The Role of Goals in Design Reasoning

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Outline

1. Goals
2. Design reasoning
• Rethinking goals

• Background: Systems engineering, product design, marketing, some logic, some philosophy of science

Desire

• To live is to desire

• Designers produce objects of desire
Fear

• To live is to have fears

• Designers produce objects of fear

• Desires and fears are feelings of stakeholders.

A **stakeholder** is a biological or legal person affected by solving a problem

• Actors without desires or fears cannot be stakeholders

• Stakeholders have something to lose and to gain.
Stakeholder awareness and commitment

- **Not aware:** Some possibility that stakeholders are not aware of
  - An event pushes the possibility into awareness
  - **Possibility to receive satellite TV in car**
  - **Passively aware:** Aware, but not important enough to do something
    - We could upgrade car DVD player to TV
  - Stakeholder makes resources (time, money) available
  - **Aware & Committed:** Resources committed to act for a goal
    - Invest in car satellite TV


Possible worlds

- Technology is the creation of new possibilities
- Most stakeholders are **not aware** of most possibilities
  - People would get stuck in livelock if they tried to consider all possibilities for action every time they wanted to act
    - We are creatures of habit and prejudice
Value

• Awareness of a possibility involves **valuation** of the possibility
  – Also called **utility**
  – Positive (desire), negative (fear) or indifferent

• Desires, fears, indifferences
  – *Desires to save energy, watch TV in a car, reduce traveling time,* ...
  – *Fears to use more petrol, get car-sick, get stuck on an airport,* ...
  – *Disinterested in saving energy, watching TV in a car, maintaining privacy, getting a small fine for speeding, social networks, the latest gizmo,* ...

Anything can be the object of desire, fear or indifference

SW components, systems

HW components, systems

Organizations, Services

**People attach positive, negative or zero value to** ...

Desires, Fears, Resources, Values, Techniques, Conceptual structures, Norms, Methods, Business processes

• Desires, fears and indifference are mental states:
  – They can be **directed upon** anything, whether real or imaginary
  – Every mental state is **about** something
  – They can even be about desire, fear or indifference
• **Summary so far:**
  
  – A goal of a stakeholder is a desire for which the stakeholder has committed resources (time and money) to achieve it

  – Anything can be the object of desire

  – No goals without stakeholders
Conflicts

The multitude of desires

- Any one stakeholder may have infinitely many potential desires, fears and indifferences
  - (most of which he is unaware)

- Two or more stakeholders may all have different desires, fears and indifferences

- Desires are usually bigger than reality
  - They conflict
Conflicting desires

• Logical conflict:
  – Analysis of the descriptions of the desires shows that both descriptions have opposite meaning; they are logically inconsistent.
  – *Spend your money and keep it*
  – Stakeholder is incoherent

• Physical conflict:
  – Realization of one desire makes realization of the other physically impossible.
  – *Add TV to a car and reduce weight without changing anything else*
  – Stakeholder lives in a phantasy world

• Technical conflict:
  – There is currently no technology to realize both desires in the same artifact.
  – *Secure and user-friendly system*
  – New technology may remove the conflict

• Economic conflict
  – Desire bigger than the budget

• Legal conflict
  – Desire conflicts with legal norm

• Moral conflict
  – Desire conflicts with moral norm
Roel2 give linguistic tests to distinguish these kinds of conflicts

can we identify the conflict using the dictionary and logic only?

No; and we can do nothing about it: physical conflict

Can we do something about it? (technical or social conflict)
Roel Wieringa; 11-12-2012
Summary of awareness levels

• Stakeholders are not aware of most of their possible desires and fears
• They will not act on most of their other desires and fears, because:
  – Unable to choose between conflicting desires

Soft and hard goals
• Desires are usually wishy-washy

• Many goals too

Operationalization

• **Operationalization** of a concept is the definition of one or more indicators for it

• An **indicator** is a variable with a measurement procedure
Some examples of indicators

- **Utility indicator**: Opinion of stakeholder about utility
- **Accuracy indicator**: Domain dependent, e.g. spatial resolution
- **Interoperability indicator**: Effort to realize interface with a system
- **Security indicators**: Availability, compliance to standards
- **Compliance indicator**: Expert opinion about compliance
- **Reliability indicators**: Mean time between failure, time to recover
- **Usability indicators**: Effort to learn, effort to use
- **Efficiency (time or space) indicators**: Execution time, disk usage
- **Maintainability indicators**: Effort to find bugs, effort to repair, effort to test
- **Portability indicators**: Effort to adapt to new environment, effort to install, conformance to standards

See [http://www.sqa.net/iso9126](http://www.sqa.net/iso9126)

Goal trees often contain operationalizations in the form of goal decompositions

```
  Usability
     /    \
    /     \ 
Effort to learn Effort to use Number of calls to the helpdesk
```
Criteria

• Criterion = set of desired values for an indicator
  – Depending on the scale of the indicator, you may be able to define degree of satisfaction of a criterion

Criteria are often added to goal trees too

Usable

   + Easy to learn
   + Easy to use
   + Small number of calls to the helpdesk

• Adding criteria to a goal tree makes the tree semantics more complex: it adds info about values
• Making a budget available for a desire turns it into a goal

• This is a good occasion to operationalize it
  – But this is not always done

• Operationalization is an occasion for a lot of politics
  – Stakeholders try to bend indicators and criteria in their favor
• Operationalization is an occasion for a lot of philosophy too
  – What is the ``real” meaning of a concept?
  – **Paradox of analysis**: A crisp operationalization cannot be synonymous to a fuzzy concept.

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**Goal decomposition**
• Anything can be a goal
  – To be rich and famous
  – To walk to Santiago de Compostella
  – Owning a smartphone
  – Owning a house
Reachability

Has even higher value for S

W2
Even more desirable state of the world

W1
Desirable state of the world

Has higher value for S than the current state

W3
A desirable state of the world

Has another value for S, higher than that current state, but incompatible with that of W2

The goal

Has even higher value for S

Goal

W2
Even more desirable state of the world

W1
Desirable state of the world

Has higher value for S than the current state

W3
A desirable state of the world

Has another value for S, higher than that current state, but incompatible with that of W2

Stakeholder S
Simplifications in this picture

• There is a preference ordering
  – But: Preferences may emerge after we experience a possible world
  – We ignore this.

• Preferences stay the same
  – But: Many preferences are dynamic
  – We ignore this

Three kinds of goal decomposition

• Decompose the meaning of the goal statement
  – Use indicators
• Decompose the goal world
• Decompose the path to the goal world
• **Means-end decomposition**: Tasks to be performed to reach goal
Another means-end decomposition

Decomposition of goal world

To achieve the goal state, three objects must be achieved
Goal world decomposition followed by means-end decomposition
At least three kinds of goal decomposition

• By indicators.
  – Variable-based view of the world
  – This decomposition defines a construct operationally

• By components.
  – Component-based view of the world
  – This shows us the elements of the goal that need to be achieved

• By means-end.
  – Process-based view of the world
  – This tells us what to do to get there
Other relations in the Tropos example

- **Cause-effect**
  - Change in X causes change in (probability distribution of) Y
  - This is a scientific (mini)theory of the domain
- **Contribution (+ or -) to a criterion**
  - If X gets closer/further away from its criterion, then (probably), Y gets closer/further away from its criterion.

Conclusions so far

**Goal model contains**

- **Conceptual framework of the domain:**
  - Operational definitions (decomposition in terms of indicators)
  - Decomposition of the goal state (also a kind of operationalization)
- **Scientific theory of the domain:**
  - Decomposition of the means-end path to the goal state
  - Statements about cause/effect relations
- **Statement of preferences:**
  - Criteria, contribution relations (+ or -)
- **My unsolicited advice:** Represent these in different models
Outline

1. Goals
2. Design reasoning

Design reasoning

• Contribution argument
• Temporal ordering of design tasks
Design

• What is design?
  – Making a decision about what to do.

Webster’s

transitive verb
• 1 : to create, fashion, execute, or construct according to
  plan : devise, contrive
• 2a : to conceive and plan out in the mind <he designed the
  perfect crime>
• 2b : to have as a purpose : intend <she designed to excel in
  her studies>
• 2c : to devise for a specific function or end <a book
  designed primarily as a college textbook>
• 3 archaic : to indicate with a distinctive mark, sign, or name
• 4a : to make a drawing, pattern, or sketch of
• 4b : to draw the plans for <design a building>
Webster’s

intransitive verb
• 1: to conceive or execute a plan
• 2: to draw, lay out, or prepare a design

Webster’s

• **Origin of DESIGN**
• Middle English, to outline, indicate, mean, from Anglo-French & Medieval Latin; Anglo-French *designer* to designate, from Medieval Latin *designare*, from Latin, to mark out, from *de- + signare* to mark — more at *sign*
• First Known Use: 14th century
Elements of the concept of design

- Making a decision about what to do.
- Documenting that decision
- Decisions can be executed
- To achieve goals

Historical note

- 14th century architects were illiterate.
  - But they could read a sketch
  - And use the sketch to coordinate their work

- Designers were builders until Josiah Wedgwood separated the two roles in the late 18th century
  - Mail order catalog of porcelain
  - Reproducibility
The contribution argument

Defeasible implication

• Artifact X Context ⇒Goals

Artifact

Social entity

Software entity

Other artifact

Hardware entity

norm

goal

stakeholder

value

desire

fear

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going
The contribution argument

• Artifact X Context ⇒ Goals

Example: Industrial design

• Design assignment:
  – Given a context C and desired outcomes O
  – Find an artifact such that Artifact X Context ⇒ O

• Design deliverables:
  – Artifact
  – Contribution argument Artifact X Context ⇒ Desired outcomes

• E.g. design a dish washer for use in sailing boats

Example: organization design

- Technological rule
  - In this class of problems in Context, use this type of Intervention, which will produce through these Mechanisms these direct Outcomes.

  \[
  \text{Intervention} = \text{Inserting the artifact in the context}
  \]


Example: Software engineering

World, Requirements, Specification, Program, Machine

- \( W \land S \Rightarrow R \)
- \( M \land P \Rightarrow S \)
• Artifact X Context ⇒ Goal

The contribution argument

• Artifact X Context ⇒ Goals
  – Widespread (universal?) design reasoning
  – Artifact and Goals are actually part of Context
  – ⇒ is defeasible: We may predict that goals will be achieved, but something else may happen
• Design science looks not only for outcomes, but also for
  – Mechanisms that produce them
  – Goal satisfaction of outcomes

Extended conclusions

Goal model contains

• Conceptual framework of the domain:
  – Operational definitions of variables in terms of indicators
  – Operational definition of goal state of the goal state in terms of components
• Scientific theory of the domain:
  – Decomposition of the means-end path to the goal state
  – statements about cause/effect relations
  – **Mechanisms that produce outcomes**
• Statement of preferences:
  – criteria, contribution relations (+ or -)
  – **Goal satisfaction of outcomes**
Mechanisms

• Mechanism is interaction between components
  – To identify a mechanism, you need a component-based conceptual model of the domain

• Contrast with causality
  – Cause-effect is a relation between variables
  – Assumes a variable-based view of the domain

• Mechanisms may explain cause-effect relations

• Glennan - "Mechanisms and the nature of causation". 1996
• Glennan - “Mechanisms and the nature of causation”. 1996

• Bechtel & Abrahamsen – “Explanation; a mechanistic alternative.” 2005
• Mechanisms, defined in terms of components, can explain cause-effect relations between variables

• Some cause-effect relations do not have known mechanisms
  – Gravity
Elements of the concept of design

- Artifact X Context ⇒ Outcomes
  - Effect theory: Theory of the mechanisms that produce these outcomes
  - Value theory: Theory that predicts contribution (+ or -) of outcomes to goals

- Goal models often contain (fragments of) both kinds of theory

Design reasoning

- Contribution argument
- Temporal ordering of tasks
Temporal ordering of tasks in creative design

Relevant first principles:
- Principle of operation
- Mechanisms
- Theories

• Cross. “Design Cognition: Results From Protocol And Other Empirical Studies Of Design Activity” 2001

• Context x Artifact ⇒ Goal

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Tension Resolution

Feasibility

Explored to establish

Used to identify

To satisfy Solution concept

Realized in

Problem understanding and artifact design are refined in parallel, maintaining goal satisfaction

Initially known vaguely as some goal plus an intended context of use

Initially specified by means of a few requirements

Then conceptualized

Then conceptualized

Then connected and mechanized
Systems engineering

- Iteratively reduce uncertainty about the problem
- Once the goals are clear enough, reduce risk of choosing the wrong treatment
Agile development

• The same

Nonmonotonic refinement

• During the design process, the designer may revise beliefs about the context, stakeholders and goals,
• And may revise his or her design
  – Nonmonotonic process
• System development methods are a way to constrain and control nonmonotonicity.
Rational reconstruction

- After the design is finished, you can present the contribution argument as if it has been conceived like that from the beginning.
  - Rational reconstruction of history (Lakatos)
  - Constructing accountability (Suchman)
  - Faking rationality (Parnas)

Discussion
Implications for GORE notations

• GORE notation as an artifact
  – Used in which context?
  – By whom?
  – For which goals?

• Desire to include everything in the notation may be the result of lack of clarity about the goals of the notation

Implications for GORE notations

• If we know what the context of use is:
  • What to express?
    – Conceptual framework of the domain: definitions, operationalizations, decompositions
    – Effect theory: statements about causes, mechanisms
    – Value theory: criteria, preference ordering, contributions

• Cannot all be represented in the same model
• Who are the users?
• What are their possible goals?