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

•*Possibility to receive satellite TV in car*

An event pushes the possibility into awareness

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*

Bossworth. *Solution Selling. Creating Buyers in Difficult Markets.* 1995.

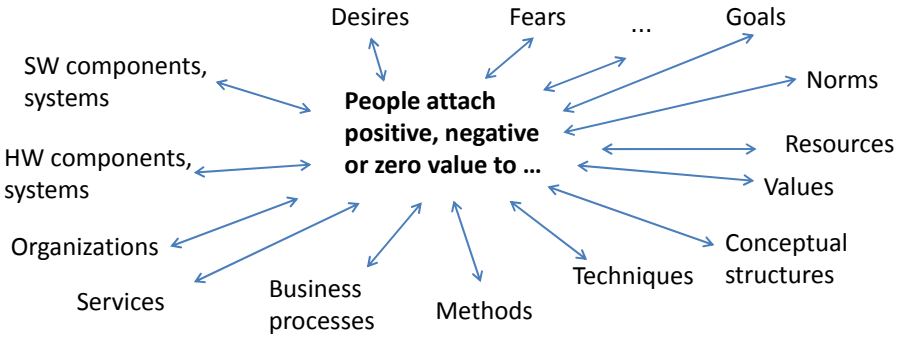
Possible worlds

- 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

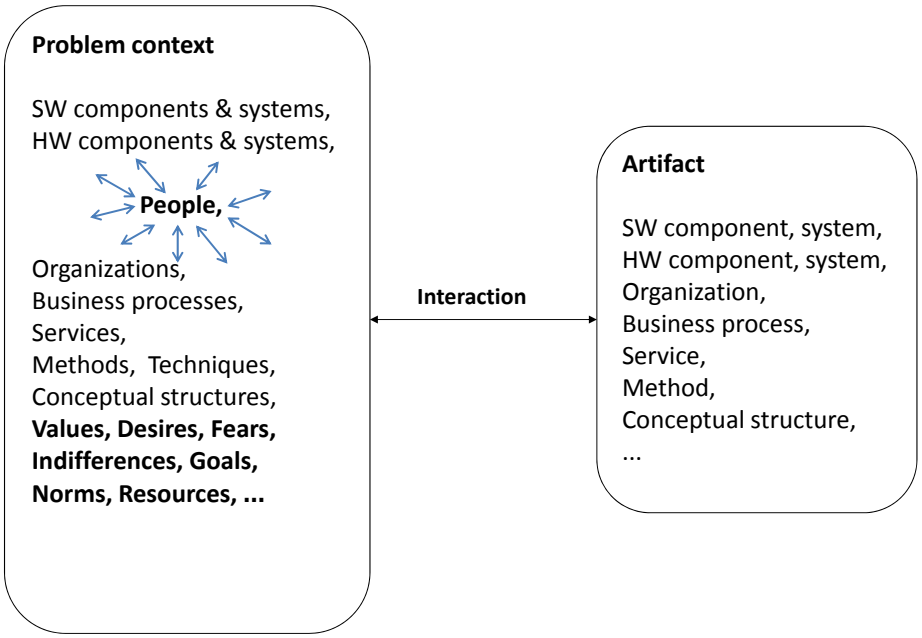
Value

- 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



- 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

Roel2

- 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

Slide 15

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

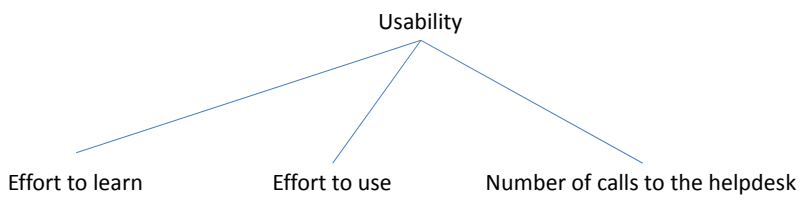
- **Operationalization** of a concept is the definition of one or more indicators for it
- An **indicator** is a variable with a measurement procedure

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

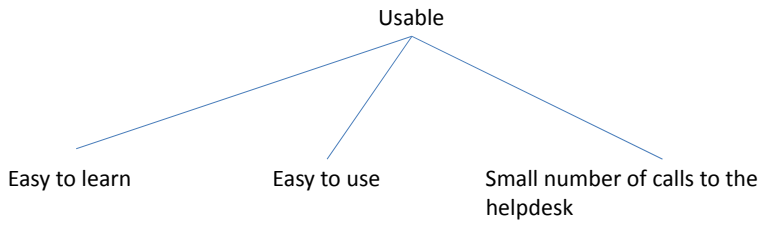
Goal trees often contain operationalizations in the form of goal decompositions



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



- 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 occassion to operationalize it
  - But this is not always done

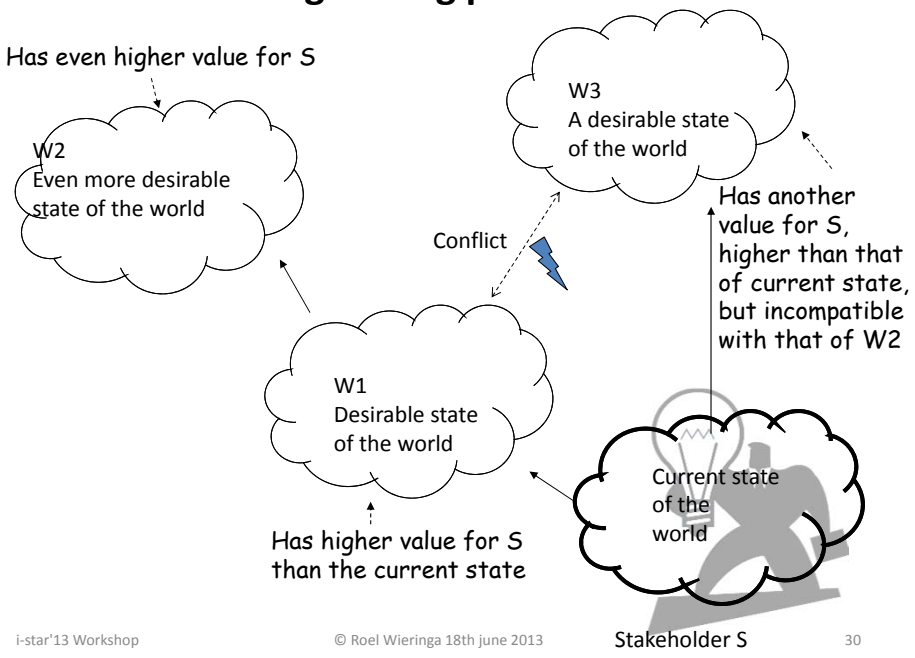
- Operationalization is an occassion for a lot of politics
  - Stakeholders try to bend indicators and criteria in their favor

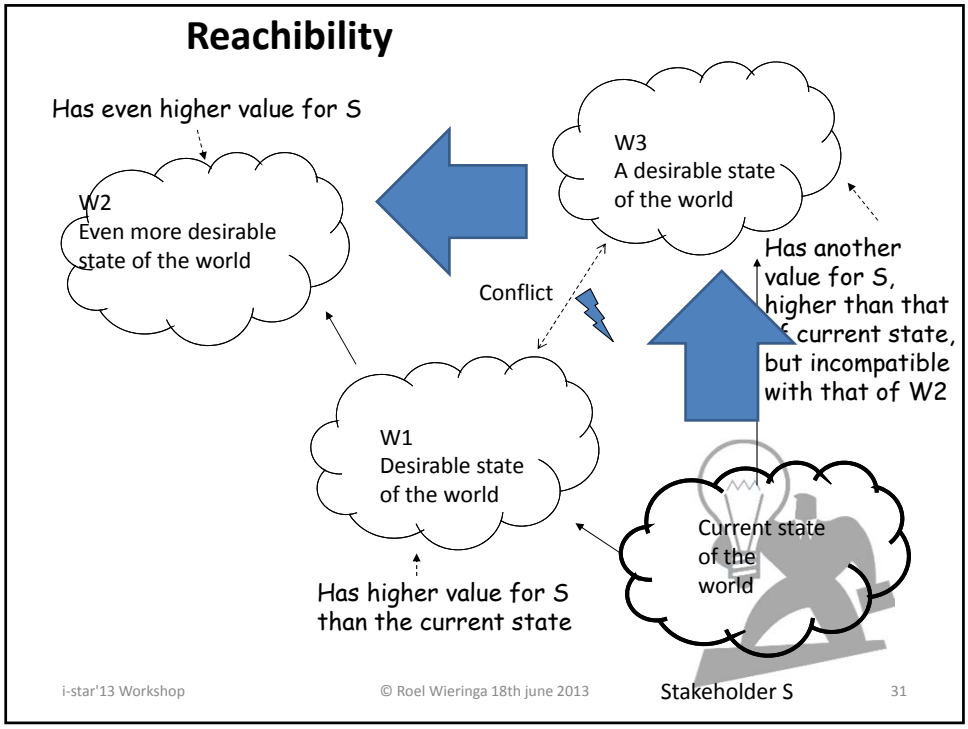
- Operationalization is an occassion for a lot of philosophy too
  - What is the ``real'' meaning of a concept?
  - **Paradox of analysis**: A crisp operationalization cannot be synonynmous to a fuzzy concept.

Goal decomposition

- Anything can be a goal
  - To be rich and famous
  - To walk to Santiago de Compostella
  - Owning a smartphone
  - Owning a house

Preference ordering among possible worlds

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Has even higher value for S
W2
Even more desirable state of the world
W3
A desirable state of the world
Conflict
Has another value for S, higher than that of current state, but incompatible with that of W2
W1
Desirable state of the world
Current state of the world
Has higher value for S than the current state
i-star'13 Workshop
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Stakeholder S
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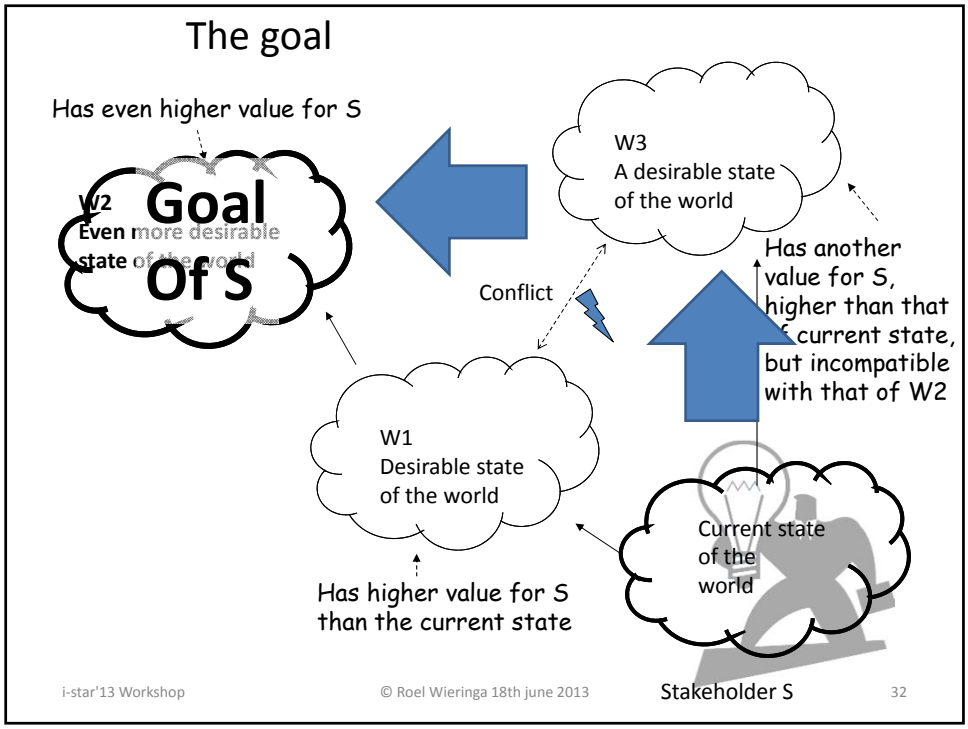
The goal
Has even higher value for S
W2
Goal Of S
W3
A desirable state of the world
Conflict
Has another value for S, higher than that of current state, but incompatible with that of W2
W1
Desirable state of the world
Current state of the world
Has higher value for S than the current state
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Stakeholder S
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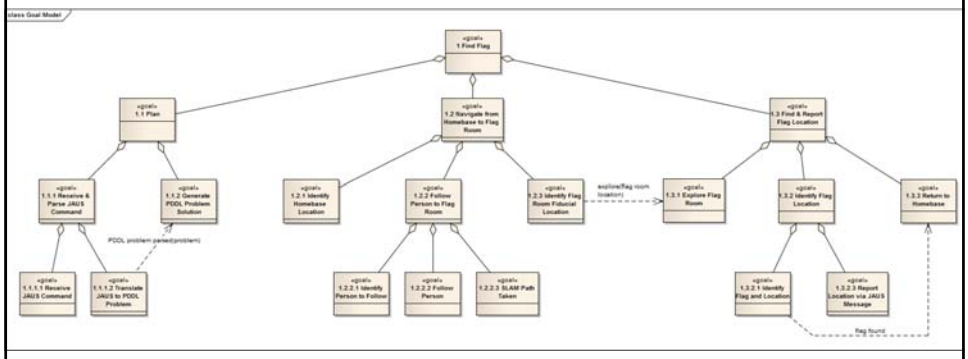
Simplifications in this picture

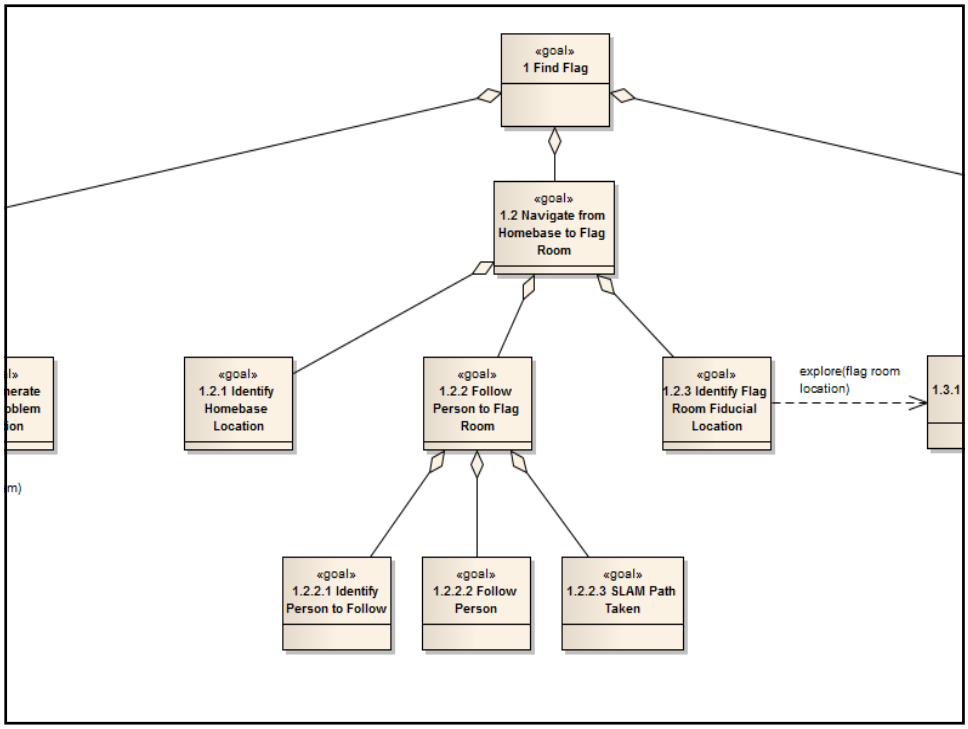
- There is a preference ordering
  - But: Preferences may emerge after we experience a possible world
  - We ignore this.
- Preferences stay the same
  - But: Many preferences are dynamic
  - We ignore this

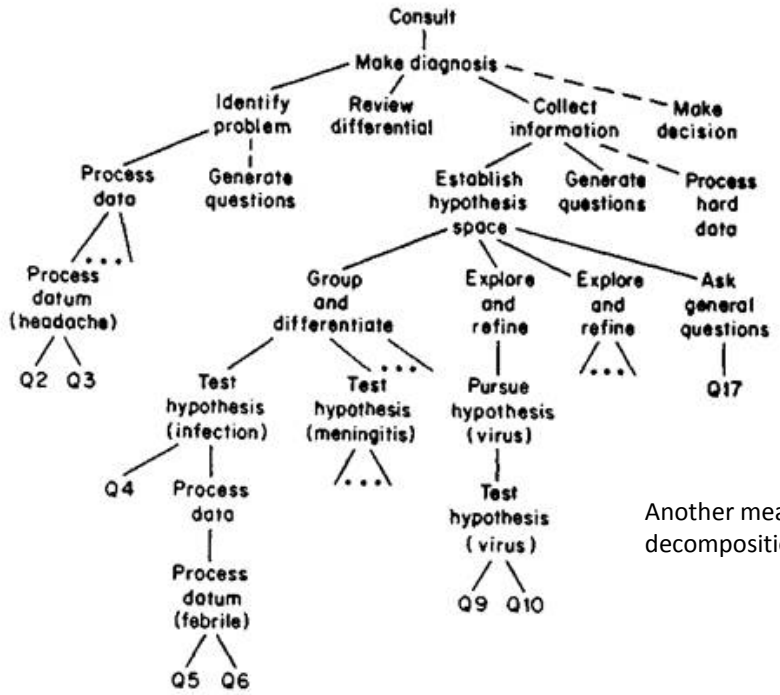
Three kinds of goal decomposition

- 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

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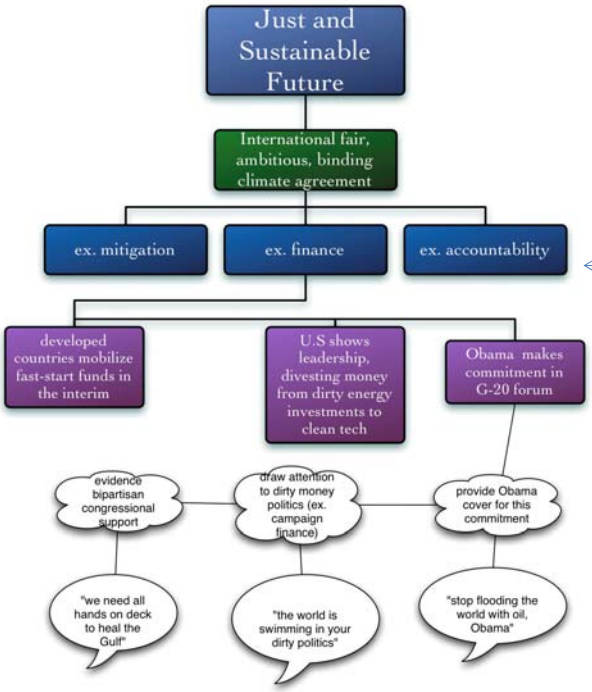

Decomposition of goal world

To achieve the goal state, three objects must be achieved

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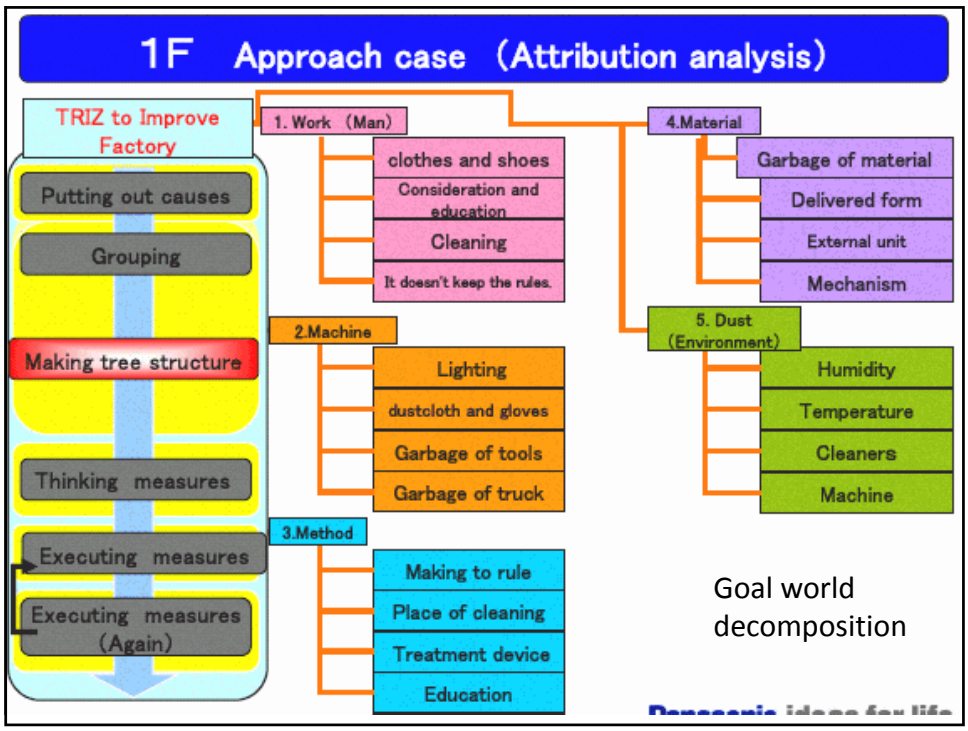
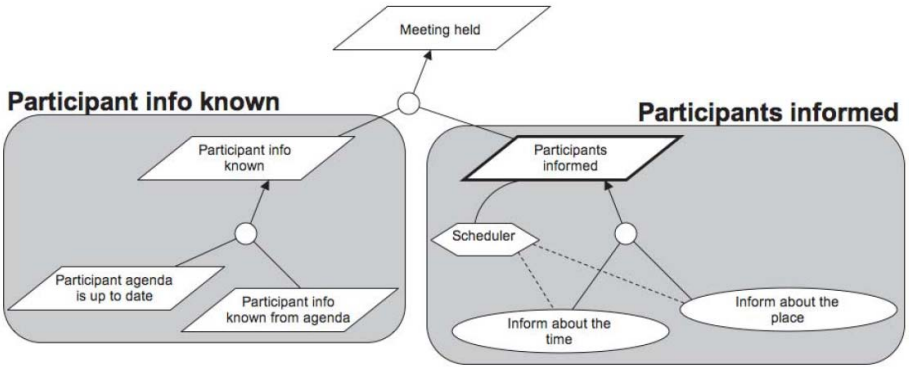
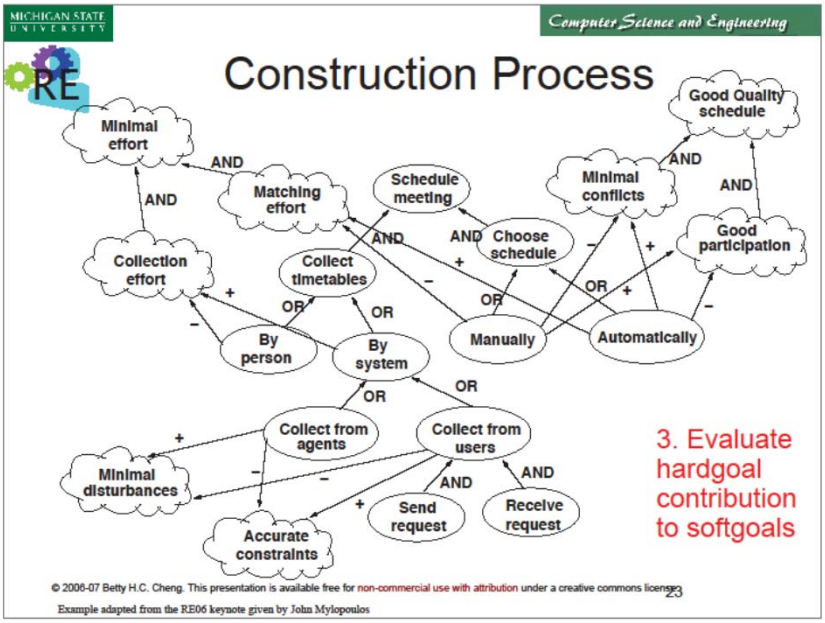




- Goal world decomposition followed by means-end decomposition



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 unsollicited 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
- 2*a* **:** 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
- 4*a* **:** 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

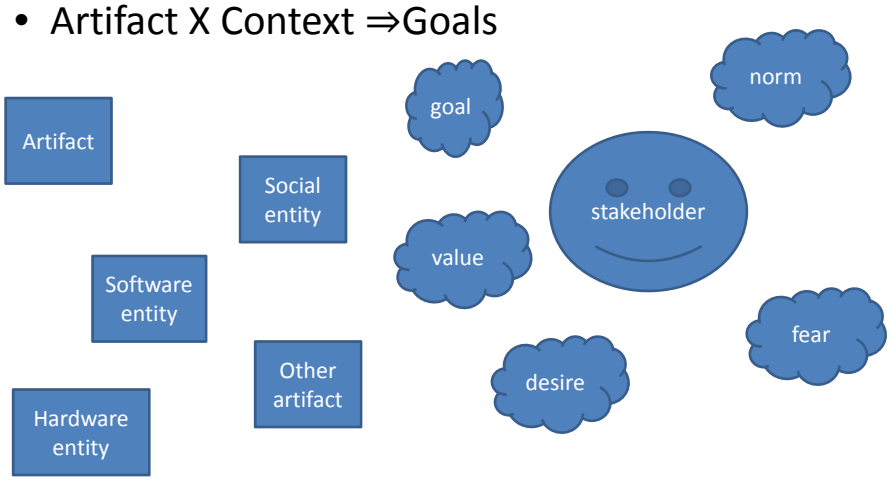
Historical note

- 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

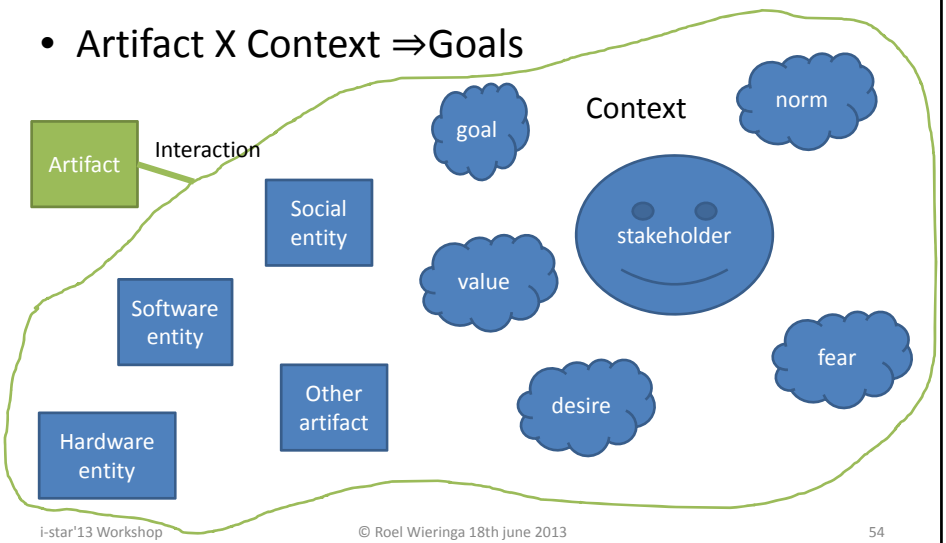
Defeasible implication

- Artifact X Context ⇒Goals



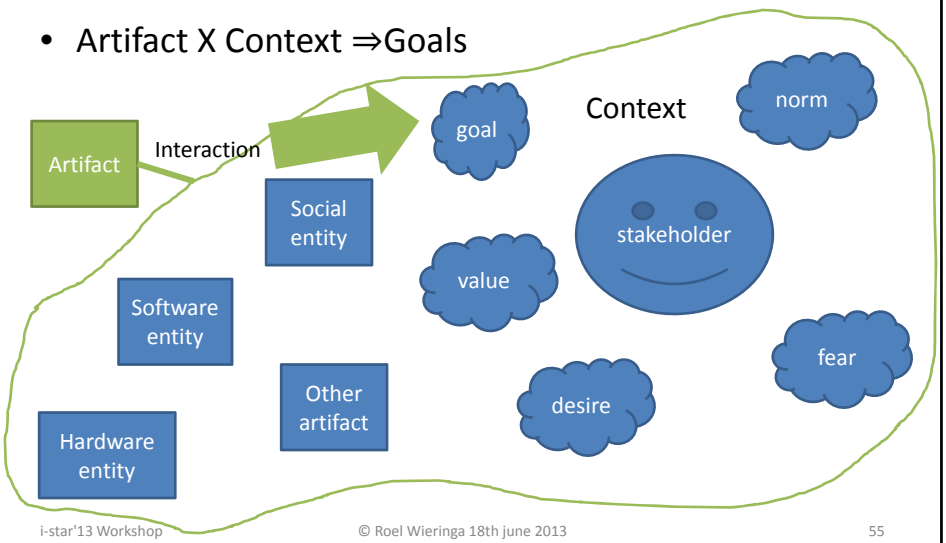
The contribution argument

- Artifact X Context ⇒Goals



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

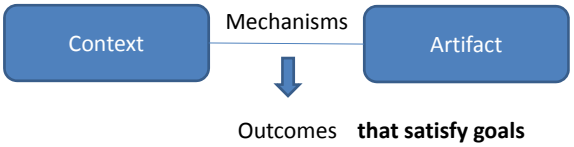
Causes

- Roozenburg & Eekels. *Product design: Fundamentals and Methods*. Wiley 1995.

Example: organization design

Intervention = Inserting the artifact in the context

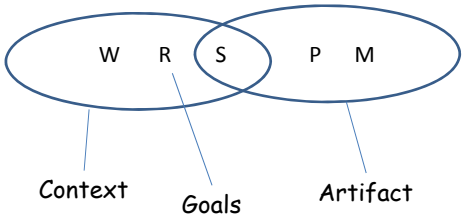
- Technological rule
  - In this class of problems in **C**ontext, use this type of **I**ntervention, which will produce through these **M**echanisms these *direct* **O**utcomes'.



- Van Aken. ``Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules''. *Journal of Management Studies* 41:2 March 2004
- Pawson and Tilley. *Realistic Evaluation.* 1997.

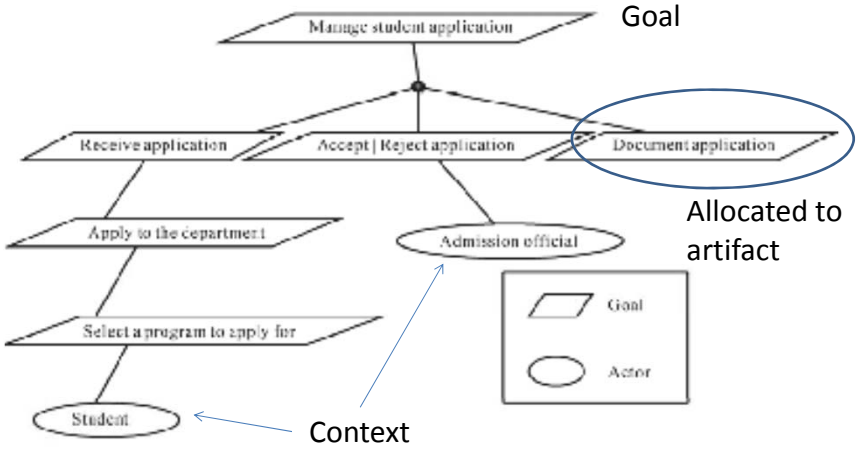
Example: Software engineering

World, Requirements, Specification, Program, Machine



- $W \wedge S \Rightarrow R$
- $M \wedge P \Rightarrow S$
- Gunter, Gunter, Jackson, Zave. ``A reference model for requirements specifications'' . IEEE Software, may/june 2000

KAOS



- 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

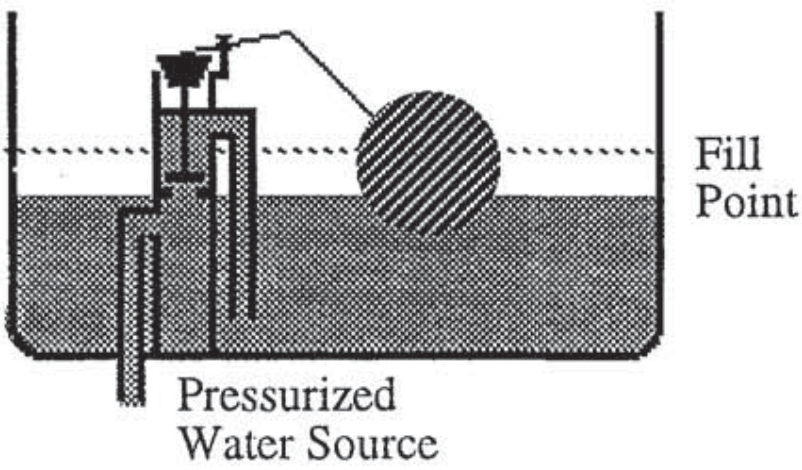
Extended conclusions

Goal model contains

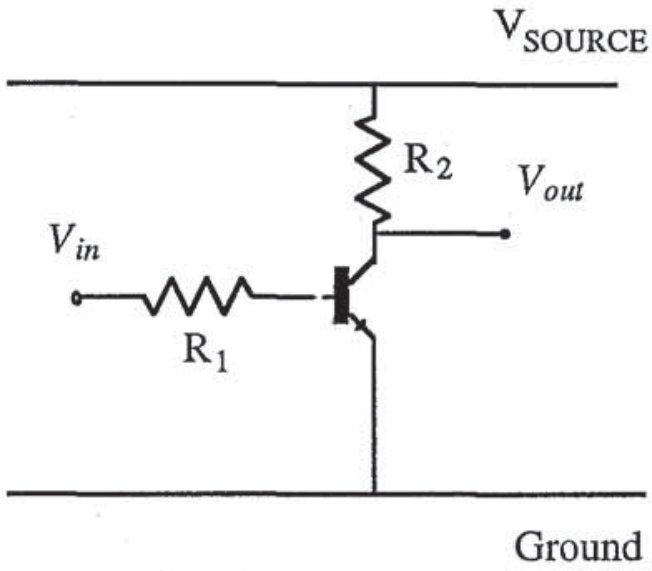
- Conceptual framework of the domain: — Definitions
  - Operational definitions of variables in terms of indicators
  - Operational definjition of goal state of the goal state in terms of components
- Scientific theory of the domain: — Causes, mechanisms
  - Decomposition of the means-end path to the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

Mechanisms

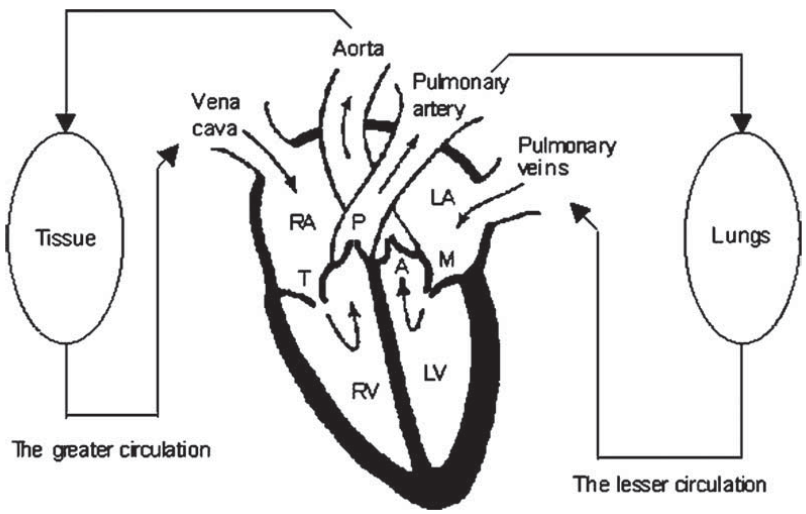
- Mechanism is interaction between components
  - To identify a mechanism, you need a component-based conceptual model of the domain
- Contrast with causality
  - Cause-effect is a relation between variables
  - Assumes a variable-based view of the domain
- Mechanisms may explain cause-effect relations



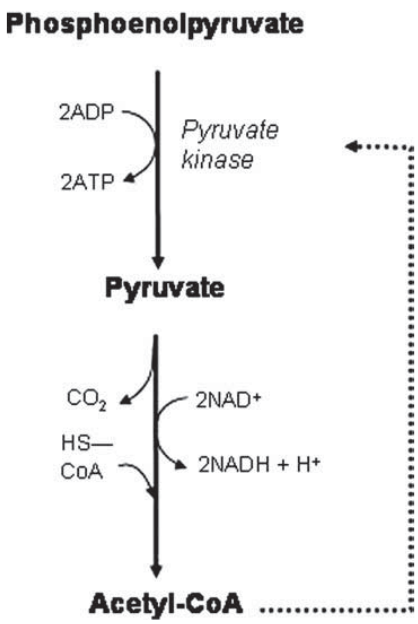
- Glennan - ``Mechanisms and the nature of causation''. 1996



- Glennan - ``Mechanisms and the nature of causation''. 1996



- Bechtel & Abrahamsen – ``Explanation; a mechanistic alternative.'' 2005



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

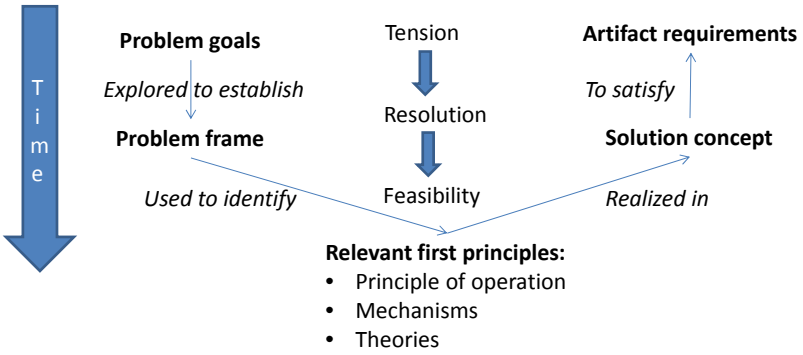
Elements of the concept of design

- 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



- Cross. ``Design Cognition: Results From Protocol And Other Empirical Studies Of Design Activity'' 2001
- Cross. ``Creative cognition in design: processes of exceptional designers''. 2002.

- Context x Artifact ⇒Goal

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

Then conceptualized

Initially specified by means of a few requirements

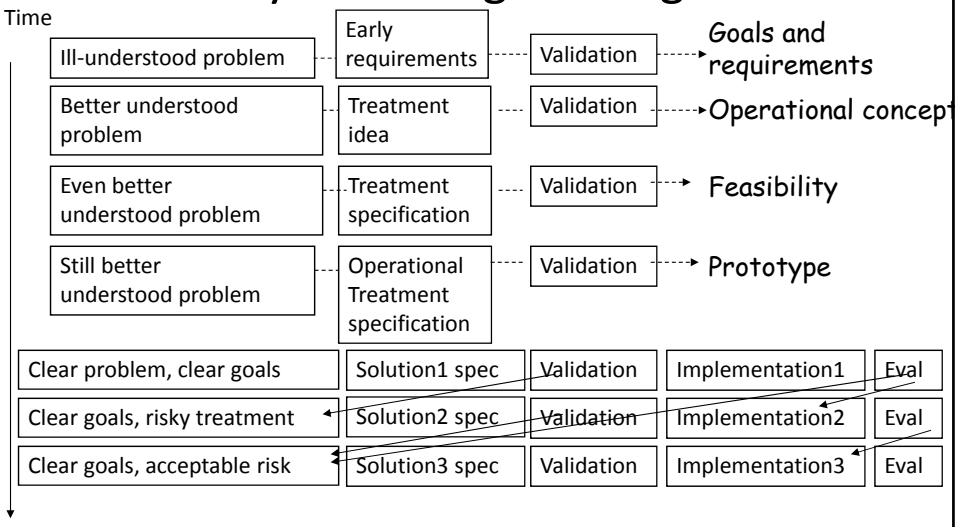
Then conceptualized

Then connected and mechanized

Problem understanding and artifact design are refined in parallel,

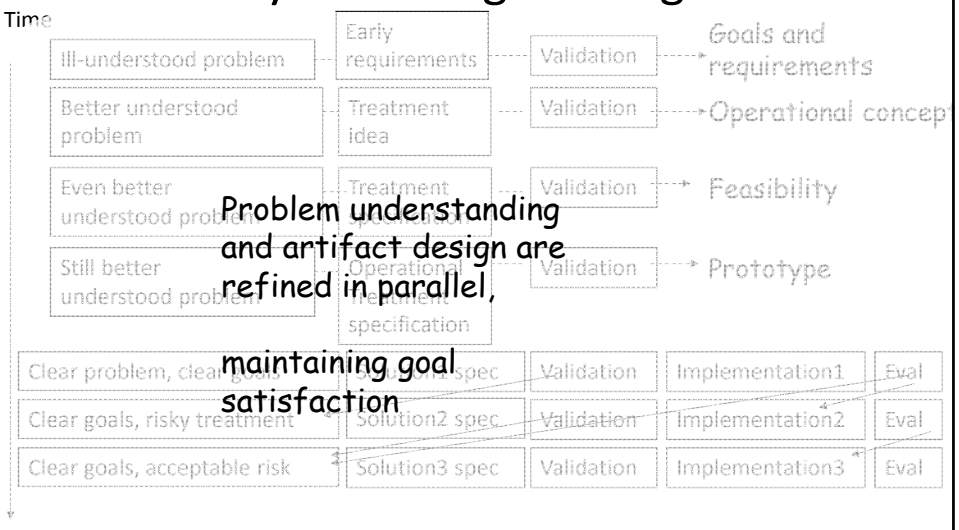
maintaining goal satisfaction

Systems engineering



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

Systems engineering



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

- 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 of 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?