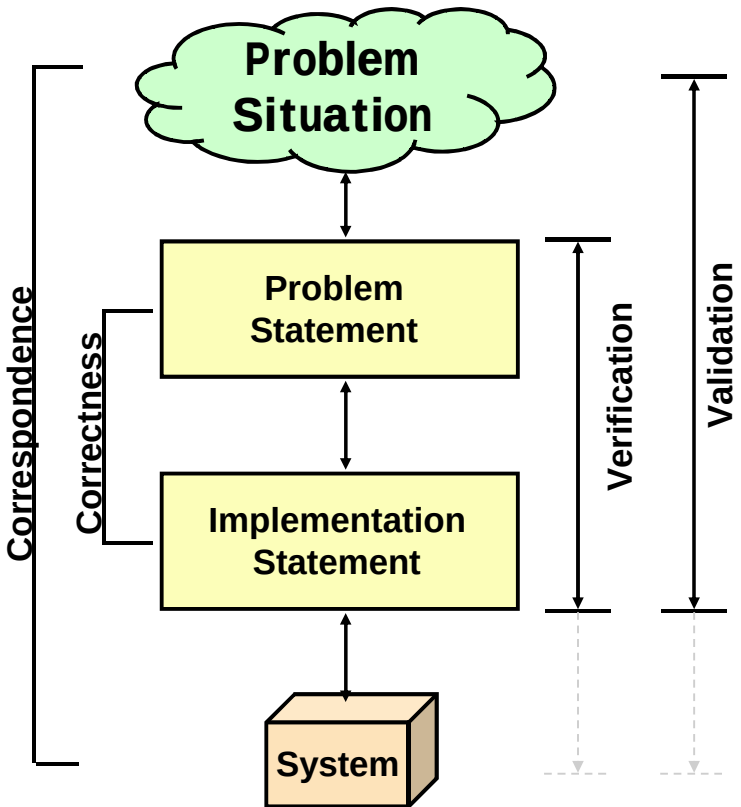
Lecture 2: What are Requirements?

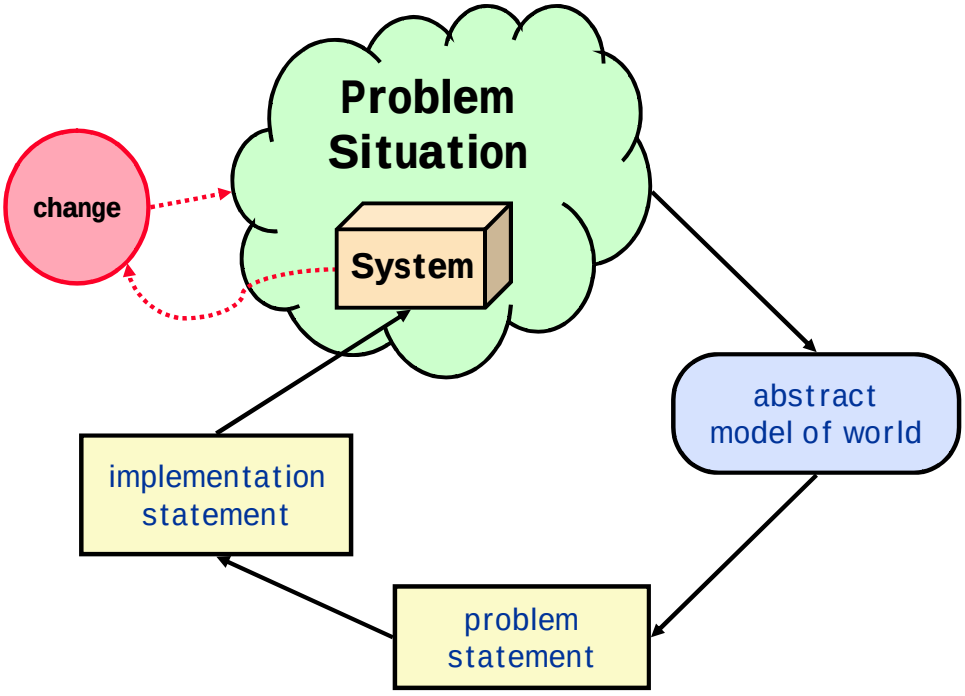
- Two basic principles of requirements engineering:
  - Separate the problem from the solution
  - Problems and solutions intertwine with one another
- Describing problems:
  - Application Domains vs. Machine Domains
  - Verification vs. Validation
- Systems Engineering
  - Systems vs. software
- Patterns and Types of Problem
  - Requirements patterns
  - Problem Frames

Separate the problem from the solution

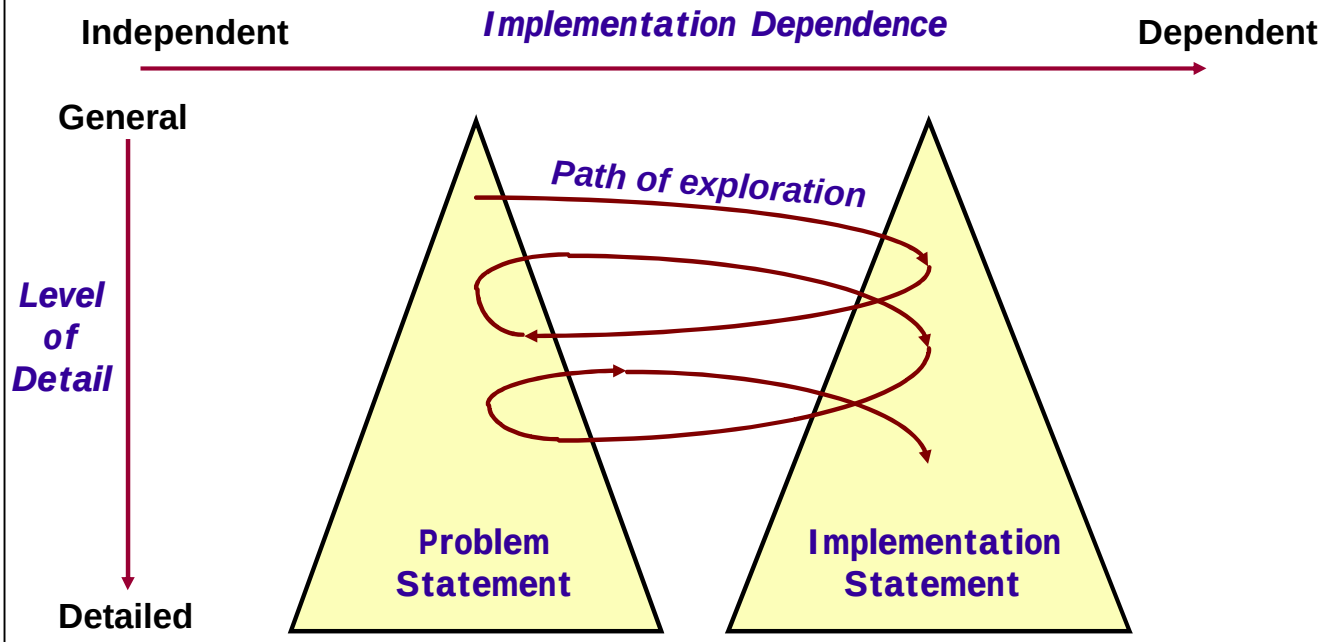
- A separate problem description is useful:
  - Most obvious problem might not the right one to solve
  - Problem statement can be discussed with stakeholders
  - Problem statement can be used to evaluate design choices
  - Problem statement is a source of good test cases
- Still need to check:
  - Solution correctly solves the stated problem
  - Problem statement corresponds to the needs of the stakeholders



But design changes the world...



Intertwining of problems and solutions

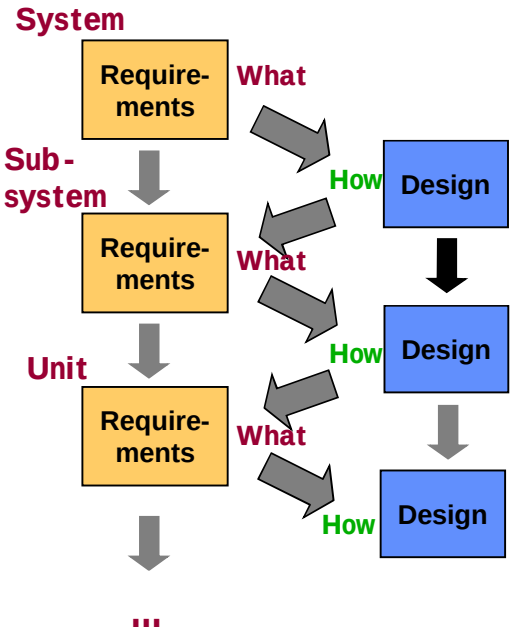


Some observations about RE

- 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

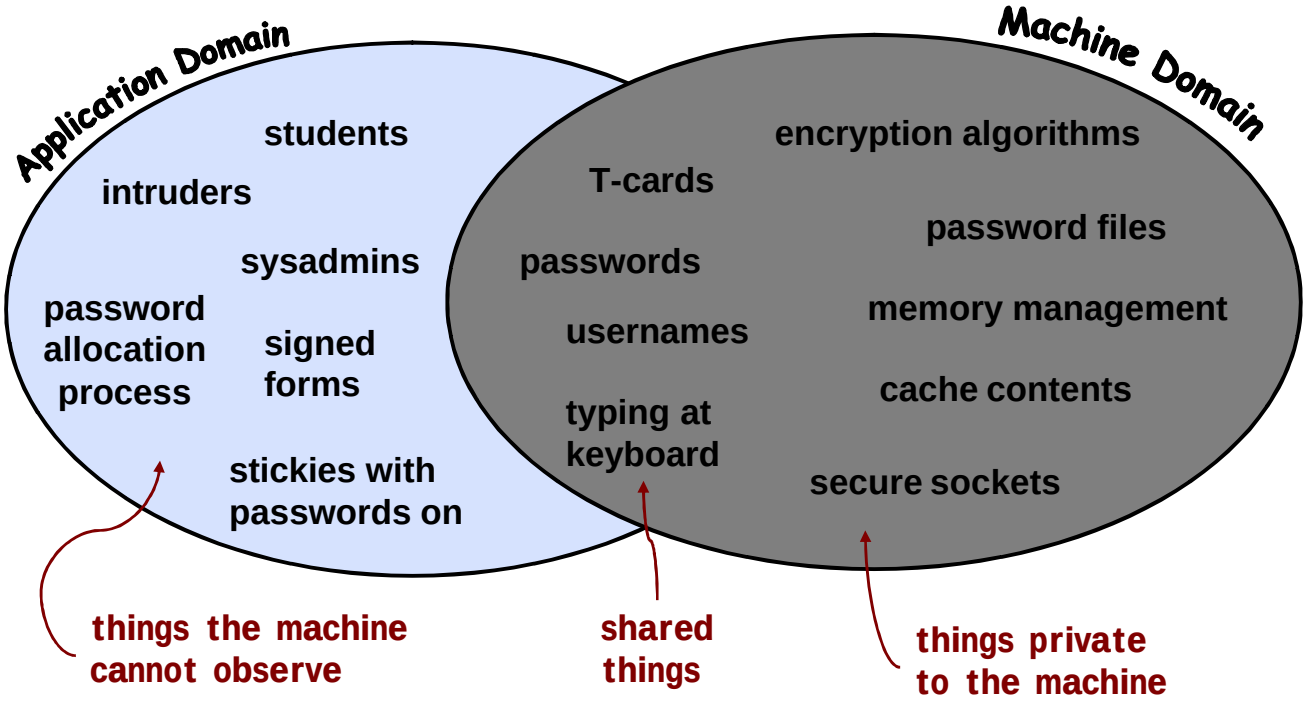
What vs. How

- 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?

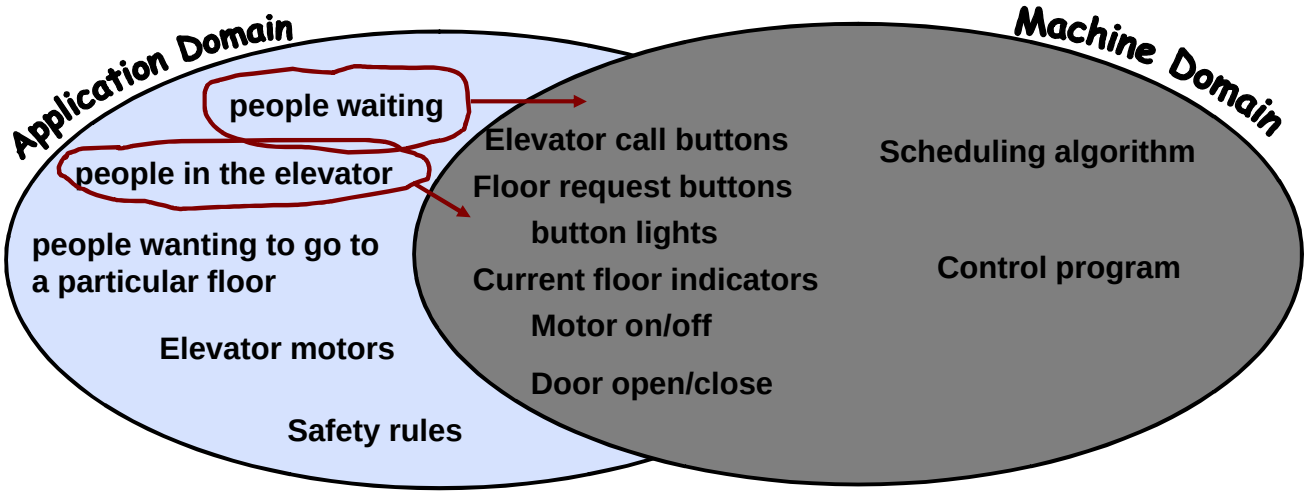
- Two correctness (verification) criteria:
  - The Program running on a particular Computer satisfies the Specification
  - The Specification, in the context of the given domain properties, satisfies the requirements
- Two completeness (validation) criteria:
  - We discovered all the important requirements
  - 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 $\models$ 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?

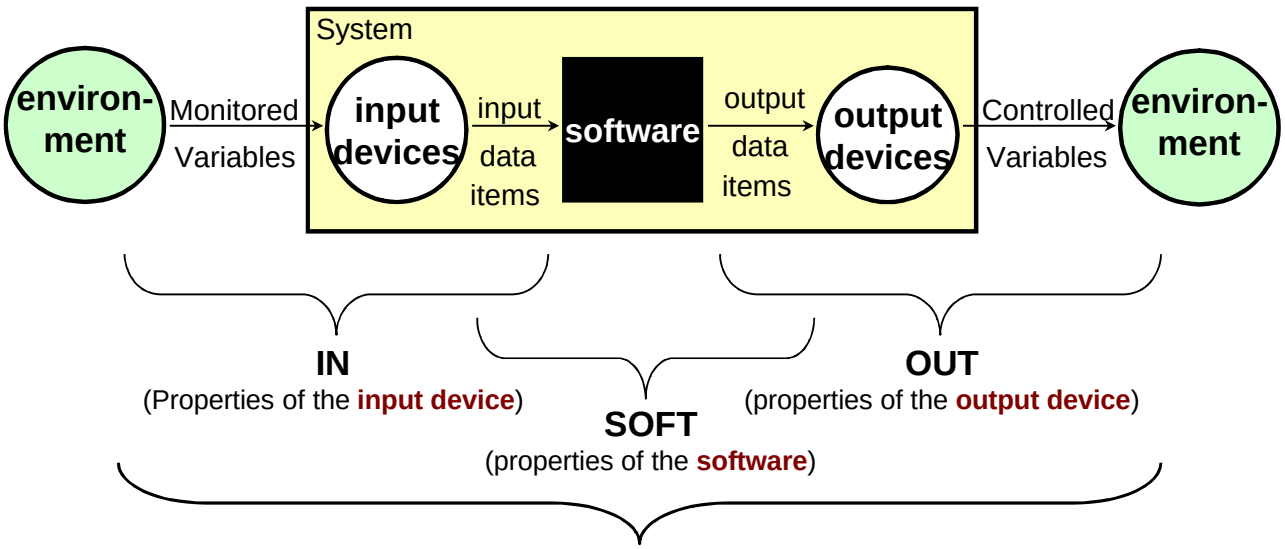
But we can also move the boundaries…

- E.g. Elevator control system:



- 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

Systems vs. Software Engineering

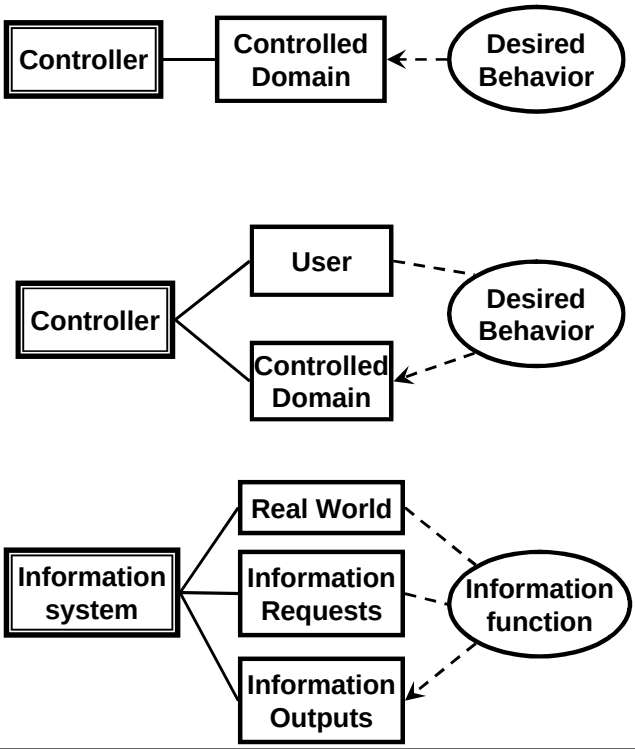


REQ (the requirements - relationships between monitored and controlled variables that the **system** is required to establish or maintain)

NAT (natural relationships between monitored and controlled variables that are part of the domain)

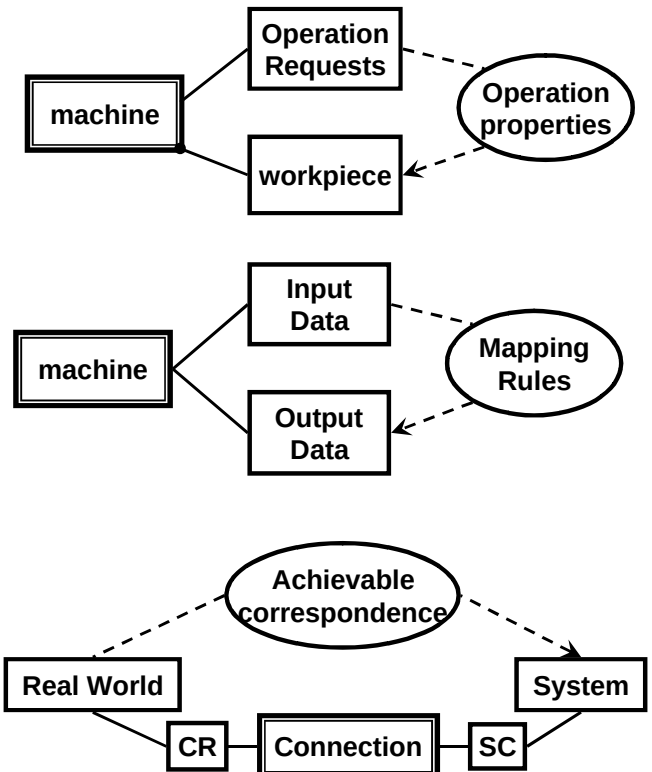
Example Problem Frames

- **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