Programming Paradigm

Object Modeling using Unified Modeling Language (UML)

What is a Model ?

A model is an abstraction of a real problem (or situation), and is constructed by leaving out unnecessary details.

- This reduces the problem complexity and makes it easy to understand the problem

Need of a Model ?

An important reason behind constructing a model is that it helps manage complexity.

Once models of a system have been constructed, these can be used for a variety of purposes during software development, including the following :

- Analysis
- Specification
- Code generation
- Design
- Visualize and understand the problem and the working of a system
- Testing, etc.

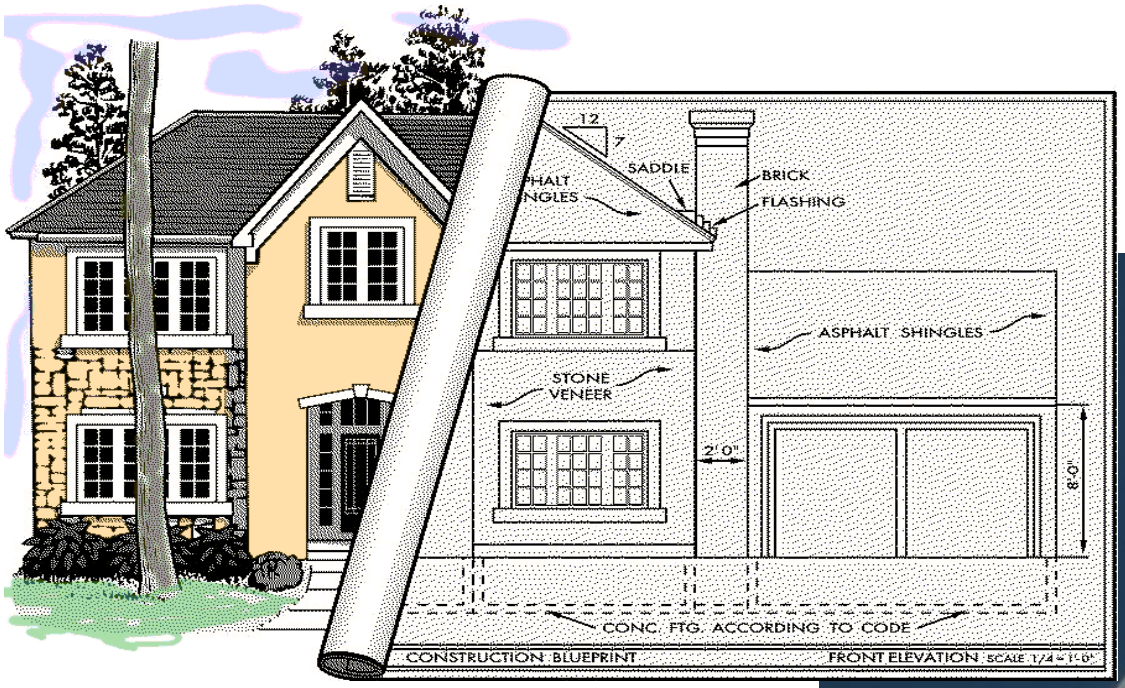
Need of a Model ? Contd...

Since a model can be used for a variety of purposes, it is expected that the model would vary depending on the purpose for which it is being constructed.

For example :- A model developed for initial analysis and specification should be very different from the one used for design

So it is a good idea to explicitly mention the purpose for which a model has been developed, along with the model.

Modeling a House



Unified Modeling Language (UML)

UML, is a modelling language that may be used to visualize, specify, construct, and document the artifacts of a software system.

- Not a system design or development methodology

It provides a set of notations (e.g. rectangles, lines, ellipses, etc.) to create a visual model of the system – such that it has its own syntax (symbols or sentences) and semantics (meanings of symbols and sentences).

Used to document object-oriented analysis and design results. Independent of any specific design methodology.

UML Origin

OOD in late 1980s and early 1990s:

- Different software development houses were using different notations.
- Methodologies were tied to notations.

UML developed in early 1990s to:

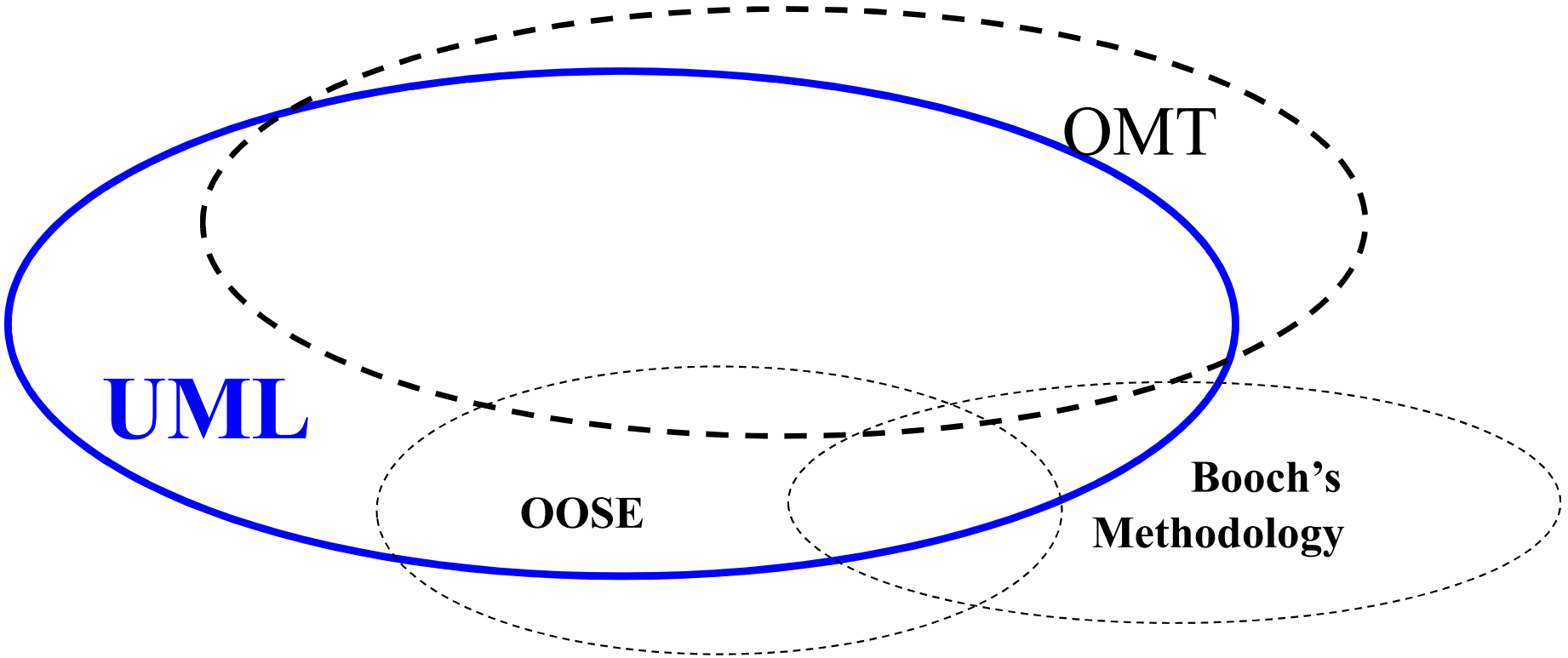
- Standardize the large number of object-oriented modeling notations

UML Origin Contd

Based on :

- Object Management Technology (OMT) [Rumbaugh 1991]
- Booch's methodology[Booch 1991]
- Object-Oriented Software Engineering (OOSE) [Jacobson 1992]
- Odell's methodology[Odell 1992]

Different Object Modeling Techniques in UML



UML as a Standard

Adopted by Object Management Group (OMG) in 1997

- OMG is an association of industries

Promotes consensus notations and techniques

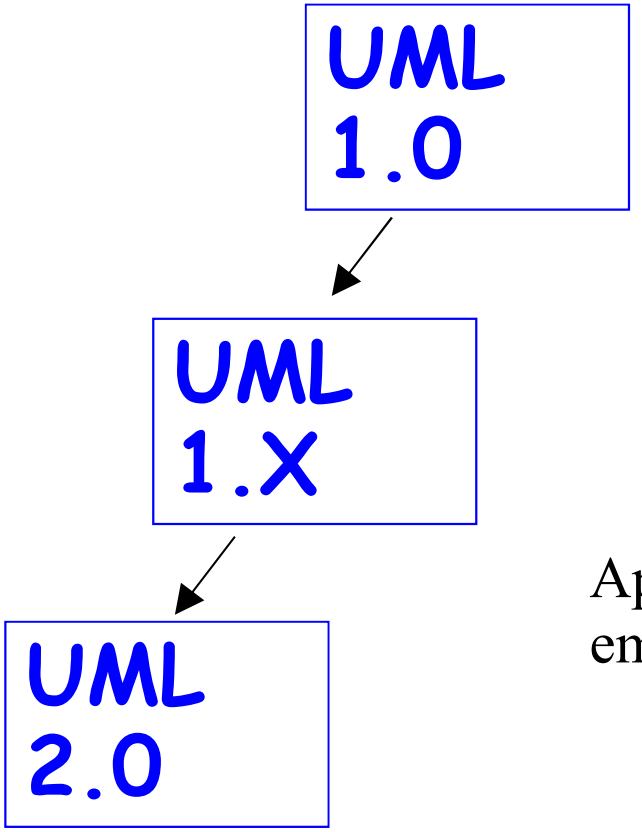
Used outside software development

- Example car manufacturing

Developments to UML

UML continues to develop :

- Refinements
- Making it applicable to new contexts



Application to embedded systems

Why are UML Models Required?

A model is an abstraction mechanism:

- Capture only important aspects and ignores the rest.
- Different models result when different aspects are ignored.
- An effective mechanism to handle complexity.

UML is a graphical modeling tool

Easy to understand and construct

Diagrams in UML 1.x

Nine diagrams in UML 1.x : used to capture 5 different **views** of a system.

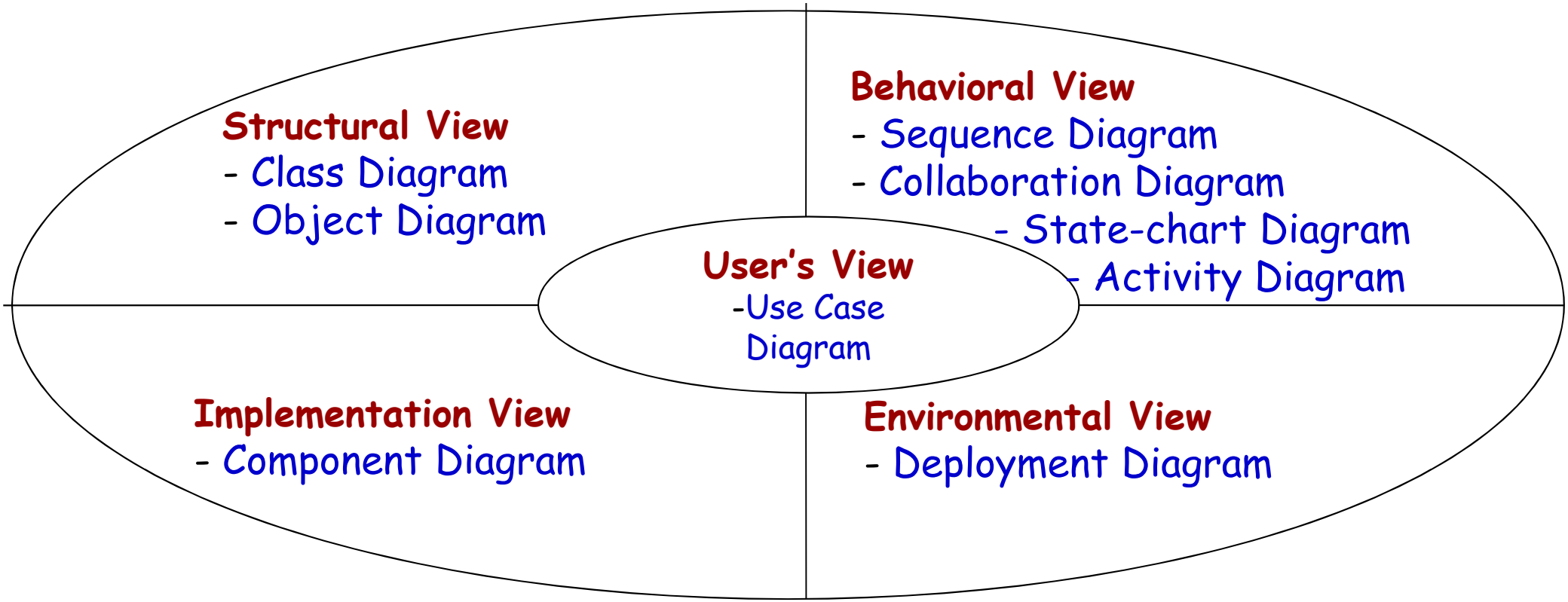
- **Views** provide different perspectives of a software system
- **Diagrams** can be refined to get the actual implementation of a system

UML Model Views

Views of a system:

- User's view
- Structural view
- Behavioral view
- Implementation view
- Environmental view

UML Diagrams



Diagrams and views in UML

User's view

It defines the functionalities (facilities) made available by the system to its users

> Captures the external users' view of the system in terms of the functionalities offered by the system.

Is a black-box view of the system where the internal structure, the dynamic behavior of different system components, the implementation etc. are not visible.

Is very different from all other views in the sense that it is a functional model compared to the object model of all other views.

Can be considered as the central view and all other views are expected to conform to this view.

Structural view

Defines the kinds of objects (classes) important to the understanding of the working of a system and to its implementation.

Also captures the relationships among the classes (objects).

The structural model is also called the static model, since the structure of a system does not change with time.

Other views

Behavioral view

Captures how objects interact with each other to realize the system behavior.

The system behavior captures the time-dependent (dynamic) behavior of the system.

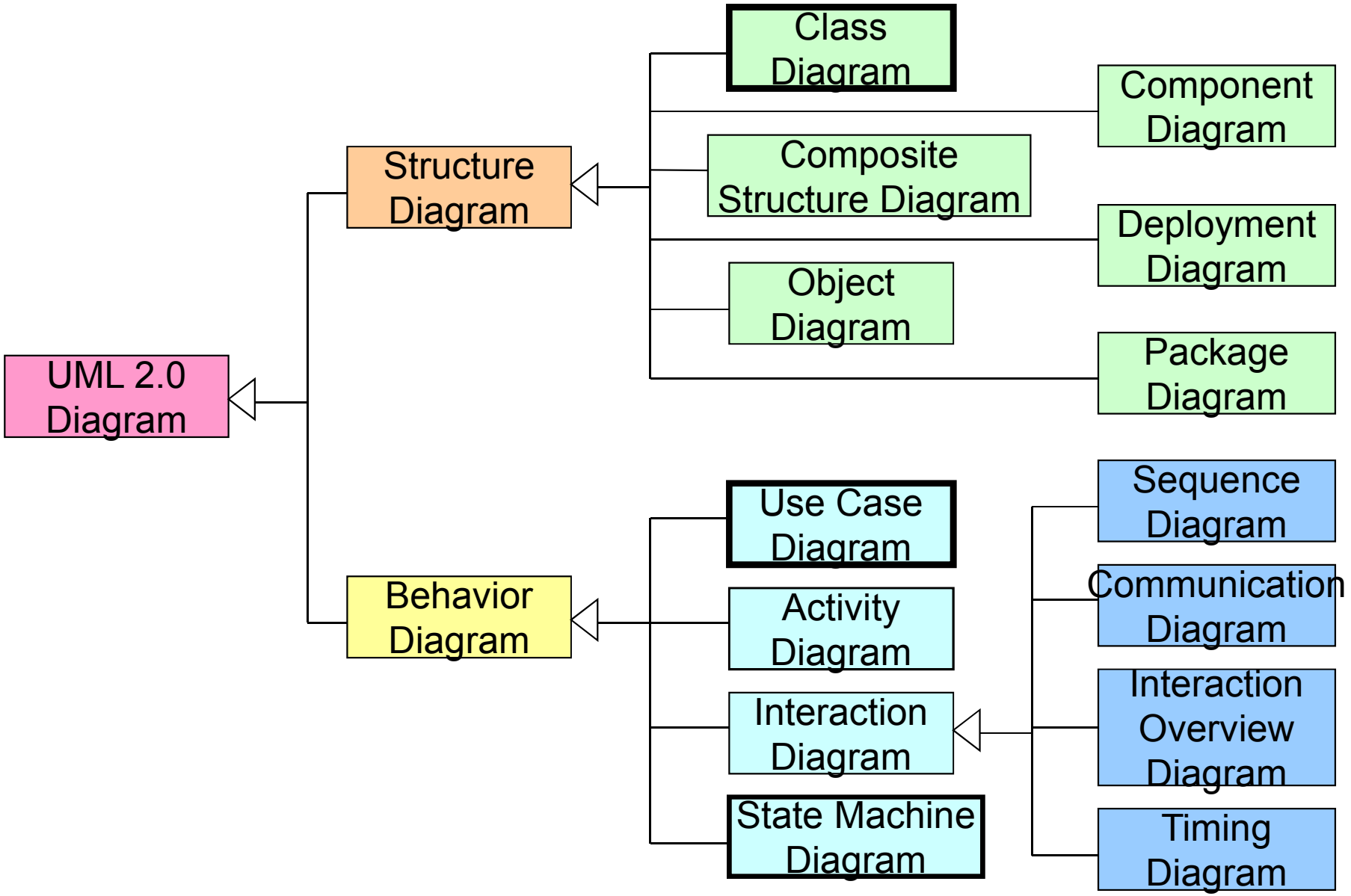
Implementation view

Captures the important components of the system and their dependencies.

Environmental view

Models how the different components are implemented on different pieces of hardware.

UML 2.0 Diagrams – 13 diagrams



Are all views required for developing a typical system?

Answer is NO

Use case diagram, class diagram and one of the interaction diagram for a simple system

State chart diagram required to be developed when a class state changes

However, when states are only one or two, state chart model becomes trivial

Deployment diagram in case of large number of hardware components used to develop the system

Use case View

Use Case Diagram

Use Case Model

Consists of set of “use cases” - such as list of steps

An important analysis and design artifact

The central model:

- Other models must confirm to this model
- Not really an object-oriented model
- Represents a functional or process model

Use Cases

Different ways in which a system can be used by the users

Corresponds to the high-level requirements

Represents transaction between the user and the system

Defines external behavior without revealing internal structure of system

Set of related scenarios tied together by a common goal.

Use Cases Contd...

Normally, use cases are independent of each other

Implicit dependencies may exist

Example: In Library Automation System, renew-book & reserve-book are independent use cases.

> But in actual implementation of renew-book: a check is made to see if any book has been reserved using reserve-book.

Example Use Cases

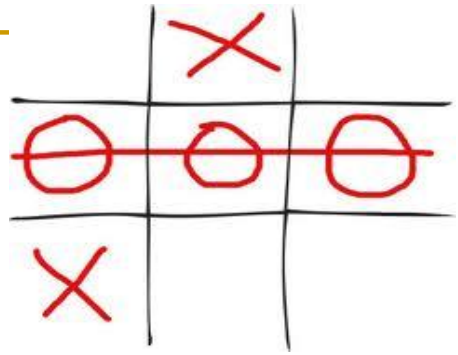
For library information system

- Issue-book
- Query-book
- Return-book
- Create-member
- Add-book, etc.

Representation of Use Cases

- Represented by use case diagram
- A use case is represented by an ellipse
- System boundary is represented by a rectangle
- Users are represented by stick person icons (actor)
- Communication relationship between actor and use case by a line

Example problem 1 : Tic-tac-toe



Tic-tac-toe is a computer game in which a human player and the computer make alternative moves on a 3×3 square.

A **move** consists of marking previously unmarked square.

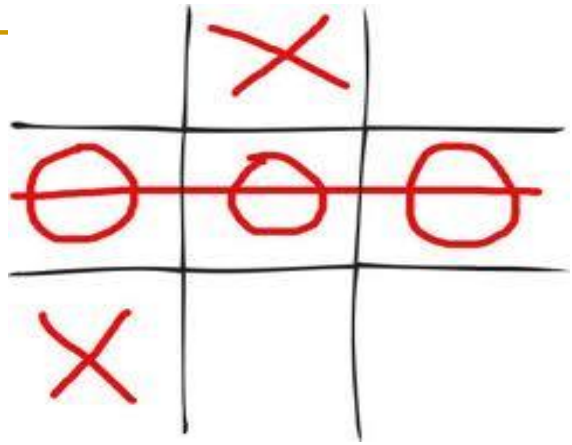
The **player plays** by placing three consecutive marks along a straight line on the square (i.e. along a row, column, or diagonal) wins the game.

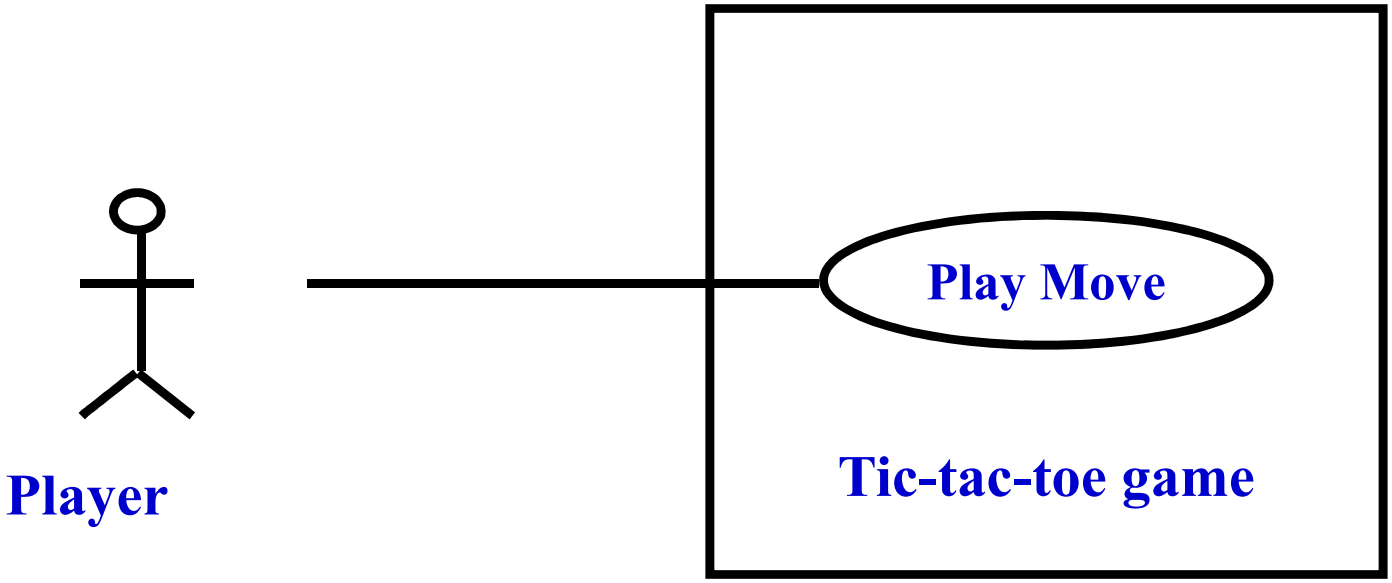
As soon as either the human player or the computer wins, a message congratulating the winner should be displayed.

If neither player manages to get three consecutive marks along a straight line, but all the squares on the board are filled up, then the game is drawn.

The computer always tries to win a game.

Use Case Diagram





Use case model

Example problem 2 : Supermarket Prize Scheme

A supermarket needs to develop the following software to encourage regular customers.

For this, the customer needs to supply his/her residence address, telephone number, and the driving license number. Each customer who registers for this scheme is assigned a unique customer number (CN) by the computer.

A customer can present his CN to the check out staff when he makes any purchase.

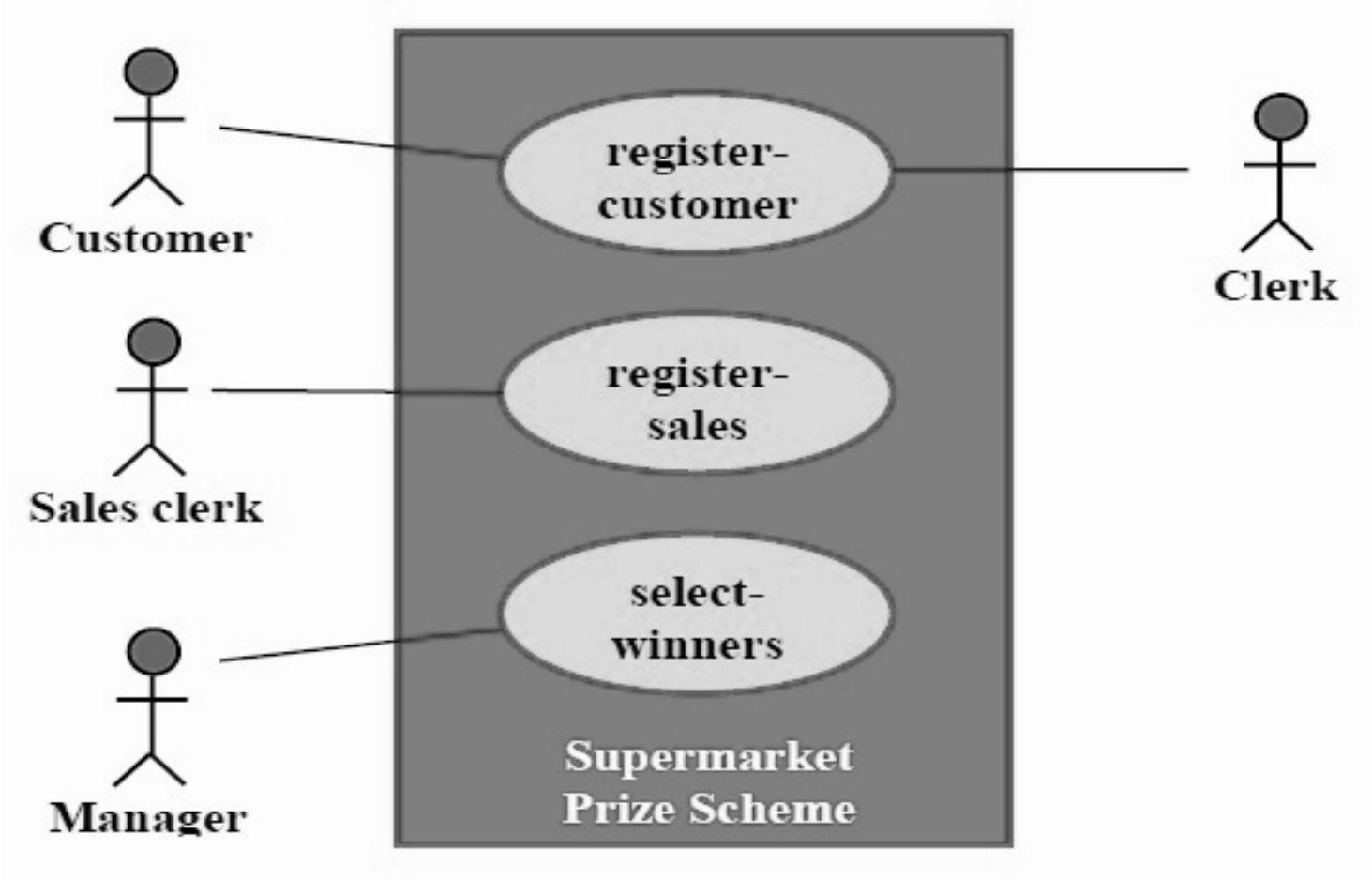
In this case, the value of his purchase is credited against his CN.

At the end of each year, the supermarket intends to award surprise gifts to 10 customers who make the highest total purchase over the year.

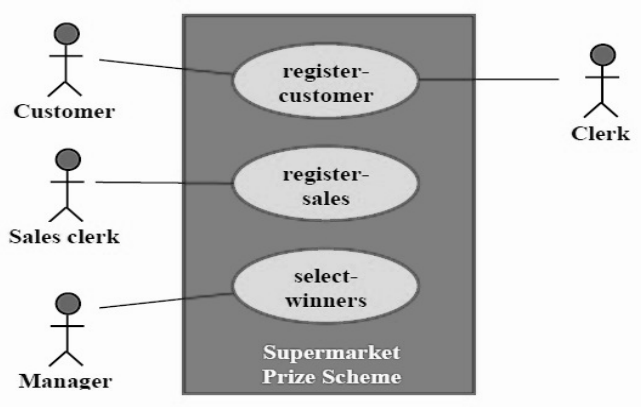
Also, it intends to award a gold coin to every customer whose purchase exceeded Rs.100,000.

The entries against the CN are the reset on the day of every year after the prize winners' lists are generated.

Use Case Diagram



Text description



U1: register-customer : Using this use case, the customer can register himself by providing the necessary details.

Scenario 1 : Mainline sequence

1. Customer/Clerk : select register customer option.
2. System: display prompt to enter name, address, and telephone number.
3. Customer/Clerk : enter the necessary values.
4. System: display the generated id and the message that the customer has been successfully registered.

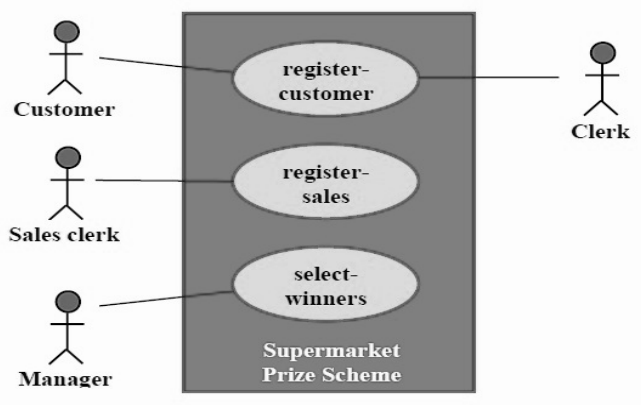
Scenario 2 : at **step 4** of mainline sequence

1. System: displays the message that the customer has already registered.

Scenario 3 : at **step 4** of mainline sequence

1. System: displays the message that some input information has not been entered. The system display a prompt to enter the missing value.

Text description Contd...



U2: register-sales : Using this use case, the clerk can register the details of the purchase made by a customer

Scenario 1 : Mainline sequence

1. Sales-Clerk: select register sale option.
2. System: display prompt to enter purchase details and the id of the customer
3. Sales-Clerk: enter the required detail.
4. System: display the message of having successfully registered the sale

U3: select-winner : Using this use case, the manager can generate the winner list

Scenario 1 : Mainline sequence

1. Manager: selects the select -winner option.
2. System: display the gold coin and the surprise gift winner list

Why Develop A Use Case Diagram?

- Serves as requirements specification
- How are actor identification useful in software development:
  - User identification helps in implementing appropriate interfaces for different categories of users
  - Another use in preparing appropriate documents (e.g. user's manual).

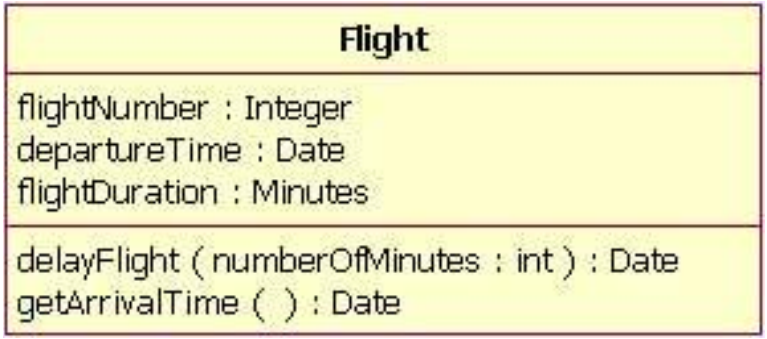
Structural View

Class Diagram

Class representation

Classes are represented with boxes which contain three parts:

- The top part contains the name of the class. It is printed in Bold, centered and the first letter capitalized.
- The middle part contains the attributes of the class. They are left aligned and the first letter is lower case.
- The bottom part gives the methods or operations of the class. They are also left aligned and the first letter is lower case.



Class representation
Visibility

To specify the visibility of a class member (i.e., any attribute or method) these are the following notations that must be placed before the member's name.

Mainly :

"+"	Public
"-"	Private
"#"	Protected
"_"	Static

That all ?

In the design of a system, a number of classes are identified and grouped together in a class diagram which helps to determine the static relations between those objects.

With detailed modeling, the classes of the conceptual design are often split into a number of subclasses.

In order to further describe the behavior of systems, we need to understand relationship among the class in the system

Class relationship

A relationship is a general term covering the specific types of logical connections found on class diagrams.

Four types of Class relationships among the classes in a software system :

- Inheritance
- Association
- Aggregation/Composition
- Dependency