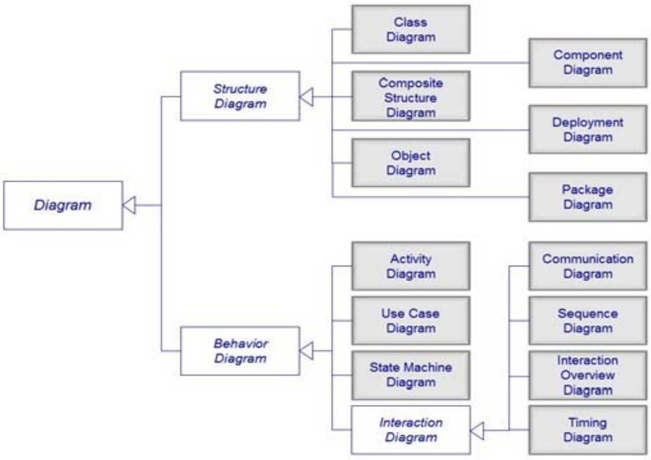
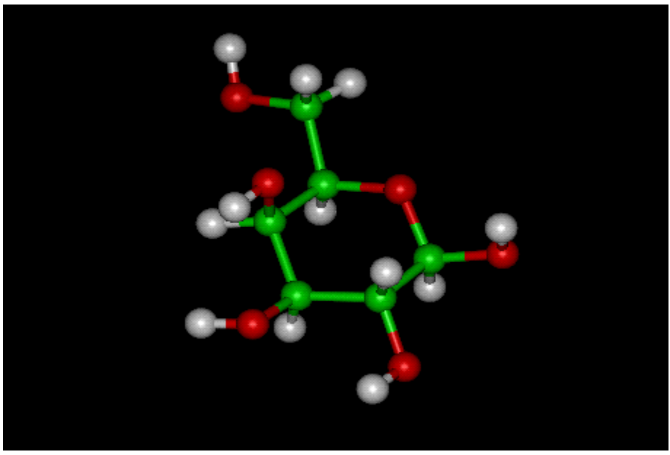
Object-Oriented Analysis and Design using UML and Patterns

Unified Modeling Language (UML)



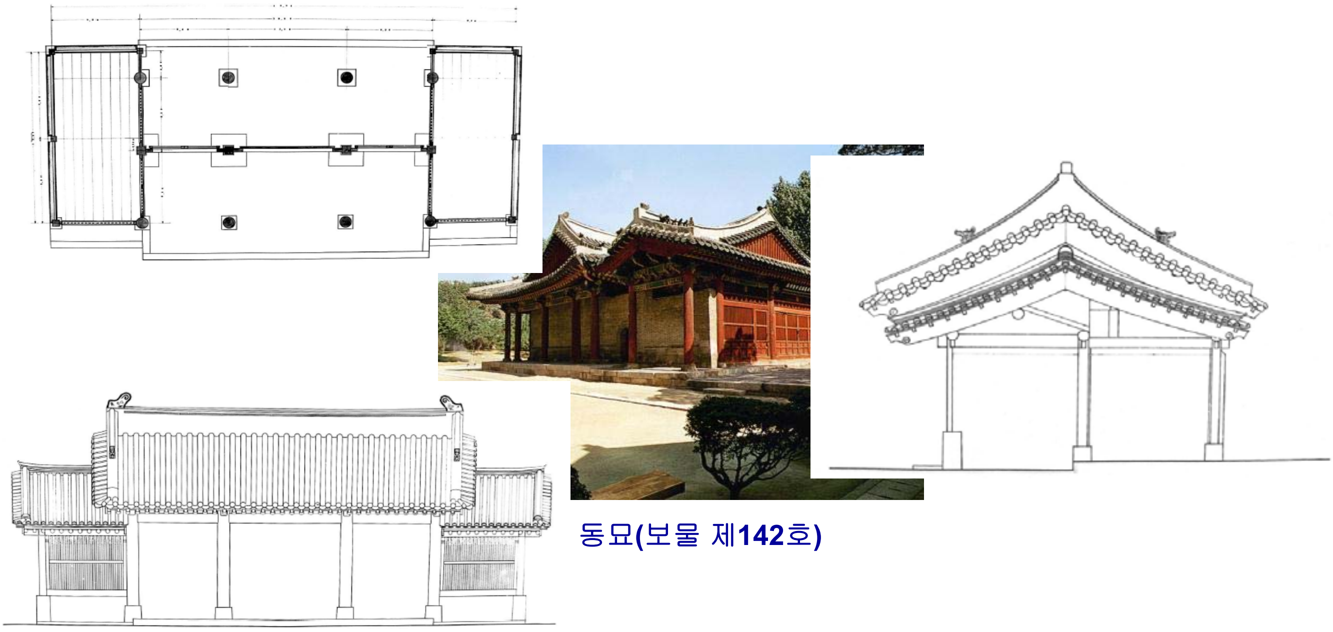
What is a “model”?

A model is a simplification of reality



Models capture the essential aspects of a system which are relevant to a given level of abstraction

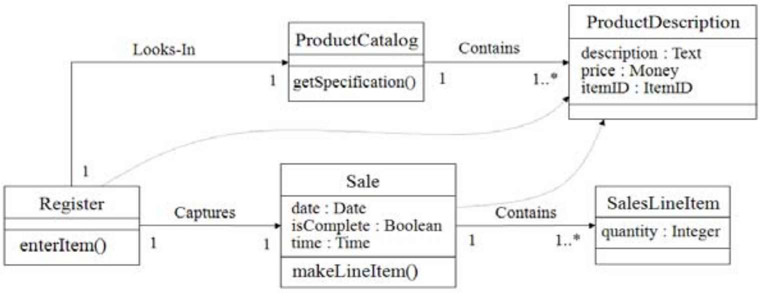
Every system may be described from different aspects using different models



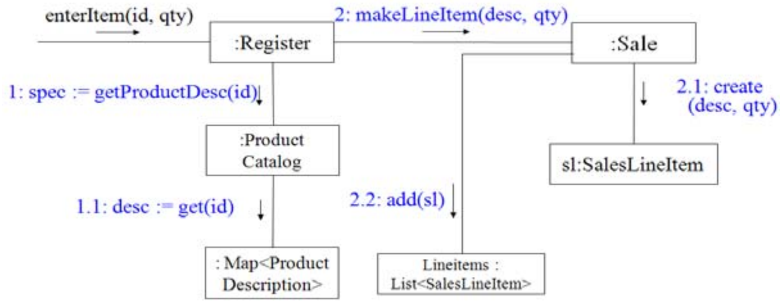
동묘(보물 제142호)

A model may be structural or behavioral

Static models:
describe a structural properties of a system



Dynamic models:
describe a behavioral properties of a system



We build models so that we can better understand the system we are developing

We build models of complex systems because we cannot comprehend such a system in its entirety

Through modeling,
we achieve four aims:

To visualize a system as it is
or as we want it to be

To specify the structure
or behavior of a system

To give a blueprint
to construct a system

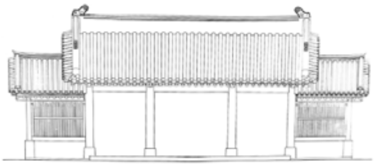
To document the decisions
we have made

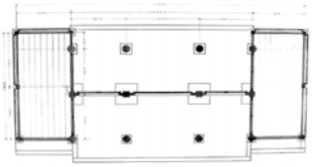
Principles of modeling

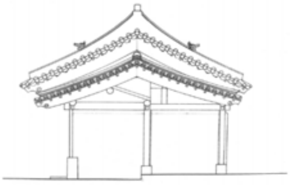
The choice of what models to create has a profound influence on how a problem is attacked and how a solution is shaped

Every model may be expressed at different levels of precision

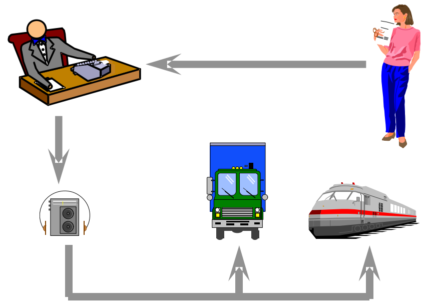
No single model is sufficient. Every nontrivial system is best approached through a small set of nearly independent models





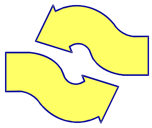


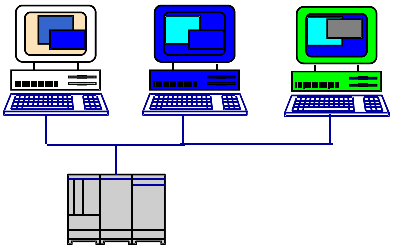
What is visual modeling?



Business Process

“Modeling captures essential parts of the system.”
Dr. James Rumbaugh





Computer System

Visual modeling is modeling using standard graphical notations

UML is a standard visual modeling language

Leading notations among > 50 (~ mid 90’s):

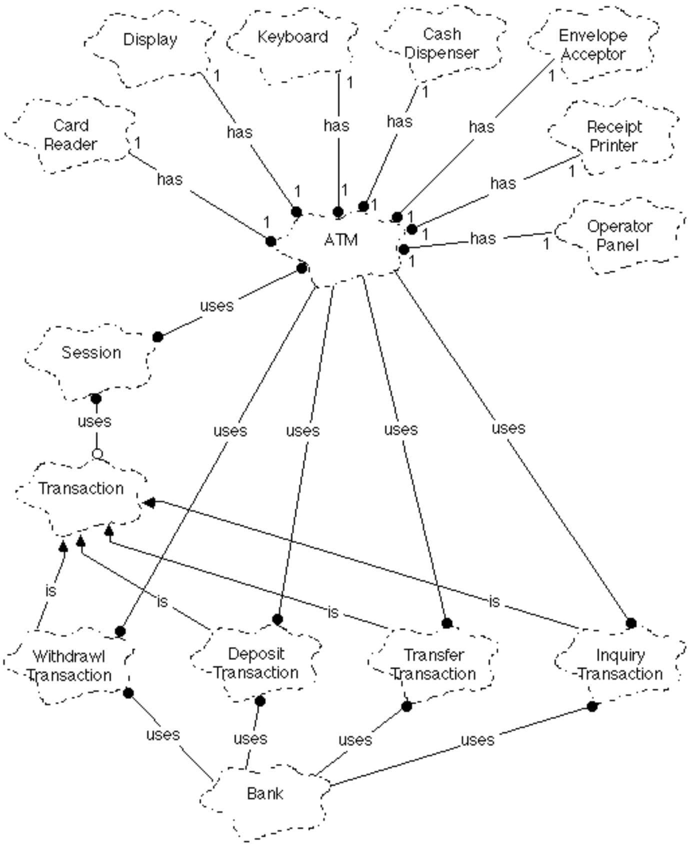
- Booch
- OMT

New OMG standard (since 1997):

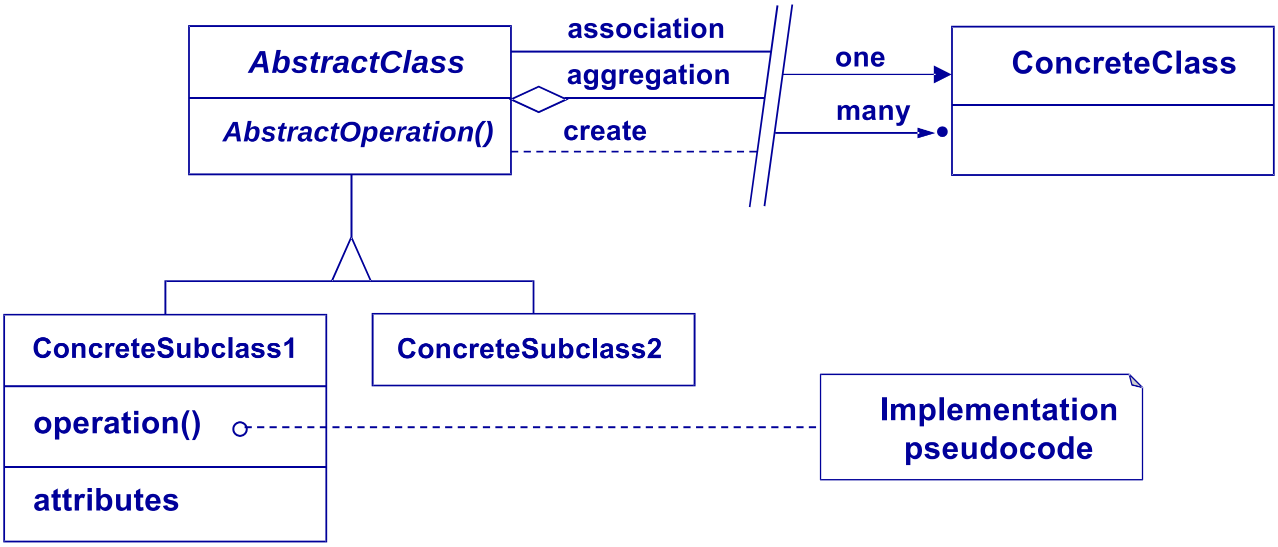
- Unified Modeling Language (UML)
  - Visual notation and semantics
  - *Process independent!*
  - *www.omg.org*

UNIFIED
MODELING
LANGUAGE

Booch: Class Diagram



OMT: Class Diagram



AbstractClass

AbstractOperation()

association

aggregation

create

one

many

ConcreteClass

ConcreteSubclass1

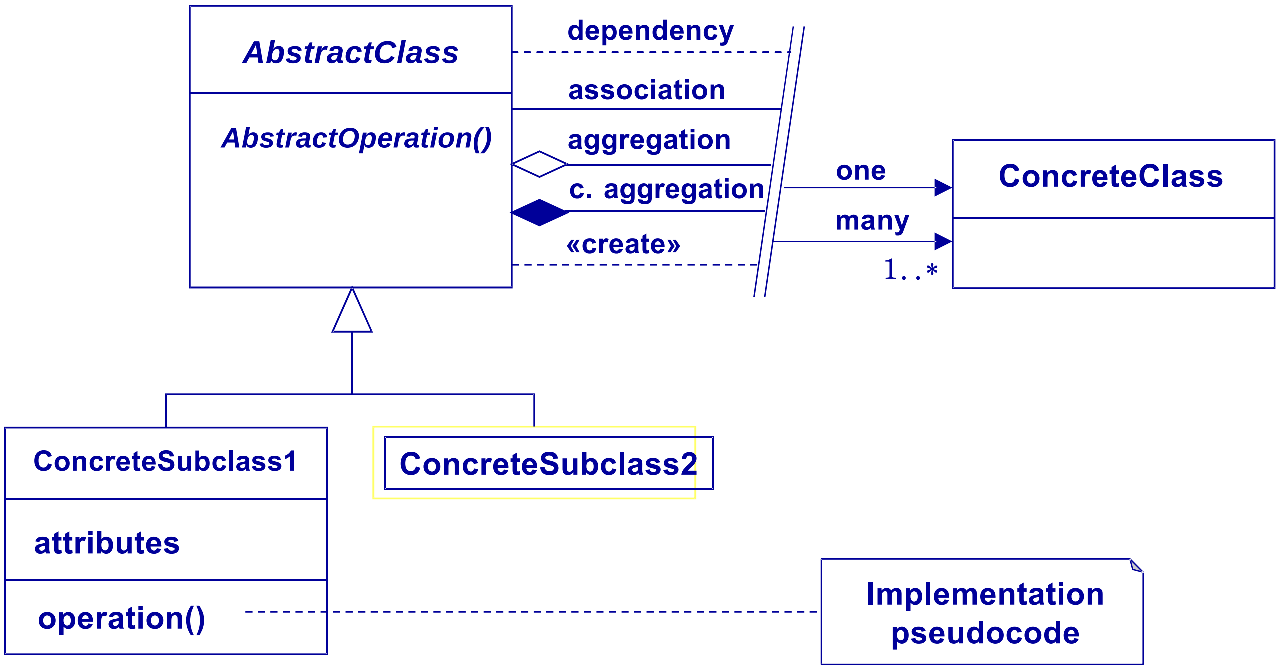
operation()

attributes

ConcreteSubclass2

Implementation pseudocode

UML: Class Diagram



UML attempts in being unified across several different domains (not just historical)

Development life cycle

- from requirements engineering to implementation

Application domains

- from hard real-time embedded systems to management decision support systems

Implementation languages and platforms

- language and platform neutral

Development processes

- development process neutral

Its own internal concepts

- consistent and uniform in its application of small set of internal concepts

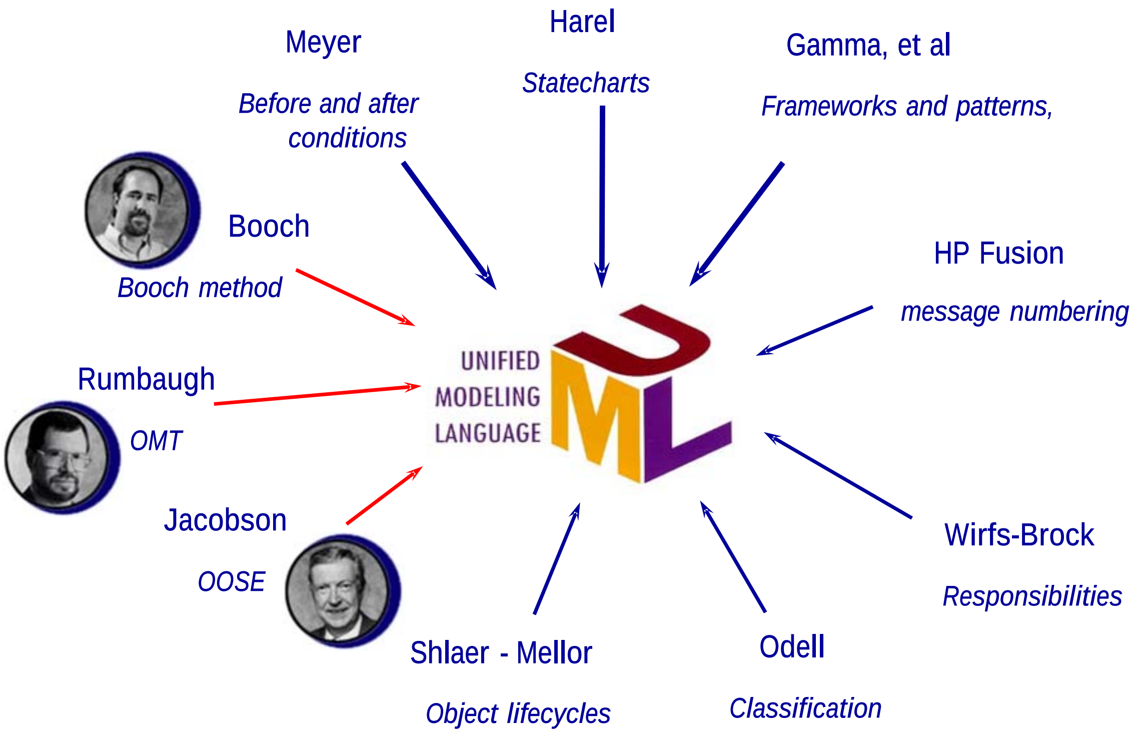
Where can the UML be used?

The UML is primarily intended for software-intensive systems (oriented towards OO systems)

- Enterprise information systems
- e-commerce
- Banking and insurance
- Computer games
- Command and control
- Telephony
- Defense/aerospace
- Medical electronics
- etc.

However, UML can also be used to model non-software systems such as workflow.

Contributions to the UML



Meyer

Before and after conditions

Harel

Statecharts

Gamma, et al

Frameworks and patterns,

Booch

Booch method

HP Fusion

message numbering

Rumbaugh

OMT

UNIFIED MODELING LANGUAGE

Jacobson

OOSE

Wirfs-Brock

Responsibilities

Shlaer - Mellor

Object lifecycles

Odell

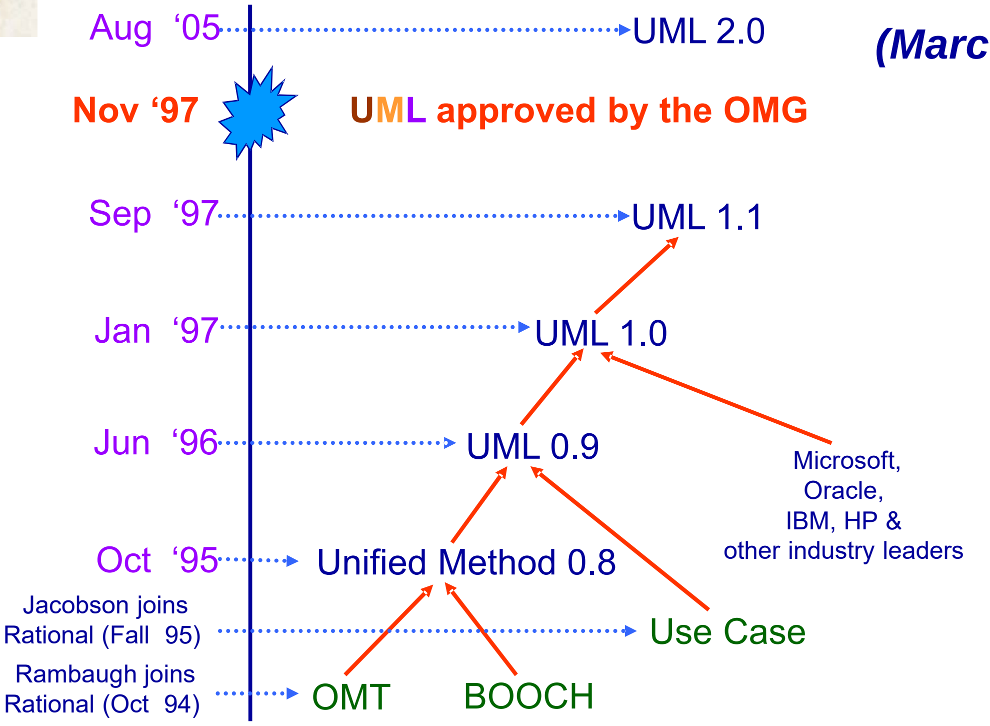
Classification

History of UML

Latest version

UML 2.4

(March 2011)



Aug '05 → UML 2.0

Nov '97 **UML approved by the OMG**

Sep '97 → UML 1.1

Jan '97 → UML 1.0

Jun '96 → UML 0.9

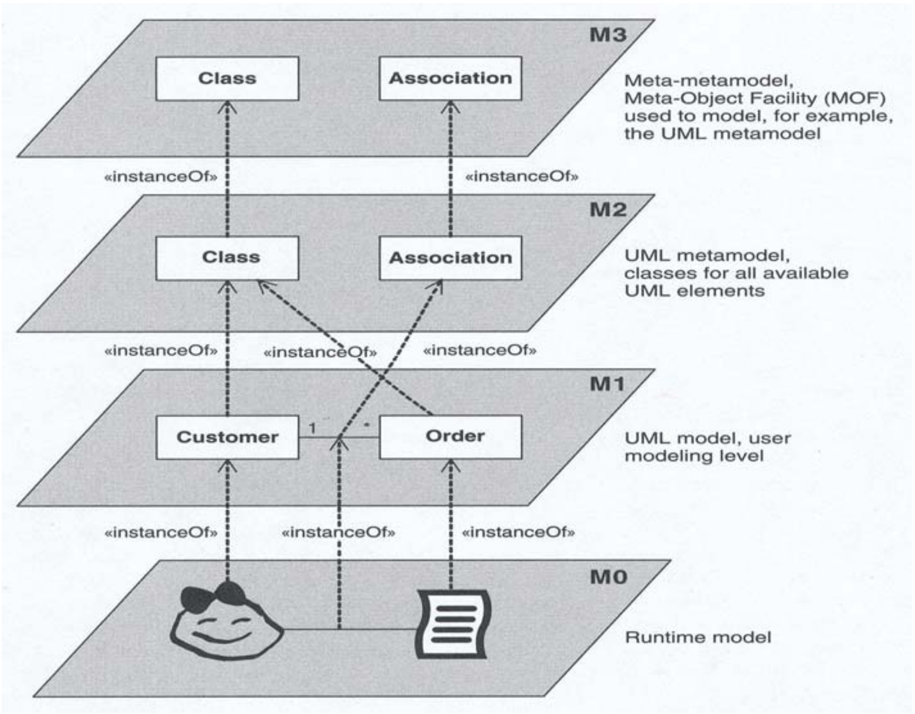
Oct '95 → Unified Method 0.8

Jacobson joins Rational (Fall 95) → Use Case

Rambaugh joins Rational (Oct 94) → OMT BOOCH

Microsoft, Oracle, IBM, HP & other industry leaders

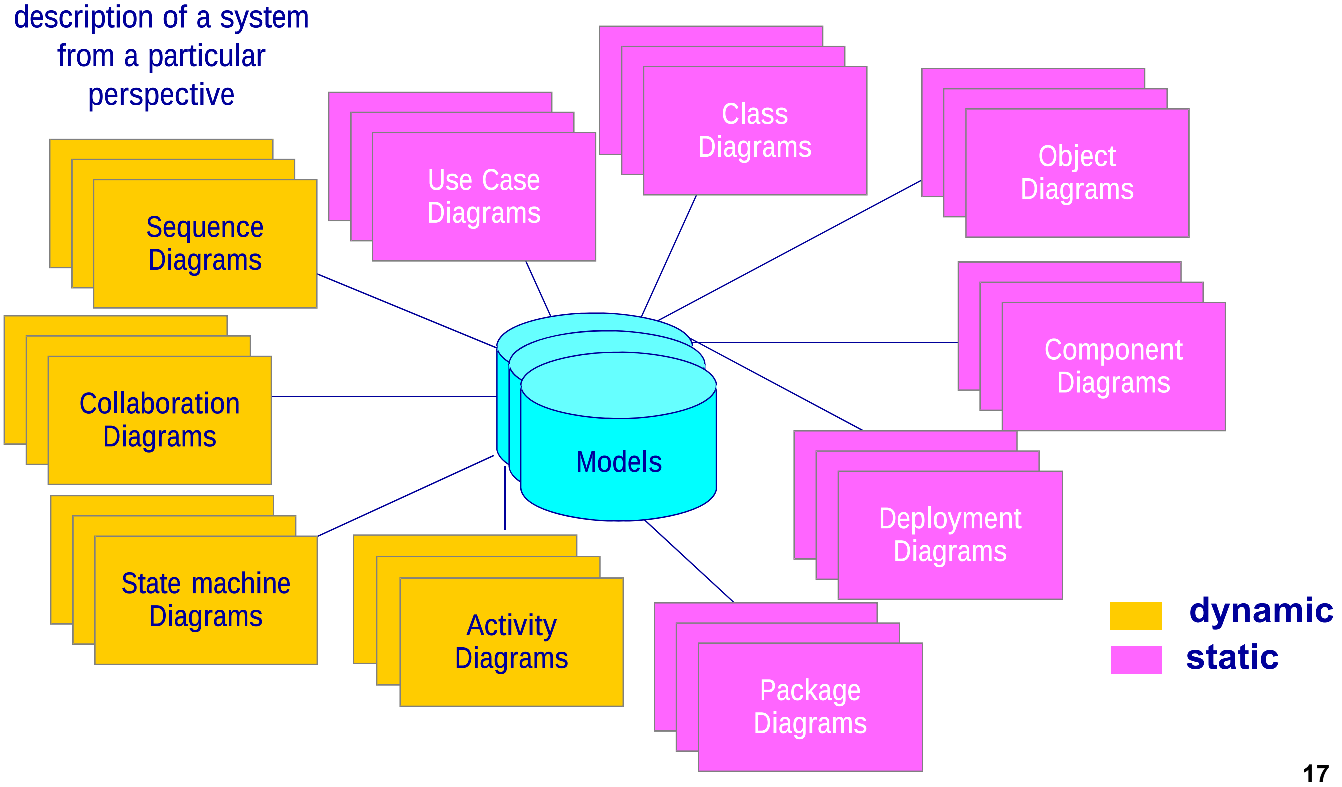
The Four layer Meta-model Hierarchy



M3
Class
Association
Meta-metamodel, Meta-Object Facility (MOF) used to model, for example, the UML metamodel
«instanceOf»
«instanceOf»
M2
Class
Association
UML metamodel, classes for all available UML elements
«instanceOf»
«instanceOf»
«instanceOf»
M1
Customer
1
*
Order
UML model, user modeling level
«instanceOf»
«instanceOf»
«instanceOf»
M0
Runtime model

Models and UML 1.x Diagrams

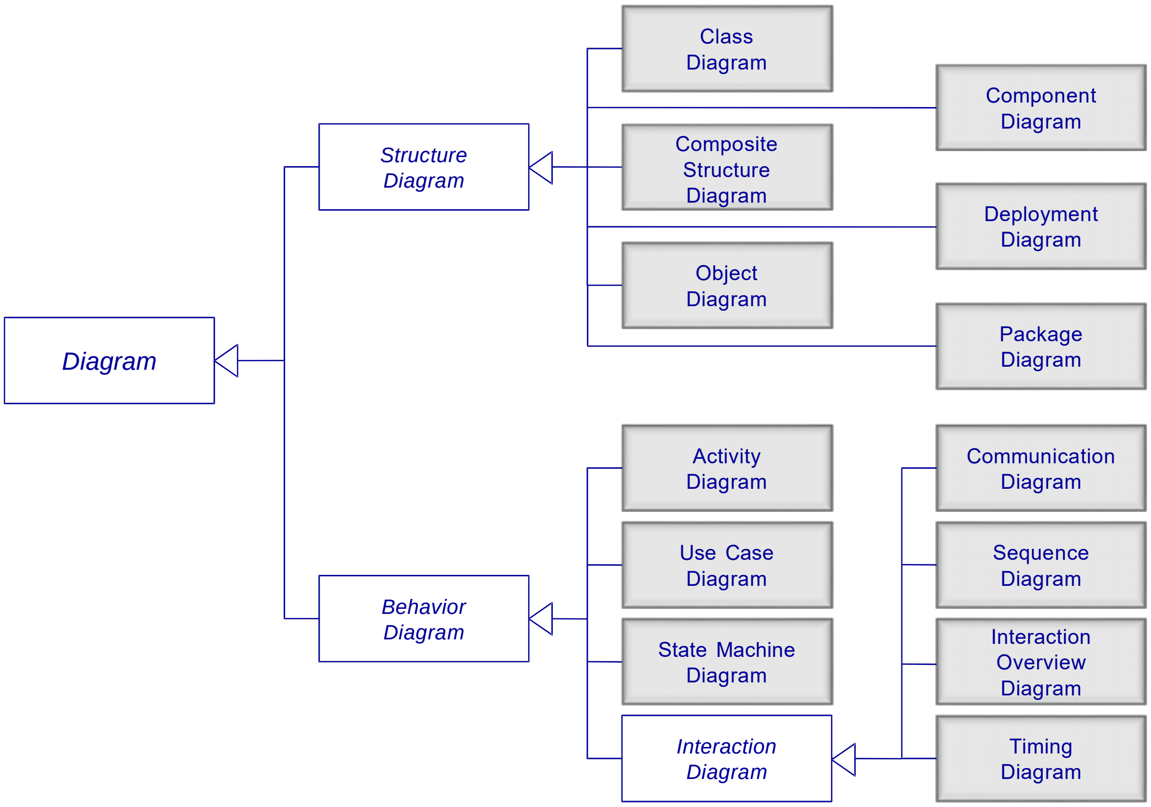
A *model* is a complete description of a system from a particular perspective



🟨 dynamic

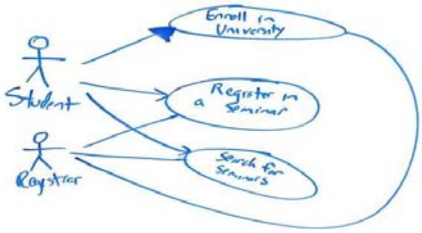
🟪 static

Classification of UML 2.0 Diagrams



Ways of Using UML

UML as a Sketch

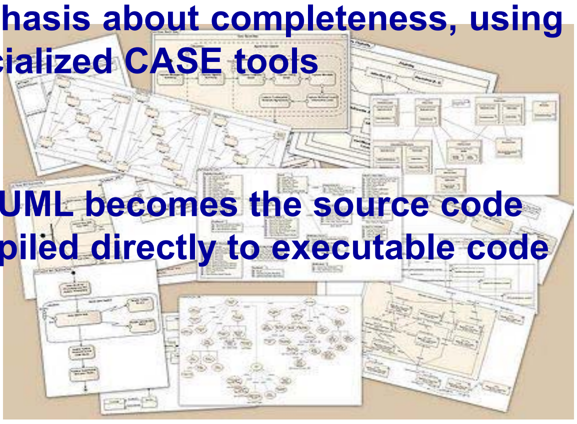


Emphasis is on selective communication rather than complete specification

Developers use the UML to help communicate some aspects of a system using lightweight drawing tools

UML as a Blueprint

Emphasis about completeness, using specialized CASE tools



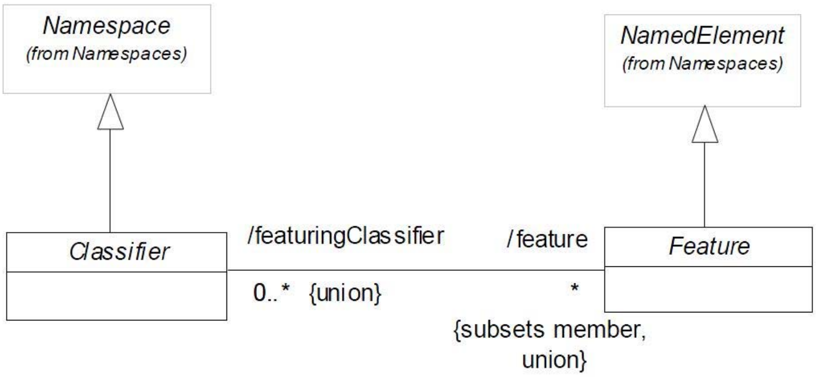
UML as
a Programming Language

The UML becomes the source code compiled directly to executable code

Classifiers
(abstract metaclass)

A classifier is a classification of instances – it describes a set of instances that have features in common

A feature declares a behavior or structural characteristics of instances of classifiers



Namespace
(from Namespaces)

NamedElement
(from Namespaces)

Classifier

/featuringClassifier

0..* {union}

/feature

*

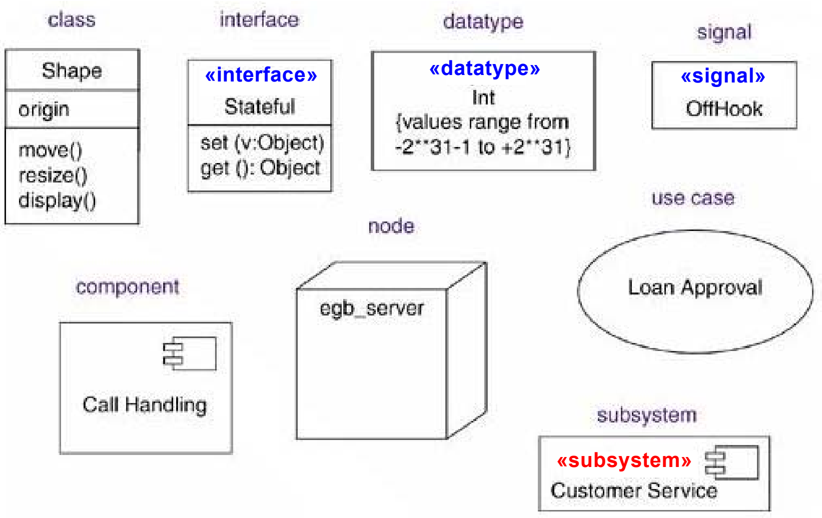
{subsets member, union}

Feature

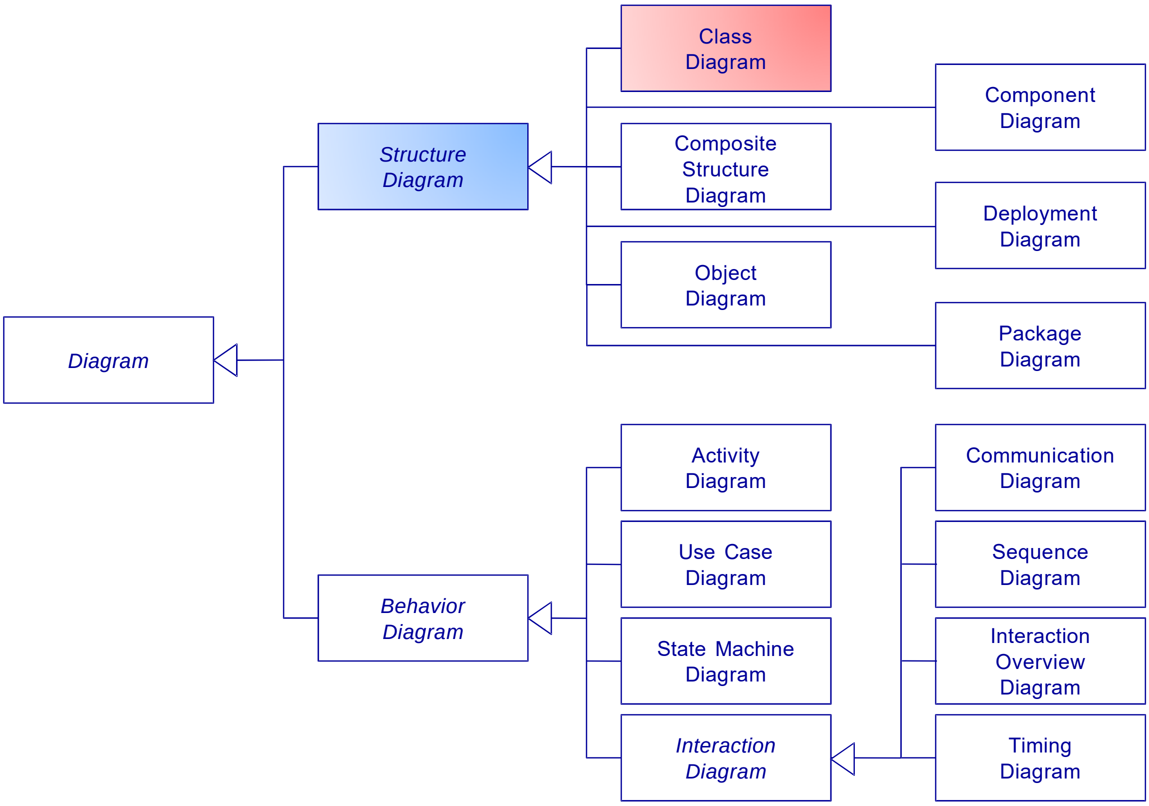
Concrete Subclasses of Classifier

Classifiers include classes, associations, interfaces, datatypes, signals, components, nodes, use cases, and subsystems

Icons



Class Diagram



Class Diagram

A class diagram shows the existence of classes (and interfaces) and their relationships in the logical view of a system

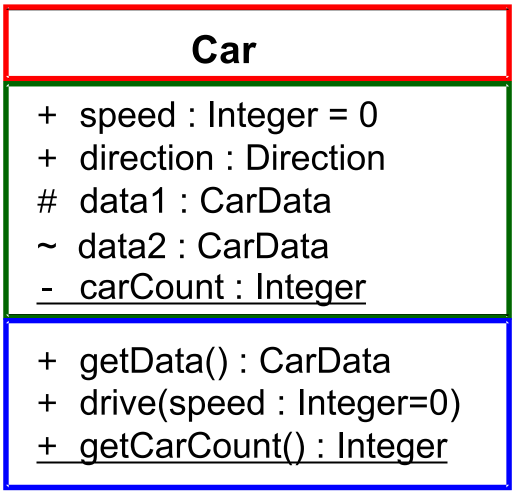
A class is a classifier whose features are attributes and operations

UML modeling elements

- Classes and Interfaces
- Association, Aggregation, Composition, Dependency, and Generalization relationships
- Role names, Multiplicity, Navigation indicators
- Stereotypes
- Tagged values

Class Icon

Class icon consists of *compartments*



Car

+ speed : Integer = 0
+ direction : Direction
# data1 : CarData
~ data2 : CarData
- carCount : Integer

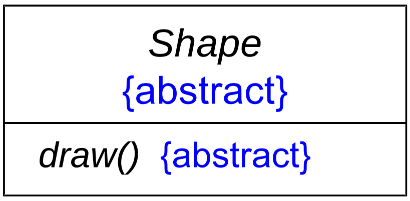
+ getData() : CarData
+ drive(speed : Integer=0)
+ getCarCount() : Integer

(a) Concrete class

```
class Car {
  public int speed;
  public Direction direction;
  protected CarData data1;
  CarData data2;
  static private int carCount;
  public CarData getData(){...}
  public void drive(int speed){...}
  static public int getCarCount(){...}
}
```

☞ visibility ::= {+|-|#|~}

Class Icon (Cont'd)



(b) Abstract class

In Java:

```
abstract class Shape {
  public abstract void draw();
}
```

In C++:

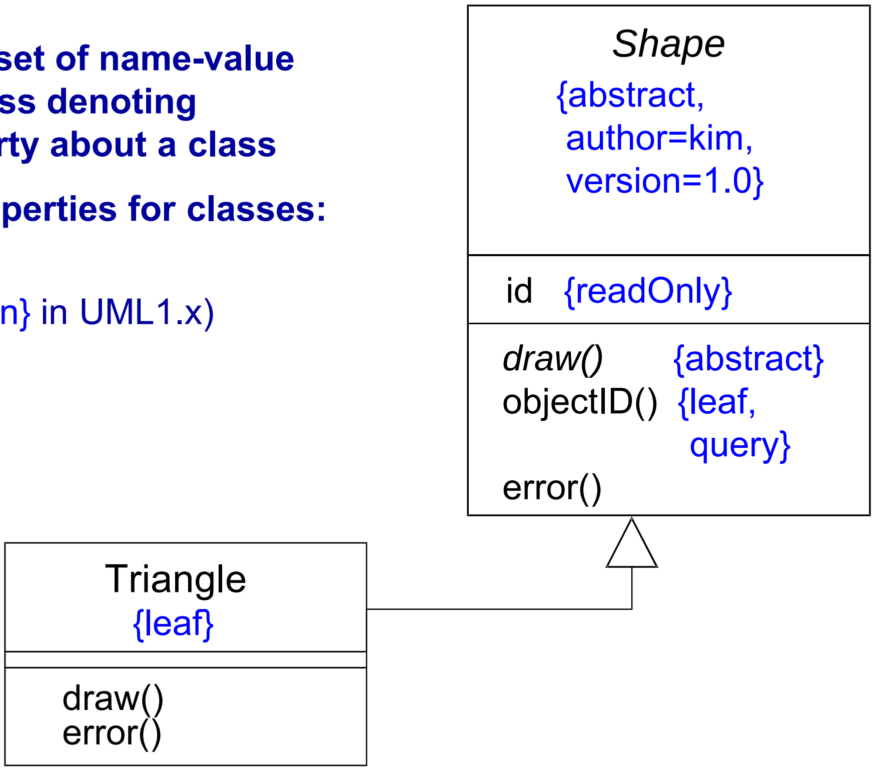
```
class Shape {
public:
  virtual void draw() = 0;
};
```

Tagged Values

Tagged values are a set of name-value associated with a class denoting information or property about a class

Some predefined properties for classes:

- {abstract}, {leaf}
- {readOnly} ({frozen} in UML1.x)
- {query}



Stereotypes

What is a stereotype?

A stereotype extends the vocabulary of UML, allowing you to create new kinds of building blocks that are derived from existing ones but that are specific to your problem

It is drawn in **«guillemets»**

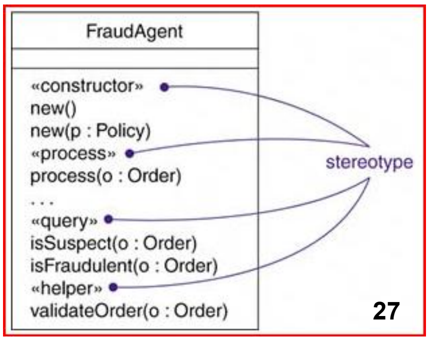
A class stereotype marks the class as having certain properties

Some standard class stereotypes

«metaclass» , **«stereotype»** , **«type»**, **«utility»**, **«powertype»**

You can define your own stereotypes if you like.

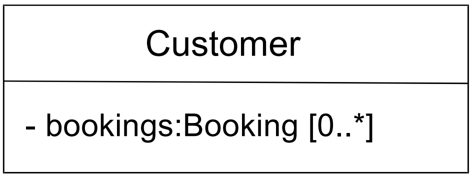
«singleton», **«constructor»**

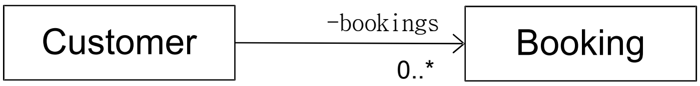


Attributes

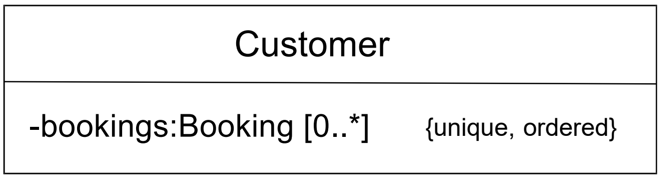
Can be simple data types or relationships to other objects

Can be represented as inlined attributes or relationships between classes





Multiplicity, uniqueness, and ordering can also be specified



Relationships

A class relationship might indicate some kind of *semantic connection* or some sort of *sharing*

- Association
- Aggregation
- Composition
- Generalization
- Dependency

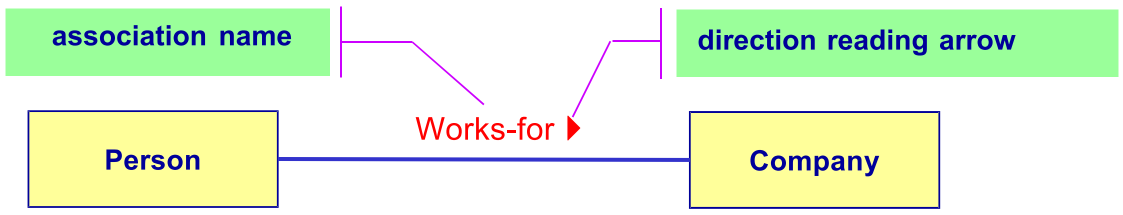
Association

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

- "knows-of" relationship
- An association only denotes a semantic dependency between two classes, but it does not state the exact way in which one class relates to another
- Bi-directional unless otherwise specified *(More on this later!)*

The most weaker form of structural relationship normally identified at analysis and early design phases

- Turned into concrete class relationships as design and implementation continues



association name

direction reading arrow

Person

Works-for ▶

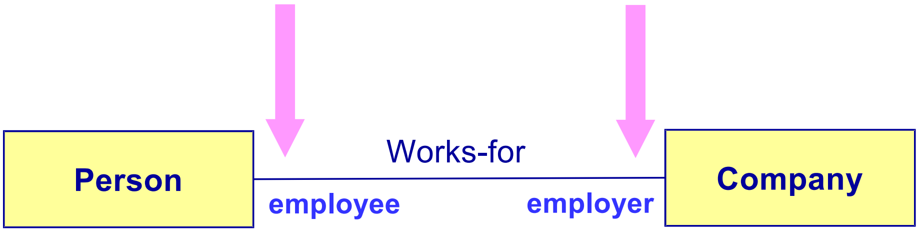
Company

Role Name

Each end of an association is called an "Association End"

A role name is a noun that describes the role that the class plays in the association

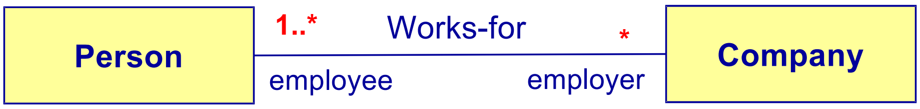
The role name is attached shown near the association end



Association

The multiplicity describes the number of instances of one class that is related to ONE instance of the other class *at any point in time*

* or 0..*	Zero to many
1..*	One to many
0..1	Zero or One
1	One and only one
n..m	Where n and m are any two integers

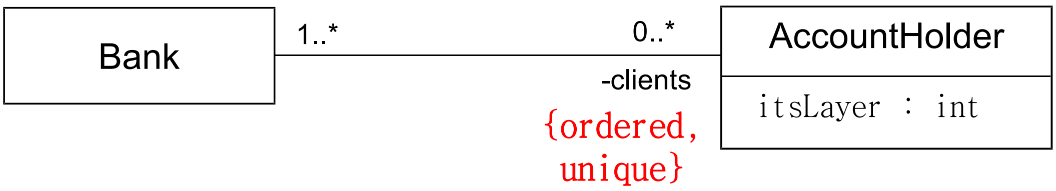


If not explicitly specified, it is "undecided"

Properties

There are several predefined properties for multiplicities greater than 1:

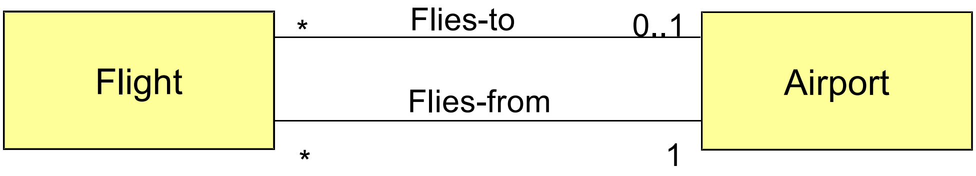
ordered	The elements are ordered into a list
unique	[Default], no duplicate elements

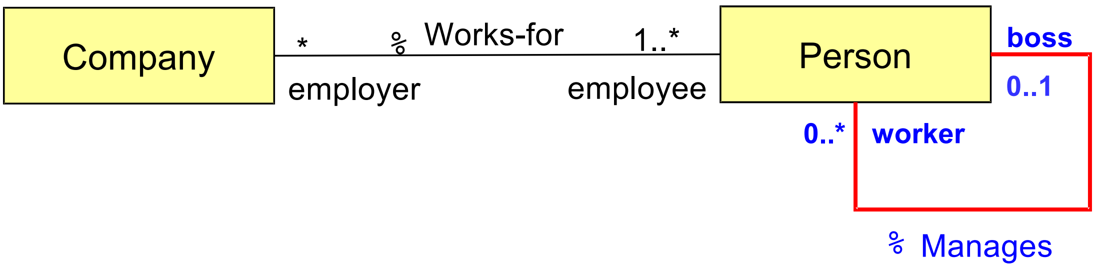


Other properties for attributes can also be specified:

eg. {readOnly}

Multiple & Self Associations

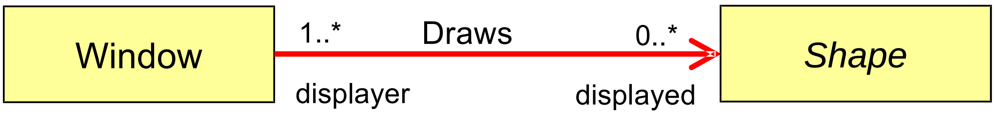




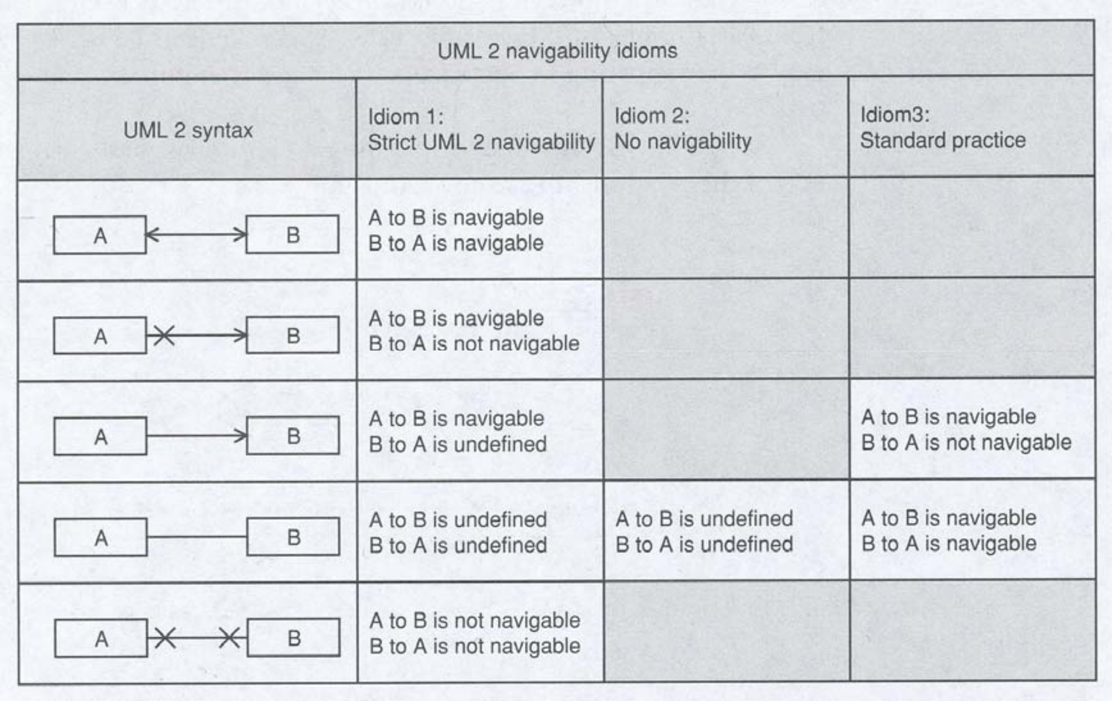
Unidirectional Association

Navigability is shown as an arrowhead on the association end pointing to the class that can be navigated to

“Messages can only be sent in the direction of the arrow”

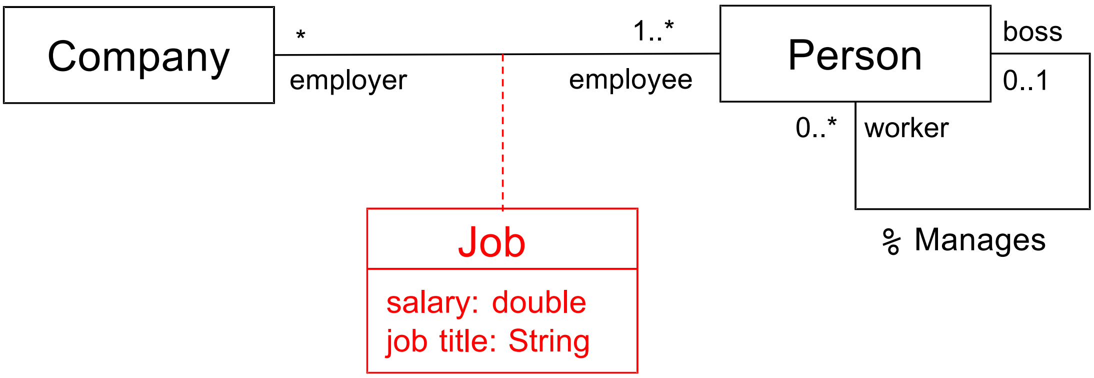


UML 2 Navigability Idioms



UML 2 navigability idioms			
UML 2 syntax	Idiom 1: Strict UML 2 navigability	Idiom 2: No navigability	Idiom3: Standard practice
A ←→ B	A to B is navigable B to A is navigable		
A ×—→ B	A to B is navigable B to A is not navigable		
A —→ B	A to B is navigable B to A is undefined		A to B is navigable B to A is not navigable
A —— B	A to B is undefined B to A is undefined	A to B is undefined B to A is undefined	A to B is navigable B to A is navigable
A ×—× B	A to B is not navigable B to A is not navigable		

Association Class

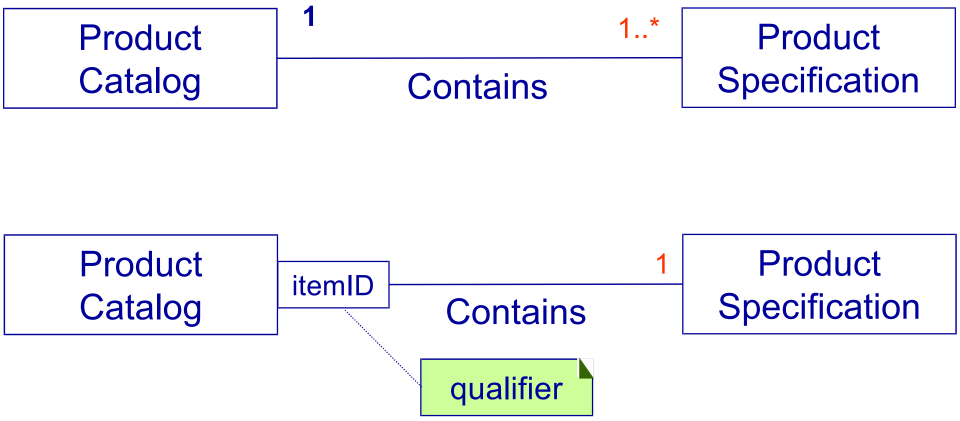


It is useful to model an association as a class when it can have class-like properties, such as attributes, operations, and other associations

Association class can be used only when there is a *single unique link* between two objects at any point in time

Qualified Associations

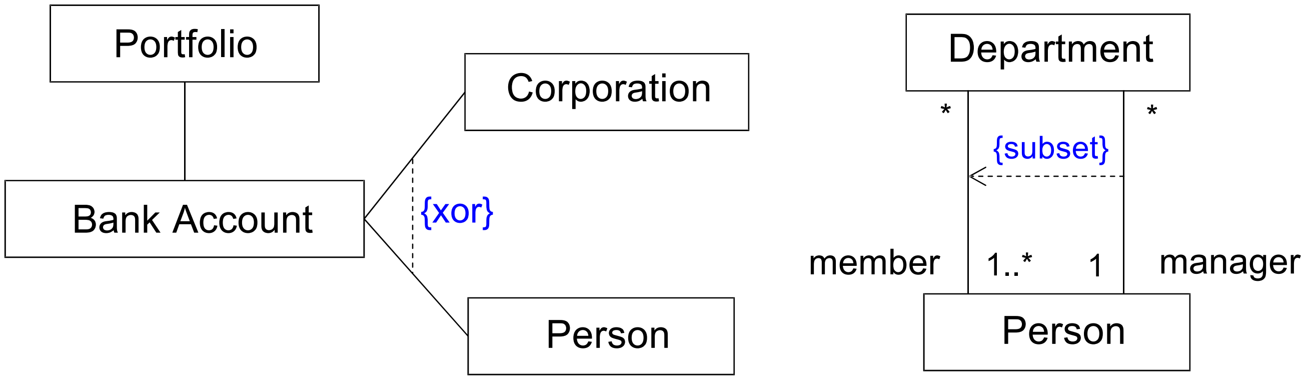
A *qualifier* distinguishes the set of objects at the far end of the association based on the qualifier value. An association with a qualifier is a *qualified association*



Constraints

A constraint specifies a conditions that must be held true for the model to be well-formed

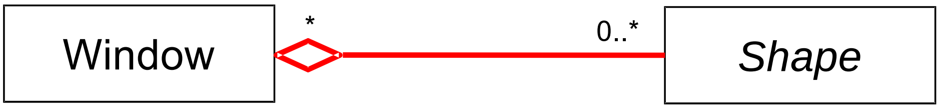
With constraints, you can add new semantics or change existing rules



Aggregation

No semantic difference from "association"

Aggregation represents a "*part-whole* "or "*has-a*" relationship, i.e., the aggregate object (whole) is made up of other objects (parts)



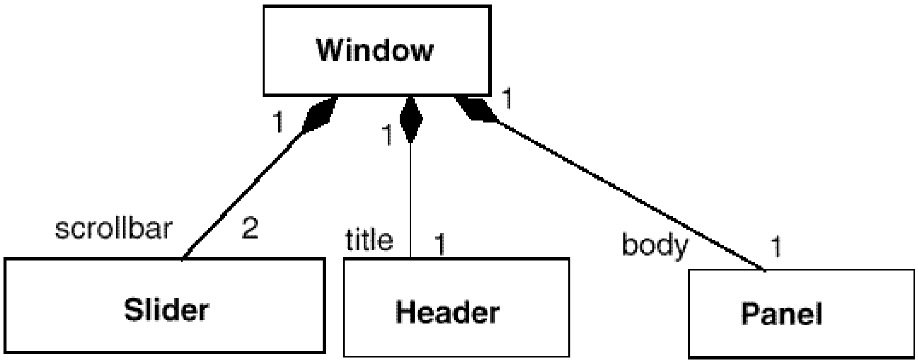
```
class Window {
public: ...
  void  addShape(Shape*); Shape* removeShape(Shape*);
private:
  vector<Shape*> itsShapes;
};
```

Composition Aggregation

A hard form of aggregation denoting *ownership*

Composites control the lifetime of their constituents

Ownership can be transferred, but cannot be shared



Difference between Association and Aggregation

Aggregation denotes part-whole relationship whereas associations do not

However, there is not likely to be much difference in the way the two relationships are implemented

Rule of thumb by three amigos (Rumbaugh, Booch, Jacobson):

" ... if you don't understand [aggregation] don't use it."

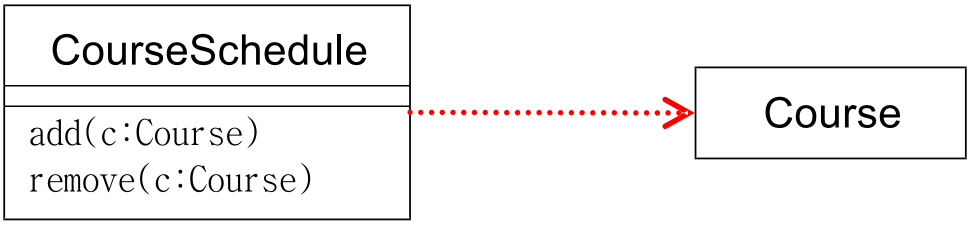
Dependency

A dependency denotes a *using* (*or client-supplier*) relationship, specifying a compile, link, or load time dependence

An object of a client class uses the services of the supplier class to provide its own service

Used when objects share very short term relationships:

- So short that they are not held in pointer or reference variables.



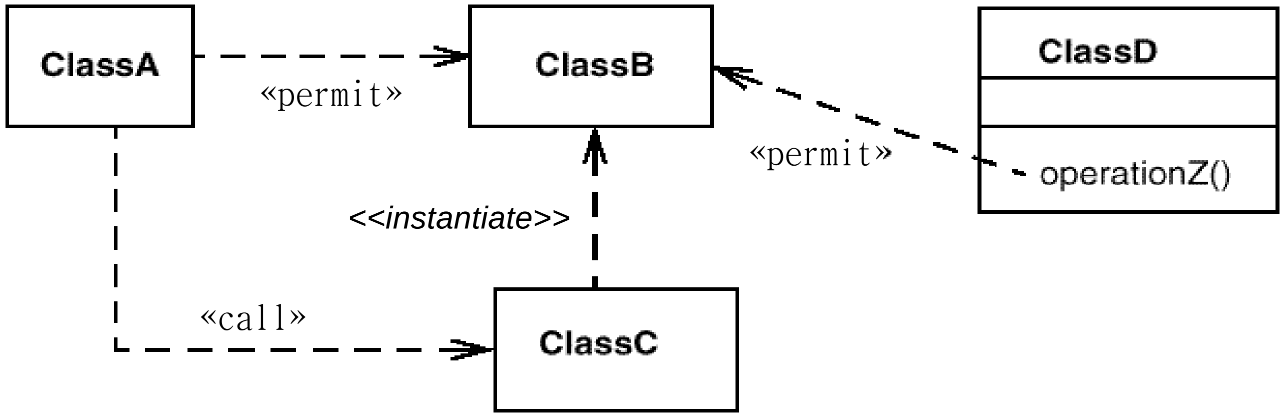
Navigable associations, aggregations, and compositions are also forms of dependency

Dependency
(Cont'd)

Typically used to indicate the decision that

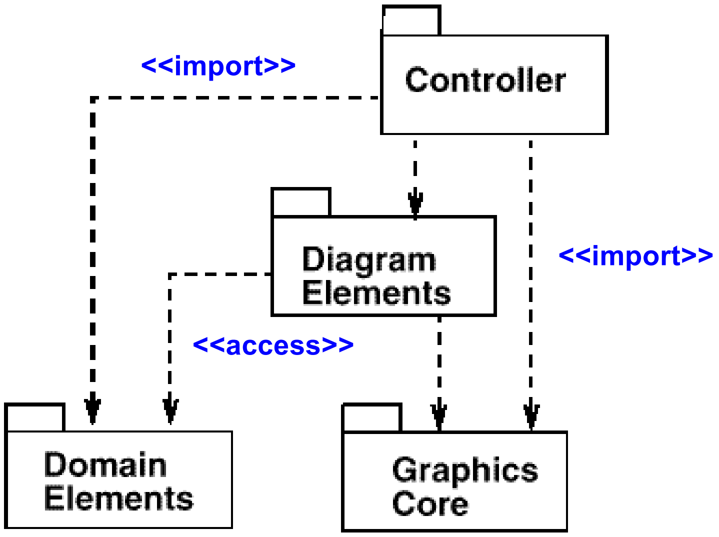
- Operations of the client class invoke operations of the supplier class, or
- Have signatures whose return class or arguments are instances of the supplier class, or
- Creates an instance of the supplier class as a local object

Dependency Example (among Classes)



☞ «permit» used to be «friend», finally dropped in UML 2

Dependency Example (among Packages)

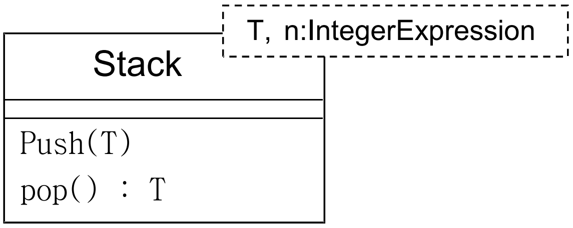


Parameterized Class

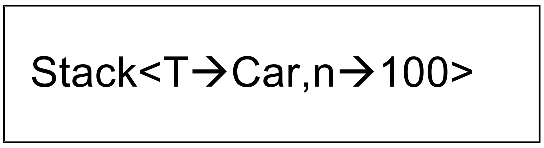
A parameterized class denotes a family of classes whose structure and behavior are defined independently of their formal class parameters

Relationship between a parameterized class and its instantiated classes is also denoted as a dependency with «bind» stereotype.

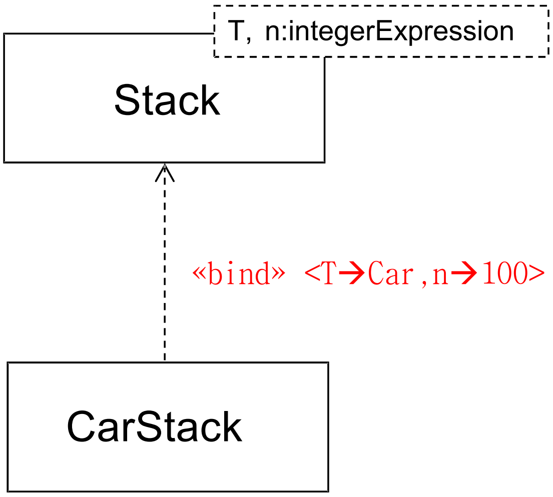
```
template<class T,int n>
class Stack {
public:
   void push(const T&);
   T pop();
..
}
```



Instantiation of Template Classes



(a) Implicit binding

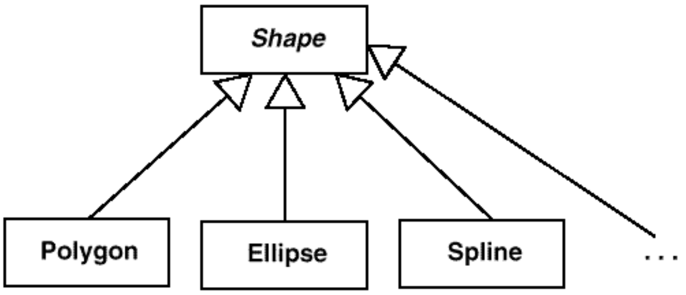


(b) Explicit binding

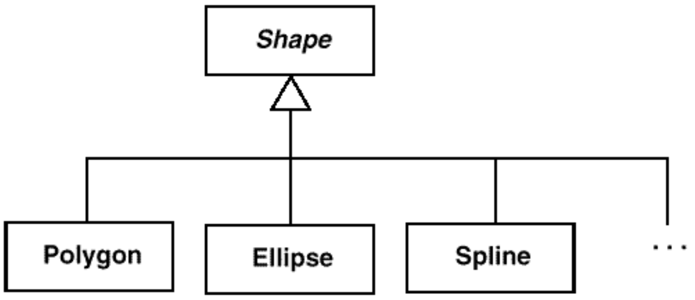
Generalization

- **Relationship between superclass and subclass**
- **Generalization/specialization relationship**
- ***"is a"* relationship**
  - subclass *is a* superclass
  - Cat *is a* Mammal
- **Primary purpose of inheritance is for *subtyping***
  - Remember the Liskov substitution principle
- **Sometimes programmers use the inheritance to accomplish a code reuse by *subclassing* from a super class, which should be avoided whenever possible**
  - Use aggregation instead

Inheritance

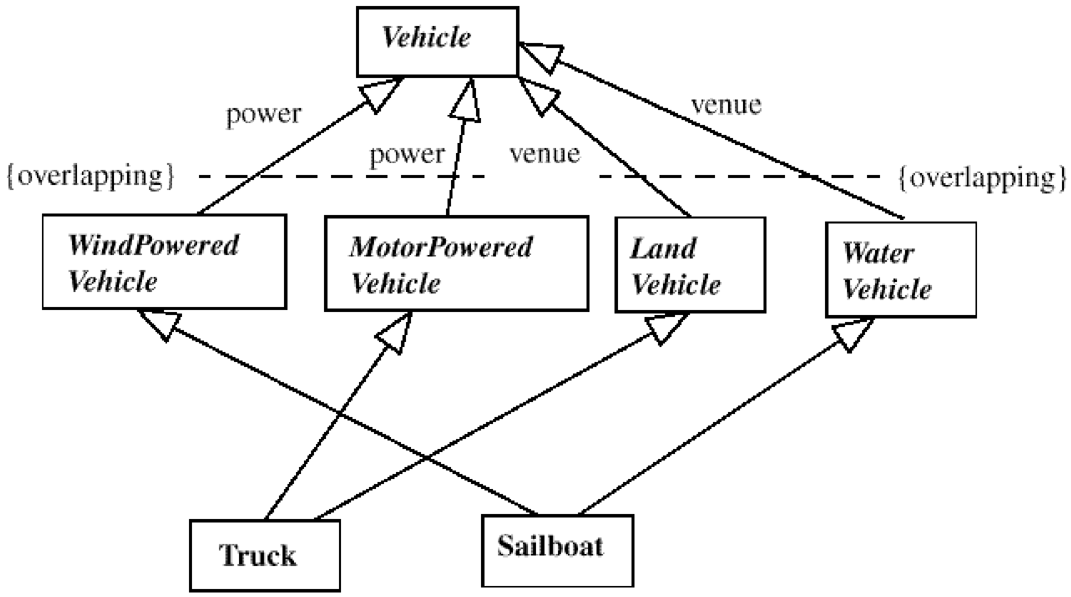


(a) Separate Target Style

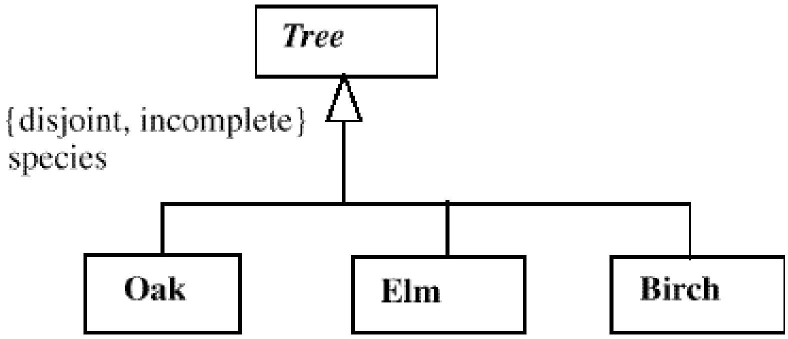


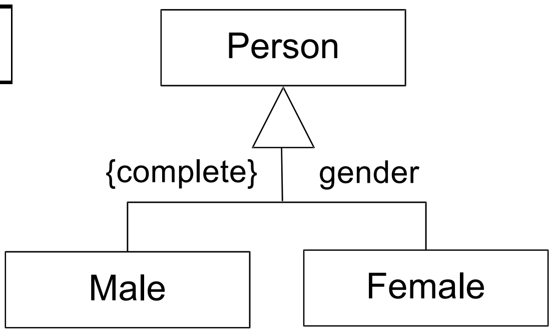
(b) Shared Target Style

Inheritance
(with generalization set names and constraints)



Inheritance
(with Constraints)





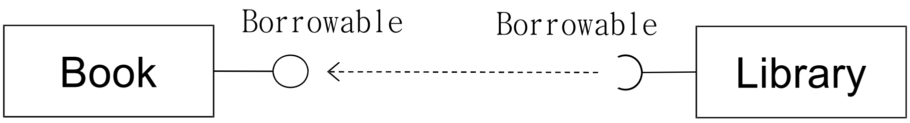
Interfaces

A collection of (abstract) operations that are used to specify a service (or contract) of a class or a component

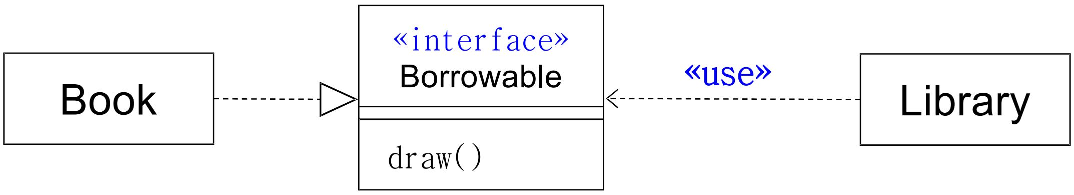
UML interface can also have attributes.

An interface uses a classifier icon with «interface» keyword.

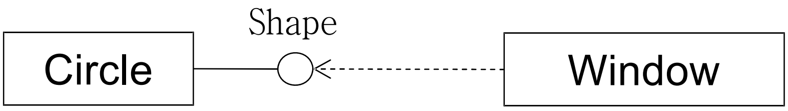
Provided interface *vs.* Required interface



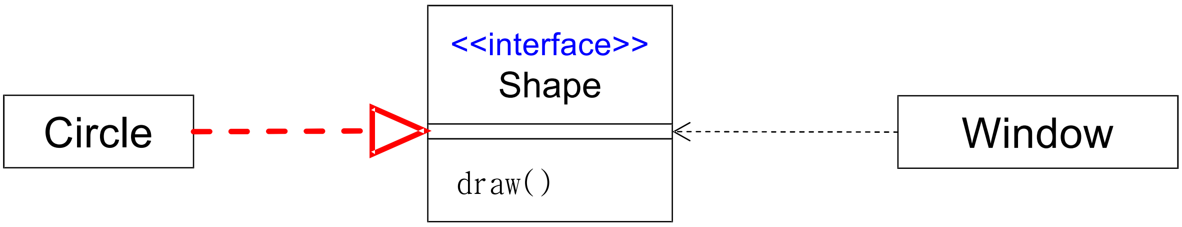
< *ball-socket notation* >



Realization Relationship

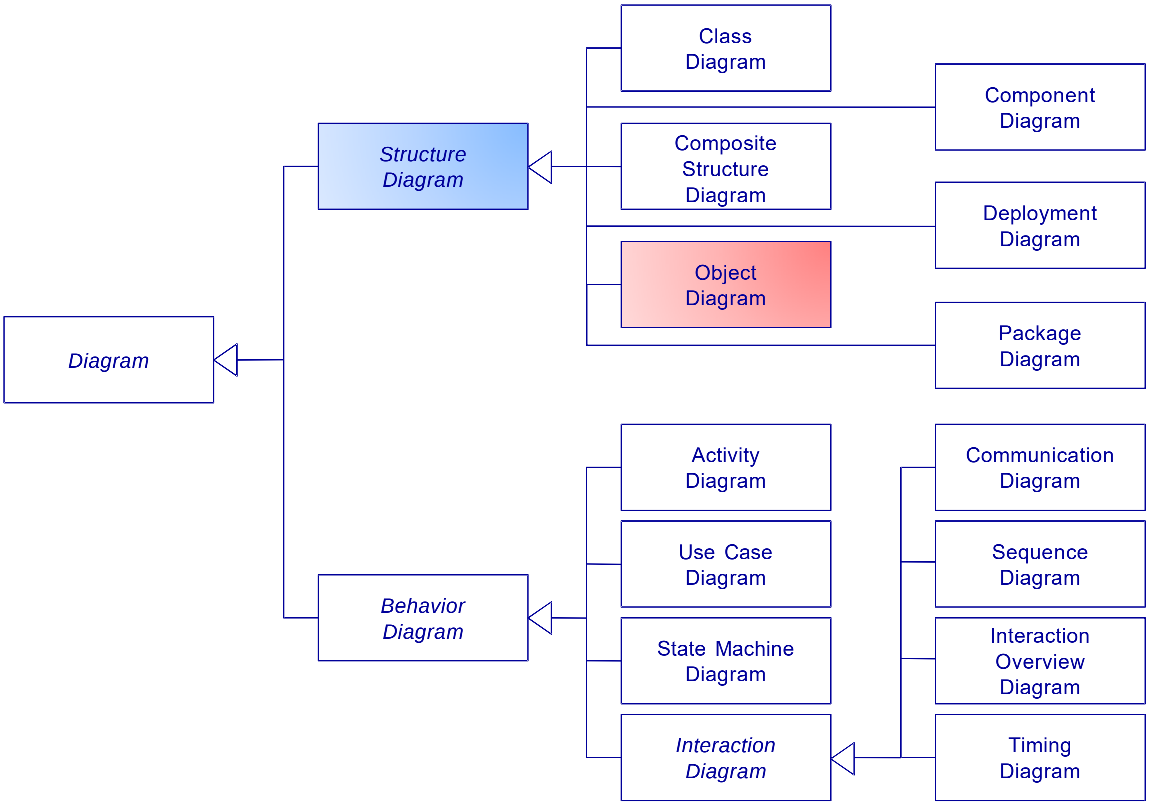


(a) Simple form



(b) Expanded form

Object Diagram



Object Diagram

An object diagram is a graph of instances, including objects and data values.

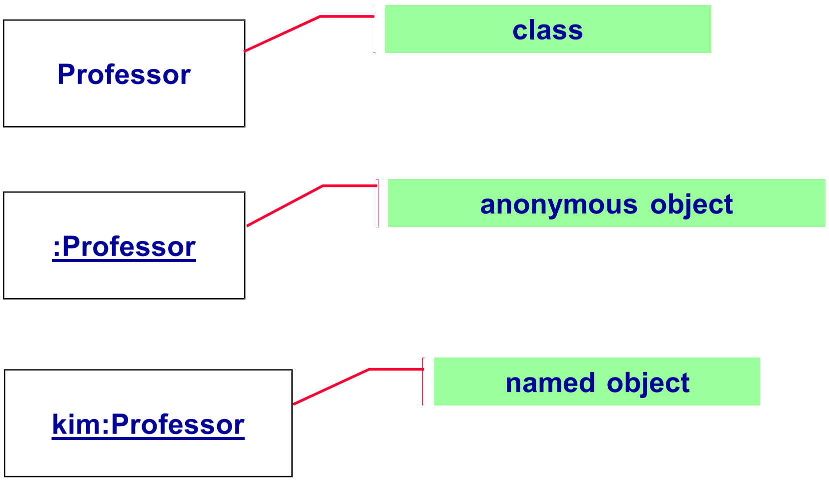
It shows a snapshot of the detailed state of a system at a point in time.

UML modeling elements

Objects

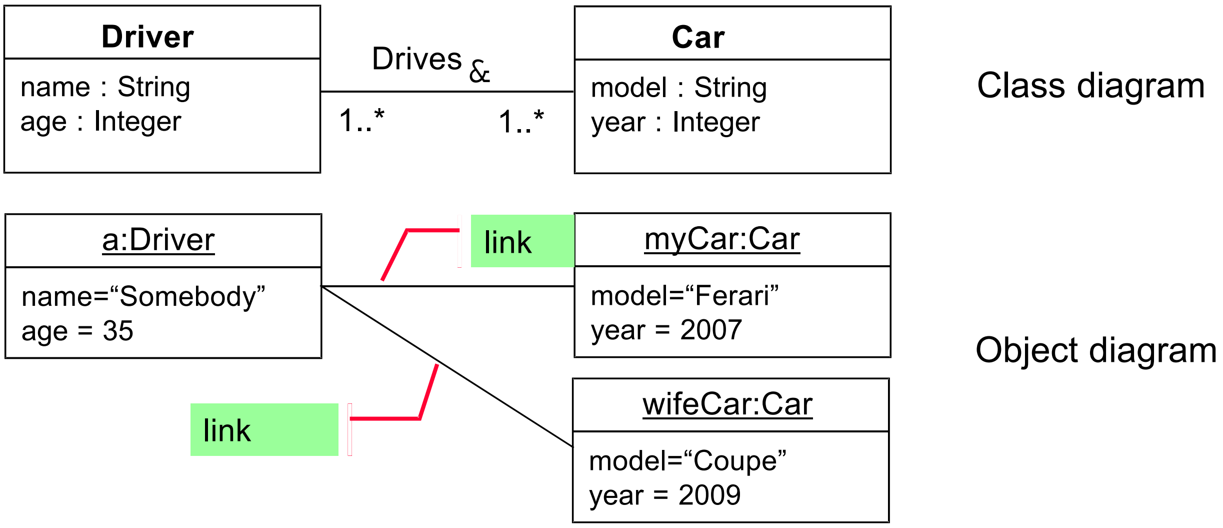
Links

UML Object Icons

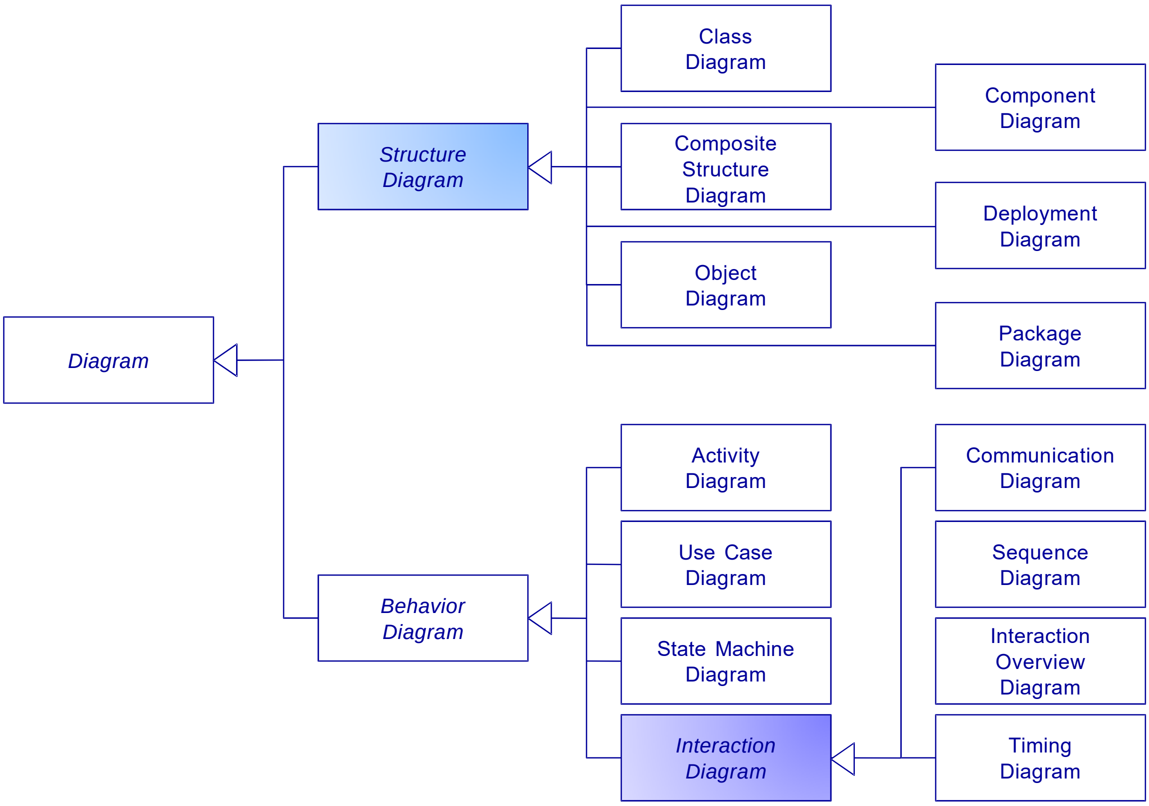


Links

A *link* is an instance of an association which denotes a path between two objects



Interaction Diagram



Interaction Diagram

Describes the communications between Lifelines for a particular scenario by showing Lifelines participating in the interaction and the messages that they exchange

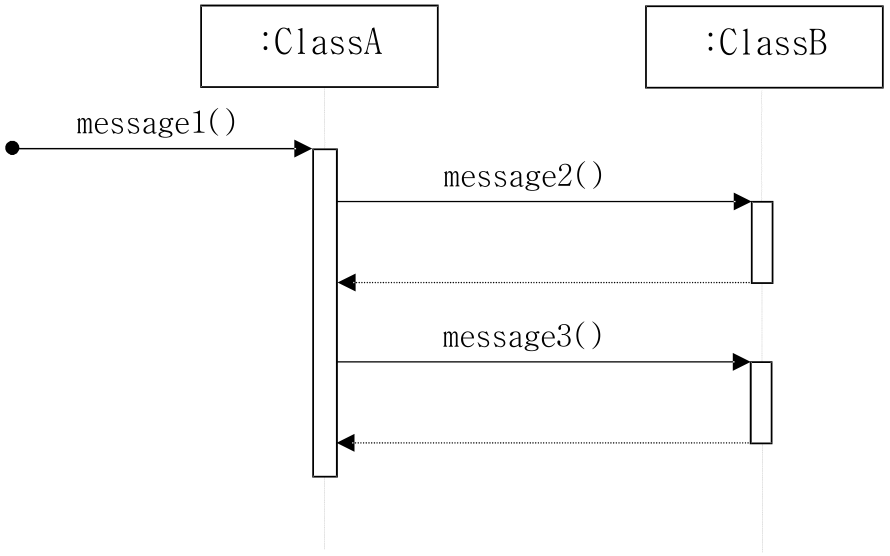
Sequence diagram

focuses on the ***time*** (i.e., order in which the messages are sent)

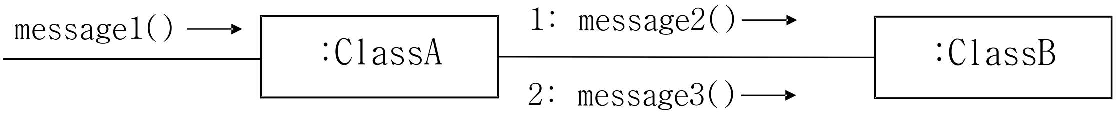
Communication diagram (*was* Collaboration diagram)

focuses on the ***space*** (relationships between Lifelines)

Sequence Diagram



Communication Diagram



Lifeline

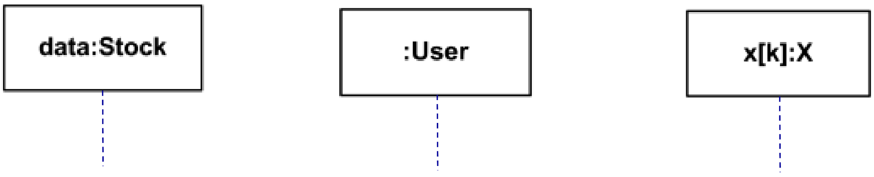
Lifeline denotes a connectable element which represents an *individual participant* in the interaction

Lifelines represent *only one* interacting entity

Must use a *selector* to specify only one specific element from multivalued connectable element (i.e., multiplicity > 1)

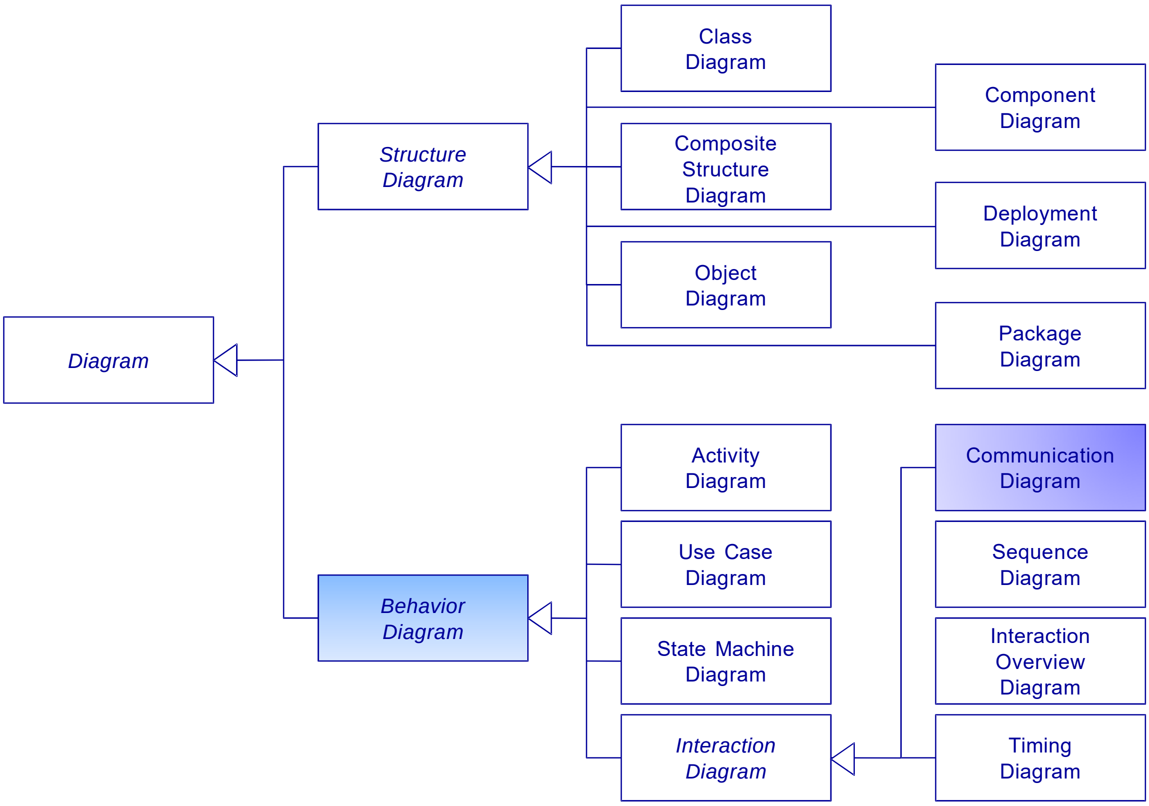
A Lifeline is shown as a rectangle, called "head "

Lifeline in sequence diagrams does have "tail" representing the **line of life** whereas "lifeline" in **communication diagram** has no tail



[k] is a selector

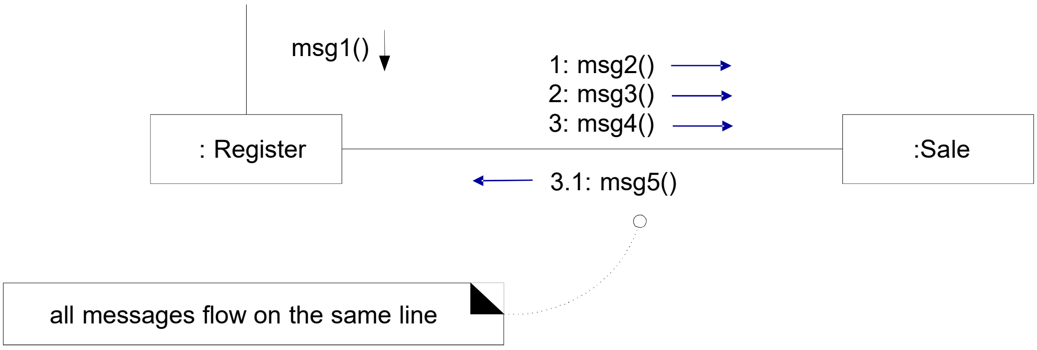
Communication Diagram



Illustrating Messages

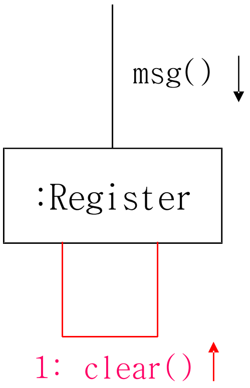
A message is represented via a labeled arrow on a line

A sequence number is added to show the sequential order of messages in the current thread of control

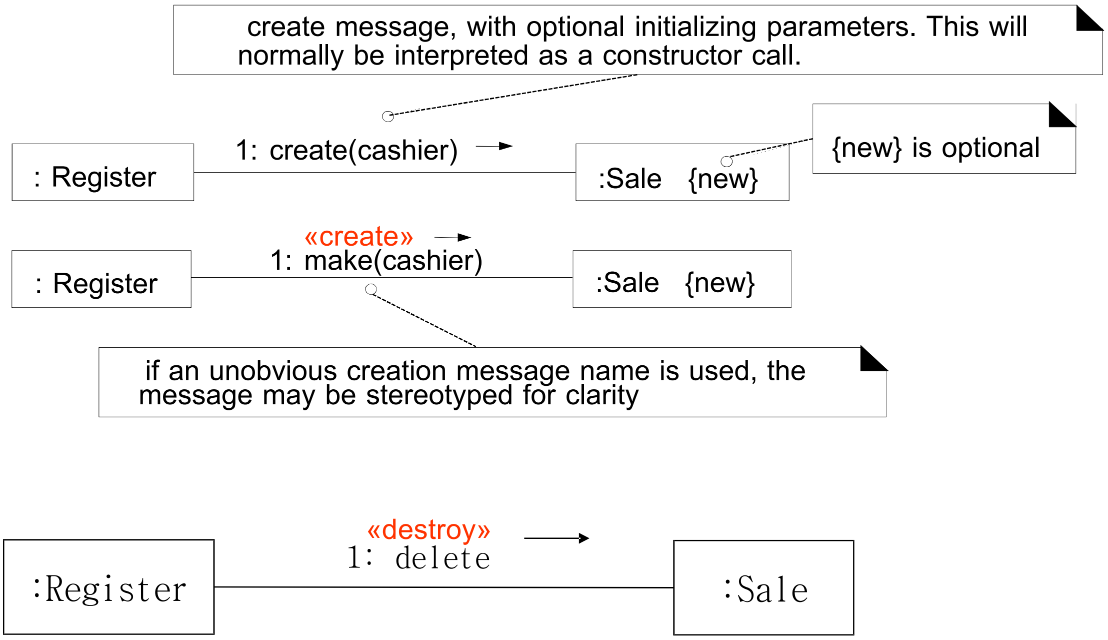


Illustrating Messages to “self”

A message can be sent from a Lifeline to itself



Illustrating Object Creation & Deletion



create message, with optional initializing parameters. This will normally be interpreted as a constructor call.

: Register

1: create(cashier)

:Sale {new}

{new} is optional

«create»

1: make(cashier)

: Register

:Sale {new}

if an unobvious creation message name is used, the message may be stereotyped for clarity

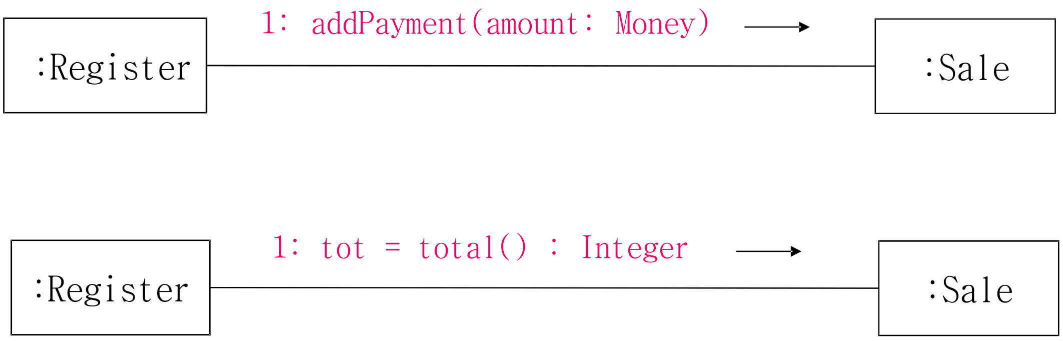
:Register

«destroy»

1: delete

:Sale

Illustrating Parameters & Return Value



:Register

1: addPayment(amount: Money)

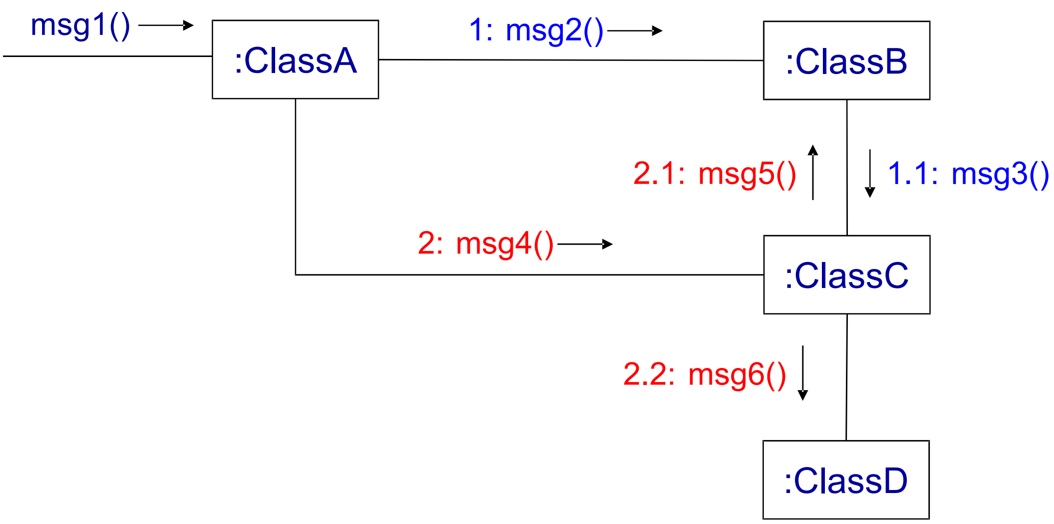
:Sale

:Register

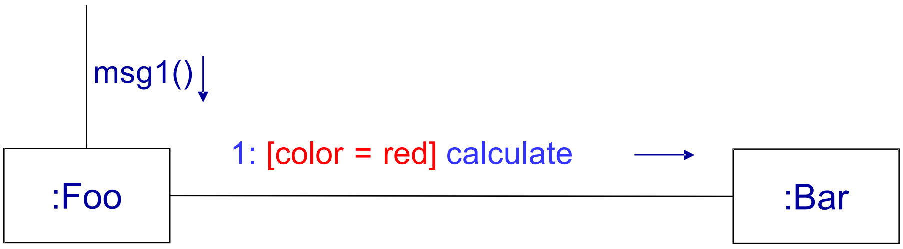
1: tot = total() : Integer

:Sale

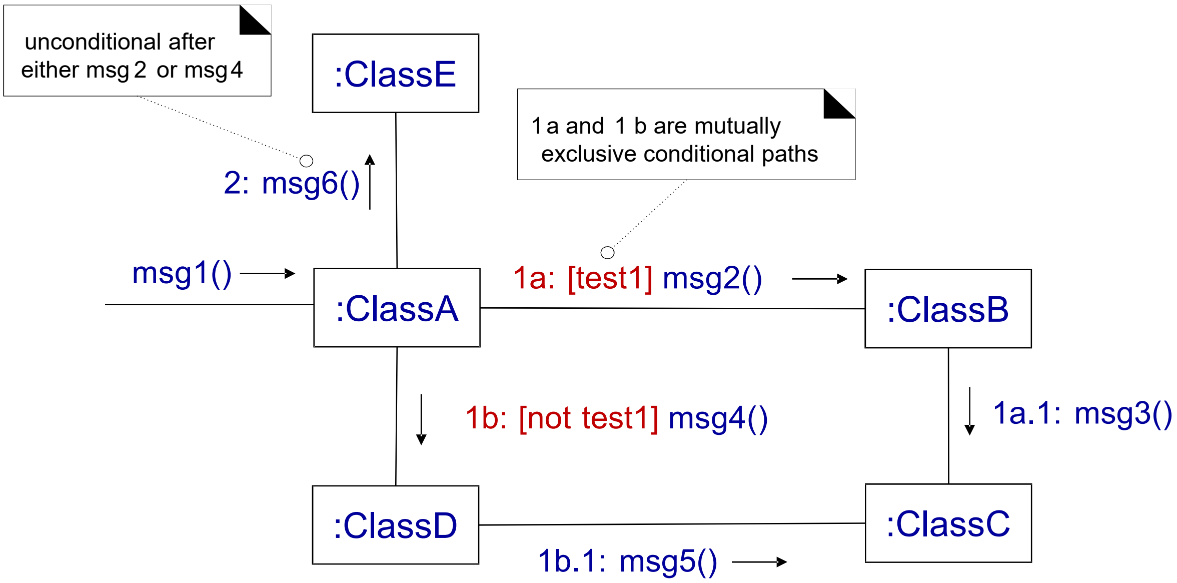
Message Number Sequencing



Illustrating Conditional Messages

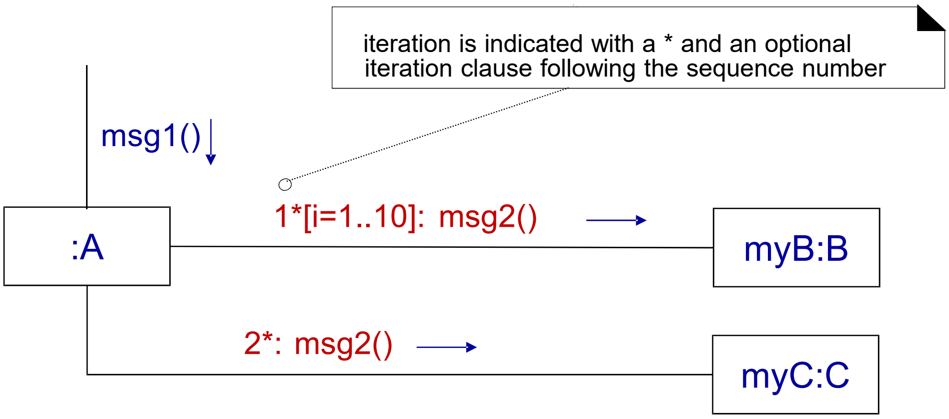


Mutually Exclusive Conditional Paths

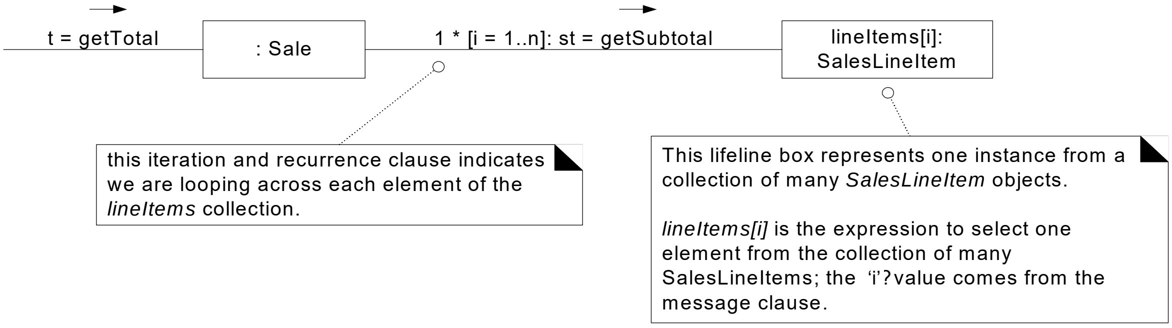

unconditional after either msg 2 or msg 4

1 a and 1 b are mutually exclusive conditional paths

Illustrating Iteration or Looping


iteration is indicated with a * and an optional iteration clause following the sequence number

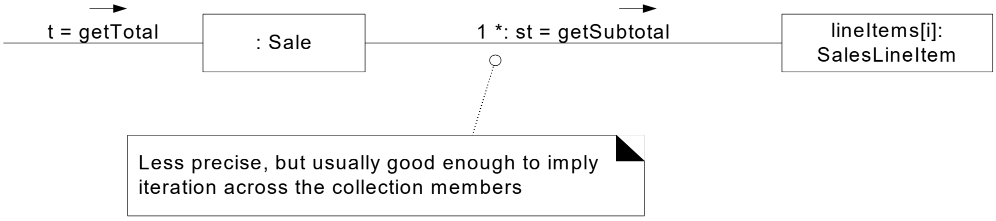
Illustrating Iterations



this iteration and recurrence clause indicates we are looping across each element of the *lineItems* collection.

This lifeline box represents one instance from a collection of many *SalesLineItem* objects.

lineItems[i] is the expression to select one element from the collection of many SalesLineItems; the ‘i’?value comes from the message clause.

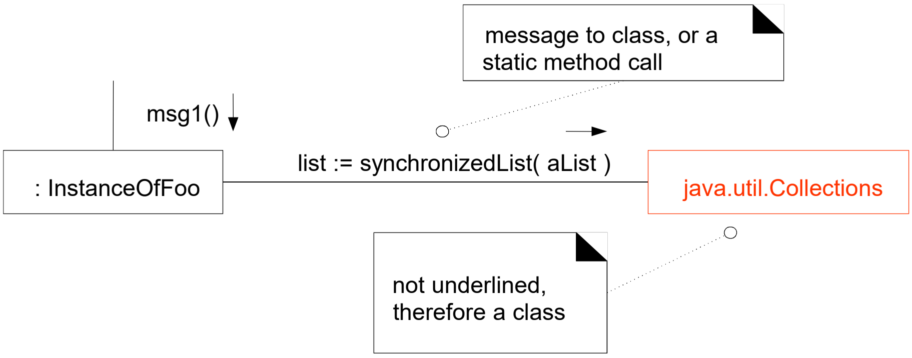


Less precise, but usually good enough to imply iteration across the collection members

Messages to a Class

Messages may be sent to a class itself, rather than an instance

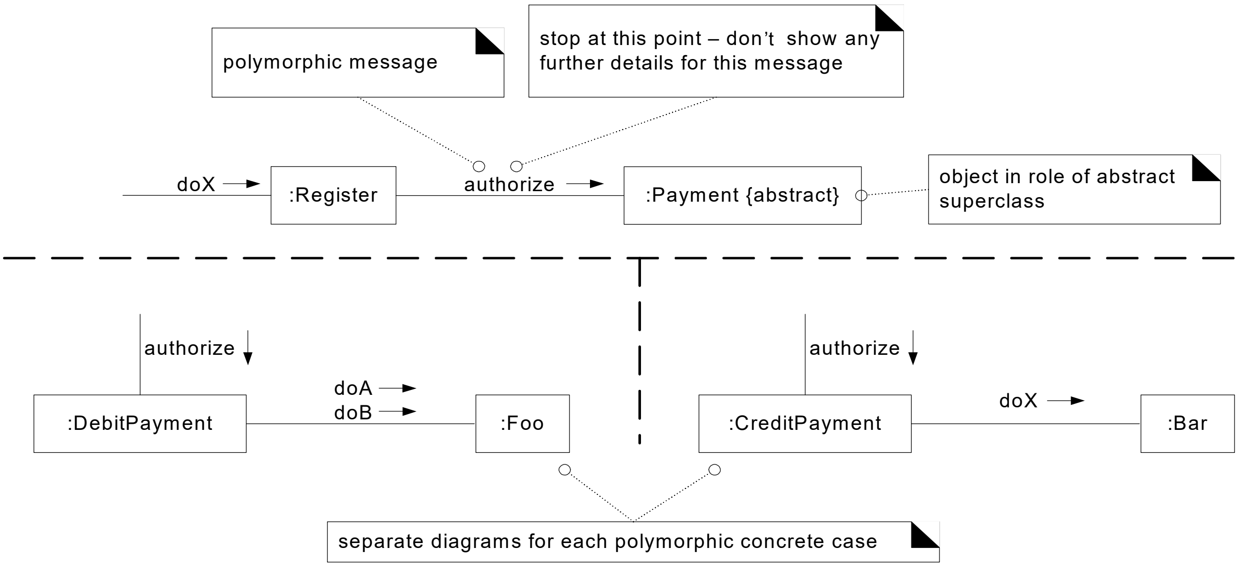
Class methods (aka, static methods) in Java and C++



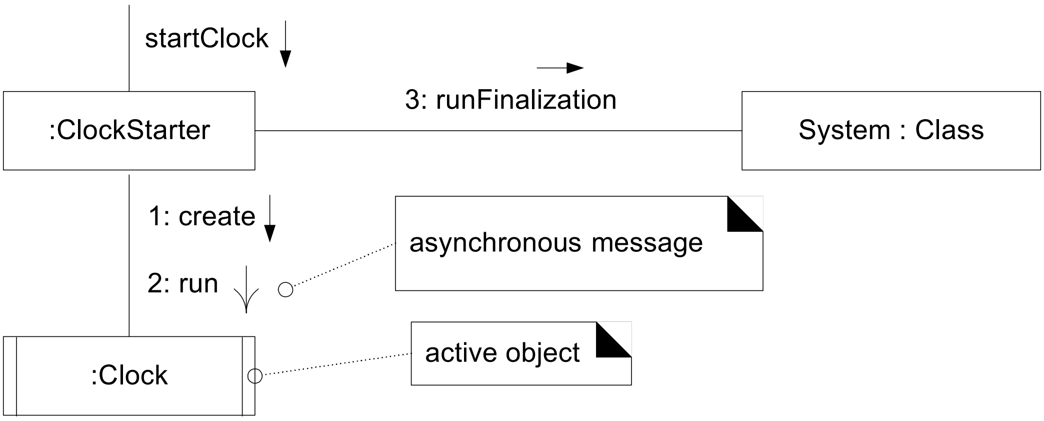
message to class, or a static method call

not underlined, therefore a class

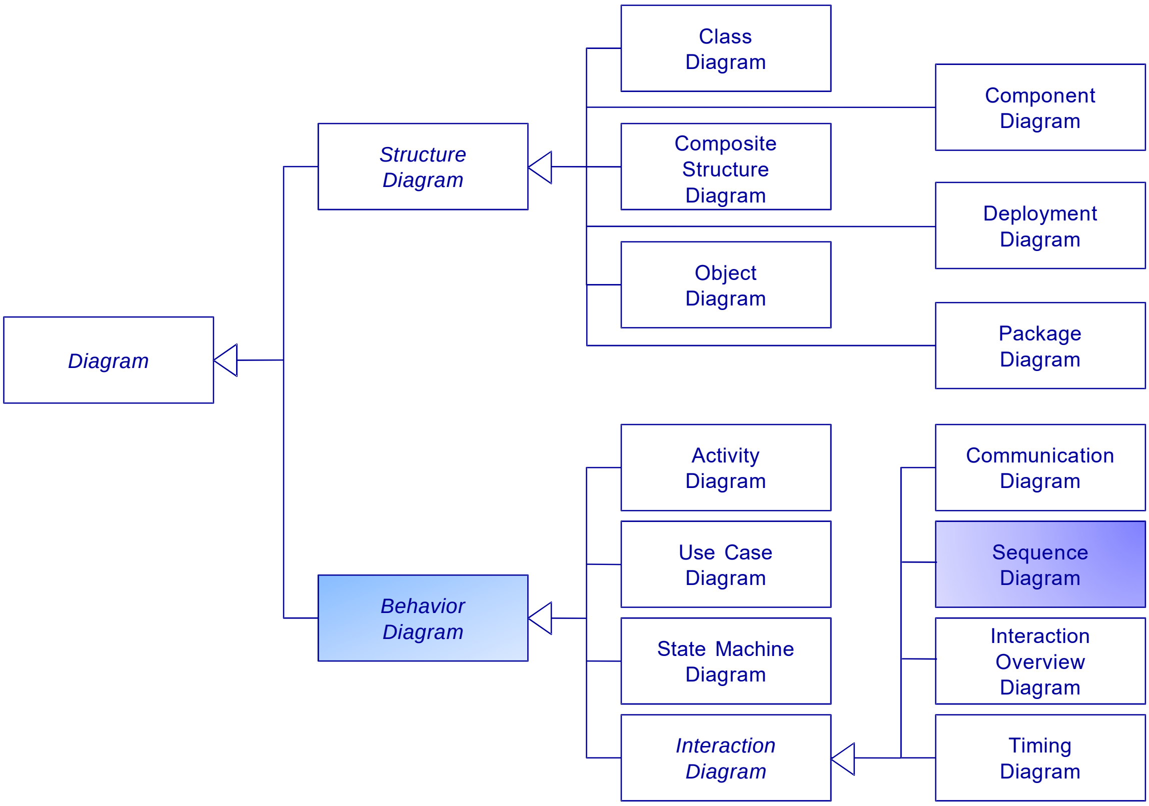
Polymorphic Messages


polymorphic message
stop at this point – don't show any further details for this message
doX
:Register
authorize
:Payment {abstract}
object in role of abstract superclass
authorize
:DebitPayment
doA
doB
:Foo
authorize
:CreditPayment
doX
:Bar
separate diagrams for each polymorphic concrete case

Active Objects & Asynchronous Messages



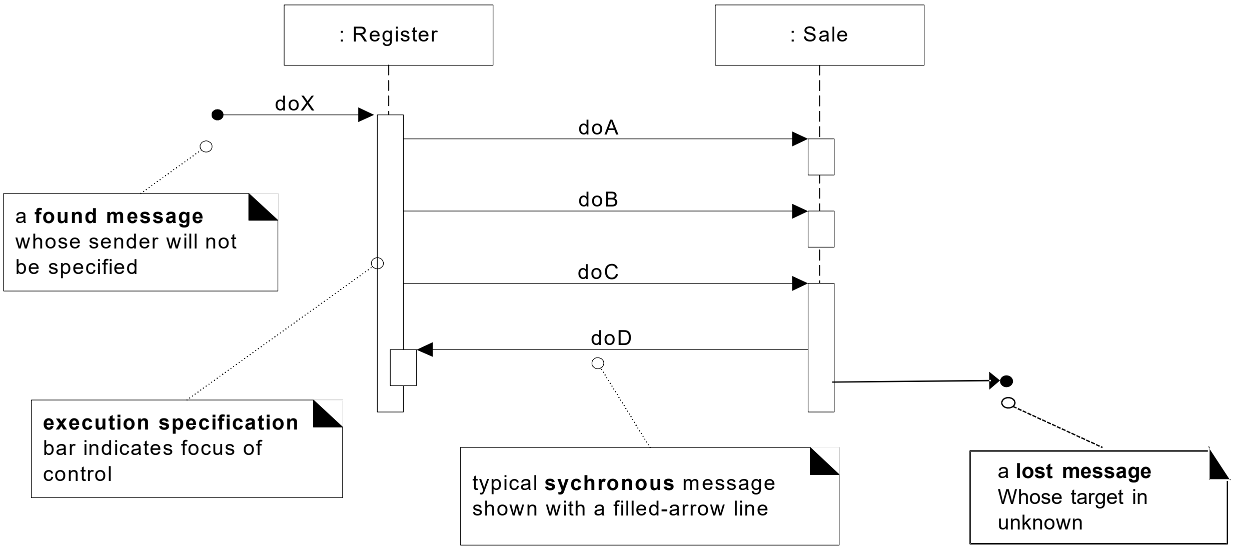
Sequence Diagram



Sequence Diagram

A message is represented via a labeled arrow line between Lifelines

The time ordering is organized from top to bottom



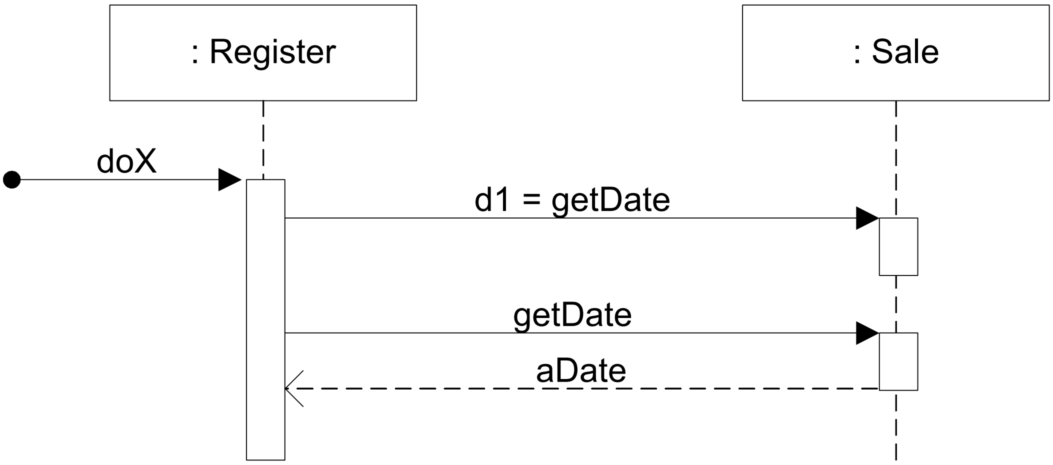
a **found message** whose sender will not be specified

execution specification bar indicates focus of control

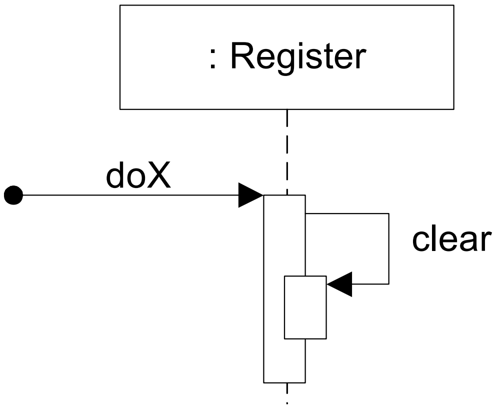
typical **sychronous** message shown with a filled-arrow line

a **lost message** Whose target in unknown

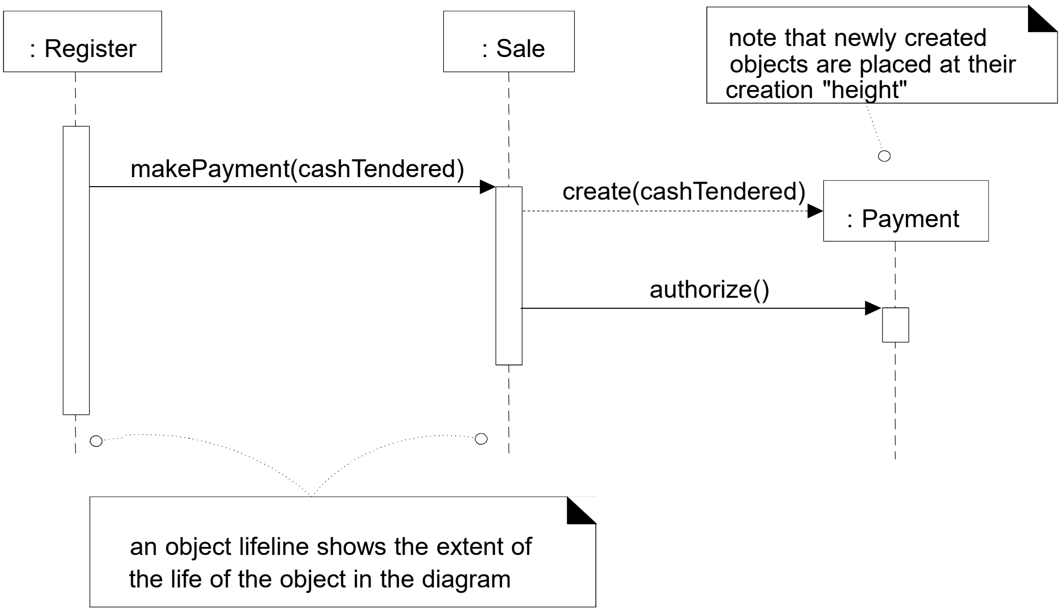
Illustrating Returns



Illustrating Messages to “self”



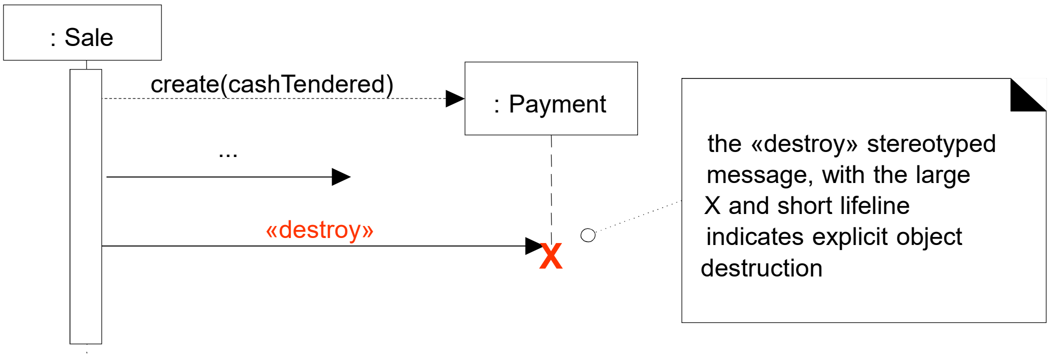
Illustrating Object Creation



note that newly created objects are placed at their creation "height"

an object lifeline shows the extent of the life of the object in the diagram

Illustrating Object Destruction

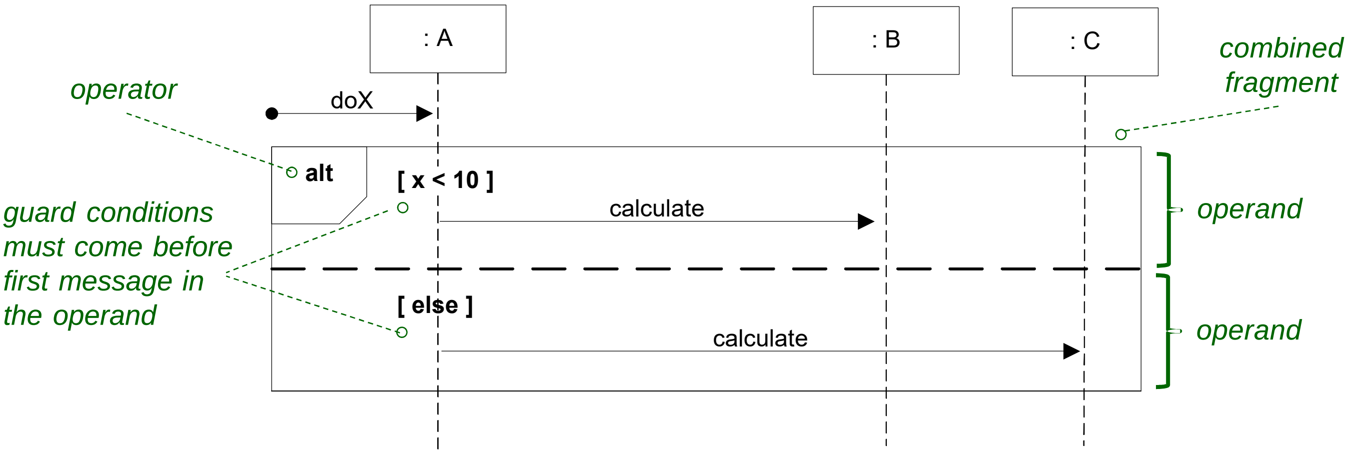


the «destroy» stereotyped message, with the large X and short lifeline indicates explicit object destruction

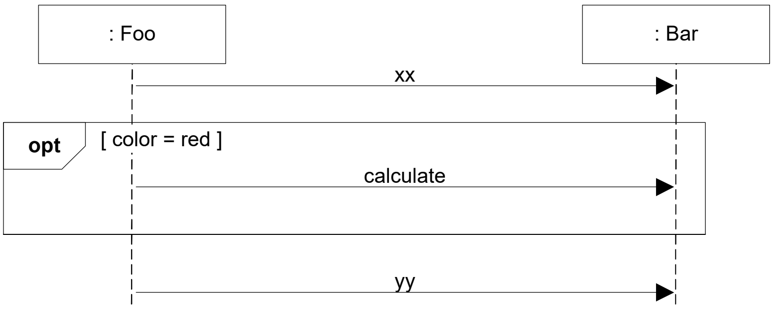
Combined Fragment

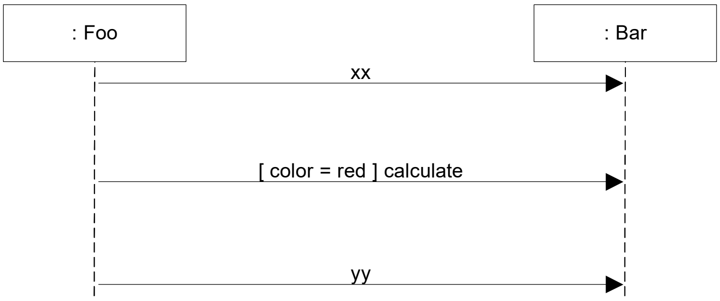
A combined fragment has one *operator*, one or more *operands*, and zero or more *guard conditions*

- The operator determines how its operands are executed
- Guard conditions are Boolean expressions to determine whether their operands execute

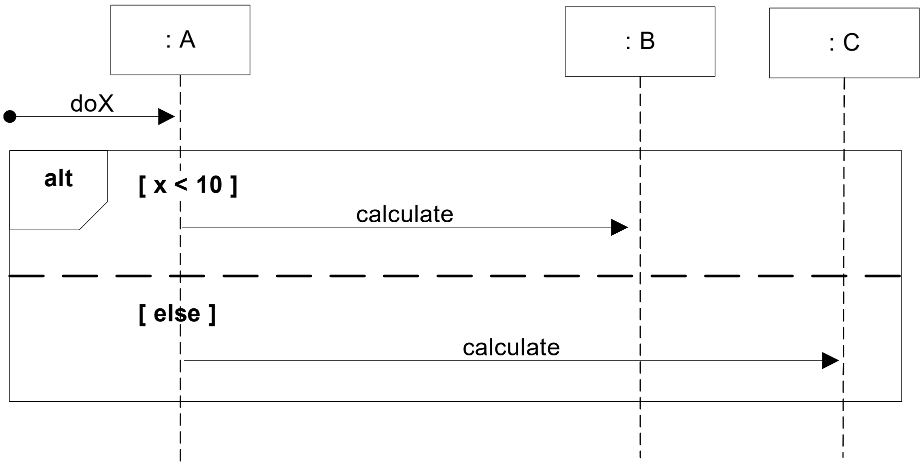


Illustrating Conditional Messages

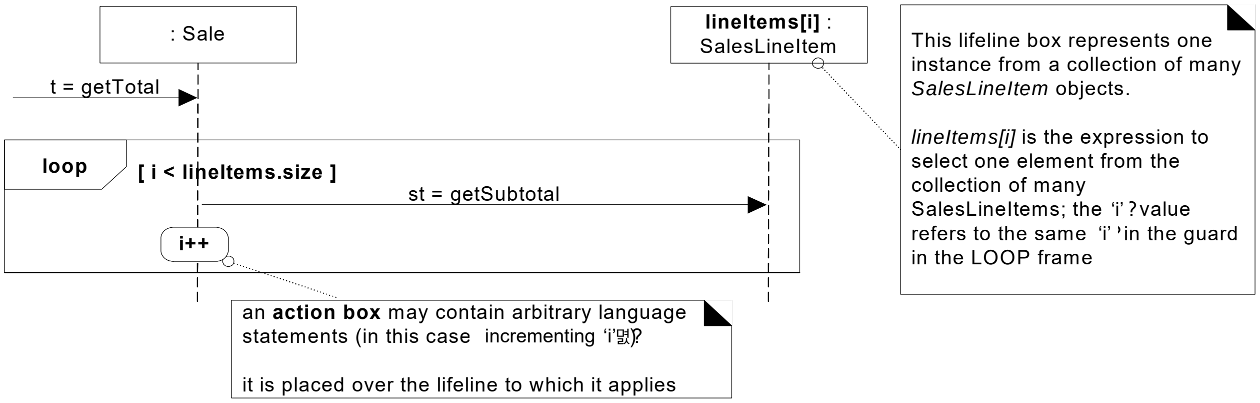




Illustrating Conditional Messages
(Cont’d)



Illustrating Iteration or Looping

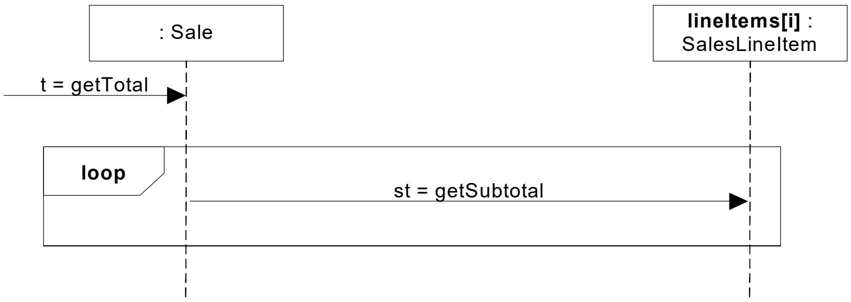


This lifeline box represents one instance from a collection of many *SalesLineItem* objects.

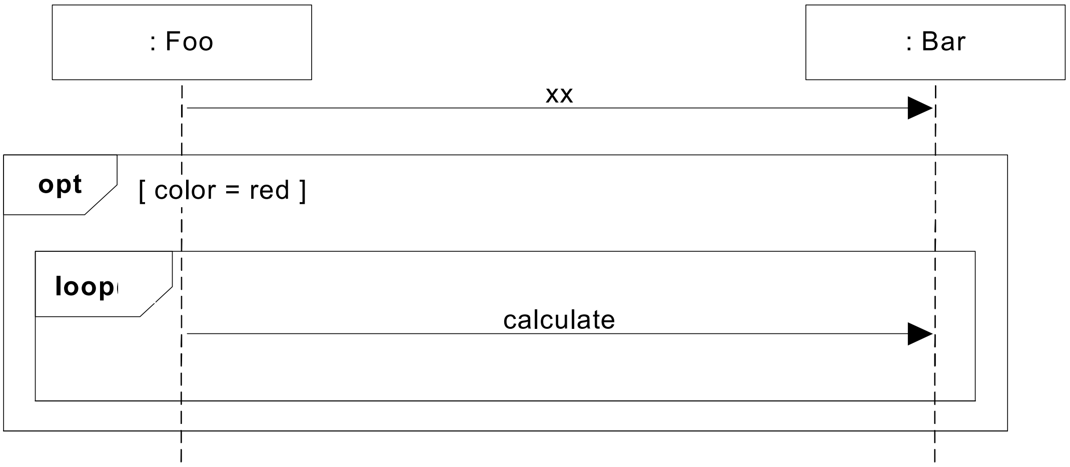
lineItems[i] is the expression to select one element from the collection of many SalesLineItems; the ‘i’ ?value refers to the same ‘i’ ’in the guard in the LOOP frame

an **action box** may contain arbitrary language statements (in this case incrementing ‘i’몄)?

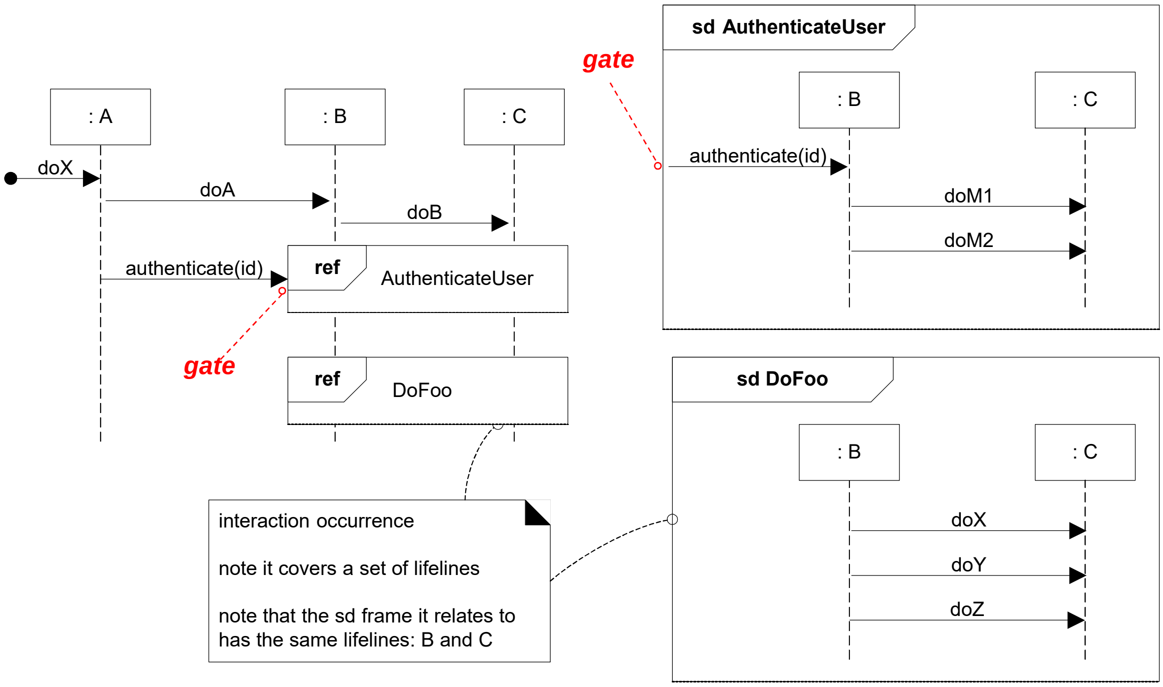
it is placed over the lifeline to which it applies



Illustrating Condition & Iteration



Reference to Other SD

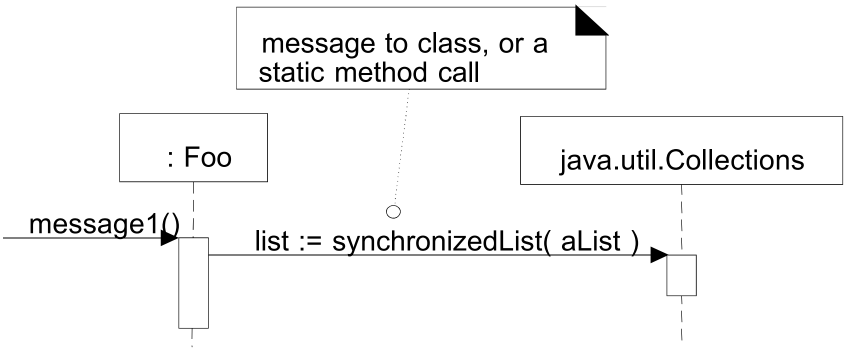


interaction occurrence

note it covers a set of lifelines

note that the sd frame it relates to has the same lifelines: B and C

Messages to a Class

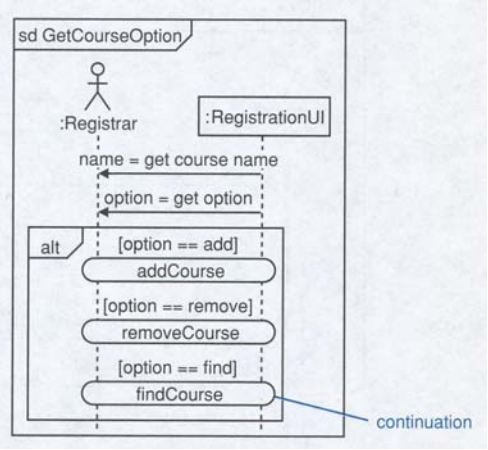


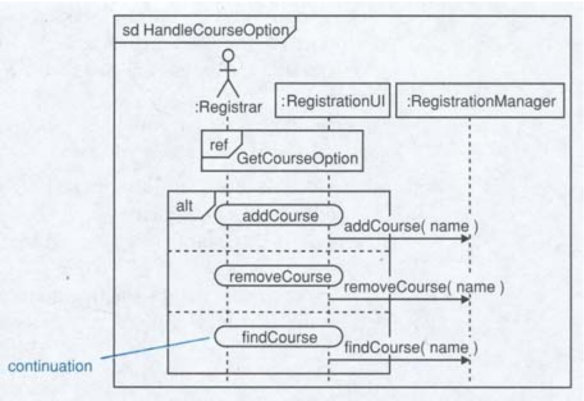
message to class, or a static method call

Continuations

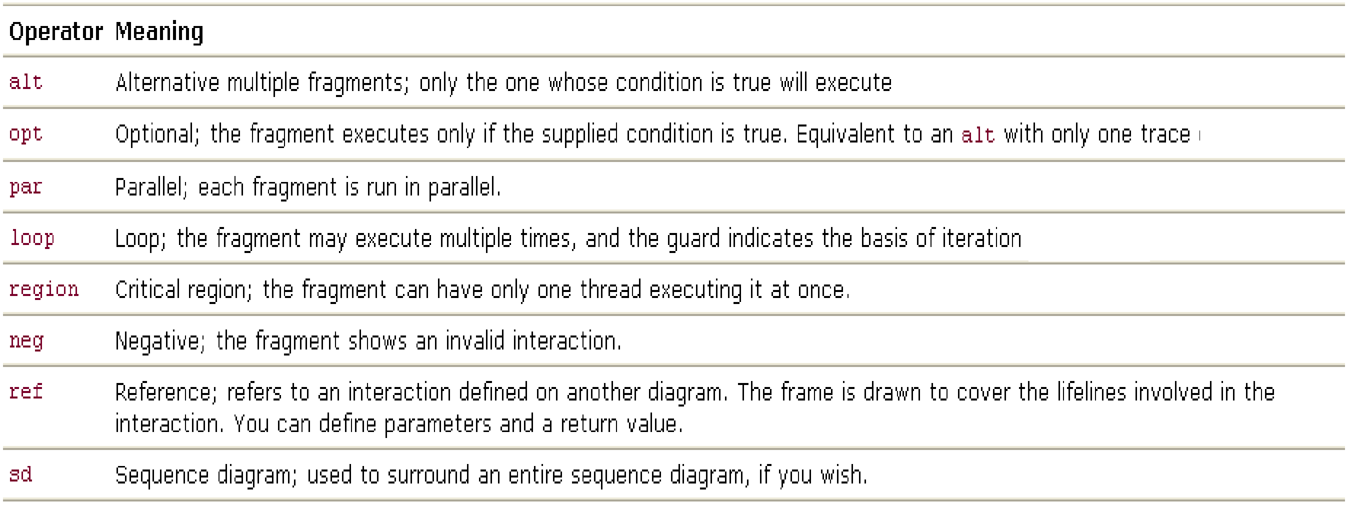
Continuations terminate an interaction fragment so that it can be continued by another fragment.

- Used first item in the fragment → will be continuing from another fragment
- Used last item in the fragment → the fragment terminates but may be continued by another fragment





Operators for Combined Fragments



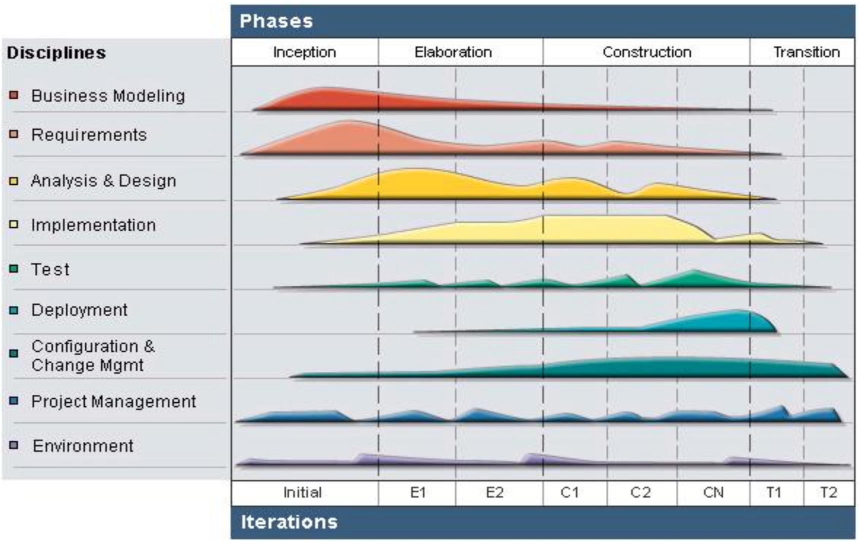
Operator	Meaning
alt	Alternative multiple fragments; only the one whose condition is true will execute
opt	Optional; the fragment executes only if the supplied condition is true. Equivalent to an alt with only one trace
par	Parallel; each fragment is run in parallel.
loop	Loop; the fragment may execute multiple times, and the guard indicates the basis of iteration
region	Critical region; the fragment can have only one thread executing it at once.
neg	Negative; the fragment shows an invalid interaction.
ref	Reference; refers to an interaction defined on another diagram. The frame is drawn to cover the lifelines involved in the interaction. You can define parameters and a return value.
sd	Sequence diagram; used to surround an entire sequence diagram, if you wish.

UML References

- Grady Booch, James Rumbaugh, Ivar Jacobson, *The Unified Modeling Language User Guide*, 2nd ed., Addison-Wesley, 2005.
- James Rumbaugh, Ivar Jacobson, Grady Booch, *The Unified Modeling Language Reference Manual, 2nd ed.*, Addison-Wesley, 2004.
- Ivar Jacobson, Grady Booch, James Rumbaugh, *The Unified Software Development Process,* Addison-Wesley, 1999.
- Dan Pilone et al, *UML 2.0 In a Nutshell,* O'Reilly, 2005.
- Martin Fowler, *UML Distilled, 3rd ed.*, Addison-Wesley, 2004.
- Tim Weilkens et al, *UML 2 Certification Guide,* 3rd ed., Morgan Kaufman Publishers, 2007.
- Bruce Powel Douglass, *Real-Time UML*, 3rd ed., Addison-Wesley, 2004.

Object-Oriented Analysis and Design using UML and Patterns

Unified Process (UP)



OOAD and Unified Process

Objectives

Define object-oriented analysis and design (OOA/D)

Illustrate a brief OOA/D example

Overview UP and define fundamental concepts in UP

Introduce our case study

Analysis

Analysis emphasizes an *investigation*, *understanding*, and *discovery* of the problem domain and requirements

what the problem is about and *what a system must do*

Analysis does not concern how a logical solution is defined

All the vocabularies (e.g., class name, relationships, etc.) used in the analysis must come from the problem domain

Analysis requires domain knowledge and analyst expertise

Requirements Analysis & Object Analysis

Requirements Analysis

Investigation of functional & non-functional requirements

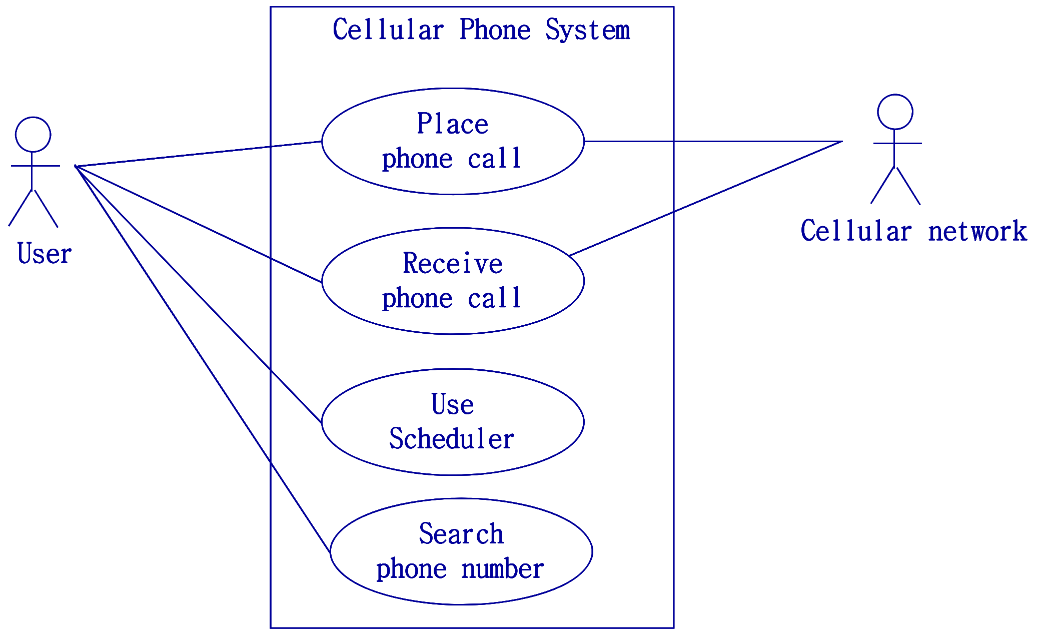
Functional requirements are captured by Use-Case Model

Object (or Domain) Analysis

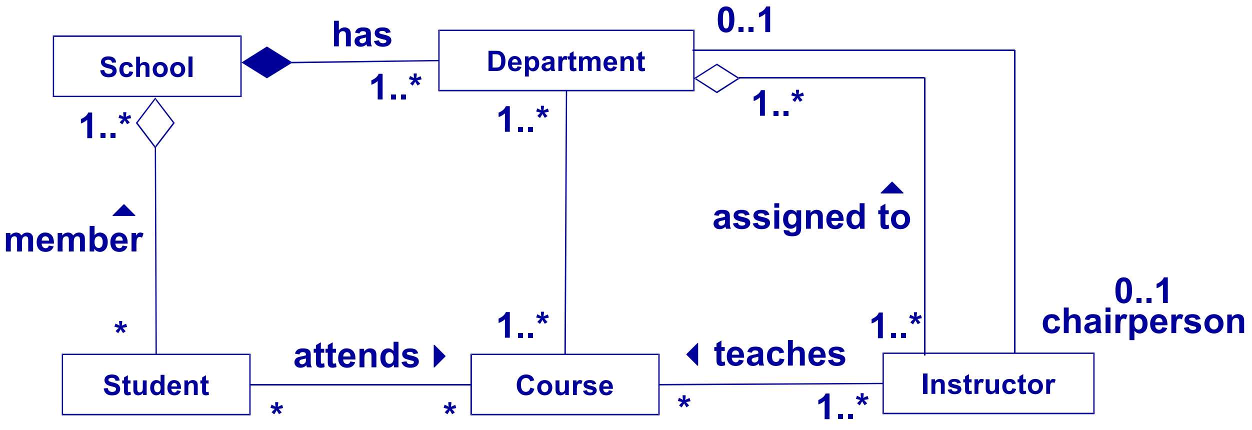
Investigation of domain objects, i.e., emphasizing on finding and describing objects (or concepts), relationships among those concepts, and attributes of those concepts, in the problem domain

Captured by Domain Model

Use-Case Diagrams



Example: Domain Model



Object-Oriented Design

OO design (OOD) is primarily a process of *invention* and *adaptation of conceptual solution.*

The development team defines software objects and how they collaborate to fulfill the system's behavioral requirements that are determined at requirements discipline.

OOD tends to be relatively independent of the language used.

e.g., design patterns help to transcend programming language-centric viewpoints

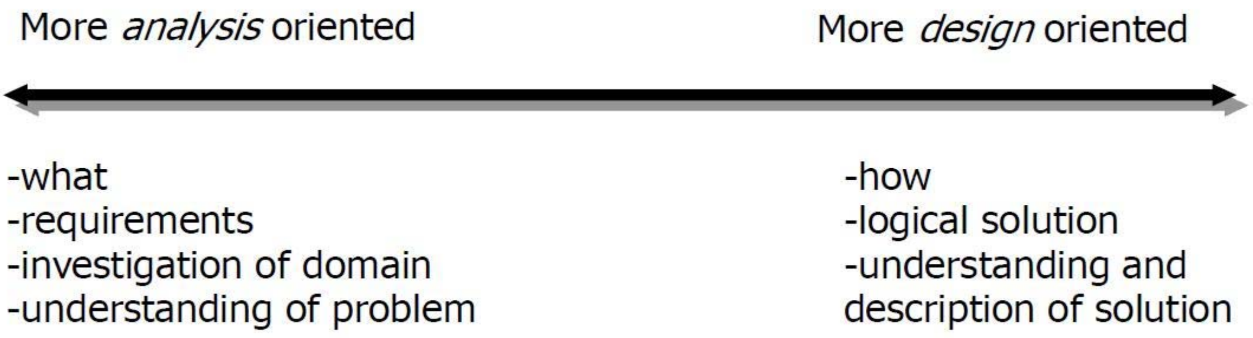
Obviously, the more consistent/related the OOP and OOD techniques, the easier they are to apply in real-life.

OOA & OOD

Division between OOA & OOD is fuzzy

OOA & OOD activities exist on a continuum

Some practitioners can classify an activity as analysis while others put it into design category



More *analysis* oriented

More *design* oriented

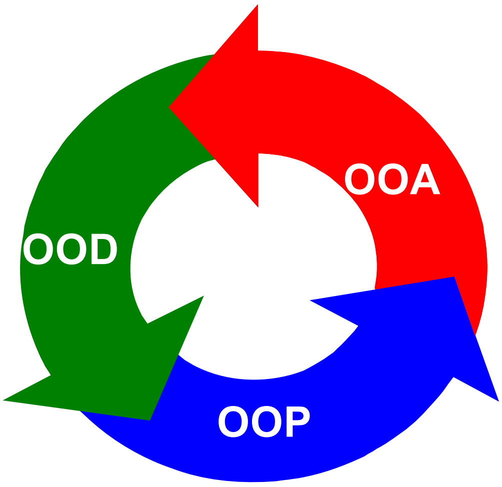
-what
-requirements
-investigation of domain
-understanding of problem

-how
-logical solution
-understanding and description of solution

Object-Oriented Programming

This corresponds to the implementation discipline.

The classes and class operations are coded, tested, and integrated.



How Objects Are Used?

During analysis:

to promote understanding of the real world

During design and programming:

to provide a basis for logical solution and implementation

Decomposition of a problem into objects depends on judgment and the nature of the problem.

There is no one correct representation!

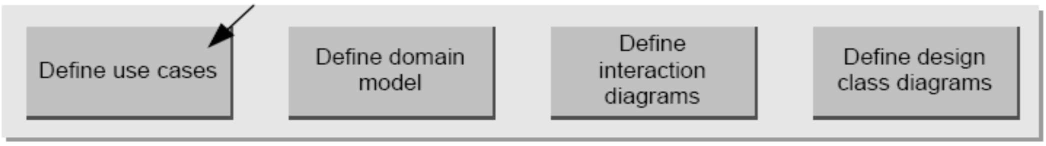
A Simple Example

Birds-eye view of Requirement Analysis and OOA/D

Example) A “dice game” in which a player rolls two die.

- If the total is seven, they win; otherwise, they lose.

– Four Steps



Define use cases

Define domain model

Define interaction diagrams

Define design class diagrams

Requirement Analysis

Object–oriented Analysis

Object–oriented Design **I**

Object–oriented Design **II**

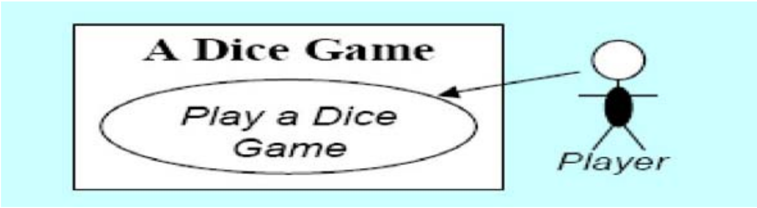
A Simple Example (Cont’d)

1. Define Use Cases (Requirement Analysis)

   ➢ A description of related domain processes as *use cases*.

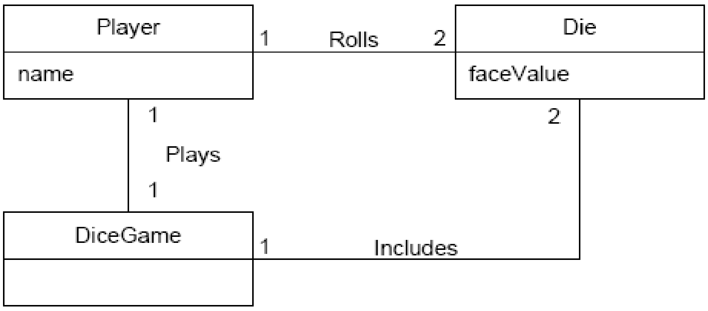
   ➢ Play a Dice Game use case:

   Play a Dice Game: A player picks up and rolls the dice. If the dice face value total seven, they win; otherwise, they lose.



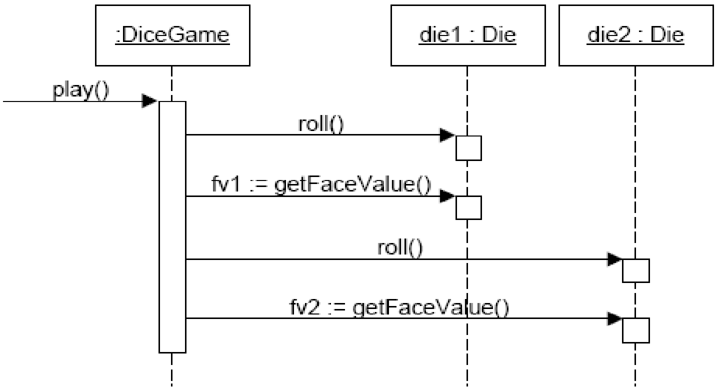
A Simple Example (Cont'd)

2. Define a Domain Model (OOA)
   - ➢ Creating a description of the domain from the perspective of classification by objects.
   - ➢ Domain model
     - – A set of diagrams that show domain concepts or objects
     - – Not a description of software objects



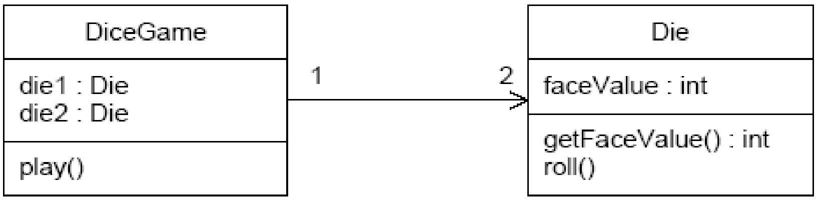
A Simple Example (Cont'd)

3. Define Interaction Diagrams (OOD)
   - ➢ Defining software objects and their collaborations.
   - ➢ Interaction diagram (dynamic view of collaborating objects)
     - – The flow of messages between software objects
     - – The invocation of methods



A Simple Example (Cont’d)

4. Define Design Class Diagrams (OOD)
   - ➢ A static view of the class definitions with a design class diagrams.
   - ➢ Design class diagram
     - – The attributes and methods of the classes



Unified Process (UP) /Rational Unified Process (RUP)

Developed by “*three amigos*” at Rational Software (IBM)

Grady Booch
(Booch Method)

Ivar Jacobson
(OOSE)

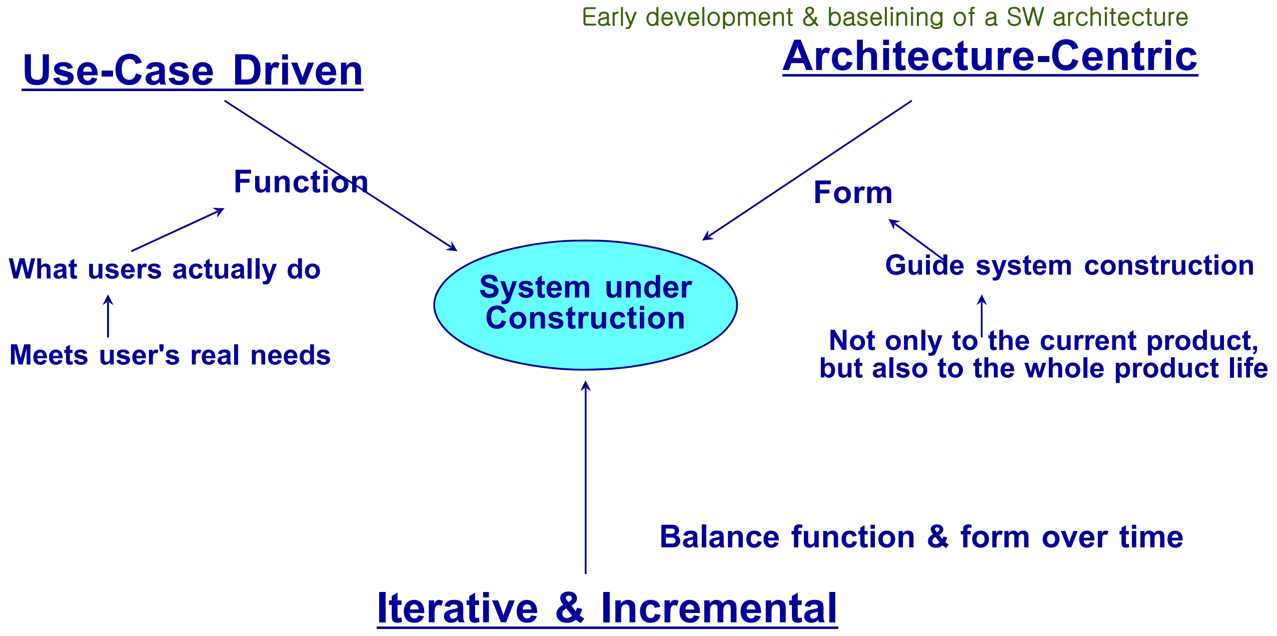
James Rumbaugh
(OMT)

Interestingly different from the traditional waterfall model

Unified Modeling Language (UML) is a set of graphical notations for modeling systems, not a process or method.

You don’t have to use UP to use UML.

Core of the Unified Process (UP)



Early development & baselining of a SW architecture

Use-Case Driven

Architecture-Centric

Function

Form

What users actually do

Meets user's real needs

System under Construction

Guide system construction

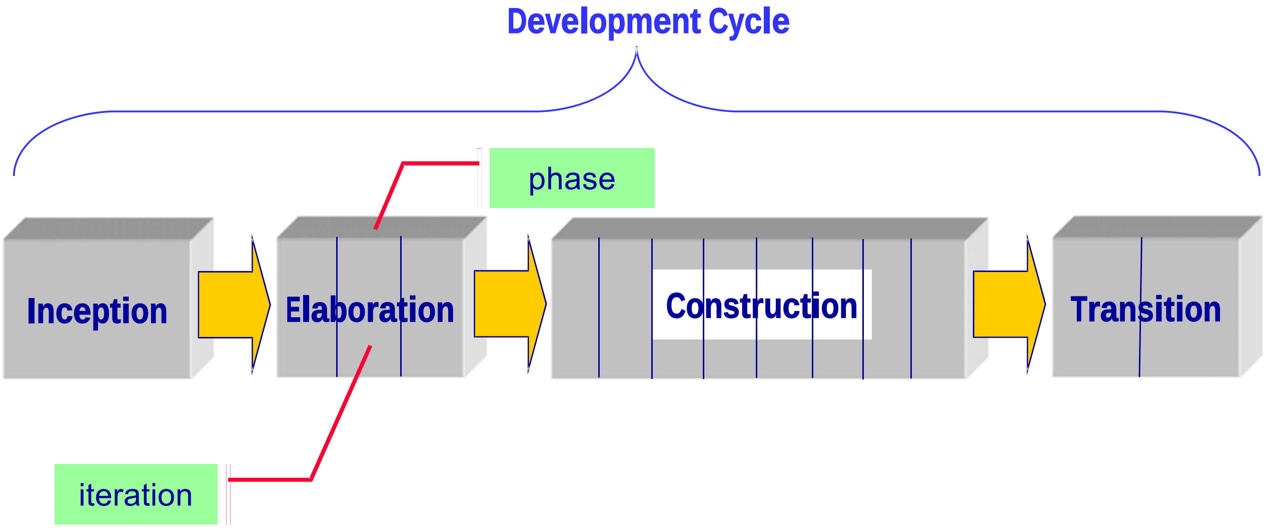
Not only to the current product, but also to the whole product life

Balance function & form over time

Iterative & Incremental

Four Phases of Unified Process

(Phases are *not* the classical requirements/ design/coding/implementation activities)



Development Cycle

phase

Inception

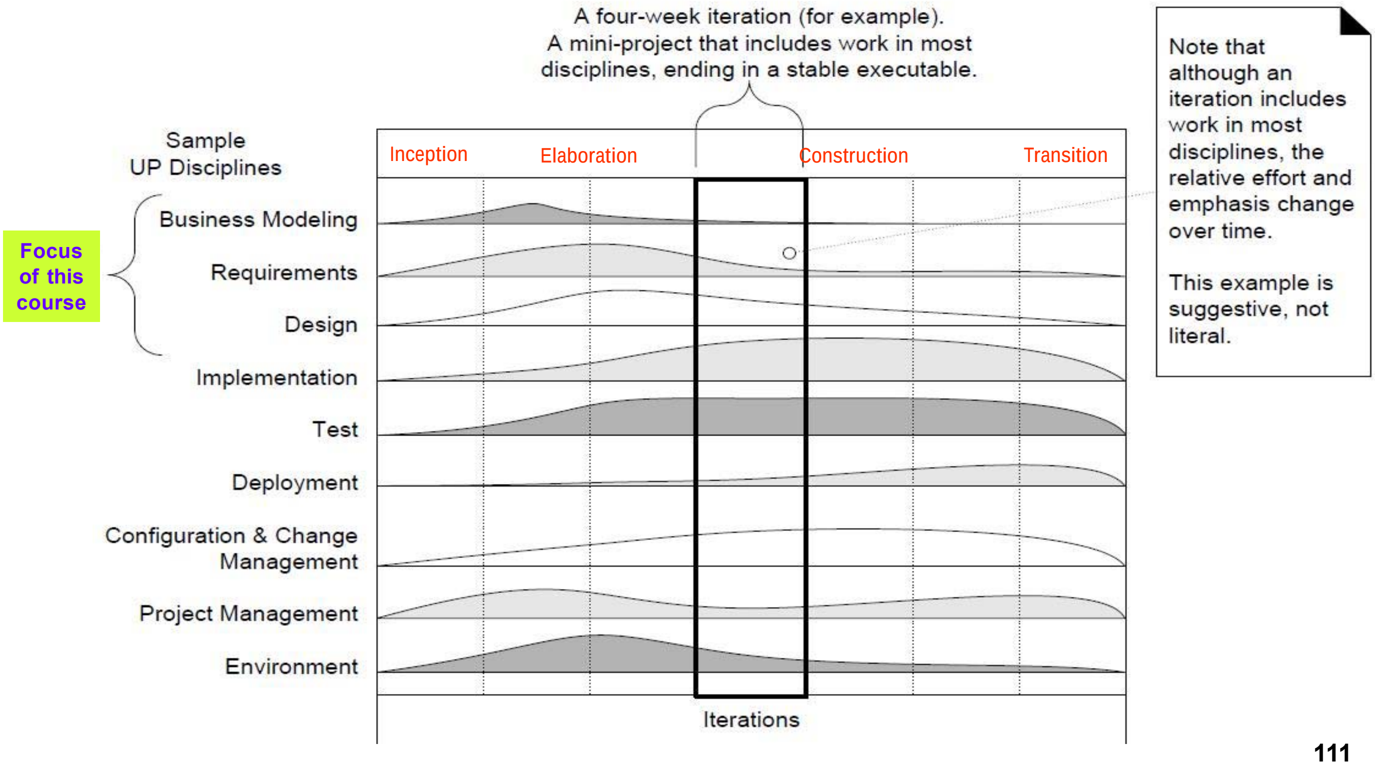
Elaboration

Construction

Transition

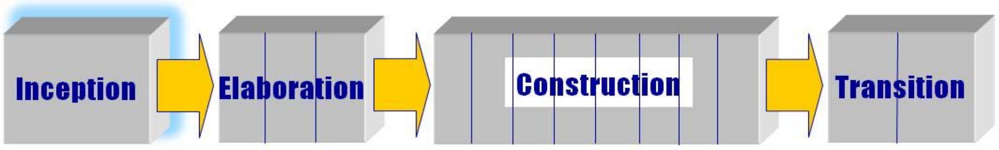
iteration

2D View of Unified Process



Inception Phase (Feasibility Phase)

Envision the product scope, vision, and business case

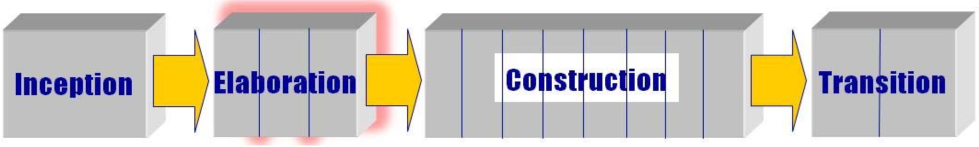


A short initial step in which the following questions are explored:

What is the vision and business case for this project?
Feasible?
Buy and/or build?
Rough estimate of cost: Is it $10K-100K or in the millions?
Should we proceed or stop?

Elaboration Phase

Define most requirements, build the core architecture, resolve the high-risk elements, and estimate overall schedule and resources



The majority of requirements are discovered and stabilized.

Write most of the use cases and other requirements in detail, through a series of workshops, once per elaboration iteration.

The major risks (in terms of techniques and/or business value) are mitigated or retired.

The core (or baseline) architecture is implemented and proven.

More realistic estimates and clear milestones are specified.

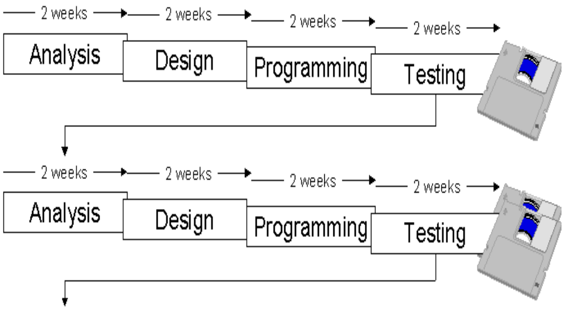
Elaboration Phase (Cont'd)

Elaboration consists of between 2 and 4 iterations; each iteration is recommended to be between 2 and 6 weeks, unless the team size is massive.

Each iteration is timeboxed, meaning its end date is fixed.

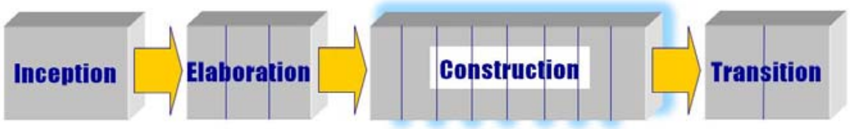
What do we have to do if we cannot meet the deadline?

At the end of each iteration, stable and tested production-quality portions of the final system must be released.



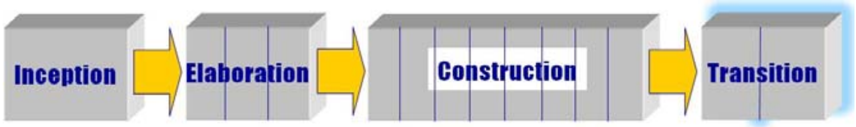
Construction and Transition Phases

Construction Phase



Iterative implementation of remaining lower risk & easier elements

Transition Phase



Beta Test, Performance Tuning

Additional UP Best Practices

Tackle high-risk and high-value issues in early iterations.

Continuously engage users for evaluation, feedback and requirements.

Continuously verify quality; test early, often, and realistically.

Model software visually (with the UML).

Carefully manage requirements.

Practice change request and configuration management.

UP Disciplines and Artifacts

A *discipline* is a set of activities (and related artifacts) in one subject area, such as activities in requirements analysis

An *artifact* is the general term used for any work product

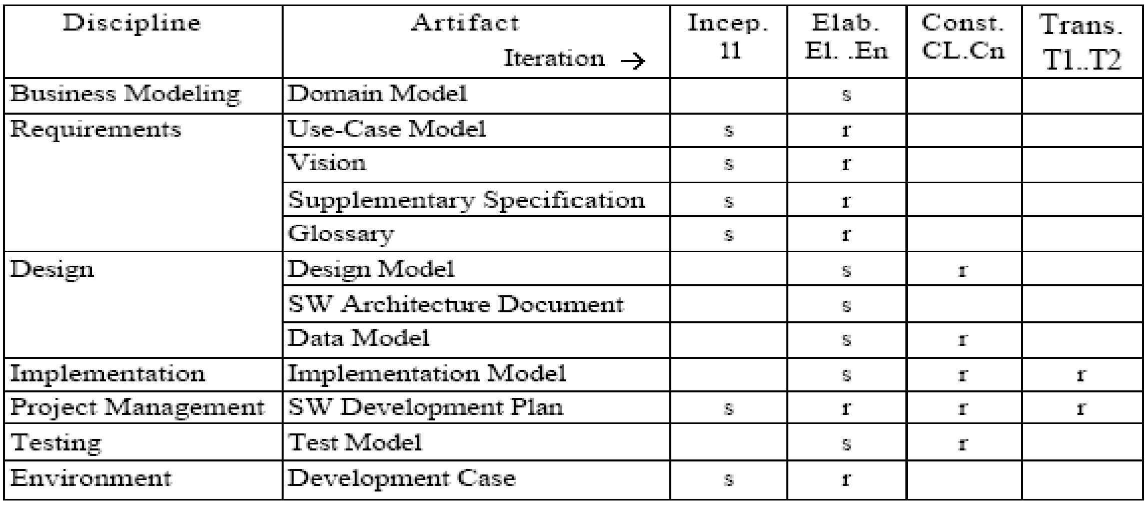
We will focus on some artifacts in the following disciplines

Business modeling → Domain Model

Requirements → Use-Case Model

Design → Design Model

Unified Process Artifacts



Discipline	Artifact Iteration →	Incep. I1	Elab. E1..En	Const. C1..Cn	Trans. T1..T2
Business Modeling	Domain Model		s		
Requirements	Use-Case Model	s	r		
	Vision	s	r		
	Supplementary Specification	s	r		
	Glossary	s	r		
Design	Design Model		s	r	
	SW Architecture Document		s		
	Data Model		s	r	
Implementation	Implementation Model		s	r	r
Project Management	SW Development Plan	s	r	r	r
Testing	Test Model		s	r	
Environment	Development Case	s	r		

s – start; r – refine

Artifacts in Inception Phase

Artifacts	Comments
Vision and Business Case	Describes high-level goals and constraints, the business case, and provides an executive summary.
Use-Case Model	Describes functional requirements, and related non-functional requirements.
Supplementary Specification	Describes other requirements.
Glossary	Key domain terminology.
Risk List & Risk Management Plan	Describes business, technical, resource, schedule risks, and ideas for their mitigation or response.
Prototypes and proof-of-concepts	To clarify the vision, and validate technical ideas.
Iteration Plan	Describes what to do in the first elaboration iteration.
Phase Plan & Software Development Plan	Low-precision guess for elaboration phase duration and effort, Tools, people, education, and other resources.
Development Case	A description of customized UP steps and artifacts for this project. In UP, one always customizes it for the project.

Artifacts that May Start in Elaboration

Artifacts	Comments
Domain Model	This is a visualization of the domain concepts; it is similar to a static information model of the domain entities.
Design Model	This is the set of diagrams that describe the logical design. This includes software class diagrams, object interaction diagrams, package diagrams, and so forth.
Software Architecture Document	A learning aid that summarizes the key architectural issues and their resolution in design. It is a summary of the outstanding design ideas and their motivation in the system.
Data Model	This includes the database schemas, and the mapping strategies between object and non-object representations.
Test Model	A description of what will be tested, and how.
Implementation Model	This is the actual implementation – the source code, executables, databases, and so on.
Use-Case Storyboards, UI Prototypes	A description of the user interface, paths of navigation, usability models, and so forth.

Fitting a Process to a Project

Software projects are greatly diverse in:

kind of system to build
technology to use
size & distribution of the team
nature of the risks
consequences of failure
working styles of the team
culture of the organization

- ***No one-size-fits-all process that will work for all projects.***
- ***Adapt an appropriate process to fit your particular project environment.***

The Development Case

The choice of UP artifacts for a project may be written up in a short document called the Development Case (an artifact in the Environment discipline)

In the UP, one always customize the steps and artifacts (i.e., Development Case) for the project.

Agile UP

- **Prefer a small set of UP activities and artifacts.**
  - *Focus on early programming, not early documentation*
- **Requirements and designs emerge through a series of iterations, based on feedback.**
- **Apply the UML with agile modeling practices.**
- **There isn't a detailed plan for the entire project.**
  - **Phase Plan**: *estimates project duration and other major milestones*
  - **Iteration Plan**: *adaptively plans with greater detail one iteration in advance*

What is Agile Modeling?

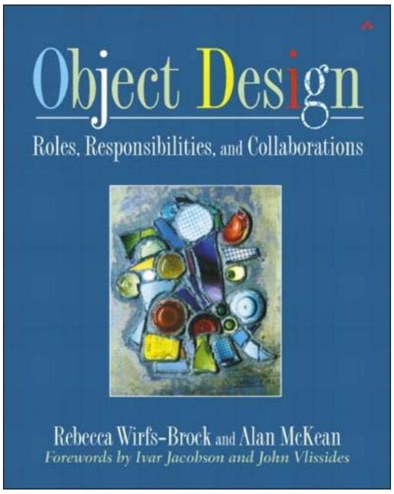
- Adopting an agile method does not mean avoiding any modeling
- The purpose of modeling and models is primarily to support understanding and communication, not documentation
- Don't model or apply the UML to all or most of the software design
- Use the simplest tool possible
  - Prefer "low energy" creativity-enhancing simple tools that support rapid input and change

Two Desert Island Skills in OOA & OOD

Assigning responsibilities to software components

Finding suitable objects or abstractions

Rebecca Wirfs-Brock


Object Design
Roles, Responsibilities, and Collaborations
Rebecca Wirfs-Brock and Alan McKean
Forewords by Ivar Jacobson and John Vlissides

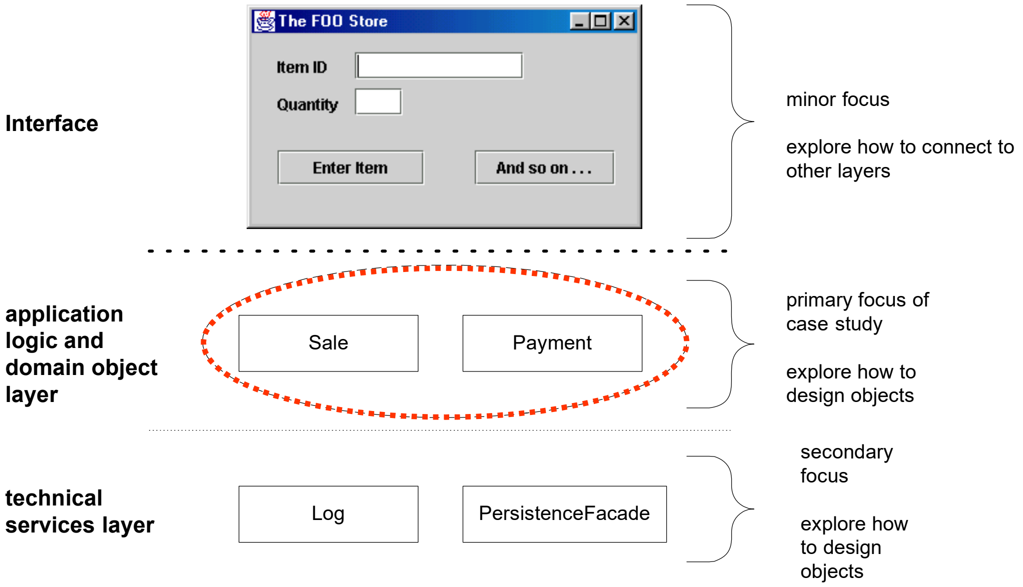
Case Study:
The NextGen POS System

The POS (Point-Of-Sale) system is a computerized system used to record sales and handle payments; primary goal of the system is

- Quick checkout for the customer
- Fast and accurate sales analysis
- Automatic inventory control

Assume that we have been requested to create the software to run a POS system. Using an iterative-incremental development strategy, we are going to proceed through OO analysis, design, and implementation.

Architectural Layers



Interface

minor focus

explore how to connect to other layers

application logic and domain object layer

primary focus of case study

explore how to design objects

technical services layer

secondary focus

explore how to design objects

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