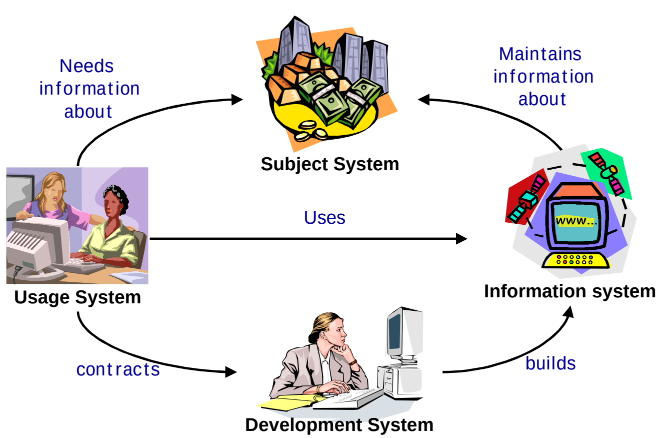
Lecture 11: Requirements Modelling

- **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

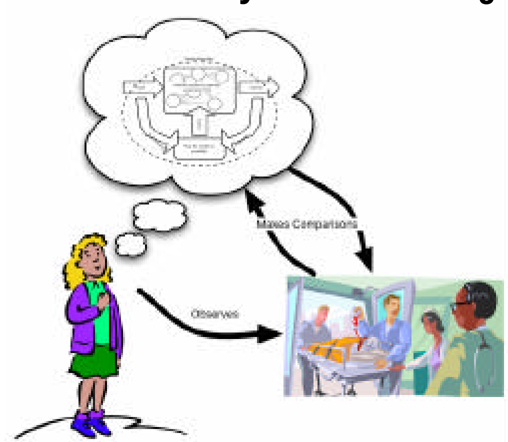
- **Some distinctions:**
  - Domain Properties - things in the application domain that are true whether or not we ever build the proposed system
  - Requirements - things in the application domain that we wish to be made true by delivering the proposed system
  - A specification - a description of the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

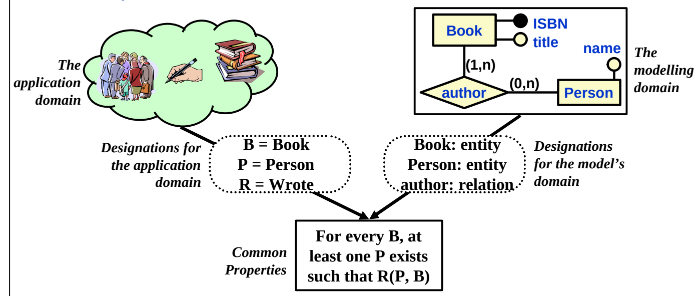


Modelling…

- 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

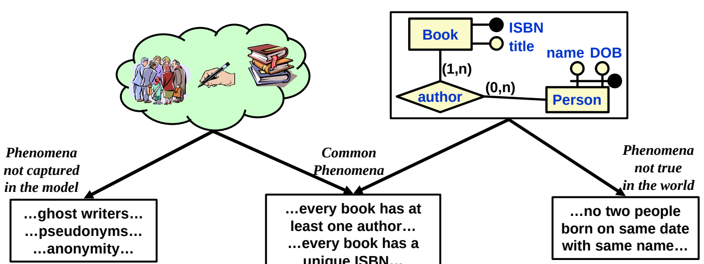
- A model is more than just a description
  - it has its own phenomena, and its own relationships among those phenomena.
    - The model is only useful if the model's phenomena correspond in a systematic way to the phenomena of the domain being modelled.
  - Example:



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
  - 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

UML fits in here

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,…

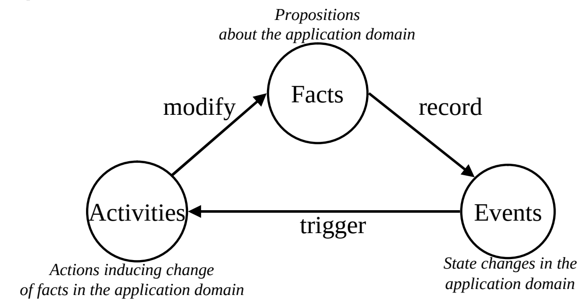
Quality tradeoffs: QFD, win-win, AHP,
Specific NFRs: Timed Petri nets (performance)
Task models (usability)
Probabilistic MTTF (reliability)

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

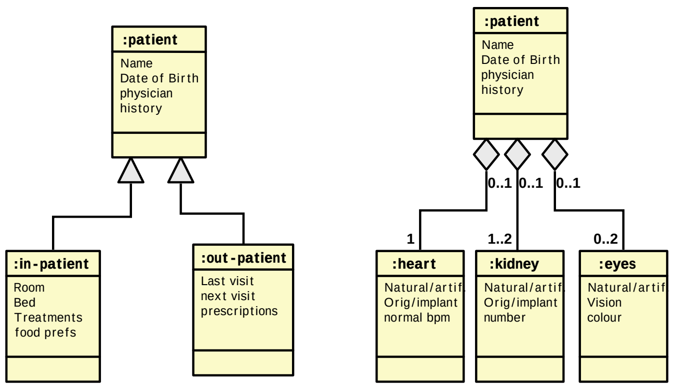
- **Projection:**
  - separates aspects of the model into multiple viewpoints
    - similar to projections used by architects for buildings
- **Example:**
  - Need to model the requirements for a spacecraft
  - Model separately:
    - safety
    - commandability
    - fault tolerance
    - timing and 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

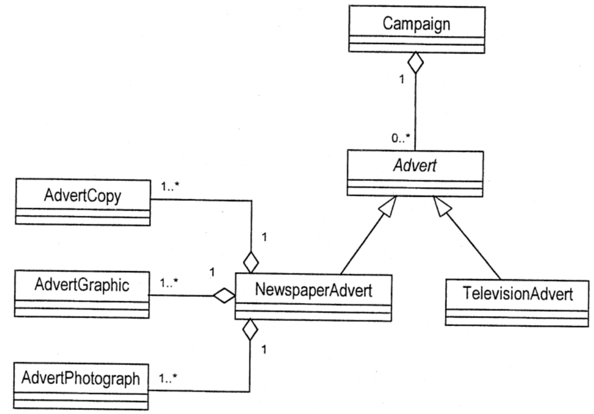
Generalization (an abstraction hierarchy)

Aggregation (a partitioning hierarchy)



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