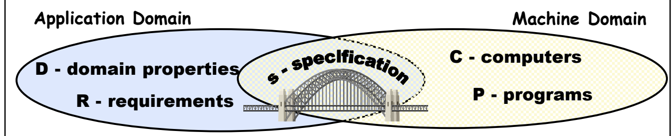
Lecture 11: Requirements Modelling

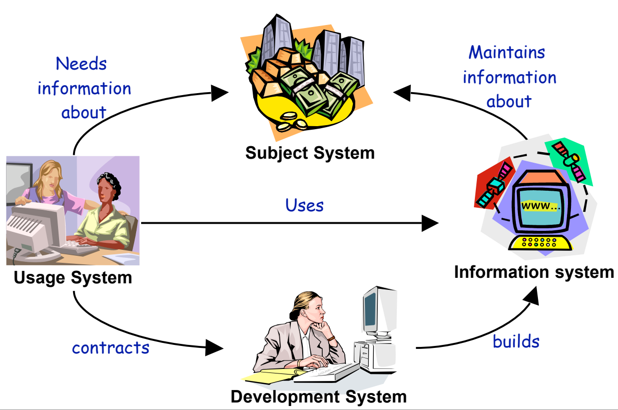
- **A little refresher:**
  - What are we modelling?
  - Requirements; Systems; Systems Thinking
- **Role of Modelling in RE**
  - Why modelling is important
  - Limitations of modelling
- **Brief overview of modelling languages**
- **Modelling principles**
  - Abstraction
  - Decomposition
  - Projection
  - Modularity

Refresher: Definitions



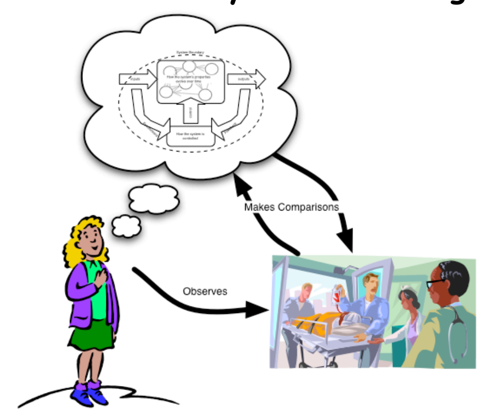
- **Some distinctions:**
  - Domain Properties - things in the application domain that are true whether or not we ever build the proposed system
  - Requirements - things in the application domain that we wish to be made true by delivering the proposed system
  - A specification - a description of the behaviours the program must have in order to meet the requirements
- **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

Refresher: Systems to model



 Source: Adapted from Loucopoulos & Karakostas, 1995, p73

Refresher: Systems Thinking



Modelling…

→ **Modelling can guide elicitation:**
- It can help you figure out what questions to ask
- It can help to surface hidden requirements
  - i.e. does it help you ask the right questions?

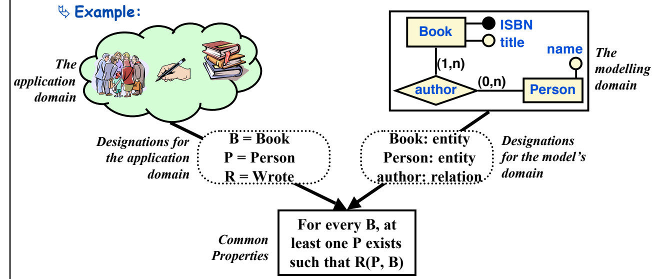
→ **Modelling can provide a measure of progress:**
- Completeness of the models -> completeness of the elicitation (?)
  - i.e. if we've filled in all the pieces of the models, are we done?

→ **Modelling can help to uncover problems**
- Inconsistency in the models can reveal interesting things…
  - e.g. conflicting or infeasible requirements
  - e.g. confusion over terminology, scope, etc
  - e.g. disagreements between stakeholders

→ **Modelling can help us check our understanding**
- Reason over the model to understand its consequences
  - Does it have the properties we expect?
- Animate the model to help us visualize/validate the requirements

RE involves a lot of modelling

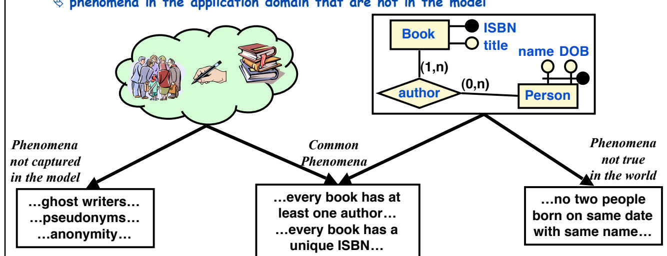
→ **A model is more than just a description**
- it has its own phenomena, and its own relationships among those phenomena.
  - The model is only useful if the model's phenomena correspond in a systematic way to the phenomena of the domain being modelled.
- Example:



Source: Adapted from Jackson, 1995, p120-122

"It's only a model"

→ **There will always be:**
- phenomena in the model that are not present in the application domain
- phenomena in the application domain that are not in the model



→ **A model is never perfect**
- "If the map and the terrain disagree, believe the terrain"
- Perfecting the model is not always a good use of your time…

Source: Adapted from Jackson, 1995, p124-5

Choice of modelling notation

→ **natural language**
- extremely expressive and flexible
  - useful for elicitation, and to annotate models for readability
- poor at capturing key relationships

→ **semi-formal notation** ← UML fits in here
- captures structure and some semantics
- can perform (some) reasoning, consistency checking, animation, etc.
  - E.g. diagrams, tables, structured English, etc.
- mostly visual - for rapid communication with a variety of stakeholders

→ **formal notation**
- precise semantics, extensive reasoning possible
  - Underlying mathematical model (e.g. set theory, FSMs, etc)
- very detailed models (may be more detailed than we need)
  - RE formalisms are for conceptual modelling, hence differ from most computer science formalisms

Source: Adapted from Loucopoulos & Karakostas, 1995, p72-73

Desiderata for Modelling Notations

- **Implementation Independence**
  - does not model data representation, internal organization, etc.
- **Abstraction**
  - extracts essential aspects
    - e.g. things not subject to frequent change
- **Formality**
  - unambiguous syntax
  - rich semantic theory
- **Constructability**
  - can construct pieces of the model to handle complexity and size
  - construction should facilitate communication
- **Ease of analysis**
  - ability to analyze for ambiguity, incompleteness, inconsistency
- **Traceability**
  - ability to cross-reference elements
  - ability to link to design, implementation, etc.
- **Executability**
  - can animate the model, to compare it to reality
- **Minimality**
  - No redundancy of concepts in the modelling scheme
    - i.e. no extraneous choices of how to represent something

Survey of Modelling Techniques

- **Modelling Enterprises**
  - Goals & objectives
  - Organizational structure
  - Tasks & dependencies
  - Agents, roles, intentionality

> **Organization modelling:** i*, SSM, ISAC
> **Goal modelling:** KAOS, CREWS

- **Modelling Information & Behaviour**
  - Information Structure
  - Behavioral views
    - Scenarios and Use Cases
    - State machine models
    - Information flow
  - Timing/Sequencing requirements

> **Information modelling:** E-R, Class Diagrams
> **Structured Analysis:** SADT, SSADM, JSD
> **Object Oriented Analysis:** OOA, OOSE, OMT, UML
> **Formal Methods:** SCR, RSML, Z, Larch, VDM

- **Modelling System Qualities** (NFRs)
  - All the 'ilities':
    - Usability, reliability, evolvability, safety, security, performance, interoperability,…

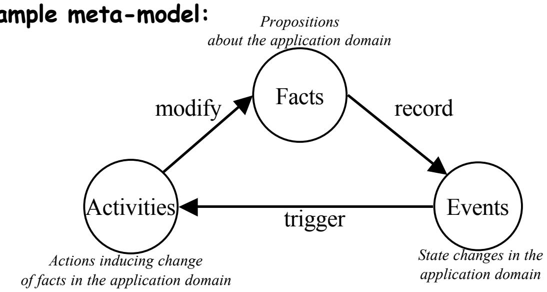
> **Quality tradeoffs:** QFD, win-win, AHP,
> **Specific NFRs:** Timed Petri nets (performance), Task models (usability), Probabilistic MTTF (reliability)

the Unified Modelling Language (UML)

- **Third generation OO method**
  - Booch, Rumbaugh & Jacobson are principal authors
    - Still evolving
    - Attempt to standardize the proliferation of OO variants
  - Is purely a notation
    - No modelling method associated with it!
    - Was intended as a design notation (some features unsuitable for RE)
  - Has become an industry standard
    - But is primarily owned by Rational Corp. (who sell lots of UML tools and services)
- **Has a standardized meta-model**
  - Use case diagrams
  - Class diagrams
  - Message sequence charts
  - Activity diagrams
  - State Diagrams
  - Module Diagrams
  - Platform diagrams

Meta-Modelling

- **Can compare modelling schema using meta-models:**
  - What phenomena does each scheme capture?
  - What guidance is there for how to elaborate the models?
  - What analysis can be performed on the models?
- **Example meta-model:**



Modelling principles

→ Facilitate Modification and Reuse

- Experienced analysts reuse their past experience
  - they reuse components (of the models they have built in the past)
  - they reuse structure (of the models they have built in the past)
- Smart analysts plan for the future
  - they create components in their models that might be reusable
  - they structure their models to make them easy to modify

→ Helpful ideas:

- Abstraction
  - strip away detail to concentrate on the important things
- Decomposition (Partitioning)
  - Partition a problem into independent pieces, to study separately
- Viewpoints (Projection)
  - Separate different concerns (views) and describe them separately
- Modularization
  - Choose structures that are stable over time, to localize change
- Patterns
  - Structure of a model that is known to occur in many different applications

Modelling 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

Modelling Principle 2: Abstraction

→ 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

based on location:

- instrumentation fault,
- communication fault,
- processor fault,
- etc

OR

based on symptoms:

- no response from device;
- incorrect response;
- self-test failure;
- etc...

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

Modelling Principle 3: Projection

→ Projection:

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

→ Example:

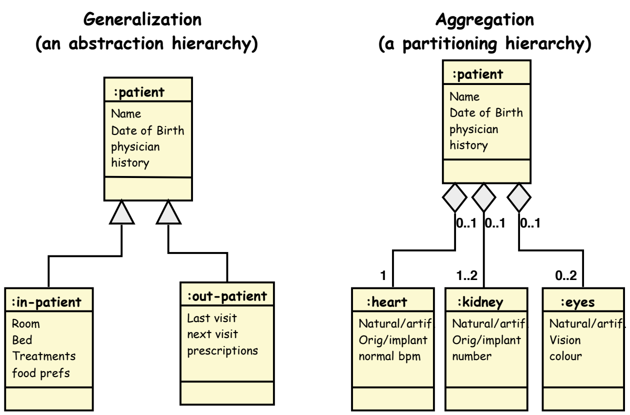
- Need to model the requirements for a spacecraft
- Model separately:
  - safety
  - commandability
  - fault tolerance
  - timing and sequencing
  - Etc…

→ 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

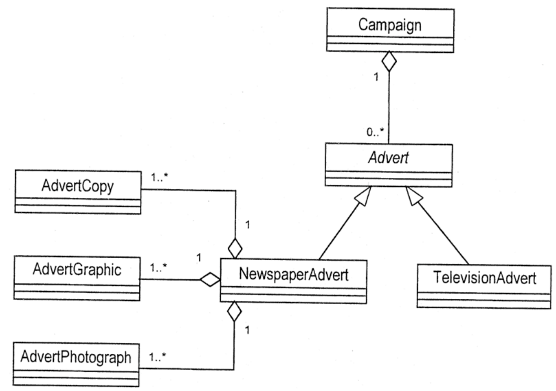
Source: *Adapted from Davis, 1990, p48-51*

A brief UML example



Source: *Adapted from Davis, 1990, p67-68*

What is this a model of?



Summary

→ **Modelling plays a central role in RE**
- Allows us to study a problem systematically
- Allows us to test our understanding

→ **Many choices for modelling notation**
- In this course, we'll use (and adapt) various UML notations

→ **All models are inaccurate** (to some extent)
- Use successive approximation
- …but know when to stop perfecting the model
- Every model is created for a purpose
- The purpose is not usually expressed in the model
- …So every model needs an explanation