Problem structuring methods & structuring a value model
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A Taxonomy of Decision Models

Problem dominated by

Uncertainty
- EXTEND conversation
  - Event tree
  - Fault tree
  - Influence diagram
- REVISE opinion
  - Bayesian nets
  - Bayesian statistics
- SEPARATE into components
  - Credence decomposition
  - Risk analysis

Multiple Objectives
- EVALUATE options
  - Multi-criteria decision analysis
- CHOOSE option
  - Payoff matrix
  - Decision tree
- ALLOCATE resources
  - Multi-criteria commons dilemma
- NEGOTIATE
  - Multi-criteria bargaining analysis
The decision-making process

A Decision-Making Process:

- divergent phase
- convergent phase
- problematic situation
- implementation of actions
- time

stakeholders?
decision-makers?
objectives and values?
options?
ideas and views?
uncertainties?

- type of evaluation?
objectives?
alternatives?
performances?
trade-offs?
probabilities of outcomes?
risk attitude?

implementation of actions
The decision-making process

Supporting divergence and convergence in decision-making

Problem Structuring Methods (PSMs) supporting divergence in decision-making

Decision Analysis supporting convergence in decision-making

© Gilberto Montibeller, Structuring value models
I Problem Structuring Methods

References:
Problem structuring methods (PSMs)

... are a family of methods for supporting decisions for groups of diverse composition within a complex environment to agree a problem focus and make commitments to a series of actions

... are usually applied to unstructured problems characterized by:
• multiple actors
• multiple perspectives
• conflicting interests
• high levels of uncertainty

To tackle problems with these characteristics, PSMs must:
- enable alternative perspectives to be considered with each other
- be transparent to a range of participants
- operate iteratively
- allow contingent solutions

Key characteristics of PSMs

• Techniques to facilitate exploration / definition of a problem situation
• Group based
• Uncovering options
• Enabling group action
• Accepting uncertainty / alternative scenarios or versions of the situation
• Managing conflict
• Facilitator – Analyst
• Generating constructive improvements
PSMs

**Messes**
- SODA
- SSM
- SCA
- Drama theory & confrontation analysis
- Dialogue mapping
- …

**Problems**
- Decision analysis
- Simulation
- Queuing theory
- Game theory
- Markov modelling
- …

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SODA – Strategic Options Development and Analysis

Selecting a process, for example:

- Individual interviews \(\rightarrow\) Cognitive maps

- Merge maps \(\rightarrow\) Group map

- Group workshops \(\rightarrow\) Expand/Refine map & group ownership
A cognitive map: strategies for growth in an organization

CEO needs to communicate with partners directly
CEO upset by partners’ recent messages
Company owners ending different messages
Need to remove fear of global hidden agenda
Need to minimize gap in perceptions of future direction
Global pricing strategy need to be agreed
Need to manage tension between entrepreneurial spirit and central control
Inclusion of attitudinal element
Improve customer interface
Increase validity
Web based
Need to be move to selling learning solutions
Sign license agreements
Regeneration of profiling instrument
Partners need exit strategy
Develop global strategy
Grow company
Need consistent capabilities
Need additional resources

How to evaluate equipment in a hospital? An example

INTERVIEWS

COGNITIVE MAPPING

VALUE TREES

Advisors

SIE Members

Merging the information of the interviews into a cognitive map

A cognitive map after group discussion

Bruno Barroso (2011) "An integrated approach to medical equipment management in a hospital context", MSc thesis in Biomedical Engineering
Ongoing analysis…

Value tree

SUBSTITUTION OF MEDICAL EQUIPMENT

- Usage
  - Usage level
  - User-friendliness
- Physical condition
  - Technological obsolescence
  - Age
- Manufacturer impact
  - Technical Assistance
    - Operational availability
- Comparison with new equipment
  - Current vs new equipment total operation costs
  - Current maintenance costs vs Acquisition costs of a new equipment
  - Current vs new production capacity

& definition of options

Theory and concepts guiding SODA

SSM - Soft Systems Methodology

Enter situation considered problematic

Take action to improve the problem situation

Express the problem situation

Define possible changes which are both desirable and feasible

Compare models with the real world

Formulate root definitions

Build conceptual models of the systems named in the root definitions

Real world

Systems thinking about the real world
Hard vs. Soft systems?

**Hard**
- Data available
- Single objective and optimisation
- People are passive
- Attempts to abolish uncertainty

**Soft**
- Data Unavailable
- Multiple objectives and non-optimisation
- People are active subjects
- Accepts uncertainty and encourages flexibility
CATWOE

Formulation of Root Definitions
Consider the following elements: CATWOE

- Customer (C): Who would be victims/propitiators of the purposeful activity?
- Actors (A): Who would do the activities?
- Transformation process (T): What is the purposeful activity expressed as input-→ transformation-→ output?
- Weltanschauung (W): What view of the world makes this definition meaningful?
- Owners (O): Who could stop this activity?
- Environmental constraints (E): What constraints in its environment does this system face as such?

Rosenhead and Mingers (2001)

Example:
A professionally-managed system in a manufacturing company, which, in the light of market forecasts and raw material availability, makes detailed production plans for a defined period.

- CATWOE analysis:
  - C: People in the production function
  - A: Professional planners
  - T: Need for production plan → need met
  - W: Rational planning of production is desirable and is a possibility; there is the degree of stability needed to make rational planning feasible
  - O: The company
  - E: Staff and line rules, information availability

Rosenhead and Mingers (2001)
Dialogue mapping

see more at: http://cognexus.org/
To conclude – PSM Pros

- Problem structuring, not problem solving
- Gathering information, generating ideas
- Retain flexibility in early stages
- Demonstrate understanding of complexity, diversity and inconsistency
- Prioritising and simplifying

To conclude – PSM Cons

- Methods development required
- Methods need to be adapted to the context
- New skills
- Ownership
- Facilitation of group decision making
- Reproducibility
Further concepts to structure a Value Model

A note on group processes

- Interviews
- Group sessions – format:
  - Facilitated workshops
  - Decision conferencing
  - …
- Group sessions – content:
  - Facilitated post-it sessions to build a cognitive map
  - Decision conferencing to build a model of values
  - …
Actors are primarily interested in the ‘requisite’ specification of their values → this is the objective of structuring

Structuring activities:

• Problem structuring
• Model structuring
• Impact assessment.

Problem-structuring (framing the problem):

• Analyse the type of decision context (public, private, mixed, ...) and its boundaries (scoping)
• Identify the key actors (decision-maker(s), stakeholders, ...) and
  – the type of their value-systems
  – their level of intervention in the process
  – the type of conflicts that can emerge
• Make a first appraisal of:
  – The type of core objectives to be achieved
  – The type of actions to achieve the objectives
  – The main sources of uncertainty
  – The main sources of potential conflicts
Turning point from problem-structuring to model-structuring:

When it becomes clear to the decision analyst / facilitator which type of decision-aiding model will be more adequate for value analysis in the specific problem-context!

Model structuring:

- an interactive and learning process?
- an individual or group process (depending on the decision-aid strategy adopted)?

- seeking to build a (more-or-less) formal model integrating:
  - objective components of the problem (such as the characteristics of the options) and
  - subjective components (the values and objectives of the actors)
- making explicit the actors’ value-systems
Framing decision problems

Two basic model-structuring strategies

**BOTTOM-UP (ALTERNATIVE-FOCUSED THINKING):**
- Define a set of options
- Analyse the characteristics of these options to find out those that are relevant to achieve actors’ values and can they be used as criteria to evaluate the options
- Find out the key objectives to the actors want to achieve and then create options to achieve them.

**TOP-DOWN (VALUE-FOCUSED THINKING):**
- Define objectives
- Separate means from ends objectives
- Identify the fundamental objectives
- Find options as means to achieve the objectives
“The primitive notion for a decision problem should be values and not alternatives. If, in fact, we begin with values, we might not even think of situations as decision problems, but rather as decision opportunities”

(Keeney, 1988, p. 466).

In practice, a mixed strategy may be more realistic:

Actors’ objectives and options’ characteristics have different but complementary roles in the model-structuring process.

Towards the identification of evaluation criteria

- Start model structuring by a broad discussion of the key issues.

- Values emerge during the discussion either as objectives or characteristics relevant for the analysis.

- They should be well defined and perceived by all the key players to avoid ambiguity and misunderstanding.

- Separate means-objectives from end objectives.

- Agree on a coherent family of key objectives (exhaustive, concise, decomposable, ...) that will be used as the criteria to evaluate options and

- Structure them in a criteria value-tree

Associate a descriptor of performance to each criterion, to make it operational for the assessment and appraisal of options’ consequences.
Means-ends networks: Integrated resource planning in a gas company

“Post-it” sessions and oval / cognitive mapping:

The five key dimensions to prioritise public investments in social infrastructures
Separate screening from evaluation criteria and describe well each one of them. Example:

- ‘Social priority’: the extent to which the project objectives are within the national social policy priorities defined for the sector.
- ‘Cohesion’: the extent to which the project contributes to bridge the gaps in social infra-structures (of all types) between urban developed regions and the rural impoverished or deteriorated urban areas.
- ‘Coverage’: The extent to which the level of spatial coverage by the social infra-structures of the type of the project in its sub-region deviates from the national level of coverage of that type.
- ‘Dimension’: The number of places created or remodelled by the project.
- ‘Quality’: The extent to which the project contributes to the improvement of the quality of the existent network.

Desirable properties for a good set of “fundamental objectives” (Keeney 1992) can be directly adopted for a family of evaluation criteria. It should be:

- **consensual**, and therefore
- **exhaustive**, but also
- **concise** and **non-redundant**, and
- **decomposable**, which requires:

  ✓ each criterion is **measurable** and **operational**
  ✓ the criteria are **mutually preferential independent**

in the context in which options are to be evaluated.

Additive aggregation requires that each criterion is an isolate evaluation axis, that is mutual cardinal independence to hold (ordinal independence is not enough)

Example: Structuring the process of choosing rice varieties at the South of Brazil:

![Diagram of rice variety criteria](image)
Tolerance to non-biological aspects - The extent to which a variety is likely to tolerate iron in the soil and to resist low temperatures.

The culture of irrigated rice in the region is usually done in soils that have a high level of iron ("Fe"), and where the rice is often exposed to “low temperatures” (lower than 11°C) during the biological cycle. These two non-biological aspects may reduce considerably the productivity of some varieties that are not tolerant to both of them. The farmers considered these aspects the most constraining ones to rice culture in the region.

Tolerance to iron and to low temperatures are two aspects that are mutually ordinal preferential independent…

…because whatever the level of tolerance to iron, more tolerance to low temperature is always better than less, and vice-versa.

…however “resistance to low temperature” is cardinally dependent of “resistance to iron”, due to synergetic effects: the required actions to mitigate the combined effects of intolerance both to low temperature and iron involve a risk of failure perceived as higher than the sum of the individual risks associated with the mitigating measures for each intolerance phenomenon taken separately.

Consequently, the two effects could not be taken as two separate criteria in the value model!
To measure the extent to which fundamental objectives can be achieved:

Associate with each criterion a **descriptor of performance**, that is:

A qualitative or quantitative measure of the extent to which the criterion can be satisfied.

Note: This measure has been called an “**attribute**” in decision analysis, since Keeney and Raiffa (1976), although von Winterfeldt and Edwards (1986, p. 38) prefer “**value dimension**” and Kirkwood (1997, p. 24) uses “**evaluation measure (also called measure of effectiveness, attribute or metric)**”. We prefer to call it a “**descriptor of performance**” to avoid the common misinterpretation of the notion of an attribute as a criterion, characteristic or quality.