Lecture 6: Requirements Modeling I

Last Week:
Elicitation (II)
Cognitive approaches
Contextual approaches
Ethnography

This Week:
Modeling and Analysis (I)
General Modeling Issues
Modeling Goals, Organizations,
and Non-Functional Requirements

Next Week:
Modeling and Analysis (II)
Modeling Functionality
Structured and OO methods
Formal Methods

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Motivation for modeling...

Imagine we have interviewed some stakeholders...

Chief Executive
- When flight is full VIPs are first to be upgraded.
- Discounted tickets should be offered to politicians, since they make important decisions affecting the airline.
- Info about frequent fliers should not be made available to outside contractors.

Chief Security Officer
- The number of bags in the aircraft's hold should tally against the list of passengers on board.
- Passenger lists should not be made available to the public.
- Passengers should check-in only once.

Travel Agent
- An agent is responsible for holding and canceling reservations.
- Tickets offered by an agency have different fares, negotiated with the airline sales department.

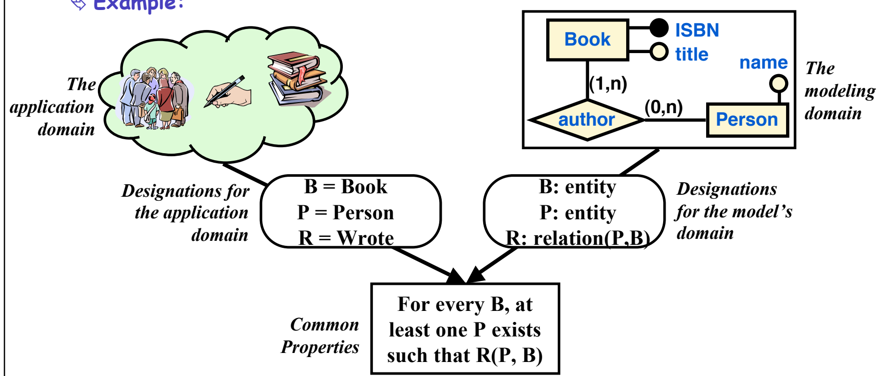
Catering Manager
- The food loaded is dictated by the number of passengers travelling in a particular class.
- A predicted number of passengers on a flight must be available 24 hours prior to departure.
- Passengers requiring special meals must indicate their request 24 hours prior to departure.

Airline Sales manager
- A ticket may only be issued when a fare is paid
- For some fares, a reservation can be held and not confirmed.
- When a discounted ticket is booked, the normal book-ahead requirements do not apply.
- All tickets must carry appropriate endorsements relating to the terms and conditions of issue of tickets.

How do we get from here to an agreed specification?

RE involves a lot of modelling

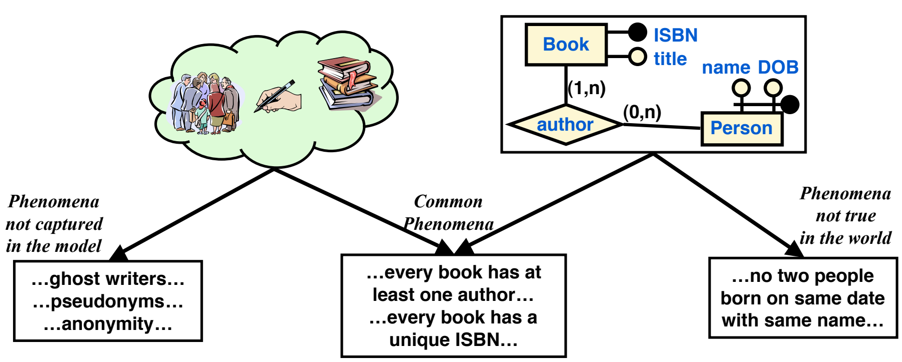
- **A model is more than just a description**
  - it has its own phenomena, and its own relationships among those phenomena.
    - The model is only useful if the model's phenomena correspond in a systematic way to the phenomena of the domain being modelled.
  - Example:



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

Remember: "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*

Modeling…

- Modeling can guide elicitation:
  - Does the modeling process help you figure out what questions to ask?
  - Does the modeling process help to surface hidden requirements?
    - i.e. does it help you ask the right questions?
- Modeling can provide a measure of progress:
  - Does completeness of the model imply completeness of the elicitation?
    - i.e. if we've filled in all the pieces of the model, are we done?
- Modeling can help to uncover problems
  - Does inconsistency in the model reveal interesting things…?
    - e.g. inconsistency could correspond to conflicting or infeasible requirements
    - e.g. inconsistency could mean confusion over terminology, scope, etc
    - e.g. inconsistency could reveal disagreements between stakeholders
- Modeling can help us check our understanding
  - Can we test that the model has the properties we expect?
  - Can we reason over the model to understand its consequences?
  - Can we animate the model to help us visualize/validate the requirements?

Type of Model

Can choose a variety of conceptual schema:

- natural language
  - extremely expressive and flexible
  - very poor at capturing the semantics of the model
  - better used for elicitation, and to annotate models for communication
- semi-formal notation
  - captures structure and some semantics
  - can perform (some) reasoning, consistency checking, animation, etc.
    - E.g.s: diagrams, tables, structured English, etc.
- formal notation
  - very precise semantics, extensive reasoning possible
  - long way removed from the application domain
    - note: requirements formalisms are geared towards cognitive considerations, hence differ from most computer science formalisms

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

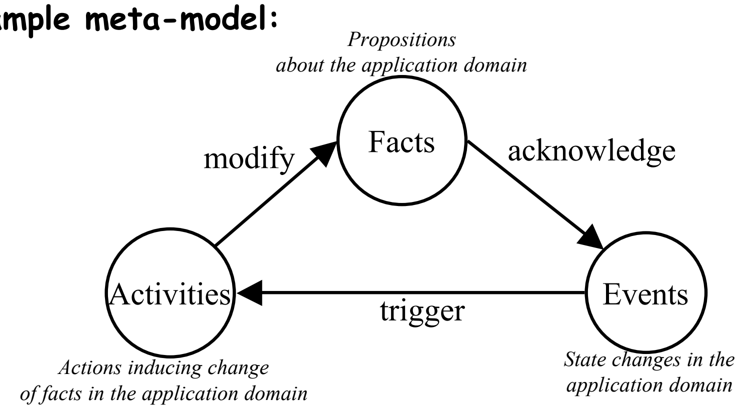
Desiderata for Conceptual Schema

- **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 modeling scheme
    - i.e. no extraneous choices of how to represent something

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

Meta-Modeling

- **Can compare modeling 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:**



Modeling 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

Modeling 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 of fault:

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

OR

based on symptoms of fault:

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

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

Modeling 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 communication between spacecraft and ground system
  - Model separately:
    - sequencing of messages;
    - format of data packets;
    - error correction behavior;
    - 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*

Survey of Modeling Techniques

- **Modeling Enterprises**
  - Goals & objectives
  - Organizational structure
  - Activities, processes, and products
  - Agents and work roles
- **Modeling Functional Requirements**
  - Information Structure
  - Behavioral views
  - Timing/Sequencing requirements
- **Modeling Non-functional Requirements**
  - Product requirements
  - Process requirements
  - External requirements

Information modeling:
ERD
Organization modeling:
i*, SSM, ISAC
Goal modeling:
KAOS, CREWS

Structured Analysis:
SADT, SSADM, JSD
Object Oriented Analysis:
OOA, OOSE, OMT, UML
Formal Methods:
SCR, RSML, Z, Larch, VDM

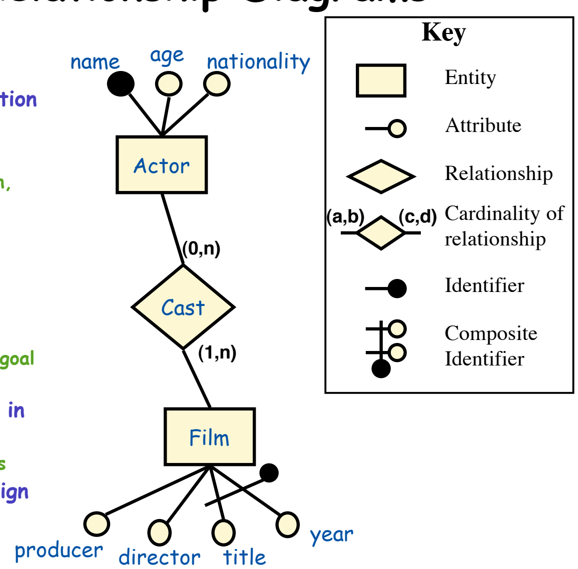
Quality tradeoffs:
QFD, win-win
Specific NFRs:
Timed Petri nets (performance)
Task models (usability)
Probabilistic MTTF (reliability)

Approaches to Enterprise Modeling

- **1970's**
  - Soft Systems Approaches:
    - involve the entire organisation
    - Be sensitive to political and social context for organisational change
  - Examples: SSM, ISAC
- **1980's**
  - Knowledge-based Approaches:
    - Use knowledge representation schemes to build executable domain models
    - capture static and dynamic aspects of the domain
  - Examples: RML, Requirements Apprentice, Nature
- **1990's**
  - Teleological Approaches:
    - Requirements are really just goals, so model goal hierarchies
    - Focus on the 'why' question, rather than 'what'/'how'
    - …and use scenarios as concrete examples of how goals are (can be) satisfied
  - Examples: KAOS, i*, CREWS,…
- **2000's …?**

Entity Relationship Diagrams

- **ER diagrams**
  - widely used for information modeling
  - simple, easy to use
    - Note: this is a notation, not a method!
- **Used in many contexts:**
  - domain concepts
    - objects referred to in goal models, scenarios, etc.
  - Data to be represented in the system
    - for information systems
  - Relational Database design
  - Meta-modeling



ISAC

- **Information Systems Work & Analysis of Changes (ISAC)**
  - Developed in the 1970's in Sweden
  - Emphasizes cooperation between users, developers and sponsors
    - Developers' role is to facilitate the process
  - Good for information systems; not applicable to control systems.
- **ISAC Process**
  1. Change Analysis
     - What does the organization want?
     - How flexible is the organization with respect to changes?
  2. Activity Study
     - Which activities should we regroup into information systems?
     - Which priorities do the information systems have?
  3. Information Analysis
     - Which inputs and outputs do each information system have?
     - What are the quantitative requirements on each information system?
  4. Implementation
     - Which technology (info carriers; h/w; s/w) do we use for the information systems?
     - Which activities of each information system are manual, which automatic?

ISAC Change Analysis

1. List problems
   - dissatisfactions with current system
     - list all problems…
     - …then remove any that are trivial or intractable
2. List interest groups
   - these are *"problem owners"*
   - draw matrix of problems against owners
     - This exercise is done with the problem owner's involvement
3. Analyze problems
   - Use cause-effect analysis
     - Eliminate solution-oriented problems, to get to underlying causes
   - performed by domain specialists
   - quantify the problems
4. Make Current Activity Model
   - Notation: A-schemas (similar to dataflow diagrams)
5. Analyze Goals
   - Declarative statement of goals
     - i.e. desired result, not how to get there
   - Result should be a tree of goals
6. Define Change Needs
   - Goals should explain why the problems exist; problems frustrate goals
   - Cluster problems into related groups
     - Each group is a change need
7. Generate Change Alternatives
8. Model desired situations
   - make packages of change alternatives
9. Evaluate Alternatives
10. Choose an alternative

Soft System Methodology (SSM)

Background

- Developed by Checkland in late 1970's
- Reality is socially constructed, and therefore requirements are not objective
- Rationale:
  - Problem situations are fuzzy (not structured) and solutions not readily apparent.
  - Impact of a computerization may be negative *(e.g. intro of new system reduced productivity as it removed employee motivation)*
  - Full exploitation of computerization may need radical restructuring of work processes.

Approach

- Analyze problem situation using different viewpoints
  - Determining the requirements is a discussion, bargaining and construction process.
- Out of this process emerges not just a specification, but also:
  - plans for a modified organization structure
  - task structures
  - objectives
  - understanding of the environment

SSM Approach

1 Existing situation (unstructured problem)

2 Analyze the problem situation
- Draw a rich picture
- look for problem themes (describe them in natural language)

3 Define relevant systems and root definitions (CATWOE)
- a root definition is a concise description of a human activity system

4 Build a conceptual model
- of the activity system needed to achieve the transformation
- process oriented model, with activities & flow of resources

5 Compare conceptual model with step (2)
- Ordered questioning - questions based on the model
- Event reconstruction - take past events and compare them to the model
- General comparison - look for features of the model that are different from current situation
- Model overlay - point by point comparison of the two models

6 Debate feasible and desirable changes

Three types of change: structural, procedural, attitudinal

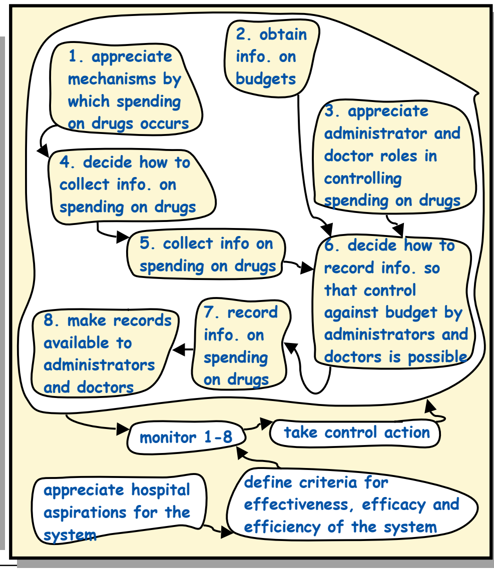
7 Implement changes

SSM modeling

Root definition:

"A hospital-owned system, which provides records of spending on drugs so that control action by administrators and doctors to meet defined budgets can be taken jointly"

Customers: Administrators, Doctors
Actors: not stated
Transformation: Need to know spending on drugs → Need met by recording info.
Weltanschauung: Monitoring spending on drugs is possible and is an adequate basis for joint control action
Owner: Hospital
Environment: Hospital mechanisms, roles of administrators and doctors, defined budgets



*i**

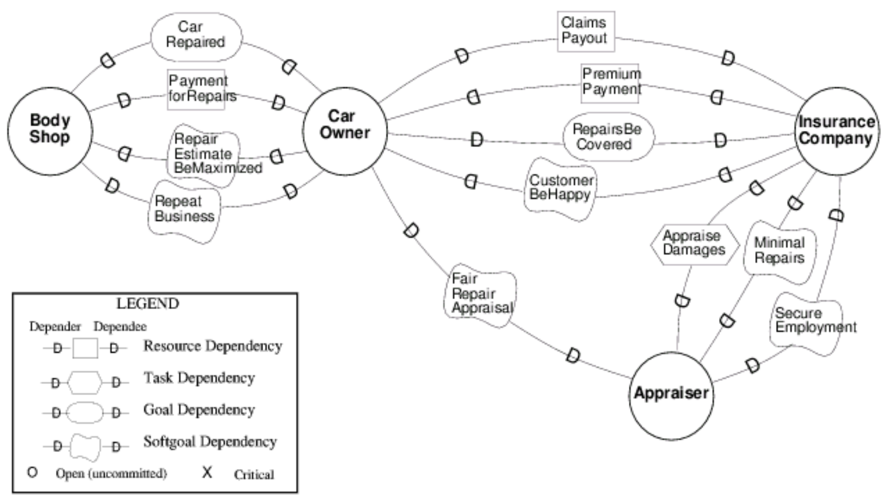
→ Background

- Developed in the early 90's
  - provides a structure for asking 'why' questions in RE
  - models the organisational context for information systems
  - based on the notion of an "intentional actor"
- Two parts to the model
  - Strategic dependency model - models relationships between the actors
  - Strategic rationale model - models concerns and interests of the actors

→ Approach

- SD model shows dependencies between actors:
  - goal/softgoal dependency - an actor depends on another actor to attain a goal
  - resource dependency - an actor needs a resource from another actor
  - task dependency - an actor needs another actor to carry out a task
- SR model shows interactions between goals within each actor
  - Shows task decompositions
  - Shows means-ends links between tasks and goals

E.g. Strategic Dependency Model



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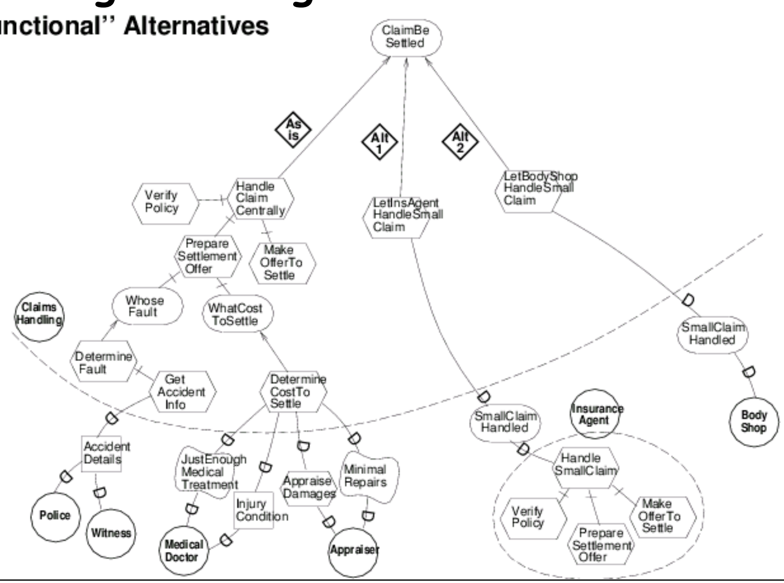
E.g. Strategic Rationale Model

"Functional" Alternatives



KAOS

➜ Background

- Developed in the early 90's
  - first major teleological requirements modeling language
  - full tool support available
  - has been applied to a number of industrial case studies
- Two parts:
  - Informal goal structuring model
  - Formal definitions for each entity in temporal logic

➜ Approach

- Method focuses on goal elaboration:
  - define initial set of high level goals & objects they refer to
  - define initial set of agents and actions they are capable of
- Then iteratively:
  - refine goals using AND/OR decomposition
  - identify obstacles to goals, and goal conflicts
  - operationalize goals into constraints that can be assigned to individual agents
  - refine & formalize definitions of objects & actions

KAOS meta-model