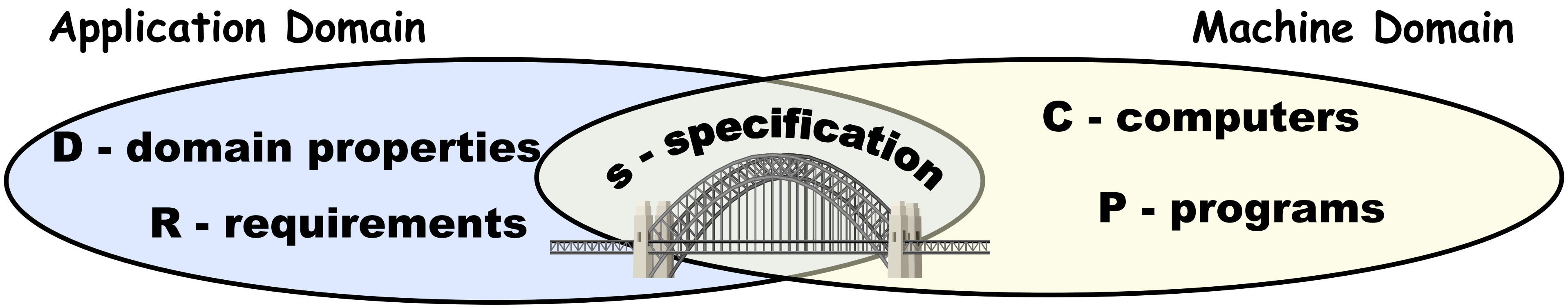
Lecture 9: Requirements Modelling

- 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

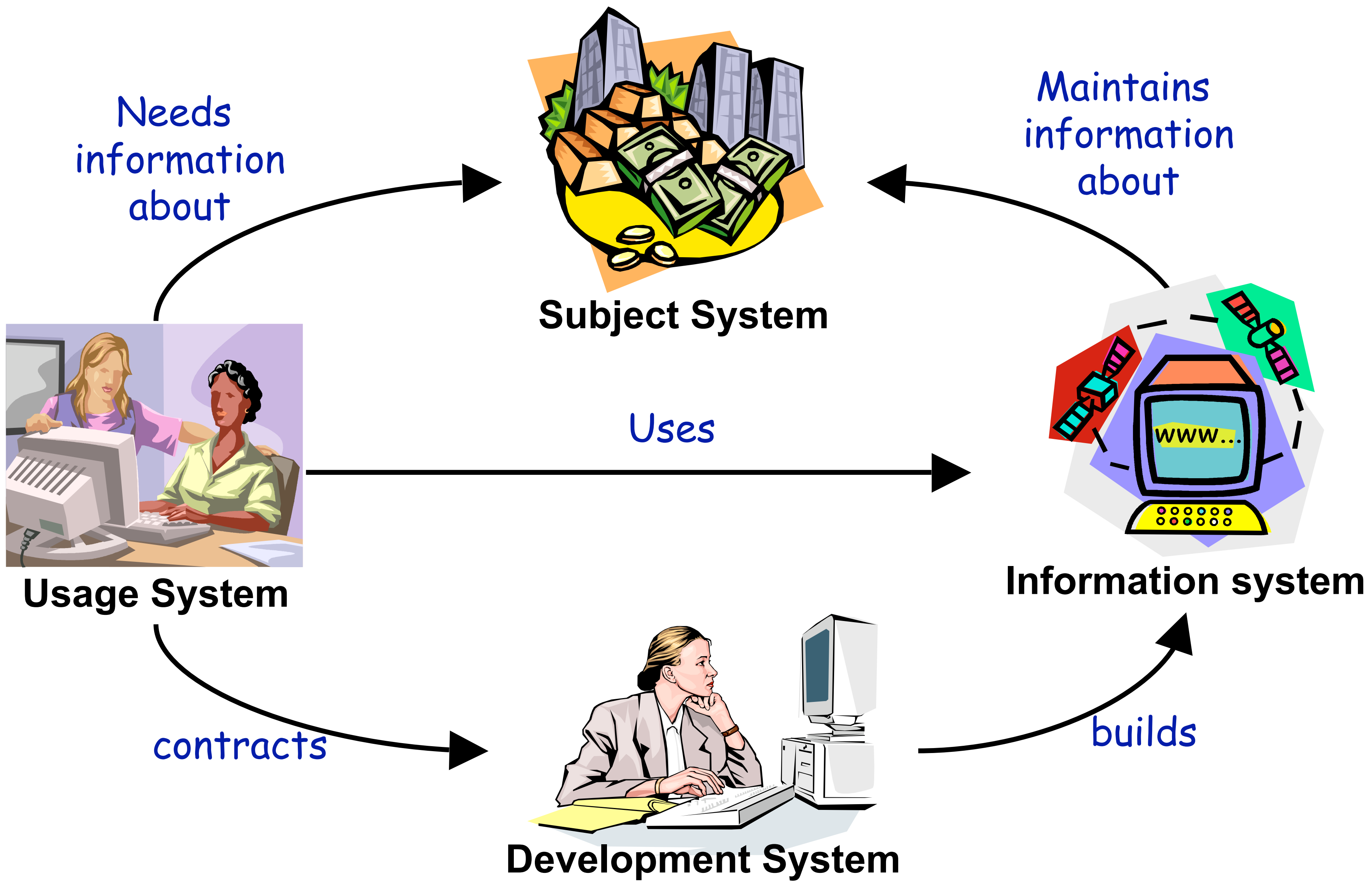
Refresher: Definitions



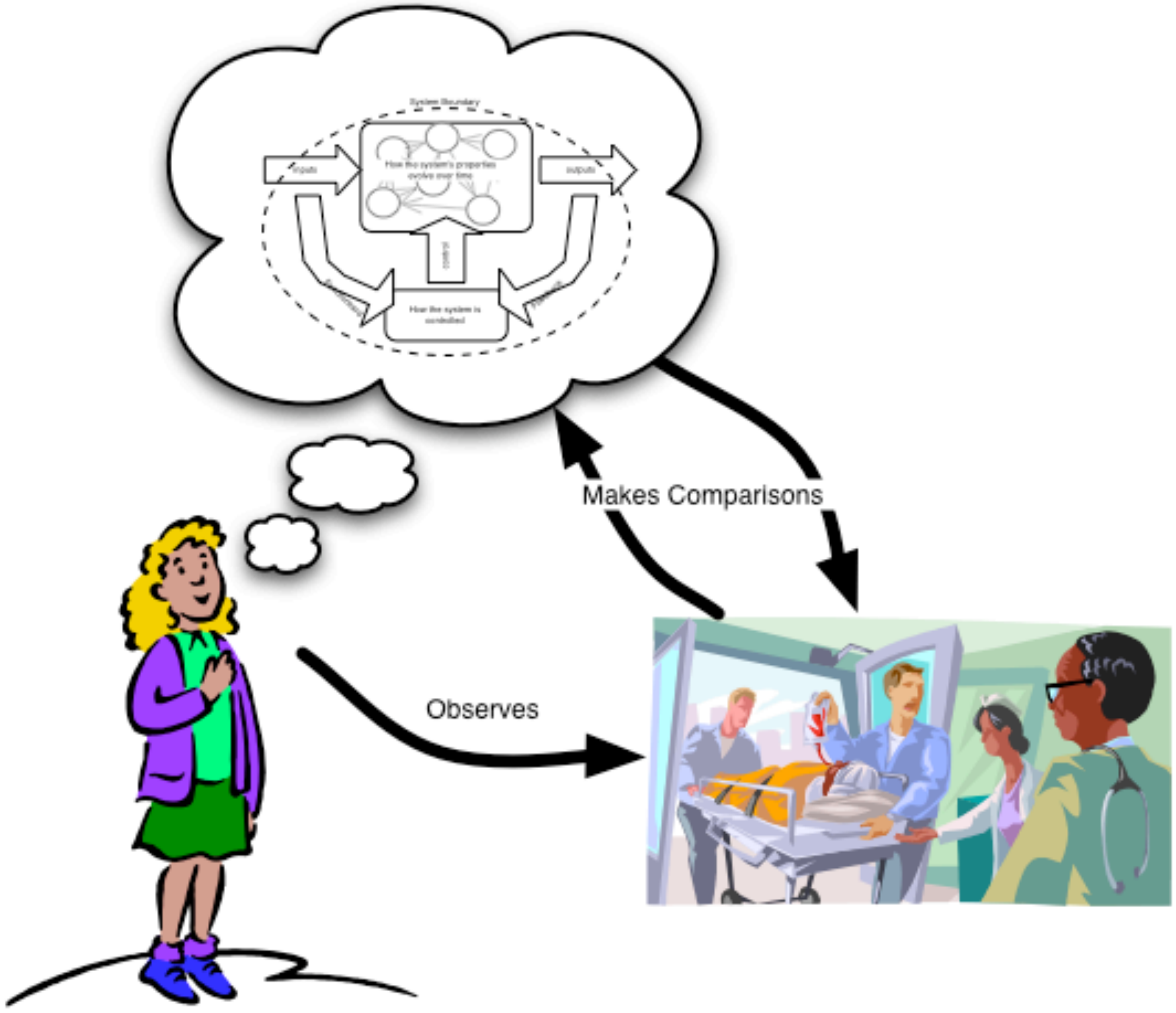
- Some distinctions:
  - Domain Properties - things in the application domain that are true whether or not we ever build the proposed system
  - Requirements - things in the application domain that we wish to be made true by delivering the proposed system
  - A specification - a description of the behaviours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


System Boundary
inputs
How the system's properties evolve over time
outputs
control
How the system is controlled
Makes Comparisons
Observes

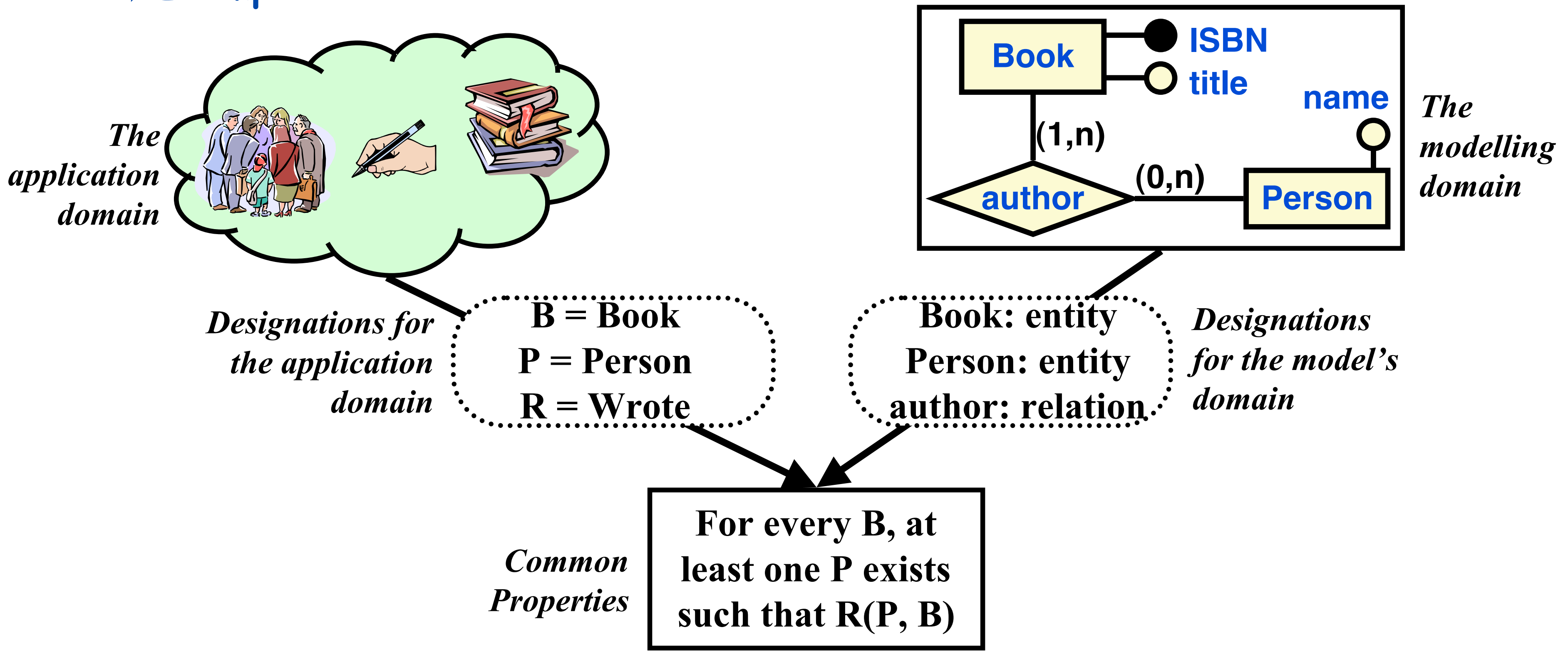
Modelling…

- 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

***Source:** Adapted from Jackson, 1995, p120-122*

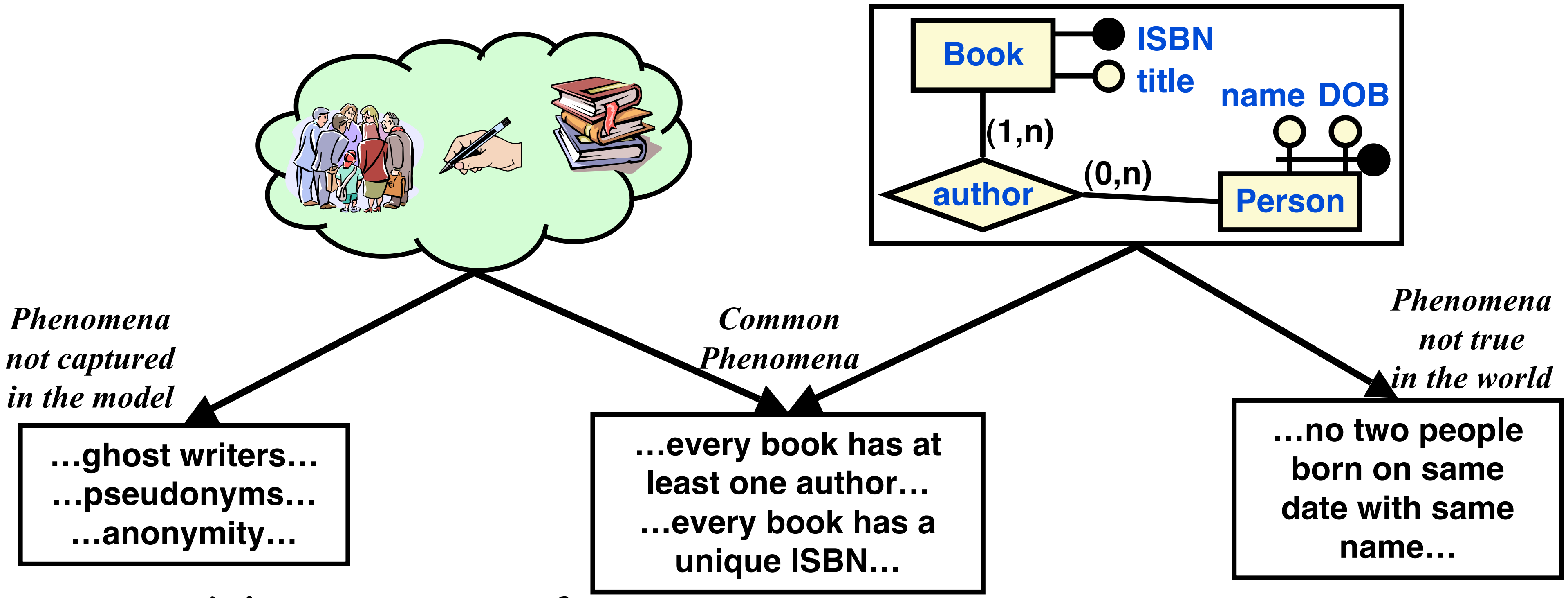
- A model is more than just a description
  - it has its own phenomena, and its own relationships among those phenomena.
    - The model is only useful if the model's phenomena correspond in a systematic way to the phenomena of the domain being modelled.
  - Example:



"It's only a model"

***Source:** Adapted from Jackson, 1995, p124-5*

- 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


Book
ISBN
title
name DOB
(1,n)
(0,n)
author
Person
Phenomena not captured in the model
Common Phenomena
Phenomena not true in the world
...ghost writers... ...pseudonyms... ...anonymity...
...every book has at least one author... ...every book has a unique ISBN...
...no two people born on same date with same name...

- 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...

Choice of modelling notation

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

- **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

Desiderata for Modelling Notations

Source: *Adapted from Loucopoulos & Karakostas, 1995, p77*

- **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,…

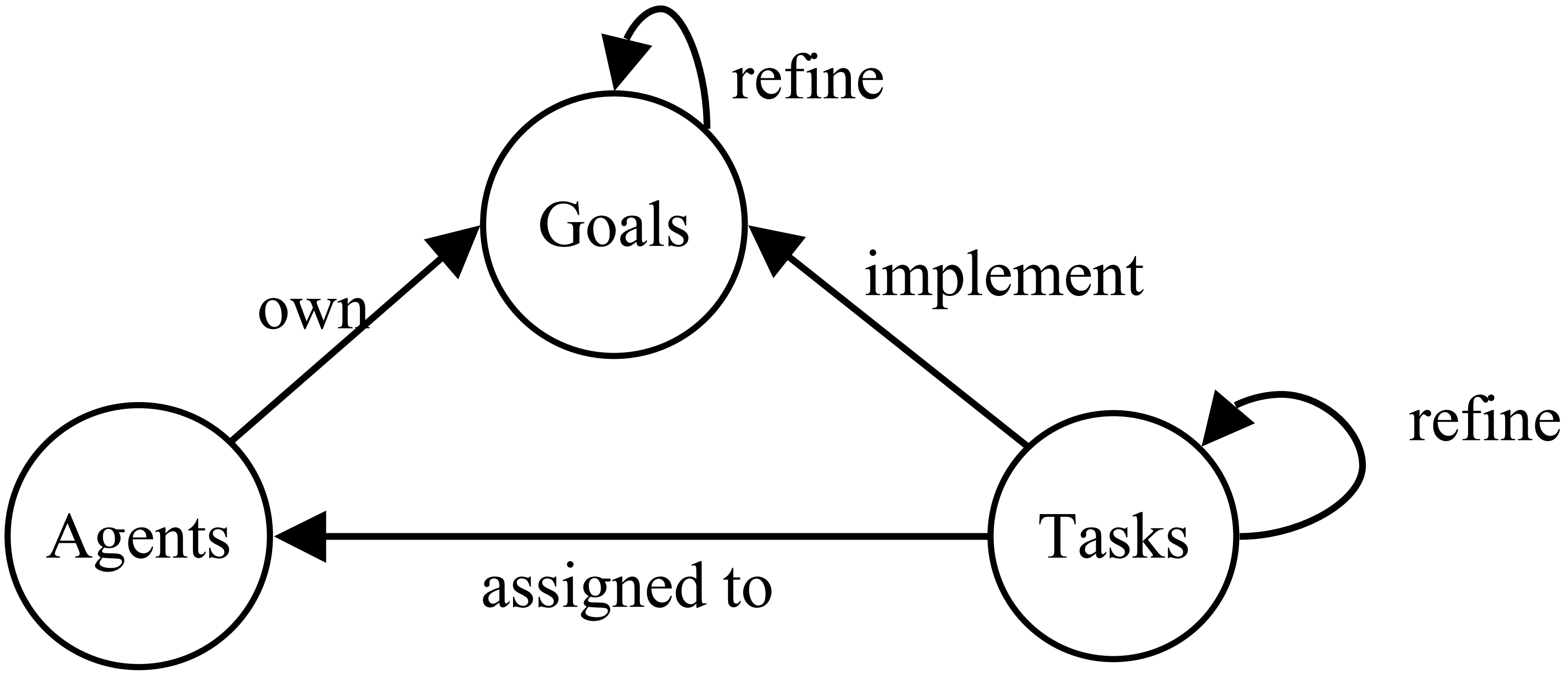
Quality tradeoffs:
QFD, win-win, AHP,
Specific NFRs:
Timed Petri nets (performance)
Task models (usability)
Probabilistic MTTF (reliability)

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 IBM/Rational (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

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

- 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...

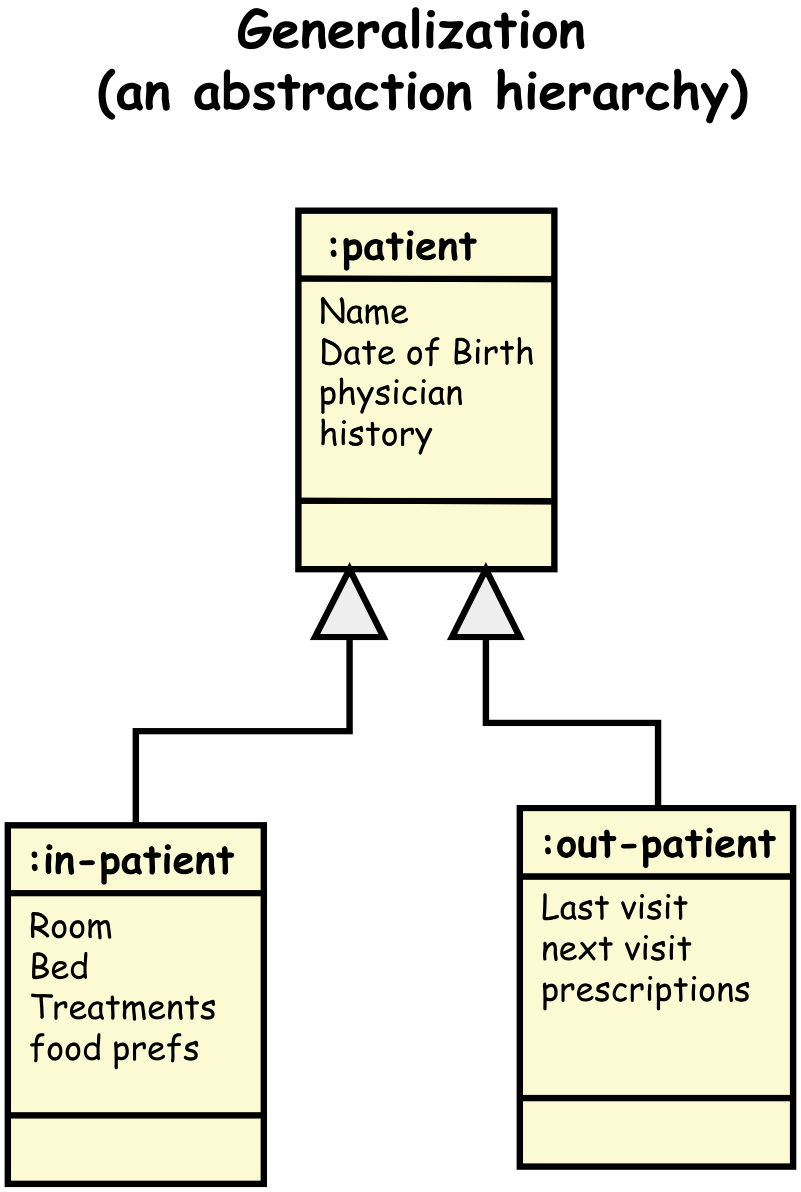
Modelling Principle 3: Projection

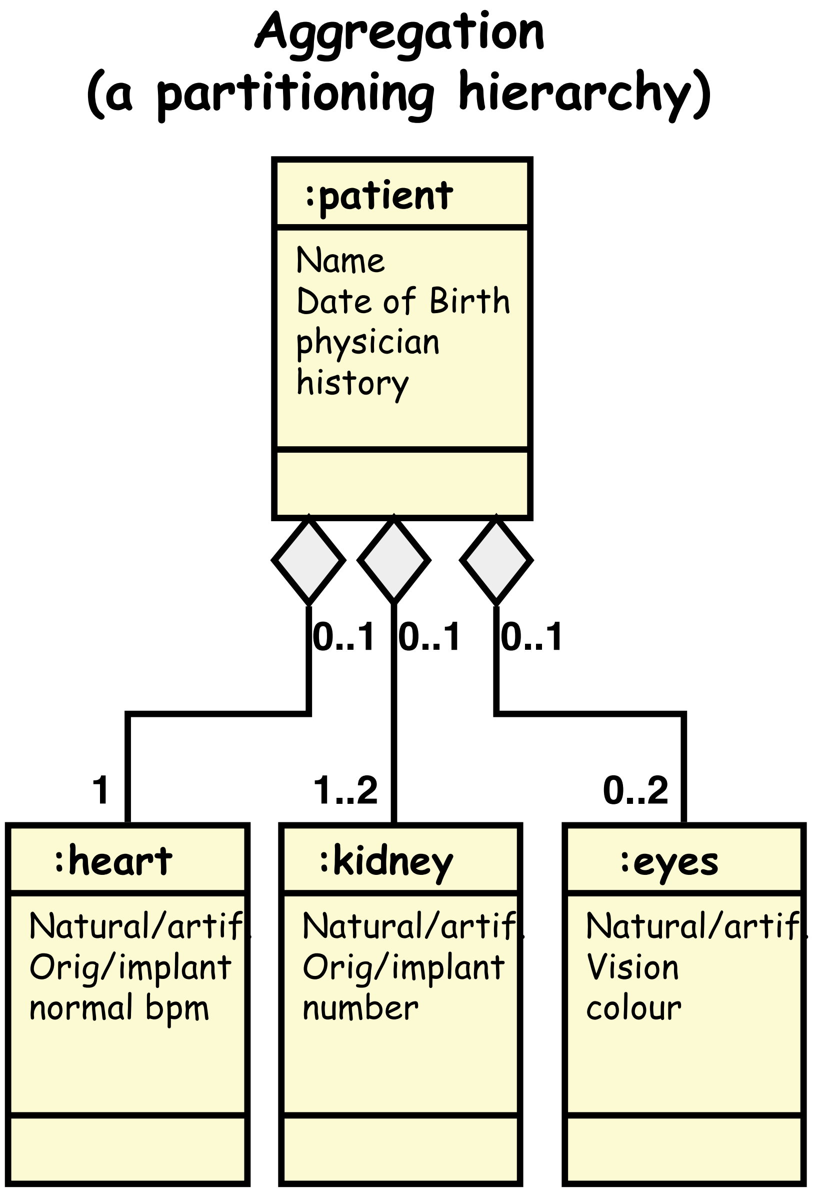
Source: *Adapted from Davis, 1990, p48-51*

- **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

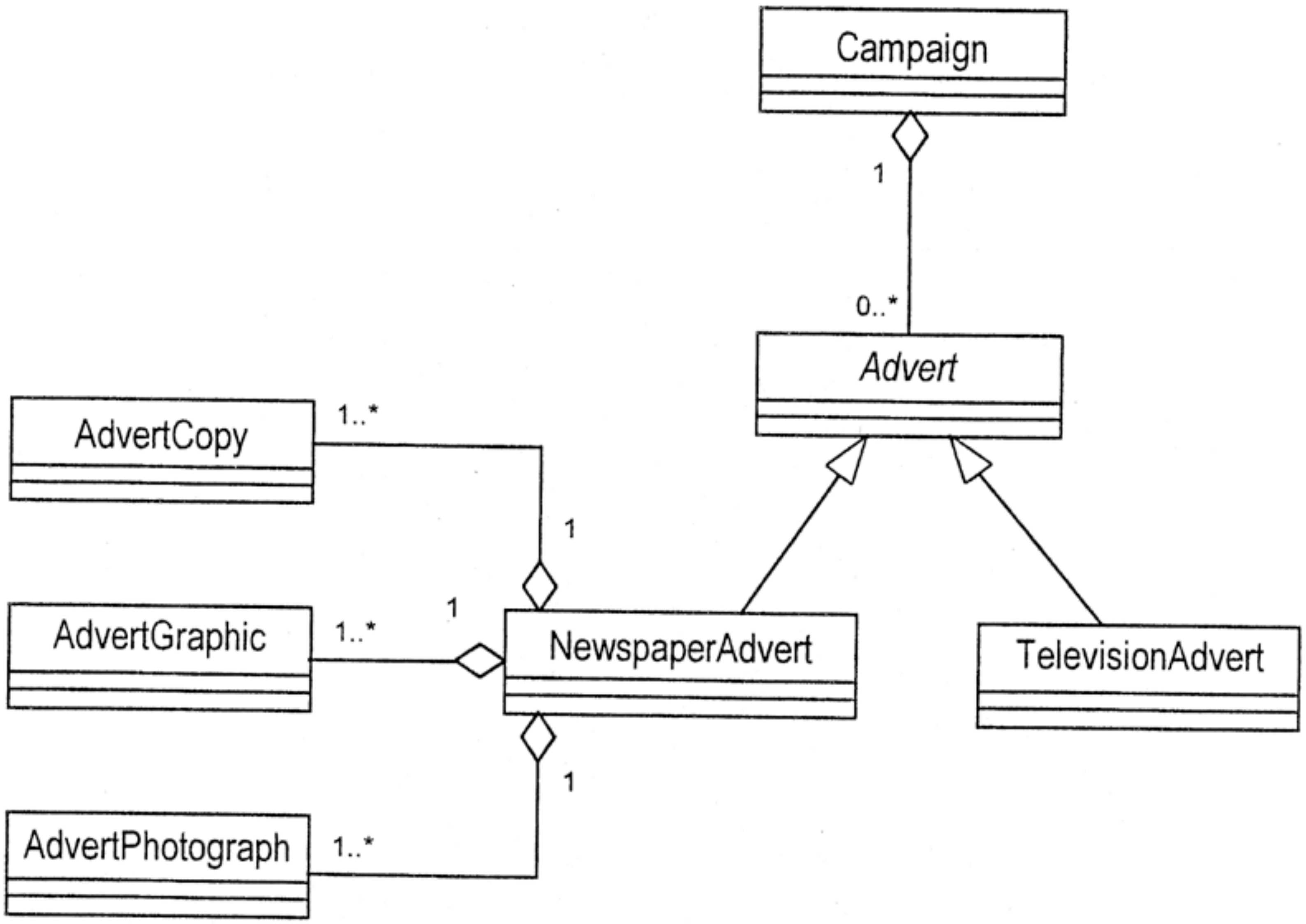
A brief UML example

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