Introduction to UML

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Evolution of OO Development Methods

70/80ies
- structured programming
  - structured design
  - structured analysis

80/90ies
- object-oriented programming
  - object-oriented design
  - object-oriented analysis
History of OOAD leading to UML

1970
First object-oriented languages (Simula-67, Smalltalk).

1980
More than 50 different OOAD languages cause the users trouble to find complete and appropriate tools.

1992
New iterations of methods appear. Booch ’93, OOSE (Jacobson), OMT-2 (Rumbaugh)

1995
Unification, UML 0.9 by Booch, Rumbaugh

1997
Standardization, UML 1.1 by Booch, Rumbaugh, Jacobson
Object Management Group (OMG) adapts UML as OOAD standard
Why Model?

- Analyse the problem – domain
  - Simplify reality
  - Capture requirements
  - Visualize the system in its entirety
  - Specify the structure and/or behavior of the system

- Design the solution
  - Document the solution – in terms of its structure, behavior, etc
Principles of Modeling

► Choose your model well
  • The model give impacts the analysis of the problem and the design of the solution

► Every model may be expressed at different levels of precision
  • The same model can be scaled up (or down) to different granularities
Principles of Modeling

- The best models are connected to reality
  - Simplify the model, but don’t hide important details

- No single model suffices
  - Every nontrivial system has different dimensions to the problem and its solution
Unified Modeling Language

- UML is a modeling language, not methodology or process
- UML is modeling language for visualizing, specifying, constructing, and documenting the artifacts of software systems

UML provides a pictorial and graphical notation for documenting the artifacts such as classes, objects, and packages that make up an OO systems
Unified Modeling Language

- **Visualizing**
  - A graphical notation articulates and unambiguously communicates the overall view of the system (problem-domain)

- **Specifying**
  - UML provides the means to model precisely, unambiguously and completely the system in question
Unified Modeling Language

- **Constructing**
  - Model built with UML have a “design” dimension

- **Documenting**
  - Every software project involves a lot of documentation – from the inception phase to the deliverables
Conceptual Model of UML

- Building Block
  - Things
  - Relationships
  - Diagram

- Rules

- Common Mechanisms
  Specification, Adornments, common division, extensibility mechanism
Structural Things

- The nouns of UML; usually the static parts of the system in question
- Class – an abstraction of a set of things in the problem domain that have similar properties and/or functionality
- Notation: 

- Interface – a collection of operations that specify the services rendered by a class or component
- Notation: 

Customer
Structural Things

- Collaboration – a collection of UML building blocks (classes, interfaces, relationships) that work together to provide some functionality within the system
  
  Notation:

  ![Collaboration Diagram]

- Use case – an abstraction of a set of functions that the system performs; a use case is “realized” by collaboration
Structural Things

- Active Class – a class whose instance is an active object; an active object is an object that owns a process or thread (units of execution)

  Notation:

  ![Component Notation](image)

- Component – a physical part (typically manifest itself as a piece of software) of the systems

  ![Component Diagram](image)
Structural Things

- Node – a physical element that exists at run-time and represents a computational resource (typically, hardware resource)
Behavioral Things

- The verbs of UML models; usually the dynamic parts of the system in question
- Interaction – some behavior constituted by messages exchanged among objects; the exchange of messages is with a view to achieving some purpose
- Notation:

  Parse
Behavioral Things

- State machine – a behavior that specifies the sequence of “states” an object goes through, during its lifetime. A “state” is a condition or situation during the lifetime of an object during which it exhibits certain characteristics and/or perform some function.
Grouping Things

- The organizational part of the UML model; provides a higher level of abstraction (granularity)
- Package – a general purpose element that comprises UML element – structural, behavioral or even group things.
- Package are conceptual groupings of the system and need not necessarily be implemented as cohesive software modules
Notational Things

- The explanatory part of the UML model; adds information/meaning to the model elements

- Note – a graphical notation for attaching constraints and/or comments to the element of the model
Relationships

- **Dependency** – a semantic relationship where a change in one thing (the independent thing) causes a change in the semantics of the other thing (the dependent thing)

  ![Arrow-head points to the independent thing](image)

- **Association** – a structural relationship that describes the connection between two things

- **Notation**: 

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Generalisation – a relationship between a general thing (called “parent” or superclass) and a more specific kind of that thing (called “child” or subclass) such that the latter can substitute the former.

*Arrow-head points to the superclass*
Relationships

- Realization – a semantic relationship between two things where in one specifies the behavior to be carried out, and the other carries out the behavior

- A collaboration realizes a use case
  
The use case specifies the behavior (functionality) to be carried out (provided), and the collaboration actually implements that behavior

  Arrow-head points to the thing being realized
## UML Diagrams

- **Use Case Diagrams**
  - Nodes: Actor, Use (case)
  - Links: Involvement, Extension, Usage

- **Class Diagrams**
  - Nodes: Class
  - Links: Association, Generalization

- **Interaction Diagrams**
  - Nodes: Object
  - Links: Message, Lifeline

- **State Diagrams**
  - Nodes: State, Sub-State
  - Links: Transition

- **Activity Diagrams**
  - Nodes: Activity
  - Links: Guard, Synchronization

- **Package Diagrams**
  - Nodes: Package
  - Links: Dependency

- **Deployment Diagrams**
  - Nodes: Processor, Node
  - Links: Dependency
UML Diagrams

- **Class Diagrams**
  - Diagram shows a set of classes, interfaces, collaborations and their relationships. Models the static view of the system

- **Object diagram**
  - Snapshot of a class diagram; models the instances of things contained in a class diagram

- **Use case diagram**
  - Shows a set of “use cases”, the actor and their relationships
  - What the system is expected to do

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UML Diagrams

- **Sequence Diagram**
  - Models the flow of control by time-ordering, depicts the interaction between various objects by messages passed, with a temporal dimension to it

- **Collaboration diagram**
  - Models the interaction between objects, without the temporal dimension; depict the messages passed between objects

- **Statechart diagram**
  - Shows the different state machines and the events that leads to each of these state machines
UML Diagrams

- Activity Diagram
  - Shows the flow from activity to activity; an “activity” is an ongoing non-atomic execution within a state machine

- Component Diagram
  - Shows the physical packaging of software in terms of components and the dependencies between them

- Deployment Diagram
  - Shows the configuration of the processing nodes at run-time and the components that live on them
Dimensions

- Structural View
  - Class Diagrams
  - Object Diagrams
- Implementation View
  - Component Diagrams
- User View
  - Sequence Diagrams
  - Collaboration Diagrams
  - Statechart Diagrams
  - Activity Diagrams
- Behavioral View
  - Deployment Diagrams
  - Environment View

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UML Diagrams

- **Use Case Diagrams**
  - workflows
  - scenarios

- **Activity Diagrams**
  - inter-class behavior

- **Class Diagrams**
  - structures
  - interaction sequences between objects
  - intra-class behavior

- **Interaction Diagrams**
  - interaction sequences between objects

- **State Diagrams**
  - structuring

- **Package Diagrams**
Diagrams and Process

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Diagrams and Process

Use Case Diagrams
Diagrams and Process

Class & Package Diagrams
Diagrams and Process

Interaction Diagrams (Scenarios)
Diagrams and Process

Activity Diagrams (Workflow, Interclass Behavior)
Diagrams and Process

State Transition Diagrams (Intraclass Behavior)
// Shapes.java
import java.util.*;
class Shape {
    void draw() {}
    void erase() {}
}
class Circle extends Shape {
    void draw() {
        System.out.println("Circle.draw()");
    }
    void erase() {
        System.out.println("Circle.erase()");
    }
}
public static void main(String args[]) {
    Shape s[] = new Shape[5];
    // Fill up the array with shapes:
    for(int i = 0; i < s.length; i++)
        s[i] = randShape();
    // Make polymorphic method calls:
    for(int i = 0; i < s.length; i++)
        s[i].draw();
}
Diagrams and Process

Deployment Diagrams

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Why Modeling?

*Modeling capture important part of system*  
(James Rumbaugh)

Business Process  
Computer System
Unified Modeling Language

- UML diagrams can be divided into three categories:
  1. Structure diagrams
  2. Behavior diagrams
  3. Interaction diagrams
Structure Diagrams

- Structure diagrams show the static architecture of the system irrespective of time.
- Structure diagram may depict:
  - The architectural organization of the system
  - The physical elements of the system

Example:
Structure diagram for a university system
Diagram depict of classes such as student, faculty
Structure Diagrams

- Package Diagram
- Class Diagram
- Component Diagram
- Deployment Diagram
- Object Diagram
- Composite Structure Diagram
Behavior Diagrams

- Diagram depict the behavior of system or business process
- The UML behavior diagrams include the following:
  - Use case diagram
  - Activity diagram
  - State machine diagram
Interaction Diagrams

- Show the methods, interactions and activities of the object
- The UML interaction diagrams include the following:
  Sequence Diagram, Communication Diagram, Timing Diagram, Interaction Overview Diagram
Class Diagram

- Show the classes, methods, and fields
- A class diagram is used to show the existence of classes and their relationship in the logical of a system
- Class diagram is represented by a box, which is divided into three categories:
  1. The name of the class is given in the top of rectangle
  2. The attributes are shown in the second box
  3. The methods with their return types and parameter are shown in the third box
Example

```
Student

- name : String
- address : String
- gpa : double

+ Student(studentName : String, studentAddress : String)
+ Student(studentName : String)
+ Student()
+ setName(studentName : String) : void
+ setAddress(studentAddress : String) : void
+ getName() : String
+ getGpa() : double
+ getAddress() : String
+ computeGpa(course : Course, grade : char) : void
```
Class Relationships

- Classes collaborate with other classes in a variety of ways
- The essential connections among classes:
  - Association
  - Generalization
  - Aggregation
  - composition
Use Case Diagram

- Use case diagrams are used to depict the context of the system to be built and the functionality provided by the system.
- Who/what interact with the system.
- What the system to do.
- Use case involves a user and the system.
- Example: student registration for a course.
Use Case Diagram

- **Actor**
  - Actor are entities that interface with the system
  - They can be people or other system

- **Use cases**
  - Use cases represent what the actor want your system to do for them
Include Relationship

- `<include>` relationship represents behavior that is \textit{factored out} of the use case
- `<include>` behavior is factored out for reuse. Not because it is an exception
- `<include>` relationship is \textit{to} the using use case
Extend Relationship

- <<extend>> relationships represent exceptional or seldom invoked cases
- The exceptional event flows are separated from the main event flow for clarity
- A use case representing exceptional event flows may extend one or more use case
- The direction of a <<extend>> relationships is to the extended use case
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