UML - Unified Modeling Language

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Most slides by courtesy of Kristian Sandahl

Software engineering process

- Support, Management, Tools, Methods, Techniques, Resources
- Requirements analysis
- System design
- Program design
- Coding
- Acceptance testing
- System testing
- Unit & integration testing
- Operation & Maintenance
Modeling as a Design Technique

- Testing a physical entity before building it
- Communication with customers
- Visualization
- Reduction of complexity

- Models supplement natural language
- Models support understanding, design, documentation
- Creating a model forces you to take necessary design decisions
- **UML** is now the standard notation for modeling software.

Literature on UML

- Current version is UML 2.0 (2004/2005)
  - OMG documents: *UML Infrastructure, UML Superstructure*
- Books:
  - Pfleeger: *Software Engineering* 3rd ed., 2005 (mostly Chapter 6)
  - And many others…
UML: Different diagram types for different views of software

Modeling (logical) structure of software:
- Static view: Class diagram
- Design view: Structure diagram, collaboration diagram, component diagram
- Use case view: Use case diagram

Modeling behavior of software:
- Activity view: Activity diagram
- State machine view: State machine diagram
- Interaction view: Sequence diagram, communication diagram

Modeling physical structure of software:
- Deployment view: Deployment diagram

Modeling the model, and extending UML itself:
- Model management view: Package Diagram
- Profiles

Use-case modelling

A use-case is:

“… a particular form or pattern or exemplar of usage, a scenario that begins with some user of the system initiating some transaction of sequence of interrelated events.”

Jacobson, m fl 1992: Object-oriented software engineering. Addison-Wesley
A CoffeeDrinker approaches the machine with her cup and a coin of SEK 5. She places the cup on the shelf just under the pipe. She then inserts the coin, and presses the button for coffee to get coffee according to default settings. Optionally she might use other buttons to adjust the strength and decide to add sugar and/or whitener. The machine processes the coffee and rings a bell when it is ready. The CoffeeDrinker takes her cup from the shelf.

**Actor:** a user of the system in a particular role. Can be human or system.
Relations between use-cases

Please, keep as simple as possible.

Stereotype: extended classification of meaning

"Reuse"

"Separating scenarios" (often conditional)

Identifying classes: noun analysis

A CoffeeDrinker approaches the machine with her cup and a coin of SEK 5. She places the cup on the shelf just under the pipe. She then inserts the coin, and presses the button for coffee to get coffee according to default settings. Optionally, she might use other buttons to adjust the strength and decide to add sugar and/or whitener. The machine processes the coffee and rings a bell when it is ready. The CoffeeDrinker takes her cup from the shelf.
The single class model

CoffeeCustomer

- name: String
- numberOfCoins() : Integer
- buy ( c : CupOfCoffee )

Associations between classes

- CoffeeCustomer
  - association
  - multiplicities:
    - an exact number
    - a range of numbers
    - unspecified number denoted by *
Extended class model

CoffeeCustomer \(0..*\) buys \(0..*\) CupOfCoffee

Porter \(0..*\) buys \(0..*\) CanOfCoffee

Revised class model

CoffeeCustomer \(0..*\) buys \(0..*\) CupOfCoffee

Porter \(0..*\) buys \(0..*\) CanOfCoffee

Generalisation association
Class model with navigability

CoffeeCustomer \( \xrightarrow{0..* \text{ buys} \ 0..*} \) CupOfCoffee

Porter \( \xrightarrow{0..* \text{ buys} \ 0..*} \) CanOfCoffee

Generalisation association

Class model with inheritance and abstract classes

CoffeeCustomer

\begin{itemize}
  \item pay( c: coin )
\end{itemize}

Abstract class (cannot be instantiated, only extended/specialized)

IndividualCustomer

\begin{itemize}
  \item getCup()
\end{itemize}

Porter

\begin{itemize}
  \item getCan()
\end{itemize}

pay() method is inherited from CoffeeCustomer
Class model with aggregation

Aggregation: part-of relationship

More relations between classes

aggregation

composition

qualified association

constraint
The coffee machine class model

Classes and objects

Classes:

Objects:
Reasoning about an arbitrary object

Like this:

```
| aCoffeeCustomer: CoffeeCustomer | buys | theCupOfCoffee: CupOfCoffee |
```

...or simply like this:

```
| : CoffeeCustomer | buys | : CupOfCoffee |
```

Sequence diagram
Sequence diagram with several objects

Communication diagram

Shows message flows with sequence numbers
Similar information as sequence diagram
State machine diagram

For class CoinHandler:

- State: idle
  - Start state marker
- State: checking

- Transition: 
  - FalseCoin() / returnCoin(self)
- Transition: 
  - InsertCoin() / checkCoin(self)

- Action, reaction to the event:
  - This object

Can formally describe protocols

Activity Diagram

- Graph
  - Nodes are activities (actions)
    - Method invocations, operations, sending / receiving messages, handling events, creating / accessing / modifying / deleting objects, variables …
    - Data flow by input and output parameter pins
  - Edges are control flow transitions
    - To some degree dual to the state diagram
- Might be refined to a low-level specification; cf. control flow graph (~ compiler IR)
- A Petri Net
  - Interpretation by moving tokens along edges
  - Models concurrency by multiple tokens for "current state"
  - Fork / join for synchronization
- Models real-world workflows

brew coffee
Activity diagram

initial node → insert coin

coin accepted? [no] → final node

[yes]

fork

brew coffee

add sugar/whitener

add hot water to adjust strength

join

pour coffee

Other features…

• Comments
• Constraints in OCL (Object Constraint Language)
• Profiles: Collections of stereotypes for specific domains, e.g. Realtime-profile for UML
  – Customize (specialize) UML elements, e.g. associations
  – Can introduce own symbols
• MOF (Meta-Object Facility):
  – UML is specified in UML
  – Powerful mechanism for extending UML by adding new language elements
UML Summary

• UML – the standard for modeling software
• Modeling before/during design, precedes coding
• Different diagrams for different views
• Model a software system only partially, focus on a certain aspect and/or part at a time
• Problem: Maintaining consistency across diagrams
• Tools
• Trend towards more detailed modeling
  – Stepwise refinement
  – "executable UML": UML 2 is almost a programming language…
  – UML is customizable and extendible: Profiles, MOF
• Trend towards automatized partial generation of models and code from models (MDA – model-driven architecture)

Homework Exercise

• Draw a class diagram for the following scenario:

A customer, characterized by his/her name and phone number, may purchase reservations of tickets for a performance of a show. A reservation of tickets, annotated with the reservation date, can be either a reservation by subscription, in which case it is characterized by a subscription series number, or an individual reservation. A subscription series comprehends at least 3 and at most 6 tickets; an individual reservation at most one ticket. Every ticket is part of a subscription series or an individual reservation, but not both. Customers may have many reservations, but each reservation is owned by exactly one customer. Tickets may be available or not, and one may sell or exchange them. A ticket is associated with one specific seat in a specific performance, given by date and time, of a show, which is characterized by its name. A show may have several performances.