

Web Engineering as Design Science

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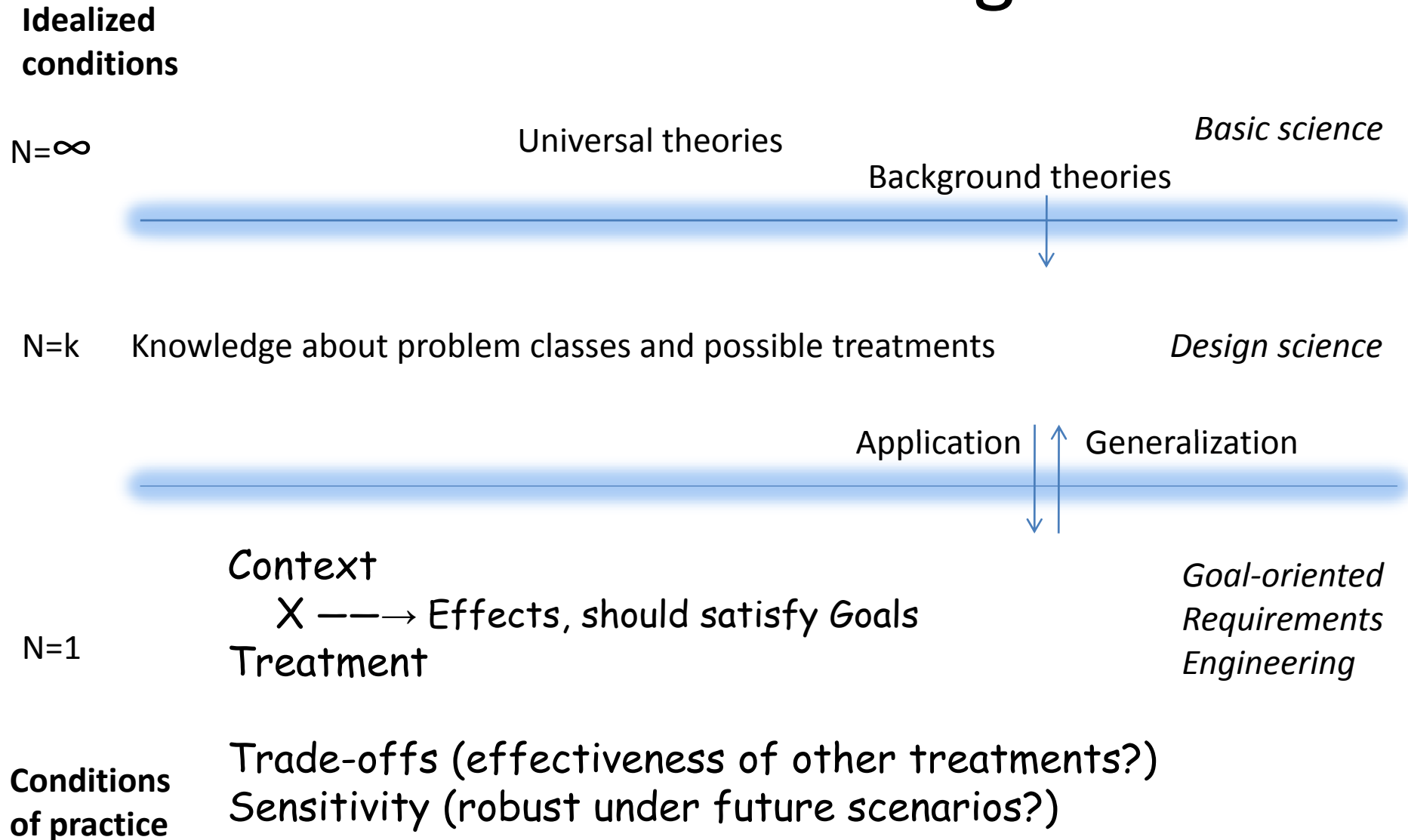
What is design science?

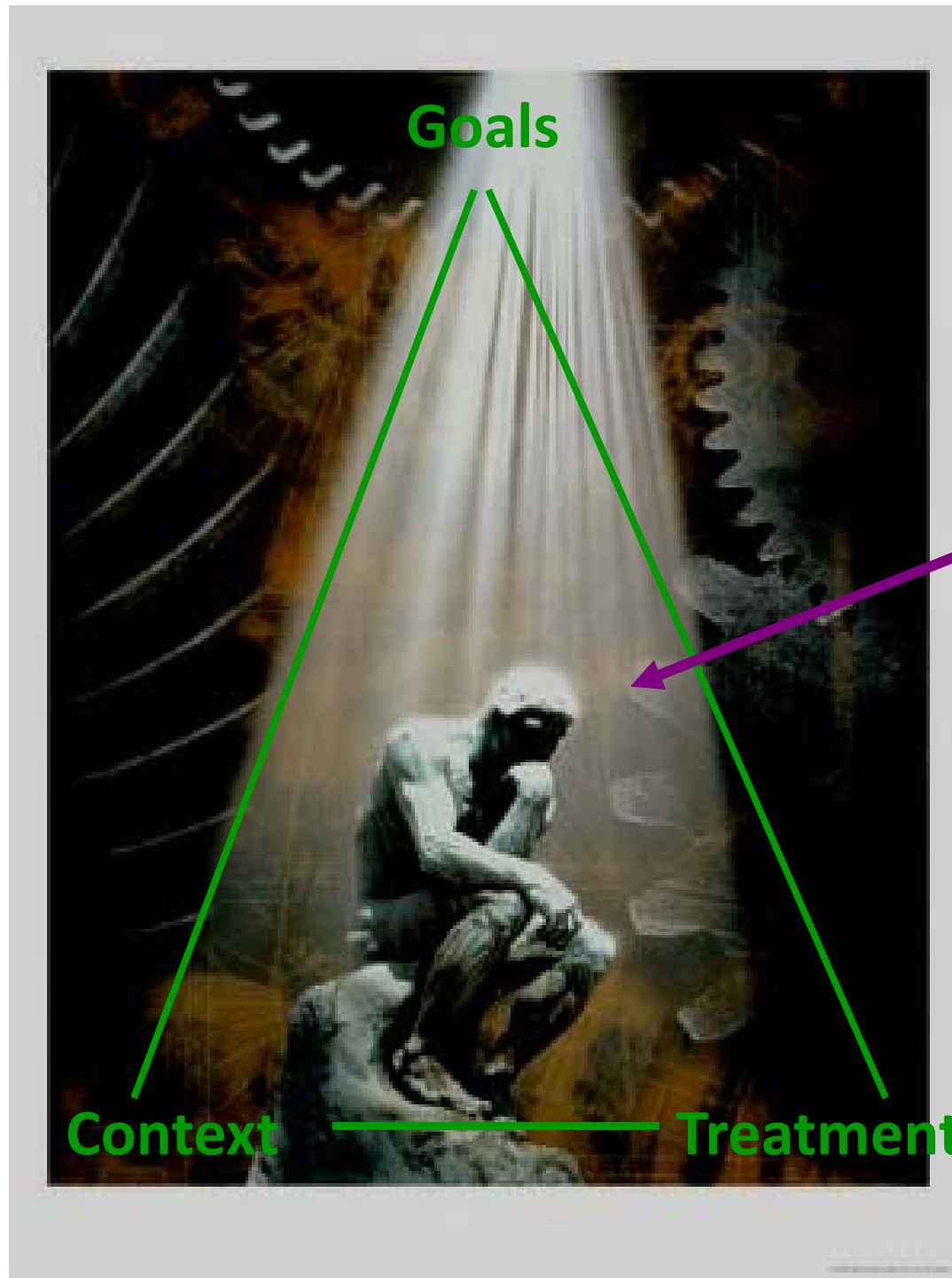
- Design science is technical science, engineering science
- It validates **proposed artefacts**
 - *New jet propulsion technology*
 - *New information risk assessment method*
- And studies **implemented artefacts**
 - *Steam machines*
 - *Smallpox vaccination*
 - *IS impact studies*
- Natural science studies entities not constructed by people

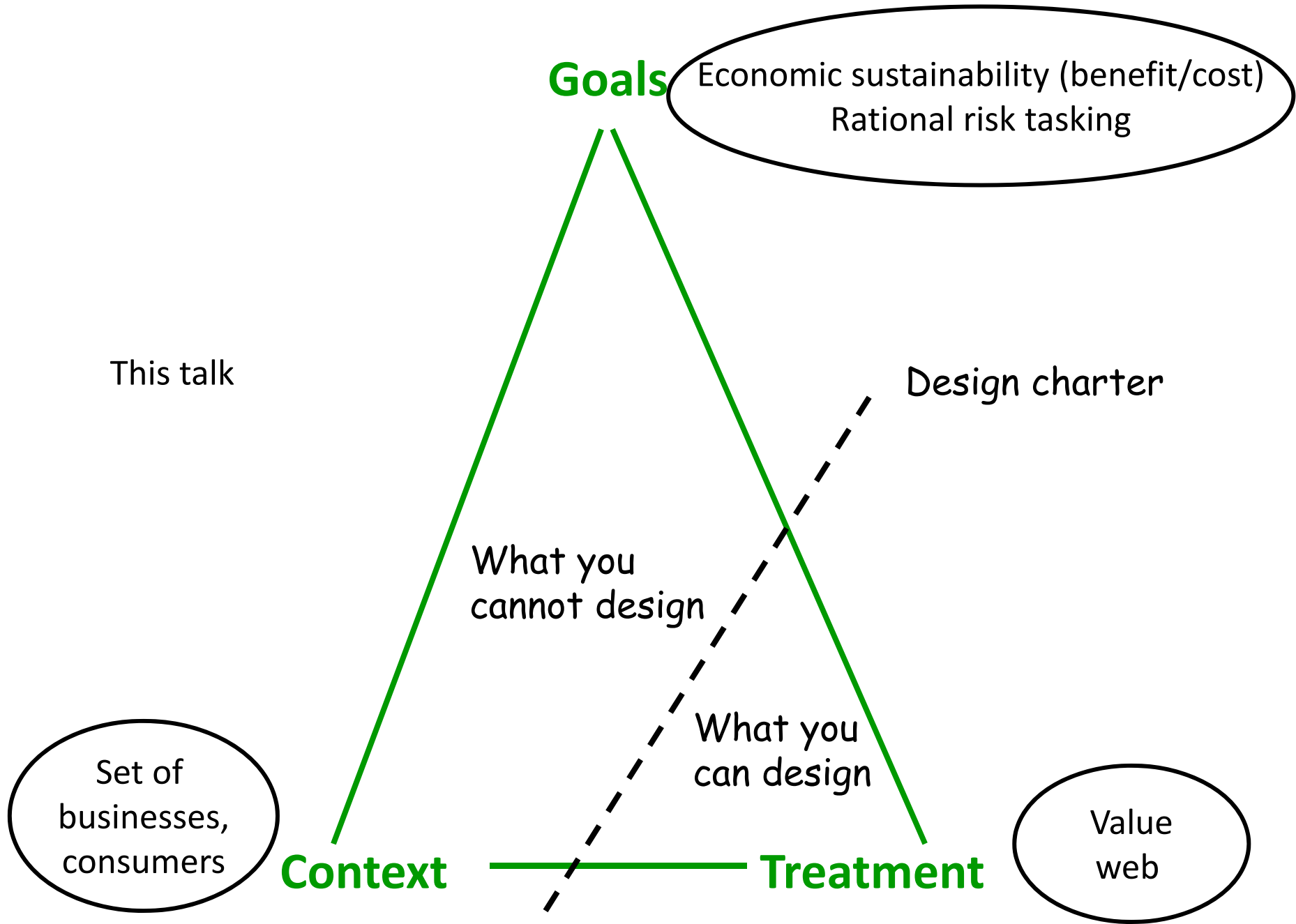
Requirements Engineering

- Requirements engineering is matching problems and treatments
- Problems
 - Stakeholders
 - Goals
 - Improvement opportunities
 - Problematic phenomena
- Treatments
 - Hardware
 - Networks
 - Software
 - Business processes
 - Business roles
- Alignment

Levels of knowledge







Value webs

- Value web
 - Network of economic (rational) actors
 - They have something to lose: Profit & loss responsible
 - They can decide for themselves: Actors have own goals
 - Many topologies: Outsourcing, Joint product development, Joint service delivery, Portals, Market places
 - Decentralized coordination
- We restrict to IT-enabled value webs
- Examples:
 - Philips delivering MRI scanners to hospitals
 - and its suppliers and subcontractors required to deliver this
 - XS4All delivering Voice over IP to consumers
 - plus the ADSL network provider, supplier of router, install service supplier, postal service
 - DSM outsourcing ERP management to Atos Origin
 - *Misdaadkaart.nl* offering map of crimes on Google maps

Value web design

- We design techniques to design value webs.
- Design science research questions:
 - What problem (class) do we want to solve?
 - Which goals,
 - whose goals?
 - How well do our techniques perform?
 - Satisfy stakeholder goals?
 - Effect of using our techniques?
 - Criteria against which to evaluate?
 - Trade-off w.r.t. alternative techniques
 - Sensitivity to changes in the problem?
 - For which problem class do we recommend our techniques?
 - Risk?

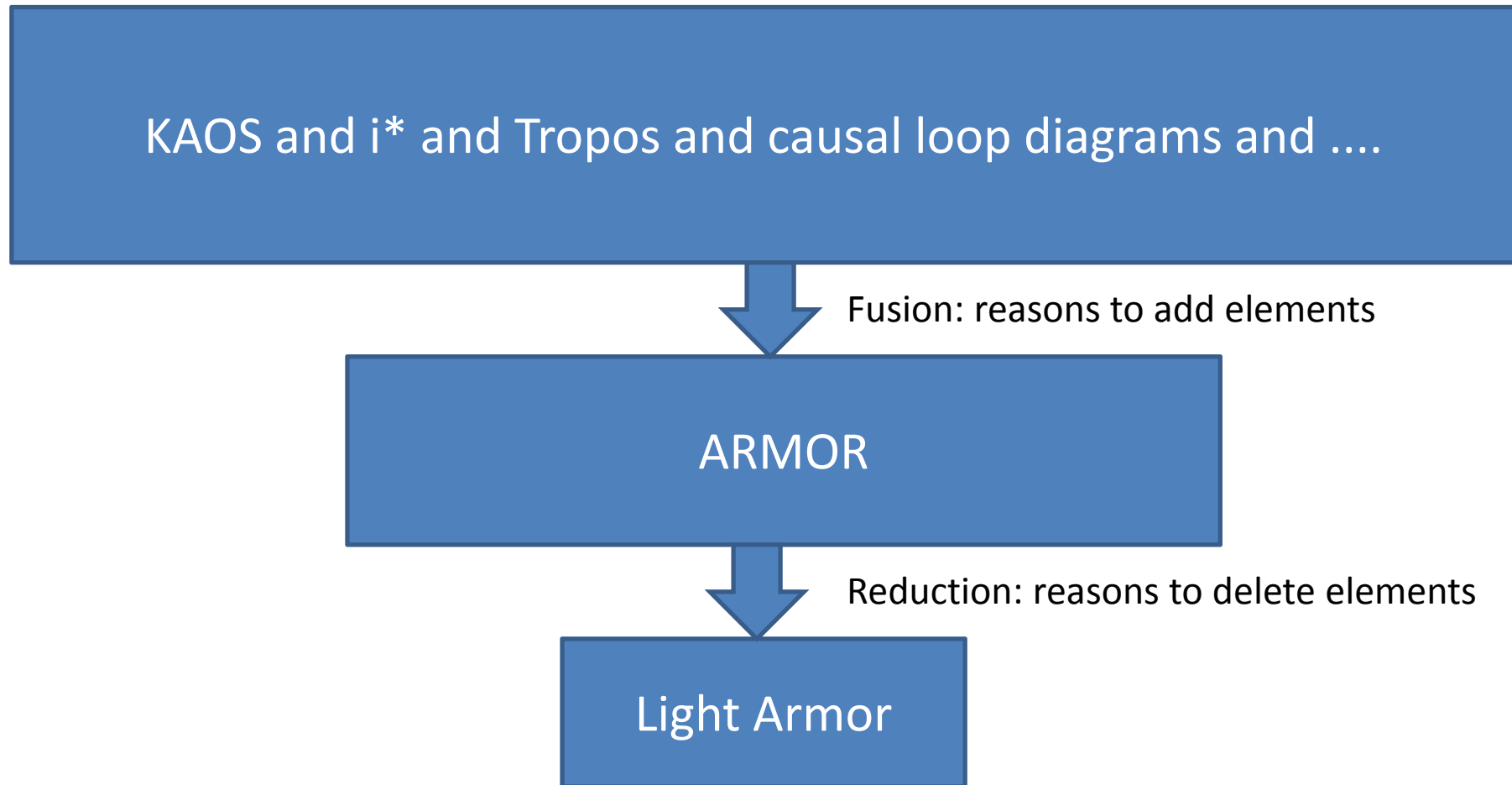
Examples

1. Extending enterprise architecture design method with Goal-Oriented RE
2. Developing a method to develop a business case for business network design
3. Developing a method to assess confidentiality risks in business networks

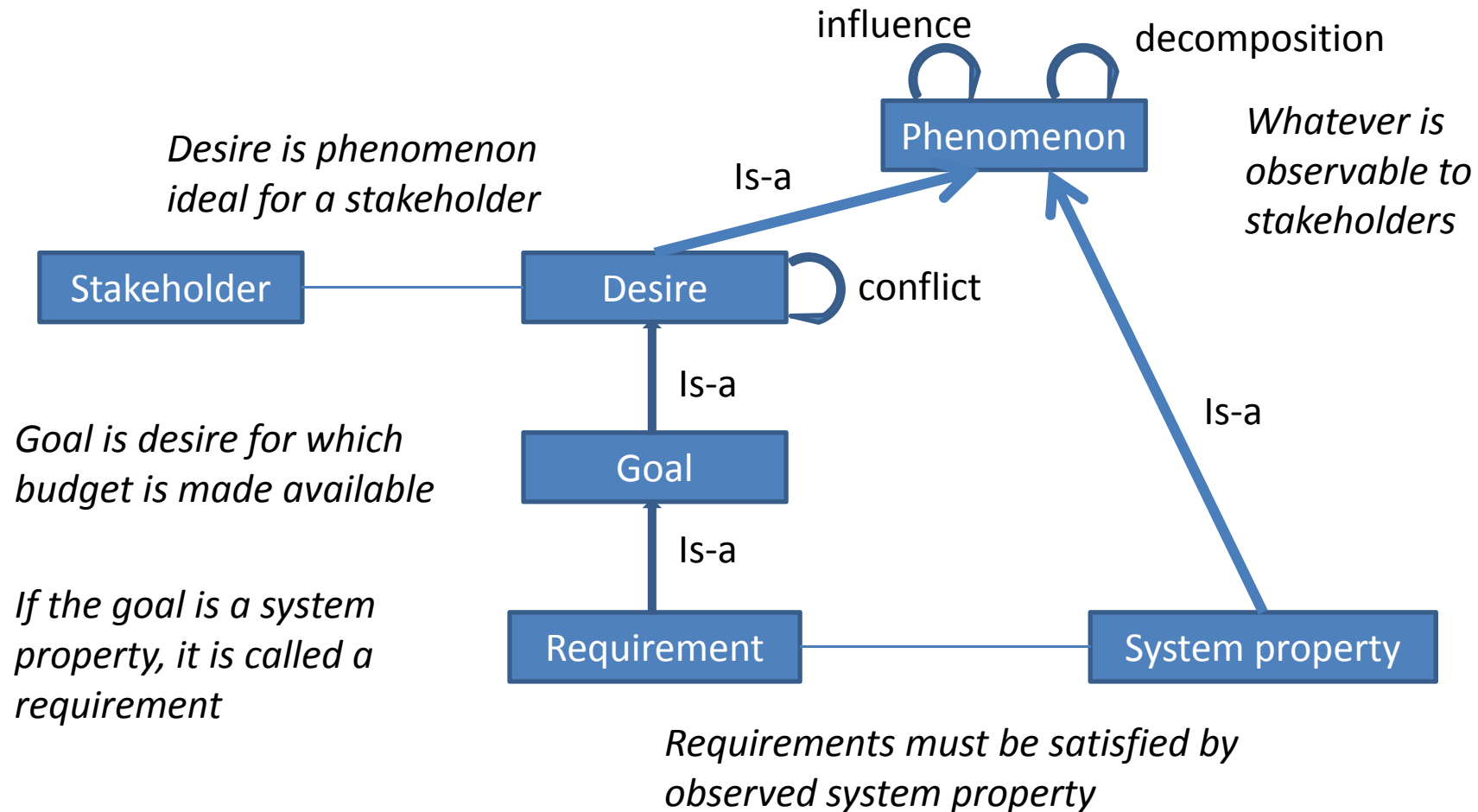
Example 1: The project

- Project goal:
 - Extending enterprise architecture design method with goal-oriented requirements engineering
- Partners:
 - BizzDesign (Wilco Engelsman)
 - Novay (Dick Quartel)
 - UT (Roel Wieringa)

Work done so far



Result (roughly)



Status

- Concepts are stable for now ... Fixed point in improvement iterations
 - Still to look at action goals and state goals
 - Measure of preferences?
- Relationships require a lot more work
 - Influence: state \rightarrow state, action \rightarrow state, action \rightarrow action.
 - Use + and – of causal loop diagram for state \rightarrow state?
 - Decomposition: analytic and synthetic
 - Conflict: logically impossible, physically impossible, technically impossible, violation of standards, socially impossible, humanly impossible, too expensive ...
- We will do some empirical work before we return to this

Example 1: Methodological structure

Engineering cycle (a.k.a. regulative cycle):

- Problem investigation
- Treatment design
- Treatment validation
- Implementation (transfer to Bizzdesign)
- Implementation evaluation



Methodological structure of PhD thesis

- Problem investigation
- Treatment design
- Treatment validation
- Implementation (transfer to Bizzdesign)
- Implementation evaluation

What did we do so far

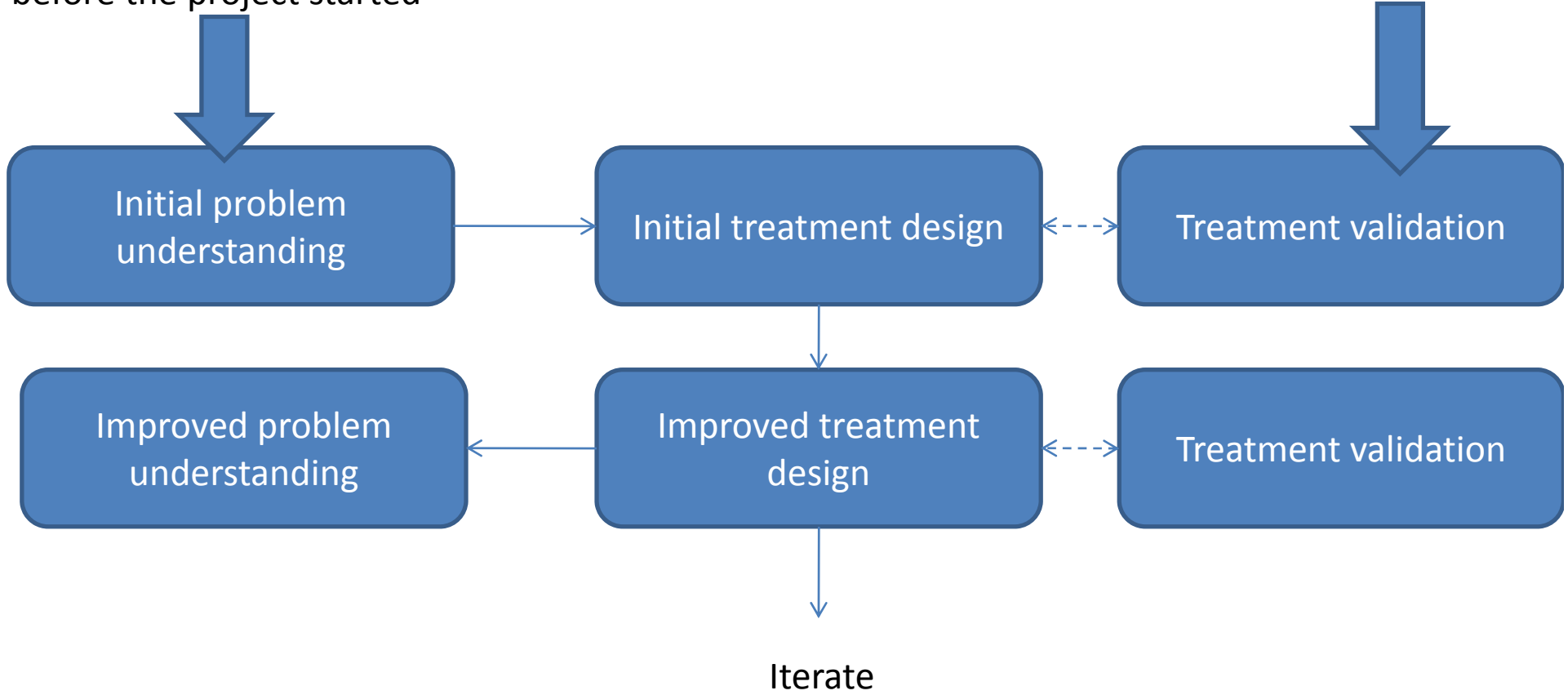
- Problem investigation: TBD
- Treatment design: light Armor
- Treatment validation: TBD
- Implementation (transfer to Bizzdesign)
- Implementation evaluation

Methodological options

- Problem investigation
 - What we know now:
 - Mging large # of reqs is lot of effort, many mistakes;
 - tracing EA to reqs is hard, determining impact of req change or EA change is often impossible.
 - This causes dissatisfied customers and unnecessary rework.
 - To do: survey
 - Among BizzDesign consultants? BizzDesign customers?
 - In-depth interviews?
 - Questionnaire
- Treatment design: light Armor
- Treatment validation: TBD

BizzDesign had an understanding of the problem before the project started

Using a toy example



Methodological options

- Problem investigation: Some survey
- Treatment design: light Armor
- Treatment validation: TBD

Methodological options

- Problem investigation: Some survey
- Treatment design: light Armor
- Treatment validation questions
 - Internal validity: LArmor in BizzDesign consultancy mitigates identified problems?
 - Trade-offs: All of LArmor?
 - Sensitivity: All of BizzDesign consultancy? Only Bizzdesign consultancy?

Methodological options

- Problem investigation
- Treatment design: light Larmor
- Treatment validation methods
 - Simulation: Wilco uses Larmor with toy example
 - Simulation: Wilco uses Larmor with past project data
 - Action research: Wilco uses Larmor in a project
 - Opinion research: Wilco elicits opinion of Bizzdesign consultants about Larmor concepts & method
 - Experiment: Wilco studies BizzDesign consultants using Larmor on an artificial problem, compares to control group using current BizzDesign method
 - Case study: Wilco studies BizzDesign consultants using Larmor in a (pilot) project

Methodological issues

- Generalization
 - Would similar GORE methods work too? Trade-offs?
 - Applicable to similar companies/projects?
- Theory
 - A theory is an **ontology** plus a **statement** with **scope** of application
 - Preferably, statement indicates mechanism
 - Scope = generalization; always uncertain, possibly limited
 - Mechanism
 - Counterfactual
 - Theories applied?
 - Theory that will explain case study observations?

Example 2: The project

- Multi-agent planning for barge sojourns in Rotterdam harbor
 - Containers from/to inland barge operator via terminal to/from overseas carrier
 - Goals
 - to reduce waiting time of barge operators (most efficient route through the harbor)
 - to ensure that the terminals have always work when they have workers available
- Partners
 - University of Twente: Silja Eckartz & others
 - Rotterdam port authority

What is a business case?

- An argument to convince management to make an investment decision (to do A rather than B)
- Example
 - Desired decision: To implement an ERP system
 - Estimated cost: Hardware, software, maintenance, operations, etc.
 - Estimated benefits: Speed, reliability, etc.
 - Known risks: e.g. that context changes, that benefits are not achieved, cost reductions not achieved, that project runs out of budget, over time etc.

Problems in business networks

- There often is no central decision maker
 - Each partner can walk out at any moment
 - Each partner has its own BC
 - Need a sustainable BC for each partner
- Relevant information to make the business case is confidential
 - Business processes and IT available in a partner are confidential
 - Expected benefits per partner is tactical information
- Business case development often fails due to lack of trust
 - Lack of understanding of the network

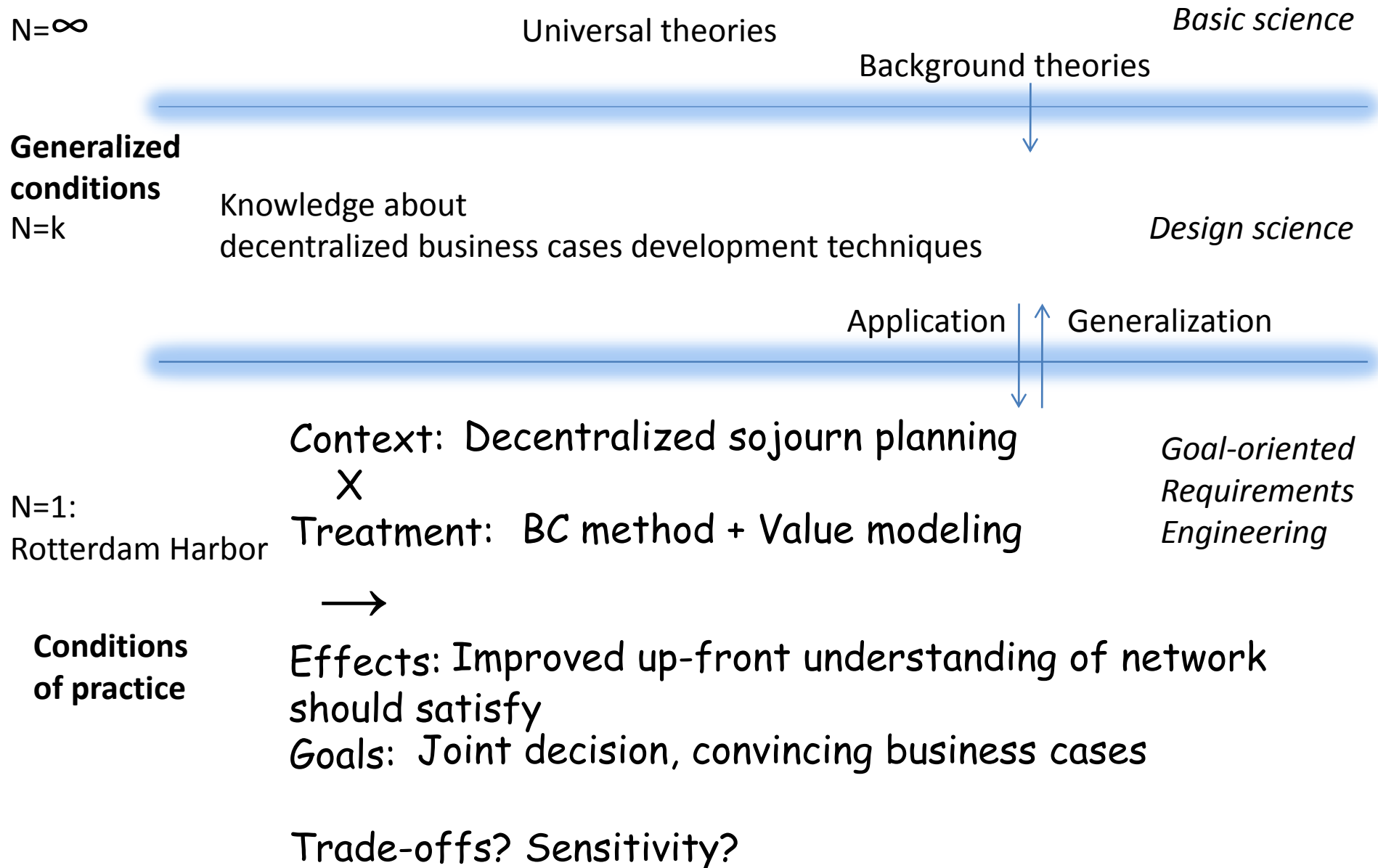
Solution idea

- Make a value model (= business model) with public information
 - Which partners
 - Which services against which return service
 - Estimation of traffic
- Extend business case with value model
- This allows each partner to estimate
 - Required changes in IT
 - Required changes in business processes
 - Expected benefits

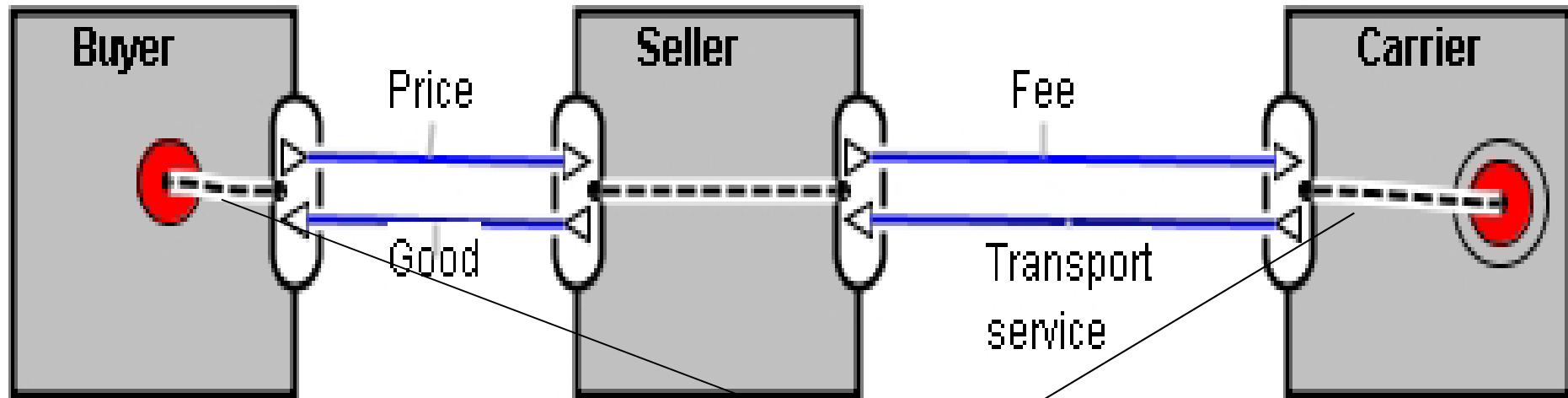
And still keep sensitive information confidential

As shown by
earlier research

Methodological interrupt



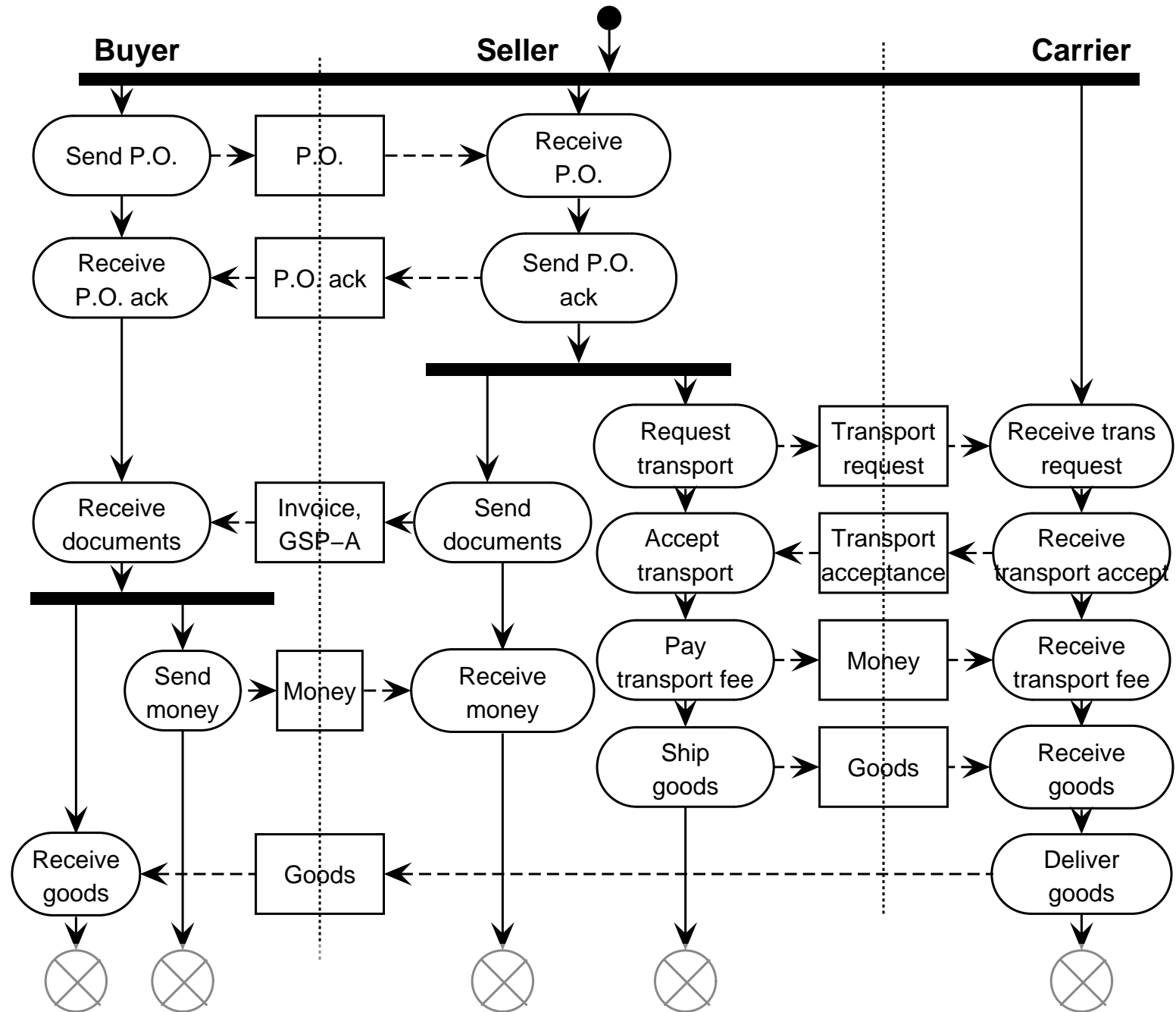
Value view



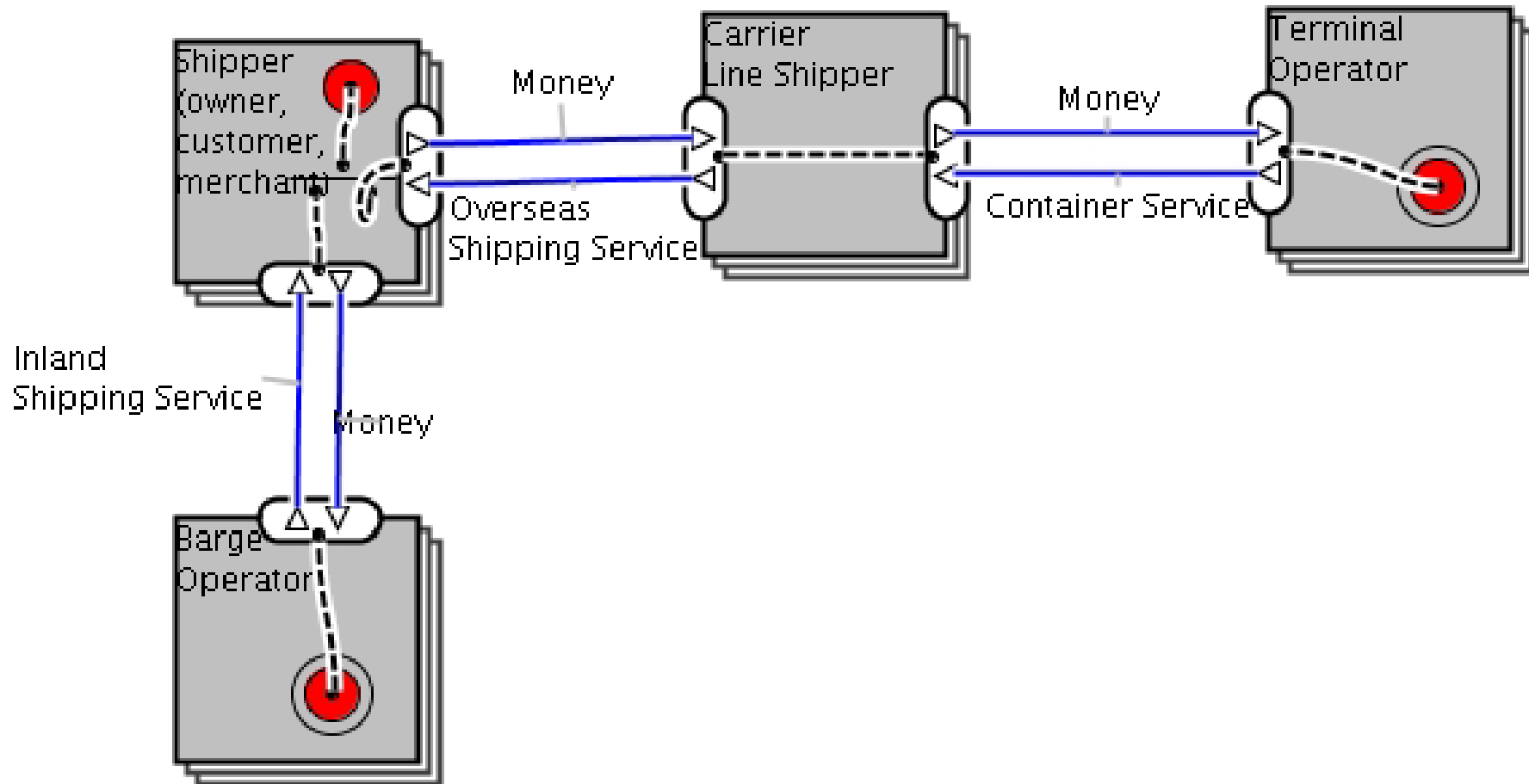
- Actors
- Value transfers
- Value interfaces
- Commercial transactions
- Consumer need
- Dependency path
- Model boundary
- Validity period
- Profitability estimations
- Not a process

Dependency path

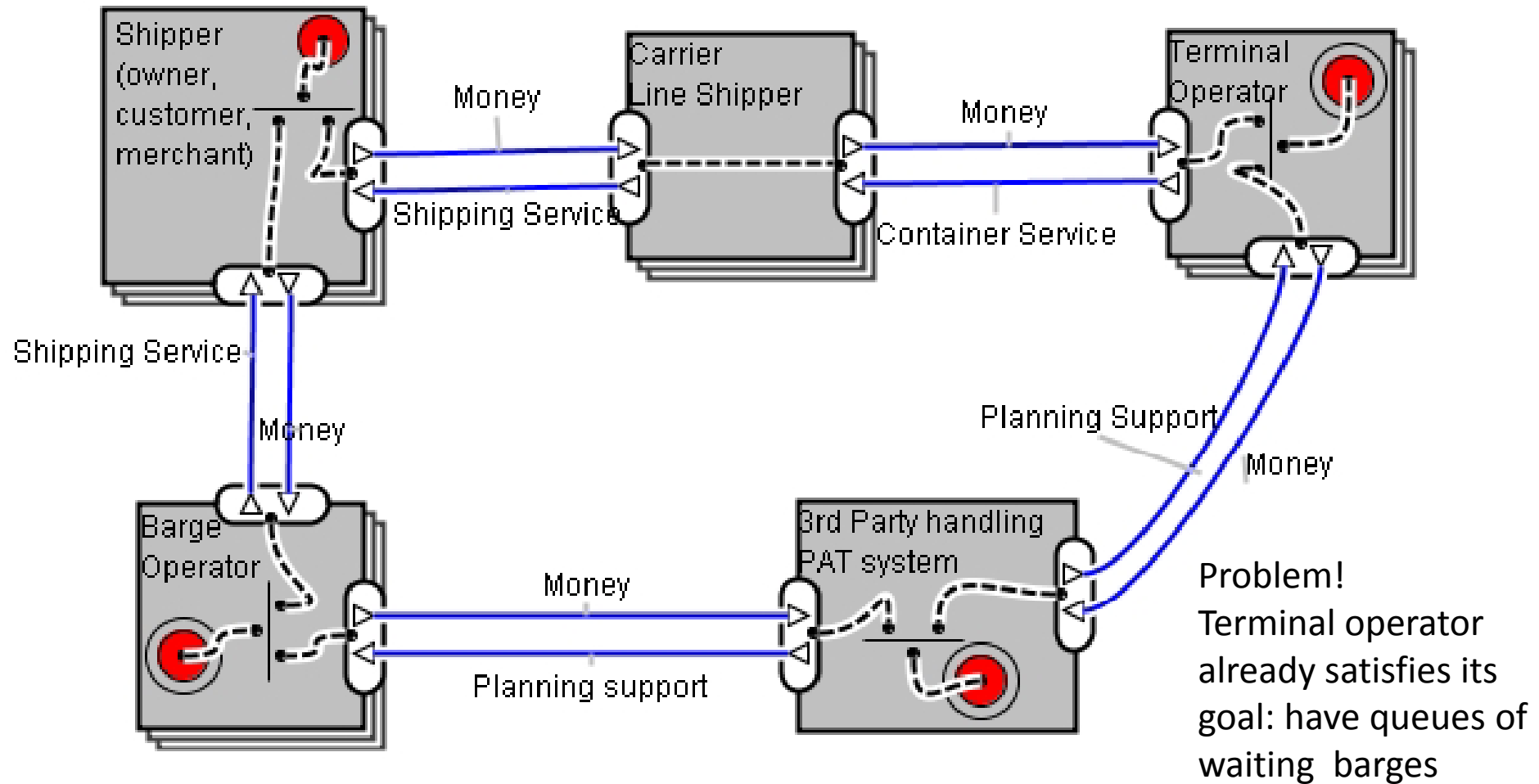
- “If a consumer need occurs in the validity period of the model, these transactions will occur in the period of validity.”
- Represents a commercial transaction from an economic point of view
 - Instructions for a profitability computation
 - In general it is an acyclic and/or path
 - Not a process model



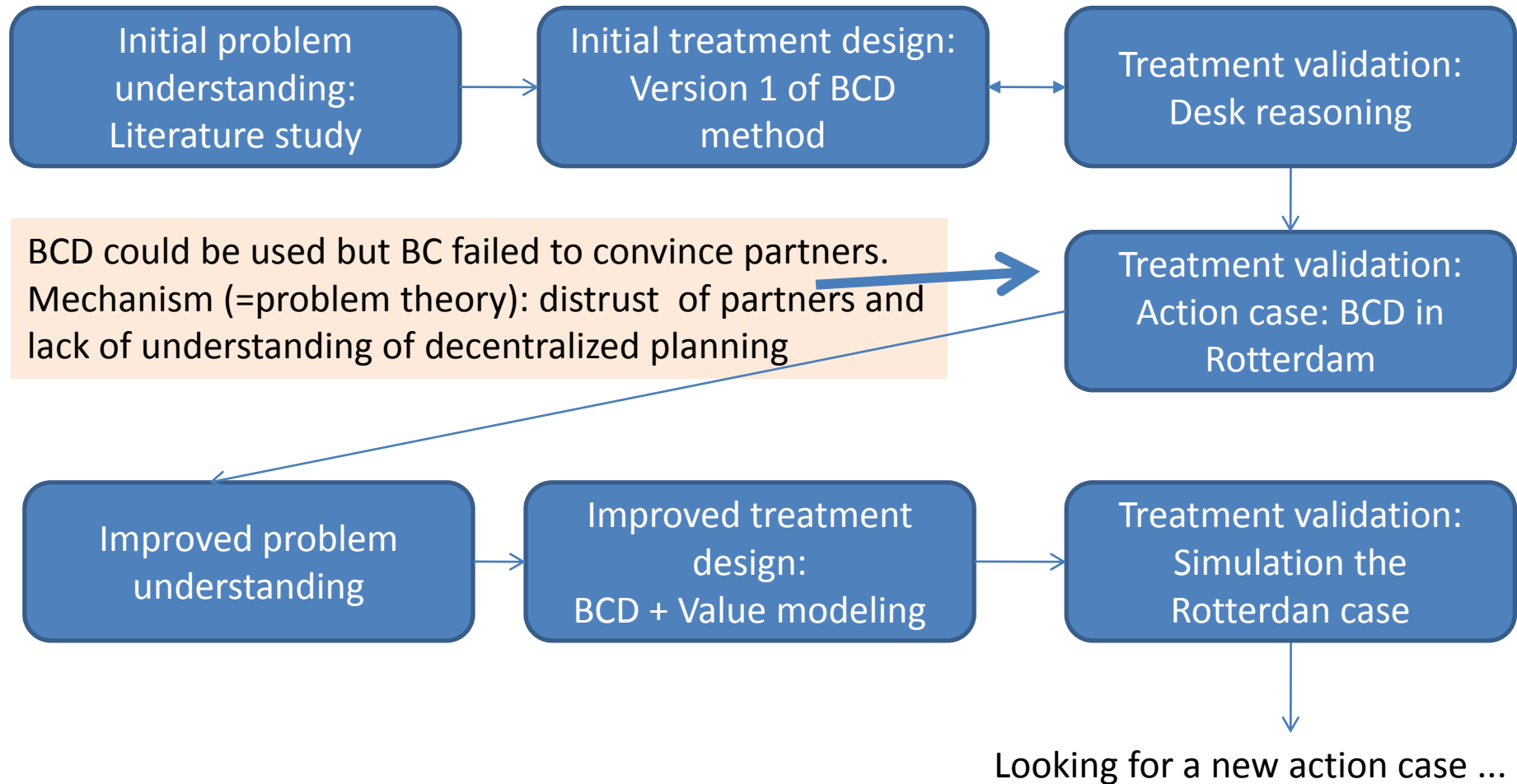
Value model of current situation



Simplest possible value model if BC would lead to implementation decision



Methodological structure



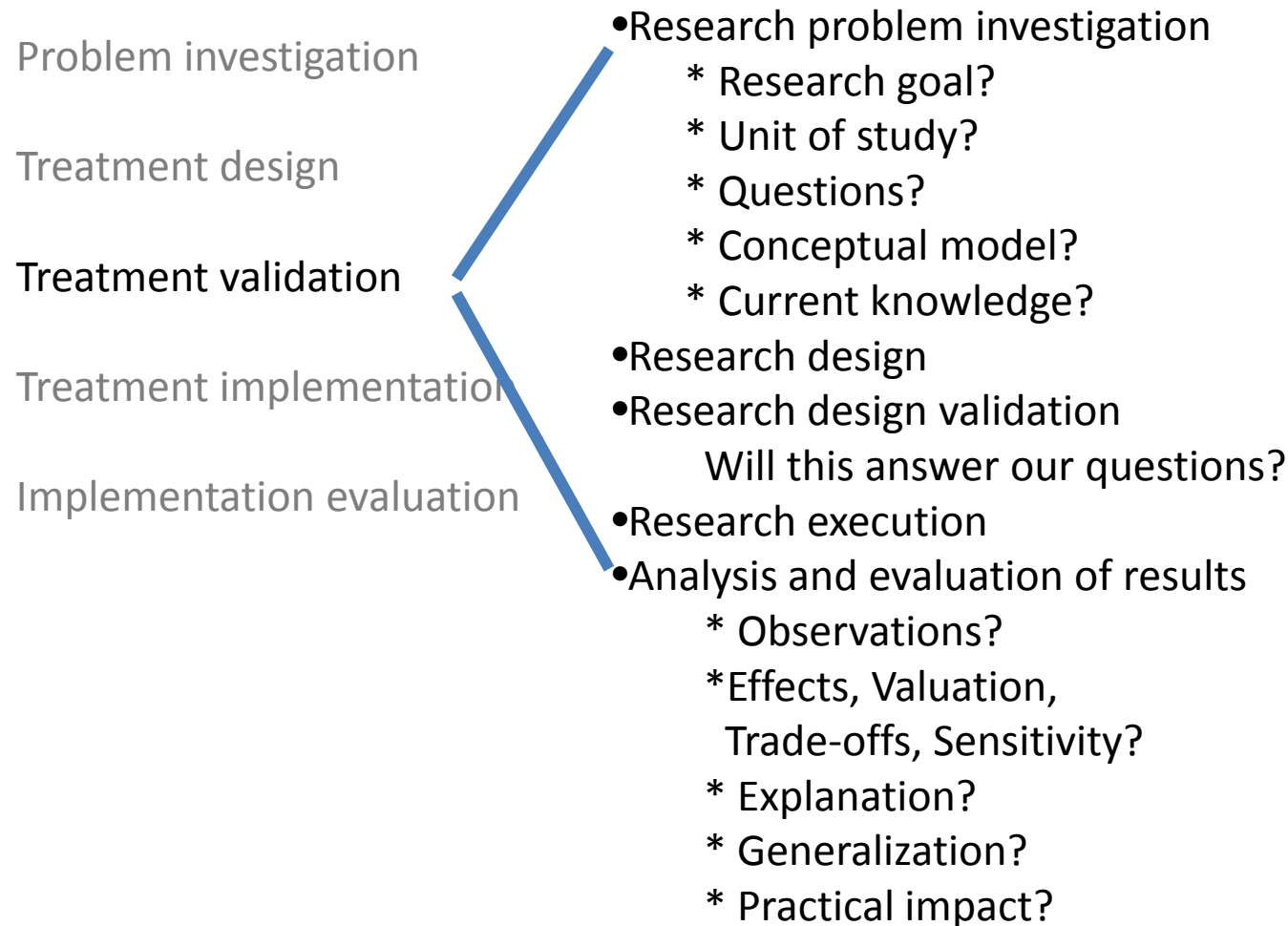
Validation methods in design science

Scaling up to conditions of practice	Cond. of pract.	Cntrl of cntxt	Unit of data collect.	Example	User	Goals
Illustration	no	yes	model	small	designer	illustration
Opinion survey	imagined	yes	model	any	stakeh.	support
Lab demo	no	yes	model	realistic	designer	knowledge
Lab expt.	no	yes	model !	artificial	subjects	knowledge
Benchmark	no	yes	model	standard	designer	knowledge
Field trial	yes	yes	model	realistic	designer	knowledge
Field experiment	yes	yes	model	realistic	stakeh.	knowledge
Action case	yes	no	model	real	designer	knowledge and change
Pilot project	yes	no	model	realistic	stakeh.	knowledge and change
Case study	yes	no	model	real	stakeh.	knowledge and change

Validation **research** methods in design science

	Cond. of pract.	Cntrl of cntxt	Unit of data collect.	Example	User	Goals
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Action case	yes	no	model	real	designer	knowledge and change
Pilot project	yes	no	model	realistic	stakeh.	knowledge and change
Case study	yes	no	model	real	stakeh.	knowledge and change

Validation research, generally



Practical problem

Research problem

Technical action research



Analysis of results of TAR



Example 3: The project

- Developing a confidentiality risk assessment method in business networks
- Researcher used method herself to help a client do this assessment
- Next slide
 - (Morali, A. and Wieringa, R.J. (2010) [Risk-Based Confidentiality Requirements Specification for Outsourced IT Systems](#). In: Proceedings of the 18th IEEE International Requirements Engineering Conference (RE 2010), 27 Sept - 1 Oct 2010, Sydney, Australia. IEEE Computer Society.)

Example 3: Methodological structure

Practical problem:

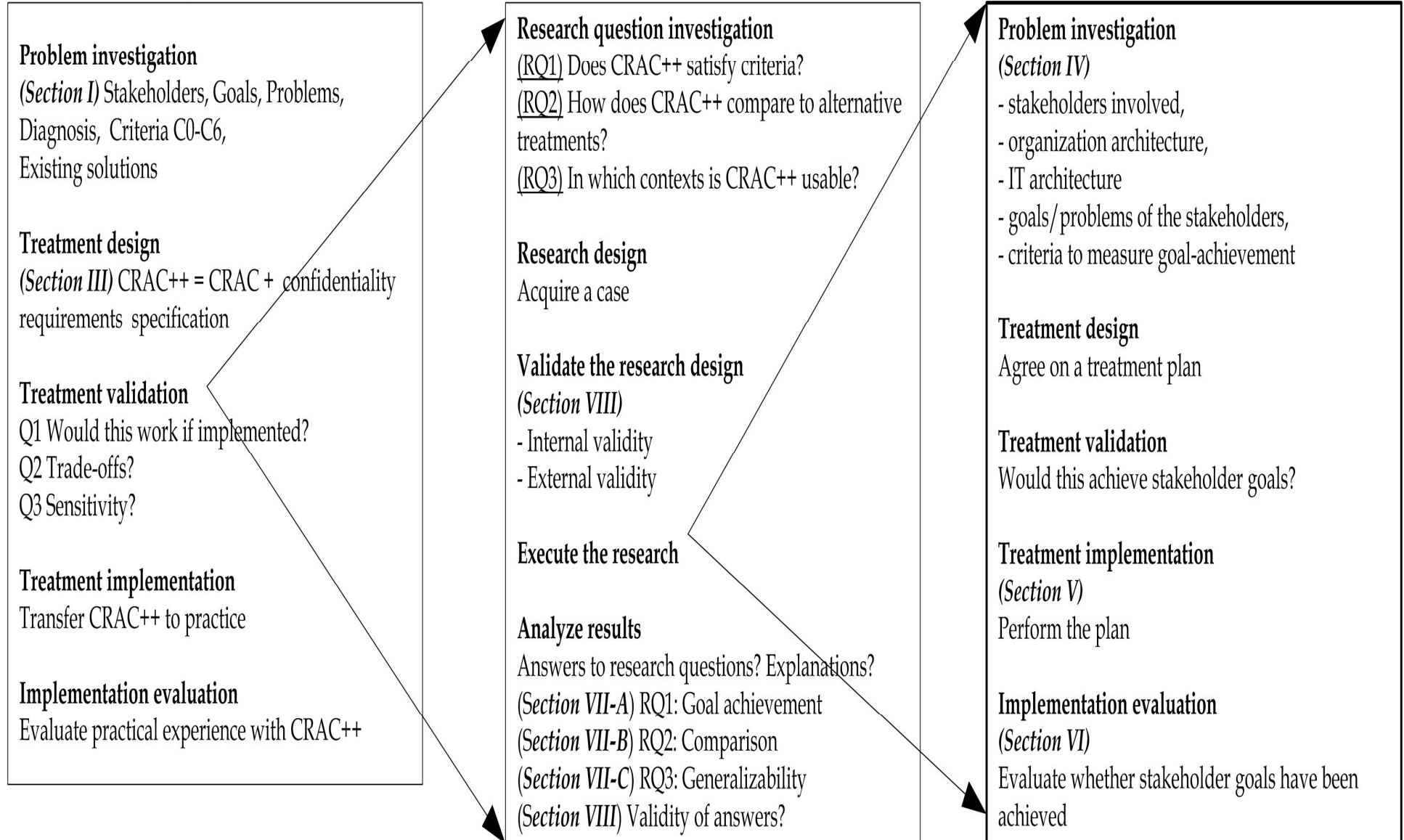
Specify confidentiality control requirements of an outsourcing client in an SLA.

Research question:

Is the proposed method valid?

Practical problem:

Specify confidentiality requirements of X in a particular outsourcing relation.



Take home about design science

1. In design science research, we iterate over technology (practical problem solving) and research (knowledge question answering)
2. Much of design science research is validation research
 - Treatment & Context produces effects?
 - Effects satisfy criteria?
 - Trade-offs?
 - Sensitivity?
 - Risks? Understanding of mechanisms?
3. Validation research must simulate the treatment in practice
 - Opinion poll of practitioners
 - Experimenting with models
 - Action case

Take home about business network design

- Decentralized decision making may fail in distrust
- Value model can be used to:
 - Clarify the business cases for all partners, keeping sensitive info confidential
 - Designing the required IT services
 - Designing the required coordination process

Discussion