls one number and speaks with a customer service representative. The customer service representative acts as a Facade, providing an interface to the order fulfillment department, the billing department, and the shipping department.



Check list

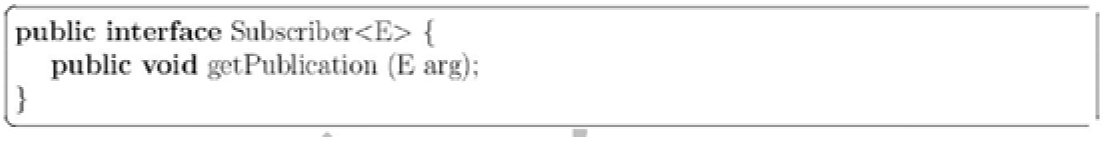
1. Identify a simpler, unified interface for the subsystem or component.
2. Design a 'wrapper' class that encapsulates the subsystem.
3. The facade/wrapper captures the complexity and collaborations of the component, and delegates to the appropriate methods.
4. The client uses (is coupled to) the Facade only.
5. Consider whether additional Facades would add value.

Rules of thumb

- ✓ Facade defines a new interface, whereas Adapter uses an old interface. Remember that Adapter makes two existing interfaces work together as opposed to defining an entirely new one.
- ✓ Whereas Flyweight shows how to make lots of little objects, Facade shows how to make a single object represent an entire subsystem.
- ✓ Mediator is similar to Facade in that it abstracts functionality of existing classes. Mediator abstracts/centralizes arbitrary communications between colleague objects. It routinely "adds value", and it is known/referenced by the colleague objects. In contrast, Facade defines a simpler interface to a subsystem, it doesn't add new functionality, and it is not known by the subsystem classes.
- ✓ Abstract Factory can be used as an alternative to Facade to hide platform-specific classes.
- ✓ Facade objects are often Singletons because only one Facade object is required.
- ✓ Adapter and Facade are both wrappers; but they are different kinds of wrappers. The intent of Facade is to produce a simpler interface, and the intent of Adapter is to design to an existing interface. While Facade routinely wraps multiple objects and Adapter wraps a single object; Facade could front-end a single complex object and Adapter could wrap several legacy objects.

Publish-Subscribe:

- The next design pattern is a bit different than the last ones. It is moreArchitectural, in the sense that it pertains to how classes are put together to achieve a certain goal. The motivating scenario is as follows. Suppose we have an object in the system that is in charge of generating news of interest for the rest of the application. For instance, perhaps it is in charge of keeping track of user input, and tells the rest of the application whenever the user does something of interest. Or, it is in charge of maintaining a clock, and tells the rest of the application whenever the clock ticks one time step. Is there a general approach for handling this kind of thing?
- If we analyze the situation carefully, you'll notice that we have two sorts of entities around: a publisher that is in charge of publishing or generating items of interest to the rest of the application, and the dualSubscribers that are the parts of the application that are interestedin getting these updates. (The Publish-Subscribe design pattern is sometimes called the Observer design pattern, in which context publishers are called observables, and subscribers are called observers.
-
- Think about the operations that we would like to support on subscribers, rst. Well, the main thing we want a subscriber to be able to do is to be noted when a news item is published. Thus, this calls for a subscriber implementing the following interface, parameterized by aType E of values conveyed during the notification (e.g., the news item itself)



```
public interface Subscriber<E> {
   public void getPublication (E arg);
}
```

What about the other end? What do we want a publisher to do? we need to register (or subscribe) a subscriber, so that that subscriber can be notified when a news item is produced. The other operation, naturally enough, is to publish a piece of data,which should let every subscriber know that the data has been produced. When notifying a subscriber, we will also pass a value (perhaps the news item in question). This leads to the following interface that a publisher should implement, parameterized over a type E of values to pass when notifying a subscriber.

UNIT-5

Activity Diagrams:

- An activity diagram shows the flow from activity to activity. An is an ongoing non atomic execution within a state machine.
- Activities ultimately result in some action, which is made up of executable atomic computations that result in a change in state of the system or the return of a value.
- Actions encompass calling another operation, sending a signal, creating or destroying an object, or some pure computation, such as evaluating an expression.
- Graphically, an activity diagram is a collection of vertices and arcs.

Contents

Activity diagrams commonly contain

1. Activity states and action states o Transitions
2. Objects
3. Like all other diagrams, activity diagrams may contain notes and constraints

Action States and Activity States:

- Executable, atomic computations are called **action states** because they are states of the system, each representing the execution of an action.
- We represent an action state using a lozenge shape (a symbol with horizontal top and bottom and convex sides). Inside that shape, you may write any expression.
- Action states can't be decomposed. Furthermore, action states are atomic, meaning that events may occur, but the work of the action state is not interrupted.
- Finally, the work of an action state is generally considered to take insignificant execution time.

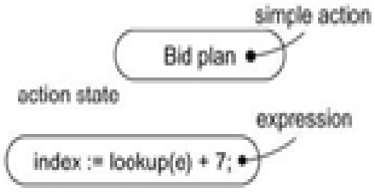


Fig:-Action States

5. **activity states** can be further decomposed, their activity being represented by other activity diagrams
6. Furthermore, activity states are not atomic, meaning that they may be interrupted and, in general, are considered to take some duration to complete.
7. An action state is an activity state that cannot be further decomposed.

8. We can think of an activity state as a composite, whose flow of control is made up of other activity states and action states.

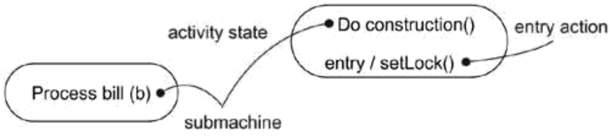


Fig:-Activity States

Transitions

- When the action or activity of a state completes, flow of control passes immediately to the next action or activity state.
- We specify this flow by using transitions to show the path from one action or activity state to the next action or activity state.
- In the UML, you represent a transition as a simple directed line

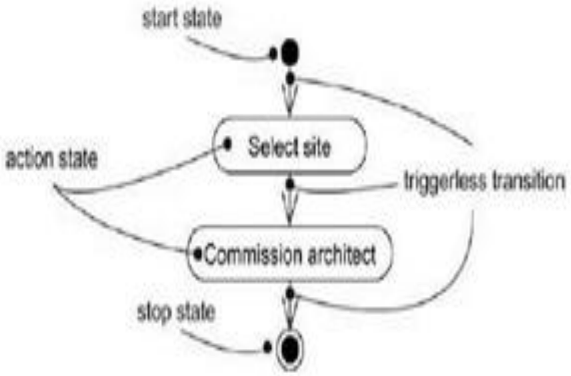
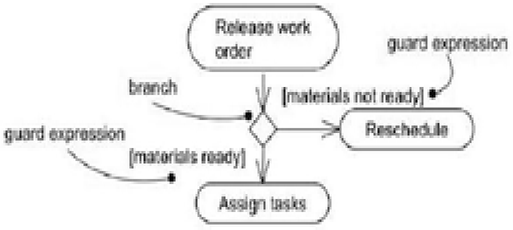


Fig:-Triggerless Transitions

- As in a flowchart, you can include a branch, which specifies alternate paths taken based on some Boolean expression.
- We represent a branch as a diamond. A branch may have one incoming transition and two or more outgoing ones.
- On each outgoing transition, you place a Boolean expression, which is evaluated only once on entering the branch.
- On each outgoing transition, you place a Boolean expression, which is evaluated only once on entering the branch. Across all these outgoing transitions, guards should not overlap (otherwise, the flow of control would be ambiguous), but they should cover all possibilities (otherwise, the flow of control would freeze).

- As a convenience, you can use the keyword else to mark one outgoing transition, representing the path taken if no other guard expression evaluates to true.



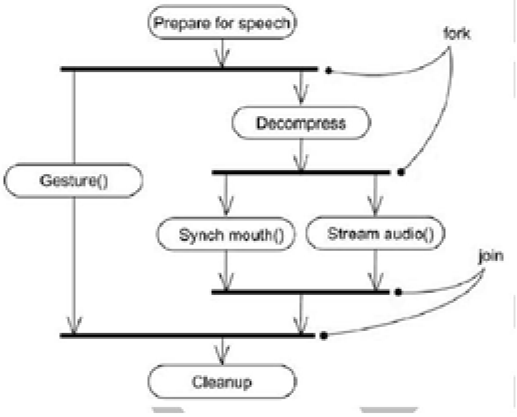
Forking and Joining:

- When we are modeling workflows of business processes—we might encounter flows that are concurrent.

- In the UML, you use a synchronization bar to specify the forking and joining of these parallel flows of control. A synchronization bar is rendered as a thick horizontal or vertical line.

- **Fork** represents the splitting of a single flow of control into two or more concurrent flows of control

- A fork may have one incoming transition and two or more outgoing transitions, each of which represents an independent flow of control.
- Below the fork, the activities associated with each of these paths continues in parallel. Conceptually, the activities of each of these flows are truly concurrent, although, in a running system, these flows may be either truly concurrent or sequential yet interleaved, thus giving only the illusion of true concurrency.



o **A Join** represents the synchronization of two or more concurrent flows of control. o A join may have two or more incoming transitions and one outgoing transition.

o Above the join, the activities associated with each of these paths continues in parallel.

- At the join, the concurrent flows synchronize, meaning that each waits until all incoming flows have reached the join, at which point one flow of control continues on below the join.

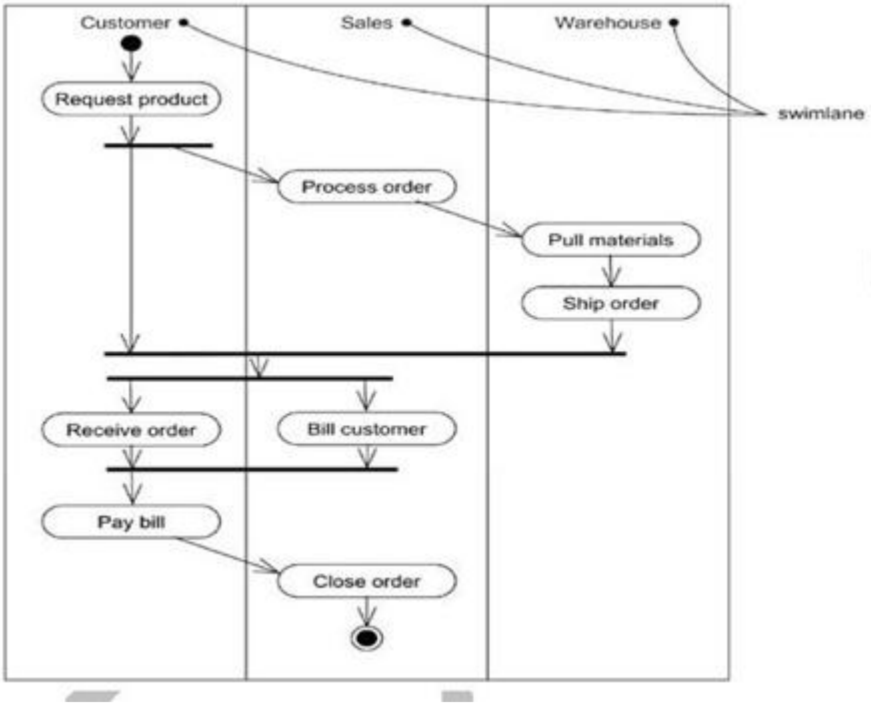
Swimlanes:

- We'll find it useful, especially when you are modeling workflows of business processes, to partition the activity states on an activity diagram into groups, each group representing the business organization responsible for those activities.

- In the UML, each group is called a swimlane because, visually, each group is divided from its neighbor by a vertical solid line
- A swimlane specifies a locus of activities
- Each swimlane has a name unique within its diagram.

- Each swimlane represents a high-level responsibility for part of the overall activity of an activity diagram, and each swimlane may eventually be implemented by one or more classes.

In an activity diagram partitioned into swimlanes, every activity belongs to exactly one swimlane, but transitions may cross lanes.

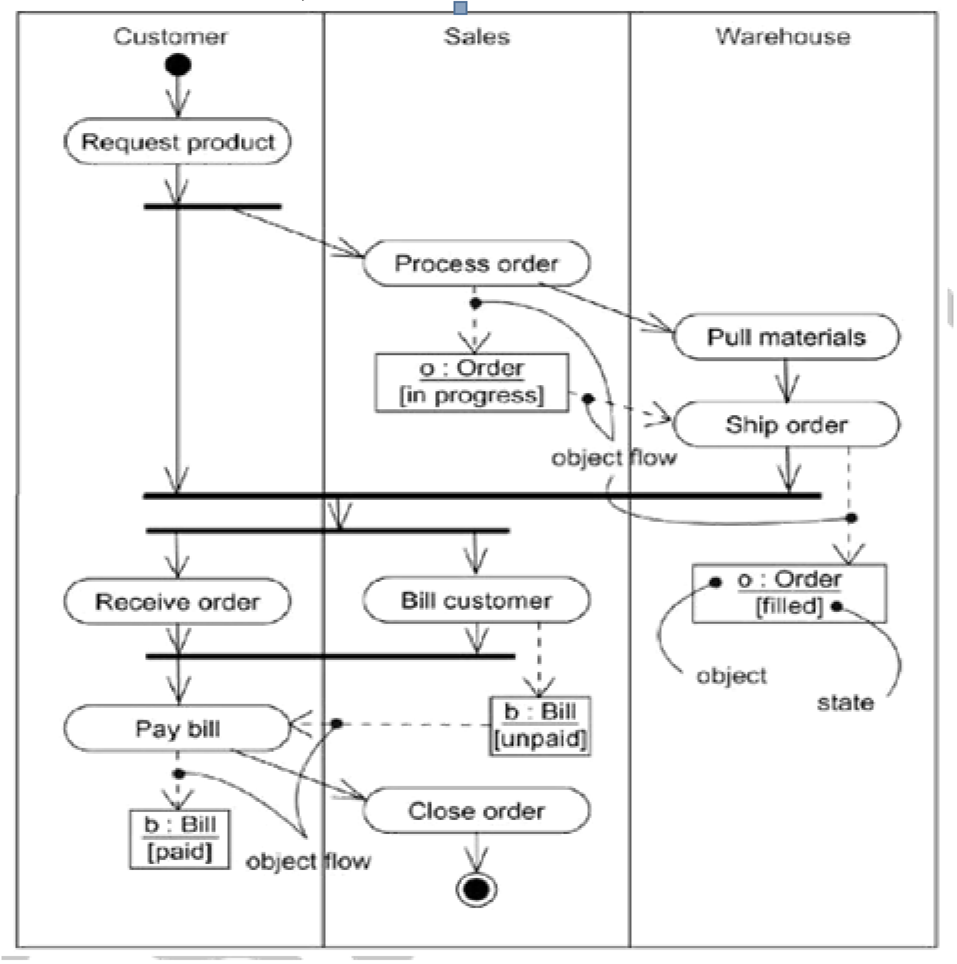


Object Flow

- Objects may be involved in the flow of control associated with an activity diagram.
- We can specify the things that are involved in an activity diagram by placing these objects in the diagram, connected using a dependency to the activity or transition that creates, destroys, or modifies them.
- This use of dependency relationships and objects is called an object flow because it represents the participation of an object in a flow of control.
- We can also show how its role, state and attribute values change.
- We represent the state of an object by naming its state in brackets below the

object's name.

- Similarly, We can represent the value of an object's attributes by rendering them in a compartment below the object's name.



Common Uses

- We use activity diagrams to model the dynamic aspects of a system
- These dynamic aspects may involve the activity of any kind of abstraction in any view of a system's architecture, including classes, interfaces, components, and nodes.
- When you model the dynamic aspects of a system, we'll typically use activity diagrams in two ways.
    - To model a workflow
    - To model an operation

Common Modeling Techniques:

Modeling a work flow:

- No software-intensive system exists in isolation; there's always some context in which a system lives, and that context always encompasses actors that interact with the system.

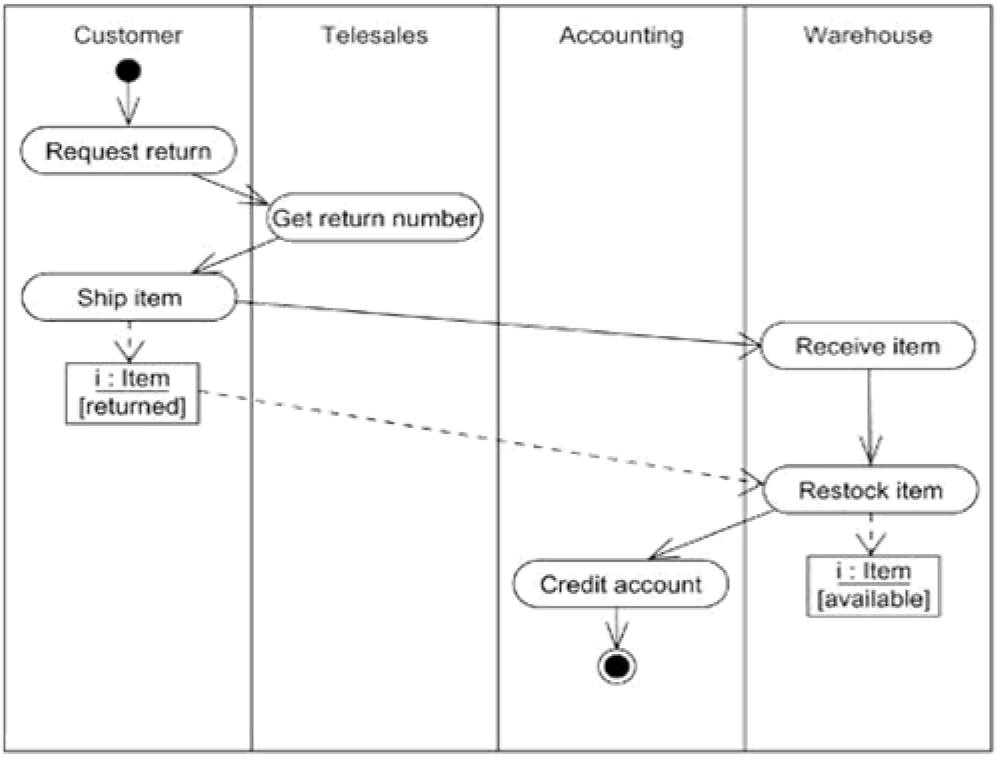
- Especially for mission critical, enterprise software, you'll find automated systems working in the context of higher-level business processes.

- These business processes are kinds of workflows because they represent the flow of work and objects through the business.

To model a workflow,

- Establish a focus for the workflow. For nontrivial systems, it's impossible to show all interesting workflows in one diagram.
- Select the business objects that have the high-level responsibilities for parts of the overall workflow. These may be real things from the vocabulary of the system, or they may be more abstract. In either case, create a swimlane for each important business object.
- Identify the preconditions of the workflow's initial state and the postconditions of the workflow's final state. This is important in helping you model the boundaries of the workflow.
- Beginning at the workflow's initial state, specify the activities and actions that take place over time and render them in the activity diagram as either activity states or action states.
- For complicated actions, or for sets of actions that appear multiple times, collapse these into activity states, and provide a separate activity diagram that expands on each.
- Render the transitions that connect these activity and action states. Start with the sequential flows in the workflow first, next consider branching, and only then consider forking and joining.

If there are important objects that are involved in the workflow, render them in the activity diagram, as well. Show their changing values and state as necessary to communicate the intent of the object flow.



Modeling an Operation

- ➢ An activity diagram can be attached to any modeling element for the purpose of visualizing, specifying, constructing, and documenting that element's behavior.

- ➢ You can attach activity diagrams to classes, interfaces, components, nodes, use cases, and collaborations.

- ➢ The most common element to which you'll attach an activity diagram is an operation.
- ➢ An activity diagram is simply a flowchart of an operation's actions.

- ➢ An activity diagram's primary advantage is that all the elements in the diagram are semantically tied to a rich underlying model.

To model an operation,

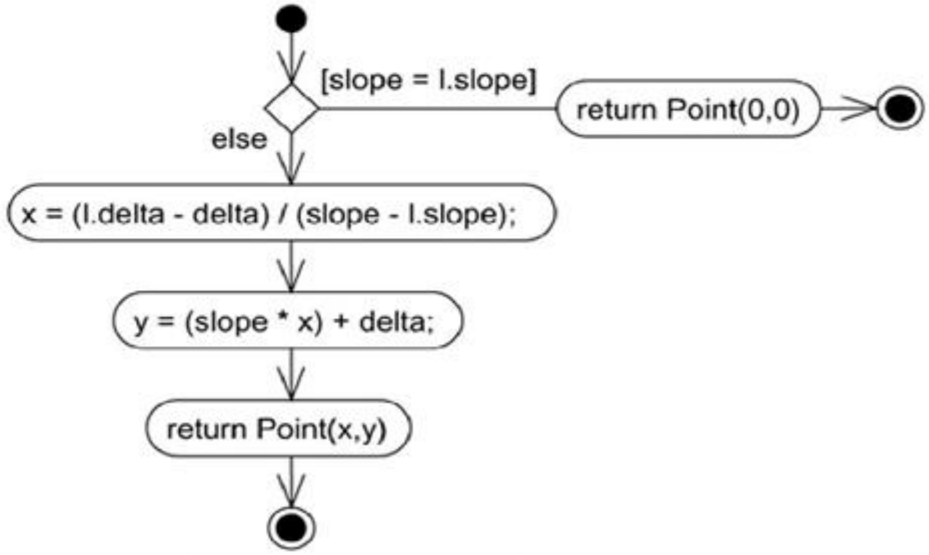
Collect the abstractions that are involved in this operation. This includes the operation's parameters (including its return type, if any), the attributes of the enclosing class, and certain neighboring classes.

Identify the preconditions at the operation's initial state and the post conditions at the operation's final state. Also identify any invariants of the enclosing class that must hold during the execution of the operation.

o Beginning at the operation's initial state, specify the activities and actions that take place over time and render them in the activity diagram as either activity states or action states.

o Use branching as necessary to specify conditional paths and iteration.

o Only if this operation is owned by an active class, use forking and joining as necessary to specify parallel flows of control.



<u>Forward and Reverse Engineering</u>

- **Forward engineering** (the creation of code from a model) is possible for activity diagrams, especially if the context of the diagram is an operation.

- For example, using the previous activity diagram, a forward engineering tool could generate the following C++ code for the operation intersection.

```
Point Line::intersection (l : Line) {

  if (slope == l.slope) return Point(0,0);
  int x = (l.delta - delta) / (slope -
  l.slope); int y = (slope * x) + delta;
  return Point(x, y);

  }
```

- **Reverse engineering** (the creation of a model from code) is also possible for activity diagrams, especially if the context of the code is the body of an operation.

- In particular, the previous diagram could have been generated from the implementation of the class Line.

Events and Signals

✓ •An event is the specification of a significant occurrence that has a location in time and space.

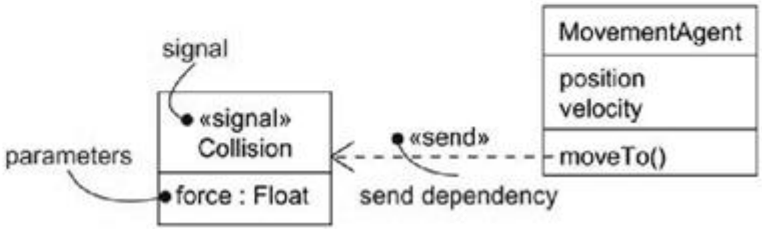
- ✓ In the context of state machines, an event is an occurrence of a stimulus that can trigger a state transition.
- ✓ A signal is a kind of event that represents the specification of an asynchronous stimulus communicated between instances.

Kinds of Events

- Events may be external or internal.
- External events are those that pass between the system and its actors.
- Internal events are those that pass among the objects that live inside the system.
- An overflow exception is an example of an internal event.
- In the UML, you can model four kinds of events: signals, calls, the passing of time, and a change in state.

Signals

- A signal represents a named object that is dispatched (thrown) asynchronously by one object and then received (caught) by another.
- Exceptions are supported by most contemporary programming languages and are the most common kind of internal signal that you will need to model.
- Signals may also be involved in generalization relationships, permitting you to model hierarchies of events, some of which are general and some of which are specific
- Also as for classes, signals may have attributes and operations.
- A signal may be sent as the action of a state transition in a state machine or the sending of a message in an interaction. The execution of an operation can also send signals
- In fact, when you model a class or an interface, an important part of specifying the behavior of that element is specifying the signals that its operations can send.
- We model signals (and exceptions) as stereotyped classes. We can use a dependency, stereotyped as **send**, to indicate that an operation sends a particular signal.



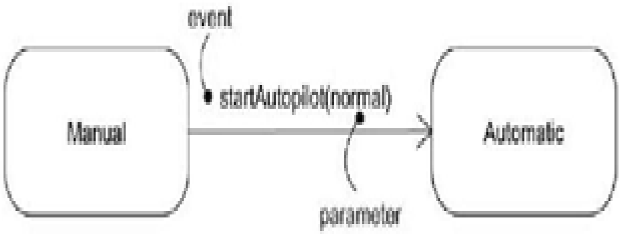
Signals

- ➢ Just as a signal event represents the occurrence of a signal, a **call** event represents the dispatch of an operation. In both cases, the event may trigger a state transition in a state machine

- Whereas a signal is an asynchronous event, a call event is synchronous

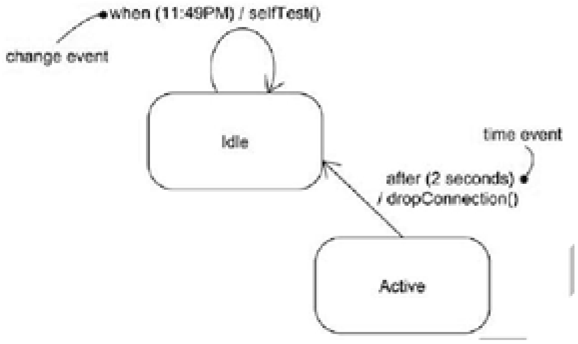
- This means that when an object invokes an operation on another object that has a state machine, control passes from the sender to the receiver, the transition is triggered by the event, the operation is completed, the receiver transitions to a new state, and control returns to the sender.

- Modeling a call event is indistinguishable from modeling a signal event. In both cases, you show the event, along with its parameters, as the trigger for a state transition.



Call Events

- **A time event** is an event that represents the passage of time in the UML you model a time event by using the keyword after followed by some expression that evaluates to a period of time.
- Unless you specify it explicitly, the starting time of such an expression is the time since entering the current state.
- **A change event** is an event that represents a change in state or the satisfaction of some condition
- In the UML you model a change event by using the keyword when followed by some Boolean expression.
- You can use such expressions to mark an absolute time (such as when time = 11:59) or for the continuous test of an expression



Note: Although a change event models a condition that is tested continuously, you can typically analyze the situation to see when to test the condition at discrete points in time.

- <u>Signal events and call events involve at least two objects:</u>
    - The object that sends the signal or invokes the operation
    - The object to which the event is directed.

- Any instance of any class can send a signal to or invoke an operation of a receiving object.

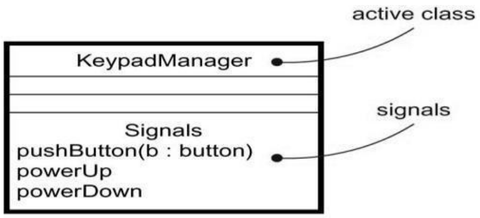
- When an object sends a signal, the sender dispatches the signal and then continues along its flow of control, not waiting for any return from the receiver.

- Any instance of any class can receive a call event or a signal. If this is a synchronous call event, then the sender and the receiver are in a rendezvous(assignation) for the duration of the operation.

- This means that the flow of control of the sender is put in lock step with the flow of control of the receiver until the activity of the operation is carried out.

- If this is a signal, then the sender and receiver do not rendezvous: the sender dispatches the signal but does not wait for a response from the receiver. In either case, this event may be lost

- In the UML, you model the named signals that an object may receive by naming them in an extra compartment of the class



<u>Signals and Active Classes</u>

<u>Common Modeling Technique:</u>

Modeling a family of signal:

- ✓ In most event-driven systems, signal events are hierarchical.

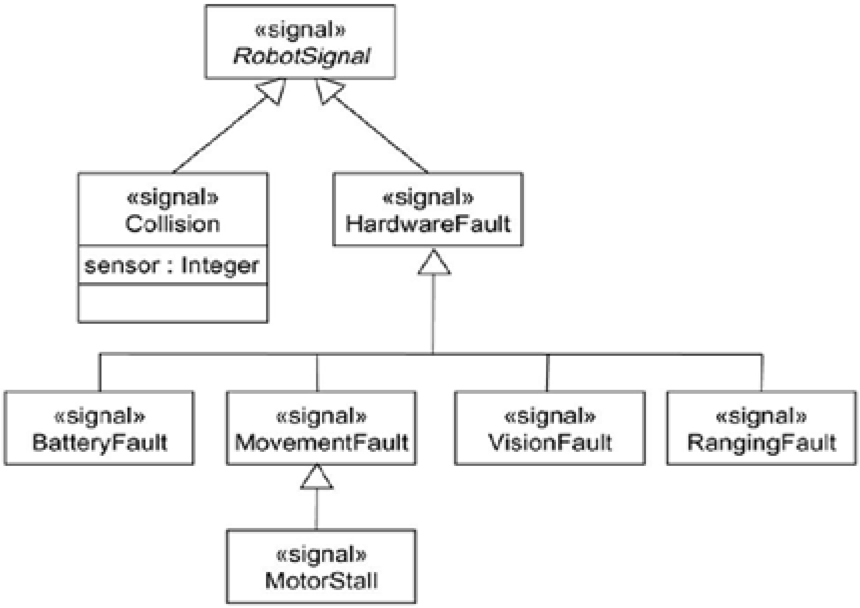
- ✓ External and internal signals need not be disjoint, however. Even within these two broad classifications, you might find specializations

<u>To model a family of signals</u>

- Consider all the different kinds of signals to which a given set of active objects may respond.

- o Look for the common kinds of signals and place them in a generalization/specialization hierarchy using inheritance. Elevate more general ones and lower more specialized ones.

Look for the opportunity for polymorphism in the state machines of these active objects. Where you find polymorphism, adjust the hierarchy as necessary by introducing intermediate abstract signals.



Modeling Exceptions

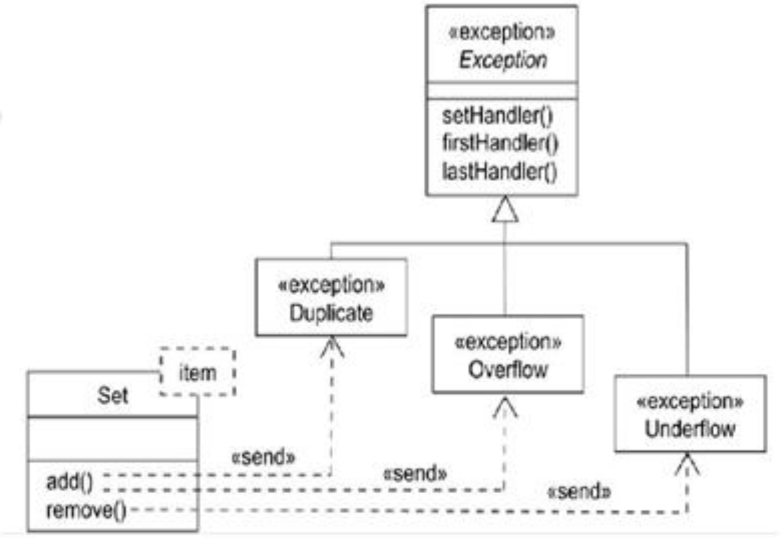
- An important part of visualizing, specifying, and documenting the behavior of a class or an interface is specifying the exceptions that its operations can raise.
- In the UML, exceptions are kinds of signals, which you model as stereotyped classes. Exceptions may be attached to specification operations.
- Modeling exceptions is somewhat the inverse of modeling a general family of signals.
- We model a family of signals primarily to specify the kinds of signals an active object may receive
- We model exceptions primarily to specify the kinds of exceptions that an object may throw through its operations

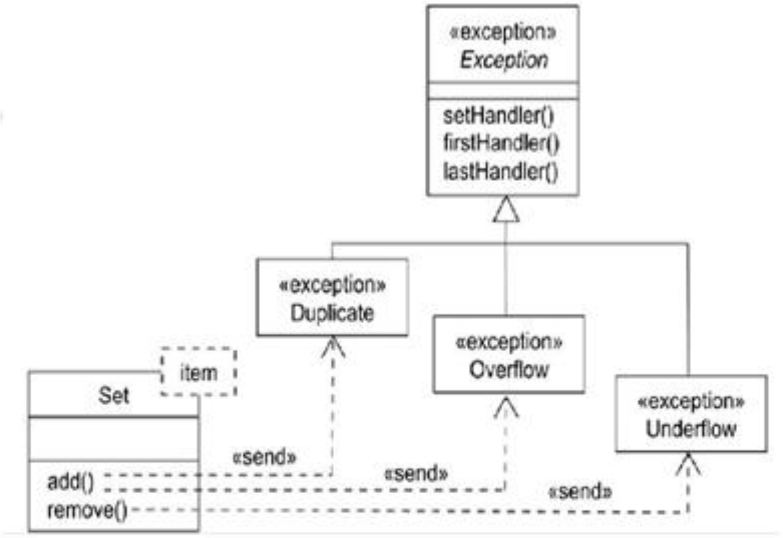
To model exceptions

- o For each class and interface, and for each operation of such elements, consider the exceptional conditions that may be raised.
- o Arrange these exceptions in a hierarchy. Elevate general ones, lower specialized

ones, and introduce intermediate exceptions, as necessary.

- For each operation, specify the exceptions that it may raise. You can do so explicitly (by showing send dependencies from an operation to its exceptions) or you can put this in the operation's specification.





State-Chart diagrams:

A statechart diagram is a view of a **state machine** that models the changing behavior of a state. Statechart diagrams show the various states that an object goes through, as well as the events that cause a transition from one state to another.

Statechart diagram model elements

The common model elements that statechart diagrams contain are:

- ✓ States
- ✓ Start and end states

✓ Transitions
✓ Entry, do, and exit actions

A state represents a condition during the life of an object during which it satisfies some condition or waits for some event. Start and end states represent the beginning or ending of a process. A state transition is a relationship between two states that indicates when an object can move the focus of control on to another state once certain conditions are met. In a statechart diagram, a transition to self element is similar to a state transition. However, it does not move the focus of control. A state transition contains the same source and target state.

Actions in a Statechart diagram

Each state on a statechart diagram can contain multiple internal actions. An action is best described as a task that takes place within a state. There are four possible actions within a state:

✓ On entry
✓ On exit
✓ Do
✓ On event

Creating a statechart diagram in Rational Rose

A statechart diagram is usually placed under the Logical View package. Right-click on the Logical View package and select New>Statechart Diagram to create a Statechart Diagram. Name your diagram and then double-click on the name to open the diagram work area.

States

Place the start state, ●, end state, ◉, and states, ▭, on the diagram work area by selecting the respective icon from the diagram toolbox and then clicking on the work area at the point where you want to place the states.

To name the states, double-click on the state. This action will bring up the State Specification dialog box. In the General tab, type the name of your state in the Name text box.

Actions

To add an action to a state, select the Actions tab in the State Specification dialog box, right-click anywhere in the white area and select Insert from the shortcut menu. An action will be automatically placed. Double-click the action item to bring up the Action Specification dialog box. Select an action from the When drop-down list box. Type the action description in the Name field. Click OK and then click OK again to exit the State Specification dialog box.

Transitions

To create a transition to self , click the ⟲ icon and then click on the state. To create transitions between the states, click the ↗ icon and then click on the first state and drag and release on the next state. To name the transitions, double-click on the transition to bring up the State Transition Specification dialog box. Type the name or label in the Event text box and click OK.

Figure 1.shows a Statechart Diagram depicting the various elements of a state machine.

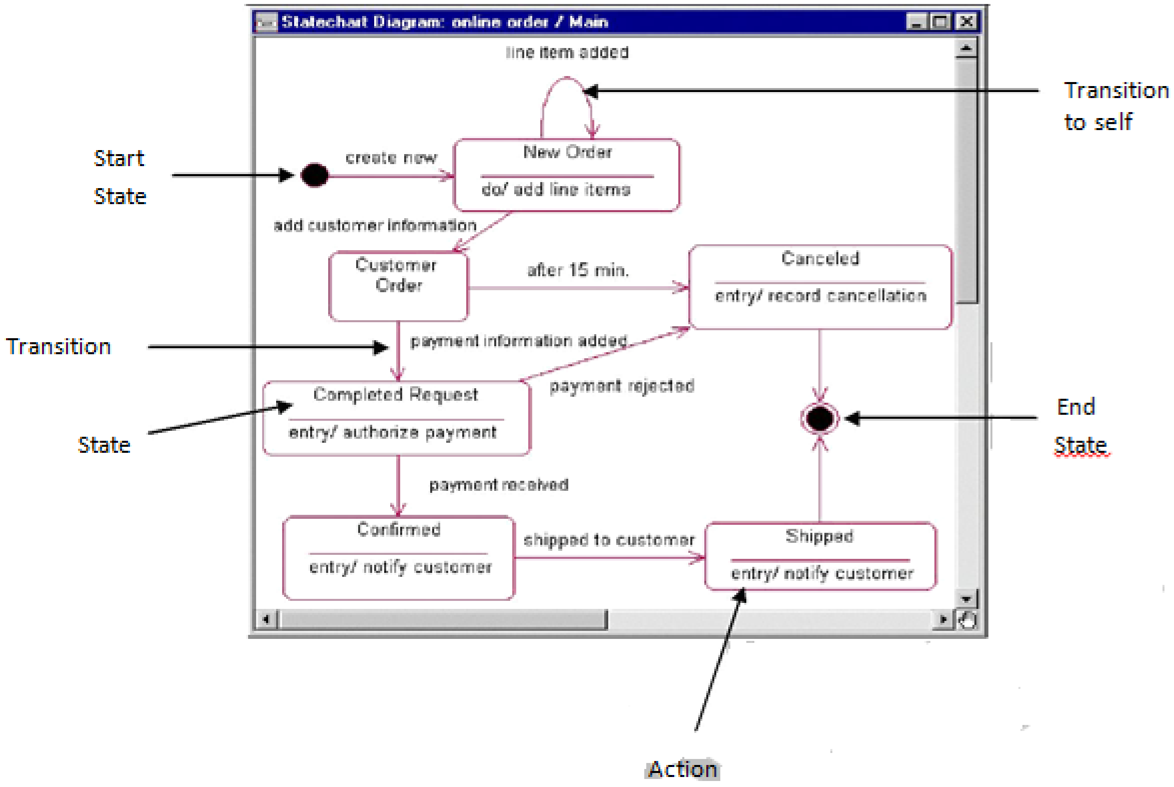


Figure 1. A state machine

Component diagrams:

- Component diagrams are different in terms of nature and behavior. Component diagrams are used to model physical aspects of a system.
- Now the question is what are these physical aspects? Physical aspects are the elements like executable, libraries, files, documents etc which resides in a node.So component diagrams are used to visualize the organization and relationships among components in a system. These diagrams are also used to make executable systems.
- Component diagram is a special kind of diagram in UML. The purpose is also different from all other diagrams discussed so far. It does not describe the functionality of the system but it describes the components used to make those functionalities.
- So from that point component diagrams are used to visualize the physical components in a system. These components are libraries, packages, files etc.
- Component diagrams can also be described as a static implementation view of a system.

Static implementation represents the organization of the components at a particular moment.

- A single component diagram cannot represent the entire system but a collection of diagrams are used to represent the whole.

So the purpose of the component diagram can be summarized as:

- Visualize the components of a system.
- Construct executables by using forward and reverse engineering.
- Describe the organization and relationships of the components.

Component diagrams are used to describe the physical artifacts of a system. This artifact includes files, executable, libraries etc.So the purpose of this diagram is different, and Component diagrams are used during the implementation phase of an application. But it is prepared well in advance to visualize the implementation details. Initially the system is designed using different UML diagrams and then when the artifacts are ready component diagrams are used to get an idea of the implementation.This diagram is very important because without it the application cannot be implemented efficiently. A well prepared component diagram is also important for other aspects like application performance, maintenance etc.

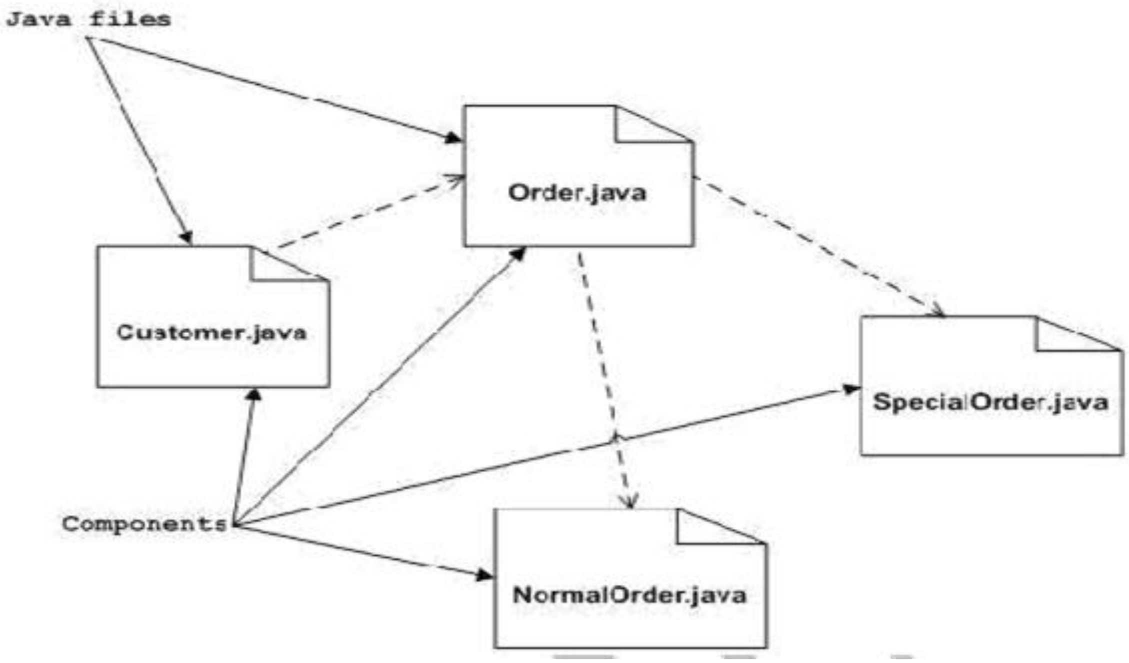
So before drawing a component diagram the following artifacts are to be identified clearly:

- Files used in the system.
- Libraries and other artifacts relevant to the application.
- Relationships among the artifacts.

Now after identifying the artifacts the following points needs to be followed:

- Use a meaningful name to identify the component for which the diagram is to be drawn.
- Prepare a mental layout before producing using tools.
- Use notes for clarifying important points.

The following is a component diagram for order management system. Here the artifacts are files. So the diagram shows the files in the application and their relationships. In actual the component diagram also contains dlls, libraries, folders etc.In the following diagram four files are identified and their relationships are produced. Component diagram cannot be matched directly with other UML diagrams discussed so far. Because it is drawn for completely different purpose.So the following component diagram has been drawn considering all the points mentioned above:



Component diagram of an order management system

Deployment diagrams:

Deployment diagrams are used to visualize the topology of the physical components of a system where the software components are deployed. So deployment diagrams are used to describe the static deployment view of a system. Deployment diagrams consist of nodes and their relationships. The name *Deployment* itself describes the purpose of the diagram. Deployment diagrams are used for describing the hardware components where software components are deployed.

Component diagrams and deployment diagrams are closely related. Component diagrams are used to describe the components and deployment diagrams shows how they are deployed in hardware. UML is mainly designed to focus on software artifacts of a system. But these two diagrams are special diagrams used to focus on software components and hardware components. So most of the UML diagrams are used to handle logical components but deployment diagrams are made to focus on hardware topology of a system. Deployment diagrams are used by the system engineers.

The purpose of deployment diagrams can be described as:

- Visualize hardware topology of a system.
- Describe the hardware components used to deploy software components.
- Describe runtime processing nodes.

Deployment diagram represents the deployment view of a system. It is related to the component diagram. Because the components are deployed using the deployment diagrams. A deployment diagram consists of nodes. Nodes are nothing but physical hardwares used to deploy the application.

Deployment diagrams are useful for system engineers. An efficient deployment diagram is very important because it controls the following parameters

- Performance
- Scalability
- Maintainability
- Portability

So before drawing a deployment diagram the following artifacts should be identified:

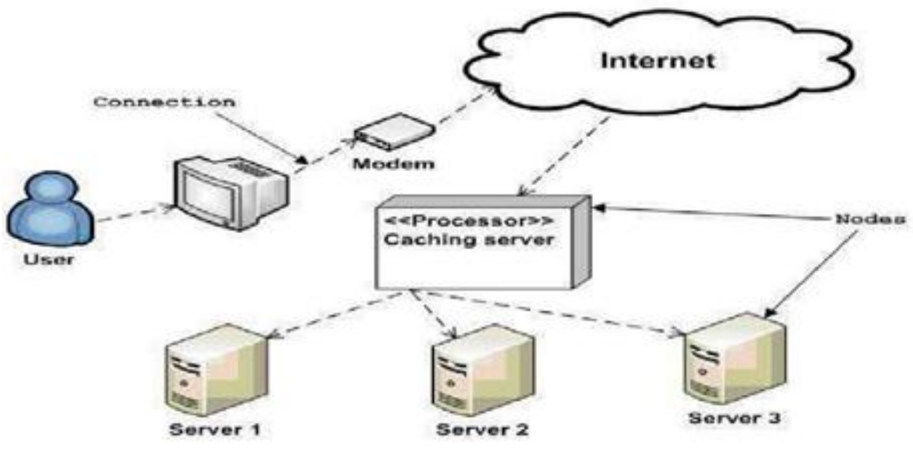
- Nodes
- Relationships among nodes

The following deployment diagram is a sample to give an idea of the deployment view of order management system. Here we have shown nodes as:

- Monitor
- Modem
- Caching server
- Server

The application is assumed to be a web based application which is deployed in a clustered environment using server 1, server 2 and server 3. The user is connecting to the application using internet. The control is flowing from the caching server to the clustered environment.So the following deployment diagram has been drawn considering all the points mentioned above:

Deployment diagram of an order management system



Unit-6
Advanced concepts in OOAD

Use case relationships:

There can be 5 relationship types in a use case diagram.

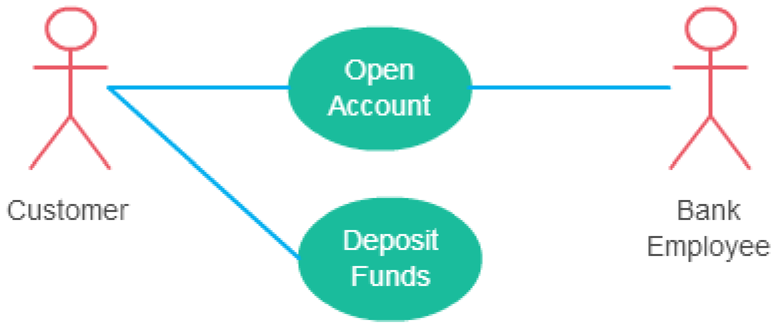
- Association between actor and use case
- Generalization of an actor
- Extend between two use cases
- Include between two use cases
- Generalization of a use case

Lets take a look at these relationships in detail.

Association Between Actor and Use Case

This one is straightforward and present in every use case diagram. Few things to note.

- An actor must be associated with at least one use case.
- An actor can be associated with multiple use cases.
- Multiple actors can be associated with a single use case.

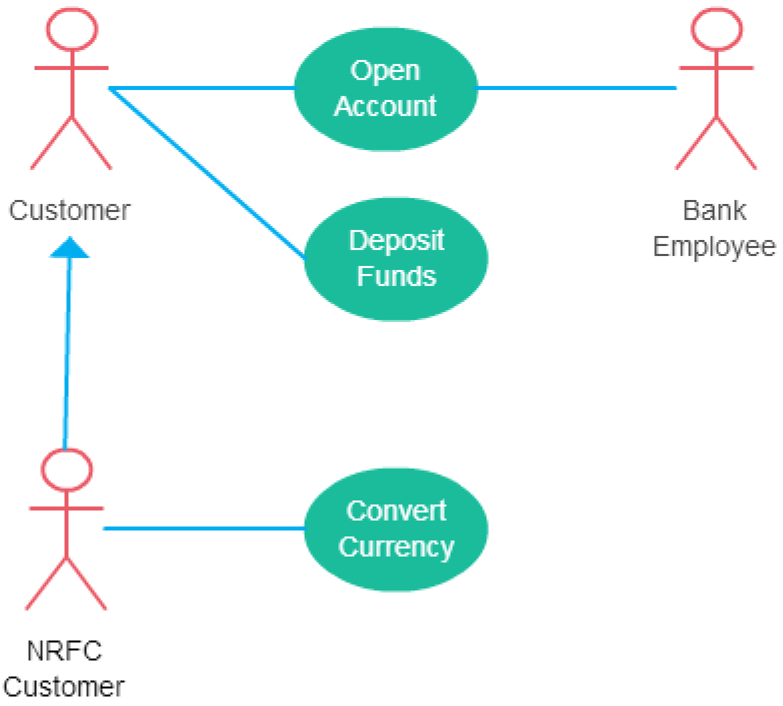


Different ways association relationship appears in use case diagrams

Checkout the **use case diagram guidelines** for other things to consider when adding an actor.

Generalization of an Actor

Generalization of an actor means that one actor can inherit the role of an other actor. The descendant inherits all the use cases of the ancestor. The descendant have one or more use cases that are specific to that role. Lets expand the previous use case diagram to show the generalization of an actor.



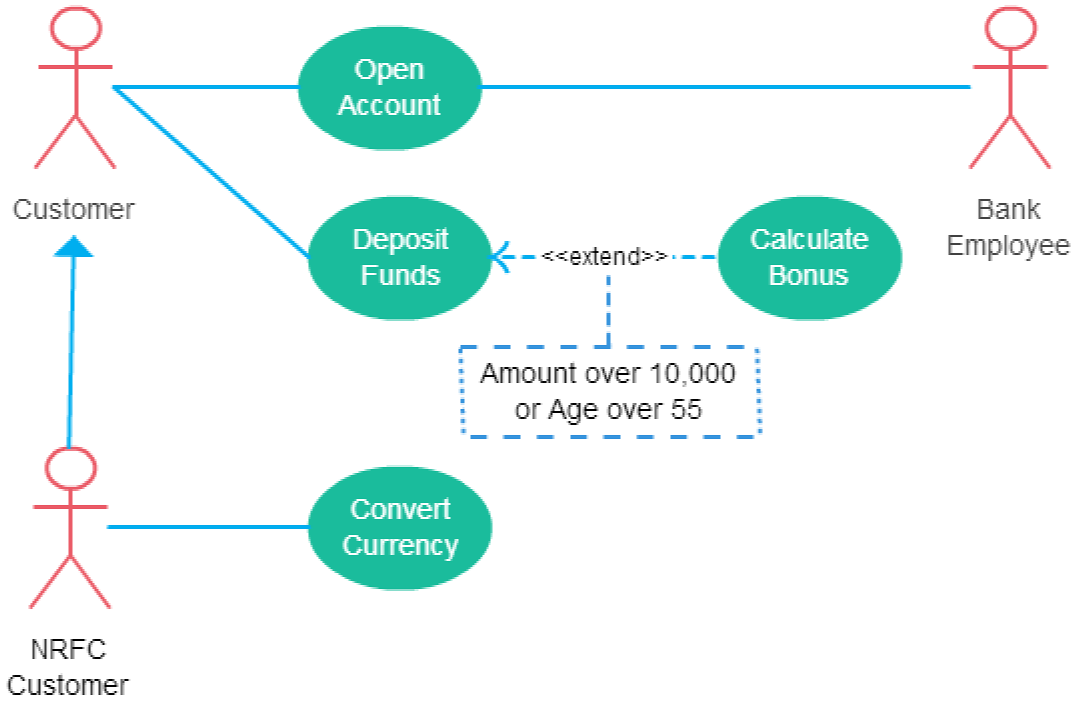
A generalized actor in an use case diagram

Extend Relationship Between Two Use Cases

Many people confuse the extend relationship in use cases. As the name implies it extends the base use case and adds more functionality to the system. Here are few things to consider when using the <<**extend**>> relationship.

- **The extending use case is dependent on the extended (base) use case**. In the below diagram the “Calculate Bonus” use case doesn’t make much sense without the “Deposit Funds” use case.
- **The extending use case is usually optional** and can be triggered conditionally. In the diagram you can see that the extending use case is triggered only for deposits over 10,000 or when the age is over 55.
- **The extended (base) use case must be meaningful on its own**. This means it should be independent and must not rely on the behavior of the extending use case.

Lets expand our current example to show the <<extend>> relationship.



Extend relationship in use case diagrams

Although extending use case is optional most of the time it is not a must. An extending use case can have non optional behavior as well. This mostly happens when your modeling complex behaviors.

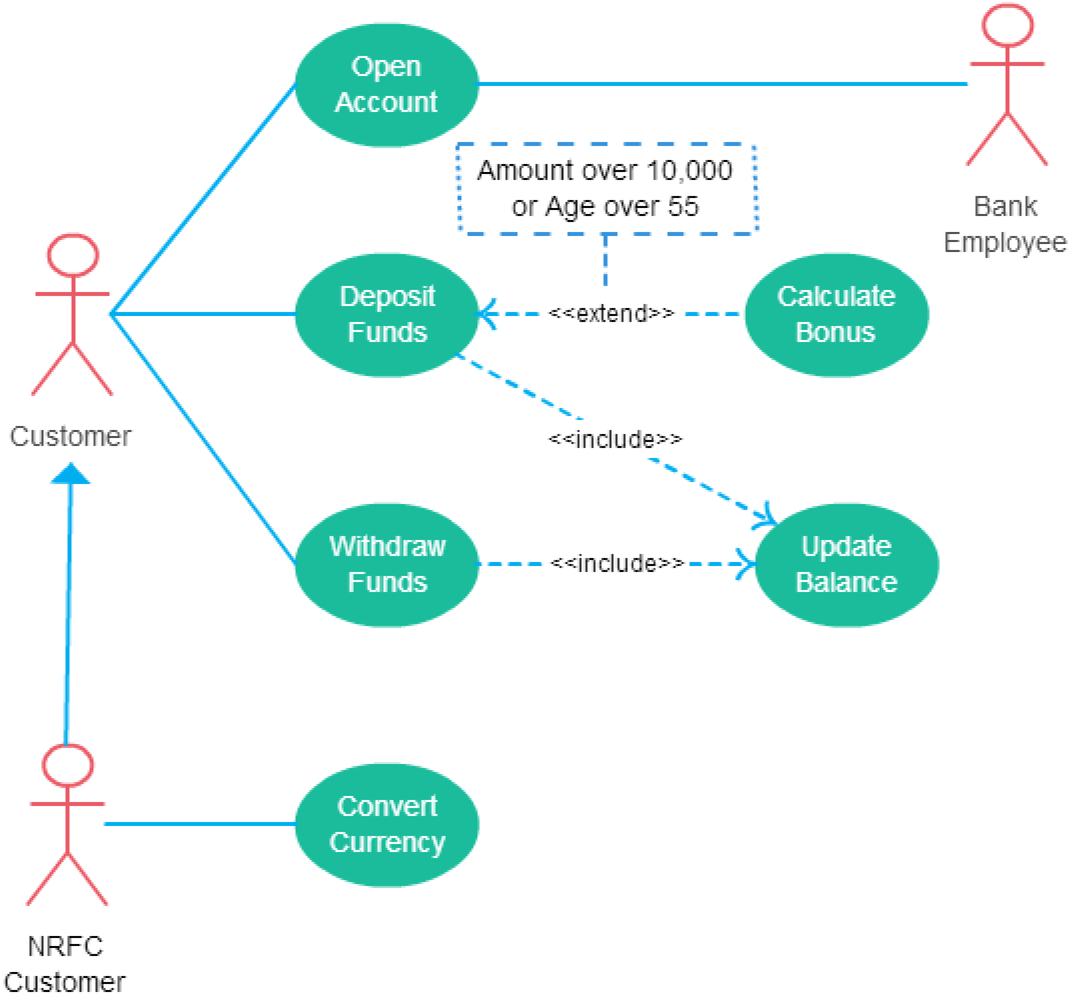
For example in an accounting system one use case might be “Add Account Ledger Entry”. This might have extending use cases “Add Tax Ledger Entry” and “Add Payment Ledger Entry”. These are not optional but depend on the account ledger entry. Also they have their own specific behavior to be modeled as a separate use case.

Include Relationship Between Two Use Cases

Include relationship show that the behavior of the included use case is part of the including (base) use case. The main reason for this is to reuse the common actions across multiple use cases. In some situations this is done to simplify complex behaviors. Few things to consider when using the <<include>> relationship.

- The base use case is incomplete without the included use case.
- The included use case is mandatory and not optional.

Lest expand our banking system use case diagram to show include relationships as well.



Includes is usually used to model common behavior

Domain Model refinements

STATIC modeling

 Generalization and specialization are fundamental concepts in domain modeling.

 Conceptual class hierarchies are often the basis of the inspiration for software class hierarchies that exploit inheritance.

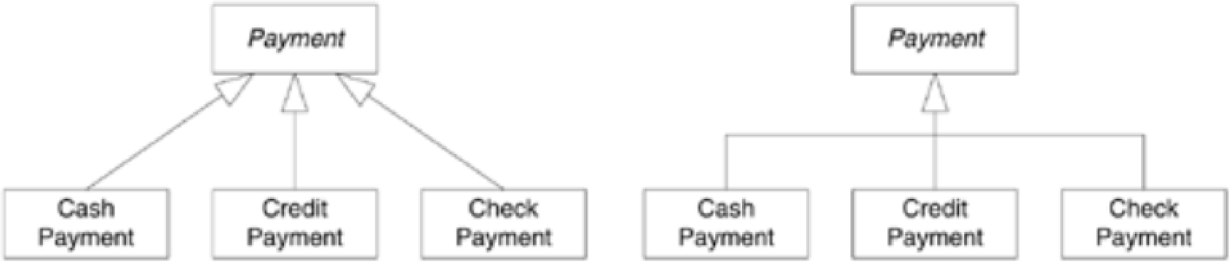


Fig:- Class hierarchy with separate and shared arrow notations

 Create a conceptual subclass of a superclass when:

1. The subclass has additional attributes of interest.

2. The subclass has additional associations of interest.

3. The subclass concept is operated on, handled, reacted to, or manipulated differently than the superclass or other subclasses, in ways that are of interest.

4. The subclass concept represents an animate thing (for example, animal, robot) that behaves differently than the superclass or other subclasses, in ways that are of interest.

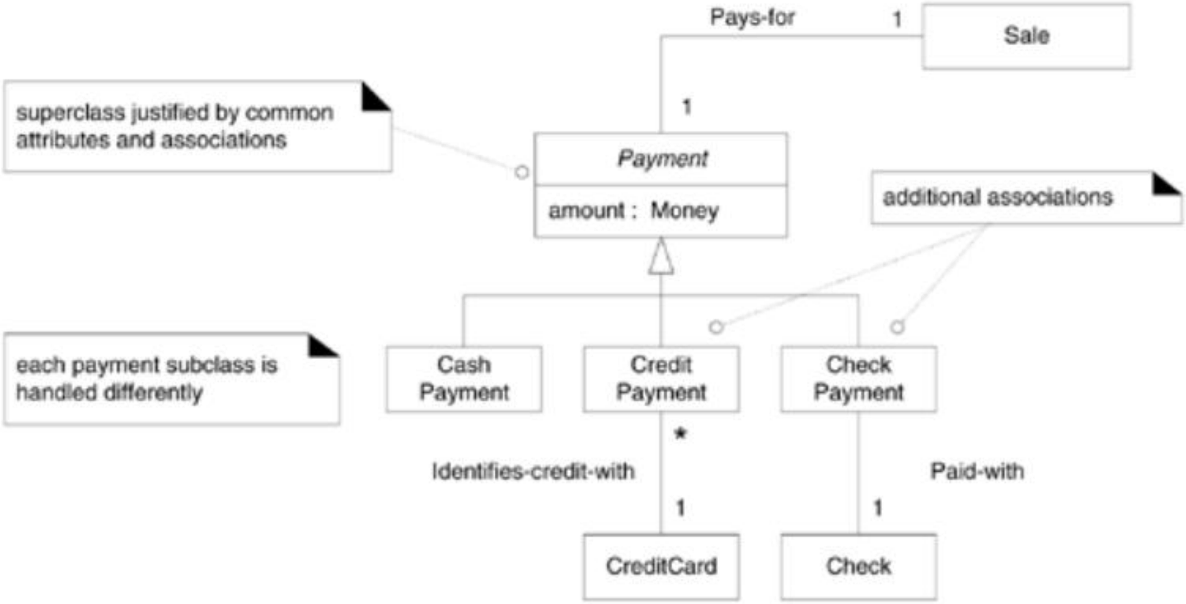
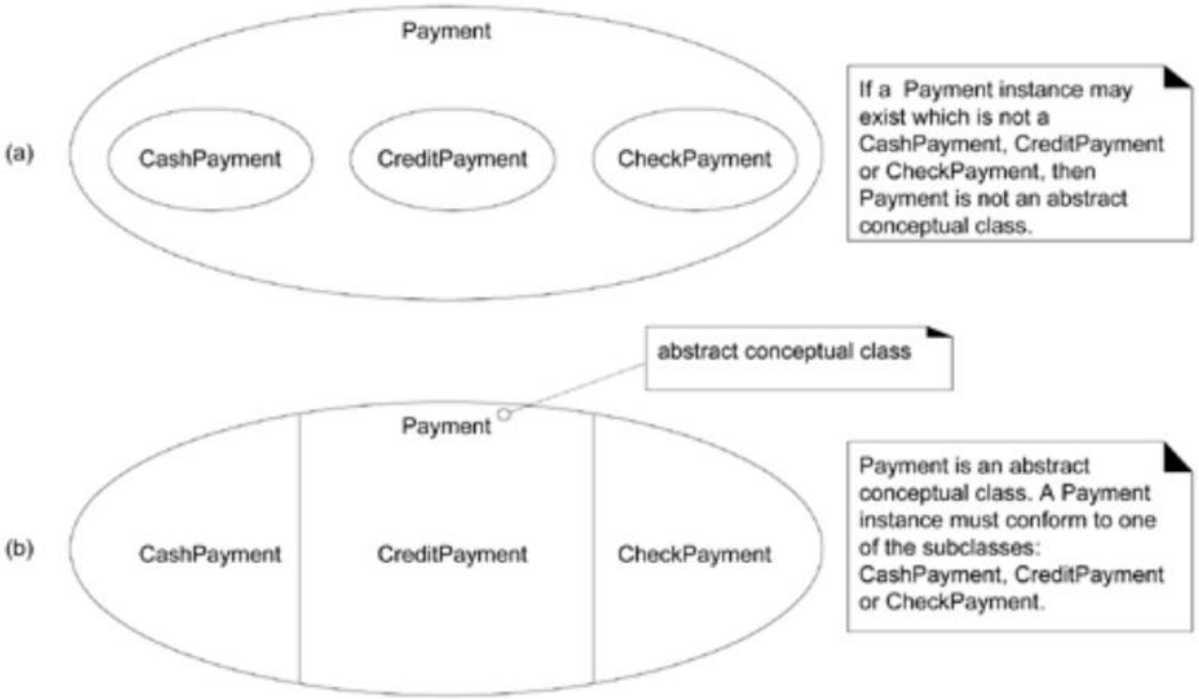


Fig:- Justifying Payment subclasses

Abstract Conceptual Classes: If every member of a class C must also be a member of a subclass, then class C is called an abstract conceptual class.



If a Payment instance may exist which is not a CashPayment, CreditPayment or CheckPayment, then Payment is not an abstract conceptual class.

abstract conceptual class

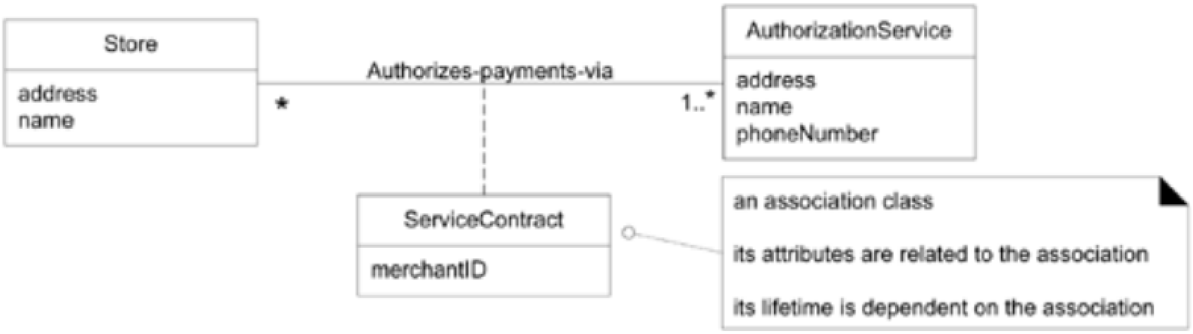
Payment is an abstract conceptual class. A Payment instance must conform to one of the subclasses: CashPayment, CreditPayment or CheckPayment.

Association Classes—Multivalued

- In a domain model, if a class C can simultaneously have many values for the same kind of attribute A, do not place attribute A in C. Place attribute A in another class that is associated with C.

- For example:

- A Person may have many phone numbers. Place phone number in another class, such as PhoneNumber associate many of these to Person.



an association class

its attributes are related to the association

its lifetime is dependent on the association

Association Classes

 Clues that an association class might be useful in a domain model:

1. An attribute is related to an association.

2. Instances of the association class have a lifetime dependency on the association.

3. There is a many-to-many association between two concepts and information associated with the association itself.

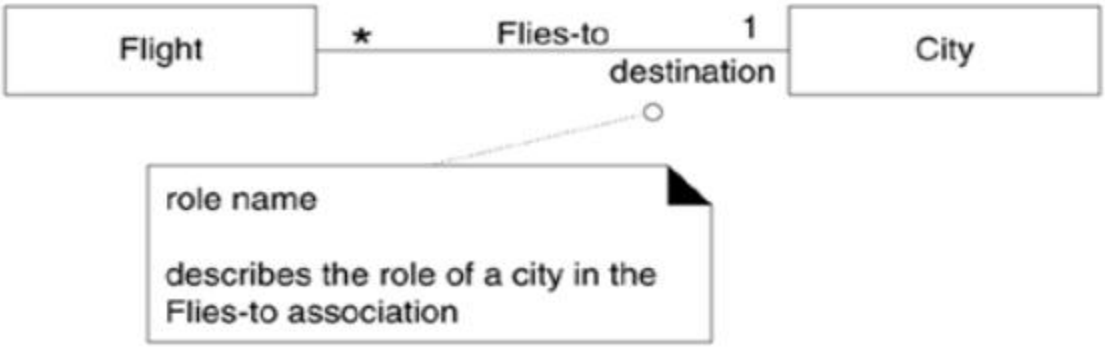
Association Role Names

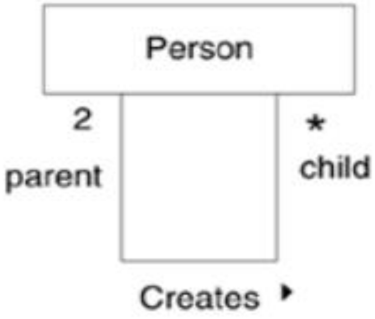
 Each end of an association is a role, which has various properties, such as:

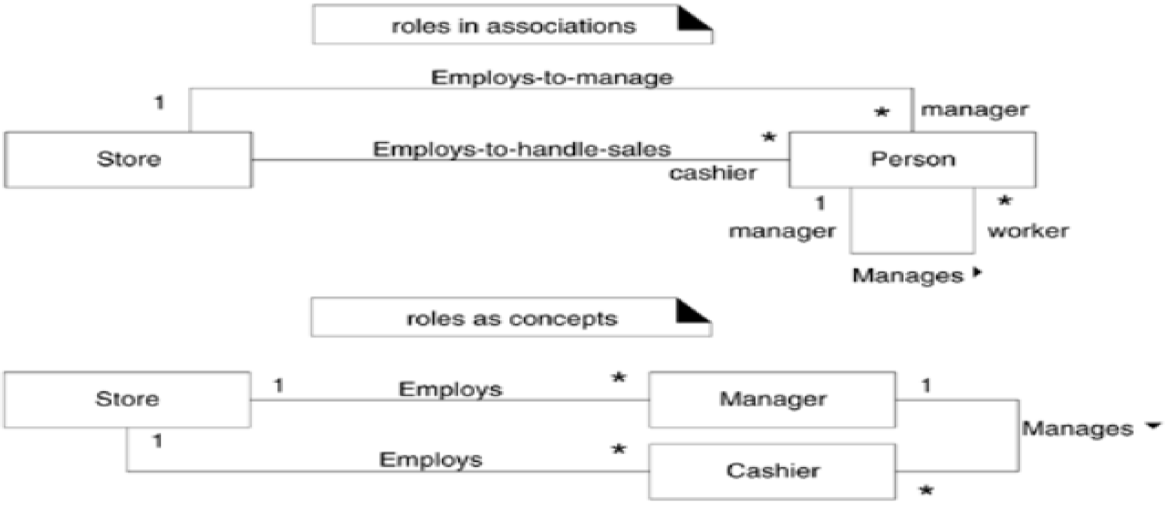
◦ name

◦ multiplicity
An explicit role name is NOT required—it is useful when the role of the object is not clear.

 It usually starts with a lowercase letter. If not explicitly present, assume that the default role name is equal to the related class name, though starting with a lowercase letter.







Same instance of a person takes on multiple (and dynamically changing) roles in various associations

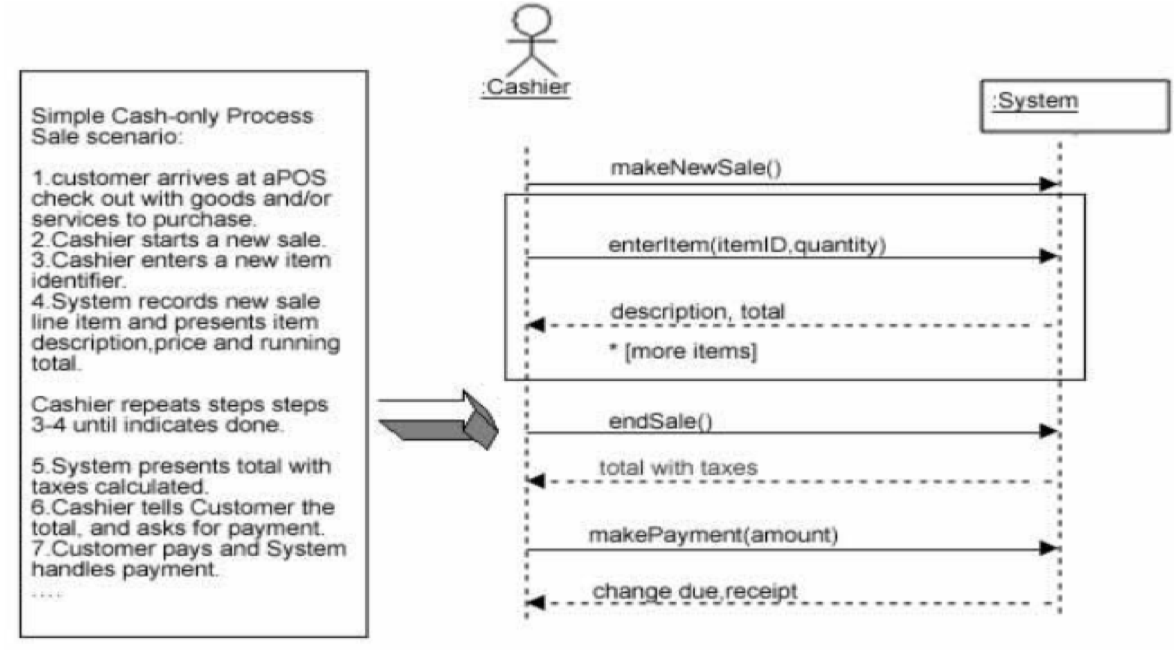
DYNAMIC modeling:

System Sequence Diagrams (=SSD)

 Having explored domain modeling, SSD will be used to identify SYSTEM operations . (their effect on the domain model objects will be discussed in OCs)

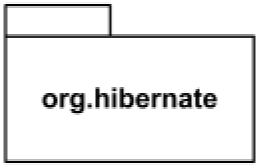
 An SSD shows, for a particular course of events within use case.

 Guideline: Draw an SSD for a main success scenario of each use case, and frequent or complex alternative scenarios.

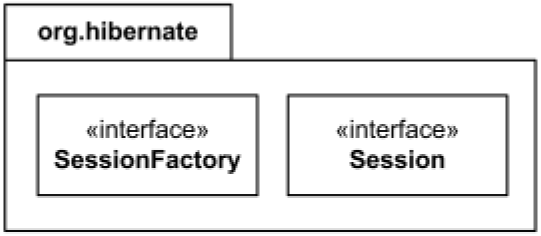

Simple Cash-only Process Sale scenario:
1.customer arrives at aPOS check out with goods and/or services to purchase.
2.Cashier starts a new sale.
3.Cashier enters a new item identifier.
4.System records new sale line item and presents item description,price and running total.
Cashier repeats steps steps 3-4 until indicates done.
5.System presents total with taxes calculated.
6.Cashier tells Customer the total, and asks for payment.
7.Customer pays and System handles payment.
....
:Cashier
:System
makeNewSale()
enterItem(itemID,quantity)
description, total
* [more items]
endSale()
total with taxes
makePayment(amount)
change due,receipt

Packaging model elements:

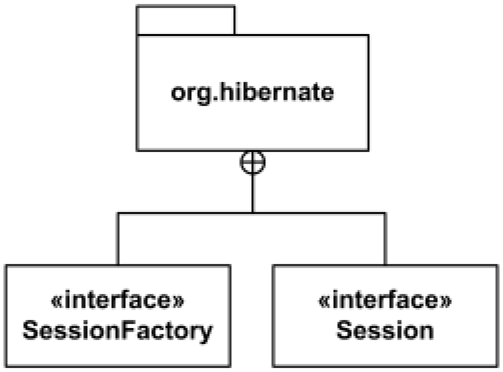
Package is a **namespace** used to group together elements that are semantically related and might change together. It is a general purpose mechanism to organize elements into groups to provide better structure for system model.
Owned members of a package should all be **packageable elements**. If a package is removed from a model, so are all the elements **owned** by the package. Package by itself is **packageable element**, so any package could be also a **member** of other packages.
Because package is a namespace, elements of related or the same type should have unique names within the enclosing package. Different types of elements are allowed to have the same name.
As a **namespace**, a package can **import** either individual members of other packages or all the members of other packages. Package can also be **merged**with other packages.
A package is rendered as a tabbed folder - a rectangle with a small tab attached to the left side of the top of the rectangle. If the members of the package are not shown inside the package rectangle, then the name of the package should be placed inside.



Package org.hibernate
The members of the package may be shown within the boundaries of the package. In this case the name of the package should be placed on the tab.



Package org.hibernate contains SessionFactory and Session
A diagram showing a package with content is allowed to show only a subset of the contained elements according to some criterion.
Members of the package may be shown **outside** of the package by branching lines from the package to the members. A **plus sign (+) within a circle** is drawn at the end attached to the namespace (package). This notation for packages is semantically equivalent to **composition** (which is shown using solid diamond.)



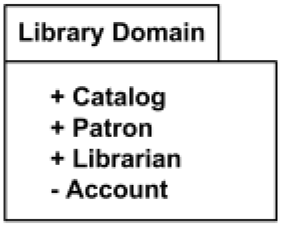
Package org.hibernate contains interfaces SessionFactory and Session.

The elements that can be referred to within a package using **non-qualified** names are:

- owned elements,
- imported elements, and
- elements in enclosing (outer) namespaces.

Owned and imported elements may have a **visibility** that determines whether they are available outside the package.

If an element that is owned by a package has visibility, it could be only **public** or **private** visibility. Protected or package visibility is not allowed. The visibility of a package element may be indicated by preceding the name of the element by a visibility symbol ("+" for public and "-" for private).



All elements of Library Domain package are public except for Accoun

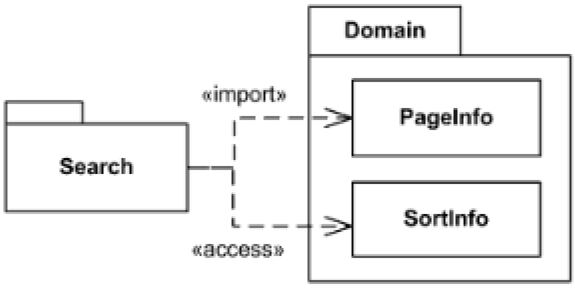
Packageable element is a **named element** that may be **owned** directly by a **package.**

Some examples of **packageable elements** are:

- **Type**
- **Classifier** (--> Type)
- **Class** (--> Classifier)
- **Use Case** (--> Classifier)
- **Component** (--> Classifier)
- **Package**
- **Constraint**
- **Dependency**
- **Event**

Packageable element by itself has no notation, see specific subclasses.

Element import is a **directed relationship** between an importing **namespace** and imported **packageable element**. It allows the element to be referenced using its name without a qualifier. An element import is used to selectively import individual elements without relying on a **package import**.



Package import is a **directed relationship** between an importing **namespace** and imported **package**, that allows the use of unqualified names to refer to the package members from the other namespace(s).

Importing namespace adds the names of the members of the imported package to its own namespace. Conceptually, a package import is equivalent to having an **element import** to each individual member of the imported namespace, unless there is already a separately-defined element import.

A package import is shown using a dashed arrow with an open arrowhead from the importing namespace to the imported package.

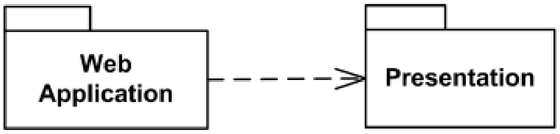


Fig:- WebApplication imports Presentation package.

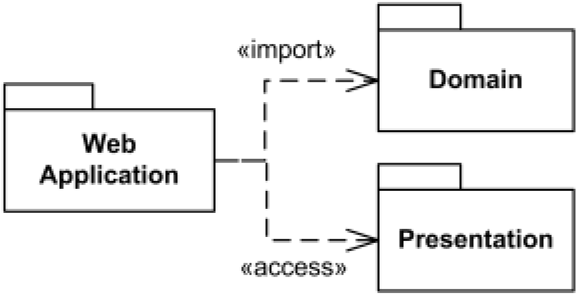
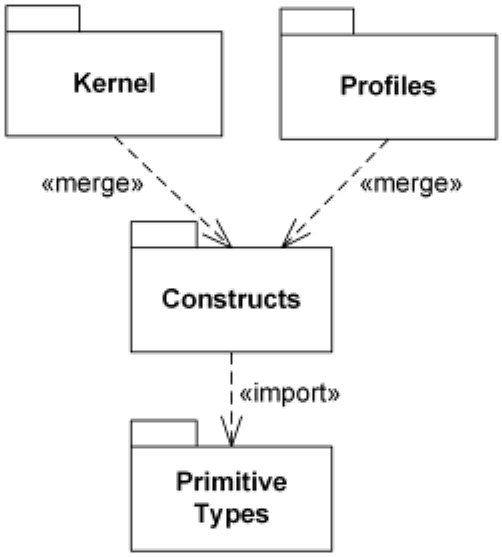


Fig:- Private import of Presentation package and **public import** of Domain package

A **package merge** is a **directed relationship** between two packages that indicates that content of one package is extended by the contents of another package.

Package merge is similar to **generalization** in the sense that the source element conceptually adds the characteristics of the target element to its own characteristics resulting in an element that combines the characteristics of both.

Package merge is shown using a dashed line with an open arrowhead pointing from the receiving package to the merged package. Keyword «merge» is shown near the dashed line.


Kernel
Profiles
«merge»
«merge»
Constructs
«import»
Primitive Types