Unit1: INTRODUCTION, MODELING CONCEPTS, CLASS MODELING:

Syllabus ---7hr

- What is object orientation?
- What is oo development?
- Oo themes
- Evidence for usefulness of oo development
- Oo modeling history
- Modeling
- Abstraction
- The tree models
- Objects and class concepts
- Link and association concepts
- Generalization and inheritance
- A sample class model
- Navigation of class models
- Practical tips

INTRODUCTION

Note 1:

Intention of this subject (object oriented modeling and design) is to learn how to apply object -oriented concepts to all the stages of the software development life cycle.

Note 2:

Object-oriented modeling and design is a way of thinking about problems using models organized around real world concepts. The fundamental construct is the object, which combines both data structure and behavior.

WHAT IS OBJECT ORIENTATION?

□□**Definition:** OO means that we organize software as a collection of discrete objects (that incorporate both data structure and behavior).

□□There are four **aspects (characteristics)** required by an OO approacho Identity.

- Classification.
- Inheritance.
- Polymorphism.

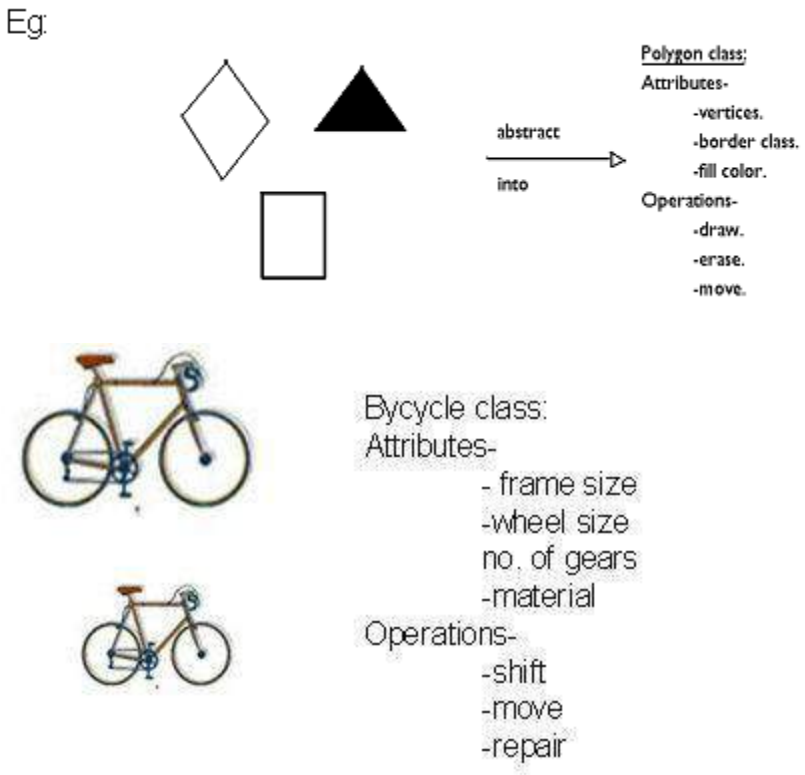
□□**Identity:**

- **Identity** means that data is quantized into discrete, distinguishable entities called objects.
- **E.g. for objects:** personal computer, bicycle, queen in chess etc.

- Objects can be concrete (such as a file in a file system) or conceptual (such as scheduling policy in a multiprocessing OS). Each object has its own inherent identity. (i.e two objects are distinct even if all their attribute values are identical).
- In programming languages, an object is referenced by a unique handle.

Classification:

- **Classification** means that objects with the same data structure (attribute) and behavior (operations) are grouped into a class.
- E.g. paragraph, monitor, chess piece.
- Each object is said to be an instance of its class.
- Fig below shows objects and classes: Each class describes a possibly infinite set of individual objects.



Inheritance:

- It is the sharing of attributes and operations (features) among classes based on a hierarchical relationship. A super class has general information that sub classes refine and elaborate.
- E.g. Scrolling window and fixed window are sub classes of window.

Polymorphism:

- **Polymorphism** means that the same operation may behave differently for different classes.
- For E.g. move operation behaves differently for a pawn than for the queen in a chess game.

Note: An *operation* is a procedure/transformation that an object performs or is subjected to. An implementation of an operation by a specific class is called a *method*.

WHAT IS OO DEVELOPMENT?

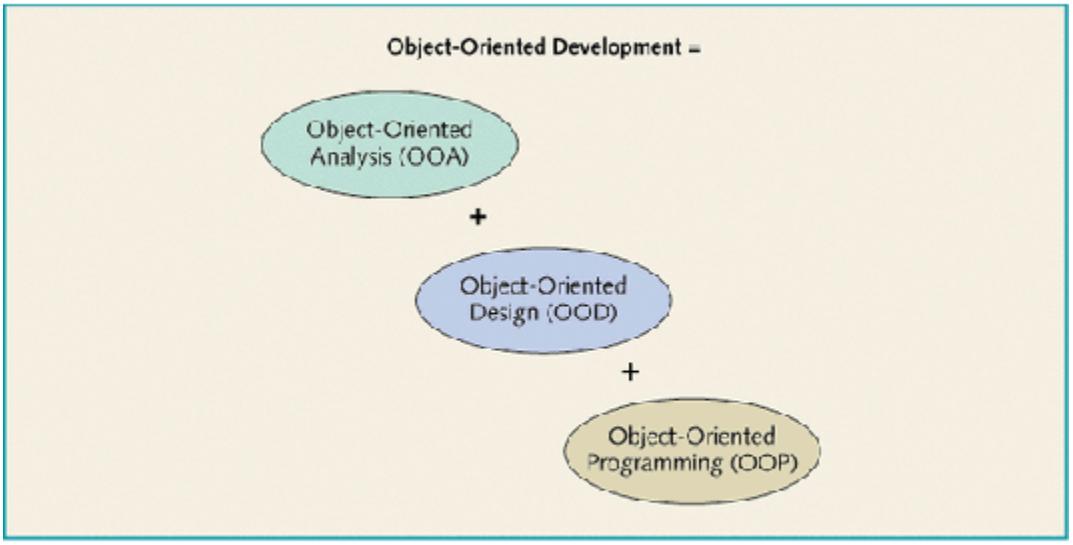


Figure 1-3 Object-oriented development

□□**Development** refers to the software life cycle: Analysis, Design and Implementation. The essence of OO Development is the *identification* and *organization* of application concepts, rather than their final representation in a programming language. It's a conceptual process independent of programming languages. OO development is fundamentally a way of thinking and not a programming technique.

OO methodology

□□Here we present a process for OO development and a graphical notation for representing OO concepts. The process consists of building a model of an application and then adding details to it during design.

□□**The methodology has the following stages**

- **System conception:** Software development begins with business analysis or users conceiving an application and formulating tentative requirements.
- **Analysis:** The analyst scrutinizes and rigorously restates the requirements from the system conception by constructing models. The analysis model is a concise, precise abstraction of what the desired system must do, not how it will be done.
- The analysis model has two parts-

- **Domain Model**- a description of real world objects reflected within the system.
- **Application Model**- a description of parts of the application system itself that are visible to the user.
- E.g. In case of stock broker application-
- Domain objects may include- stock, bond, trade & commission.
- Application objects might control the execution of trades and present the results.
- **System Design:** The development teams devise a high-level strategy- The System Architecture- for solving the application problem. The system designer should decide what performance characteristics to optimize, chose a strategy of attacking the problem, and make tentative resource allocations.
- **Class Design:** The class designer adds details to the analysis model in accordance with the system design strategy. His focus is the data structures and algorithms needed to implement each class.
- **Implementation:** Implementers translate the classes and relationships developed during class design into a particular programming language, database or hardware. During implementation, it is important to follow good software engineering practice.

Three models

We use three kinds of models to describe a system from different view points.

1. **Class Model—**for the objects in the system & their relationships.

It describes the static structure of the objects in the system and their relationships.

Class model contains class diagrams- a graph whose nodes are classes and arcs are relationships among the classes.

2. **State model—**for the life history of objects.

It describes the aspects of an object that change over time. It specifies and implements control with state diagrams-a graph whose nodes are states and whose arcs are transition between states caused by events.

3. **Interaction Model**—for the interaction among objects.

It describes how the objects in the system co-operate to achieve broader results. This model starts with use cases that are then elaborated with sequence and activity diagrams.

Use case – focuses on functionality of a system – i.e what a system does for users.

Sequence diagrams – shows the object that interact and the time sequence of their interactions.

Activity diagrams – elaborates important processing steps.

OO THEMES

Several themes pervade OO technology. Few are –

1. **Abstraction**

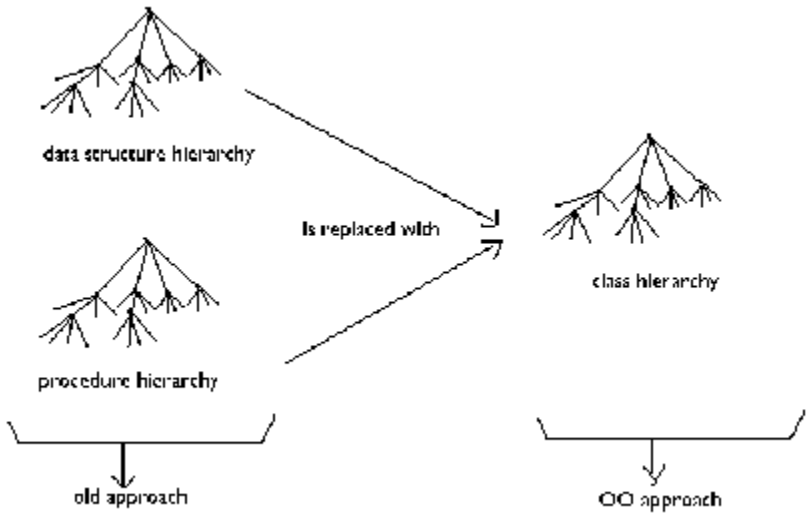
- Abstraction lets you focus on essential aspects of an application while ignoring details i.e focusing on what an object is and does, before deciding how to implement it.
- It's the most important skill required for OO development.

2. **Encapsulation (information hiding)**

- It separates the external aspects of an object (that are accessible to other objects) from the internal implementation details (that are hidden from other objects)
- Encapsulation prevents portions of a program from becoming so interdependent that a small change has massive ripple effects.

3. **Combining data and behavior**

- Caller of an operation need not consider how many implementations exist.
- In OO system the data structure hierarchy matches the operation inheritance
- hierarchy (fig).



4. Sharing

- OO techniques provide sharing at different levels.
- Inheritance of both data structure and behavior lets sub classes share common code.
- OO development not only lets you share information within an application, but also offers the prospect of reusing designs and code on future projects.

5. **Emphasis on the essence of an object**

- OO development places a greater emphasis on data structure and a lesser emphasis on procedure structure than functional-decomposition methodologies.

6. **Synergy**

- Identity, classification, polymorphism and inheritance characterize OO languages.

- Each of these concepts can be used in isolation, but together they complement each other synergistically.

MODELLING AS A DESIGN TECHNIQUE

Note: A model is an abstraction of something for the purpose of understanding it before building it.

MODELLING

Designers build many kinds of models for various purposes before constructing things.

Models serve several purposes –

- **Testing a physical entity before building it:** Medieval built scale models of Gothic Cathedrals to test the forces on the structures. Engineers test scale models of airplanes, cars and boats to improve their dynamics.
- **Communication with customers:** Architects and product designers build models to show their customers (note: mock-ups are demonstration products that imitate some of the external behavior of a system).
- **Visualization:** Storyboards of movies, TV shows and advertisements let writers see how their ideas flow.
- **Reduction of complexity:** Models reduce complexity to understand directly by separating out a small number of important things to do with at a time.

ABSTRACTION

Abstraction is the selective examination of certain aspects of a problem.

The goal of abstraction is to isolate those aspects that are important for some purpose and suppress those aspects that are unimportant.

THE THREE MODELS

1. **Class Model**: represents the static, structural, "data" aspects of a system.

- It describes the structure of objects in a system- their identity, their relationships to other objects, their attributes, and their operations.
- Goal in constructing class model is to capture those concepts from the real world that are important to an application.
- Class diagrams express the class model.

2. **State Model**: represents the temporal, behavioral, "control" aspects of a system.

- State model describes those aspects of objects concerned with time and the sequencing of operations – events that mark changes, states that define the context for events, and the organization of events and states.
- State diagram express the state model.
- Each state diagram shows the state and event sequences permitted in a system for one class of objects.
- State diagram refer to the other models.

- Actions and events in a state diagram become operations on objects in the class model. References between state diagrams become interactions in the interaction model.

3. **Interaction model** – represents the collaboration of individual objects, the "interaction" aspects of a system.

- Interaction model describes interactions between objects – how individual objects collaborate to achieve the behavior of the system as a whole.
- The state and interaction models describe different aspects of behavior, and you need both to describe behavior fully.
- Use cases, sequence diagrams and activity diagrams document the interaction model.

CLASS MODELLING

Note: A class model captures the static structure of a system by characterizing the objects in the system, the relationships between the objects, and the attributes and operations for each class of objects.

OBJECT AND CLASS CONCEPT

Objects

Purpose of class modeling is to describe objects.

An **object** is a concept, abstraction or thing with identity that has meaning for an application.

Ex: Joe Smith, Infosys Company, process number 7648 and top window are objects.

Classes

An object is an instance or occurrence of a class.

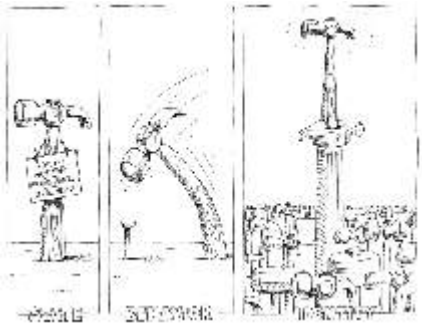
A **class** describes a group of objects with the same properties (attributes), behavior (operations), kinds of relationships and semantics.

Ex: Person, company, process and window are classes.

Note: All objects have identity and are distinguishable. Two apples with same color, shape and texture are still individual apples: a person can eat one and then the other. The term identity means that the objects are distinguished by their inherent existence and not by descriptive properties that they may have.

CLASS MODELLING

- **OBJECT AND CLASS CONCEPT**
- An **object** has three characteristics: **state**, **behavior** and **a unique identification**. or
- **An object is a concept, abstraction or thing with identity that has meaning for an application. Eg:**
- Note: The term identity means that the objects are distinguished by their inherent existence and not by descriptive properties that they may have.



Class diagrams

Class diagrams provide a graphic notation for modeling classes and their relationships, thereby describing possible objects.

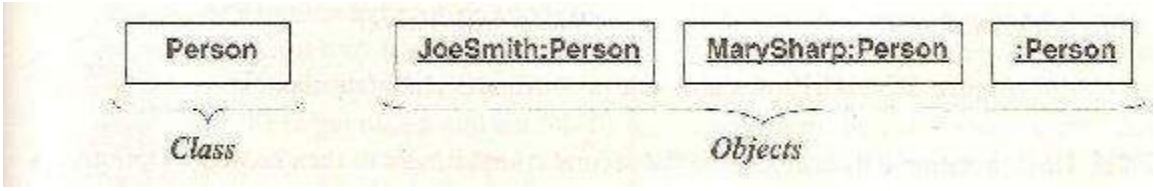
Note: An object diagram shows individual objects and their relationships.

Useful for documenting test cases and discussing examples.

Class diagrams are useful both for abstract modeling and for designing actual programs.

Note: A class diagram corresponds to infinite set of object diagrams.

Figure below shows a class (left) and instances (right) described by it.



Conventions used (UML):

- UML symbol for both classes and objects is box.
- Objects are modeled using box with object name followed by colon followed by class name.
- Use boldface to list class name, center the name in the box and capitalize the first letter. Use singular nouns for names of classes.
- To run together multiword names (such as JoeSmith), separate the words with
- intervening capital letter.

Values and Attributes:

Value is a piece of data.

Attribute is a named property of a class that describes a value held by each object of the class.

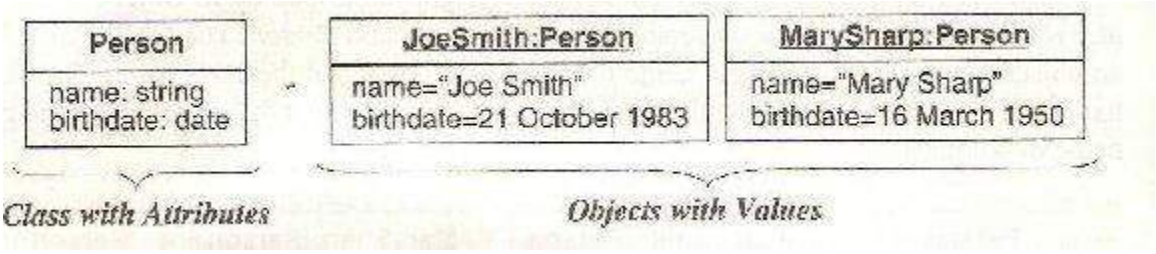
Following analogy holds:

Object is to class as value is to attribute.

E.g. Attributes: Name, bdate, weight.

Values: JoeSmith, 21 October 1983, 64. (Of person object).

Fig shows modeling notation



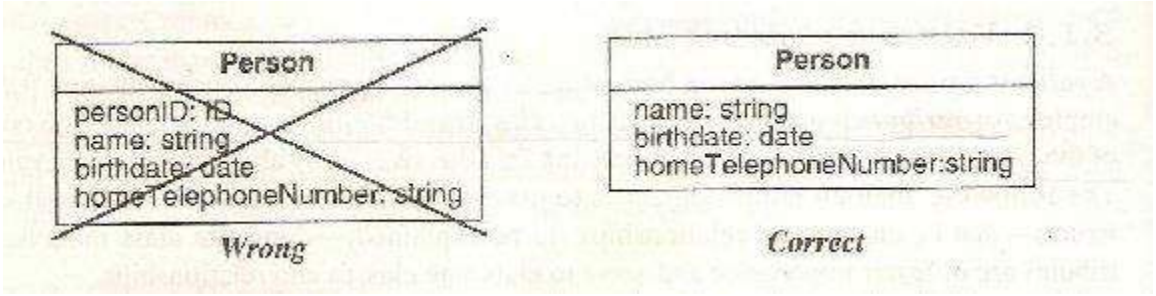
Conventions used (UML):

- List attributes in the 2nd compartment of the class box. Optional details (like default value) may follow each attribute.
- A colon precedes the type, an equal sign precedes default value.
- Show attribute name in regular face, left align the name in the box and use small case for the first letter.

Similarly we may also include attribute values in the 2nd compartment of object boxes with same conventions.

Note: Do not list object identifiers; they are implicit in models.

E.g.



An **operation** is a function or procedure that maybe applied to or by objects in a class.

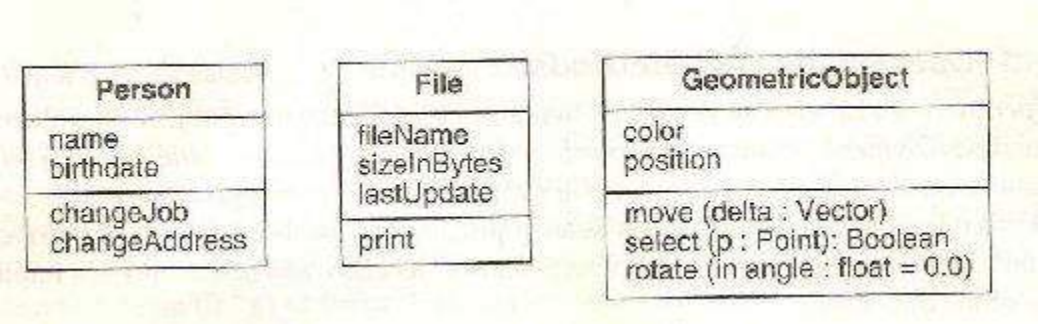
E.g. Hire, fire and pay dividend are operations on Class Company. Open, close, hide and redisplay are operations on class window.

A **method** is the implementation of an operation for a class.

E.g. In class file, print is an operation you could implement different methods to print files.

Note: Same operation may apply to many different classes. Such an operation is polymorphic.

Fig shows modeling notation.



UML conventions used –

- List operations in 3rd compartment of class box.
- List operation name in regular face, left align and use lower case for first letter.
- Optional details like argument list and return type may follow each operation name.
- Parenthesis enclose an argument list, commas separate the arguments. A colon precedes the result type.

Note: We do not list operations for objects, because they do not vary among objects of same class.

Summary of Notation for classes

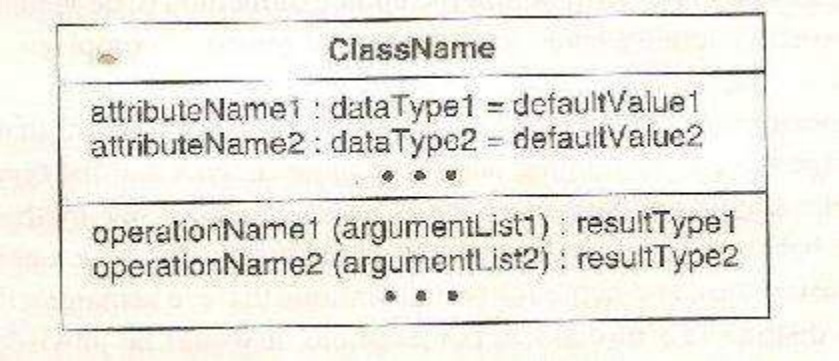


Fig: Summary of modeling notation for classes

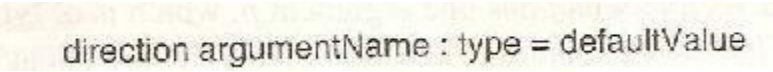
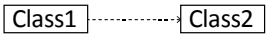
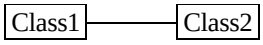
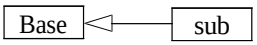


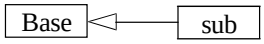
Fig: Notation for an argument of an operation

Class Diagrams: Relationships

- Classes can related to each other through different relationships:
  - Dependency 

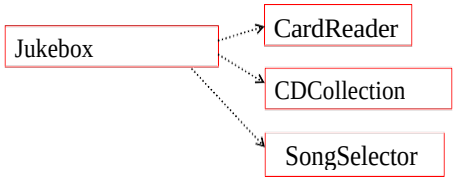
  - Association (delegation) 

  - Generalization (inheritance) 

  - Realization (interfaces) 

1) Dependency: A Uses Relationship

- Dependencies
  - occurs when one object depends on another
  - if you change one object's interface, you need to change the dependent object
  - arrow points from dependent to needed objects



2)Association: Structural Relationship

- **Association**
  - a relationship between classes indicates some meaningful and interesting connection
  - Can label associations with a hyphen connected verb phrase which reads well between concepts

if association name is replaced with "owns>",
it would read "Class 1 owns Class 2"

LINK AND ASSOCIATION CONCEPTS

Note: Links and associations are the means for establishing relationships among objects and classes.

Links and associations

□□A **link** is a physical or conceptual connection among objects.

E.g. JoeSmith *WorksFor* Simplex Company.

□□Mathematically, we define a link as a tuple – that is, a list of objects.

□□A link is an instance of an **association**.

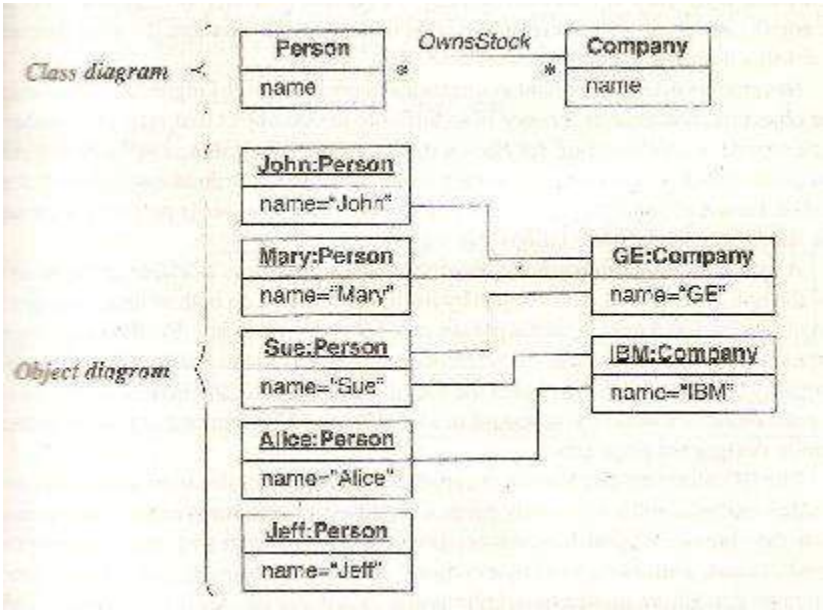
□□An **association** is a description of a group of links with common structure and common semantics.

E.g. a person *WorksFor* a company.

□□An association describes a set of potential links in the same way that a class

describes a set of potential objects.

□□Fig shows many-to-many association (model for a financial application).

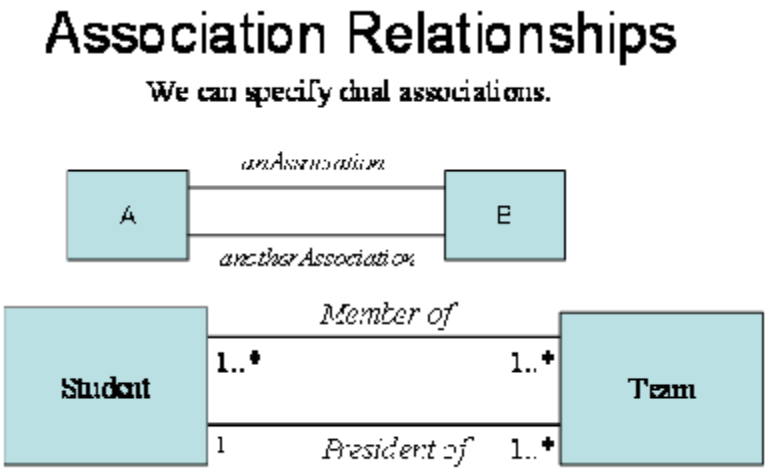


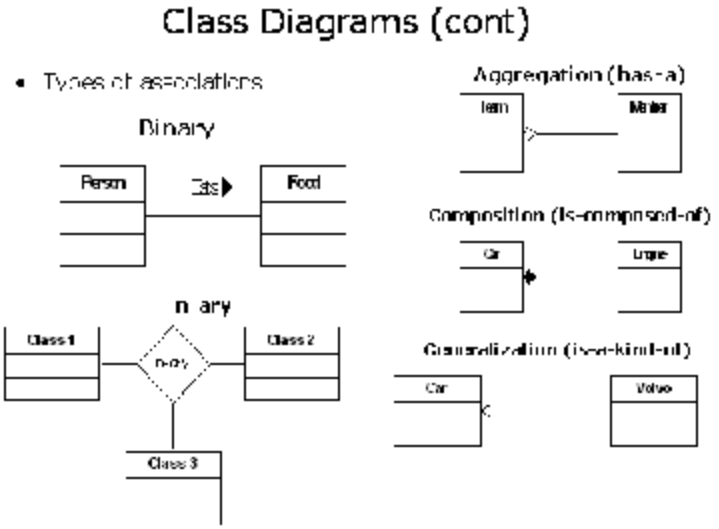
□□**Conventions used (UML):**

- Link is a line between objects; a line may consist of several line segments.
- If the link has the name, it is underlined.
- Association connects related classes and is also denoted by a line.
- Show link and association names in italics.

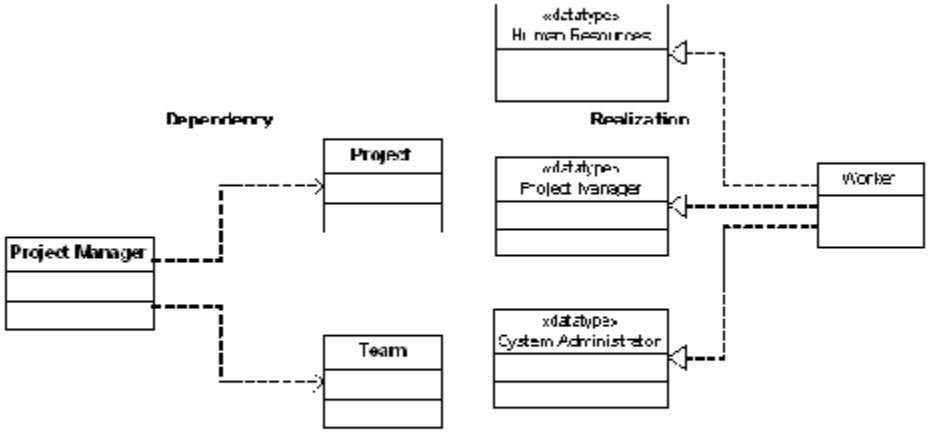
Note:

- Association name is optional, if the model is unambiguous. Ambiguity arises when a model has multiple associations among same classes.
- Developers often implement associations in programming languages as references from one object to another. A reference is an attribute in one object that refers to another object.





Class Diagrams (cont)



Multiplicity

Multiplicity specifies the number of instances of one class that may relate to a single instance of an associated class. Multiplicity constrains the number of related objects.

UML conventions:

- UML diagrams explicitly lists multiplicity at the ends of association lines.
- UML specifies multiplicity with an interval, such as

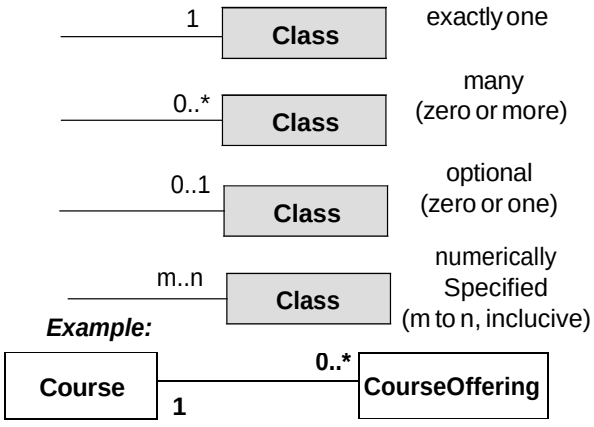
"1" (exactly one).

"1.."(one or more).

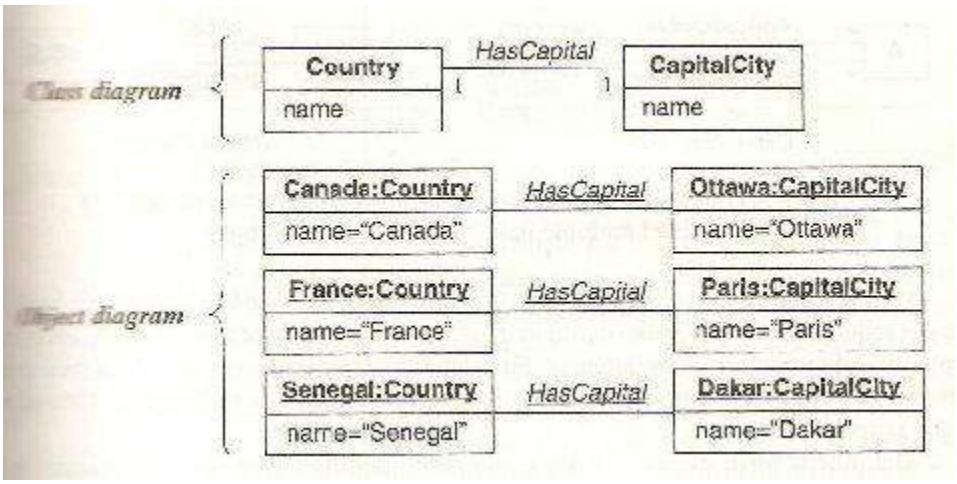
"3..5"(three to five, inclusive).

" * " (many, i.e zero or more).

- notations



Previous figure illustrates many-to-many multiplicity. Below figure illustrates **one-to-one multiplicity.**



Below figure illustrates zero-or-one multiplicity.

Note 1: Association vs Link.

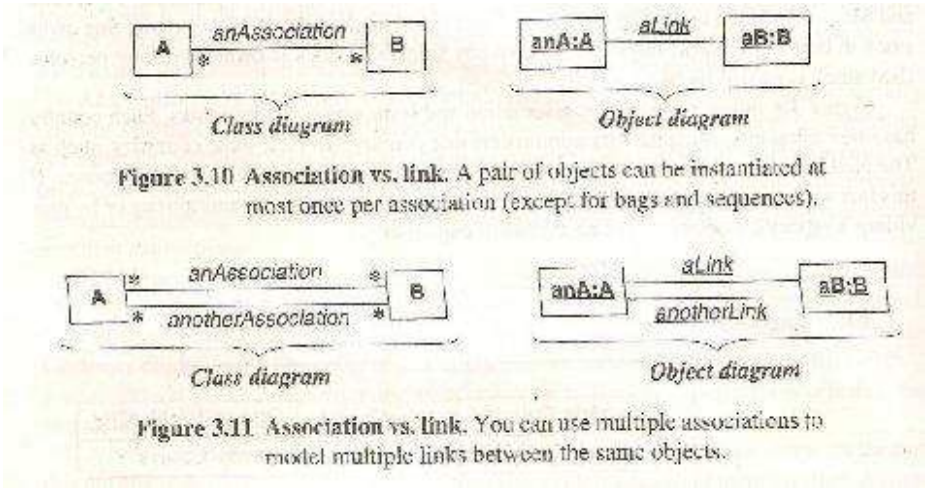
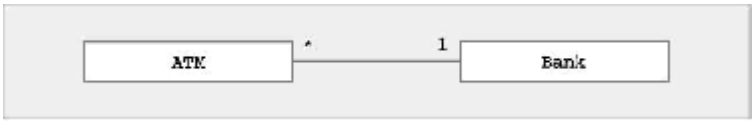


Figure 3.10 Association vs. link. A pair of objects can be instantiated at most once per association (except for bags and sequences).

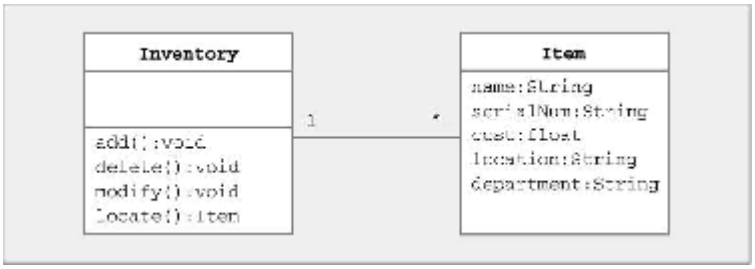
Figure 3.11 Association vs. link. You can use multiple associations to model multiple links between the same objects.

Multiplicity of Associations

- Many-to-one
  - Bank has many ATMs, ATM knows only 1 bank

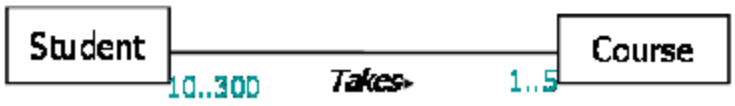


- One-to-many
  - Inventory has many items, items know 1 inventory



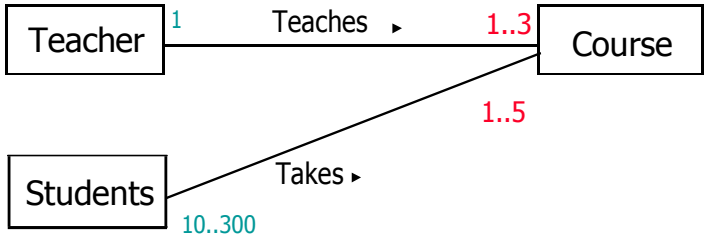
Association - Multiplicity

- A Student can take up to five Courses.
- Student has to be enrolled in at least one course.
- Up to 300 students can enroll in a course.
- A class should have at least 10 students.



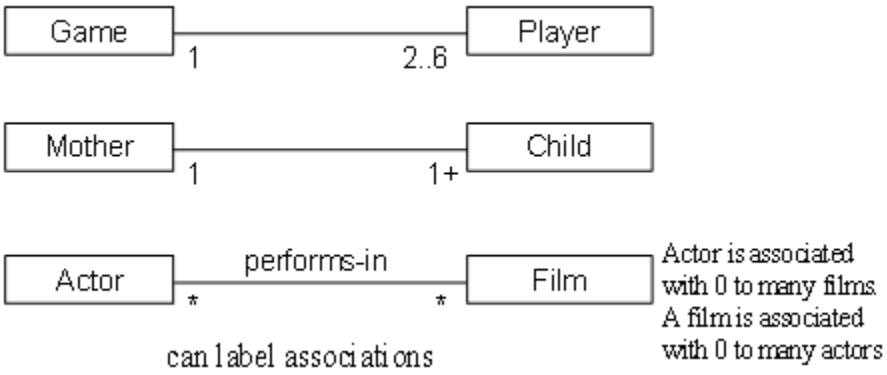
Association – Multiplicity

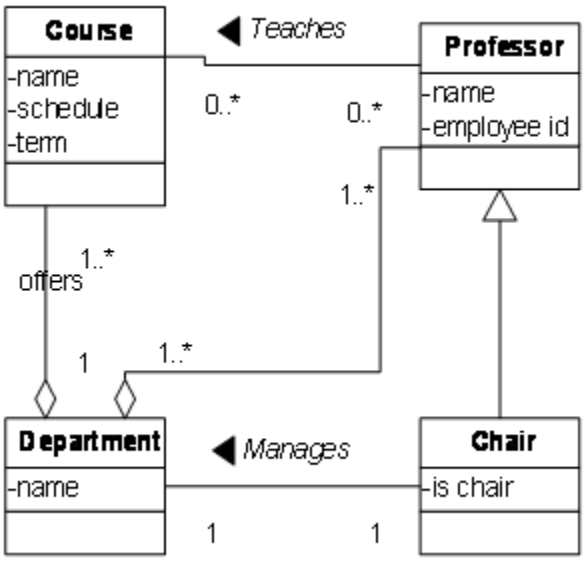
- A teacher teaches 1 to 3 courses (subjects)
- Each course is taught by only one teacher.
- A student can take between 1 to 5 courses.
- A course can have 10 to 300 students.



Multiplicity

- Multiplicity defines how many instances of type A can be associated with one instance of type B at some point





MULTIPLICITIES IN ASSOCIATIONS

min..max notation (related to at least min objects and at most max objects)	0..*	related to zero or more objects
	0..1	related to no object or at most one object
	1..*	related to at least one object
	1..1	related to exactly one object.
	3..5	related to at least three objects and at most five objects
short hand notation	1	same as 1..1
	*	same as 0..*

Note 2: Multiplicity vs Cardinality.

- Multiplicity is a constraint on the size of a collection.
- Cardinality is a count of elements that are actually in a collection.

Therefore, multiplicity is a constraint on cardinality.

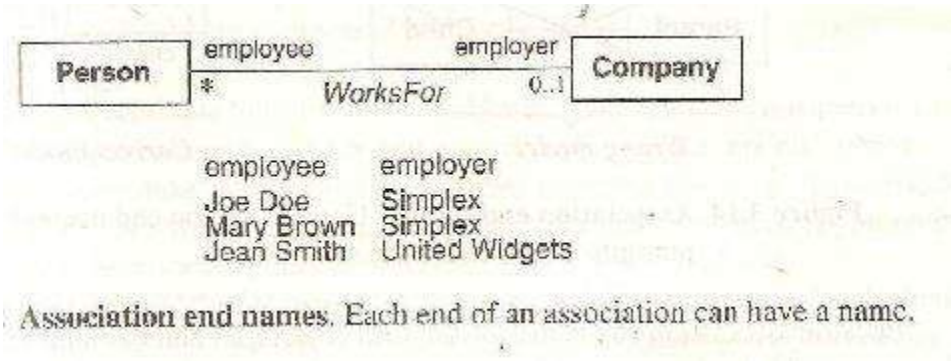
Note 3: The literature often describes multiplicity as being "one" or "many", but more generally it is a subset of the non negative numbers.

Association end names

Multiplicity implicitly refers to the ends of associations. For E.g. A one-to- many association has two ends –

- an end with a multiplicity of "one"
- an end with a multiplicity of "many"

You can not only assign a multiplicity to an association end, but you can give it a name as well.



Association end names. Each end of an association can have a name.

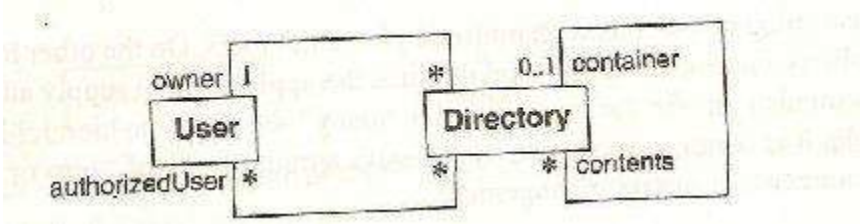
A person is an employee with respect to company.

A company is an employer with respect to a person.

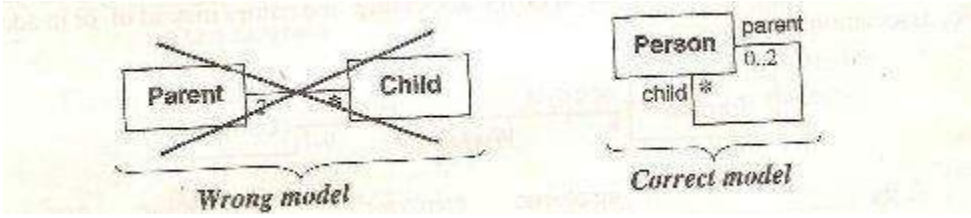
□□**Note 1:** Association end names are optional.

□□**Note 2:** Association end names are necessary for associations between two objects of the same class. They can also distinguish multiple associations between a pair of classes.

E.g. each directory has exactly one user who is an owner and many users who are authorized to use the directory. When there is only a single association between a pair of distinct classes, the names of the classes often suffice, and you may omit association end names.



□□**Note 3:** Association end names let you unify multiple references to the same class. When constructing class diagrams you should properly use association end names and not introduce a separate class for each reference as below fig shows.



Sometimes, the objects on a "many" association end have an explicit order.

E.g. Workstation screen containing a number of overlapping windows. Each window on a screen occurs at most once. The windows have explicit order so only the top most windows are visible at any point on the screen.

□□**Ordering** is an inherent part of association. You can indicate an ordered set of objects by writing "{ordered}" next to the appropriate association end.

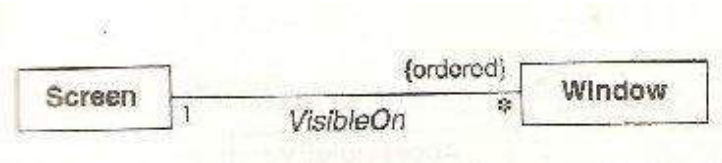


Fig: ordering sometimes occurs for "many" multiplicity

Bags and Sequences

Normally, a binary association has **at most one link** for a pair of objects.

However, you can permit **multiple links** for a pair of objects by annotating an association end with {bag} or {sequence}.

A **bag** is a collection of elements with duplicates allowed.

A **sequence** is an ordered collection of elements with duplicates allowed. Example:

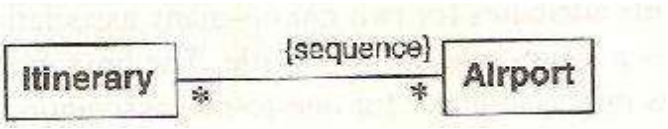


fig: an itinerary may visit multiple airports, so you should use {sequence} and not {ordered}

Note: {ordered} and {sequence} annotations are same, except that the first disallows duplicates and the other allows them.

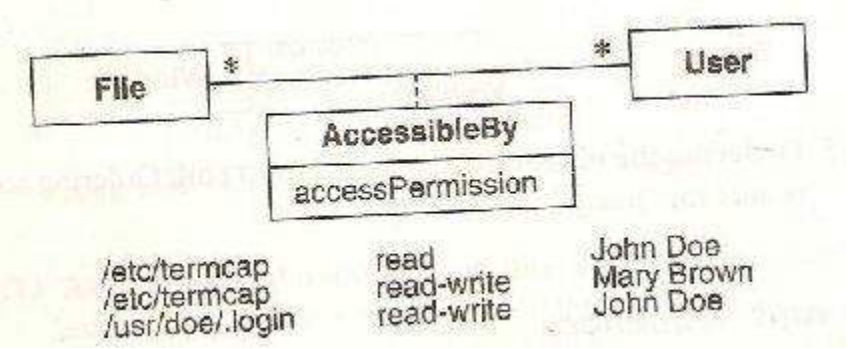
Association classes

An **association class** is an association that is also a class.

Like the links of an association, the instances of an association class derive identity from instances of the constituent classes.

Like a class, an association class can have attributes and operations and participate in associations.

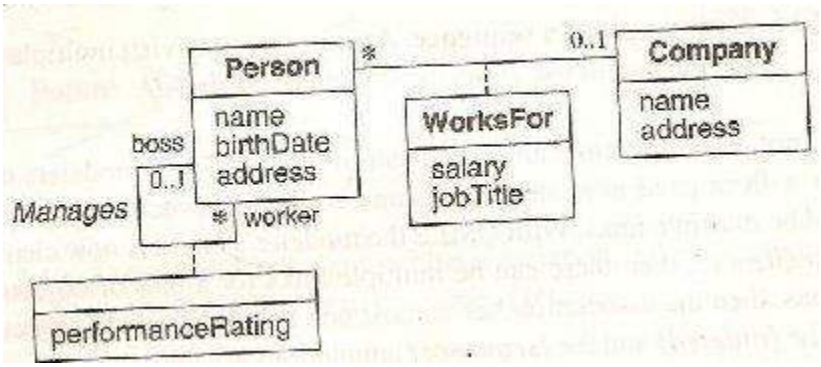
Ex:



UML notation for association class is a box attached to the association by a dashed line.

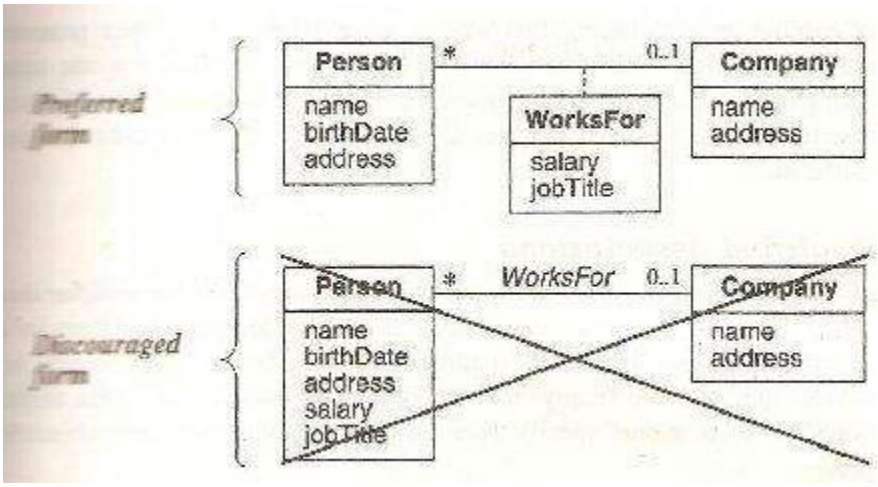
Note: Attributes for association class unmistakably belong to the link and cannot be ascribed to either object. In the above figure, accessPermission is a joint property of File and user cannot be attached to either file or user alone without losing information.

Below figure presents attributes for two one-to-many relationships. Each person working for a company receives a salary and has job title. The boss evaluates the performance of each worker. Attributes may also occur for one-to-one associations.

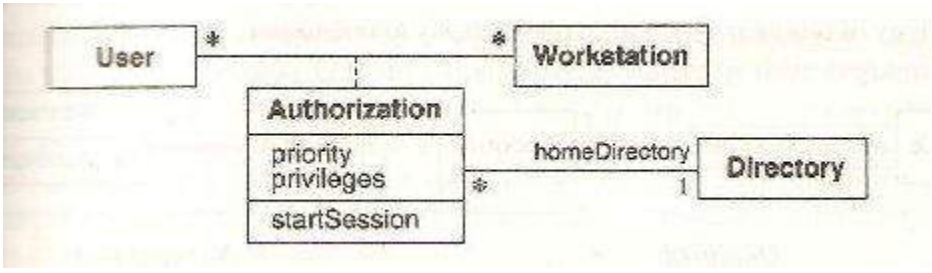


Note 1: Figure shows how it's possible to fold attributes for one-to-one and one- to-many associations into the class opposite a "one" end. This is not possible for many-to-many associations.

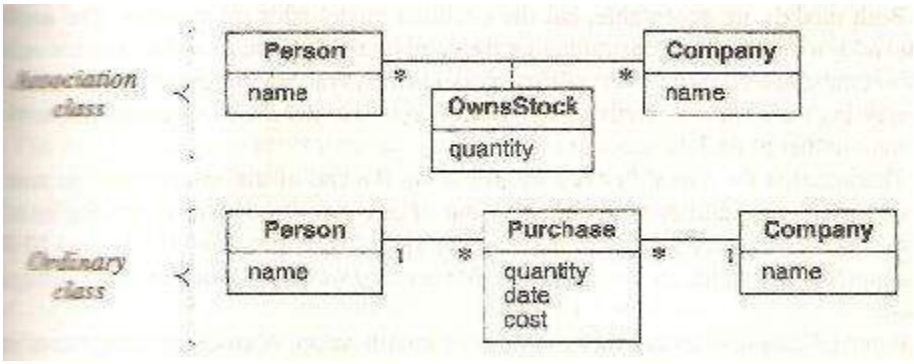
As a rule, you should not fold such attributes into a class because the multiplicity of the association may change.



Note 2: An association class participating in an association.



Note 3: Association class vs ordinary class.



eg:

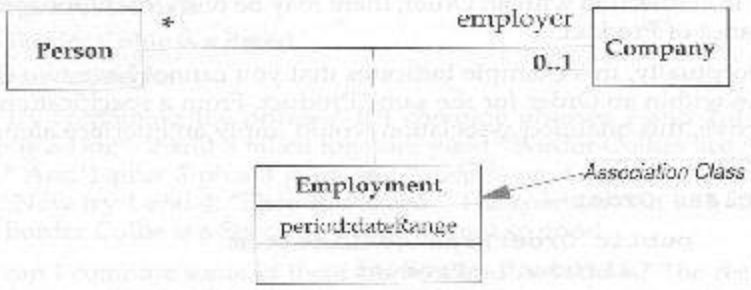
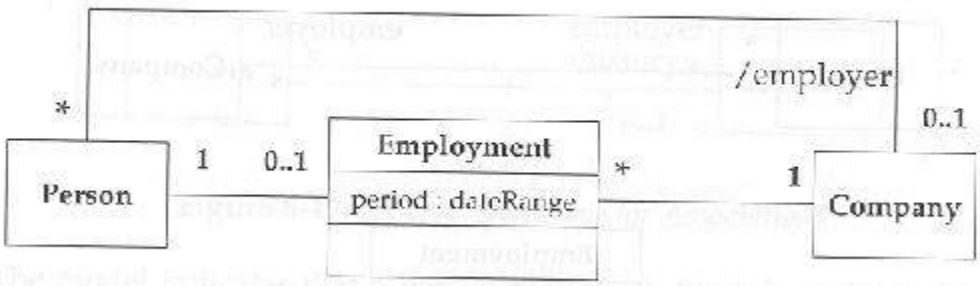


Figure 6-14: *Association Class*



Qualified associations

A **Qualified Association** is an association in which an attribute called the **qualifier** disambiguates the objects for a "many" association ends. It is possible to define qualifiers for one-to-many and many-to-many associations.

A qualifier selects among the target objects, reducing the effective multiplicity from "many" to "one".

Ex 1: qualifier for associations with one to many multiplicity. A bank services multiple accounts. An account belongs to single bank. Within the context of a bank, the Account Number specifies a unique account. Bank and account are classes, and Account Number is a qualifier. Qualification reduces effective multiplicity of this association from one-to-many to one-to-one.

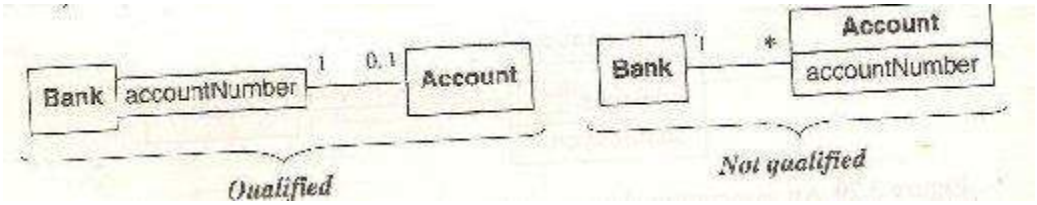
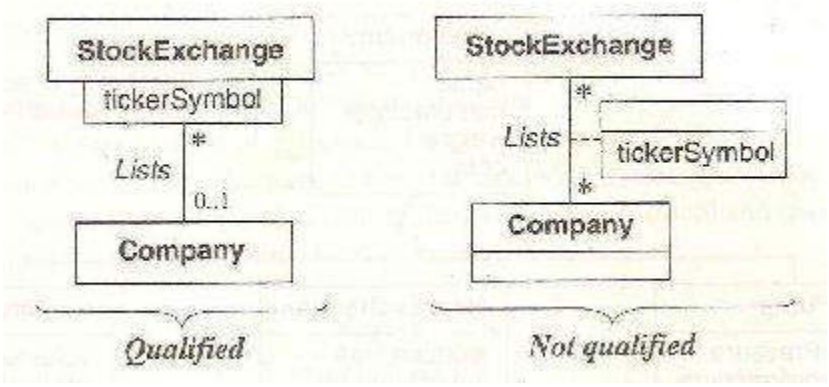
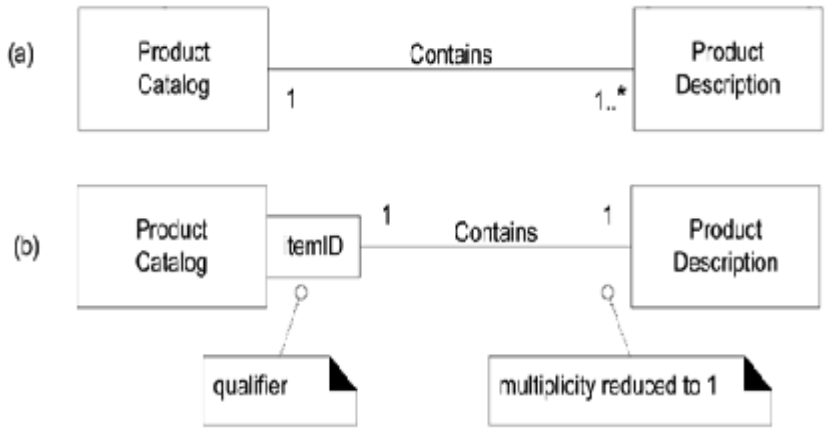


Fig: qualification increases the precision of a model. (note: however, both are acceptable)

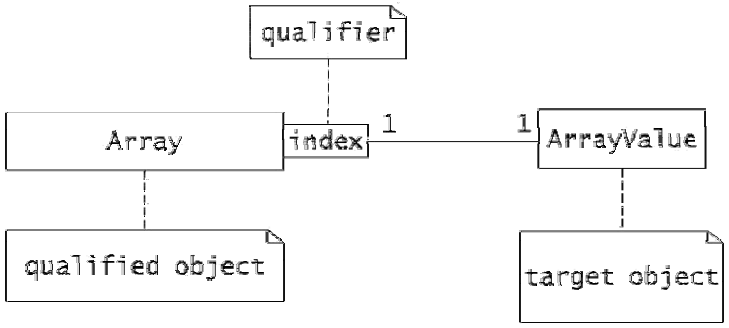
Ex 2: a stock exchange lists many companies. However, it lists only one company with a given ticker symbol. A company maybe listed on many stock exchanges, possibly under different symbols.



Eg 3: Qualified Association



eg 4:



GENERALIZATION AND INHERITANCE

Generalization is the relationship between a class (the superclass) and one or more variations of the class (the subclasses). Generalization organizes classes by their similarities and differences, structuring the description of objects.

The superclass holds common attributes, operations and associations; the subclasses add specific attributes, operations and associations. Each subclass is said to **inherit** the features of its superclass.

There can be **multiple levels** of generalization.

Fig(a) and Fig(b) (given in the following page) shows examples of generalization.

Fig(a) – Example of generalization for equipment.

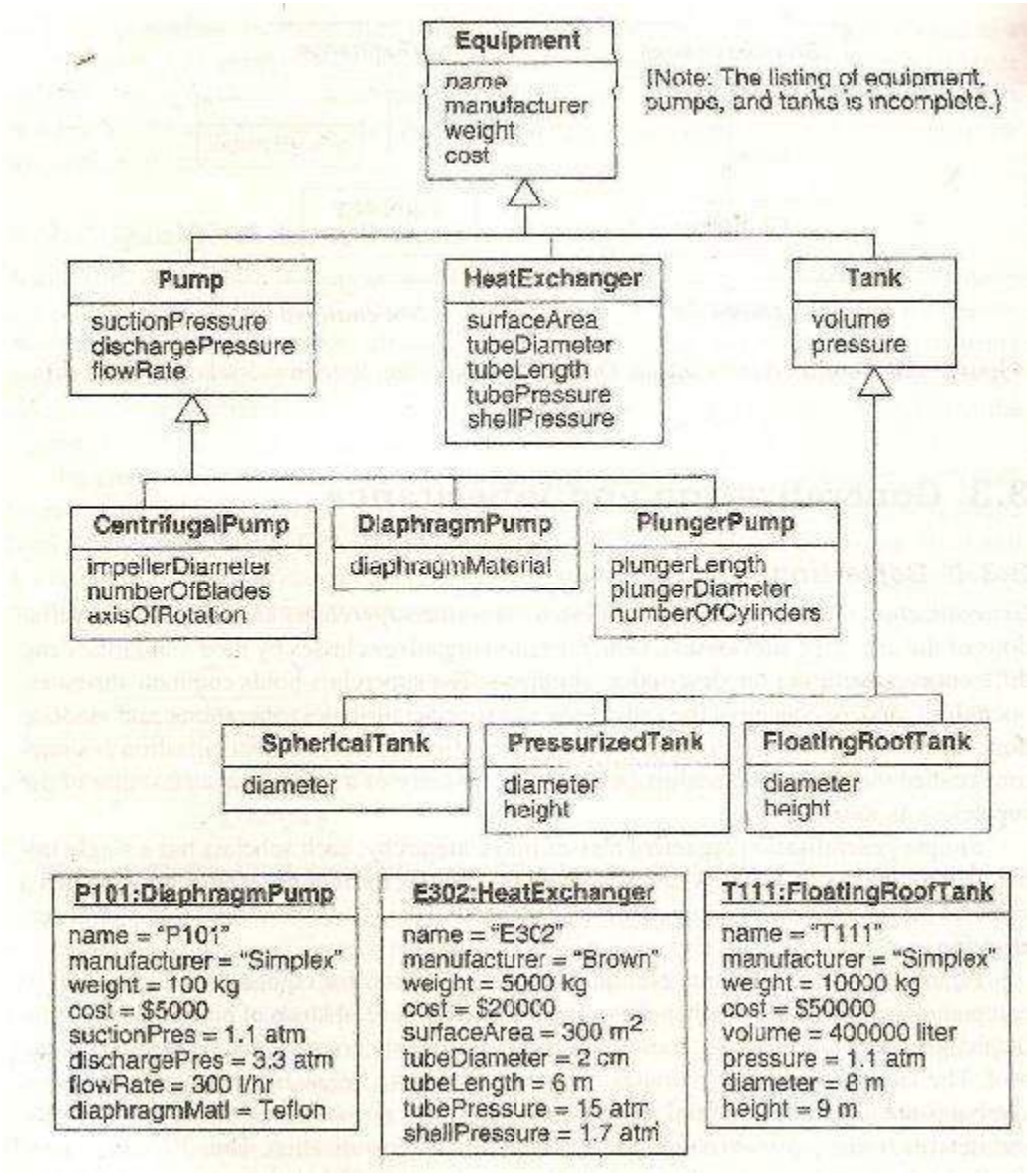
Each object inherits features from one class at each level of generalization.

UML convention used:

Use large hollow arrowhead to denote generalization. The arrowhead points to superclass.

Fig(b) – inheritance for graphic figures.

The word written next to the generalization line in the diagram (i.e dimensionality) is a generalization set name. A generalization set name is an enumerated attribute that indicates which aspect of an object is being abstracted by a particular generalization. It is optional.


Equipment
name
manufacturer
weight
cost
[Note: The listing of equipment, pumps, and tanks is incomplete.)
Pump
suctionPressure
dischargePressure
flowRate
HeatExchanger
surfaceArea
tubeDiameter
tubeLength
tubePressure
shellPressure
Tank
volume
pressure
CentrifugalPump
impellerDiameter
numberOfBlades
axisOfRotation
DiaphragmPump
diaphragmMaterial
PlungerPump
plungerLength
plungerDiameter
numberOfCylinders
SphericalTank
diameter
PressurizedTank
diameter
height
FloatingRoofTank
diameter
height
P101:DiaphragmPump
name = "P101"
manufacturer = "Simplex"
weight = 100 kg
cost = $5000
suctionPres = 1.1 atm
dischargePres = 3.3 atm
flowRate = 300 l/hr
diaphragmMatl = Teflon
E302:HeatExchanger
name = "E3C2"
manufacturer = "Brown"
weight = 5000 kg
cost = $20000
surfaceArea = 300 m2
tubeDiameter = 2 cm
tubeLength = 6 m
tubePressure = 15 atm
shellPressure = 1.7 atm
T111:FloatingRoofTank
name = "T111"
manufacturer = "Simplex"
we ght = 10000 kg
cost = $50000
volume = 400000 liter
pressure = 1.1 atm
diameter = 8 m
height = 9 m

Fig(a)

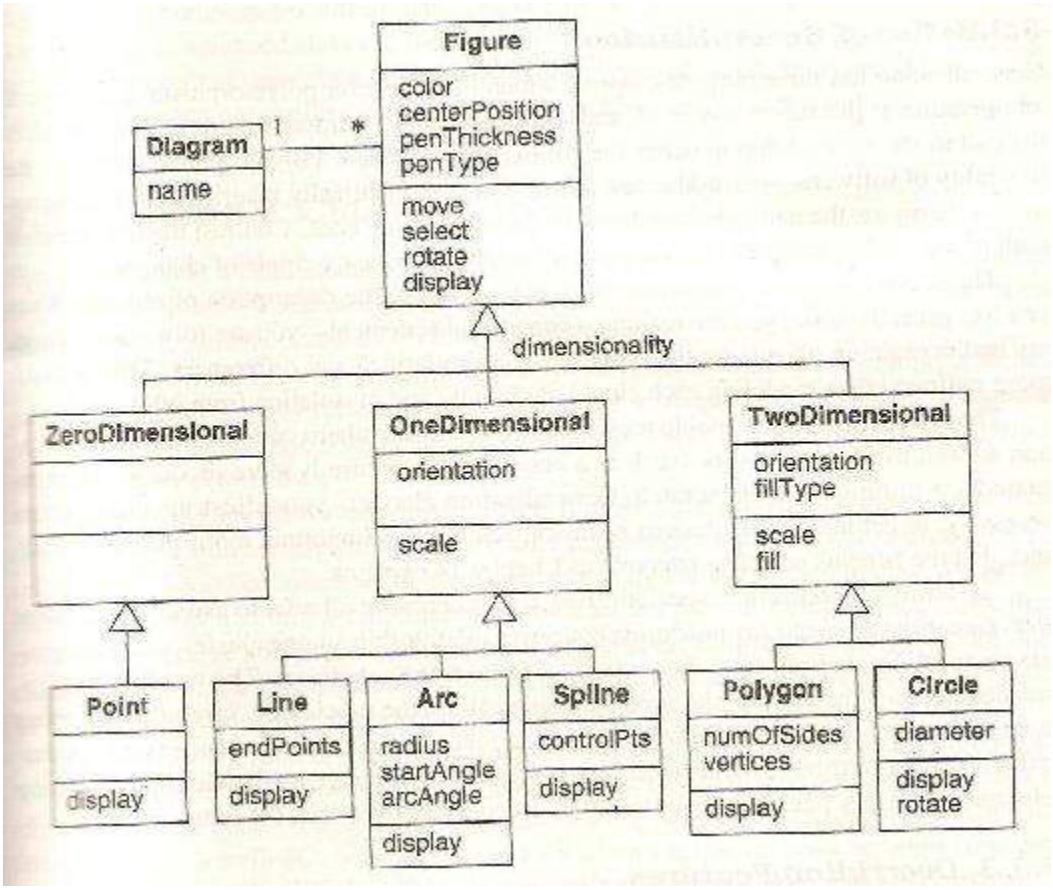


Fig (b)

'move**',** **'**select**',** 'rotate', and 'display' are operations that all subclasses inherit.

'scale**'** applies to one-dimensional and two-dimensional figures.

'fill' applies only to two-dimensional figures.

Use of generalization: Generalization has three purposes –

1. **To support polymorphism:** You can call an operation at the superclass level, and the OO language complier automatically resolves the call to the method that matches the calling object's class.

2. **To structure the description of objects:** i.e to frame a taxonomy and organizing objects on the basis of their similarities and differences.

3. **To enable reuse of code:** Reuse is more productive than repeatedly writing code from scratch.

Note: The terms generalization, specialization and inheritance all refer to aspects of the same idea.

Overriding features

A subclass may override a superclass feature by defining a feature with the same name. The overriding feature (subclass feature) refines and replaces the overridden feature (superclass feature) .

Why override feature?

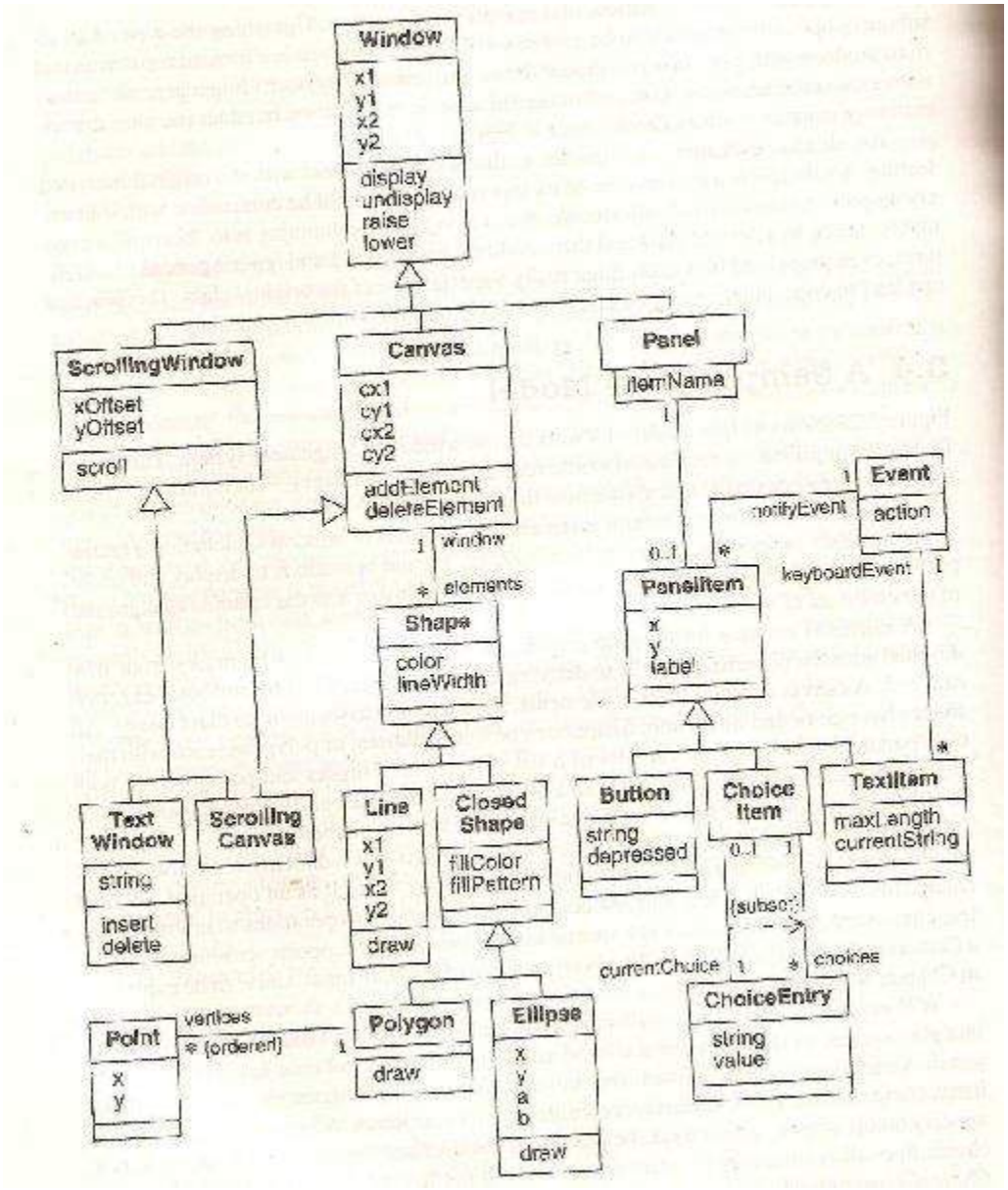
- To specify behavior that depends on subclass.
- To tighten the specification of a feature.

- To improve performance.

In fig(b) (previous page) each leaf subclasses had overridden 'display' feature.

Note: You may override methods and default values of attributes. You should never override the signature, or form of a feature.

A SAMPLE CLASS MODEL



NAVIGATION OF CLASS MODELS

Class models are useful for more than just data structure. In particular, **navigation of class model** lets you express certain behavior. Furthermore, navigation exercises a class model and uncovers hidden flaws and omission, which you can then repair.

UML incorporates a language that can be used for navigation, the **object constraint language(OCL).**

OCL constructs for traversing class models

OCL can traverse the constructs in class models.

1. **Attributes:** You can traverse from an object to an attribute value.

Syntax: source object followed by dot and then attribute name.

Ex: aCreditCardAccount.maximumcredit

2. **Operations: Y**ou can also invoke an operation for an object or collection of objects. Syntax: source object or object collection, followed by dot and then the operation followed by parenthesis even if it has no arguments. OCL has special operations that operate on entire collections (as opposed to operating on each object in a collection). Syntax for collection operation is: source object collection followed by "->", followed by the operation.

3. **Simple associations:** Dot notation is also used to traverse an association to a target end. Target end maybe indicated by an association end name, or class name (if there is no ambiguity).

Ex: refer fig in next page.

- aCustomer.MailingAddress yields a set of addresses for a customer (the target end has "many" multiplicity).
- aCreditCardAccount.MailingAddress yields a single address(the target end has multiplicity of "one").

4. **Qualified associations:** The expression aCreditCardAccount.Statement [30 November 1999] finds the statement for a credit card account with the statement date of November 1999. The syntax is to enclose the qualifier value in brackets.

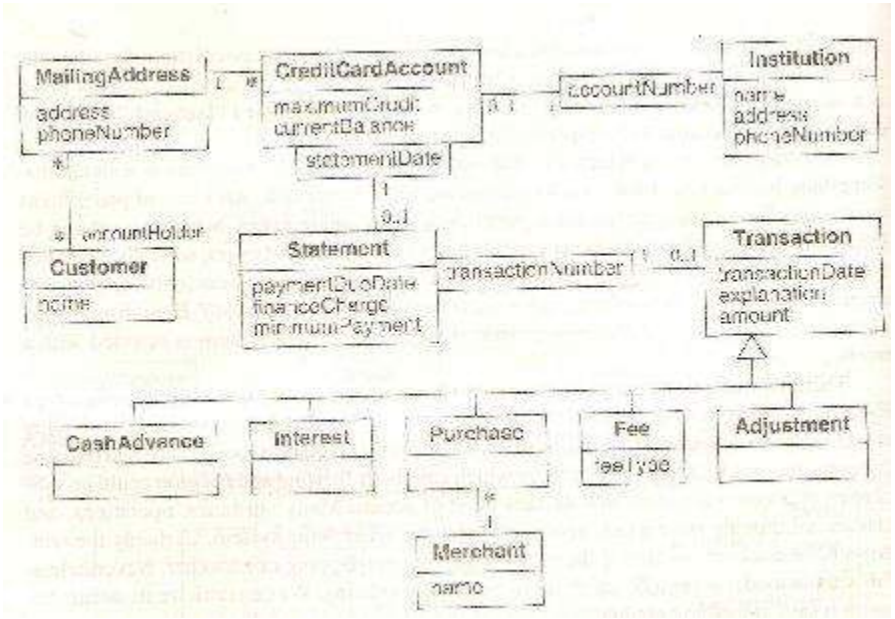
5. **Associations classes:** Given a link of an association class, you can find the constituent objects and vice versa.

6. **Generalization:** Traversal of a generalization hierarchy is implicit for the OCL notation.

7. **Filters:** Most common filter is 'select' operation.

Ex: aStatement.Transaction->select(amount>$100).

Examples of OCL expressions



Write an OCL expression for –

1. What transactions occurred for a credit card account within a time interval?

Soln: aCreditCardAccount.Statement.Transaction ->
select(aStartDate<=TransactionDate and
TransactionDate<=anEndDate)

2. What volumes of transactions were handled by an institution in the last year?

Soln: anInstitution.CreditCardAccount.Statement.Transaction ->
select(aStartDate<=TransactionDate and TransactionDate<=anEndDate).amount->sum( )

3. What customers patronized a merchant in the last year by any kind of credit card?

Soln: aMerchant.Purchase -> select(aStartDate<=TransactionDate
andtransactionDate<=anEndDate).Statement.CreditCardAccount.MailingAddress.Customer ->asset( )

4. How many credit card accounts does a customer currently have?

Soln: aCustomer.MailingAddress.CreditCardAccount -> size( )

5. What is the total maximum credit for a customer for all accounts?

Soln: acustomer.MailingAddress.CreditCardAccount.Maximumcredit -> sum( )