UNIT-I

INTRODUCTION TO UML

Contents:

1. Importance of Modeling
2. Principles of Modeling
3. Object Oriented Modeling
4. Conceptual Model of the UML
5. Architecture
6. Software Development Life Cycle

1. Importance of Modeling:

Why do we model?

A model is a simplification at some level of abstraction

We build models to better understand the systems we are developing.

- To help us visualize
- To specify structure or behavior
- To provide template for building system
- To document decisions we have made

2. Principles of Modeling:

- The models we choose have a profound influence on the solution we provide
- Every model may be expressed at different levels of abstraction
- The best models are connected to reality
- No single model is sufficient, a set of models is needed to solve any nontrivial system

UML is a visual modeling language

"A picture is worth a thousand words." - old saying

Unified Modeling Language:

"A language provides a vocabulary and the rules for combining words [...] for the purpose of communication.

A modeling language is a language whose vocabulary and rules focus on the conceptual and physical representation of a system. A modeling language such as the UML is thus a standard language for software blueprints."

Usages of UML:

UML is used in the course to
i. document designs
- design patterns / frameworks

ii. represent different views/aspects of design – visualize and construct designs
- static / dynamic / deployment / modular aspects

iii. provide a next-to-precise,common, language –specify visually
- for the benefit of analysis, discussion, comprehension...

abstraction takes precedence over precision!
- 20/80 rule
- aim is overview and comprehension; not execution

Object Oriented Modeling:

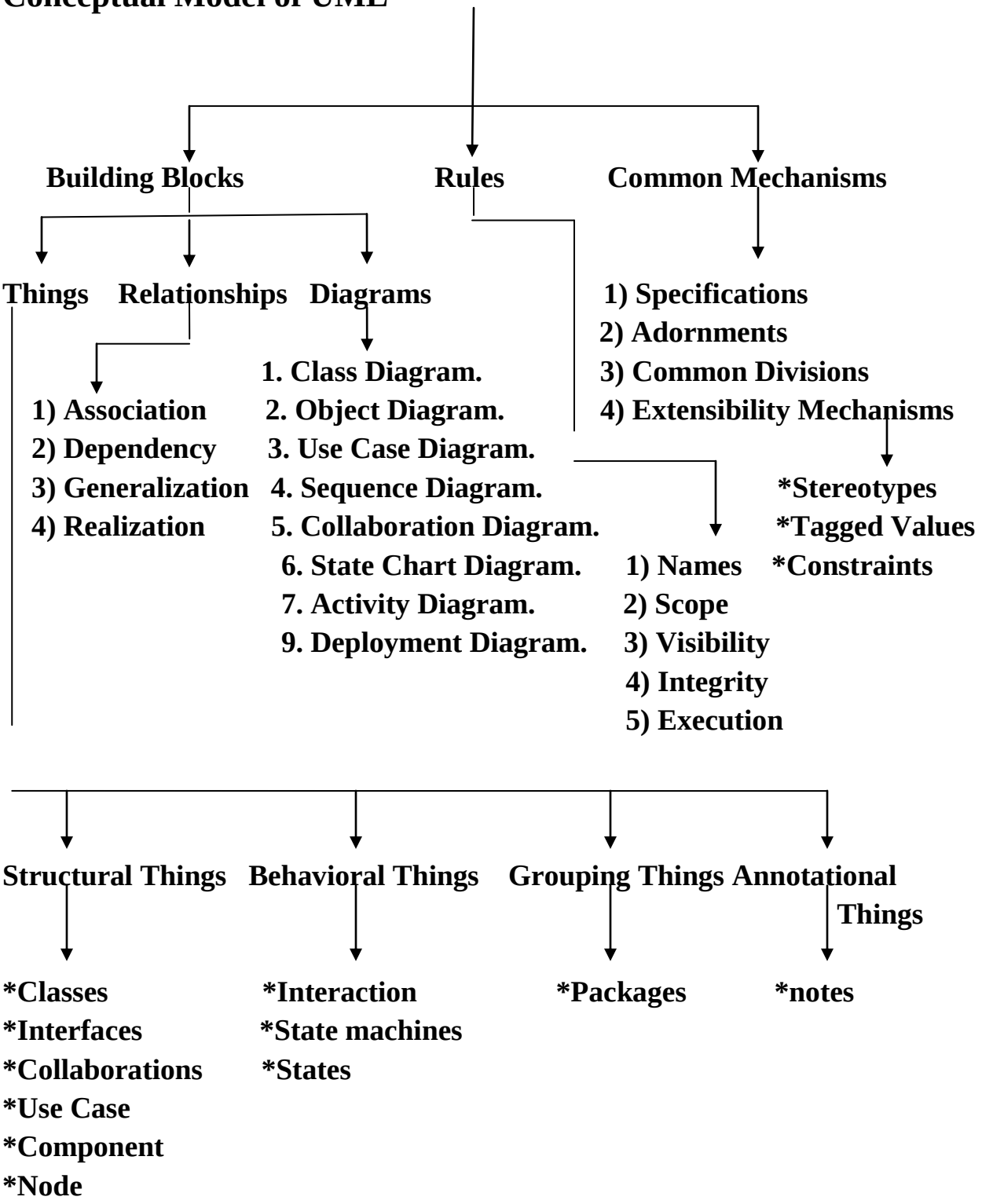
Traditionally two approaches to modeling a software system

Algorithmically – becomes hard to focus on as the requirements change

Object-oriented – models more closely real world entities

Conceptual Model of the UML:

Conceptual Model of UML



To understand the UML, you need to form a conceptual model of the language, and this requires learning three major elements: the UML's basic building blocks, the rules that dictate how those building blocks may be put together, and some common mechanisms that apply throughout the UML. Once you have grasped these ideas, you will be able to read UML models and create some basic ones. As you gain more experience in applying the UML, you can build on this conceptual model, using more advanced features of the language.

Building Blocks of the UML

The vocabulary of the UML encompasses three kinds of building blocks:

1. Things
2. Relationships
3. Diagrams

Things are the abstractions that are first-class citizens in a model; relationships tie these things together; diagrams group interesting collections of things.

Things in the UML

There are four kinds of things in the UML:

1. Structural things
2. Behavioral things
3. Grouping things
4. Annotational things

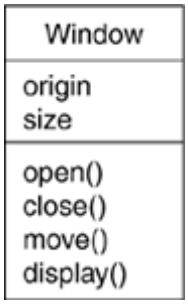
These things are the basic object-oriented building blocks of the UML. You use them to write well-formed models.

Structural Things

Structural things are the nouns of UML models. These are the mostly static parts of a model, representing elements that are either conceptual or physical. Collectively, the structural things are called *classifiers*.

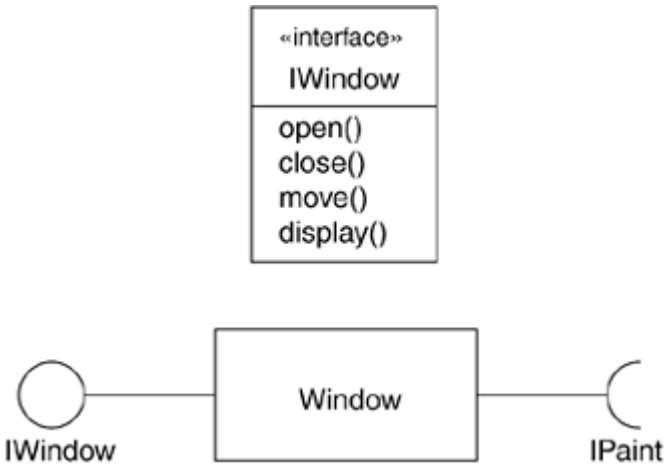
A *class* is a description of a set of objects that share the same attributes, operations, relationships, and semantics. A class implements one or more interfaces. Graphically, a class is rendered as a rectangle, usually including its name, attributes, and operations, as in Figure 2-1.

Figure 2-1. Classes



An *interface* is a collection of operations that specify a service of a class or component. An interface therefore describes the externally visible behavior of that element. An interface might represent the complete behavior of a class or component or only a part of that behavior. An interface defines a set of operation specifications (that is, their signatures) but never a set of operation implementations. The declaration of an interface looks like a class with the keyword «interface» above the name; attributes are not relevant, except sometimes to show constants. An interface rarely stands alone, however. An interface provided by a class to the outside world is shown as a small circle attached to the class box by a line. An interface required by a class from some other class is shown as a small semicircle attached to the class box by a line, as in Figure 2-2.

Figure 2-2. Interfaces



A *collaboration* defines an interaction and is a society of roles and other elements that work together to provide some cooperative behavior that's bigger than the sum of all the elements. Collaborations have structural, as well as behavioral, dimensions. A given class or object might participate in several collaborations. These collaborations therefore represent the implementation of patterns that make up a system. Graphically, a collaboration is rendered as an ellipse with dashed lines, sometimes including only its name, as in Figure 2-3.

Figure 2-3. Collaborations

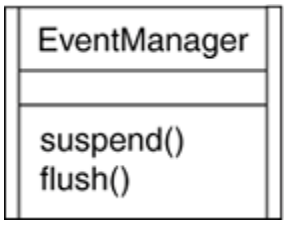
A *use case* is a description of sequences of actions that a system performs that yield observable results of value to a particular actor. A use case is used to structure the behavioral things in a model. A use case is realized by a collaboration. Graphically, a use case is rendered as an ellipse with solid lines, usually including only its name, as in Figure 2-4.

Figure 2-4. Use Cases

The remaining three thingsactive classes, components, and nodesare all class-like, meaning they also describe sets of entities that share the same attributes, operations, relationships, and semantics. However, these three are different enough and are necessary for modeling certain aspects of an object-oriented system, so they warrant special treatment.

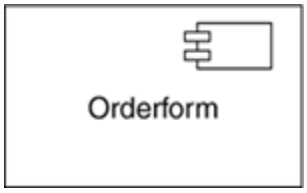
An *active class* is a class whose objects own one or more processes or threads and therefore can initiate control activity. An active class is just like a class except that its objects represent elements whose behavior is concurrent with other elements. Graphically, an active class is rendered as a class with double lines on the left and right; it usually includes its name, attributes, and operations, as in Figure 2-5.

Figure 2-5. Active Classes



A component is a modular part of the system design that hides its implementation behind a set of external interfaces. Within a system, components sharing the same interfaces can be substituted while preserving the same logical behavior. The implementation of a component can be expressed by wiring together parts and connectors; the parts can include smaller components. Graphically, a component is rendered like a class with a special icon in the upper right corner, as in Figure 2-6.

Figure 2-6. Components



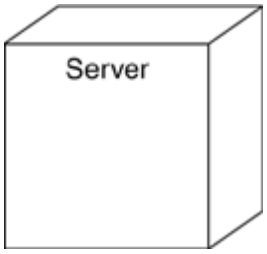
The remaining two elementsartifacts and nodesare also different. They represent physical things, whereas the previous five things represent conceptual or logical things.

An *artifact* is a physical and replaceable part of a system that contains physical information ("bits"). In a system, you'll encounter different kinds of deployment artifacts, such as source code files, executables, and scripts. An artifact typically represents the physical packaging of source or run-time information. Graphically, an artifact is rendered as a rectangle with the keyword «artifact» above the name, as in Figure 2-7.

Figure 2-7. Artifacts

A *node* is a physical element that exists at run time and represents a computational resource, generally having at least some memory and, often, processing capability. A set of components may reside on a node and may also migrate from node to node. Graphically, a node is rendered as a cube, usually including only its name, as in Figure 2-8.

Figure 2-8. Nodes



These elementsclasses, interfaces, collaborations, use cases, active classes, components, artifacts, and nodesare the basic structural things that you may include in a UML model. There are also variations on these, such as actors, signals, and utilities (kinds of classes); processes and threads (kinds of active classes); and applications, documents, files, libraries, pages, and tables (kinds of artifacts).

Behavioral Things

Behavioral things are the dynamic parts of UML models. These are the verbs of a model, representing behavior over time and space. In all, there are three primary kinds of behavioral things.

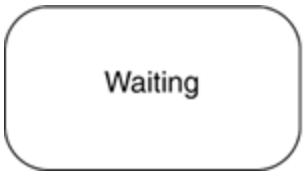
First, an *interaction* is a behavior that comprises a set of messages exchanged among a set of objects or roles within a particular context to accomplish a specific purpose. The behavior of a society of objects or of an individual operation may be specified with an interaction. An interaction involves a number of other elements, including messages, actions, and connectors (the connection between objects). Graphically, a message is rendered as a directed line, almost always including the name of its operation, as in Figure 2-9.

Figure 2-9. Messages

Second, a *state machine* is a behavior that specifies the sequences of states an object or an

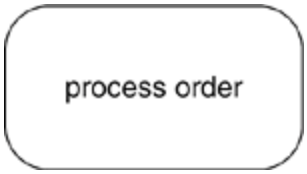
interaction goes through during its lifetime in response to events, together with its responses to those events. The behavior of an individual class or a collaboration of classes may be specified with a state machine. A state machine involves a number of other elements, including states, transitions (the flow from state to state), events (things that trigger a transition), and activities (the response to a transition). Graphically, a state is rendered as a rounded rectangle, usually including its name and its substates, if any, as in Figure 2-10.

Figure 2-10. States



Third, an activity is a behavior that specifies the sequence of steps a computational process performs. In an interaction, the focus is on the set of objects that interact. In a state machine, the focus is on the life cycle of one object at a time. In an activity, the focus is on the flows among steps without regard to which object performs each step. A step of an activity is called an *action*. Graphically, an action is rendered as a rounded rectangle with a name indicating its purpose. States and actions are distinguished by their different contexts.

Figure 2-11. Actions



These three elements interactions, state machines, and activities are the basic behavioral things that you may include in a UML model. Semantically, these elements are usually connected to various structural elements, primarily classes, collaborations, and objects.

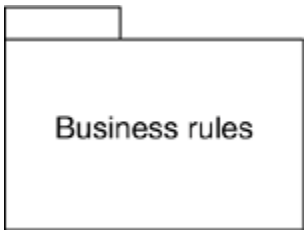
Grouping Things

Grouping things are the organizational parts of UML models. These are the boxes into which a model can be decomposed. There is one primary kind of grouping thing, namely, packages.

A *package* is a general-purpose mechanism for organizing the design itself, as opposed to classes, which organize implementation constructs. Structural things, behavioral things, and even other grouping things may be placed in a package. Unlike components (which exist at run time), a package is purely conceptual (meaning that it exists only at development time). Graphically, a

package is rendered as a tabbed folder, usually including only its name and, sometimes, its contents, as in Figure 2-12.

Figure 2-12. Packages

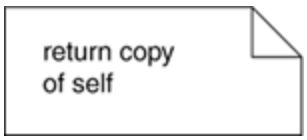


Packages are the basic grouping things with which you may organize a UML model. There are also variations, such as frameworks, models, and subsystems (kinds of packages).

Annotational Things

Annotational things are the explanatory parts of UML models. These are the comments you may apply to describe, illuminate, and remark about any element in a model. There is one primary kind of annotational thing, called a note. A *note* is simply a symbol for rendering constraints and comments attached to an element or a collection of elements. Graphically, a note is rendered as a rectangle with a dog-eared corner, together with a textual or graphical comment, as in Figure 2-13.

Figure 2-13. Notes



This element is the one basic annotational thing you may include in a UML model. You'll typically use notes to adorn your diagrams with constraints or comments that are best expressed in informal or formal text. There are also variations on this element, such as requirements (which specify some desired behavior from the perspective of outside the model).

Relationships in the UML

There are four kinds of relationships in the UML:

1. Dependency

2. Association
3. Generalization
4. Realization

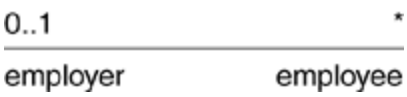
These relationships are the basic relational building blocks of the UML. You use them to write well-formed models.

First, a *dependency* is a semantic relationship between two model elements in which a change to one element (the independent one) may affect the semantics of the other element (the dependent one). Graphically, a dependency is rendered as a dashed line, possibly directed, and occasionally including a label, as in Figure 2-14.

Figure 2-14. Dependencies

Second, an *association* is a structural relationship among classes that describes a set of links, a link being a connection among objects that are instances of the classes. Aggregation is a special kind of association, representing a structural relationship between a whole and its parts. Graphically, an association is rendered as a solid line, possibly directed, occasionally including a label, and often containing other adornments, such as multiplicity and end names, as in Figure 2-15.

Figure 2-15. Associations

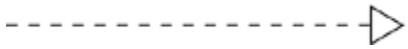


Third, a *generalization* is a specialization/generalization relationship in which the specialized element (the child) builds on the specification of the generalized element (the parent). The child shares the structure and the behavior of the parent. Graphically, a generalization relationship is rendered as a solid line with a hollow arrowhead pointing to the parent, as in Figure 2-16.

Figure 2-16. Generalizations

Fourth, a *realization* is a semantic relationship between classifiers, wherein one classifier specifies a contract that another classifier guarantees to carry out. You'll encounter realization relationships in two places: between interfaces and the classes or components that realize them, and between use cases and the collaborations that realize them. Graphically, a realization relationship is rendered as a cross between a generalization and a dependency relationship, as in Figure 2-17.

Figure 2-17. Realizations



These four elements are the basic relational things you may include in a UML model. There are also variations on these four, such as refinement, trace, include, and extend.

Diagrams in the UML

A *diagram* is the graphical presentation of a set of elements, most often rendered as a connected graph of vertices (things) and paths (relationships). You draw diagrams to visualize a system from different perspectives, so a diagram is a projection into a system. For all but the most trivial systems, a diagram represents an elided view of the elements that make up a system. The same element may appear in all diagrams, only a few diagrams (the most common case), or in no diagrams at all (a very rare case). In theory, a diagram may contain any combination of things and relationships. In practice, however, a small number of common combinations arise, which are consistent with the five most useful views that comprise the architecture of a software-intensive system. For this reason, the UML includes thirteen kinds of diagrams:

1. Class diagram
2. Object diagram
3. Component diagram
4. Composite structure diagram
5. Use case diagram
6. Sequence diagram
7. Communication diagram
8. State diagram
9. Activity diagram
10. Deployment diagram
11. Package diagram
12. Timing diagram
13. Interaction overview diagram

A *class diagram* shows a set of classes, interfaces, and collaborations and their relationships.

These diagrams are the most common diagram found in modeling object-oriented systems. Class diagrams address the static design view of a system. Class diagrams that include active classes address the static process view of a system. Component diagrams are variants of class diagrams.

An *object diagram* shows a set of objects and their relationships. Object diagrams represent static snapshots of instances of the things found in class diagrams. These diagrams address the static design view or static process view of a system as do class diagrams, but from the perspective of real or prototypical cases.

A *component diagram* is shows an encapsulated class and its interfaces, ports, and internal structure consisting of nested components and connectors. Component diagrams address the static design implementation view of a system. They are important for building large systems from smaller parts. (UML distinguishes a composite structure diagram, applicable to any class, from a component diagram, but we combine the discussion because the distinction between a component and a structured class is unnecessarily subtle.)

A *use case diagram* shows a set of use cases and actors (a special kind of class) and their relationships. Use case diagrams address the static use case view of a system. These diagrams are especially important in organizing and modeling the behaviors of a system.

Both sequence diagrams and communication diagrams are kinds of interaction diagrams. An *interaction diagram* shows an interaction, consisting of a set of objects or roles, including the messages that may be dispatched among them. Interaction diagrams address the dynamic view of a system. A *sequence diagram* is an interaction diagram that emphasizes the time-ordering of messages; a *communication diagram* is an interaction diagram that emphasizes the structural organization of the objects or roles that send and receive messages. Sequence diagrams and communication diagrams represent similar basic concepts, but each diagram emphasizes a different view of the concepts. Sequence diagrams emphasize temporal ordering, and communication diagrams emphasize the data structure through which messages flow. A timing diagram (not covered in this book) shows the actual times at which messages are exchanged.

A *state diagram* shows a state machine, consisting of states, transitions, events, and activities. A state diagrams shows the dynamic view of an object. They are especially important in modeling the behavior of an interface, class, or collaboration and emphasize the event-ordered behavior of an object, which is especially useful in modeling reactive systems

An *activity diagram* shows the structure of a process or other computation as the flow of control and data from step to step within the computation. Activity diagrams address the dynamic view of a system. They are especially important in modeling the function of a system and emphasize the flow of control among objects.

A *deployment diagram* shows the configuration of run-time processing nodes and the components that live on them. Deployment diagrams address the static deployment view of an architecture. A node typically hosts one or more artifacts.

An artifact diagram shows the physical constituents of a system on the computer. Artifacts include files, databases, and similar physical collections of bits. Artifacts are often used in conjunction with deployment diagrams. Artifacts also show the classes and components that they implement. (UML treats artifact diagrams as a variety of deployment diagram, but we discuss them separately.)

A package diagram shows the decomposition of the model itself into organization units and their dependencies.

A timing diagram is an interaction diagram that shows actual times across different objects or roles, as opposed to just relative sequences of messages. An interaction overview diagram is a hybrid of an activity diagram and a sequence diagram. These diagrams have specialized uses and so are not discussed in this book. See the UML Reference Manual for more details.

This is not a closed list of diagrams. Tools may use the UML to provide other kinds of diagrams, although these are the most common ones that you will encounter in practice.

Rules of the UML

The UML's building blocks can't simply be thrown together in a random fashion. Like any language, the UML has a number of rules that specify what a well-formed model should look like. A well-formed model is one that is semantically self-consistent and in harmony with all its related models.

The UML has syntactic and semantic rules for

- Names What you can call things, relationships, and diagrams

- Scope — The context that gives specific meaning to a name
- Visibility — How those names can be seen and used by others
- Integrity — How things properly and consistently relate to one another
- Execution — What it means to run or simulate a dynamic model

Models built during the development of a software-intensive system tend to evolve and may be viewed by many stakeholders in different ways and at different times. For this reason, it is common for the development team to not only build models that are well-formed, but also to build models that are

- Elided — Certain elements are hidden to simplify the view
- Incomplete — Certain elements may be missing
- Inconsistent — The integrity of the model is not guaranteed

These less-than-well-formed models are unavoidable as the details of a system unfold and churn during the software development life cycle. The rules of the UML encourage youbut do not force youto address the most important analysis, design, and implementation questions that push such models to become well-formed over time.

Common Mechanisms in the UML

A building is made simpler and more harmonious by the conformance to a pattern of common features. A house may be built in the Victorian or French country style largely by using certain architectural patterns that define those styles. The same is true of the UML. It is made simpler by the presence of four common mechanisms that apply consistently throughout the language.

1. Specifications
2. Adornments
3. Common divisions
4. Extensibility mechanisms

Specifications

The UML is more than just a graphical language. Rather, behind every part of its graphical notation there is a specification that provides a textual statement of the syntax and semantics of that building block. For example, behind a class icon is a specification that provides the full set of attributes, operations (including their full signatures), and behaviors that the class embodies; visually, that class icon might only show a small part of this specification. Furthermore, there might be another view of that class that presents a completely different set of parts yet is still consistent with the class's underlying specification. You use the UML's graphical notation to

visualize a system; you use the UML's specification to state the system's details. Given this split, it's possible to build up a model incrementally by drawing diagrams and then adding semantics to the model's specifications, or directly by creating a specification, perhaps by reverse engineering an existing system, and then creating diagrams that are projections into those specifications.

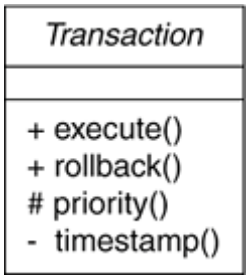
The UML's specifications provide a semantic backplane that contains all the parts of all the models of a system, each part related to one another in a consistent fashion. The UML's diagrams are thus simply visual projections into that backplane, each diagram revealing a specific interesting aspect of the system.

Adornments

Most elements in the UML have a unique and direct graphical notation that provides a visual representation of the most important aspects of the element. For example, the notation for a class is intentionally designed to be easy to draw, because classes are the most common element found in modeling object-oriented systems. The class notation also exposes the most important aspects of a class, namely its name, attributes, and operations.

A class's specification may include other details, such as whether it is abstract or the visibility of its attributes and operations. Many of these details can be rendered as graphical or textual adornments to the class's basic rectangular notation. For example, Figure 2-18 shows a class, adorned to indicate that it is an abstract class with two public, one protected, and one private operation.

Figure 2-18. Adornments



Every element in the UML's notation starts with a basic symbol, to which can be added a variety of adornments specific to that symbol.

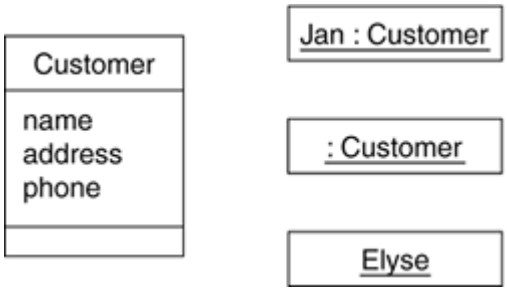
Common Divisions

In modeling object-oriented systems, the world often gets divided in several ways.

First, there is the division of class and object. A class is an abstraction; an object is one concrete

manifestation of that abstraction. In the UML, you can model classes as well as objects, as shown in Figure 2-19. Graphically, the UML distinguishes an object by using the same symbol as its class and then simply underlying the object's name.

Figure 2-19. Classes and Objects



In this figure, there is one class, named `Customer`, together with three objects: `Jan` (which is marked explicitly as being a `Customer` object), `:Customer` (an anonymous `Customer` object), and `Elyse` (which in its specification is marked as being a kind of `Customer` object, although it's not shown explicitly here).

Almost every building block in the UML has this same kind of class/object dichotomy. For example, you can have use cases and use case executions, components and component instances, nodes and node instances, and so on.

Second, there is the separation of interface and implementation. An interface declares a contract, and an implementation represents one concrete realization of that contract, responsible for faithfully carrying out the interface's complete semantics. In the UML, you can model both interfaces and their implementations, as shown in Figure 2-20.

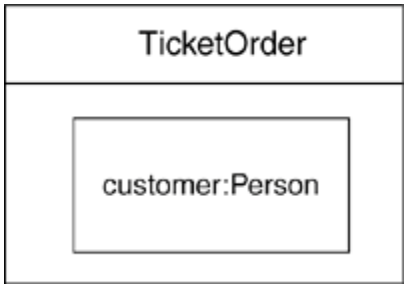
Figure 2-20. Interfaces and Implementations

In this figure, there is one component named `SpellingWizard.dll` that provides (implements) two interfaces, `IUnknown` and `ISpelling`. It also requires an interface, `IDictionary`, that must be provided by another component.

Almost every building block in the UML has this same kind of interface/implementation dichotomy. For example, you can have use cases and the collaborations that realize them, as well as operations and the methods that implement them.

Third, there is the separation of type and role. The type declares the class of an entity, such as an object, an attribute, or a parameter. A role describes the meaning of an entity within its context, such as a class, component, or collaboration. Any entity that forms part of the structure of another entity, such as an attribute, has both characteristics: It derives some of its meaning from its inherent type and some of its meaning from its role within its context (Figure 2-21).

Figure 2-21. Part with role and type



Extensibility Mechanisms

The UML provides a standard language for writing software blueprints, but it is not possible for one closed language to ever be sufficient to express all possible nuances of all models across all domains across all time. For this reason, the UML is opened-ended, making it possible for you to extend the language in controlled ways. The UML's extensibility mechanisms include

- Stereotypes
- Tagged values
- Constraints

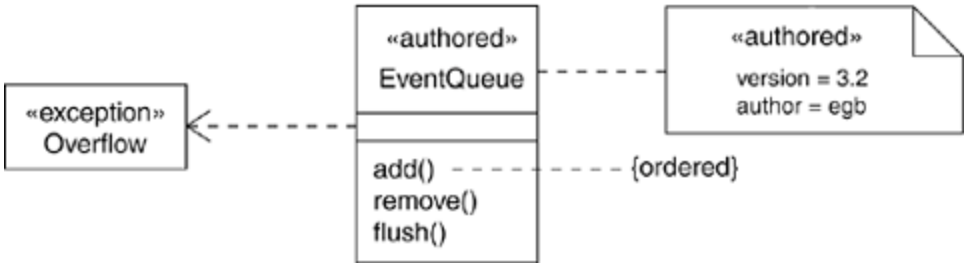
A *stereotype* extends the vocabulary of the UML, allowing you to create new kinds of building blocks that are derived from existing ones but that are specific to your problem. For example, if you are working in a programming language, such as Java or C++, you will often want to model exceptions. In these languages, exceptions are just classes, although they are treated in very special ways. Typically, you only want to allow them to be thrown and caught, nothing else. You can make exceptions first-class citizens in your modelsmeaning that they are treated like basic building blocksby marking them with an appropriate stereotype, as for the class `Overflow` in Figure 2-19.

A *tagged value* extends the properties of a UML stereotype, allowing you to create new information in the stereotype's specification. For example, if you are working on a shrink-

wrapped product that undergoes many releases over time, you often want to track the version and author of certain critical abstractions. Version and author are not primitive UML concepts. They can be added to any building block, such as a class, by introducing new tagged values to that building block. In Figure 2-19, for example, the class `EventQueue` is extended by marking its version and author explicitly.

A *constraint* extends the semantics of a UML building block, allowing you to add new rules or modify existing ones. For example, you might want to constrain the `EventQueue` class so that all additions are done in order. As Figure 2-22 shows, you can add a constraint that explicitly marks these for the operation `add`.

Figure 2-22. Extensibility Mechanisms



Collectively, these three extensibility mechanisms allow you to shape and grow the UML to your project's needs. These mechanisms also let the UML adapt to new software technology, such as the likely emergence of more powerful distributed programming languages. You can add new building blocks, modify the specification of existing ones, and even change their semantics. Naturally, it's important that you do so in controlled ways so that through these extensions, you remain true to the UML's purpose the communication of information.

Architecture:

Any real world system is used by different users. The users can be developers, testers, business people, analysts and many more. So before designing a system the architecture is made with different perspectives in mind. The most important part is to visualize the system from different viewer.s perspective. The better we understand the better we make the system.

UML plays an important role in defining different perspectives of a system. These perspectives are:

- Design View
- Implementation View
- Process View
- Deployment View
- Usecase View

And the centre is the **Use Case** view which connects all these four. A **Use case** represents the functionality of the system. So the other perspectives are connected with use case.

- **Design** of a system consists of classes, interfaces and collaboration. UML provides class diagram, object diagram to support this.
- **Implementation** defines the components assembled together to make a complete physical system. UML component diagram is used to support implementation perspective.
- **Process** defines the flow of the system. So the same elements as used in *Design* are also used to support this perspective.
- **Deployment** represents the physical nodes of the system that forms the hardware. UML deployment diagram is used to support this perspective.

Software Development Life Cycle:

The Unified Software Development Process
A software development process is the set of activities needed to transform a user‘s requirements into a software system.
Basic properties:
• use case driven
• architecture centric
• iterative and incremental

Use case Driven
Use cases
• capture requirements of the user,
• divide the development project into smaller subprojects,
• are constantly refined during the whole development process
• are used to verify the correctness of the implemented software

Architecture Centric:
• Find structures which are suitable to achive the function specified in the use cases,
• understandable,
• maintainable,
• reusable for later extensions or newly discovered use cases and describe them, so that they can be communicated between developers and users.

Inception establishes the business rationale for the project and decides on the scope of the project.

Elaboration is the phase where you collect more detailed requirements, do high-level analysis and design to establish a baseline architecture and create the plan for construction.

Construction is an iterative and incremental process. Each iteration in this phase builds production- quality software prototypes , tested and integrated as subset of the requirements of the project.

Transition contains beta testing , performance tuning and user training.