UNIT II

OBJECT –ORIENTED METHODOLOGIES

INTRODUCTION

- Object-oriented methodology is a set of methods, models, and rules for developing systems.
- Modeling is the process of describing an existing or proposed system. It can be used during any phase of the software life cycle.
- A model is an abstraction of a phenomenon for the purpose of understanding it. Since a model excludes
- Unnecessary details; it is easier to manipulate than the real object.
- Modeling provides a means for communicating ideas in an easy to understand and unambiguous form while also accommodating a system's complexity.

TOWARD UNIFICATION-TOO MANY METHODOLOGIES

- 1986 - Booch developed t e object-oriented design concept, the Booch method.
- 1987 - Sally Shlaer and Steve Mellor created the concept of the recursive design approach.
- 1989 - Beck and Cunningham produced class-responsibility-collaboration cards.
- 1990 - Wirfs-Brock, Wilkerson, and Wiener came up with responsibility driven design.
- 1991 - Jim Rumbaugh led a team at the research labs of General Electric to develop the object modeling technique (OMT) .
- 1991 -Peter Coad and Ed Yourdon developed the Coad lightweight and Prototypeoriented approach to methods.
- 1994. Ivar Jacobson introduced the concept of the use case and object-oriented software engineering (OOSE).

SURVEY OF SOME OF THE OBJECT-ORIENTED METHODOLOGIES

- Many methodologies are available to choose from for system development. Each methodology is based on modeling the business problem and implementing the application in an object-oriented

fashion; the differences lie primarily in the documentation of information and modeling notations and language.

- An application can be implemented in many ways to meet the same requirements and provide the same functionality. The largest noticeable differences will be in the trade-offs and detailed design decisions made.
- In the following sections, we look at the methodologies and their modeling notations developed by Rumbaugh et aI., Booch, and Jacobson which are the origins of the Unified Modeling Language (UML).
- **Each method has its strengths. The Rumbaugh et ai. method is well-suited for describing the object model or the static structure of the system.**
- **The Jacobson et al. method is good for producing user-driven analysis models.**
- **The Booch method produces detailed object-oriented design models**.

RUMBAUGH'S OB.JECTMODELING TECHNIQUE

- The object modeling technique (OMT) presented by Jim Rumbaugh and his coworkers describes a method for the analysis, design, and implementation of a system using an object-oriented technique.
- OMT is a fast, intuitive approach for identifying and modeling all the objects making up a system. The dynamic behavior of objects within a system can be described using the OMT dynamic model.
- This model lets you specify detailed state transitions and their descriptions within a system.
- Finally, a process description and consumer-producer relationships can be expressed using OMT's functional model.

OMT (*Object Modeling Technique)* describes a method for the analysis, design, and implementation of a system using an object-oriented technique. Class attributes, method, inheritance, and association also can be expressed easily

- OMT consists of four phases, which can be performed iteratively:

1. ***Analysis****. The results are objects and dynamic and functional models.*
2. ***System design****. The results are a structure of the basic architecture of the system along* with high-level strategy decisions.

3. ***Object design***. *This phase produces a design document, consisting of detailed objects* static, dynamic, and functional models.

4. ***Implementation.*** *This activity produces reusable, extendible, and robust code.*

- *OMT* separates modeling into three different parts:

1. An *object model, presented by the object model and the data dictionary.*

2. A *dynamic model, presented by the state diagrams and event flow diagrams.*

3. A *functional model, presented by data flow and constraints.*

2.3.1 THE OBJECT MODEL

- The object model describes the structure of objects in a system: their identity, relationships to other objects, attributes, and operations.
- The object model is represented graphically with an object diagram (see Fig: 1).
- The object diagram contains classes interconnected by association lines.
- Each class represents a set of individual objects.
- The association lines establish relationships among the classes.
- Each association line represents a set of links from the objects of one class to the objects of another class.

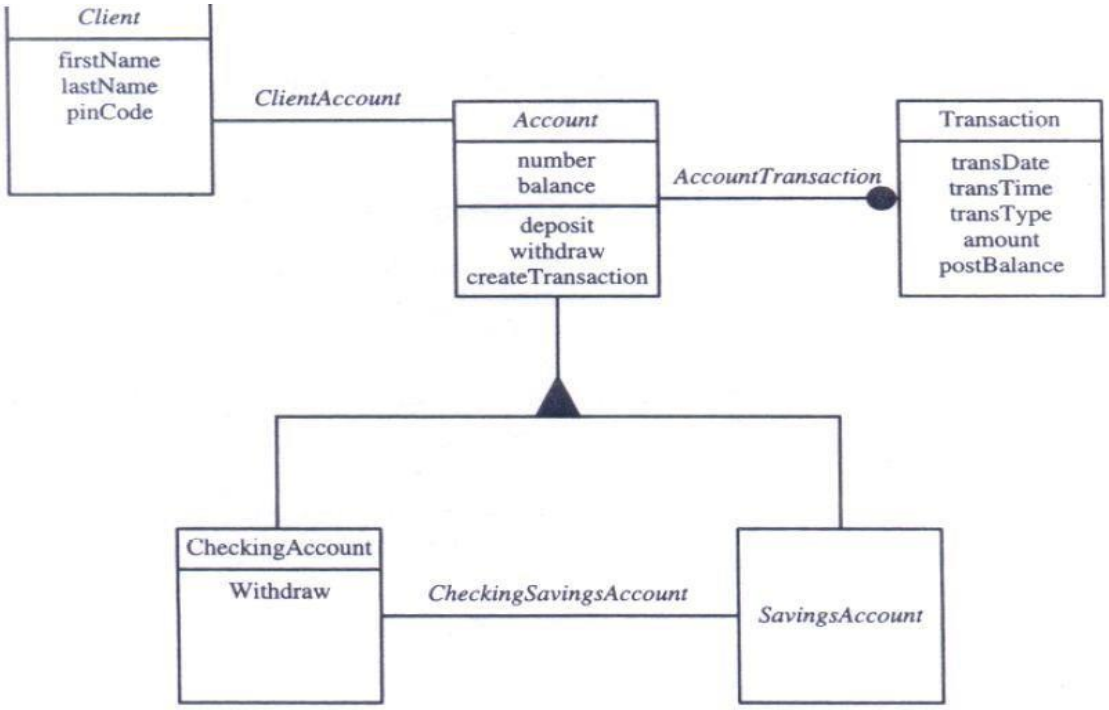

Fig 1: OMT object model of a bank system

Boxes- represents classes, Filled Triangle – represents Specialization, Association between account and transaction represents one to many, Filled Circle – represents many(zero or more) . Association between Client and Account represents one to one.

THE OMT DYNAMIC MODEL

- OMT provides a detailed and comprehensive dynamic model, in addition to letting you depict states, transitions, events, and actions.
- The OMT state transition diagram is a network of states and events (see Fig. 2).
- Each state receives one or more events, at which time it makes the transition to the next state.
- The next state depends on the current state as well as the events.

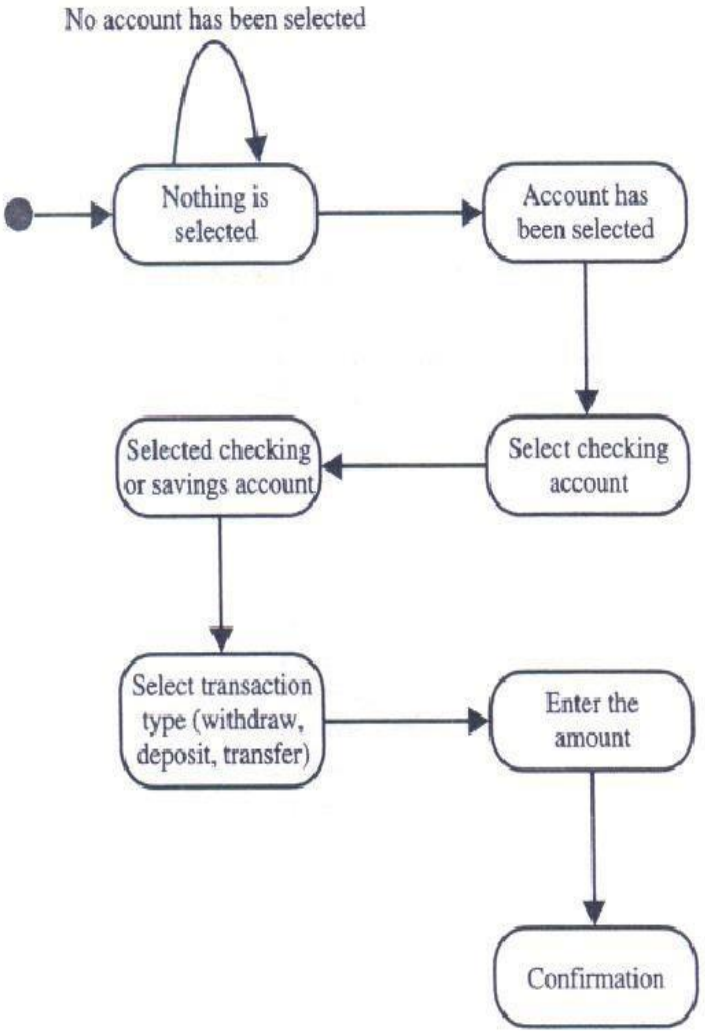

Fig. 2 : State transition diagram for the bank application user interface. The round boxes represent states and the arrows represent transitions.

THE OMT FUNCTIONAL MODEL

- The OMT data flow diagram (DFD) shows the flow of data between different processes in a business. An OMT DFD provides a simple and intuitive method for describing business processes without focusing on the details of computer systems.
- Data flow diagrams use four primary symbols:

1. The ***process*** *is any function being performed; for example, verify Password or* PIN in the ATM system (see Fig .3).
2. The ***data flow*** *shows the direction of data element movement; for example, PIN code.*
3. The ***data store*** *is a location where data are stored; for example, account is a data store* in the ATM example.
4. An ***external entity*** *is a source or destination of a data element; for example, the ATM* card reader.

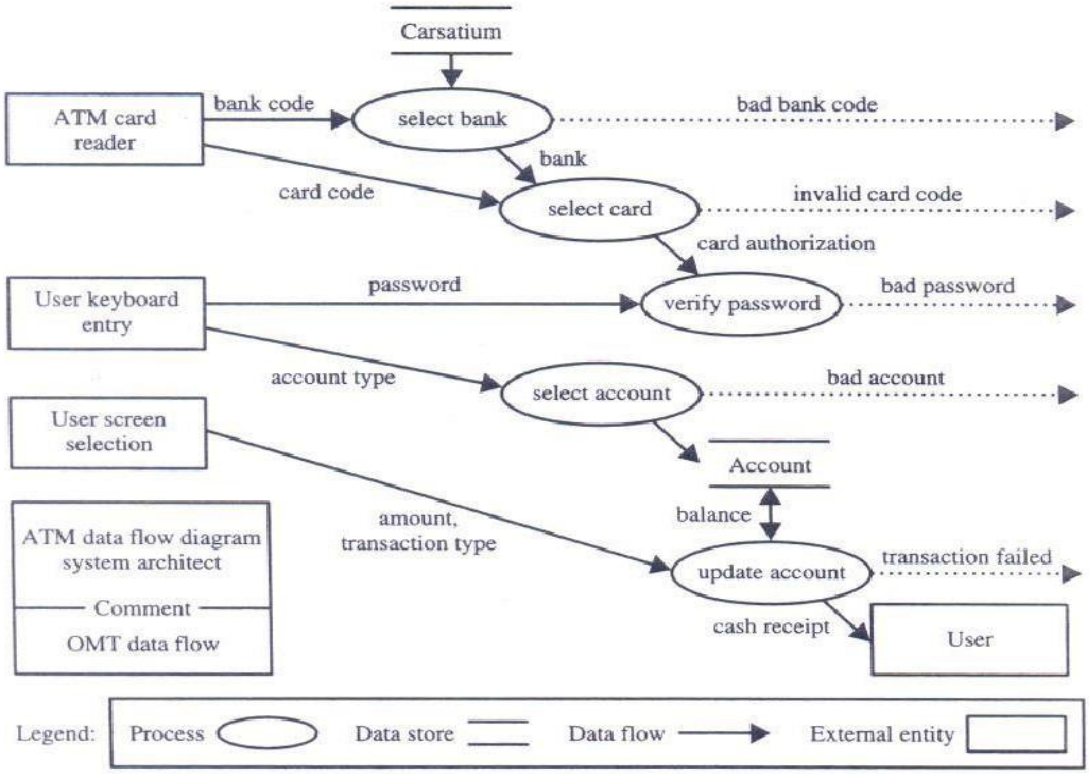

Fig 3: OMT DFD of the ATM system.

Thus, the Rumbaugh et al. OMT methodology provides one of the strongest tool sets for the analysis and design of object-oriented systems.

BOOCH METHODOLOGY

- The Booch methodology is a widely used object-oriented method that helps you design your system using the object paradigm.
- It covers the analysis and design phases of an object-oriented system.
- The Booch method consists of the following diagrams:
  - Class diagrams
  - Object diagrams
  - State transition diagrams
  - Module diagrams
  - Process diagrams
  - Interaction diagrams
- The Booch methodology prescribes a **macro development process** and **a micro development process**.

THE MACRO DEVELOPMENT PROCESS

- The macro process serves as a controlling framework for the micro process and can take weeks or even months.
- The primary concern of the macro process is technical management of the system.
- The macro development process consists of the following steps**:**

1. ***Conceptualization.*** *During conceptualization, establish the core requirements of* the system. You establish a set of goals and develop a prototype to prove the concept.

2. ***Analysis and development of the model.*** *In this step, use the class diagram to* describe the roles and responsibilities objects are to carry out in performing the desired behavior of the system. Then,use the object diagram to describe the desired behavior of the system in terms of scenarios or, alternatively, use the interaction diagram to describe behavior of the system in terms of scenarios.

3. *Design or create the system architecture.* *In the design phase, use the class* diagram to decide what classes exist and how they relate to each other. Next, use the object diagram to decide what mechanisms are used to regulate how objects collaborate. Then, use the module diagram to map out where each class and object should be declared. Finally, use the process diagram to determine to which processor to allocate a process. Also, determine the schedules for multiple processes on each relevant processor.

4. *Evolution or implementation.* *Successively refine the system through many iterations.* Produce a stream of software implementations (or executable releases), each of which is a refinement of the prior one.

5. *Maintenance.* *Make localized changes to the system to add new requirements and* eliminate bugs.

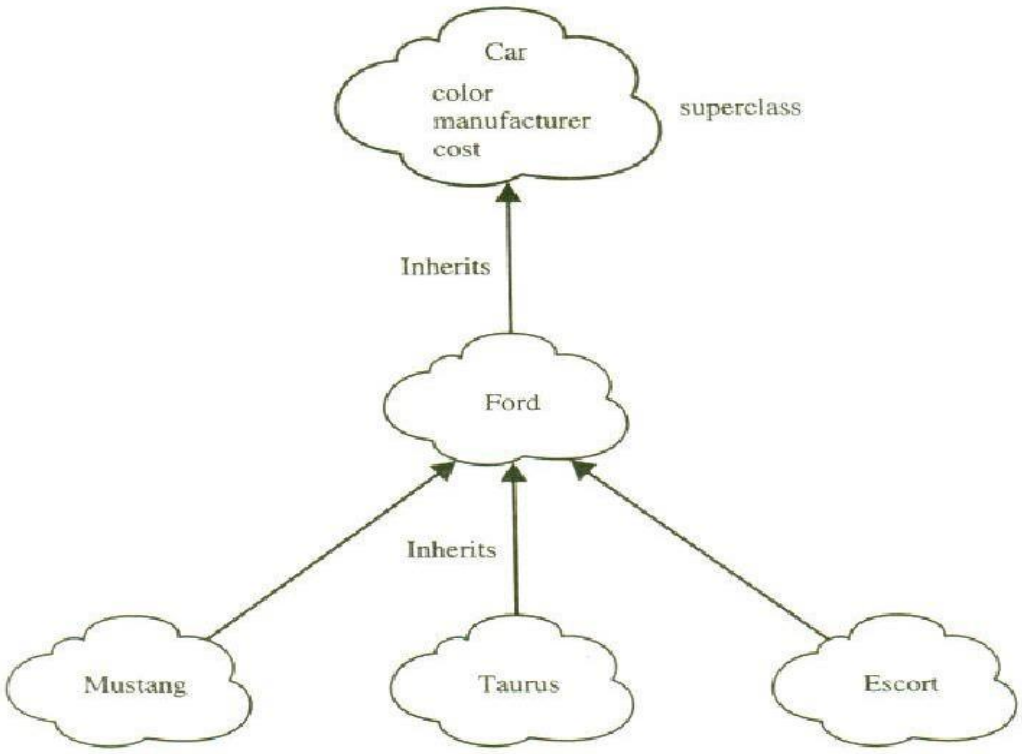

Fig .4 : Object modeling using Booch notation
The arrows represent specialization; for example, the class Taurus is subclass of the class Ford.

THE MICRO DEVELOPMENT PROCESS

- Each macro development process has its own micro development processes.
- The micro process is a description of the day-to-day activities by a single or small group of software developers, which could look blurry to an outside viewer, since the analysis and design phases are not clearly defined.
- The micro development process consists of the following steps:

1. Identify classes and objects.
2. Identify class and object semantics.
3. Identify class and object relationships.
4. Identify class and object interfaces and implementation.

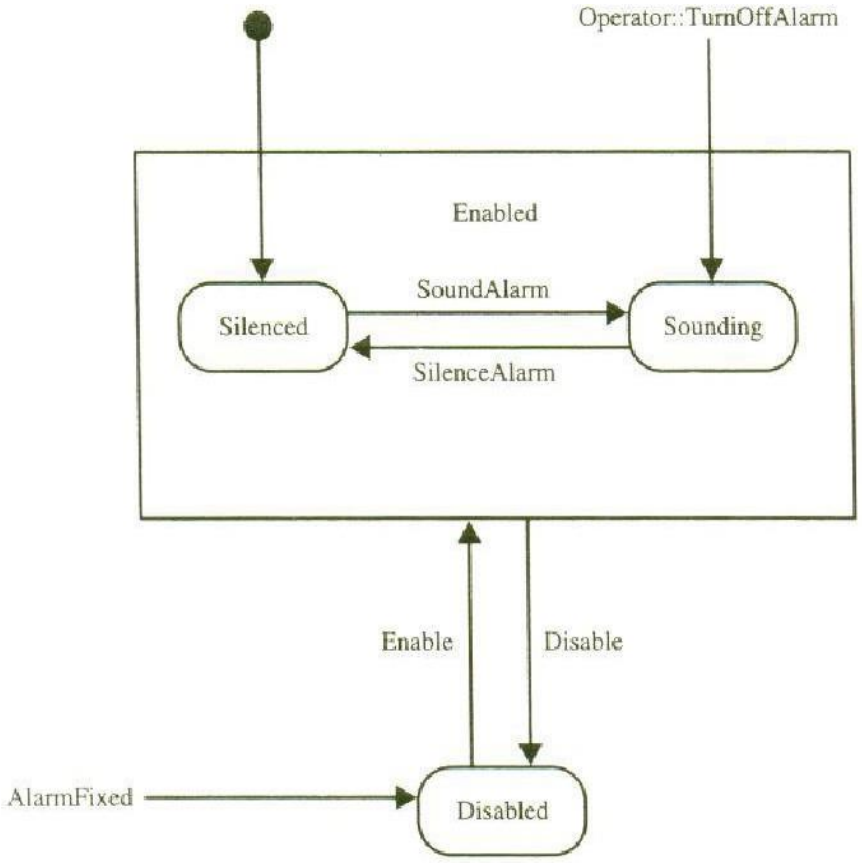

Fig. 5: An alarm class state transition diagram with Booch notation.

This diagram can capture the state of a class based on a stimulus. For example, a stimulus causes the class to perform some processing, followed by a transition to another state. In this case, the alarm silenced state can be changed to alarm sounding state and vice versa.

THE JACOBSON METHODOLOGIES

- The Jacobson et al. methodologies (e.g., object-oriented Business Engineering (OOBE), object-oriented Software Engineering (OOSE), and Objectory) cover the entire life cycle and stress traceability between the different phases, both forward and backward.
- This traceability enables reuse of analysis and design work, possibly much bigger factors in the reduction of development time than reuse of code.
- At the heart of their methodologies is the use-case concept, which evolved with Objectory (Object Factory for Software Development).

USE CASES

- Use cases are scenarios for understanding system requirements.
- A use case is an interaction between users and a system. The use-case model captures the goal of the user and the responsibility of the system to its users.(Fig.6)

Some uses of a library. As you can see, these are external views of the library system from an actor such as a member. The simpler the use case, the more effective it will be. It is unwise to capture all of the details right at the start; you can do that later.

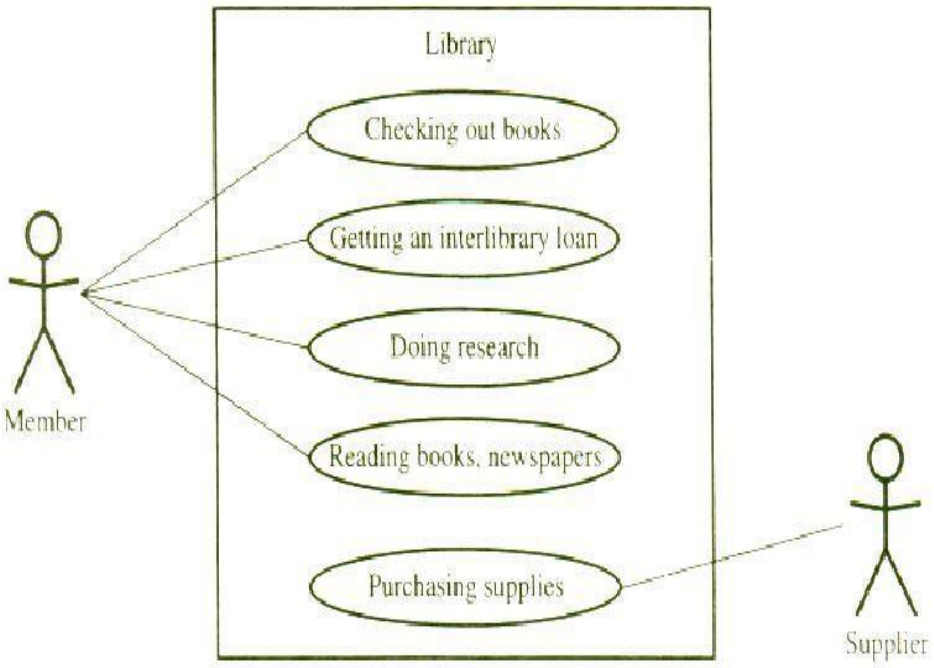

Fig.6 : Some Uses of A Library.

In the requirements analysis, the use cases are described as one of the following :

- ✓ Nonformal text with no clear flow of events.
- ✓ Text, easy to read but with a clear flow of events to follow (this is a recommended style).
- ✓ Formal style using pseudo code.

The use case description must contain

- ➢ How and when the use case begins and ends.
- ➢ The interaction between the use case and its actors, including when the interaction occurs and what is exchanged.
- ➢ How and when the use case will need data stored in the system or will store data in the system.
- ➢ Exceptions to the flow of events.
- ➢ How and when concepts of the problem domain are handled.

- Every single use case should describe one main flow of events.
- An exceptional or additional flow of events could be added. The exceptional use case extends another use case to include the additional one.
- The use-case model employs extends and uses relationships. The extends relationship is used when you have one use case that is similar to another use case but does a bit more. In essence, it extends the functionality of the original use case (like a subclass). The uses relationship reuses common behavior in different use cases.
- Use cases could be viewed as concrete or abstract. An *abstract use case is not* complete and has no actors that initiate it but is used by another use case.
- This inheritance could be used in several levels. Abstract use cases also are the ones that have uses or extends relationships.

OBJECT-ORIENTED SOFTWARE ENGINEERING: OBJECTORY

- Object-oriented software engineering (OOSE), also called ***Objectory, is a method*** of object-oriented development with the specific aim to fit the development of large, realtime systems.

- The development process, called ***use-case driven development, stresses that*** use cases are involved in several phases of the

development (see Fig. 7), including analysis, design, validation, and testing.

- The use-case scenario begins with a user of the system initiating a sequence of interrelated events.

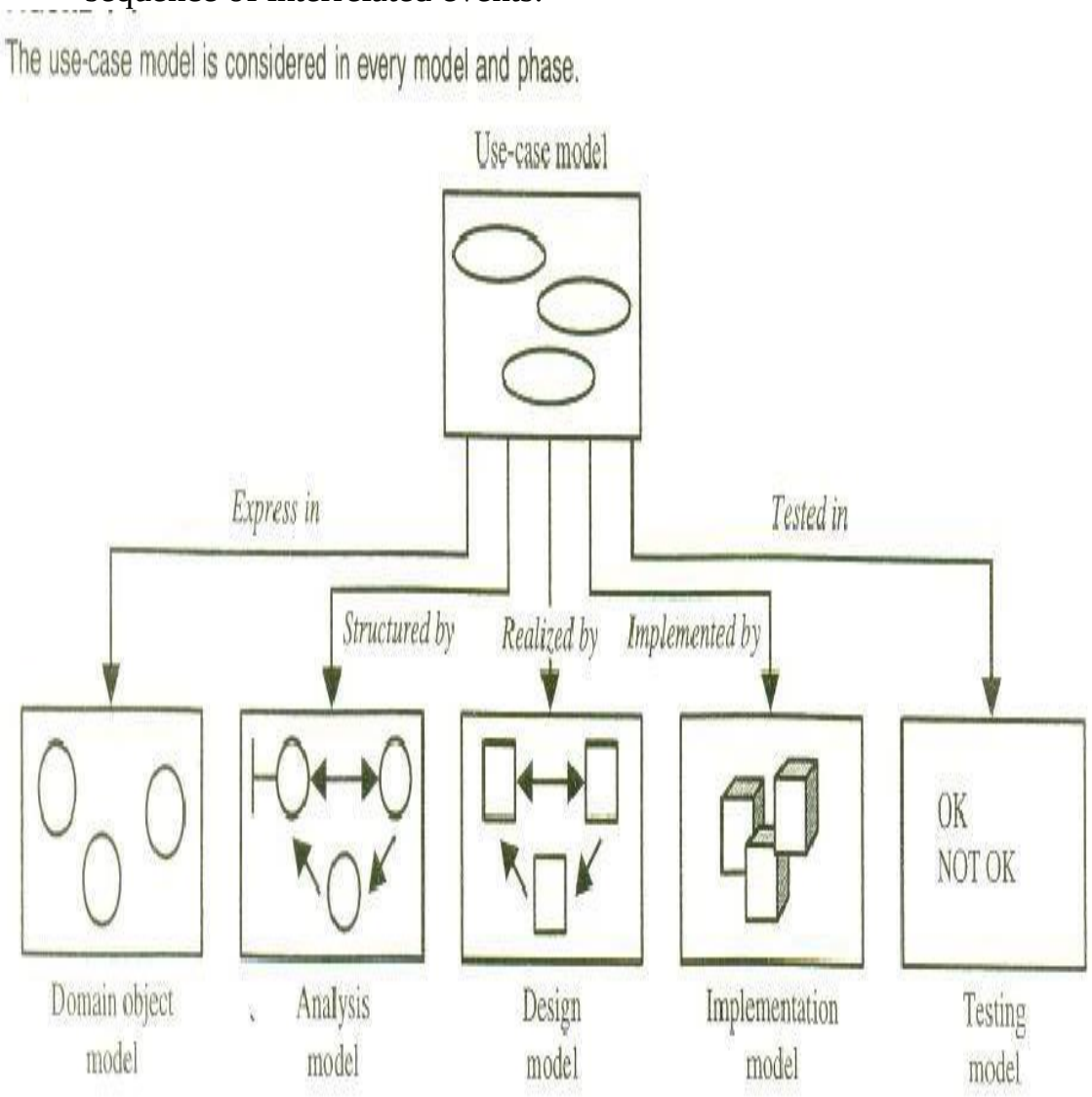

Fig. 7: The use case model is considered in every model and phase.

- The system development method based on OOSE, Objectory, is a disciplined process for the industrialized development of software, based on a use-case driven design.
- It is an approach to object-oriented analysis and design that centers on understanding the ways in which a system actually is used.
- By organizing the analysis and design models around sequences of user interaction and actual usage scenarios, the method produces

systems that are both more usable and more robust, adapting more easily to changing usage.

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Objectory is built around several different models:

- ***Use case-model.*** *The use-case model defines the outside (actors) and inside (use case) of* the system's behavior.
- ***Domain object model.*** *The objects of the "real" world are mapped into the domain object* model.
- ***Analysis object model.*** *The analysis object model presents how the source code* (implementation) should be carried out and written.
- ***Implementation model.*** *The implementation model represents the implementation of the* system.
- ***Test model.*** *The test model constitutes the test plans, specifications, and reports.*

OBJECT-ORIENTED BUSINESS ENGINEERING

- Object-oriented business engineering (OOBE) is object modeling at the enterprise level. Use cases again are the central vehicle for modeling, providing traceability throughout the software engineering process

1. ***Analysis phase.*** It defines the system to be built in terms of the problem-domain object model, the requirements model, and the analysis model. The analysis process should not take into account the actual implementation environment. This reduces complexity and promotes maintainability over the life of the system, since the description of the system will be independent of hardware and software requirements.

Jacobson does not dwell on the development of the problem-domain object model, but refers the developer to Coad and Yourdon's or

Booch's discussion of the topic, who suggest that the customer draw a picture of his view of the system to promote discussions.

In their view, a full development of the domain model will not localize changes and therefore will not result in the most "robust and extensible structure." This model should be developed just enough to form a base of understanding for the requirements model.

The analysis process is iterative but the requirements and analysis models should be stable before moving on to subsequent models. Jacobson suggest that prototyping with a tool might be useful during this phase to help specify user interfaces.

2. ***Design and implementation phases.*** The implementation environment must be identified for the design model. This includes factors such as Database Management System (DBMS), distribution of process, constraints due to the programming language, available component libraries, and incorporation of graphical user interface tools. It may be possible to identify the implementation environment concurrently with analysis. The analysis objects are translated into design objects that fit the current implementation environment.

3. ***Testing phase.*** Finally, Jacobson describes several testing levels and techniques. The levels include unit testing, integration testing, and system testing.

PATTERNS

- Any science or engineering discipline must have is a vocabulary for expressing its concepts and a language for relating them to each other.
- Therefore, we need a body of literature to help software developers resolve commonly encountered, difficult problems and a vocabulary for communicating insight and experience about these problems and their solutions.
- Gamma, Helm, Johnson, and Vlissides say that the design pattern identifies the key aspects of a common design structure that make it useful for creating a reusable objectoriented design. [Furthermore, it] identifies the participating classes and instances, their roles and collaborations, and the distribution of responsibilities. It describes when it applies, whether it can be applied in view of other design constraints, and the consequences and trade-offs of its use.

- The main idea behind using patterns is to provide documentation to help categorize and communicate about solutions to recurring problems.
- The pattern has a name to facilitate discussion and the information it represents.
- Riehle and Ztillighoven:- **A *pattern is [an] instructive information that captures the essential structure and* insight of a successful family of proven solutions to a recurring problem that arises within a certain context and system of forces.**
- A pattern involves a general description of a solution to a recurring problem bundle with various goals and constraints. But a pattern does more than just identify a solution, it also explains why the solution is needed.
- Even if something appears to have all the requisite pattern components, it should not be considered a pattern until it has been verified to be a recurring phenomenon (preferably found in at least three existing systems; this often is called **the *rule of three)***.
- *A "pattern in waiting," which is not yet* known to recur, sometimes is called a ***proto-pattern***.
- **A good pattern will do the following:**

- ***It solves a problem***. *Patterns capture solutions, not just abstract principles or strategies.*
- ***It is a proven concept***. *Patterns capture solutions with a track record, not theories or* speculation.
- ***The solution is not obvious***. *The best patterns generate a solution to a problem* indirectly-a necessary approach for the most difficult problems of design.
- ***It describes a relationship***. *Patterns do not just describe modules, but describe deeper* system structures and mechanisms.
- ***The pattern has a significant human component***. *All software serves human comfort or* quality of life; the best patterns explicitly appeal to aesthetics and utility.

Generative and Non generative Patterns

- **Generative patterns** are patterns that not only describe a recurring problem, they can tell us how to generate something and can be observed in the resulting system architectures they helped shape.

- **Nongenerative patterns** are static and passive: They describe recurring phenomena without necessarily saying how to reproduce them.
- The successive application of several patterns, each encapsulating its own problem and forces, unfolds a larger solution, which emerges indirectly as a result of the smaller solutions.
- It is the generation of such emergent behavior that appears to be what is meant by ***generativity.***
- *In* this fashion, a pattern language should guide its users to generate whole architectures that possess the quality**.**

Patterns Template

- Every pattern must be expressed "in the form of a rule [template] which establishes a relationship between a context, a system of forces which arises in that context, and a configuration, which allows these forces to resolve themselves in that context" .

Essential components should be clearly recognizable on reading a pattern :

- ***Name.*** A meaningful name. This allows us to use a single word or short phrase to refer to the pattern and the knowledge and structure it describes. Good pattern names form a vocabulary for discussing conceptual abstractions.
- ***Problem.*** A statement of the problem that describes its intent: the goals and objectives it wants to reach within the given context and forces.
- ***Context.*** The preconditions under which the problem and its solution seem to recur and for which the solution is desirable. This tells us the pattern's applicability. It can be thought of as the initial configuration of the system before the pattern is applied to it.
- ***Forces.*** A description of the relevant forces and constraints and how they interact or conflict with one another and with the goals we wish to achieve (perhaps with some indication of their priorities). A concrete scenario that serves as the motivation for the pattern frequently is employed.
- ***Solution.*** Static relationships and dynamic rules describing how to realize the desired outcome. This often is equivalent to giving instructions that describe how to construct the necessary products. The description may encompass pictures, diagrams, and prose that identify the pattern's structure, its participants, and their collaborations, to

show how the problem is solved. The solution should describe not only the static structure but also dynamic behavior.

- ***Examples.*** One or more sample applications of the pattern that illustrate a specific initial context; how the pattern is applied to and transforms that context; and the resulting context left in its wake. Examples help the reader understand the pattern's use and applicability.
- ***Resulting context.*** The state or configuration of the system after the pattern has been applied, including the consequences (both good and bad) of applying the pattern, and other problems and patterns that may arise from the new context. It describes the postconditions and side effects of the pattern. This is sometimes called a resolution of forces because it describes which forces have been resolved, which ones remain unresolved, and which patterns may now be applicable.
- ***Rationale.*** A justifying explanation of steps or rules in the pattern and also of the pattern as a whole in terms of how and why it resolves its forces in a particular way to be in alignment with desired goals, principles, and philosophies. It explains how the forces and constraints are orchestrated in concert to achieve a resonant harmony. This tells us how the pattern actually works, why it works, and why it is "good."

- ***Related patterns.*** The static and dynamic relationships between this pattern and others within the same pattern language or system. Related patterns often share common forces. They also frequently have an initial or resulting context that is compatible with the resulting or initial context of another pattern.
- **Known uses.** The known occurrences of the pattern and its application within existing systems. This helps validate a pattern by verifying that it indeed is a proven solution to a recurring problem. Known uses of the pattern often can serve as instructional examples.

ANTIPATTERNS

- A pattern represents a "best practice," whereas an antipattern represents "worst practice" or a "lesson learned."
- **Anti patterns come in two varieties:**
- ✓ **Those describing a bad solution to a problem that resulted in a bad situation.**
- ✓ **Those describing how to get out of a bad situation and how to proceed from there to a good solution.**

- Anti patterns are valuable because often it is just as important to see and understand bad solutions as to see and understand good ones.

Capturing Patterns

- Writing good patterns is very difficult, explains Appleton. Patterns should provide not only facts but also tell a story that captures the experience they are trying to convey.
- A pattern should help its users comprehend existing systems, customize systems to fit user needs, and construct new systems.
- The process of looking for patterns to document is called **pattern mining (or sometimes reverse architecting).**

Guidelines

- ***Focus on practicability.*** Patterns should describe proven solutions to recurring problems rather than the latest scientific results.
- ***Aggressive disregard of originality.*** Pattern writers do not need to be the original inventor or discoverer of the solutions that they document.
- ***Nonanonymous review.*** Pattern submissions are shepherded rather than reviewed. The shepherd contacts the pattern author(s) and discusses with him or her how the patterns might be clarified or improved on.
- ***Writers' workshops instead of presentations.*** - *T*o improve the patterns presented by discussing what they like about them and the areas in which they are lacking.
- ***Careful editing.*** The pattern authors should have the opportunity to incorporate all the comments and insights during the shepherding and writers' workshops before presenting the patterns in their finished form.

2.7. FRAMEWORKS

Frameworks are a way of delivering application development patterns to support best practice sharing during application development-not just within one company, but across many companies-through an emerging framework market. This is not an entirely new idea.

An experienced programmer almost never codes a new program from scratch - she'll use macros, copy libraries, and template like code fragments from earlier programs to make a start on a new one. Work on the new

program begins by filling in new domain specific code inside the older structures.

A seasoned business consultant who has worked on many consulting projects performing data modeling almost never builds a new data model from scratch he'll have a selection of model fragments that have been developed over time to help new modeling projects hit the ground running. New domain-specific terms will be substituted for those in his library models.

A *framework* is a way of presenting a generic solution to a problem that can be applied to all levels in a development. However, design and software frameworks are the most popular.

A definition of an object-oriented software framework is given by Gamma:

A framework is a set of cooperating classes that make up a reusable design for a specific class of software. A framework provides architectural guidance by partitioning the design into abstract classes and defining their responsibilities and collaborations. A developer customizes a framework to a particular application by subclassing and composing instances of framework classes. The framework captures the design decisions that are common to its application domain. Frameworks thus emphasize design reuse over code reuse, though a framework will usually include concrete subclasses you can put to work immediately. A single framework typically encompasses several design patterns.

In fact, a framework can be viewed as the implementation of a system of design patterns.

Differences between frameworks and design patterns:

*. A framework is executable software, whereas design patterns represent knowledge and experience about software.

*. Frameworks are of a physical nature, while patterns are of a logical nature.

*. Frameworks are the physical realization of one or more software pattern solution; patterns are the instructions for how to implement those solution.

Gamma et al. describe the major differences between design patterns and frameworks as follows:

.Design patterns are more abstract than frameworks. Frameworks can be embodied in code, but only examples of patterns can be embodied in code. A strength of frameworks is that they can be written down in programming languages and not only studied but executed and reused directly. In contrast,

design patterns have to be implemented each time they are used. Design patterns also explain the intent, trade-offs, and consequences of a design.

.Design patterns are smaller architectural elements than frameworks. A typical framework contains several design patterns but the reverse is never true.

. Design patterns are less specialized than frameworks. Frameworks always have a particular application domain. In contrast, design patterns can be used in nearly any kind of application. While more specialized design patterns are certainly possible, even these would not dictate an application architecture.

THE UNIFIED APPROACH

- The unified approach (UA) establishes a unifying and unitary framework around their works by utilizing the unified modeling language (UML) to describe, model, and document the software development process.
- The idea behind the UA is not to introduce yet another methodology. The main motivation here is to combine the best practices, processes, methodologies, and *guidelines* along with UML notations and diagrams for better understanding object-oriented concepts and system development.
- The unified approach to software development revolves around the following processes and concepts (see Fig.8). The processes are:
    - Use-case driven development
    - Object-oriented analysis
    - Object-oriented design
    - Incremental development and prototyping
    - Continuous testing

The methods and technology employed include

1. Unified modeling language used for modeling.
2. Layered approach.
3. Respository for object oriented system development patterns and frameworks.
4. Component based development.

The UA allows iterative development by allowing us to go back and forth between the design and the modeling or analysis phases.

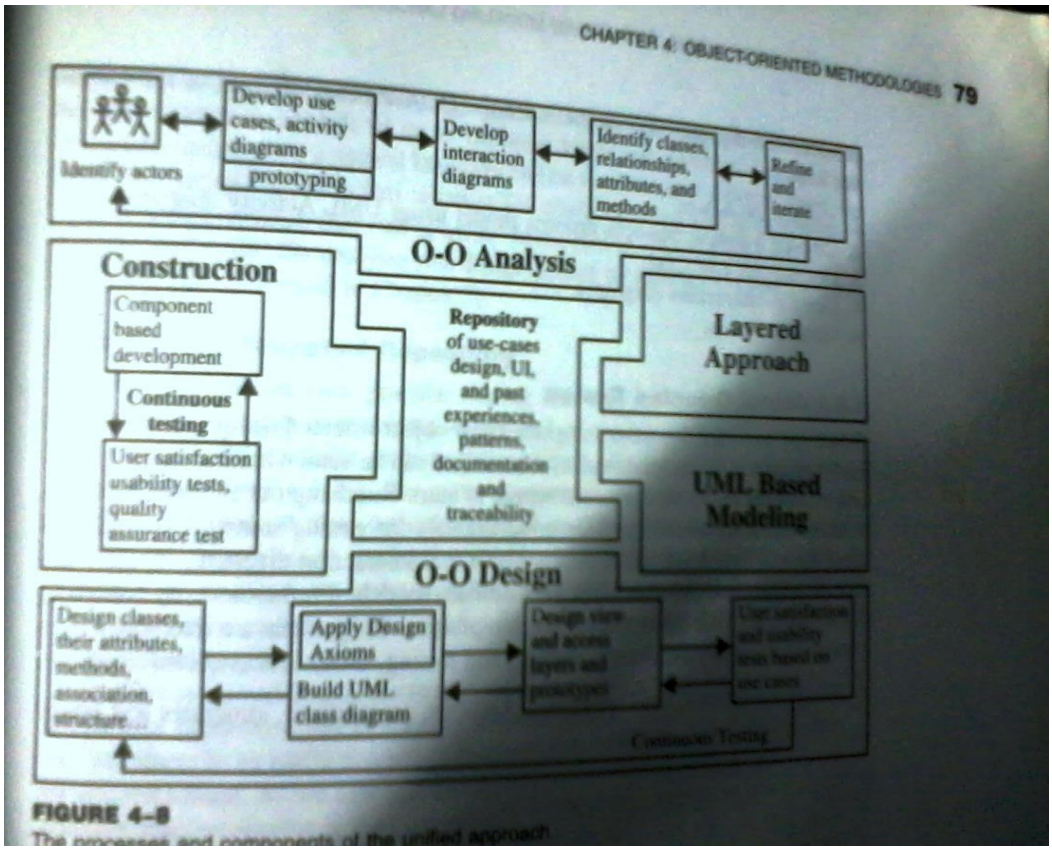


Fig 8. The Process and components of the unified approach

2.8.1 OBJECT-ORIENTED ANALYSIS

Analysis is the process of extracting the needs of a system and what the system must do to satisfy the users' requirements. The goal of object-oriented analysis is to first understand the domain of the problem and the system's responsibilities by understanding how the users use or will use the system. This is accomplished by constructing several models of the system. These models concentrate on describing what the system does rather than how it does it. Separating the behavior of a system from the way it is implemented requires viewing the system from the user's perspective rather than that of the machine.

OOA Process consists of the following Steps:

1. Identify the Actors.
2. Develop a simple business process model using UML Activity diagram.
3. Develop the Use Case.
4. Develop interaction diagrams.
5. Identify classes.

OBJECT-ORIENTED DESIGN

Booch provides the most comprehensive object-oriented design method. Ironically, since it is so comprehensive, the method can be somewhat imposing to learn and especially tricky to fig out where to start.

Rumbaugh et al.'s and Jacobson et al.'s high-level models provide good avenues for getting started. UA combines these by utilizing Jacobson et al.'s analysis and interaction diagrams,

Booch's object diagrams, and Rumbaugh et al.'s domain models. Furthermore, by following Jacobson et al.'s life cycle model, we can produce designs that are traceable across requirements, analysis, design, coding, and testing.

Process consists of:

- Designing classes, their attributes, methods, associations, structures and protocols, apply design axioms
- Design the Access Layer
- Design and prototype User interface
- User Satisfaction and Usability Tests based on the Usage/Use Cases
- Iterate and refine the design

ITERATIVE DEVELOPMENT AND CONTINUOUS TESTING

You must iterate and reiterate until, eventually, you are satisfied with the system. Since testing often uncovers design weaknesses or at least provides additional information you will want to use, repeat the entire process, taking what you have learned and reworking your design or moving on to reprototyping and retesting. Continue this refining cycle through the development process until you are satisfied with the results. During this iterative process, your prototypes will be incrementally transformed into the actual application. The UA encourages the integration of testing plans from day I of the project. Usage scenarios can become test scenarios; therefore, use cases will drive the usability testing. Usability testing is the process in which the functionality of software is measured.

MODELING BASED ON THE UNIFIED MODELING LANGUAGE

The unified modeling language was developed by the joint efforts of the leading object technologists Grady Booch, Ivar Jacobson, and James Rumbaugh with contributions from many others. The UML merges the best of the notations used by the three most popular analysis and design methodologies: Booch's methodology, Jacobson et al.'s use case, and Rumbaugh et al.'s object modeling technique.

The UML is becoming the universal language for modeling systems; it is intended to be used to express models of many different kinds and purposes, just as a programming language or a natural language can be used in many different ways. The UML has become the standard notation for object-oriented modeling systems. It is an evolving notation that still is under development. The UA uses the UML to describe and model the analysis and design phases of system development.

The UA Proposed Repository

In modem businesses, best practice sharing is a way to ensure that solutions to process and organization problems in one part of the business are communicated to other parts where similar problems occur. Best practice sharing eliminates duplication of problem solving. For many companies, best practice sharing is institutionalized as part of their constant goal of quality improvement. Best practice sharing must be applied to application development if quality and productivity are to be added to component reuse benefits. Such sharing extends the idea of software reusability to include all phases of software development such as analysis, design, and testing .

The idea promoted here is to create a repository that allows the maximum reuse of previous experience and previously defined objects, patterns, frameworks, and user interfaces in an easily accessible manner with a completely available and easily utilized format. As we saw previously, central to the discussion on developing this best practice sharing is the concept of a pattern. Everything from the original user request to maintenance of the project as it goes to production should be kept in the repository. The **advantage of repositories** is that, if your organization has done projects in the past, objects in the repositories from those projects might be useful. You can select any piece from a repository-from the definition of one data element, to a diagram, all its symbols, and all their dependent definitions, to entries- for reuse.

The UA's underlying assumption is that, if we design and develop applications based on previous experience, creating additional applications will require no more than assembling components from the library. Additionally, applying lessons learned from past developmental mistakes to future projects will increase the quality of the product and reduce the cost and development time. Some basic capability is available in most objectoriented environments, such as Microsoft repository, VisualAge, PowerBuilder, Visual C+ +, and Delphi. These repositories contain all objects that have been previously defined and can be reused for putting together a new software system for a new application.

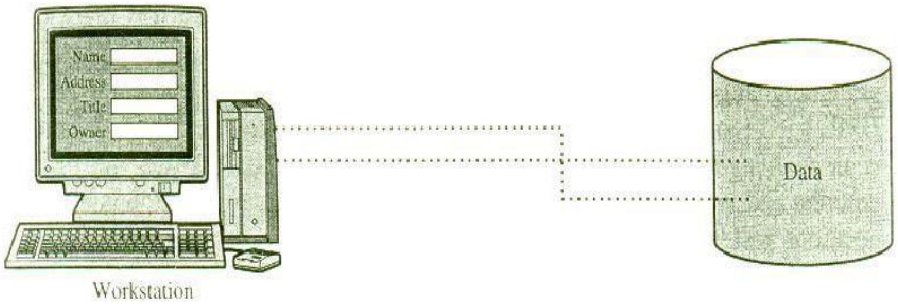


Fig. 9 : Two-layered architecture: interface and data.

If a new requirement surfaces, new objects will be designed and stored in the main repository for future use. The same arguments can be made about patterns and frameworks. Specifications of the software components, describing the behavior of the component and how it should be used, are registered in the repository for future reuse by teams of developers.

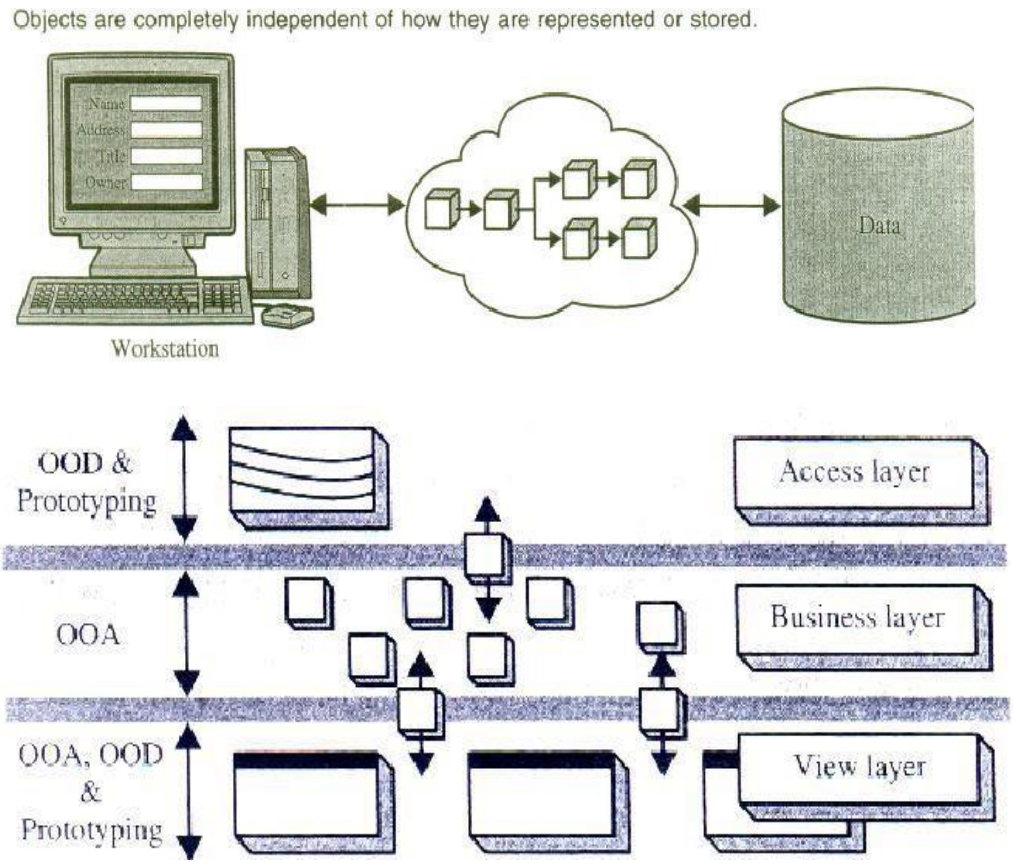
The repository should be accessible to many people. Furthermore, it should be relatively easy to search the repository for classes based on their attributes, methods, Two-layered architecture: interface and data, or other characteristics. For example, application developers could select prebuilt components from the central component repository that match their business needs and assemble these components into a single application, customizing where needed. Tools to fully support a comprehensive repository are not accessible yet, but this will change quickly and, in the near future, we will see more readily available tools to capture all phases of software development into a repository for use and reuse.

The Layered Approach to Software Development

Most systems developed with today's CASE tools or client-server application development environments tend to lean toward what is known as *two-layered architecture:* interface and data (see Fig).

In a two-layered system, user interface screens are tied to the data through routines that sit directly behind the screens; for example, a routine that executes when you click on a button. With every interface you create, you must re-create the business logic needed to run the screen. The routines required to access the data must exist within every screen. Any change to the business logic must be accomplished in every screen that deals with that portion of the business. This approach resultsin objects that are very specialized and cannot be reused easily in other projects.

A better approach to systems architecture is one that isolates the functions of the interface from the functions of the business. This approach also isolates the business from the details of the data access (see Fig).



Business objects represent tangible elements of the application. They should be completely independent of how they are represented to the user or how they are physically stored. layered approach, you are able to create objects that represent tangible elements of your business yet are completely independent of how they are represented to the user (through an interface) or how they are physically stored (in a database). The three-layered approach consists of a view or user interface layer, a business layer, and an access layer (see Fig).

The Business Layer The business layer contains all the objects that represent the business (both data and behavior). This is where the real objects such as Order, Customer, Line item, Inventory, and Invoice exist. Most modem objectoriented analysis and design methodologies are generated toward identifying these kinds of objects.

The responsibilities of the business layer are very straightforward: Model the objects of the business and how they interact to accomplish the business processes. When creating the business layer, however, it is important to keep in mind a couple of things. These objects should not be responsible for the following:

.Displaying details. Business objects should have no special knowledge of how they are being displayed and by whom. They are designed to be independent of any particular interface, so the details of how to display an object should exist in the interface (view) layer of the object displaying it.

Data access details. Business objects also should have no special knowledge of "where they come from." It does not matter to the business model whether the data are stored and retrieved via SQL or file I/O. The business objects need to know only to whom to talk about being stored or retrieved. The business objects are modeled during the object-oriented analysis. A business model captures the static and dynamic relationships among a collection of business objects. Static relationships include object associations and aggregations. For example, a customer could have more than one account or an order could be aggregated from one or more line items. Dynamic relationships show how the business objects interact to perform tasks. For example, an order interacts with inventory to determine product availability. An individual business object can appear in different business models. Business models also incorporate control objects that direct their processes. The business objects are identified during the object

oriented analysis. Use cases can provide a wonderful tool to capture business objects.

The User Interface (View) Layer: The user interface layer consists of objects with which the user interacts as well as the objects needed to manage or control the interface. The user interface layer also is called the *view layer*. This layer typically is responsible for two major aspects of the applications:

. Responding to user interaction. The user interface layer objects must be designed to translate actions by the user, such as clicking on a button or selecting .from a menu, into an appropriate response. That response may be to open or close another interface or to send a message down into the business layer to start some business process; remember, the business logic does not exist here, just the knowledge of which message to send to which business object..

. Displaying business objects. This layer must paint the best possible picture of the business objects for the user. In one interface, this may mean entry fields and list boxes to display an order and its items. In another, it may be a graph of the total price of a customer's orders.

The Access layer : The access layer contains objects that know how to communicate with the palce where the data actually reside, whether it be a relational databasem mainframe, internetm or file. The Access layer has 2 major responsiblities.

1. Translate request : The access layer must be able to translate any dat-related requests from the business layer into the appropriate protocol for data access.
2. Translate results/: tje access ;ayer also must ne able to translate the dat retrieved back into the appropriate business objects and pass those objects back up into the business layer.

   Access objets are indentified during object oriented design.

UNIFIED MODELING LANGUAGE

A ***model*** is an abstract representation of a system, constructed to understand the system prior to building or modifying it. Most of the modeling techniques involve graphical languages.

Modeling frequently is used during many of the phases of the software life cycle, such as analysis, design, and implementation. For example, Objectory is built around several different models:

. *Use-case model.* The use-case model defines the outside (actors) and inside (use case) of the system's behavior.

. *Domain object model*. Objects of the "real" world are mapped into the domain object model.

.Analysis object model. The analysis object model presents how the source code
(i.e., the implementation) should be carried out and written.

.Implementation model. The implementation model represents the implementation of the system.

. *Test model*. The test model constitutes the test plans, specifications, and reports.

Modeling is an iterative process.

Static or Dynamic Models

Static Model	*Dynamic Model*
• A static model can be viewed as "snapshot" of a system's parameters at rest or at a specific point in time. • The classes'| structure and their relationships to each other frozen in time are examples of static models.	• Is a collection of procedures or behaviors that, taken together, reflect the behavior of a system over time. • For example, an order interacts with inventory to determine product availability.

WHY MODELING?

Building a model for a software system prior to its construction is as essential as having a blueprint for building a large building. Good models are essential for communication among project teams. As the complexity of systems increases, so does the importance of good modeling techniques. Many other factors add to a project's success, but having a rigorous

modeling language is essential. A modeling language must include
- Model elements-fundamental modeling concepts and semantics.
- Notation-visual rendering of model elements.
- Guidelines-expression of usage within the trade.

In the face of increasingly complex systems, visualization and modeling become essential, since we cannot comprehend any such system in its entirety. The use of visual notation to represent or model a problem can provide us several benefits relating to clarity, familiarity, maintenance, and simplification.

- ***Clarity.*** We are much better at picking out errors and omissions from a graphicalor visual representation than from listings of code or tables of numbers. We very easily can understand the system being modeled because visual examination of the whole is possible.
- ***Familiarity.*** The representation form for the model may turn out to be similar to the way in which the information actually is represented and used by the employees currently working in the problem domain. We, too, may find it more comfortable to work with this type of representation.
- ***Maintenance.*** Visual notation can improve the main tainability of a system. The visual identification of locations to be changed and the visual confirmation of those changes will reduce errors. Thus, you can make changes faster, and fewer errors are likely to be introduced in the process of making those changes.
- ***Simplification***. Use of a higher level representation generally results in the use of fewer but more general constructs, contributing to simplicity and conceptual understanding.

Turban cites the following advantages of modeling:

1. Models make it easier to express complex ideas. For example, an architect builds a model to communicate ideas more easily to clients.
2. The main reason for modeling is the reduction of complexity. Models reduce complexity by separating those aspects that are unimportant from those that are important. Therefore, it makes complex situations easier to understand.
3. Models enhance and reinforce learning and training.
4. The cost of the modeling analysis is much lower than the cost of similar experimentation conducted with a real system.
5. Manipulation of the model (changing variables) is much easier than manipulating a real system.

key ideas regarding modeling:

- A model is rarely correct on the first try.
- Always seek the advice and criticism of others. You can improve a model by reconciling different perspectives.
- Avoid excess model revisions, as they can distort the essence of your model.

What Is the UML?

The unified modeling language is a language for specifying, constructing, visualizing, and documenting the software system and its components. The UML is a graphical language with sets of rules and semantics. The rules and semantics of a model are expressed in English, in a form known as *object constraint language* (OCL). OCL is a specification language that uses simple logic for specifying the properties of a system.

The UML is not intended to be a visual programming language in the sense of having all the necessary visual and semantic support to replace programming languages. However, the UML does have a tight mapping to a family of object-oriented languages, so that you can get the best of both worlds.

What it is/isn't? Is NOT

• A process

• A formalism

Is

• A way to describe your software

• more precise than English

• less detailed than code

What is UML Used For?

- Trace external interactions with the software
- Plan the internal behavior of the application
- Study the software structure
- View the system architecture
- Trace behavior down to physical components

The primary goals in the design of the UML were as follows :

1. Provide users 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.
7. Integrate best practices and methodologies.

UML DIAGRAMS

The UML defines nine graphical diagrams:

1. Class diagram (static)

2. Use-case diagram

3. Behavior diagrams (dynamic):

– 3.1. Interaction diagram:

• 3.1.1. Sequence diagram

• 3.1.2. Collaboration diagram

– 3.2. State chart diagram

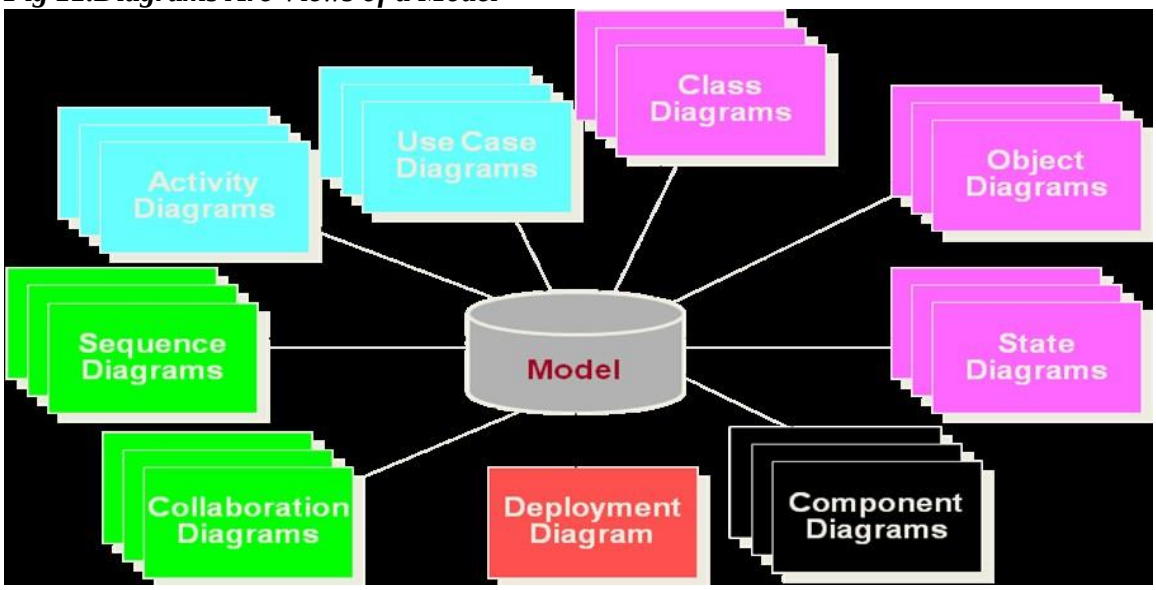
– 3.3. Activity diagram

4. Implementation diagram:

Component diagram

Deployment diagram

Fig 11.Diagrams Are Views of a Model



UML CLASS DIAGRAM

The UML ***class diagram***, also referred to as ***object modeling***, is the main static analysis diagram. These diagrams show the static structure of the model.

A class diagram is a collection of static modeling elements, such as classes and their relationships, connected as a graph to each other and to their contents; for example,the things that exist (such as classes), their internal structures, and their relationships to other classes.

Class diagrams do not show temporal information, which is required in dynamic modeling.

- A class diagram describes the types of objects in the system and the various kinds of static relationships that exist among them.
- A graphical representation of a static view on declarative static elements.
- A central modeling technique that runs through nearly all object-oriented methods.
- The richest notation in UML.
- A class diagram shows the existence of classes and their relationships in the logical view of a system

Class Notation: Static Structure

A class is drawn as a rectangle with three components separated by horizontal lines. The top name compartment holds the class name, other general properties of the class, such as attributes, are in the middle compartment, and the bottom compartment holds a list of operations (see Fig12.).

Either or both the attribute and operation compartments may be suppressed. Aseparator line is not drawn for a missing compartment if a compartment is suppressed; no inference can be drawn about the presence or absence of elements in it.

The class name and other properties should be displayed in up to three sections. A stylistic convention of UML is to use an italic font for abstract classes and a normal (roman) font for concrete classes.

Essential Elements of a UML Class Diagram

– Class
– Attributes
– Operations
– Relationships
  - Associations
  - Generalization
– Dependency
– Realization

Constraint Rules and Notes

A class is the description of a set of objects having similar attributes, operations, relationships and behavior.

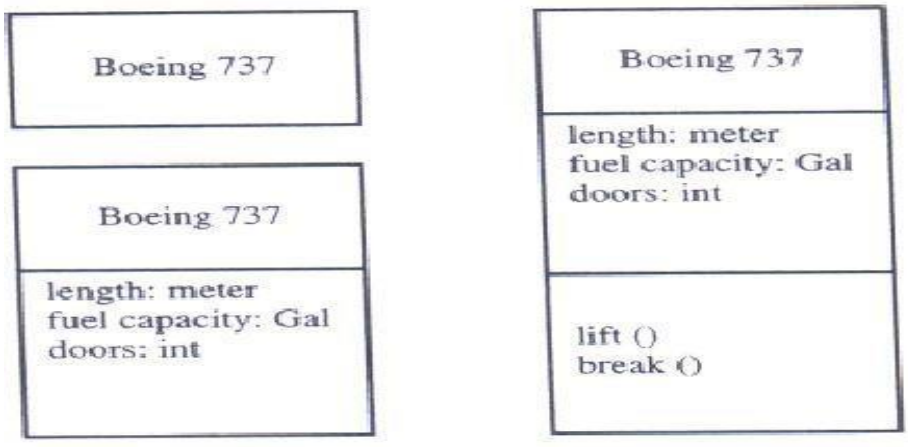


Fig.12 In class notation, either or both the attributes and operation compartments may be suppressed.

Attributes

– Classes have attributes that describe the characteristics of their objects.

– Attributes are atomic entities with no responsibilities.

– Attribute syntax (partial):

o [visibility] name [: type] [= defaultValue]

– Class scope attributes are underlined

Visibility

• Visibility describes whether an attribute or operation is visible and can be referenced from classes other than the one in which they are defined.

• language dependent

o Means different things in different languages

• UML provides four visibility abbreviations: + (public) – (private) # (protected) ~ (package)

Object Diagram

A static object diagram is an instance of a class diagram. It shows a snapshot of the detailed state of the system at a point in time. Notation is the same for an object diagram and a class diagram. Class diagrams can contain objects, so a class diagram with objects and no classes is an object diagram.

UML modeling elements in class diagrams

• Classes and their structure, association, aggregation, dependency, and inheritance relationships

• Multiplicity and navigation indicators, etc.

Class Interface Notation

Class interface notation is used to describe the externally visible behavior of a class; for example, an operation with public visibility. Identifying class interfaces is a design activity of object-oriented system development.

The UML notation for an interface is a small circle with the name of the interface connected to the class. A class that requires the operations in the interface may be attached to the circle by a dashed arrow. The dependent class is not required to actually use all of the operations.

For example, a Person object may need to interact with the BankAccount object to get the Balance; this relationship is depicted in Fig13. with UML class interface notation.

Fig 13. Interface notation of a Class

Binary Association Notation

A binary association is drawn as a solid path connecting two classes, or both ends may be connected to the same class. An association may have an association name. The association name may have an optional black triangle in it, the point of the triangle indicating the direction in which to read the name. The end of an association, where it connects to a class, is called the ***association role*** **(**see Fig14).

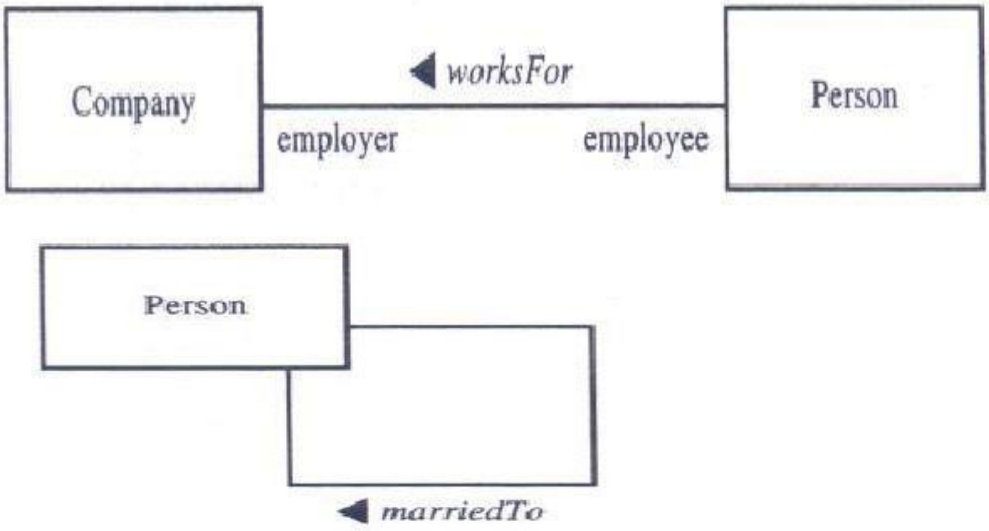


Fig 14: Association notation.

Association Role

A simple association- ***binary association****-is* drawn as a solid line connecting two class symbols. The end of an association, where it connects to a class, shows the association role. The role is part of the association, not part of the class. Each association has two or more roles to which it is connected.

In above Fig14. the association worksFor connects two roles, employee and employer. A Person is an employee of a Company and a Company is an employer of a Person.

The UML uses the term *association navigation* or *navigability* to specify a role affiliated with each end of an association relationship. An

arrow may be attached to the end of the path to indicate that navigation is supported in the direction of the class pointed to. An arrow may be attached to neither, one, or both ends of the path. In particular, arrows could be shown whenever navigation is supported in a given direction.

In the UML, association is represented by an open arrow, as represented in Fig.15. Navigability is visually distinguished from inheritance, which is denoted by an unfilled arrowhead symbol near the superclass.

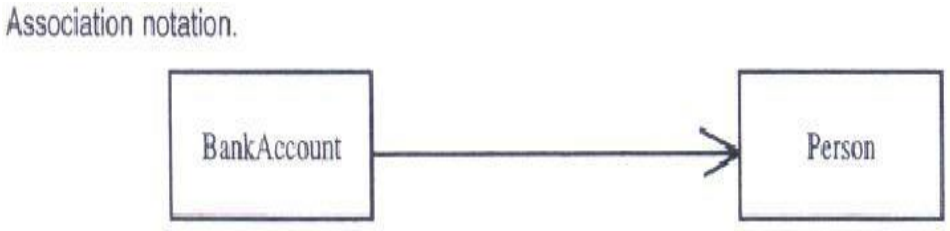


Fig 15. Association Notation

In this example, the association is navigable in only one direction, from the BankAccount to Person, but not the reverse. This might indicate a design decision, but it also might indicate an analysis decision, that the Person class is frozen and cannot be extended to know about the BankAccount class, but the BankAccount class can know about the Person class.

Qualifier

A ***qualifier*** is an association attribute. For example, a person object may be associated to a Bank object. An attribute of this association is the account#. The account# is the qualifier of this association.(Fig 16)

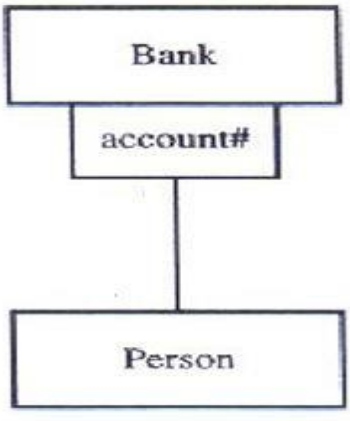


Fig 16 Association Qualifier.

A qualifier is shown as a small rectangle attached to the end of an association path, between the final path segment and the symbol of the class to which it connects. The qualifier rectangle is part of the association path, not part of the class. The qualifier rectangle usually is smaller than the attached class rectangle (see above Fig).

Multiplicity

Multiplicity specifies the range of allowable associated classes. It is given for roles within associations, parts within compositions, repetitions, and other purposes. A multiplicity specification is shown as a text string comprising a period-separated sequence of integer intervals, where an interval represents a range of integers in this format (see Fig 17):

lower bound.. upper bound.

The terms *lower bound* and *upper bound* are integer values, specifying the range of integers including the lower bound to the upper bound. The star character (*) may be used for the upper bound, denoting an unlimited upper bound. If a single integer value is specified, then the integer range contains the single values.

For example,
0..1
0..*
1..3, 7..10, 15, 19..*

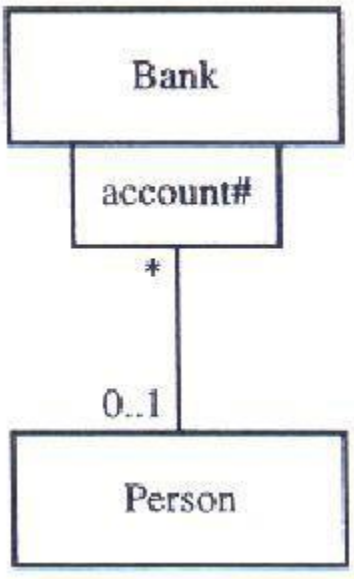


Fig 17. Assocaition Qualifier and its multiplicity.

OR Association

An ***OR association*** indicates a situation in which only one of several potential associations may be instantiated at one time for any single object. This is shown as a dashed line connecting two or more associations, all of which must have a class in common, with the constraint string {or} labeling the dashed line (see Fig 18). In other words, any instance of the class may participate in, at most, one of the associations at one time.

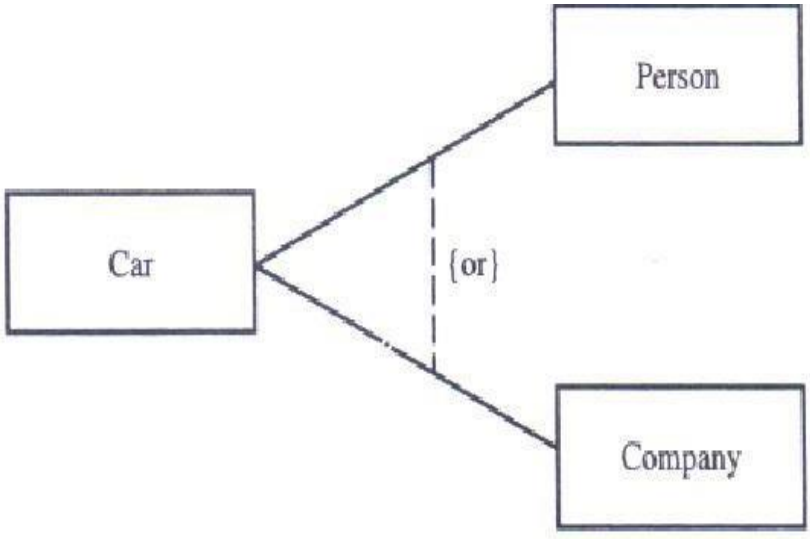


Fig 18. An OR association notation. A car may associate with a person or a company.

Association Class

An ***association class*** is an association that also has class properties. An association class is shown as a class symbol attached by a dashed line to an association path. The name in the class symbol and the name string attached to the association path are the same (see Fig 19). The name can be shown on the path or the class symbol or both. If an ssociation class has attributes but no operations or other associations, then the name may be displayed on the association path and omitted from the association class to emphasize its "association nature." If it has operations and attributes, then the name may be omitted from the path and placed in the class rectangle to emphasize its "class nature."

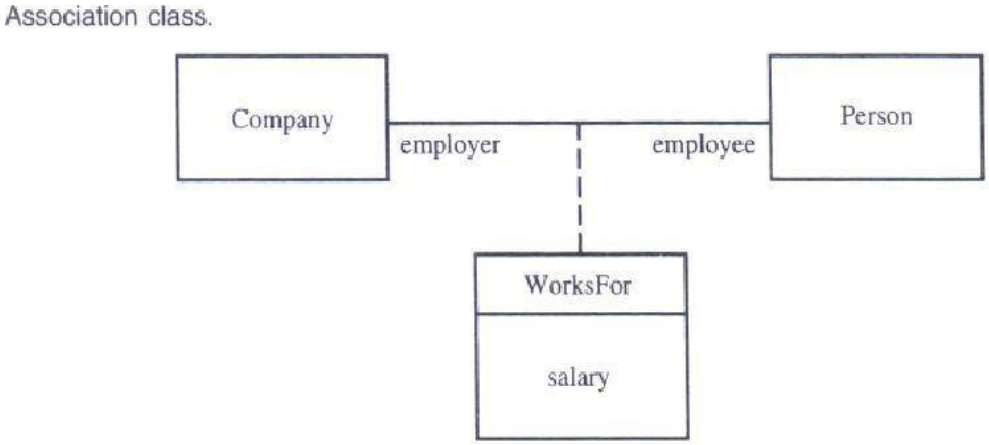


Fig 19. Association Class

N-Ary Association

An *n-ary association* is an association among more than two classes. Since n-ary association is more difficult to understand, it is better to convert an n-ary association to binary association.

An n-ary association is shown as a large diamond with a path from the diamond to each participant class. The name of the association (if any) is shown near the diamond. The role attachment may appear on each path as with a binary association. Multiplicity may be indicated; however, qualifiers and aggregation are not permitted. An association class symbol may be attached to the diamond by a dashed line, indicating an n-ary association that has attributes, operation, or associations. The example depicted in Fig 20 shows the grade book of a class in each semester.

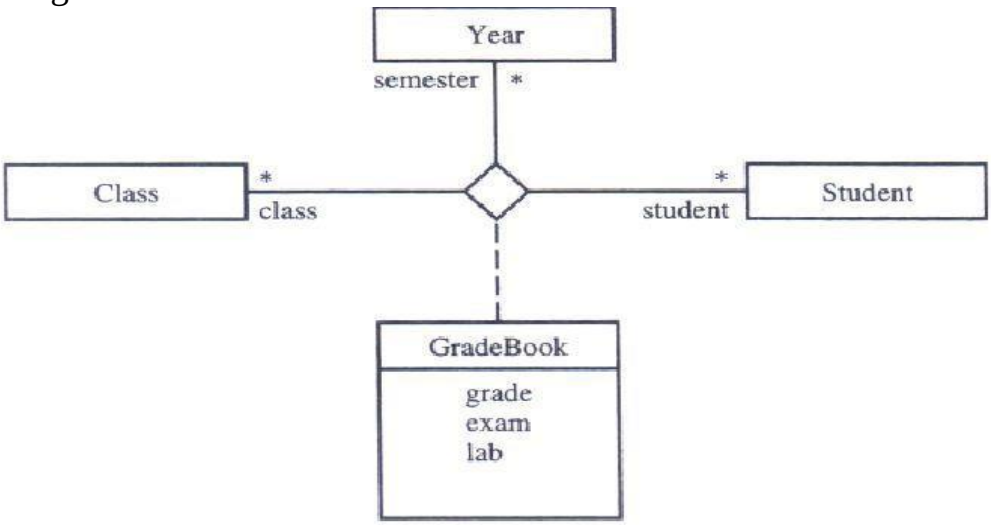


Fig 20 . An n-ary (ternary) association that shows association among class, year, and student classes. The association class GradeBook which contains the attributes of the associations such as grade, exam, and lab.

Aggregation and Composition (a.part.of)

Aggregationis a form of association. A hollow diamond is attached to the end of the path to indicate aggregation. However, the diamond may not be attached to both ends of a line, and it neednot be presentedat all (see Fig 21).

Composition, also known as the ***apart-of***, is a form of aggregation with strong ownership to represent the component of a complex object. Composition also is referred to as **a *part-whole relationship***.The UML notation for composition is a solid diamond at the end of a path. Alternatively,the UML provides a graphically nestedform that, in many cases,is more convenientfor showingcomposition (see Fig 22).

Parts with multiplicity greater than one may be created after the aggregate itself but, once created, they live and die with it. Such parts can also be explicitly removed before the death of the aggregate.

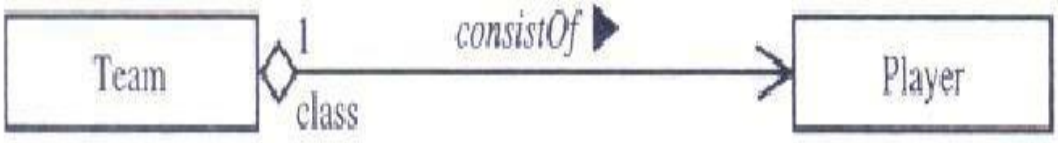


Fig 21. Association Path

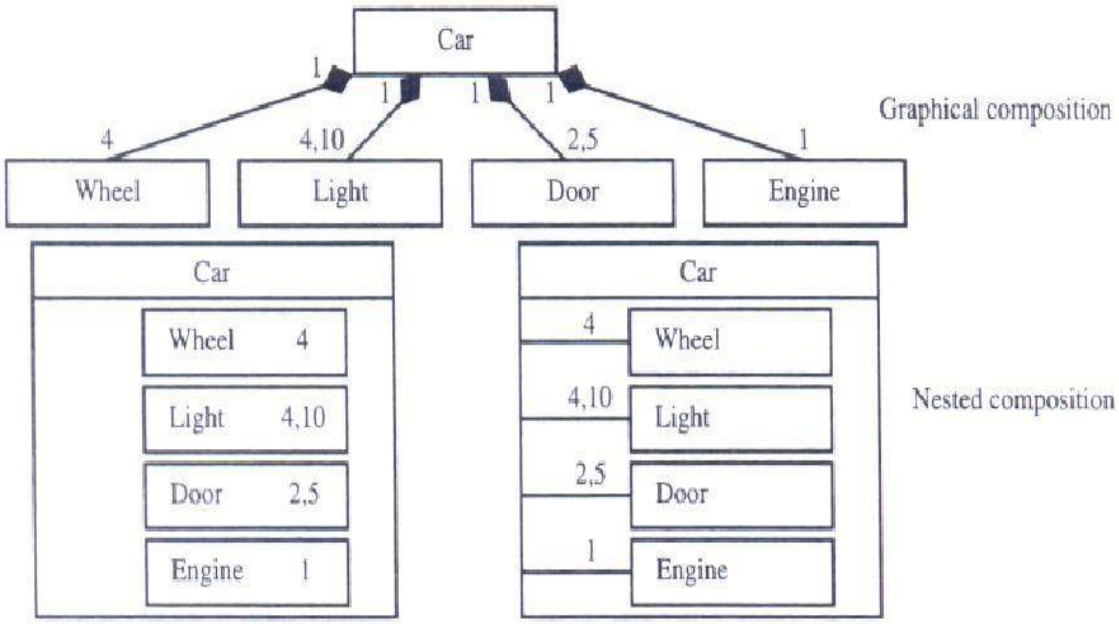


Fig 22. Different ways to show Composition.

Generalization

Generalization **is** the relationshipbetweena more generalclass and a more specific class. Generalization is displayed as a directed line with a closed, hollow arrowhead at the superclass end (see Fig 23). The UML allows a ***discriminator*** **label** to be attached to a generalization of the superclass. For example, the class Boeing- Airplane has instances of the classes Boeing 737, Boeing 747, Boeing 757, and Boeing 767, which are subclasses of the class BoeingAirplane. Ellipses (...) indicate that the generalization is incomplete and more subclasses exist that are not shown (see Fig 24).

The constructor complete indicates that the generalization is complete and no more subclasses are needed. If a text label is placed on the hollow triangle shared by several generalization paths to subclasses, the label applies to all of the paths. In other words, all subclasses share the given properties.

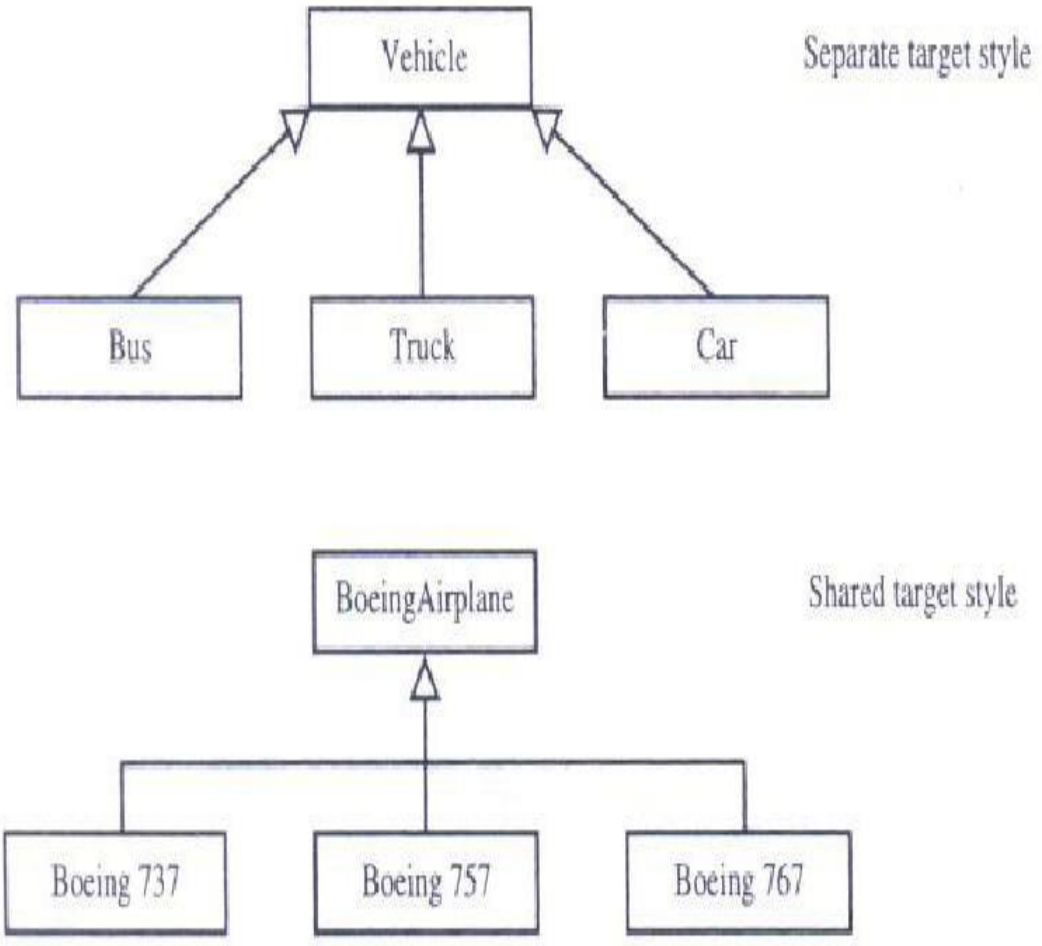


Fig 23. Generalization Notation

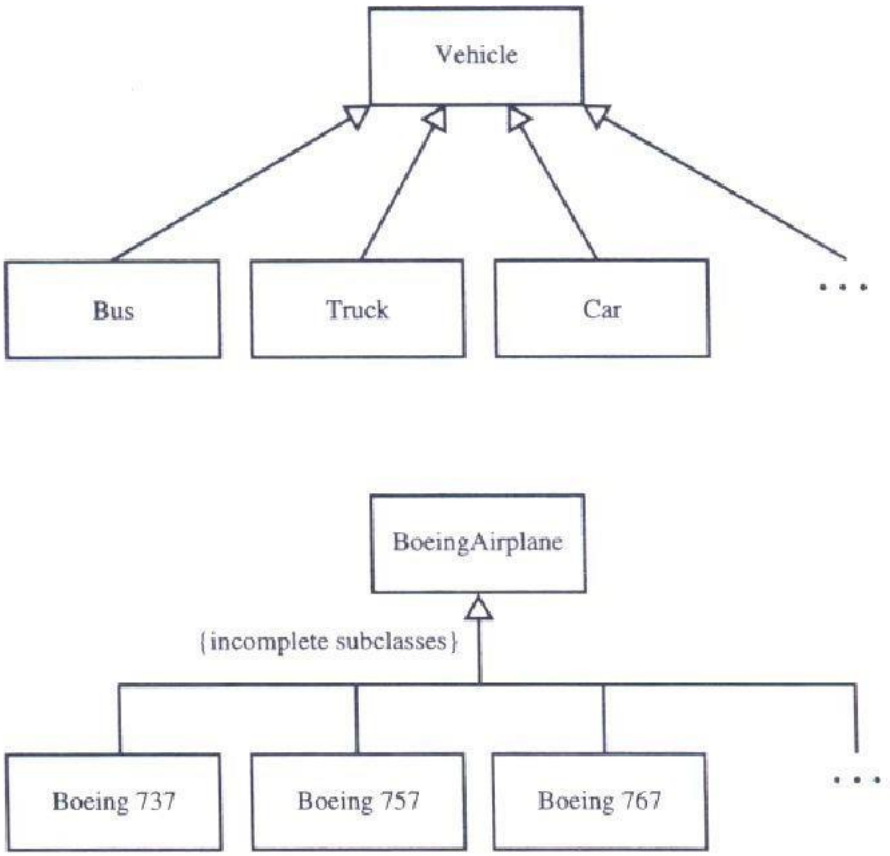


Fig 24. Ellipses(...) indicate that additional classes exist and are not shown.

USE-CASE DIAGRAM

The use-case concept was introduced by Ivar Jacobson in the object-oriented software engineering (OOSE) method. The functionality of a system is described in a number of different use cases, each of which represents a specific flow of events in the system.

A use case corresponds to a sequence of transactions, in which each transaction is invoked from outside the system (actors) and engages internal objects to interact with one another and with the system's surroundings.

The description of a **use case defines what happens in the system when the use case is performed.** In essence, the use-case model defines the outside (**actors)** and inside (**use case**) of the system's behavior. Use cases represent specific flows of events in the system. The **use cases** are initiated by actors and describe the flow of events that these actors set off. **An actor** is anything that interacts with a use case: It could be a human user, external hardware, or another system. An actor represents a category of user rather

than a physical user. Several physical users can play the same role. For example, in terms of a Member actor, many people can be members of a library, which can be represented by one actor called ***Member***.

A *use-case diagram* is a graph of actors, a set of use cases enclosed by a system boundary, communication (participation) associations between the actors and the use cases, and generalization among the use cases.

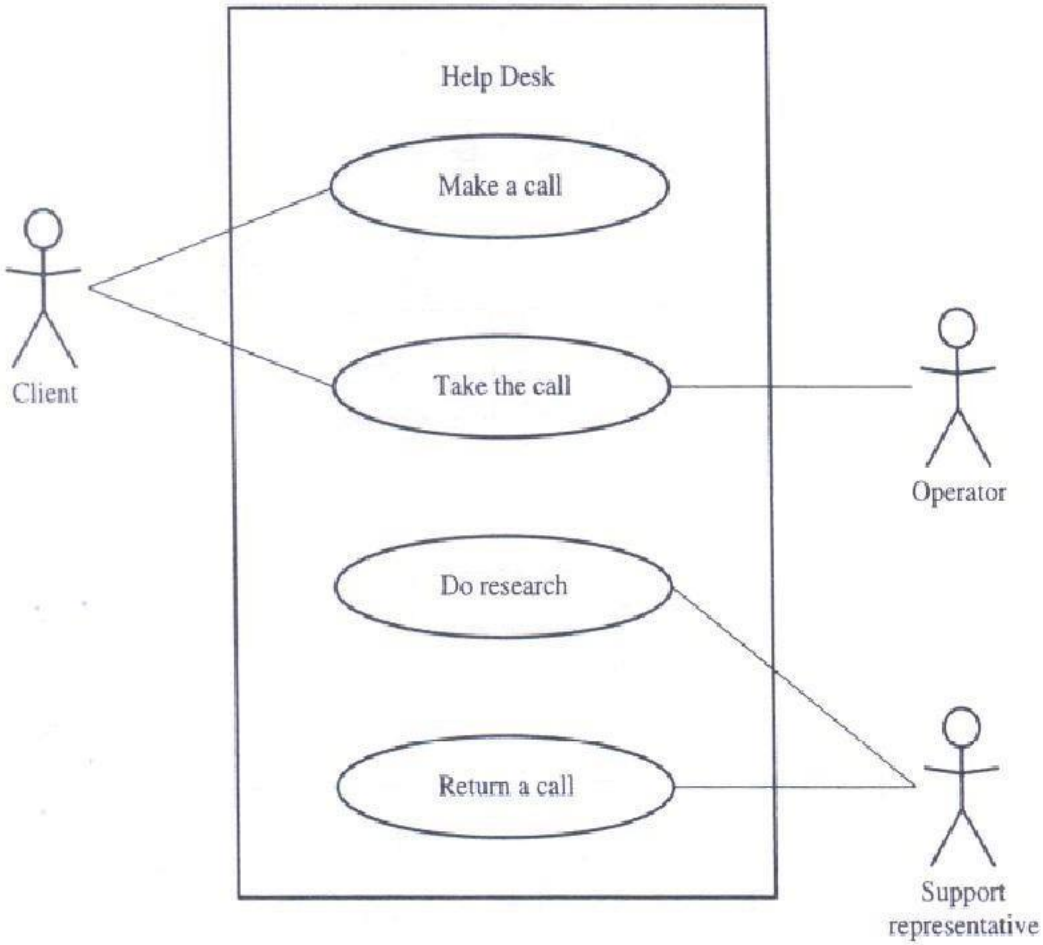


Fig 25. use-case diagram shows the relationship among actors and use cases within a system.

Fig 25. diagrams use cases for a Help Desk. A use-case diagram shows the relationship among the actors and use cases within a system. A client makes a call that is taken by an operator, who determines the nature of the problem. Some calls can be answered immediately; other calls require research and a return call.

A use case is shown as an ellipse containing the name of the use case. The name of the use case can be placed below or inside the ellipse. Actors' names and use case names should follow the capitalization and punctuation guidelines of the model.

An actor is shown as a class rectangle with the label < <actor> >, or the label and a stick fig, or just the stick fig with the name of the actor below the fig (see Fig 26).

Fig 26. The three representations of an actor are equivalent.

These relationships are shown in a use-case diagram:

1. ***Communication.*** The communication relationship of an actor in a use case is shown by connecting the actor symbol to the use-case symbol with a solid path. The actor is said to "communicate" with the use case.
2. ***Uses.*** A uses relationship between use cases is shown by a generalization arrow from the use case.
3. ***Extends.*** The extends relationship is used when you have one use case that is similar to another use case but does a bit more. In essence, it is like a subclass.

UML DYNAMIC MODELING (BEHAVIOR DIAGRAMS)

The diagrams we have looked at so far largely are static. However, events happen dynamically in all systems: Objects are created and destroyed, objects send messages to one another in an orderly fashion, and in some systems, external events trigger operations on certain objects. Furthermore, objects have states. The state of an object would be difficult to capture in a static model. The state of an object is the result of its behavior.
Booch provides us an excellent example:

"When a telephone is first installed, it is in idle state, meaning that no previous behavior is of great interest and that the phone is ready to initiate and receive calls. When someone picks up the handset, we say that the phone is now off-hook and in the dialing state; in this state,. we do not expect the phone to ring: we expect to be able to initiate a conversation with a party or parties on another telephone. When the phone is on-hook, if it rings and then we pick up the handset, the phone is now in the receiving state, and we expect to be able to converse with the party that initiated the conversation ."

Booch explains that describing a systematic event in a static medium such as on a sheet of paper is difficult, but the problem confronts almost every discipline.

The Dynamic semantics of a problem with the following diagrams:

Behavior diagrams (Dynamic)

- Interaction Diagrams:
  - ✓ Sequence diagrams
  - ✓ Collaboration diagrams
- State Chart diagrams
- Activity diagrams

Each class may have an associated activity diagram that indicates the behavior of the class's instance (its object). In conjunction with the use-case model, we may provide a scripts or an interaction diagram to show the time or event ordering of messages as they are evaluated .

UML INTERACTION DIAGRAMS

Interaction diagrams are diagrams that describe how groups of objects collaborate to get the job done.

Interaction diagrams capture the behavior of a single use case, showing the pattern of interaction among objects. The diagram shows a number of example objects and the messages passed between those objects within the use case . There are two kinds of interaction models: **sequence diagrams and collaboration diagrams.**

UML Sequence Diagram : ***Sequence diagrams*** are an easy and intuitive way of describing the behavior of a system by viewing the interaction between the system and its environment. A sequence diagram shows an interaction arranged in a time sequence. It shows the objects participating in the interaction by their lifelines and the messages they exchange, arranged in a time sequence.

A sequence diagram has two dimensions: the **vertica**l dimension represents time, the **horizontal** dimension represents different objects. The vertical line is called the **object's *lifeline***. The ***lifeline*** represents the object's existence during the interaction. This form was first popularized by Jacobson. **An object** is shown as a box at the top of a dashed vertical line (see Fig 27). A role is a slot for an object within a collaboration that describes the type of object that may play the role and its relationships to other roles. a sequence diagram does not show the relationships among the

roles or the association among the objects. An object role is shown as a vertical dashed line, the lifeline.

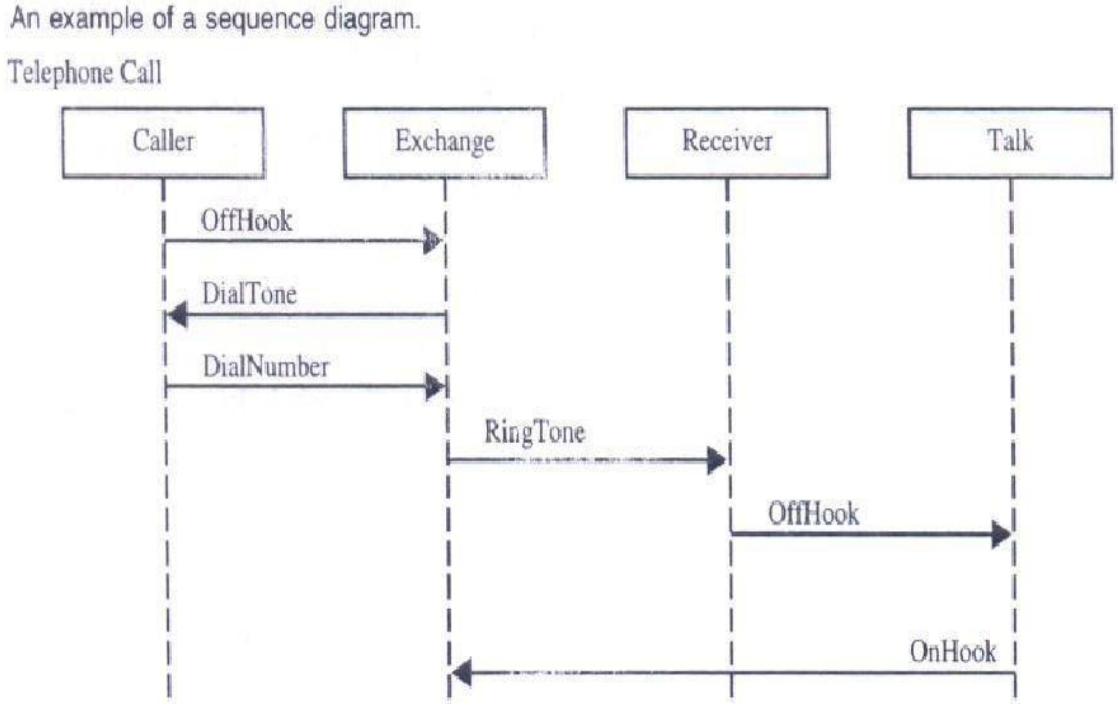


Fig 27. An example of a Sequence Diagram

Each message is represented by an arrow between the lifelines of two objects. The order in which these messages occur is shown top to bottom on the page. Each message is labeled with the message name. The label also can include the argument and some control information and show self-delegation, a message that an object sends to itself, by sending the message arrow back to the same lifeline. The horizontal ordering of the lifelines is arbitrary. Often, call arrows are arranged to proceed in one direction across the page, but this is not always possible and the order conveys no information.

The sequence diagram is very simple and has immediate visual appeal-this is its great strength. A sequence diagram is an alternative way to understand the overall flow of the control of a program. Instead of looking at the code and trying to find out the overall sequence of behavior, you can use the sequence diagram to quickly understand that sequence.

UML Collaboration Diagram : Another type of interaction diagram is the collaboration diagram. **A *collaboration diagram*** represents a collaboration, which is a set of objects related in a particular context, and interaction, which is a set of messages exchanged among the objects within the

collaboration to achieve a desired outcome. In a collaboration diagram, objects are shown as figs. As in a sequence diagram, arrows indicate the message sent within the given use case. In a collaboration diagram, the sequence is indicated by numbering the messages.

A collaboration diagram provides several numbering schemes. The simplest is illustrated in Fig 28. You can also use a decimal numbering scheme (see Fig- 28 a) where 1.2: DialNumber means that the Caller (1) is calling the Exchange (2); hence, the number 1.2.

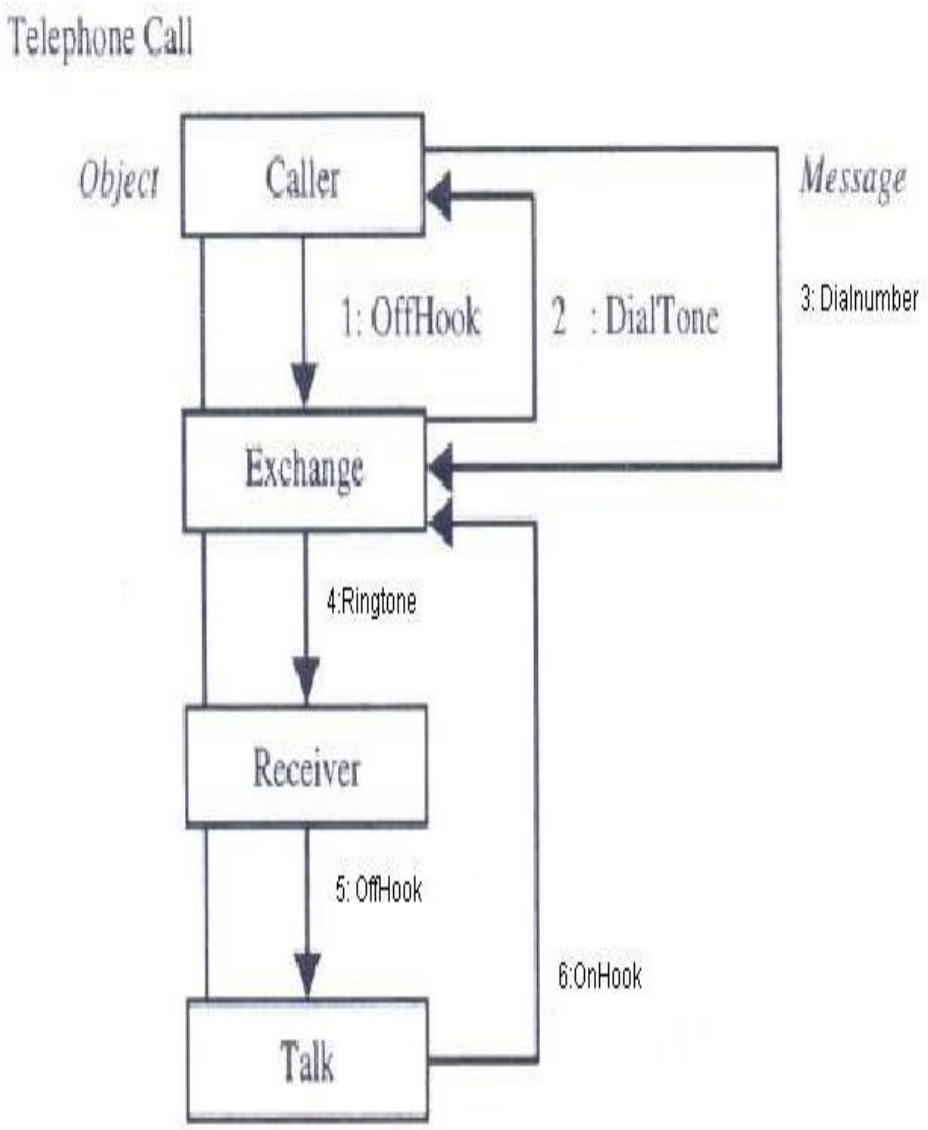


Fig.28. A collaboration diagram with simple numbering.

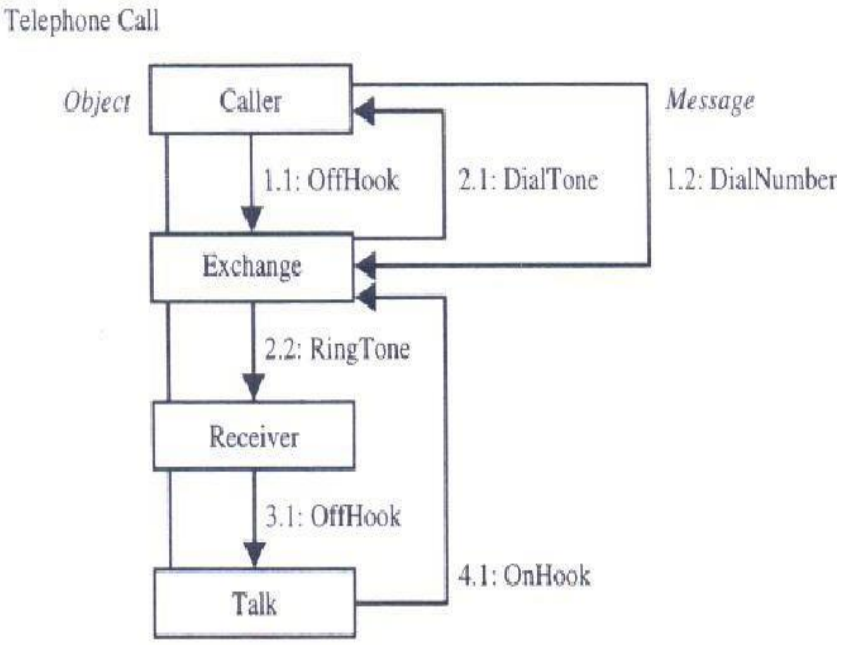


Fig.28 a. A collaboration diagram with decimal numbering.

The UML uses the decimal scheme because it makes it clear which operation is calling which other operation, although it can be hard to see the overall sequence . Different people have different preferences when it comes to deciding whether to use sequence or collaboration diagrams.

Fowler and Scott argue that the **main advantage** of interaction diagrams (both collaboration and sequence) is **simplicity**. You easily can see the message by looking at the diagram. The **disadvantage** of interaction diagrams is that they are great only for representing a single sequential process; they begin to break down when you want to represent conditional looping behavior.

Conditional behavior can be represented in sequence or collaboration diagrams through two methods.

*. The preferred method is to use separate diagrams for each scenario.

*. Another way is to use conditions on messages to indicate the behavior.

UML STATECHART DIAGRAM

A ***statechart diagram*** (also called a ***state diagram)*** shows the sequence of states that an object goes through during its life in response to outside stimuli and messages.

The state is the set of values that describes an object at a specific point in time and is represented by state symbols and the transitions are

represented by arrows connecting the state symbols. A statechart diagram may contain subdiagrams.

***A state diagram* represents *the state* of *the method execution (that is, the state* of *the* object *executing the method),* and *the activities in the diagram* represent *the* activities of the object that performs *the* method**.

The purpose of the state diagram is to understand the algorithm involved in performing a method. To complete an object-oriented design, the activities within the diagram must be assigned to objects and the control flows assigned to links in the object diagram.

A statechart diagram is similar to a Petri net diagram, where a token (shown by a solid black dot) represents an activity symbol. When an activity symbol appears within a state symbol, it indicates the execution of an operation. Executing a particular step within the diagram represents a state within the execution of the overall method. The same operation name may appear more than once in a state diagram, indicating the invocation of the same operation in a different phase. An outgoing solid arrow attached to a statechart symbol indicates a transition triggered by the completion of the activity. The name of this implicit event need not be written, but conditions that depend on the result of the activity or other values may be included. An event occurs at the instant in time when the value is changed.

A message is data passed from one object to another. At a minimum, a message is a name that will trigger an operation associated with the target object; for example, an Employee object that contains the name of an employee. If the Employee object received a message *(getEmployeeName)* asking for the name of the employee, an operation contained in the Employee class (e.g., returnEmployeeName) would be invoked. That operation would check the attribute Employee and then assign the value associated with that attribute back to the object that sent the message in the first place.

In this case, the state of the Employee object would not have been changed. Now, consider a situation where the same Employee object received a message *updateEmployeeAddress)* that contained a parameter (2000 21st Street, Seattle, WA): updateEmployeeAddress (2000 21st Street, Seattle, WA)

In this case the object would invoke an operation from its class that would modify the value associated with the attribute Employee, changing it from the old address to the new address; therefore, the state of the employee object has been changed.

A state is represented as a rounded box, which may contain one or more compartments. The compartments are all optional. The name

compartment and the internal transition compartment are two such compartments:

- The ***name compartment*** holds the optional name of the state. States without names are "anonymous" and all are distinct. Do not show the same named state twice in the same diagram, since it will be very confusing.
- The ***internal transition compartment*** holds a list of internal actions or activities performed in response to events received while the object is in the state, without changing states:

The syntax used is this: event-name argument-list / action-expression; for example, help / display help.

Two special events are *entry* and *exit*, which are reserved words and cannot be used for event names. These terms are used in the following ways: entry *I* actionexpression (the action is to be performed on entry to the state) and exit *I* actionexpressed (the action is to be performed on exit from the state).

The statechartsupports nested state machines; to activate a substate machine use the keyword *do:* do *I* machine-name (argument-list). If this state is entered, afterthe entry action is completed, the nested (sub)state machine will be executed with its initial state. When the nested state machine reaches its final state, it will exit the action of the current state, and the current state will be considered completed. An initial state is shown as a small dot, and the transition from the initial state may be labeled with the event that creates the objects; otherwise, it is unlabeled. If unlabeled, it represents any transition to the enclosing state.

A final state is shown as a circle surrounding a small dot, a bull's-eye. This represents the completion of activity in the enclosing state and triggers a transition on the enclosing state labeled by the implicit activity completion event, usually displayed as an unlabeled transition (see Fig 29).

The transition can be simple or complex. A simple transition is a relationship between two states indicating that an object in the first state will enter the second state and perform certain actions when a specific event occurs; if the specified conditions are satisfied, the transition is said to "fire." Events are processed one at a time. An event that triggers no transition is simply ignored.

A complex transition may have multiple source and target states. It represents a synchronization or a splitting of control into concurrent threads. A complex transition is enabled when all the source states are changed, after a complex transition "fires" all its destination states. A complex transition

is shown as a short heavy bar.! The bar may have one or more solid arrows from states to the bar (these are source states); the bar also may have one or more solid arrows from the bar to states (these are the destination states). A transition string may be shown near the bar. Individual arrows do not have their own transition strings (see Fig 5-30).

A simple state Idle and a nested state. The dialing state contains substates, which consist of start and dial states.

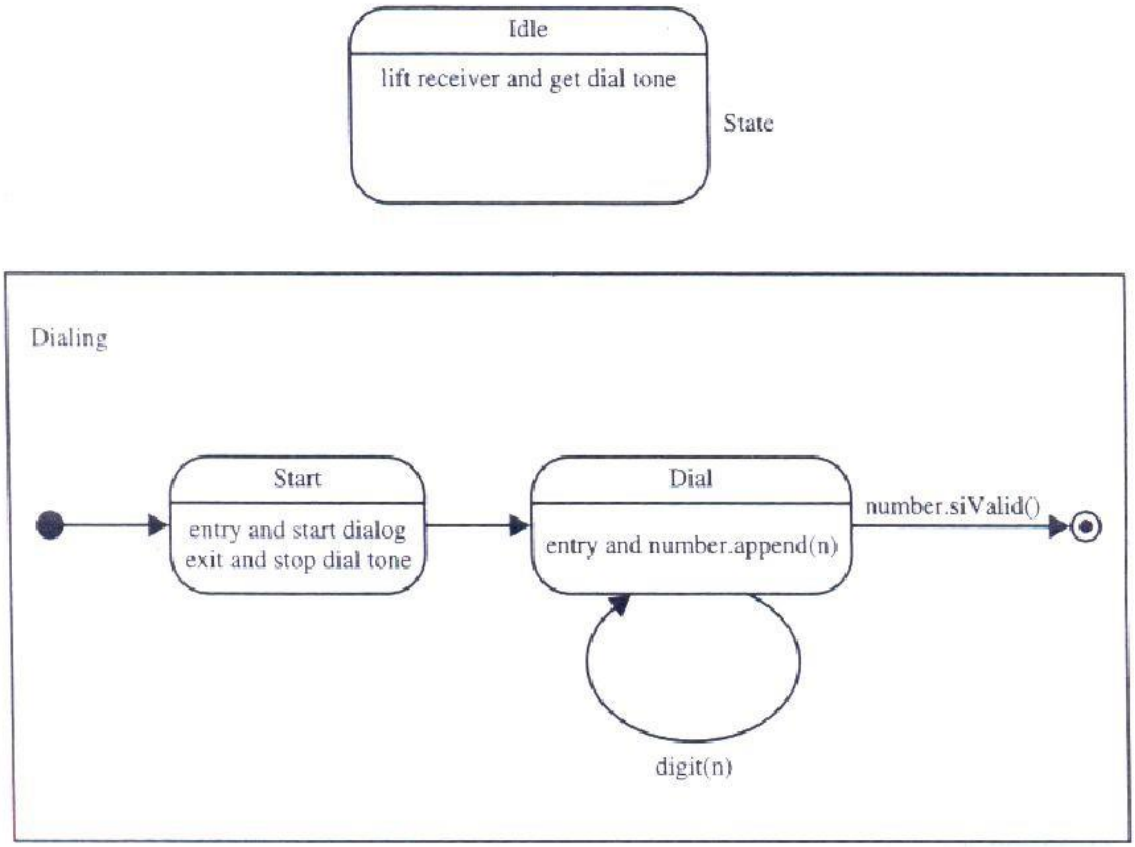


Fig 29: A simple idele and a nested state.

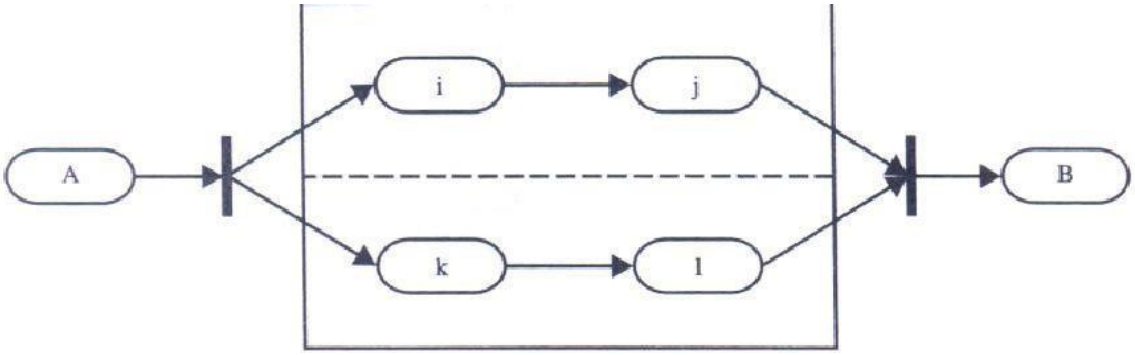


Fig 30: A complex Transition

UML ACTIVITY DIAGRAM

An *activity diagram* is a variation or special case of a state machine, in which the states are activities representing the performance of operations and the transitions are triggered by the completion of the operations. Unlike state diagrams that focus on the events occurring to a single object as it responds to messages, an activity diagram can be used to model an entire business process. The purpose of an activity diagram is to provide a view of flows and what is going on inside a use case or among several classes. An activity diagram can also be used to represent a class's method implementation.

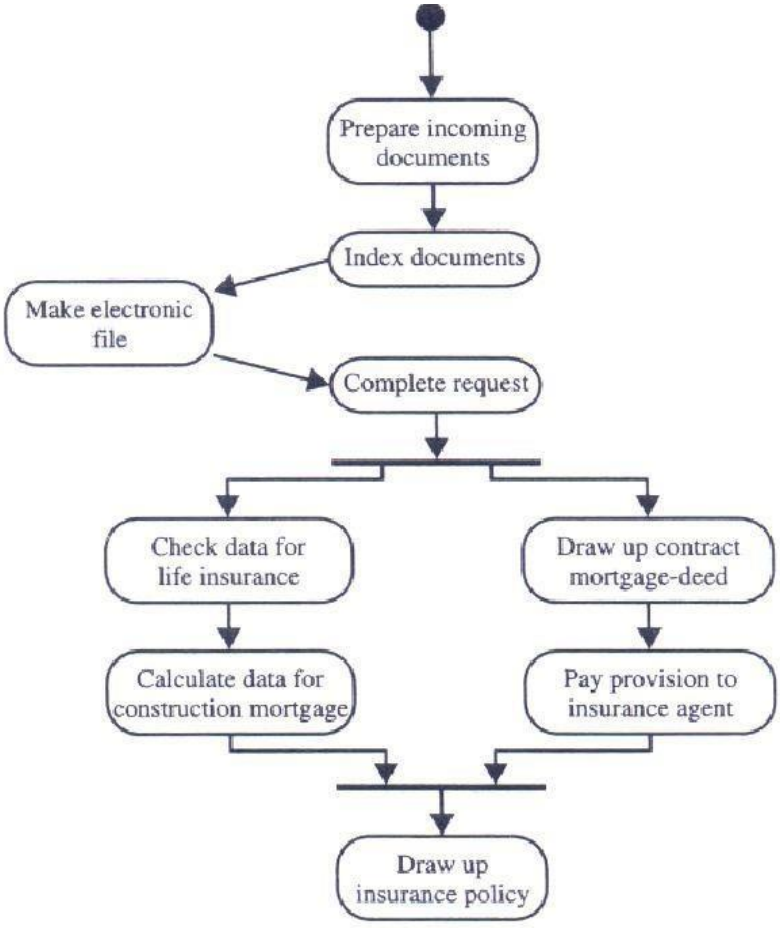


Fig 31. An activity diagram for processing mortgage requests (Loan: Processing Mortgage Request).

An activity model is similar to a statechart diagram, where a token (shown by a black dot) represents an operation. An activity is shown as a round box, containing the name of the operation. When an operation symbol

appears within an activity diagram or other state diagram, it indicates the execution of the operation.

Executing a particular step within the diagram represents a state within the execution of the overall method. The same operation name may appear more than once in a state diagram, indicating the invocation of the same operation in different phases.

An outgoing solid arrow attached to an activity symbol indicates a transition triggered by the completion of the activity. The name of this implicit event need not be written, but the conditions that depend on the result of the activity or other values may be included (see Fig 31).

Several transitions with different conditions imply a branching off of control. If conditions are not disjoint, then the branch is nondeterministic. The concurrent control is represented by multiple arrows leaving a synchronization bar, which is represented by a short thick bar with incoming and outgoing arrows. Joining concurrent control is expressed by multiple arrows entering the synchronization bar.

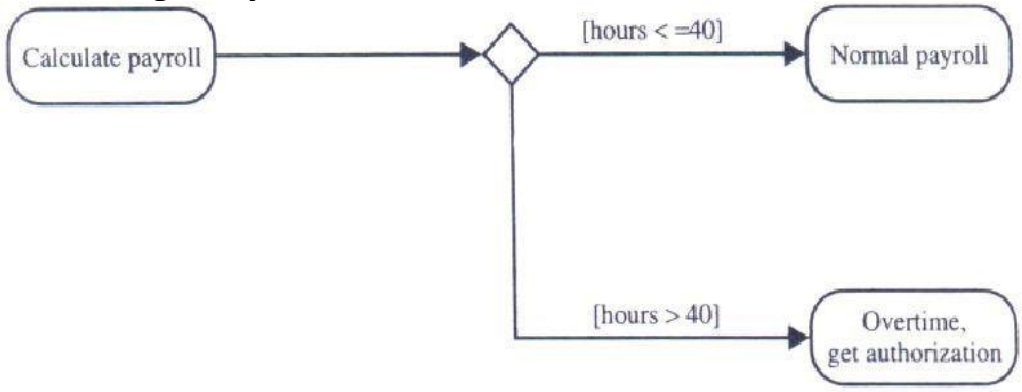


Fig 32: A decision.

An activity diagram is used mostly to show the internal state of an object, but external events may appear in them. An external event appears when the object is in a "wait state," a state during which there is no internal activity by the object and the object is waiting for some external event to occur as the result of an activity by another object (such as a user input or some other signal). The two states are wait state and activity state. More than one possible event might take the object out of the wait state; the first one that occurs triggers the transition. A wait state is the "normal" state.

Activity and state diagrams express a decision when conditions (the UML calls them ***guard conditions)*** are used to indicate different possible transitions that depend on Boolean conditions of container object. The fig 32 provided for a decision is the traditional diamond shape, with one or more

incoming arrows and two or more outgoing arrows, each labeled by a distinct guard condition. All possible outcomes should appear on one of the outgoing transitions (see Fig 32).

Actions may be organized into swimlanes, each separated from neighboring swimlanes by vertical solid lines on both sides. Each ***swimlane*** represents responsibility for part of the overall activity and may be implemented by one or more objects. The relative ordering of the swimlanes has no semantic significance but might indicate some affinity. Each action is assigned to one swimlane. A transition may cross lanes; there is no significance to the routing of the transition path (see Fig 33).

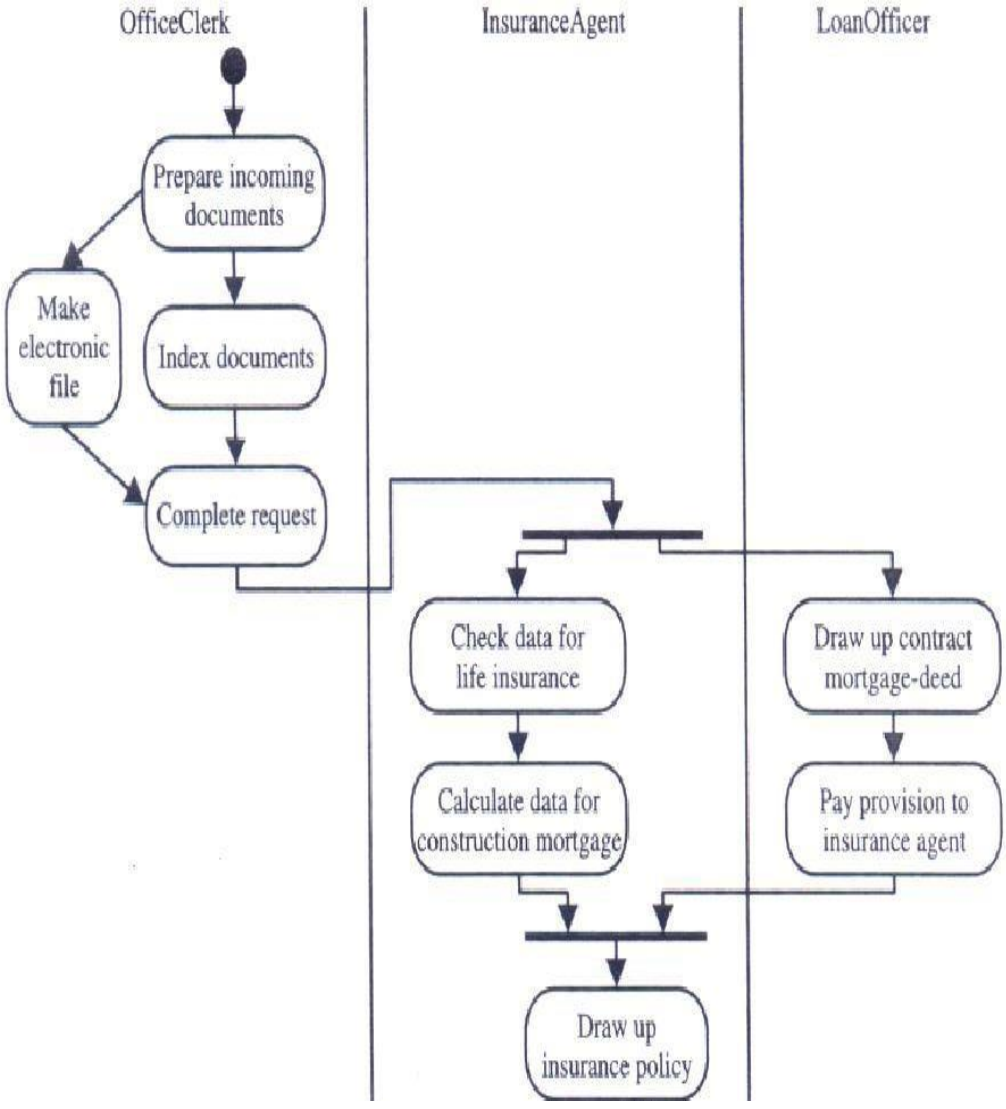


Fig 33. Swimlanes in an activity diagram.

UML IMPLEMENTATION DIAGRAMS

Implementation diagrams show the implementation phase of systems development, such as the source code structure and the run-time implementation structure. There are 2 types of implementation diagrams:

*. Component diagrams – Its Show the stucture of the code itself.

*. Deployment Diagrams – Its show the structure of the runtime system.

These are relatively simple, high-level diagrams compared with other UML diagrams.

Component Diagram *:*

Component diagrams model the physical components (such as source code, executable program, user interface) in a design. These high-level physical components mayor may not be equivalent to the many smaller components you use in the creation of your application. For example, a user interface may contain many other offtheshelf components purchased to put together a graphical user interface.

Another way of looking at components is the concept of **packages**. A package is used to show how you can group together classes, which in essence are smaller scale components. A package usually will be used to group logical components of the application, such as classes, and not necessarily physical components. However, the package could be a first approximation of what eventually will turn into physical grouping. In that case, the package will become a component .

A component diagram is a graph of the design's components connected by dependency relationships. A component is represented by the boxed fig shown in Fig 34 Dependency is shown as a dashed arrow.

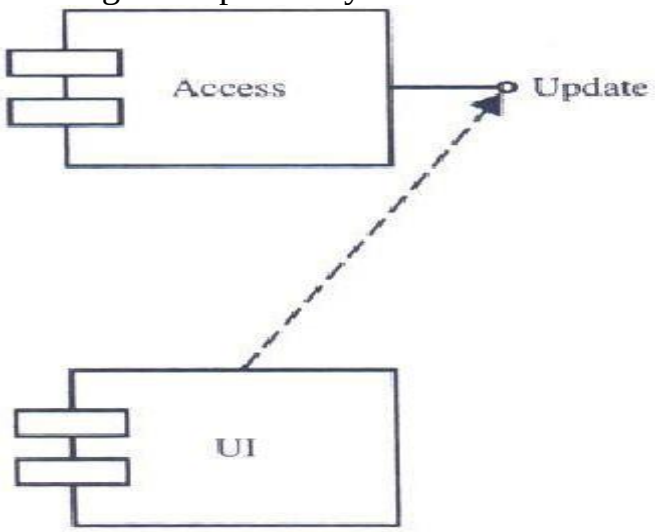


Fig 34: A Component Diagram

Deployment Diagram

Deployment diagrams show the configuration of run-time processing elements and the software components, processes, and objects that live in them. Software component instances represent run-time manifestations of code units. In most cases, component diagrams are used in conjunction with deployment diagrams to show how physical modules of code are distributed on various hardware platforms. In many cases, component and deployment diagrams can be combined.

A deployment diagram is a graph of nodes connected by communication association. Nodes may contain component instances, which mean that the component lives or runs at that node. Components may contain objects; this indicates that the object is part of the component. Components are connected to other components by dashedarrow dependencies, usually through interfaces, which indicate one component uses the services of another. Each node or processing element in the system is represented by a three-dimensional box. Connections between the nodes (or platforms) themselves are shown by solid lines (see Fig 35).

The basic UML notation for a deployment diagram.

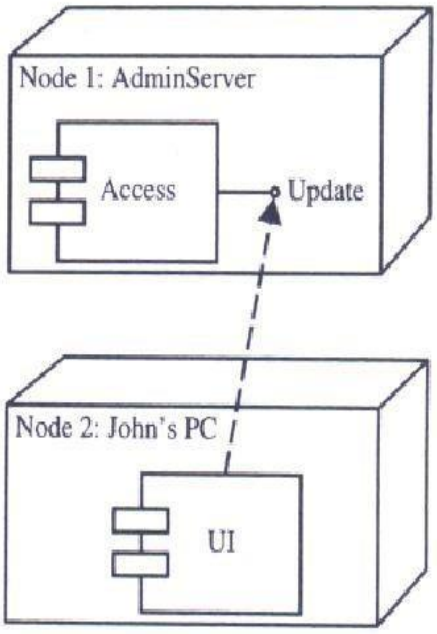


Fig 35. The Basic UML notation for a deployment diagram.

MODEL MANAGEMENT: PACKAGES AND MODEL ORGANIZATION

A ***package*** is a grouping of model elements. Packages themselves may contain other packages. A package may contain both subordinate packages and ordinary model elements. The entire system can be thought of as a single high-level package with everything else in it. All UML model elements and diagrams can be organized into packages.

A package is represented as a folder, shown as a large rectangle with a tab attached to its upper left corner. If contents of the package are not shown, then the name of the package is placed within the large rectangle. If contents of the package are shown, then the name of the package may be placed on the tab (see Fig 36). The contents of the package are shown within the large rectangle. Fig shows an example of several packages. This fig shows three packages (Clients, Bank, and Customer) and three classes, (Account class, Savings class, and Checking class) inside the Business Model package.

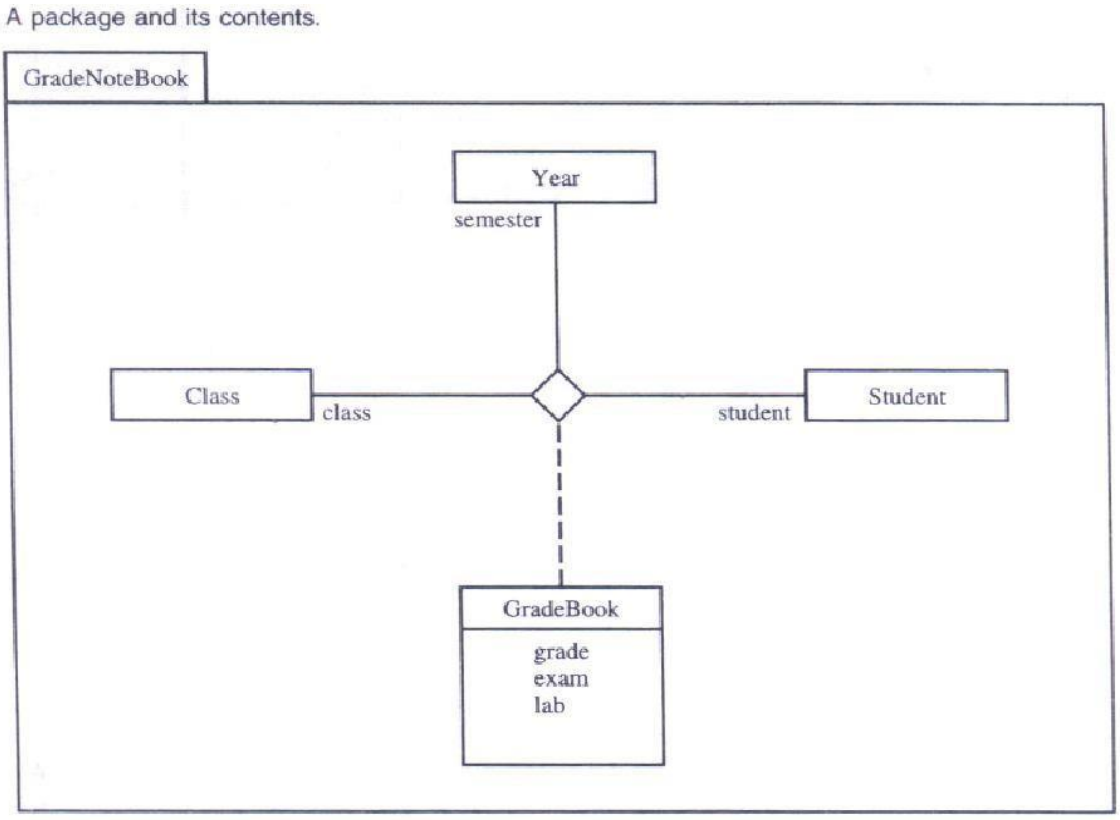


Fig 36: A package and its contents

A real model would have many more classes in each package. The contents might be shown if they are small, or they might be suppressed from higher levels. The entire system is a package. Fig 37 also shows the hierarchical structure, with one package dependent on other packages. For example, the Customer depends on the package Business Model, meaning that one or more elements within Customer depend on one or more elements within the other packages. The package Business Model is shown partially expanded. In this case, we see that the package Business Model owns the classes Bank, Checking, and Savings as well as the packages Clients and Bank. Ownership may be shown by a graphic nesting of the figs or by the expansion of a package in a separate drawing. Packages can be used to designate not only logical and physical groupings but also use-case groups. A use-case group, as the name suggests, is a package of use cases.

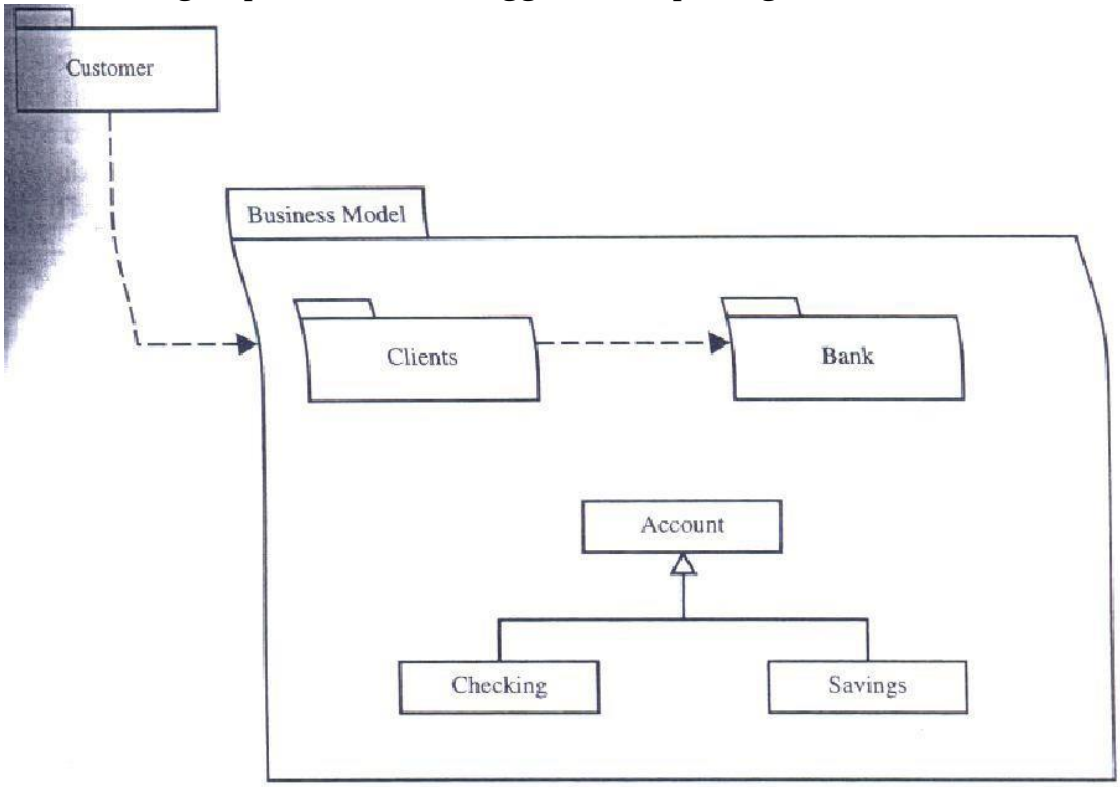


Fig 37: A package and its dependencies

Model dependency represents a situation in which a change to the target element may require a change to the source element in the dependency, thus indicating the relationship between two or more model elements. It relates the model elements themselves and does not require a set of instances for its meaning. A dependency is shown as a dashed arrow from

one model element to another on which the first element is dependent (see Fig 38).

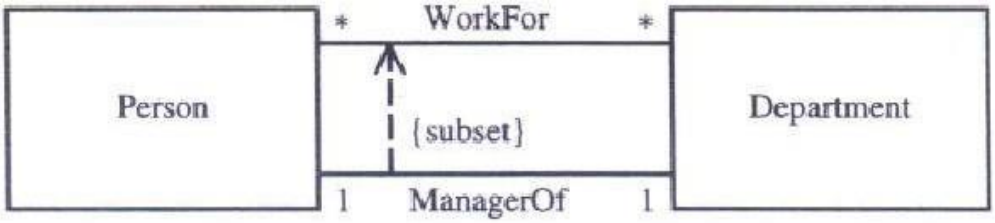


Fig 38: An e ample of constraints. A person is a manager of people who work for the accounting department.

UML EXTENSIBILITY

1.Model Constraints and comments

Constraints are assumptions or relationship among model elements specifying conditions and propositions that must be maintained as true; otherwise the system described by the model would be invalid. Some constraints, such as association OR constraints are predefined in the UML; others may be defined by users.

Constraints are shown as text in braces (ref. Fig 38). The UML also provides language for writing constraints in the OCL. The constraints may be written in a natural language.

A constraint may be a “Comment”, in which case it is written in text. For an element whose notation is a text string such as an attribute, the constraint string may follow the element text string. For a list of elements whose notation is a list of text strings, such as the attributes within class, the constraint string may appear as an element in the list. The constraint applies to all succeeding elements of the list until reaching another constraint string list element or the end of the list. A constraint attached to an individual list element does not supersede the general constraints but may modify individual constraints string may be placed near the symbol name.

The above example fig 38, shows two classes and two associations. The constraint is shown as a dashed arrow from one element to the other, labeled by the constraints string in brace. The direction of the arrow is relevant information within the constraint.

2.Note

A Note is a graphic symbol containing textual information; it also could contain embedded images. It is attached to the diagram rather than to a model element. A note is shown as a rectangle with "Bent Corner" in the upper right corner. It can contains any length text. (ref. Fig 39).

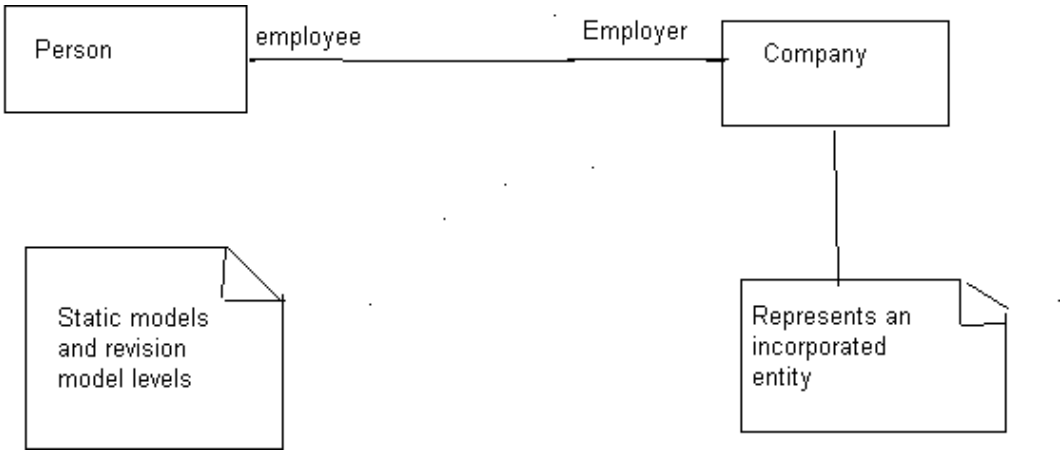


Fig 39. Note

3.Stereotype

Stereotype represent a built-in extensibility mechanism of the UML. User-defined extensions of the UML are enabled through the use of stereotypes and constraints. A stereotype is a new class of modeling element introduced during modeling, It represents a subclass of an existing modeling element with the same form (attributed and relationships) but a different intent. UML stereotype extend and tailor the UML for a specific domain or process.

The general presentation of a stereotype is to use a figure for the base element but place a keyword string above the name of the element (if used, the keyword string is the name of a stereotype within matched guillemets, "<<",">>", such as <<flow>.. Note that a guillemet looks like a angle-bracket, but it is a single character in most fonts.

<< Flow >> copy
Number of Copy
MakeCopy

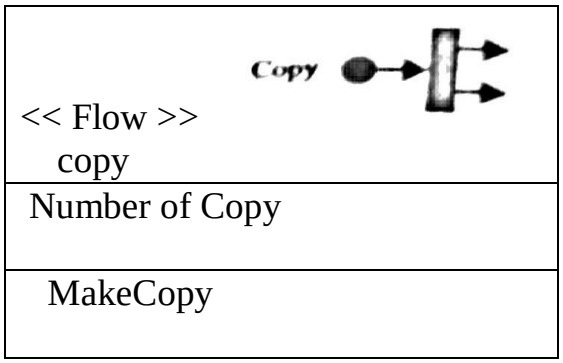


Fig 40: Various forms of Stereotype notation

The stereotype allows extension of UML notation as well as a graphic figure, texture, and color. The figure can be used in one of two ways: (1) instead of or in addition to the stereotype keyword string as part of the symbol for the base model element or (2) as the entire base model element. Other information contained by the base model element symbol is suppressed.

3. UML Meta-model

The UML defined notations as well as a meta model. UML graphic notations can be used not only to describe the system's components but also to describe a model itself. This is known as a **meta-model.**

In other words, **a meta-model** is a model of modeling elements. The purpose of the UML meta-model is to provide a single,common, and definitive statement of the syntax and semantics of the elements of the UML.

The meta model provides us a means to commect different UML diagrams. The connection between the different diagrams is very important, and the UML attempts to make these coupling more explict through defining the underlying model while imposing no methodology.

The presence of this meta model has made it possible for its developers to agree on semantics and how those semantics would be best rendered. This is an important step forword, since it can assure consistency among diagrams. The meta-model aslomcan serve as a means to exchange data between different cas tools. The fig 41 is an example fo the UML meta-model that describes relationship with association and generalization; association is depicted as a composition of association roles.

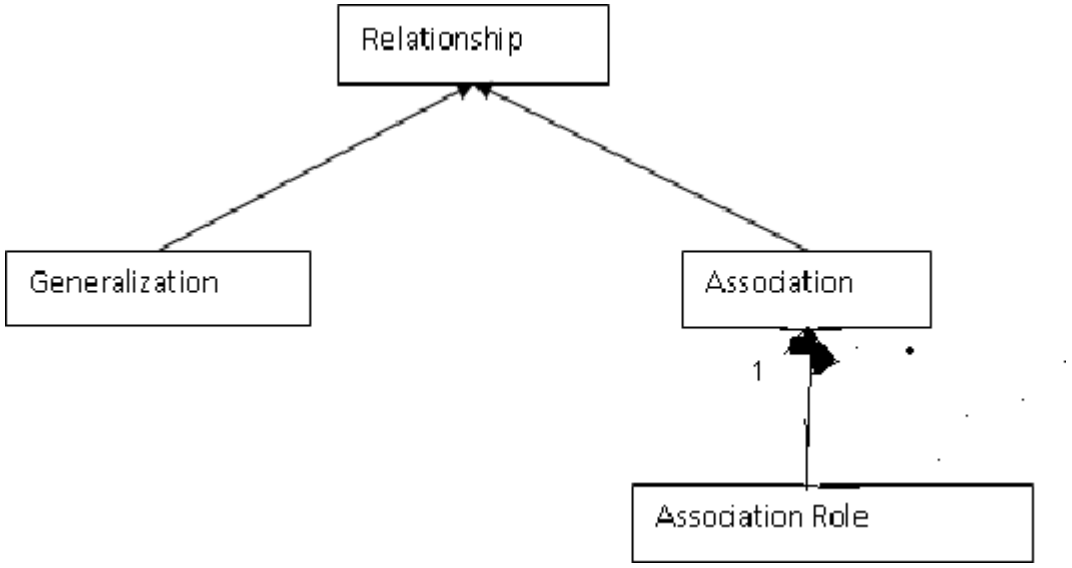


Fig 41. The UML meta-model describing the relationship between association and generalization.

Important Questions

1. What is a method?
2. What is a methodology?
3. What is process?
4. Describe the difference between a method and a process?
5. What is an object model? What are the other OMT models?
6. What is the main advantage of DFD?
7. What is the strength of OMT?
8. Name five Booch diagrams?
9. What is the strength of Booch methodology>
10. What is Objectory?
11. Name the models in Objectory.
12. What is a use case?
13. What is the reason for having abstract use cases?
14. What must a use case contain?
15. What is the strength of the Jacobson et al. methodology?
16. Describe the difference between patterns and frameworks.
17. What is model?
18. Why do we need to model a problem?
19. What is data modeling?
20. Described the class diagram.
21. How would you represent or model extremely visible behavior of a class?
22. What is association role?
23. What is multiplicity>
24. What is a qualifier?
25. What are some of the forms of associations? Draw their UML representation.
26. How would you shoe complete and incomplete generalizations?
27. What are model constraints, and how are they represented in the UML
28. How does the UML group model elements?
29. Name and describe the relationships in a use case diagram.
30. What are some of the UML dynamic diagrams?
31. When would you use interaction diagrams?
32. What is the difference between sequence diagrams and collaboration diagrams?
33. What is the purpose of an activity model?
34. What is a meta-model? Is understanding a meta-model important?
35. What are the different parts of OMT?
36. What are the different phases of OMT?

37. Write short notes on DFD.
38. What is extends and uses relationship?
39. What is an abstract use case?
40. Name different models of objectory.
41. What is a pattern?
42. Name types of patterns.
43. Explain pattern template with an example.
44. What is antipattern?
45. Define framework.
46. What is the difference between a pattern and a framework?
47. Explain UA in detail.
48. Write short notes on UA repository.
49. What are the responsibilities of access and view layer?
50. Define a model.
51. What is static and dynamic model?
52. What is a package?
53. What is model dependency?
54. Define constraints, note, stereotype and meta model.
55. Name some forms of associations. Draw some UML representations.
56. Define UML.
57. What is UML class diagram?
58. Give notation for class.
59. What is object diagram, binary association, association role, navigability?
60. Define qualifiers, multiplicity.
61. What is OR association?
62. Define association class.
63. What is n-ary association, aggregation, composition, generalization, use case diagram?
64. How actors can be represented differently?
65. What is interaction, sequence, collaboration, static, activity, component and deployment diagram?
66. What is lifeline?
67. What are the advantages and disadvantages of interaction diagrams?

PART – B

1. Describe Rumbaugh's Object Modeling Technique?
2. Give detailed notes about the Booch Methodology?
3. Give a detailed account of Jacobson methodology?
4. Describe patterns and the various pattern templates?
5. Explain in detail about the Unified approach?
6. Describe the UML Class diagram?
7. Discuss briefly about the usecase diagram with example.
8. Discuss briefly about the activity diagram with example.
9. Discuss briefly about the state chart diagram with example.
10. Write Short notes on
    a. Sequence and Collaboration Diagram

b. Component and Deployment Diagram

11. Explain static UML diagrams in detail
12. Explain dynamic UML diagrams in detail.
13. Discuss layered approach to software development.
14. Name any 5 Booch diagrams.
15. Explain Rumbaugh, Booch and Jacobson methodologies in detail.
16. What are the steps involved din micro and macro development process?
17. What are the goals of UML design?
18. What are the different types of modeling? Briefly described each.
19. What are some of the ways that use cases can be described?
20. Briefly describe the Booch system development processes.
21. What are the phases of OMT? Briefly describe each phase.
22. What are the different types of modeling? Briefly described each.
23. What is UML? What is the importance of UML?