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

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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

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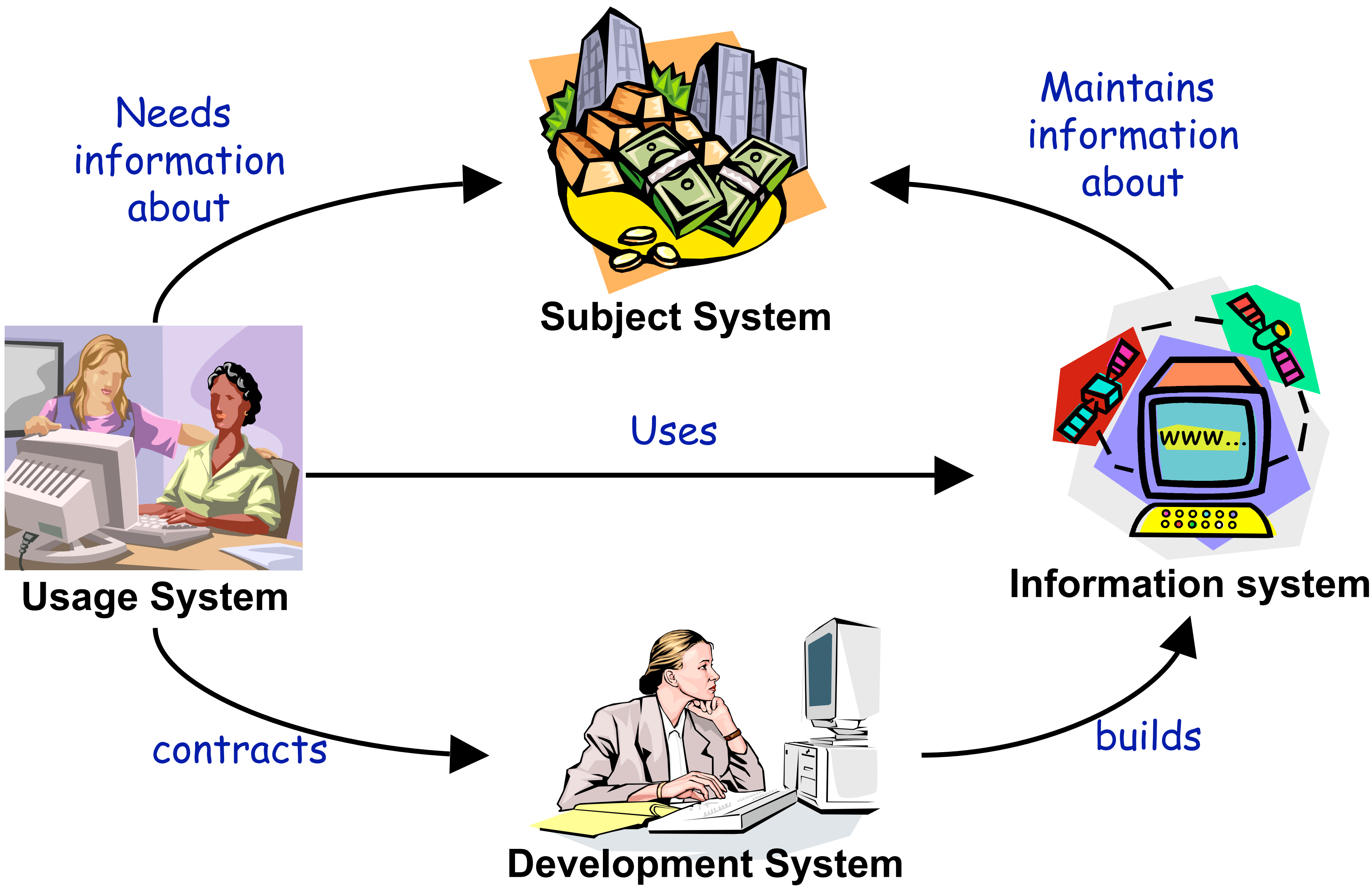
Refresher: Systems to model

Source: *Adapted from Loucopoulos & Karakostas, 1995, p73*



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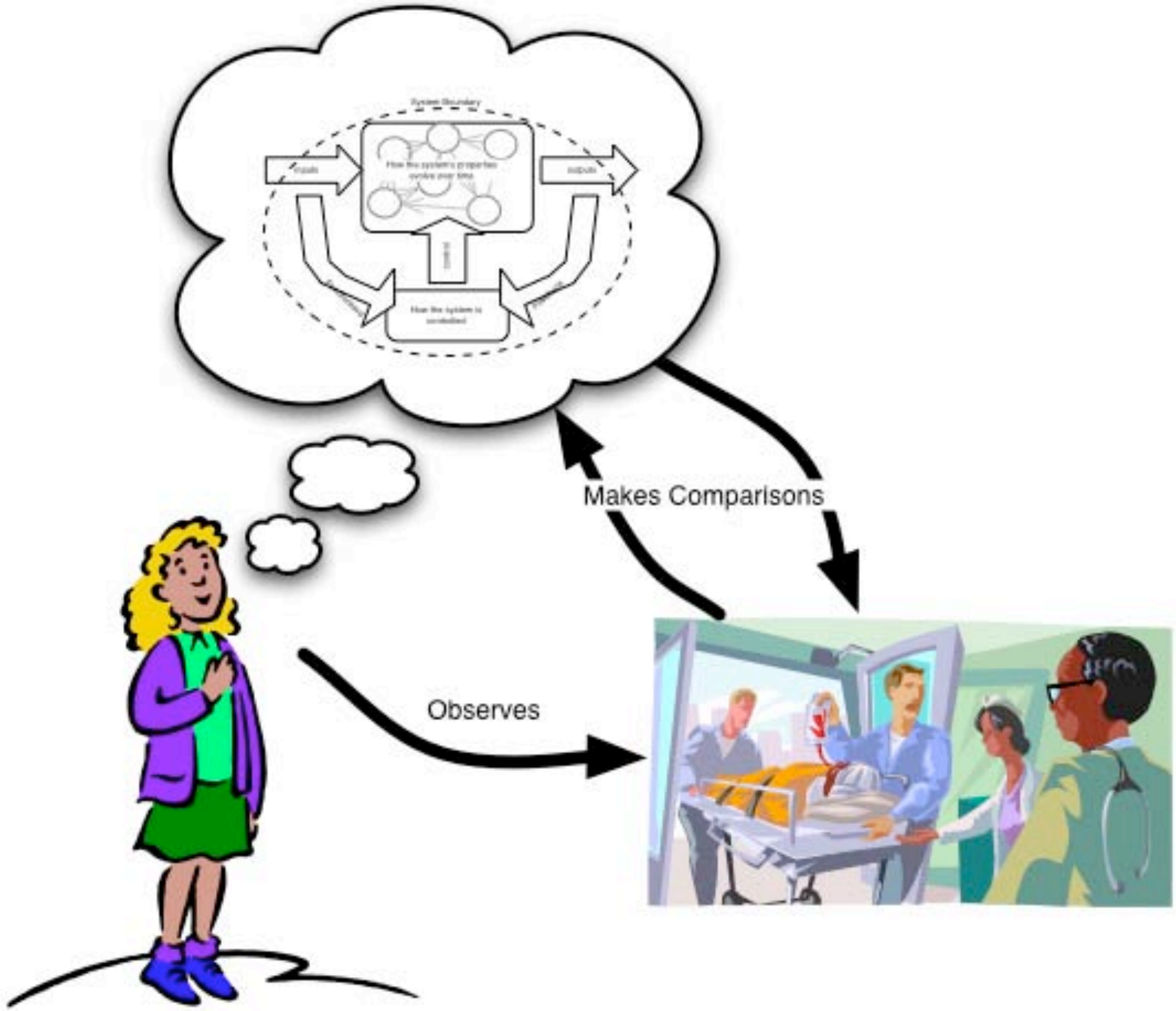
Refresher: Systems Thinking



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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

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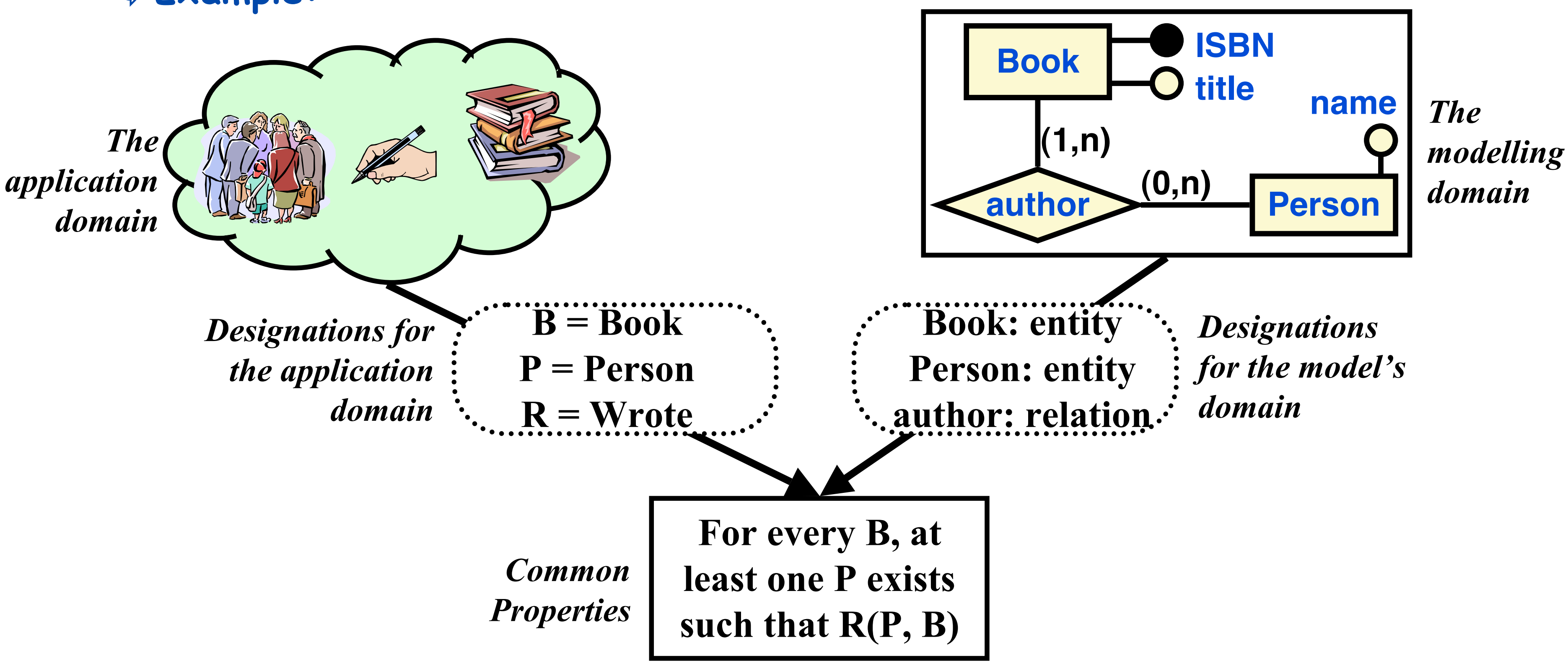
RE involves a lot of modelling

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:



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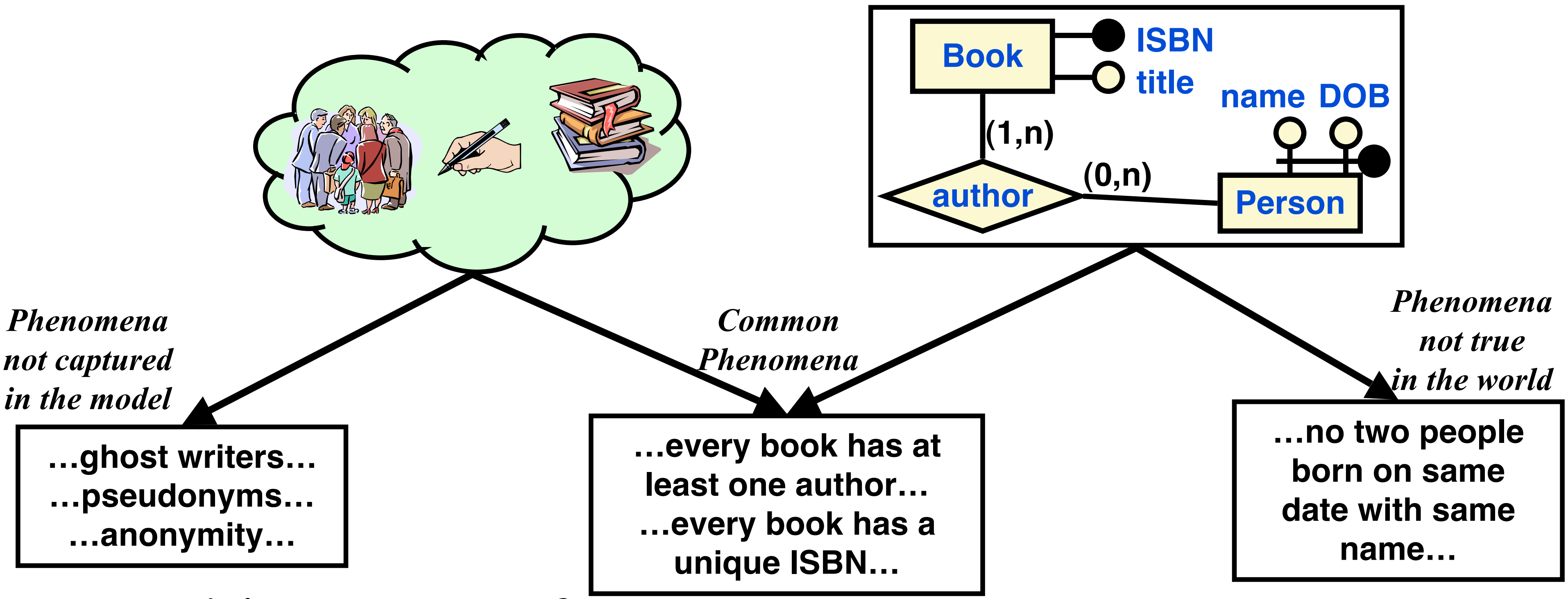
"It's only a model"

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



- 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...

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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

UML fits in here

- **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

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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

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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)

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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

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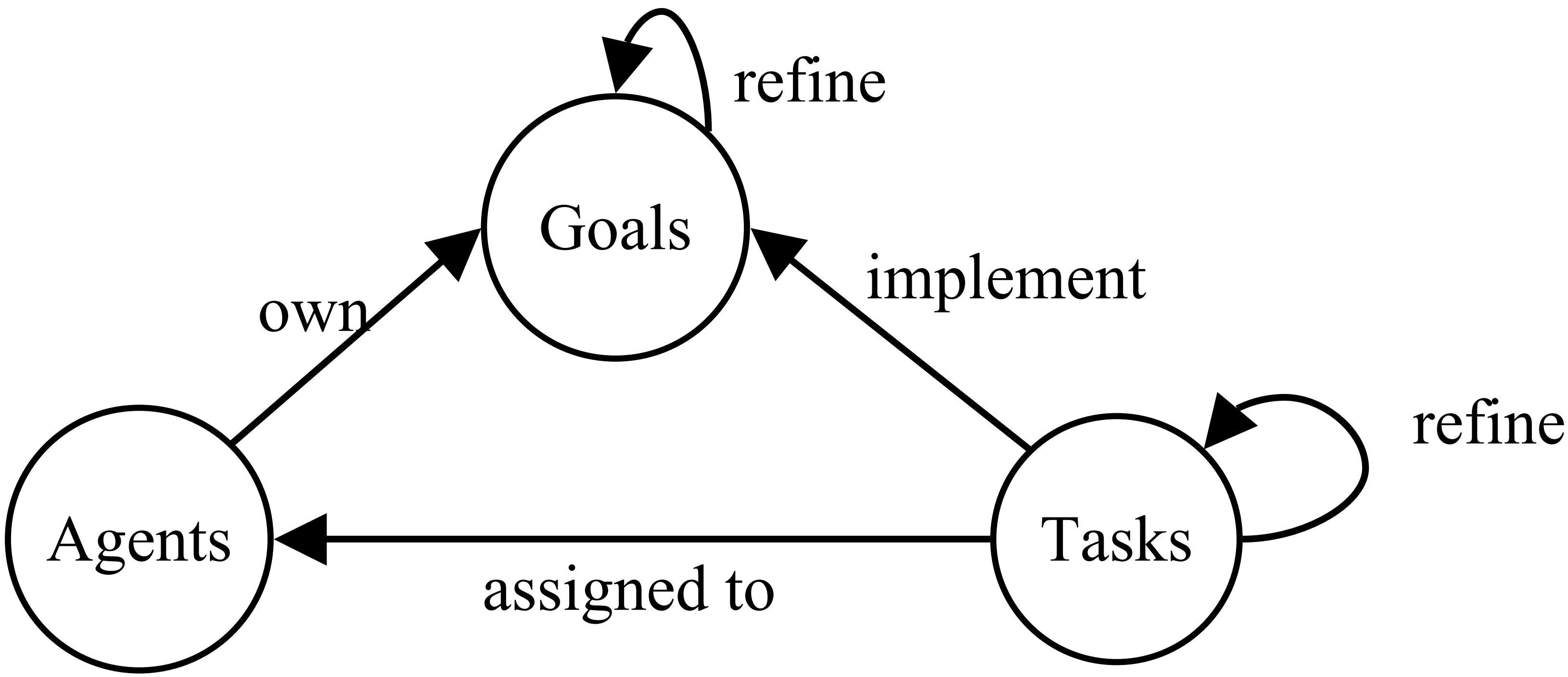
Meta-Modelling

- 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:



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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

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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

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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...

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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

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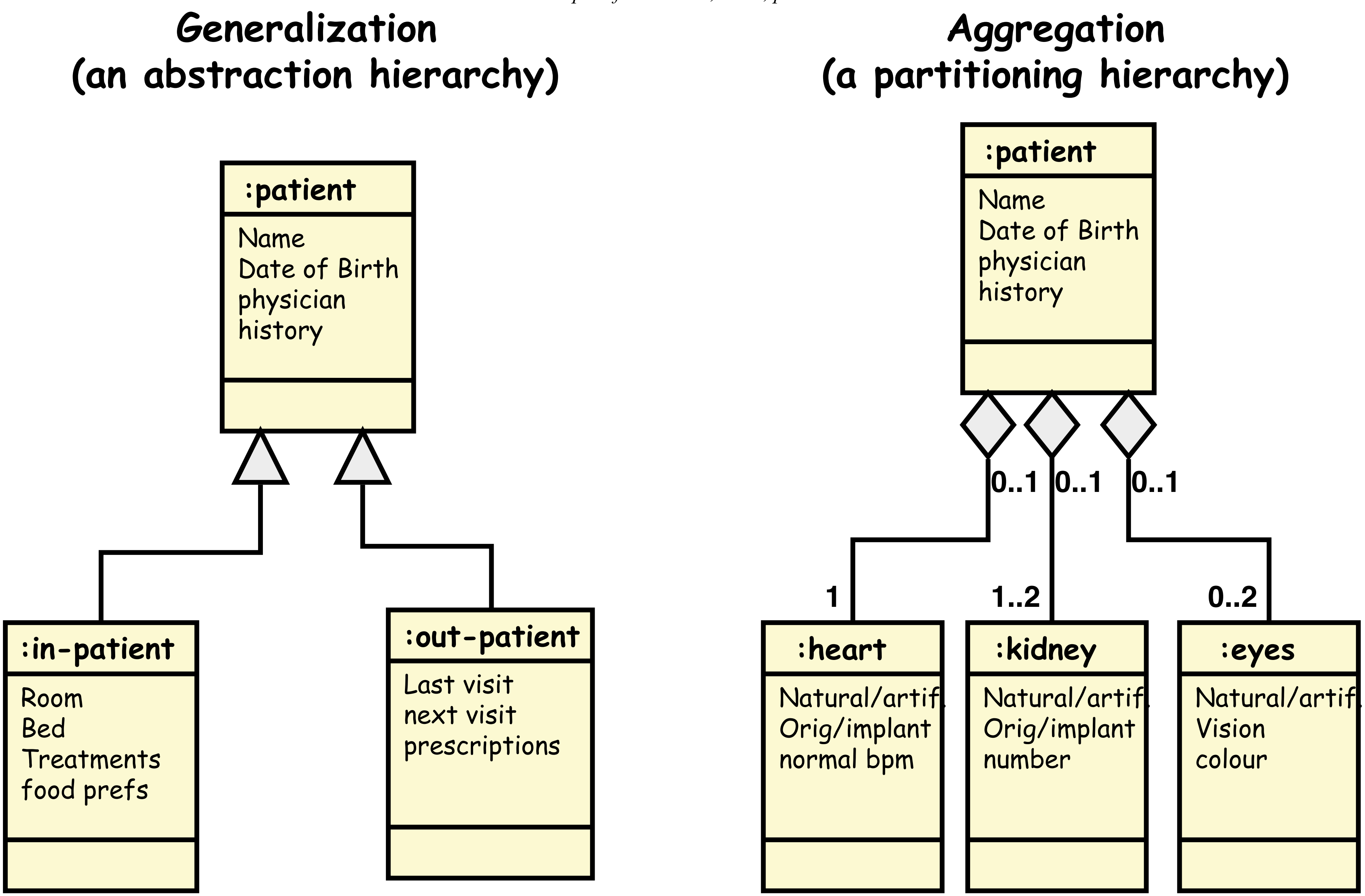
A brief UML example

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



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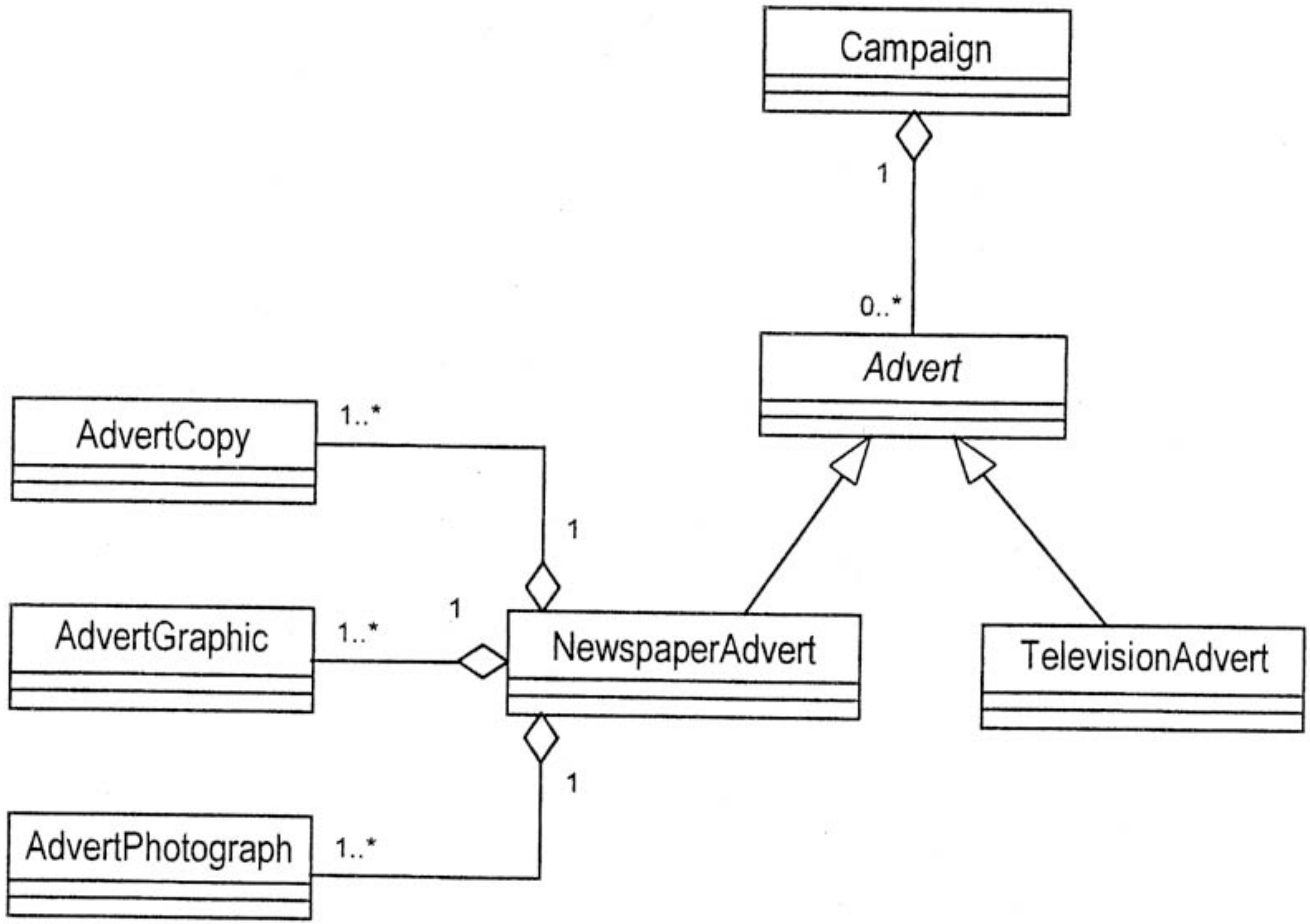
What is this a model of?



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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

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