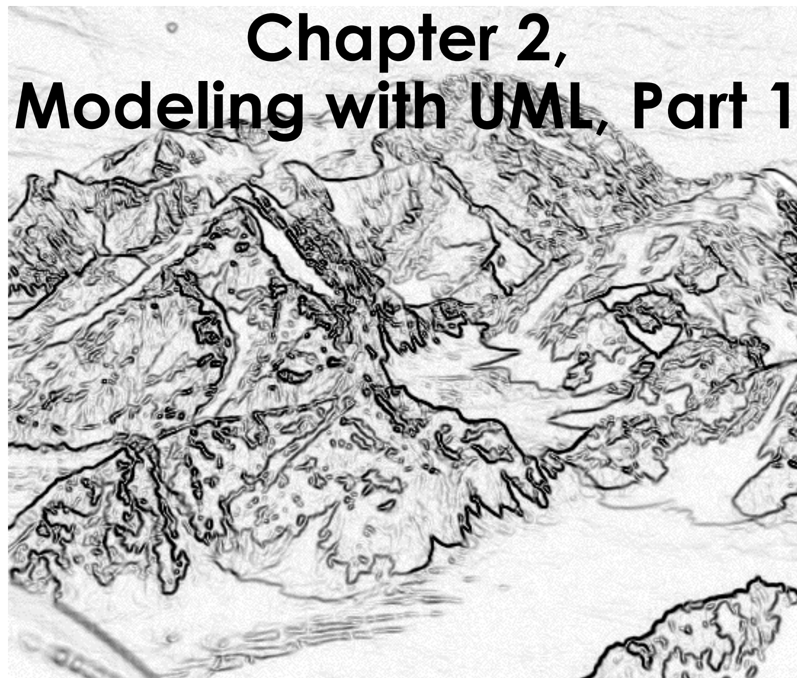
Object-Oriented Software Engineering
Using UML, Patterns, and Java



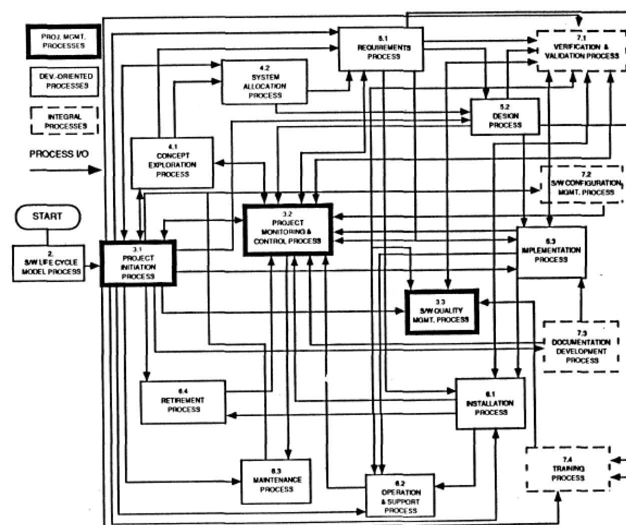
Odds and Ends

- Reading for this Lecture:
  - Chapter 1 and 2, Bruegge&Dutoit, Object-Oriented Software Engineering
- Lectures Slides:
  - Will be posted before each lecture.

Overview for the Lecture

- Three ways to deal with complexity
  - Abstraction and Modeling
    - (Abstraction -> Hiding details)
  - Decomposition
    - A complex problem or system is broken down into parts that are easier to conceive
  - Hierarchy
    - a hierarchy can be modelled as a rooted tree
- Introduction into the UML notation
- First pass on:
  - Use case diagrams
  - Class diagrams
  - Sequence diagrams
  - Statechart diagrams
  - Activity diagrams

What is the problem with this Drawing?



Abstraction

- Complex systems are hard to understand
  - The 7 +- 2 phenomena
    - Our short term memory cannot store more than 7+-2 pieces at the same time -> limitation of the brain
    - My Phone Number: 498928918204

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  - Group collection of objects to reduce complexity
  - 4 chunks:
    - State-code, Area-code, Local-Prefix, Internal-Nr

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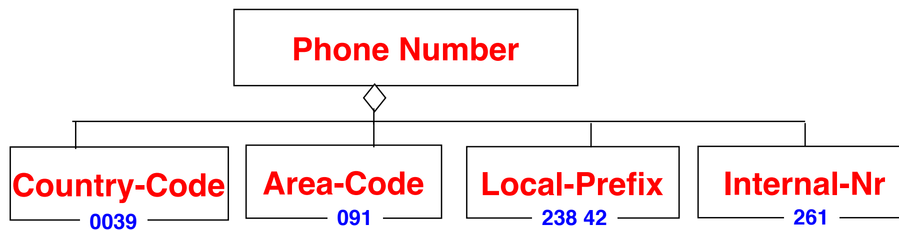


Abstraction

- Abstraction allows us to ignore unessential details
- Ideas can be expressed by models

Models

- A model is an abstraction of a system
  - A system that no longer exists
  - An existing system
  - A future system to be built.

Why model software?

Why model software?

- Software is getting increasingly more complex
  - Windows XP > 40 millions of lines of code
  - A single programmer cannot manage this amount of code in its entirety.
- Code is not easily understandable by developers who did not write it
- We need simpler representations for complex systems
  - Modeling is a mean for dealing with complexity

We use Models to describe Software Systems

- Object model: What is the structure of the system?
- Functional model: What are the functions of the system?
- Dynamic model: How does the system react to external events?

- System Model: Object model + functional model + dynamic model

2. Technique to deal with Complexity: Decomposition

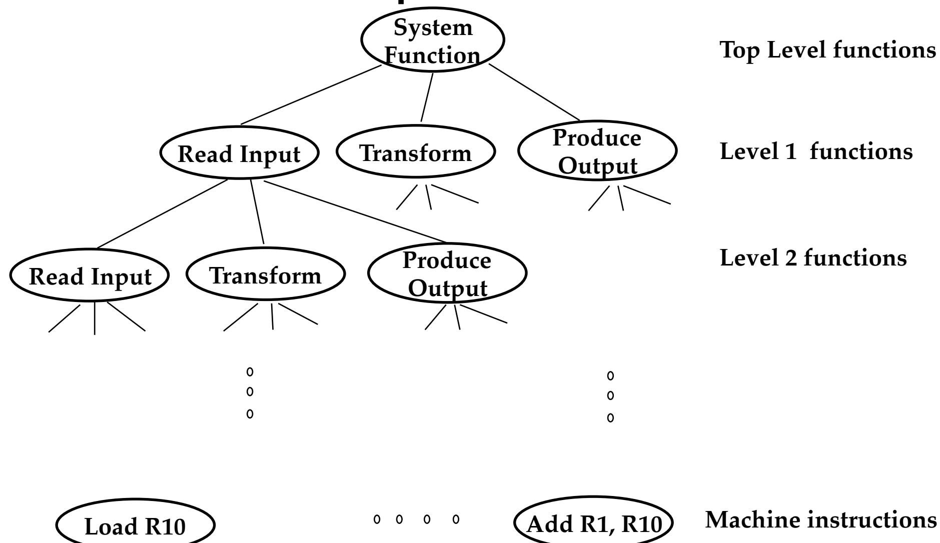
- A technique used to master complexity (“divide and conquer”)
- Two major types of decomposition
  - Functional decomposition
  - Object-oriented decomposition
- Functional decomposition
  - The system is decomposed into modules
  - Each module is a major function in the application domain
  - Modules can be decomposed into smaller modules.

Decomposition (cont' d)

- Object-oriented decomposition
  - The system is decomposed into classes ("objects")
  - Each class is a major entity in the application domain
  - Classes can be decomposed into smaller classes
- Object-oriented vs. functional decomposition

Which decomposition is the right one?

Functional Decomposition



Functional Decomposition

- The functionality is spread all over the system
- Maintainer must understand the whole system to make a single change to the system
- Consequence:
  - Source code is hard to understand
  - Source code is complex and impossible to maintain
  - User interface is often awkward and non-intuitive.

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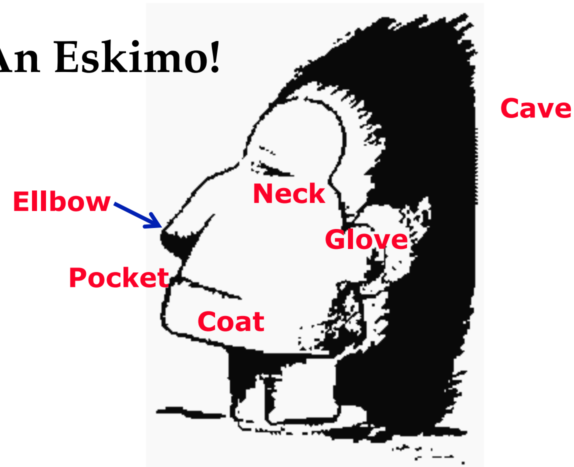
What is This?

An Eskimo!



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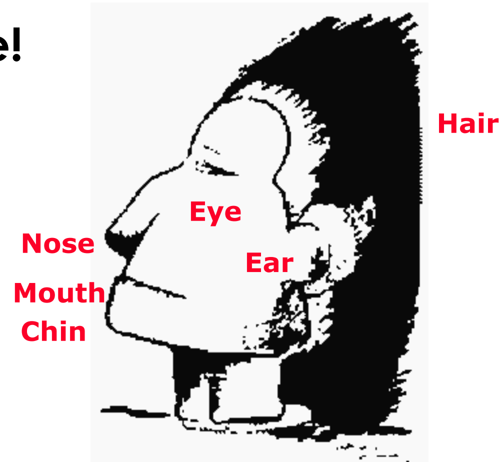
A Face!



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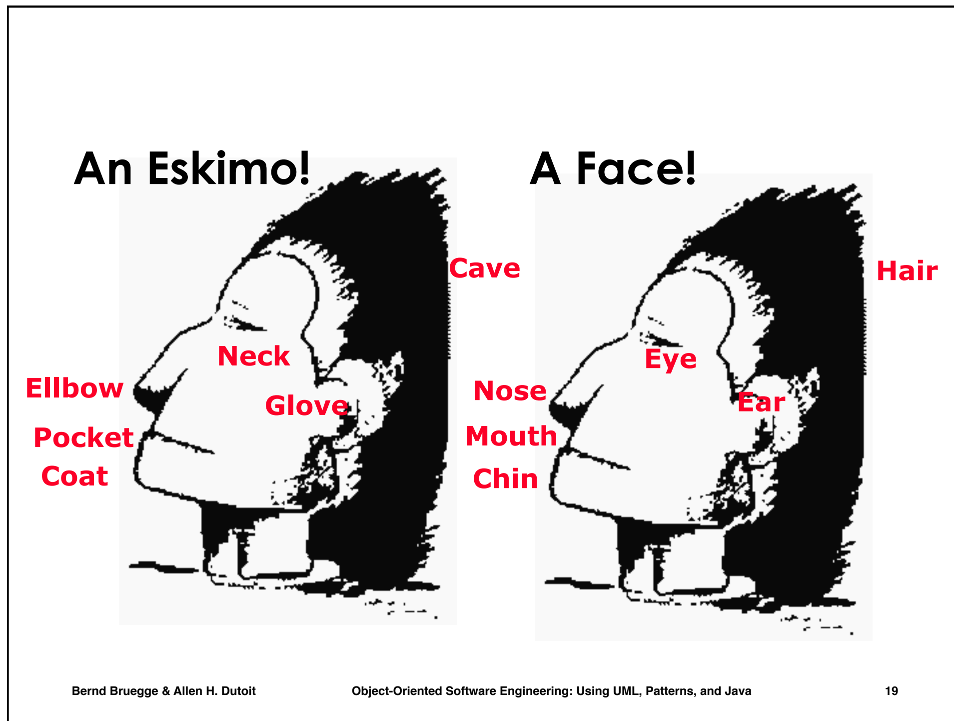


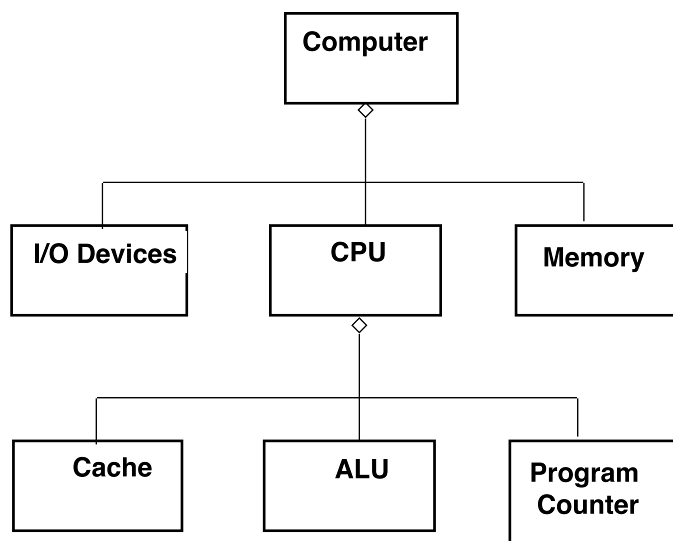
Class Identification

- **Basic assumptions:**
  - We can find the *classes for a new software system:* Greenfield Engineering
  - We can identify the *classes in an existing system*: Reengineering
  - We can create a *class-based interface to an existing system:* Interface Engineering.

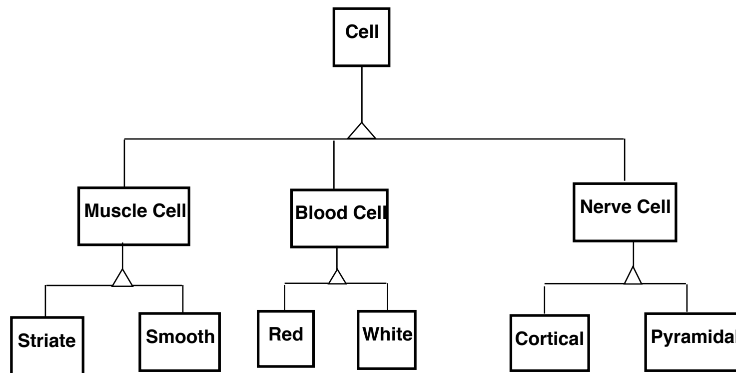
3. Hierarchy

- So far we got abstractions
  - This leads us to classes and objects
  - “Chunks”
- Another way to deal with complexity is to provide relationships between these chunks
- One of the most important relationships is hierarchy
- 2 special hierarchies
  - "Part-of" hierarchy
  - "Is-kind-of" hierarchy.

Part-of Hierarchy (Aggregation)



Is-Kind-of Hierarchy (Taxonomy)



Where are we?

- Three ways to deal with complexity:
  - Abstraction, Decomposition, Hierarchy
- Object-oriented decomposition is good
  - Unfortunately, depending on the purpose of the system, different objects can be found
- How can we do it right?
  - Start with a description of the functionality of a system
  - Then proceed to a description of its structure
- Ordering of development activities
  - Software lifecycle

Systems, Models and Views

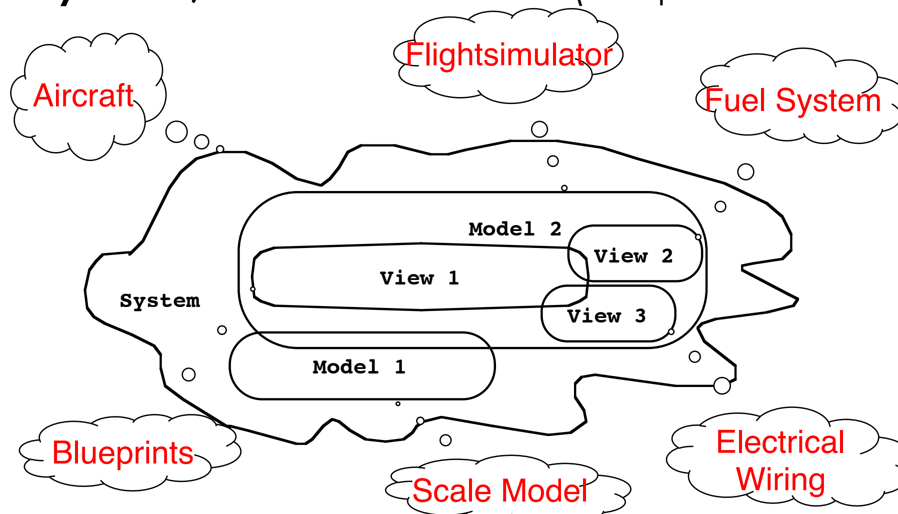
- A ***model*** is an abstraction describing a system or a subsystem
- A ***view*** depicts selected aspects of a model
- A ***notation*** is a set of graphical or textual rules for depicting models and views:
  - formal notations, "napkin designs"

System: Airplane

Models:
Flight simulator
Scale model

Views:
Blueprint of the airplane components
Electrical wiring diagram, Fuel system
Sound wave created by airplane

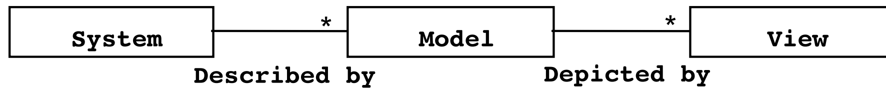
Systems, Models and Views ("Napkin" Notation)

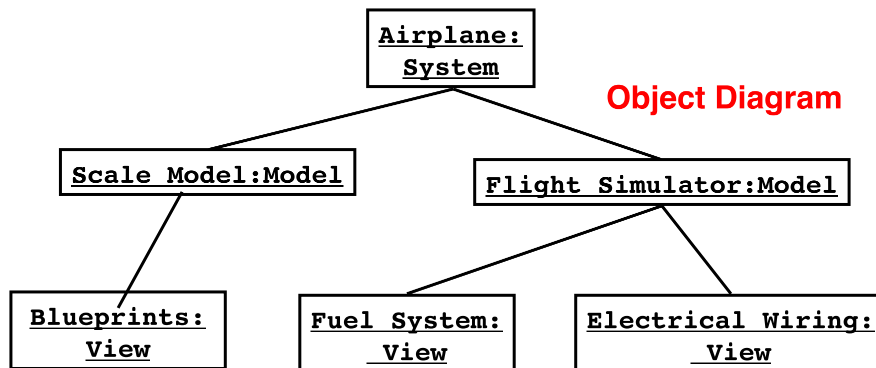


Views and models of a complex system usually overlap

Systems, Models and Views (UML Notation)

Class Diagram





Model-Driven Development

1. Build a platform-independent model of an applications functionality and behavior
   a) Describe model in modeling notation (UML)
   b) Convert model into platform-specific model
2. Generate executable from platform-specific model

Advantages:

- Code is generated from model (“mostly”)
- Portability and interoperability

- Model Driven Architecture effort:
  - http://www.omg.org/mda/
- OMG: Object Management Group

Model-driven Software Development

Reality: A stock exchange lists many companies. Each company is identified by a ticker symbol

Analysis results in analysis object model (UML Class Diagram):

Implementation results in source code (Java):

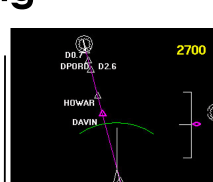
```
public class StockExchange {
    private m_Company = new Vector();
 };
public class Company  {
  private int m_tickerSymbol;
  private Vector m_StockExchange = new Vector();
};
```

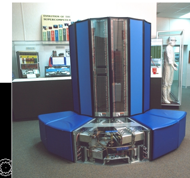

Application vs Solution Domain

- Application Domain (Analysis):
  - The environment in which the system is operating
- Solution Domain (Design, Implementation):
  - The technologies used to build the system
- Both domains contain abstractions that we can use for the construction of the system model.

Object-oriented Modeling

Application Domain
(Phenomena)

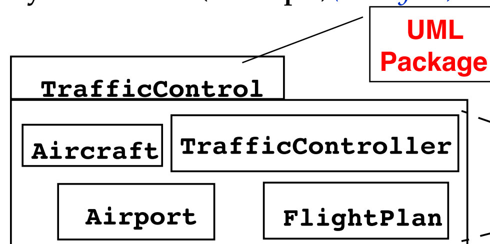


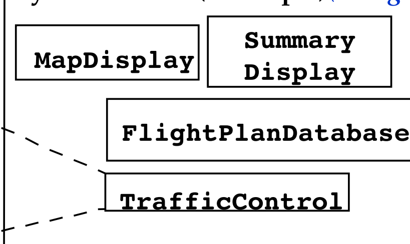


Solution Domain
(Phenomena)

System Model (Concepts) *(Analysis)*

System Model (Concepts) *(Design)*





What is UML?

- UML (Unified Modeling Language)
  - Nonproprietary standard for modeling software systems, OMG
  - Convergence of notations used in object-oriented methods
    - OMT (James Rumbaugh and collegues)
    - Booch (Grady Booch)
    - OOSE (Ivar Jacobson)
- Current Version: UML 2.4.1
  - Information at the OMG portal http://www.uml.org/
- Commercial tools: Rational (IBM),Together (Borland), Visual Architect (business processes, BCD)
- Open Source tools: ArgoUML, StarUML, Umbrello
- Commercial and Opensource: PoseidonUML (Gentleware), **Astah**, Violet

UML First Pass

- Use case diagrams
  - Describe the functional behavior of the system as seen by the user
- Class diagrams
  - Describe the static structure of the system: Objects, attributes, associations
- Sequence diagrams
  - Describe the dynamic behavior between objects of the system
- Statechart diagrams
  - Describe the dynamic behavior of an individual object
- Activity diagrams
  - Describe the dynamic behavior of a system, in particular the workflow.

UML Core Conventions

- All UML Diagrams denote graphs of nodes and edges
  - Nodes are entities and drawn as rectangles or ovals
  - Rectangles denote classes or instances
  - Ovals denote functions
- Names of Classes are not underlined
  - `SimpleWatch`
  - `Firefighter`
- Names of Instances are underlined
  - `myWatch:SimpleWatch`
  - `Joe:Firefighter`
- An edge between two nodes denotes a relationship between the corresponding entities