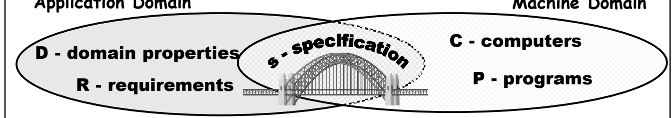
Lecture 11: Requirements Modelling

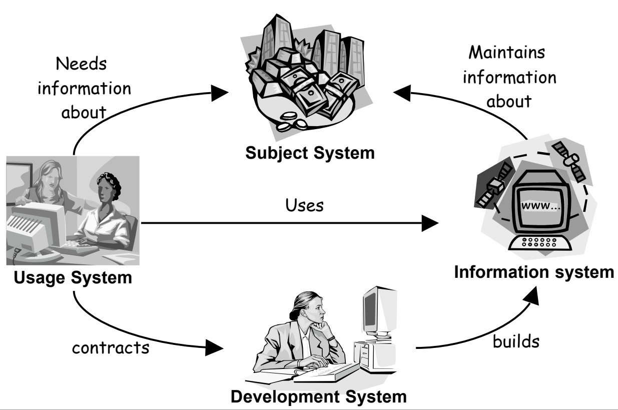
- → A little refresher:
  - ✎ What are we modelling?
  - ✎ Requirements; Systems; Systems Thinking
- → Role of Modelling in RE
  - ✎ Why modelling is important
  - ✎ Limitations of modelling
- → Brief overview of modelling languages
- → Modelling principles
  - ✎ Abstraction
  - ✎ Decomposition
  - ✎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

Refresher: Definitions



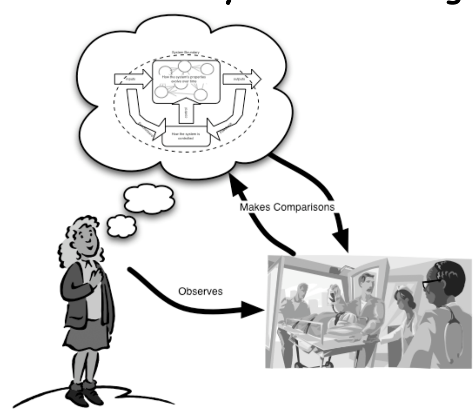
- → Some distinctions:
  - ✎ Domain Properties - things in the application domain that are true whether or not we ever build the proposed system
  - ✎ Requirements - things in the application domain that we wish to be made true by delivering the proposed system
  - ✎ A specification - a description of 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

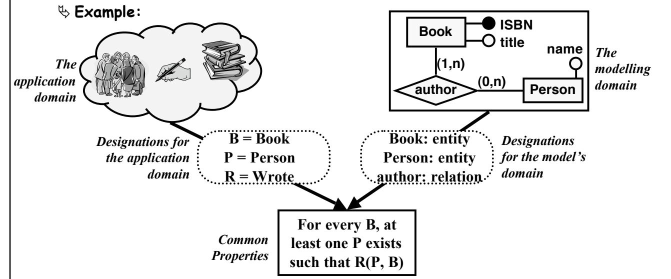


Modelling…

- **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

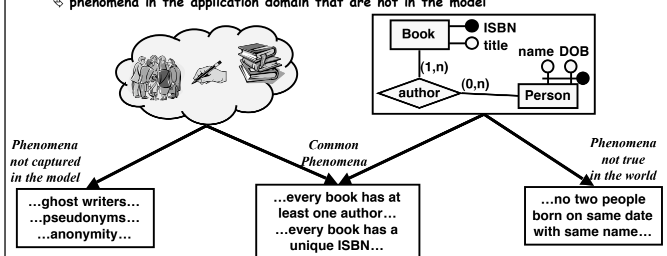
- **A model is more than just a description**
  - it has its own phenomena, and its own relationships among those phenomena.
    - The model is only useful if the model's phenomena correspond in a systematic way to the phenomena of the domain being modelled.
  - Example:



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

Source: Adapted from Loucopoulos & Karakostas, 1995, p77

Survey of Modelling Techniques

- **Modelling Enterprises**
  - Goals & objectives
  - Organizational structure
  - Tasks & dependencies
  - Agents, roles, intentionality
- **Modelling Information & Behaviour**
  - Information Structure
  - Behavioral views
    - Scenarios and Use Cases
    - State machine models
    - Information flow
  - Timing/Sequencing requirements
- **Modelling System Qualities (NFRs)**
  - All the 'ilities':
    - Usability, reliability, evolvability, safety, security, performance, interoperability,…

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

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

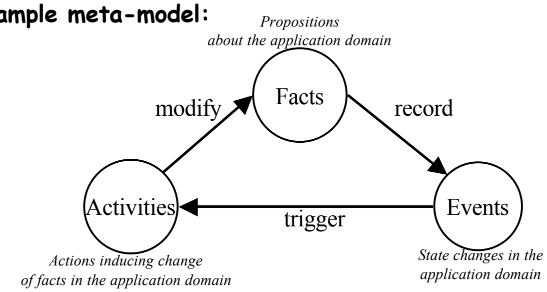
Quality tradeoffs: QFD, win-win, AHP,
Specific NFRs: Timed Petri nets (performance)
Task models (usability)
Probabilistic MTTF (reliability)

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

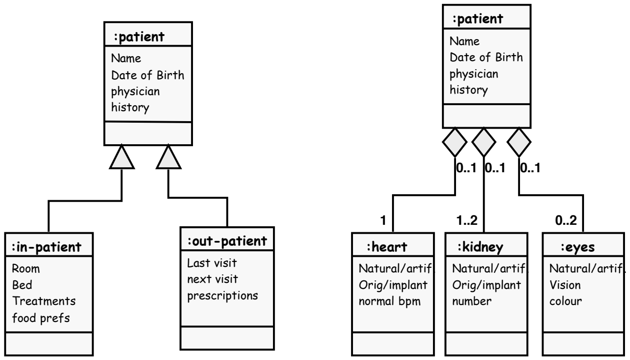
→ **Example:**
- Need to model the requirements for a spacecraft
- Model separately:
  - safety
  - commandability
  - fault tolerance
  - timing and sequencing
  - Etc…

→ **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

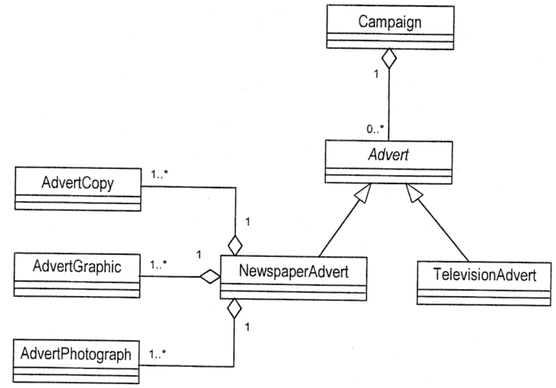
Source: Adapted from Davis, 1990, p48-51

A brief UML example

Generalization (an abstraction hierarchy) | **Aggregation (a partitioning hierarchy)**



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**