UML:
An Introduction

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- Why model ?
- Principles of modeling
- What is UML ? & its uses
- Conceptual Model of the UML
  - Building Blocks
  - Rules
  - Common Mechanisms

Why Model ?

- Analyse the problem-domain
  - simplify reality
  - capture requirements
  - visualize the system in its entirety
  - specify the structure and/or behaviour of the system
- Design the solution
  - document the solution - in terms of its structure, behaviour, etc.

Principles of Modeling

- Choose your model well – *the choice of model profoundly 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.*
- 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.*

What is UML ?

- UML – Unified Modeling language
- UML is a modeling language, not a methodology or process
- Fuses the concepts of the Booch, OMT, OOSE methods
- Developed by Grady Booch, James Rumbaugh and Ivar Jacobson at Rational Software.
- Accepted as a standard by the Object Management Group (OMG), in 1997.

More on UML...

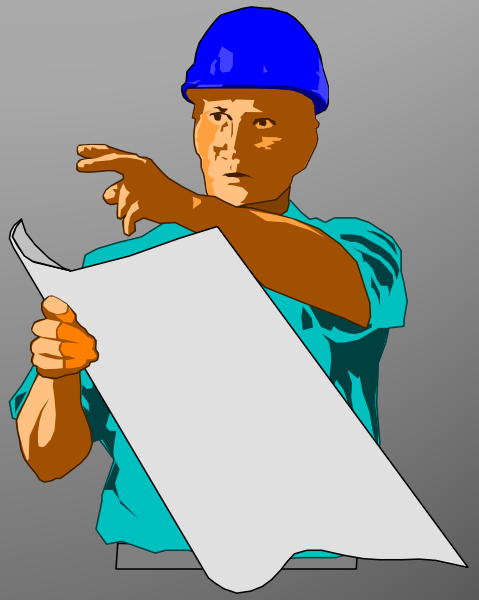
UML is a modeling language for visualising, specifying, constructing and documenting the artifacts of software systems.

Visualising - *a picture is worth a thousand words; a graphical notation articulates and unambiguously communicates the overall view of the system (problem-domain).*

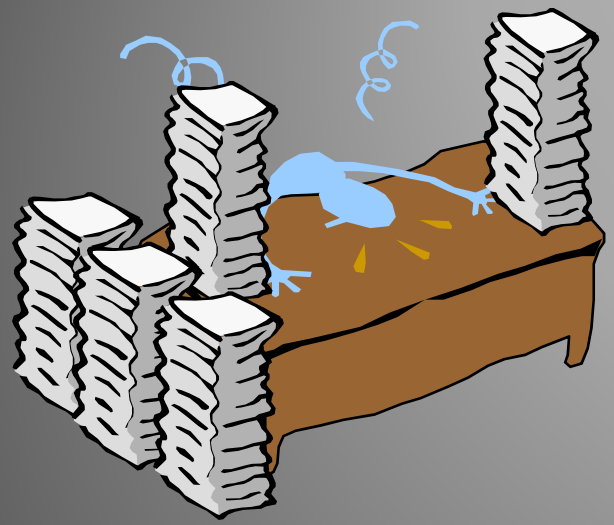
More on UML...

Specifying – *UML provides the means to model precisely, unambiguously and completely, the system in question.*

Constructing - *models built with UML have a "design" dimension to it; these are language independent and can be implemented in any programming language.*



More on UML...



Documenting – *every software project involves a lot of documentation - from the inception phase to the deliverables.*

Documentation is (among others) for:

- Requirements
- Design
- Tests

UML provides the notations for documenting some of these artifacts

Where can the UML be used

- Banking and financial services
- Enterprise information systems
- Telecommunications
- Transportations
- Defense / aerospace
- Retail
- Medical & scientific
- Distributed web-based services

Conceptual Model of UML

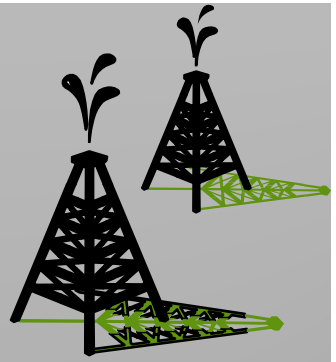
- Building Blocks
  - *Things*
  - *Relationships*
  - *Diagrams*
- Rules
- Common Mechanisms
  - *Specifications*
  - *Adornments*
  - *Common Divisions*
  - *Extensibility Mechanisms*

UML Building Blocks

- Things
  - *Structural*
  - *Behavioral*
  - *Grouping*
  - *Annotational*
- Relationships
  - *Dependency*
  - *Association*
  - *Generalisation*
  - *Realization*

- Diagrams
  - *Class Diagram*
  - *Object Diagram*
  - *Use Case Diagram*
  - *Interaction Diagram*
  - *State chart Diagram*
  - *Activity Diagram*
  - *Component Diagram*
  - *Deployment Diagram*

Structural Things



The nouns of UML models; usually the static parts of the system in question.

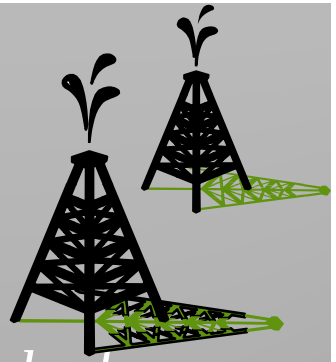
- Class – *an abstraction of a set of things in the problem-domain that have similar properties and/or functionality.*

Notation: customer

- Interface - *a collection of operations that specify the services rendered by a class or component.*

Notation: ◯

Structural Things (contd.)



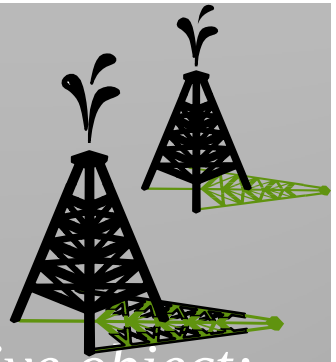
- Collaboration – *a collection of UML building blocks (classes, interfaces, relationships) that work together to provide some functionality within the system.*

Notation:

- Use Case - *an abstraction of a set of functions that the system performs; a use case is "realized" by a collaboration.*

Notation:

Structural Things (contd.)

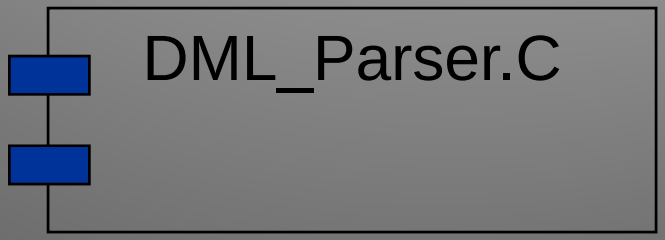


- Active Class – *a class whose instance is an active object; an active object is an object that owns a process or thread (units of execution)*

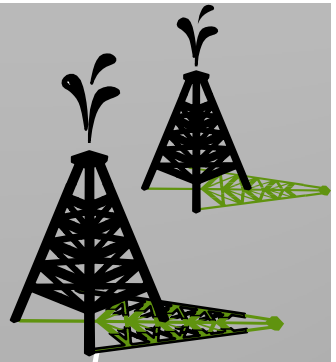
Notation:

- Component - *a physical part (typically manifests itself as a piece of software) of the system.*

Notation:

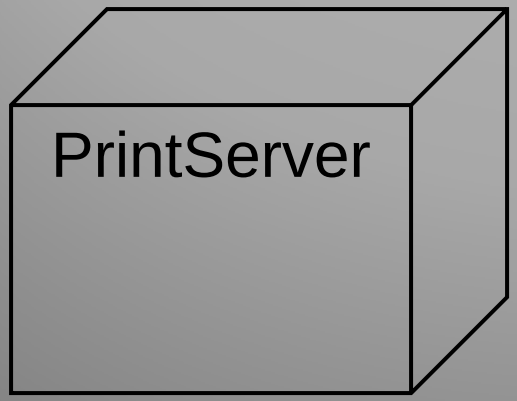


Structural Things (contd.)



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

Notation:



Behavioral Things

The verbs of UML models; usually the dynamic parts of the system in question.

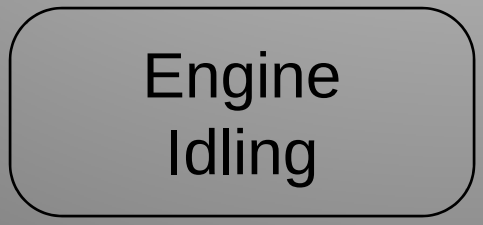
- Interaction – *some behaviour constituted by messages exchanged among objects; the exchange of messages is with a view to achieving some purpose.*

Notation: Parse →

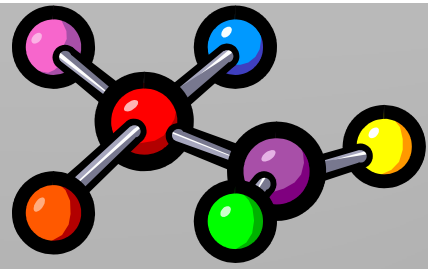
Behavioral Things (contd.)

- State machine – *a behaviour 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 performs some function.*

Notation:



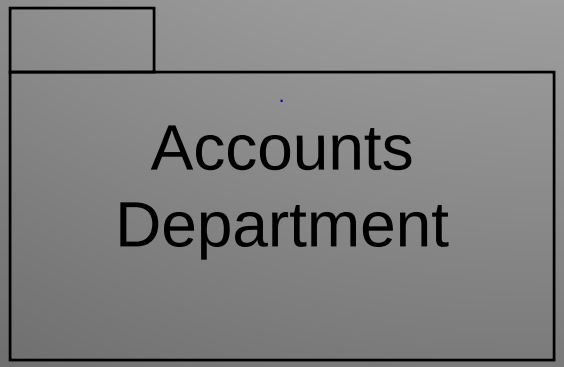
Grouping Things



The organisational part of the UML model; provides a higher level of abstraction (granularity).

- Package – *a general-purpose element that comprises UML elements - structural, behavioral or even grouping things. Packages are conceptual groupings of the system and need not necessarily be implemented as cohesive software modules.*

Notation:

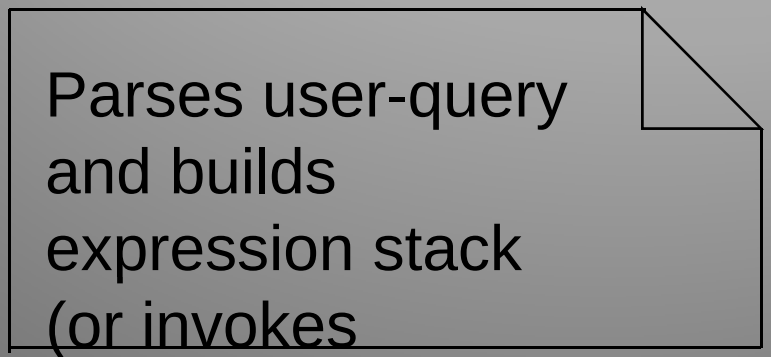


Annotational Things

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 elements of the model.*

Notation:



Relationships

Articulates the meaning of the links between things.

- 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).*

  Notation: --------->

  (arrow-head points to the independent thing)

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

  Notation: ———————

Relationships (contd.)

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

Notation: 

(arrow-head points to the superclass)

Relationships (contd.)

- Realization – *a semantic relationship between two things wherein one specifies the behaviour to be carried out, and the other carries out the behaviour.*
  - " a collaboration *realizes* a Use Case"

    the Use Case specifies the behaviour (functionality) to be carried out (provided), and the collaboration actually implements that behaviour.

Notation: ----------▷

(arrow-head points to the thing being realized)

Diagrams

The graphical presentation of the model. Represented as a connected graph - vertices (things) connected by arcs (relationships).

UML includes nine diagrams - each capturing a different dimension of a software-system architecture.

- Class Diagram
- Object Diagram
- Use Case Diagram
- Sequence Diagram
- Collaboration Diagram
- Statechart Diagram
- Activity Diagram
- Component Diagram
- Deployment Diagram

More on Diagrams…

- Class Diagram – *the most common diagram found in OOAD, shows a set of classes, interfaces, collaborations and their relationships. Models the static view of the system.*
- Object Diagram – *a snapshot of a class diagram; models the instances of things contained in a class diagram.*
- Use Case Diagram – *shows a set of "Use Cases" (sets of functionality performed by the system), the "actors" (typically, people/systems that interact with this system[problem-domain]) and their relationships. Models WHAT the system is expected to do.*

More on Diagrams…

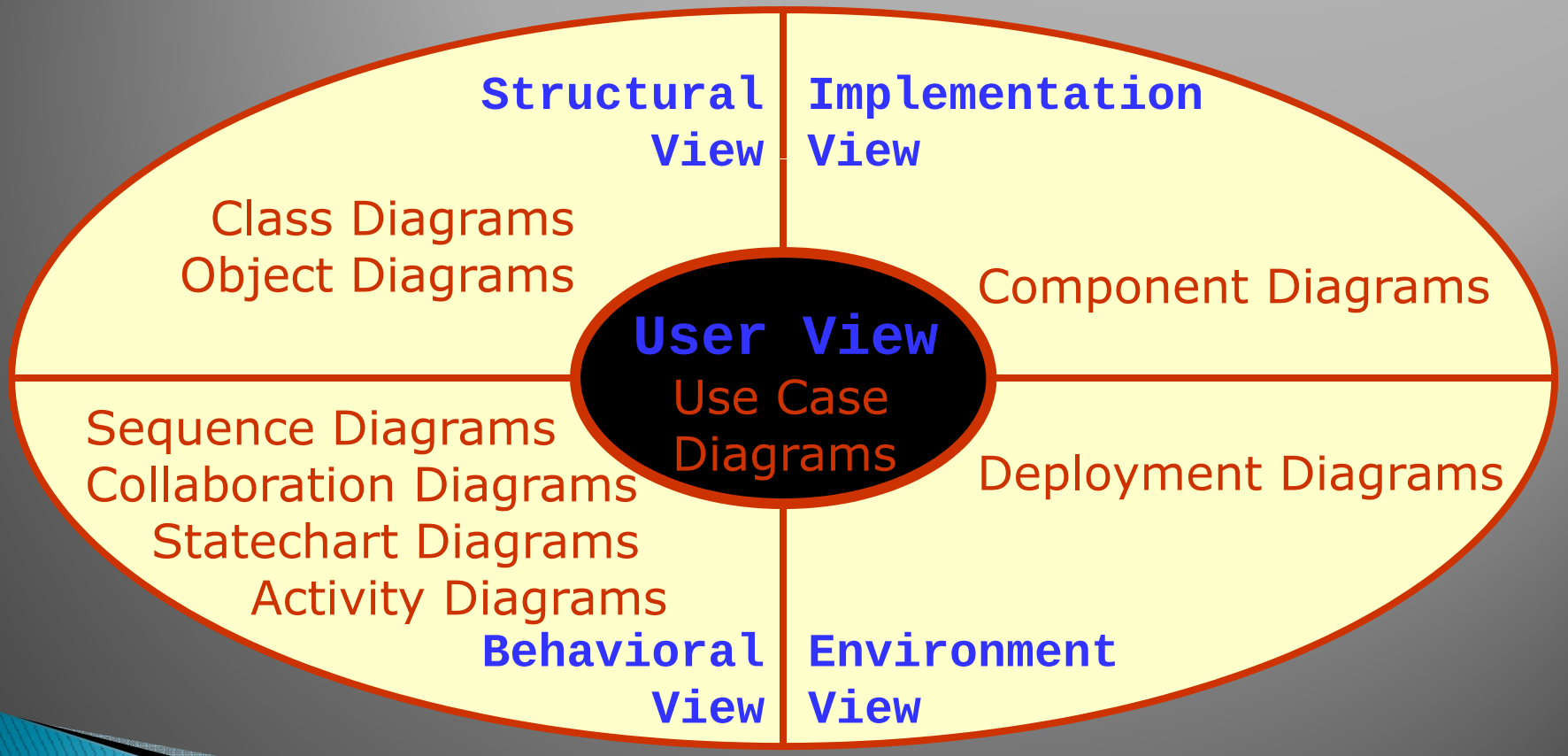
- Sequence Diagram – *models the flow of control by time-ordering; depicts the interaction between various objects by of messages passed, with a temporal dimension to it.*
- Collaboration Diagram – *models the interaction between objects, without the temporal dimension; merely depicts the messages passed between objects.*
- Statechart Diagram – *shows the different state machines and the events that leads to each of these state machines. Statechart diagrams show the flow of control from state to state.*

More on 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...

. . .of Software Architecture



Rules

- Specify what a well-formed model should look like.
- The UML has semantic rules for
  - Names – what you can call things
  - Scope – context that gives specific meaning
  - Visibility – how the names can be seen
  - Integrity – relating to one another
  - Execution – to run a dynamic model

Common Mechanisms

- Mechanisms/elements that apply consistently throughout the language:
  - Specifications
  - Adornments
  - Common Divisions
  - Extensibility Mechanisms

(Notes)

- *Stereotypes*
- *Tagged values*
- *Constraints*

Adornments

"Adorn" the model - i.e., enhance the model. Adds to the meaning and/or semantics of the element to which it pertains.

"Notes" are the mechanism provided by UML for adorning a model:

- graphical symbol to render constraints, comments, etc.
- a note that renders only a comment has no semantic impact on the element it is adorning; at most adds meaning to it and/or provides guidelines for implementation.

Stereotypes

- Used to create new building blocks from existing blocks.
- New building blocks are domain-specific.
- A particular abstraction is marked as a “stereotype” and this stereotype is then used at other places in the model to denote the associated abstraction.

Notation: «metaclass»

Tagged Values

- Used to add to the information of the element (not of its instances).
- Stereotypes help create new building blocks; tagged values help create new attributes.
- Commonly used to specify information relevant to code generation, configuration management, etc.

Notation: {version=1.4}

Constraints

- Used to create rules for the model.
- Rules that impact the semantics of the model, and specify conditions that must be met.
- Can apply to any element in the model – attributes of a class, relationship, etc.

Notation: { incomplete, disjoint }

Summary

- Modeling captures the system in its entirety, along with the different dimensions of its complexity.
- Facilitates quick and efficient analysis and design and helps communicate the overall system architecture unambiguously.
- Principles of modeling lay down that:
  - model must be chosen well
  - model should encapsulate different granularities
  - models can make simplifying assumptions, but not hide important facts
  - no single model can capture all dimensions of the complexity

Summary

- UML (Unified Modeling Language) is a language that helps analyse and design solutions for software-intensive systems
- Developed by Booch, Rumbaugh and Jacobson at Rational Software; subsequently adopted as an open standard by the Object Management Group in 1997.
- UML is a modeling language for visualising, specifying, constructing and documenting the artifacts of a software system.
- It is a modeling language and not a methodology or a process.

Summary

- The conceptual model of the UML comprises the "*Building Blocks*" of UML, its "*Rules*" and certain "*Common Mechanisms*" that are applicable across the entire language.
- The Building Blocks comprise "*Things*", "*Relationships*" and "*Diagrams*".
- "Things" are of grouped into 4 categories: *structural things*, *behavioral things*, *grouping things* and *annotational things*.

Summary

- Structural things describe the static part of the model and are of seven types: *class*, *interface*, *collaboration*, *use case*, *active class*, *component*, *node*.
- Behavioral things describe the dynamic part of the model and are of two types: *interaction* and *state machine*.
- *Packages* are included under Grouping things, and *Notes* under Annotational things
- "Relationships" link things to each other and are of four types: *Dependency*, *Association*, *Generalisation* and *Realization*.

Summary

- "Diagrams" are essentially connected graphs – a set of vertices (things) connected by arcs (relationships). There are several types of diagrams, each one capturing a different dimension of the system's complexity.
- Diagrams are of nine types: *Class Diagram*, *Object Diagram*, *Use Case Diagram*, *Sequence Diagram*, *Collaboration Diagram*, *Statechart Diagram*, *Activity Diagram*, *Implementation Diagram*, *Deployment Diagram*.
- The UML has semantic rules for Names of classifiers, Scope of these names, Visibility of these names, and the Integrity and Execution of the model.

Summary

- Certain common mechanisms apply uniformly across the model. There are four such mechanisms: *Specifications*, *Common Divisions*, *Adornments*, *Extensibility Mechanisms*.
- Notes are the most common adornments used, that add to the meaning of a classifier.
- Extensibility mechanisms include Stereotypes, Tagged values and constraints.

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