Lecture 14: Requirements Analysis

Basic Requirements Process

- requirements in the software lifecycle
- the essential requirements process

What is a requirement?

- What vs. How
- Machine Domain vs. Application Domain
- Implementation Bias

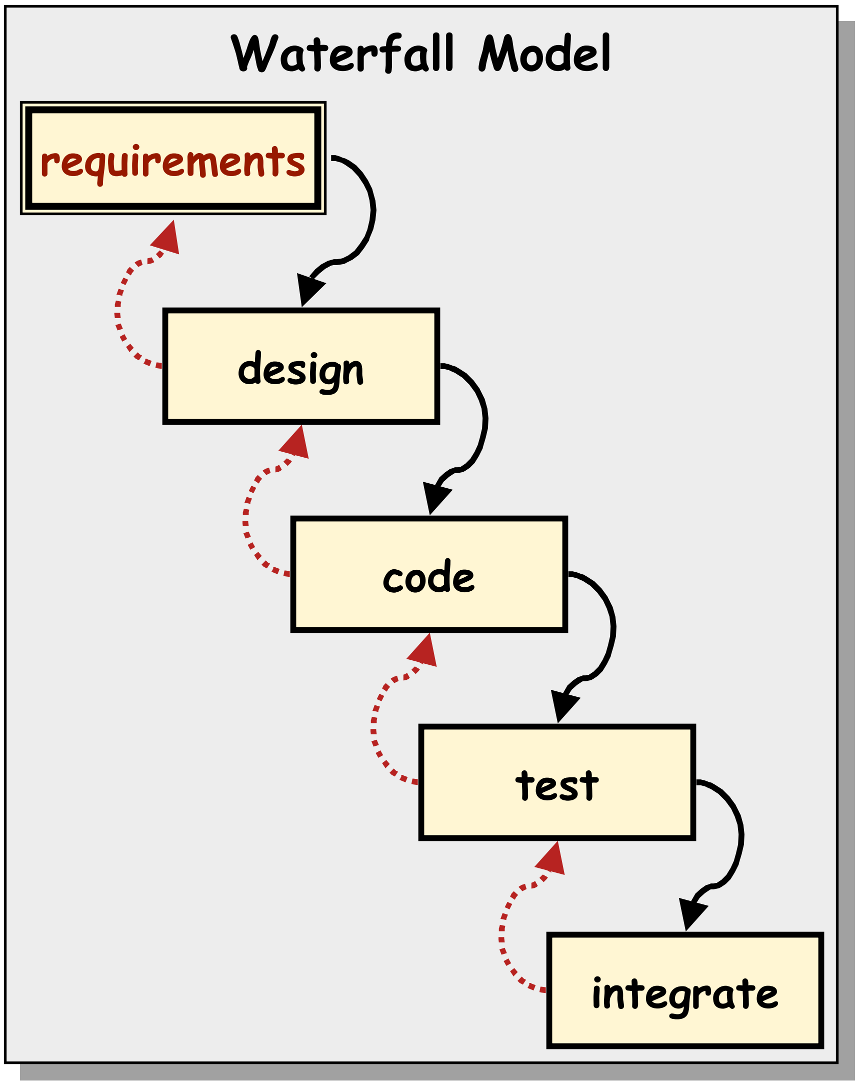
Non-functional Requirements

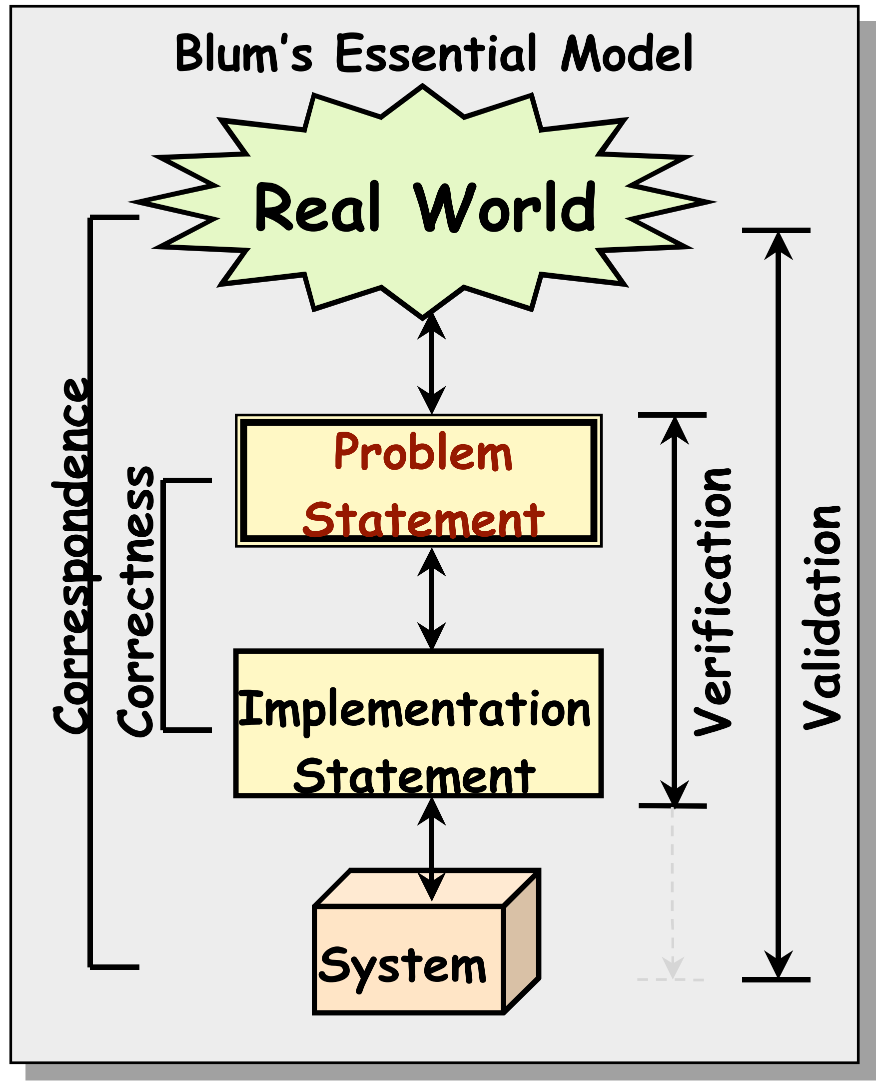
Notations, Techniques and Methods

- Elicitation techniques
- Modeling methods

Refresher: Software Lifecycles

Source: *Adapted from Lecture 2!*





Basics of Requirements Engineering

Source: *Adapted from Nuseibeh & Easterbrook, 2000*

The 'essential' requirements process:

- Understand the problem
  - use data gathering techniques to elicit requirements
  - Eg. Interviews, Questionnaires, Focus Groups, Prototyping, Observation,…
- Model and Analyze the problem
  - use some modeling method(s)
  - Eg. Structured Analysis, Object Oriented Analysis, Formal Analysis,…
- Attain agreement on the nature of the problem
  - validation
  - conflict resolution, negotiation
- Communicate the problem
  - specifications, documentation, review meetings,
- Manage change as the problem evolves
  - Requirements continue to evolve throughout software development
  - (introducing new software changes the problem!!!)
  - requirements management - maintain the agreement!

RE is the weak link in most projects

Requirements Engineering is hard (*"wicked"*):

- Analysis problems have ill-defined boundaries (open-ended)
- Requirements are found in organizational contexts (hence prone to conflict)
- Solutions to analysis problems are artificial
- Analysis problems are dynamic
- Tackling analysis requires interdisciplinary knowledge and skill

Requirements Engineering is important:

- Engineering is about developing solutions to problems
  - A good solution is only possible if the engineer fully understands the problem
- Errors cost more the longer they go undetected
  - Cost of correcting a requirements error is 100 times greater in the maintenance phase than in the requirements phase
- Experience from failed software development projects:
  - Failure to understand and manage requirements is the biggest single cause of cost and schedule over-runs
- Analysis of safety problems
  - Safety-related errors tend to be errors in specifying requirements, while non-safety errors tend to be errors in implementing requirements

What vs. How

Source: *Adapted from Jackson, 1995, p207 and van Vliet 1999, p204-210*

Requirements should specify 'what' but not 'how'

- But this is not so easy to distinguish:
  - What does a car do?
  - What does a web browser do?
- 'What' refers to a system's purpose
  - it is external to the system
  - it is a property of the *application domain*
- 'How' refers to a system's structure and behavior
  - it is internal to the system
  - it is a property of the *machine domain*

Requirements *only* exist in the application domain

- Distinguishing between the machine and the application domain is essential for good requirements engineering
- Need to draw a boundary around the application domain
  - I.e. which things are part of the problem you are analyzing and *which are not?*

Implementation Bias

Source: *Adapted from Jackson, 1995, p98*

Implementation bias is the inclusion of requirements that have no basis in the application domain

i.e. mixing some 'how' into the requirements

Examples:

The dictionary shall be stored in a hash table

The patient records shall be stored in a relational database

But sometimes it's not so clear:

The software shall be written in FORTRAN.

The software shall respond to all requests within 5 seconds.

The software shall be composed of the following 23 modules ....

The software shall use the following fifteen menu screens whenever it is communicating with the user.…

Instead of 'what' and 'how', ask:

is this requirement only a property of the machine domain?

in which case it is implementation bias

Or is there some application domain phenomena that justifies it?

Functional vs. Non-functional

Source: *Adapted from van Vliet 1999, p241-2*

"Functional Requirements"

- fundamental functions of the system
  - E.g. mapping of inputs to outputs
  - E.g. control sequencing
  - E.g. timing of functions
  - E.g. handling of exceptional situations
  - E.g. formats of input and output data (and stored data?)
  - E.g. real world entities and relationships modeled by the system

"Non-Functional Requirements (NFRs)"

- constraints/obligations (non-negotiable)
  - E.g. compatibility with (and reuse of) legacy systems
  - E.g. compliance with interface standards, data formats, communications protocols
- quality requirements (soft goals)
  - E.g. security, safety, availability, usability, performance, portability,…
  - must be specified

Elicitation Techniques

Source: *Adapted from Nuseibeh & Easterbrook, 2000 and van Vliet 1999, section 9.1.1*

Traditional Approaches

- Introspection
- Interview/survey
- Group elicitation

Observational approaches

- Protocol analysis
- Participant Observation (ethnomethodology)

Model-based approaches

- Goal-based: hierarchies of stakeholders' goals
- Scenarios: characterizations of the ways in which the system is used
- Use Cases: specific instances of interaction with the system

Exploratory approaches

- Prototyping ("plan to throw one away")

Modeling: Notations vs. Methods

Definitions:

- Notation: a systematic way of presenting something
  - may be linguistic (textual) or graphical (diagrams)
- A Method provides:
  - a set of notations (e.g. for different viewpoints)
  - techniques for using those notations (esp. analysis techniques)
  - heuristics to provide guidance
- Notation or method?
  - Some notations have been adopted by a number of different methods
  - Some 'methods' are really just notations
- Tools usually support a single method (or a single notation!!)

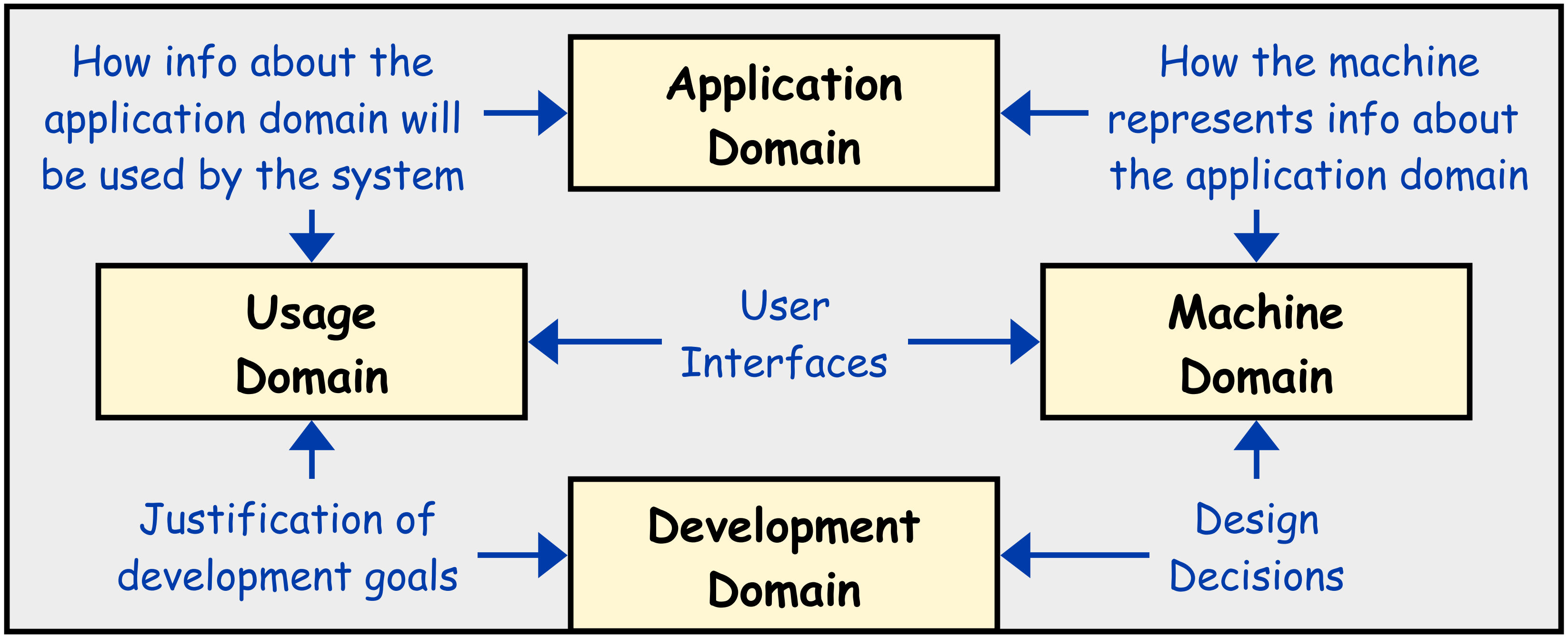
Example Methods

- Structured Analysis
  - SADT
  - SASD
  - Information Engineering
  - JSD
- Entity-Relationship Approach
- Object Oriented Analysis
  - Coad-Yourdon
  - OMT
  - UML (not a method ??)
- Formal Methods
  - SCR
  - RSML

Modeling: Where to start?

Source: *Adapted from Loucopoulos & Karakostas, 1995, p73*

There are lots of things we could (should) model:



Key questions

Where do we start?

- Structured Analysis starts by modeling the *existing* system
- Object Oriented Analysis starts by identifying candidate objects

How do we structure our modeling approach?

- We can *partition* the problem, *abstract* away detail, and create *projections*

Structuring Principle 1: Partitioning

Partitioning

- captures aggregation/part-of relationship

Example:

- goal is to develop a spacecraft
- partition the problem into parts:
  - guidance and navigation;
  - data handling;
  - command and control;
  - environmental control;
  - instrumentation;
  - etc
- Note: this is not a design, it is a problem decomposition
  - actual design might have any number of components, with no relation to these sub-problems
- However, the choice of problem decomposition will probably be reflected in the design

Structuring Principle 2: Abstraction

•***Source:*** *Adapted from Davis, 1990, p48 and Loucopoulos & Karakostas, 1995, p78*

Abstraction

A way of finding similarities between concepts by ignoring some details

Focuses on the general/specific relationship between phenomena

- *Classification* groups entities with a similar role as members of a single *class*
- *Generalization* expresses similarities between different classes in an 'is_a' association

Example:

requirement is to handle faults on the spacecraft

might group different faults into fault classes

E.g. based on location of fault:
- instrumentation fault,
- communication fault,
- processor fault,
- etc

OR:

E.g. based on symptoms of fault:
- no response from device;
- incorrect response;
- self-test failure;
- etc...

Structuring Principle 3: Projection

***Source:** Adapted from Davis, 1990, p48-51*

Projection:

- separates aspects of the model into multiple viewpoints
  - similar to projections used by architects for buildings

Example:

- Need to model the communication between spacecraft and ground system
- Model separately:
  - sequencing of messages;
  - format of data packets;
  - error correction behavior;
  - etc.

Note:

- Projection and Partitioning are similar:
  - Partitioning defines a 'part of' relationship
  - Projection defines a 'view of' relationship
- Partitioning assumes a the parts are relatively independent

References

van Vliet, H. "Software Engineering: Principles and Practice (2nd Edition)" Wiley, 1999.

Chapter 9 is an excellent introduction to the basics of requirements engineering.

B. A. Nuseibeh and S. M. Easterbrook, "Requirements Engineering: A Roadmap", In A. C. W. Finkelstein (ed) *"The Future of Software Engineering"*. IEEE Computer Society Press, 2000.

Available at http://www.cs.toronto.edu/~sme/papers/2000/ICSE2000.pdf

Jackson, M. "Software Requirements & Specifications: A Lexicon of Practice, Principles and Prejudices". Addison-Wesley, 1995.

This is my favourite requirements engineering book. It makes a wonderful and thought provoking read. It consists of a series of short essays (each typically only a couple of pages long) that together really get across the message of what requirements engineering is all about.

Davis, A. M. "Software Requirements: Analysis and Specification". Prentice-Hall, 1990.

This is probably the best textbook around on requirements analysis, although is a little dated now.

Loucopoulos, P. and Karakostas, V. "System Requirements Engineering". McGraw Hill, 1995.

This short book provides a good overview of requirements engineering, especially in a systems context.