# Software design and modelling

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Usually excludes detailed coding level.

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What is good design?

# (Some) criteria for a good design

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- ▶ It is verifiable: that is, it is practical to check that it meets the requirements
- ▶ It is straightforward to explain to implementors
- ▶ It is maintainable: that is, it will be possible to adapt it to meet future requirements
- ▶ It makes appropriate use of existing technology, e.g. reusable components

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Notice the human angle in most of these points, and the situation-dependency, e.g.

- whether an OO design or a functional design is best depends (partly) on whether it is to be implemented by OO programmers or functional programmers;
- different design choices will make different future changes easy – a good design makes the most likely ones easiest.

# A quotation from Donald Schön

Designers put things together and bring new things into being, dealing in the process with many variables and constraints, some initially known and some discovered through designing. Almost always, designers' moves have consequences other than those intended for them. Designers juggle variables, reconcile conflicting values, and maneuver around constraints – a process in which, although some design products may be superior to others, there are no unique right answers.

Donald A. Schön
*Educating the Reflective Practitioner*
Jossey-Bass, San Francisco, 1987.

# Levels of design

Design occurs at different levels, e.g. someone must decide:

- what programming languages will your system use?
- how is your system split up into subsystems? (high-level, or architectural, design)
- what are the classes in your system? (low-level, or detailed, design)
- what are the responsibilities of each bit? (both levels)
- what are the interfaces? (both levels)
- what messages are exchanged, in what order? (both levels)

# What is architecture?

Many things to many people.

> The way that components work together

More precisely, an architectural decision is a decision which affects how components work together.

Includes decisions about the high level structure of the system – what you probably first think of as "architecture".

Pervasive, hence hard to change. Indeed an alternative definition is "what stays the same" as the system develops, and between related systems.

# Classic structural view

Architecture specifies:

- what are the components?
  Looked at another way, where shall we put the encapsulation barriers? Which decisions do we want to hide inside components, so that we can change them without affecting the rest of the system?

- what are the connectors?
  Looked at another way, how and what do the components really need to communicate? E.g., what should be in the interfaces, or what protocol should be used?

The component and connector view of architecture is due to Mary Shaw and David Garlan – spawned specialist architectural description languages, and influenced UML2.0.

# More examples of architectural decisions

- what language and/or component standard are we using? (C++, Java, CORBA, DCOM, JavaBeans...)
- what conventions do components have about error handling?
- what framework does the product use?

Clean architecture helps get reuse of components.

By some definitions parts of the architecture can *be* components – frameworks, product-line architectures etc.

# Detailed design

happens inside a subsystem or component.

E.g., maybe the system architecture has been settled by a small team, written down, and reviewed. Now you are in charge of the detailed design of one subsystem. You know you have to write in Java, you know what external interfaces you have to work to and what you have to provide. Your job is to choose classes and their behaviour that will do that.

Idea: even if you're part of a huge project, your task is now no more difficult than if you were designing a small system.

(But: your interfaces are artificial, and this may make them harder to understand/negotiate/adhere to.)

# Which of these two designs is better?

```
A) public class AddressBook {
     private LinkedList<Address> theAddresses;
     public void add (Address a) {theAddresses.add(a);}
     // ... etc. ...
   }
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   // no need to write an add method, we inherit it
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# Design principles 1: Coherence

*Coherence* of a component (e.g., class, package) is:

A how similar the parts of a component are

B the degree to which a component reflects a functional abstraction

C how clear the organisation of a component is

D the density of interaction between parts of a component

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A better design has:

A higher coherence

B lower coherence

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# Design principles 2: Coupling

*Coupling* between two components is:

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C how dependent one component is on the implementation of the other component

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# Design principles 3

So... if you had to pick two design principles, they'd be:

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Why?

(human and compiler) understandability, maintainability

# Design principles 4 (from GSWEBOKCh3)

- abstraction - procedural, data
  *"the process of forgetting information so that things that are different can be treated as if they were the same"*
- decomposition, modularisation
  *splitting up, "usually with the goal of placing different functionalities or responsibilities in different components"*
- encapsulation
  *"grouping and packaging the elements and internal details of an abstraction and making those details inaccessible"*
- separation of interface and implementation *"specifying a public interface, known to the clients, separate from the details of how the component is realized."*
- sufficiency, completeness, primitivity
  *"all the important characteristics of an abstraction, and nothing more."*

Note crucial role of *interfaces*. This whole family of principles is about fitting very complex software into limited human brains.

# Modelling

Let's say: a model is any precise representation of some of the information needed to solve a problem using a computer.

E.g. a model in UML, the Unified Modeling Language. Use case diagrams are part of UML. A UML model

- is represented by a set of diagrams;
- but has a structured representation too (stored as XML);
- must obey the rules of the language;
- has a (fairly) precise meaning;
- can be used informally, e.g. for talking round a whiteboard;
- and, increasingly, for generating, and synchronising with, code, textual documentation etc.

# Why design? Why model?

Fundamentally:

Design, so that you'll be able to build a system that has the properties you want.

Model, so that you can design, and communicate your design.

Both can be done in different styles...

# Pros and cons of BDUF

Big Design Up Front

- often unavoidable in practice
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- ► and wasteful.

Alternative (often) is simple design plus refactoring.

XP maxims:

You ain't gonna need it

Do the simplest thing that could possibly work

# Reading

Suggested: GSWEBOK2004 Ch3 (see web), for an overview of the field of software design

Suggested: Stevens Ch3, a simple case study; Somerville Ch14 on OOD (and nearby chapters, maybe)

Suggested: Browse SEI's collection of architecture definitions at
http:
//www.sei.cmu.edu/architecture/definitions.html

Suggested: (architecture) Somerville ch 11-13

# Quotes of the day

*There are two ways of constructing a software design. One way is to make it so simple that there are obviously no deficiencies. And the other way is to make it so complicated that there are no obvious deficiencies.*

C.A.R. Hoare

*Software architecture is the set of design decisions which, if made incorrectly, may cause your project to be cancelled.*

Eoin Woods, software architect, co-author of Software Systems Architecture : Working With Stakeholders Using Viewpoints and Perspectives