Lecture 2: What are Requirements?

Two basic principles of requirements engineering:
- Separate the problem from the solution
- Problems and solutions intertwine with one another

Describing problems:
- Application Domains vs. Machine Domains
- Verification vs. Validation

Systems Engineering
- Systems vs. software

Patterns and Types of Problem
- Requirements patterns
- Problem Frames

Separate the problem from the solution

A separate problem description is useful:
- Most obvious problem might not the right one to solve
- Problem statement can be discussed with stakeholders
- Problem statement can be used to evaluate design choices
- Problem statement is a source of good test cases

Still need to check:
- Solution correctly solves the stated problem
- Problem statement corresponds to the needs of the stakeholders

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System

Problem Statement

Implementation Statement

Verification

Validation
But design changes the world...

Intertwining of problems and solutions

Independent Implementation Dependence Dependent

General

Level of Detail

Detailed
Some observations about RE

- RE is not necessarily a sequential process:
  - Don’t have to write the problem statement before the solution statement
  - (Re-)writing a problem statement can be useful at any stage of development
  - RE activities continue throughout the development process

- The problem statement will be imperfect:
  - RE models are approximations of the world
  - Will contain inaccuracies and inconsistencies
  - Will omit some information.
  - Analysis should reduce the risk that these will cause serious problems...

- Perfecting a specification may not be cost-effective:
  - Requirements analysis has a cost
  - For different projects, the cost-benefit balance will be different

- Problem statement should never be treated as fixed:
  - Change is inevitable, and therefore must be planned for
  - There should be a way of incorporating changes periodically

What vs. How

- Traditionally, should specify 'what' without specifying 'how':
  - But this is not always easy to distinguish:
    - What does a car do?
    - What does a web browser do?
    - What does an operating system do?
  - The 'how' at one level of abstraction forms the 'what' for the next level

- Also misses:
  - 'Why' questions:
    - Why is this system needed?
    - Why should it behave that way?
  - 'Who' questions:
    - Whose problem is it?
  - Etc.
A problem to describe...

E.g. “prevent unauthorized access to CSG machines”

What are requirements?

- Domain Properties:
  - things in the application domain that are true whether or not we ever build the proposed system

- Requirements:
  - things in the application domain that we wish to be made true by delivering the proposed system
    - Many of which will involve phenomena the machine has no access to

- A Specification:
  - is a description of the behaviours that the program must have in order to meet the requirements
    - Can only be written in terms of shared phenomena!
Fitness for purpose?

- Two correctness (verification) criteria:
  - The Program running on a particular Computer satisfies the Specification
  - The Specification, in the context of the given domain properties, satisfies the requirements

- Two completeness (validation) criteria:
  - We discovered all the important requirements
  - We discovered all the relevant domain properties

Example:

- Requirement R:
  - "Reverse thrust shall only be enabled when the aircraft is moving on the runway"

- Domain Properties D:
  - Wheel pulses on if and only if wheels turning
  - Wheels turning if and only if moving on runway

- Specification S:
  - Reverse thrust enabled if and only if wheel pulses on

Verification: S, D ⊨ R

Another Example

- Requirement R:
  - "The database shall only be accessible by authorized personnel"

- Domain Properties D:
  - Authorized personnel have passwords
  - Passwords are never shared with non-authorized personnel

- Specification S:
  - Access to the database shall only be granted after the user types an authorized password

S + D entail R

But what if the domain assumptions are wrong?
But we can also move the boundaries...

- E.g. Elevator control system:

  - Application Domain:
    - people waiting
    - people in the elevator
    - people wanting to go to a particular floor
    - Elevator motors
    - Safety rules

  - Machine Domain:
    - Elevator call buttons
    - Floor request buttons
    - button lights
    - Current floor indicators
    - Motor on/off
    - Door open/close

- We can shift things around:
  - E.g. Add some sensors to detect when people are waiting
  - This changes the nature of the problem to be solved

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Systems vs. Software Engineering

- IN (Properties of the input device)
- OUT (Properties of the output device)
- SOFT (Properties of the software)
- REQ (the requirements - relationships between monitored and controlled variables that the system is required to establish or maintain)
- NAT (natural relationships between monitored and controlled variables that are part of the domain)
Example Problem Frames

**Required behaviour**
- **Problem**: build a machine to control part of the world in accordance with a fixed set of control rules
- **Likely Solution**: an automated control system

**Commanded Behaviour**
- **Problem**: build a machine that allows part of the world to be controlled by an operator by issuing commands
- **Likely Solution**: a “human-in-the-loop” control system.

**Information Display**
- **Problem**: provide information about the current state of part of the world, in response to information requests
- **Likely Solution**: an information system.

More problem frames

**Simple workpieces frame**
- **Problem**: keep track of the edits performed on some workpiece, e.g. a text file or a graphical object
- **Likely Solution**: application software (e.g. a word processor)

**Transformation frame**
- **Problem**: take input data in a certain format, and provide a transformation according to a certain set of rules
- **Example Solutions**: data processing applications; compilers, etc.

**Connection frame**
- **Problem**: maintain a correspondence between domains that are otherwise not connected
- **Example Solutions**: data entry system, sensor network, etc.
Summary

Requirements Engineering is about describing problems
- It is useful to separate the problem from the solution
  - Even thought this cannot be achieved entirely
- Problems evolve continuously:
  - Delivering a solution changes the problem
  - Describing the problem changes the problem

Key distinctions:
- Application Domains vs. Machine Domains
- Verification vs. Validation
- Systems Engineering vs. Software Engineering

Basic Problem Frames
- Give us a starting point for understanding the problem
- Tell us what subdomains we need to describe