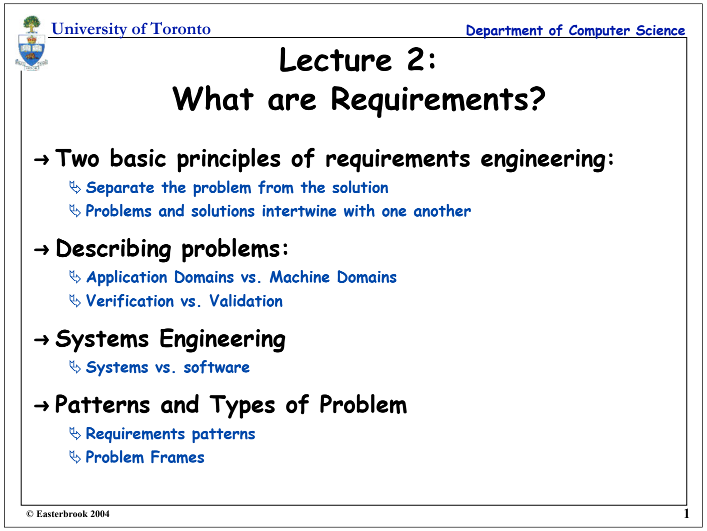
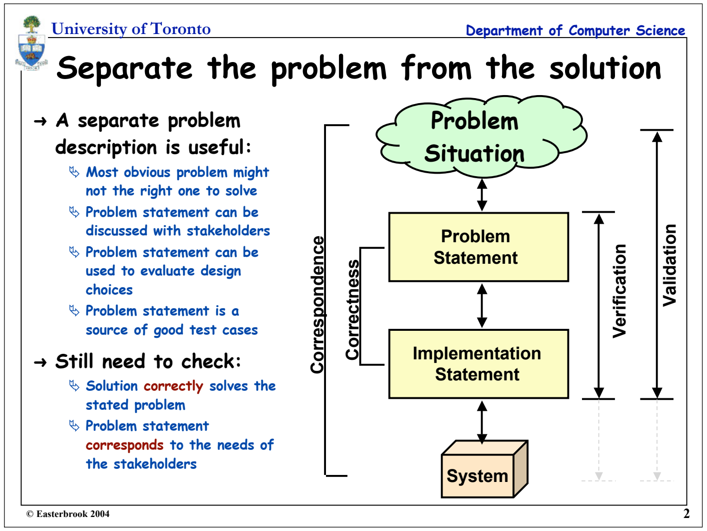


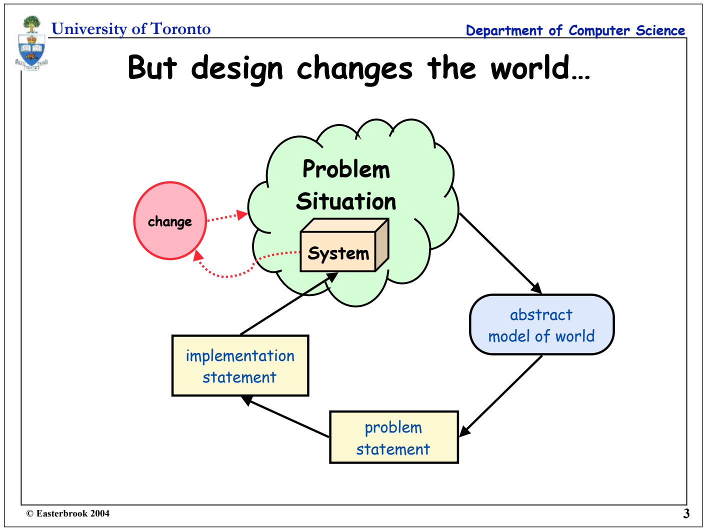
Lecture 2: What are Requirements?

- 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

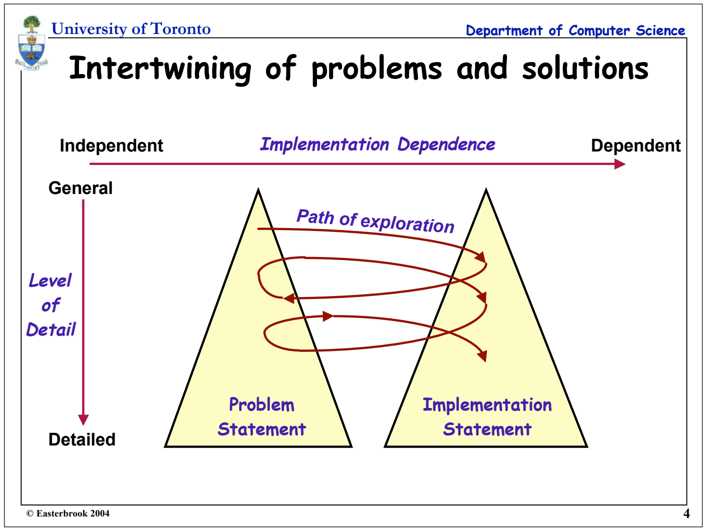


Separate the problem from the solution

- 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…



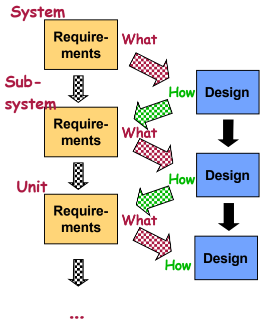
Intertwining of problems and solutions

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

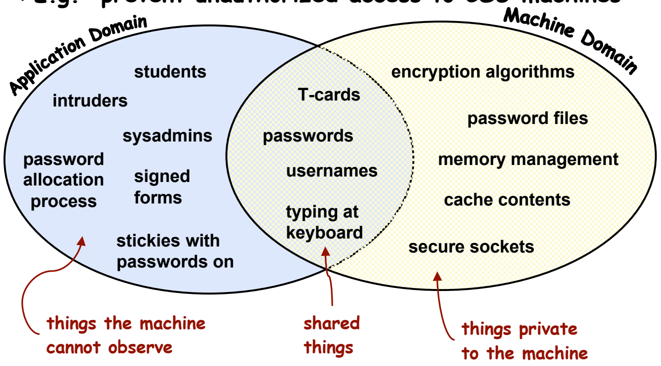
What vs. How

- → 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.

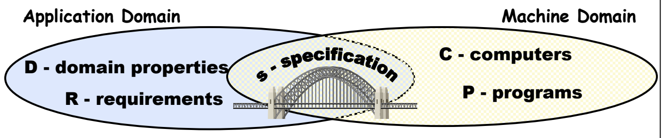


A problem to describe…

- → 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:

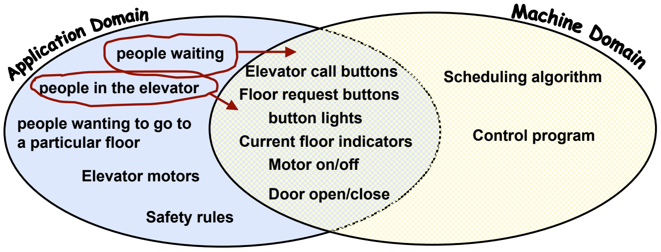
- ➪ Access to the database shall only be granted after the user types an authorized password

➜ S + D entail R

- ➪ But what if the domain assumptions are wrong?

But we can also move the boundaries…

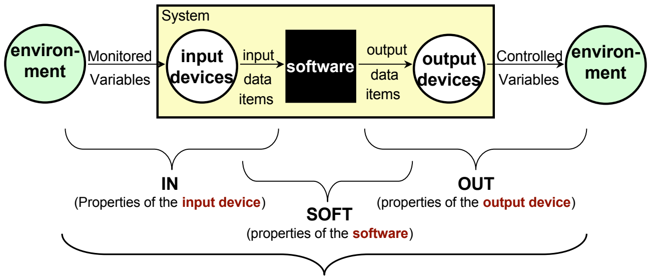
➜ E.g. Elevator control system:



➜ We can shift things around:

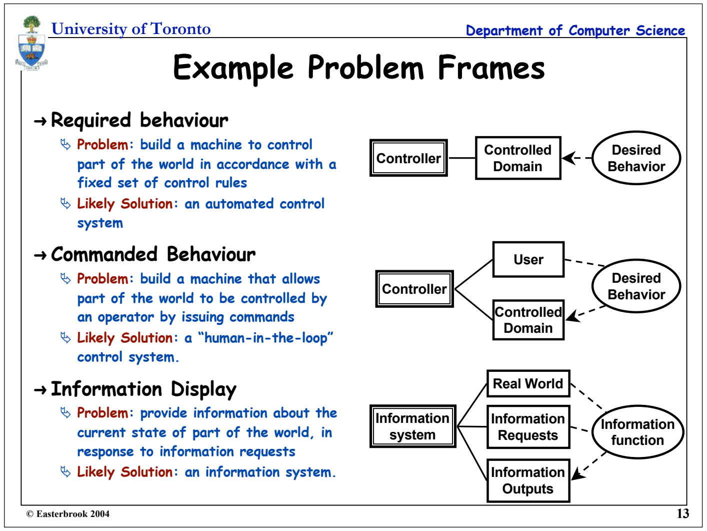
- ➪ E.g. Add some sensors to detect when people are waiting
- ➪ This changes the nature of the problem to be solved

Systems vs. Software Engineering



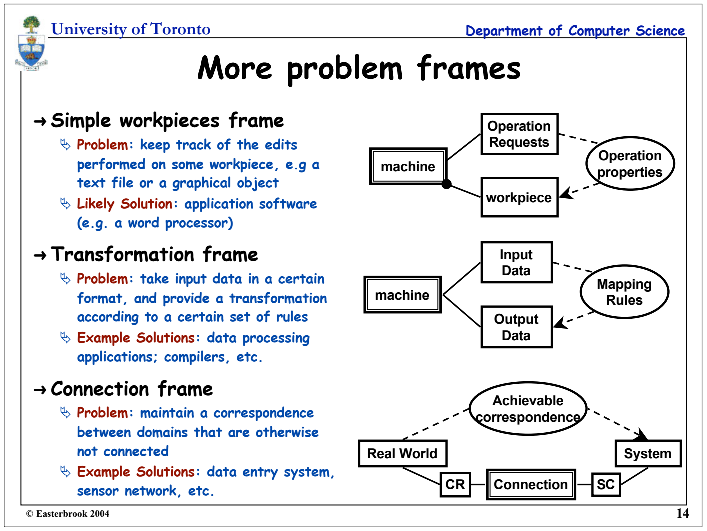
REQ (the requirements - relationships between monitored and controlled variables that the system is required to establish or maintain)

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



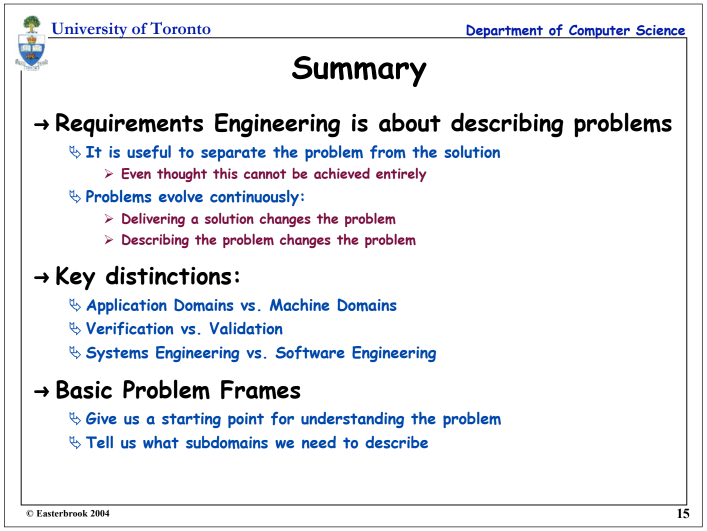
Example Problem Frames

- **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