design science
research in IS

5

prepared by yves pigneur
DRIS May 2012

1. framework & publication
2. theory & anatomy
3. methodology & action design
4. patterns & evaluation
5. **design rationale (C-K)**

questions

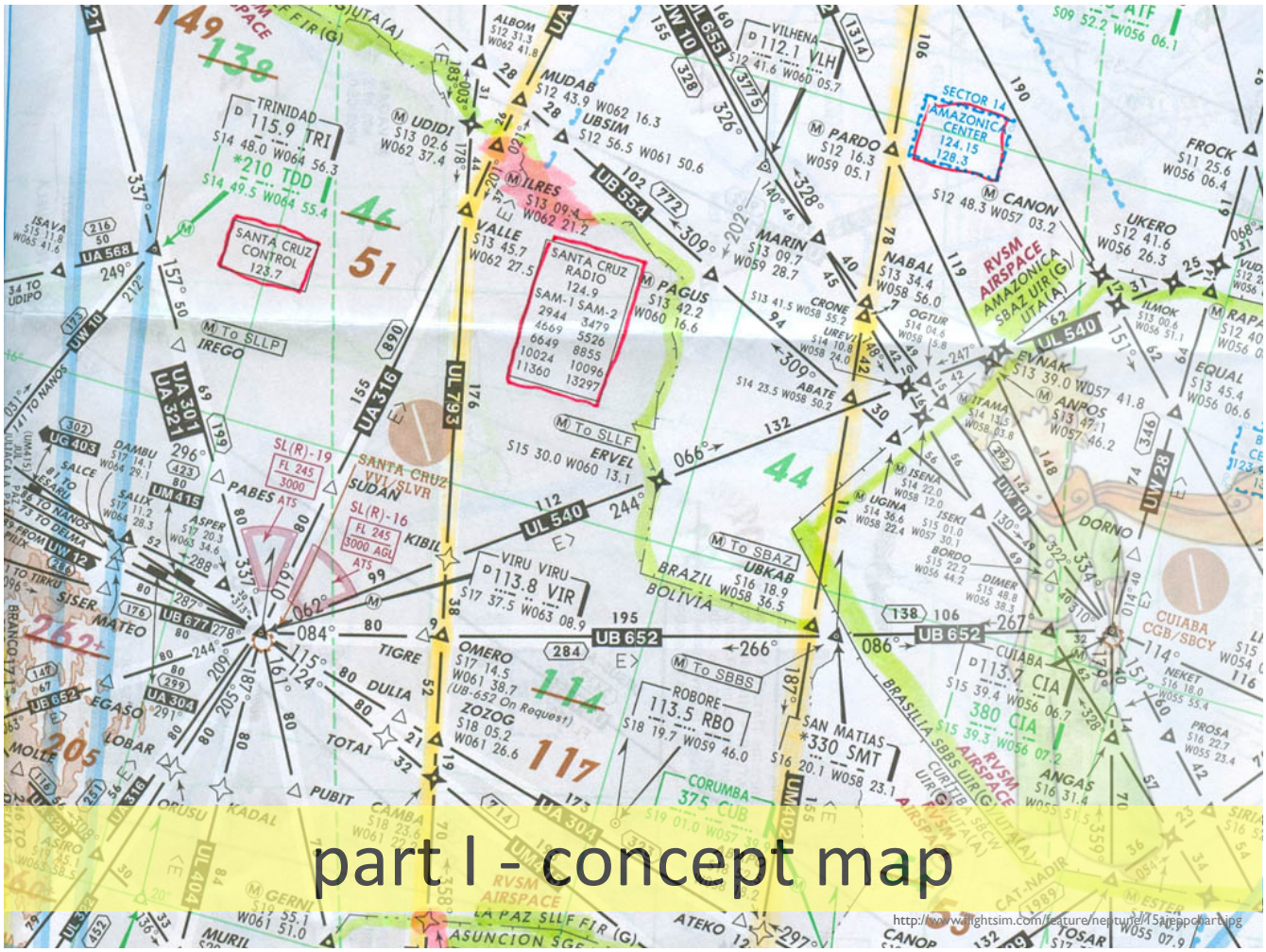
how to deal with design reasoning?

what is design rationale?

what is the *C-K theory*?

is *C-K theory* a good candidate for dealing with design reasoning?

how is it related to design science research?



part II - design rationale

why?

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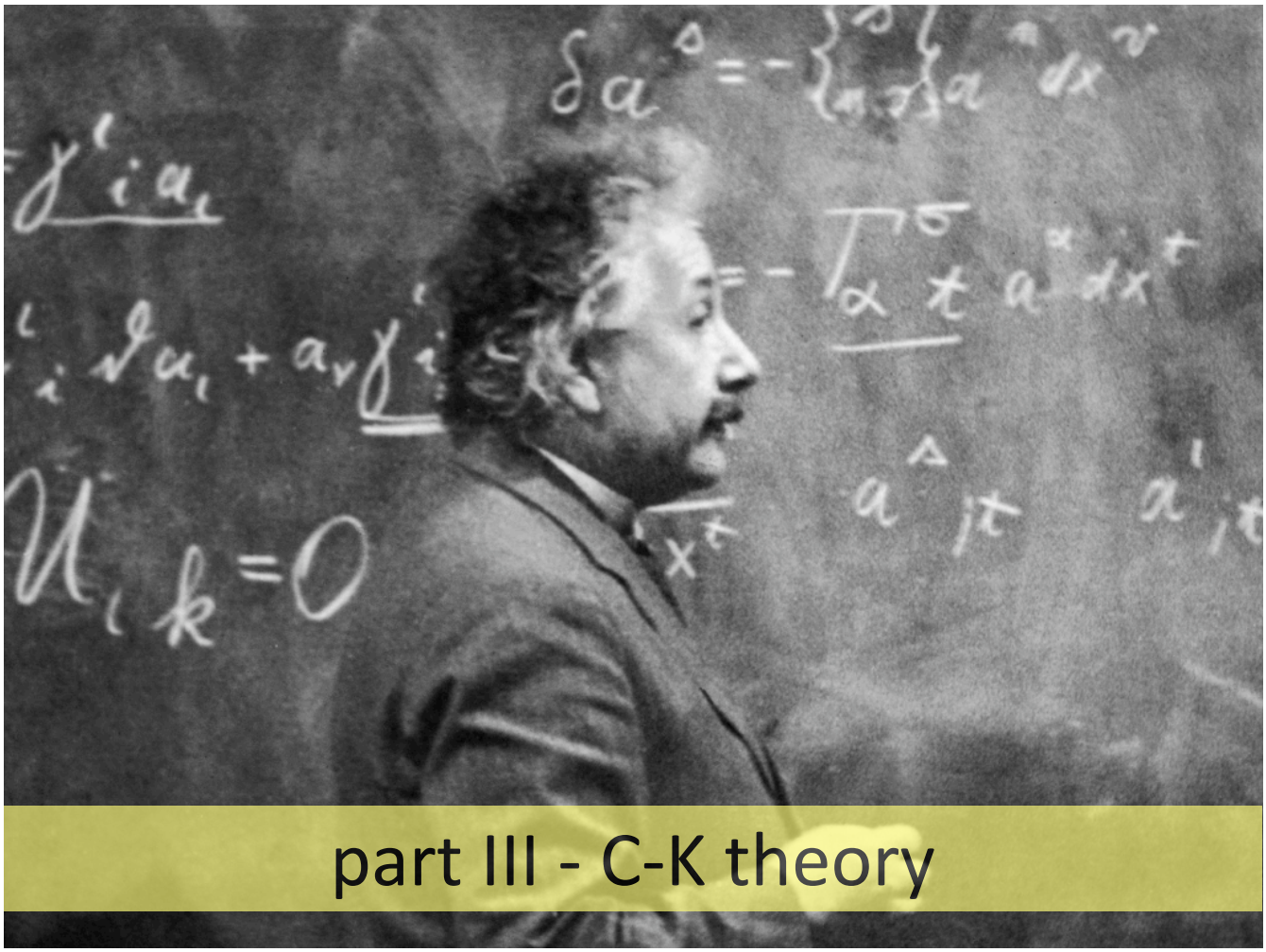


part III - C-K theory

part III - C-K theory illustration

1

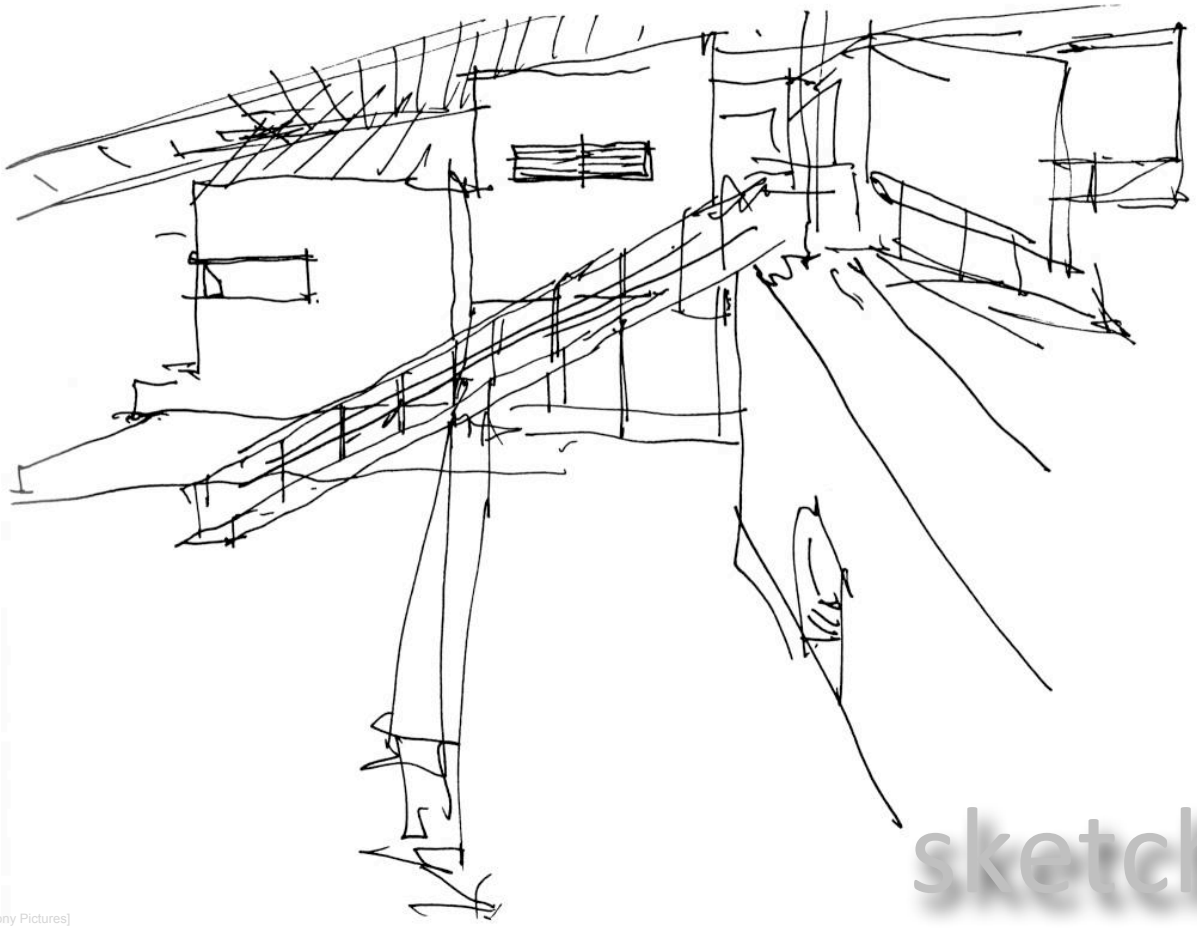
concept map

Component		Description
Core components		
1)	Purpose and scope (the *causa finalis*)	"What the system is for," the set of meta-requirements or goals that specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundary.
2)	Constructs (the *causa materialis*)	Representations of the entities of interest in the
3)	Principle of form and function (the *causa formalis*)	The abstract "blueprint" or architecture that de artifact, either product or method/intervention.
4)	Artifact mutability	The changes in state of the artifact anticipated in the theory, that is, what degree of artifact change is encompassed by the theory.
5)	Testable propositions	Truth statements about the design theory.
6)	Justificatory knowledge	The underlying knowledge or theory from the natural or social or design sciences that gives a basis and explanation for the design (kernel theories).
Additional components		
7)	Principles of implementation (the *causa efficiens*)	A description of processes for implementing the theory (either product or method) in specific contexts.
8)	Expository instantiation	A physical implementation of the artifact that can assist in representing the theory both as an expository device and for purposes of testing.

Table 2: Eight components of an IS design theory

2. constructs

- representations of the entities of interest in the theory
- words, symbols, diagrams ...
- clear definition
- decomposing problems in semi-independent parts



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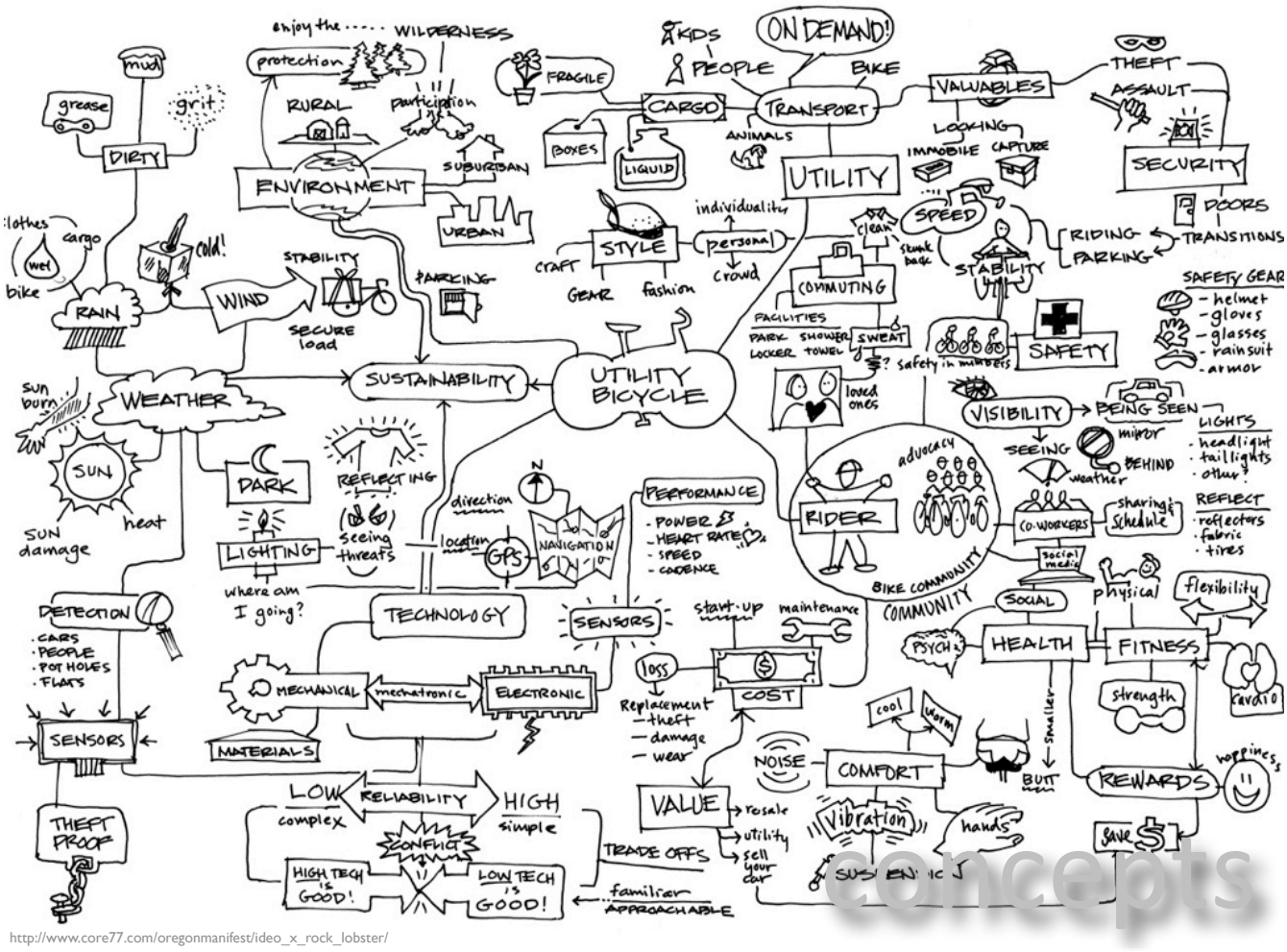

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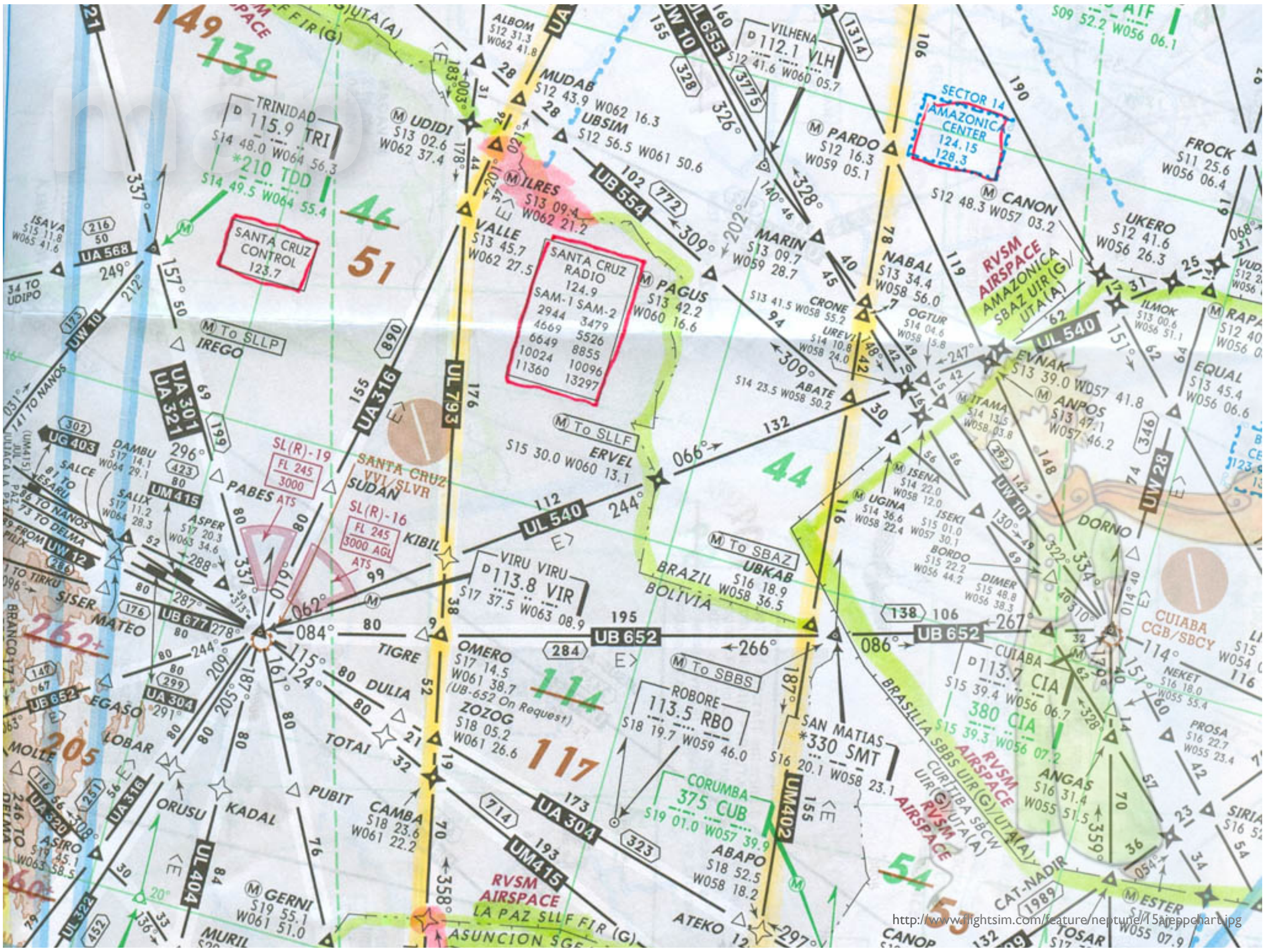
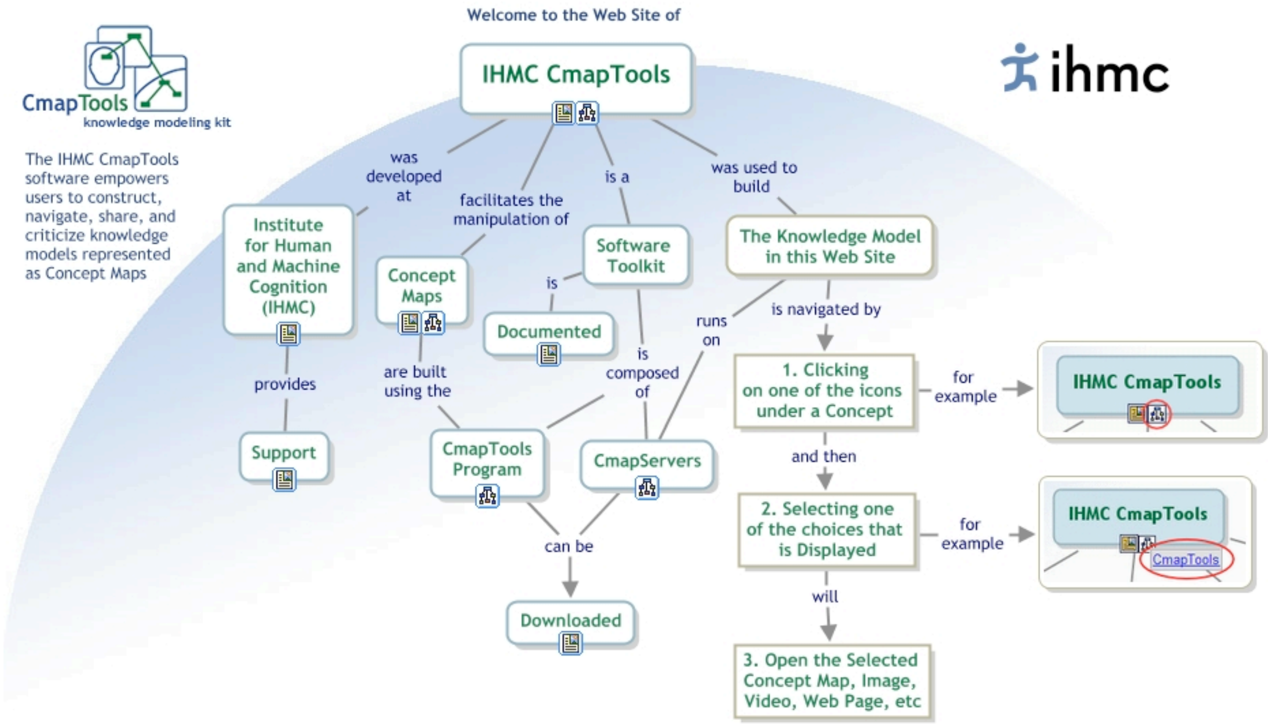
a visual representation



concept map



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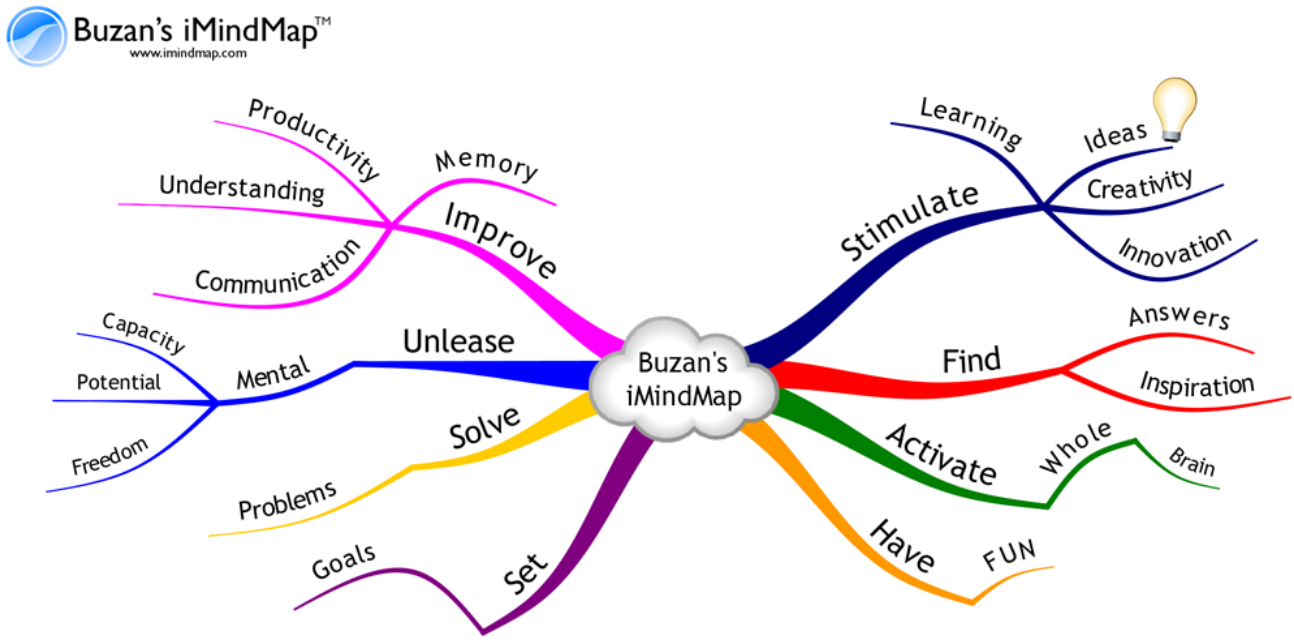
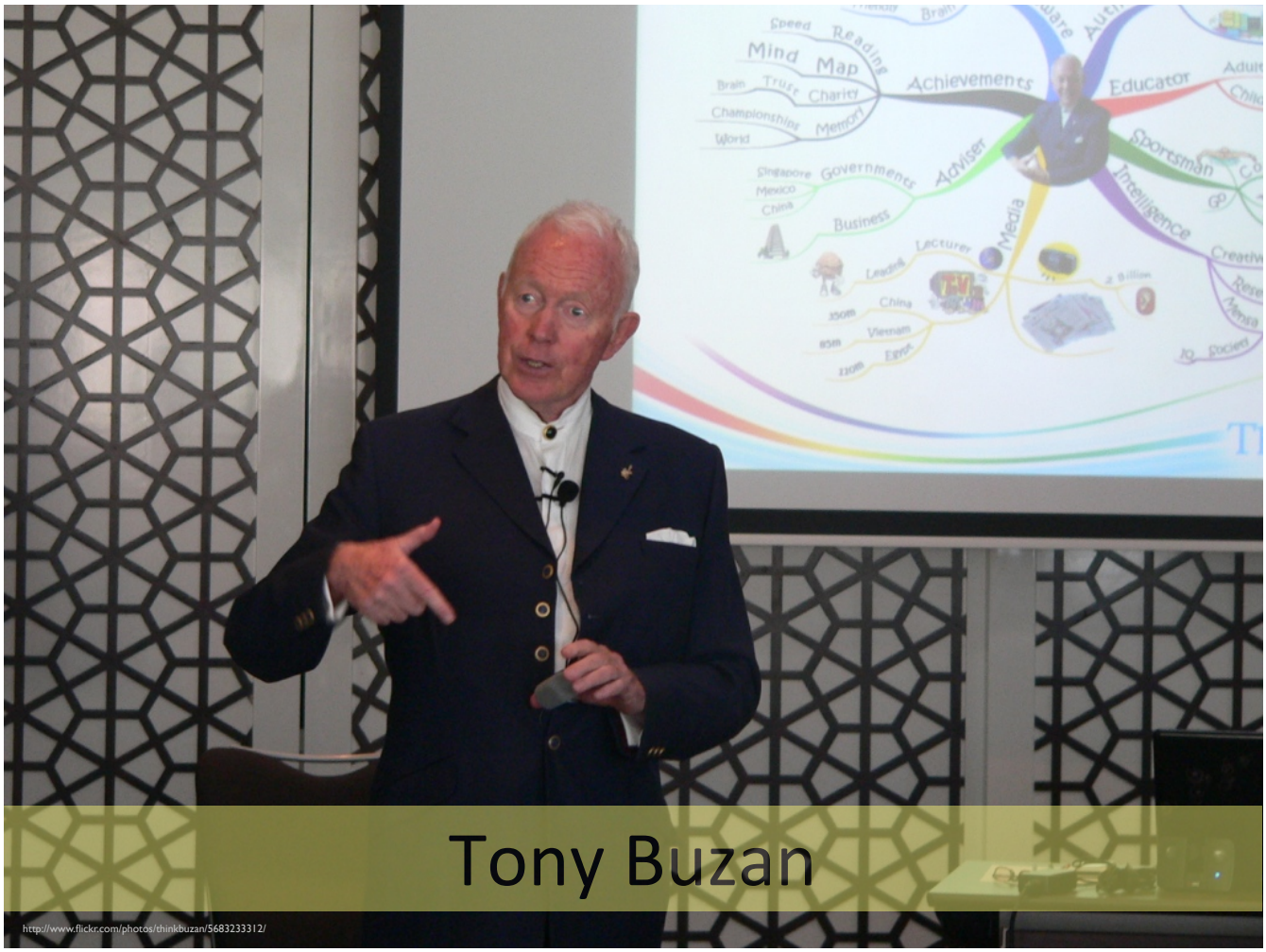
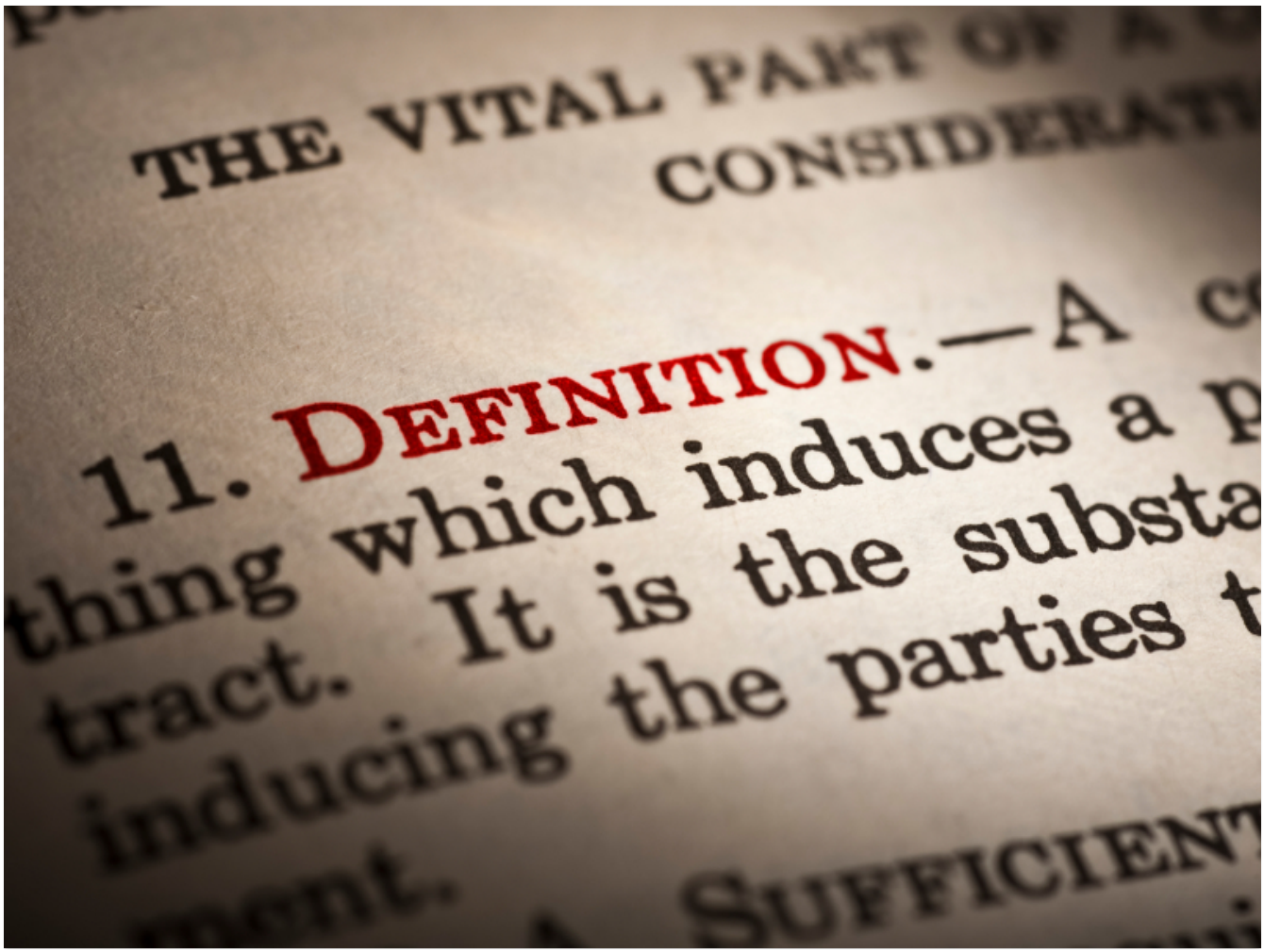
mind map



www.thinkbuzan.com/fr/home





> “a visual form of note taking used to represent words, ideas, tasks, and items linked to a central key word or idea”

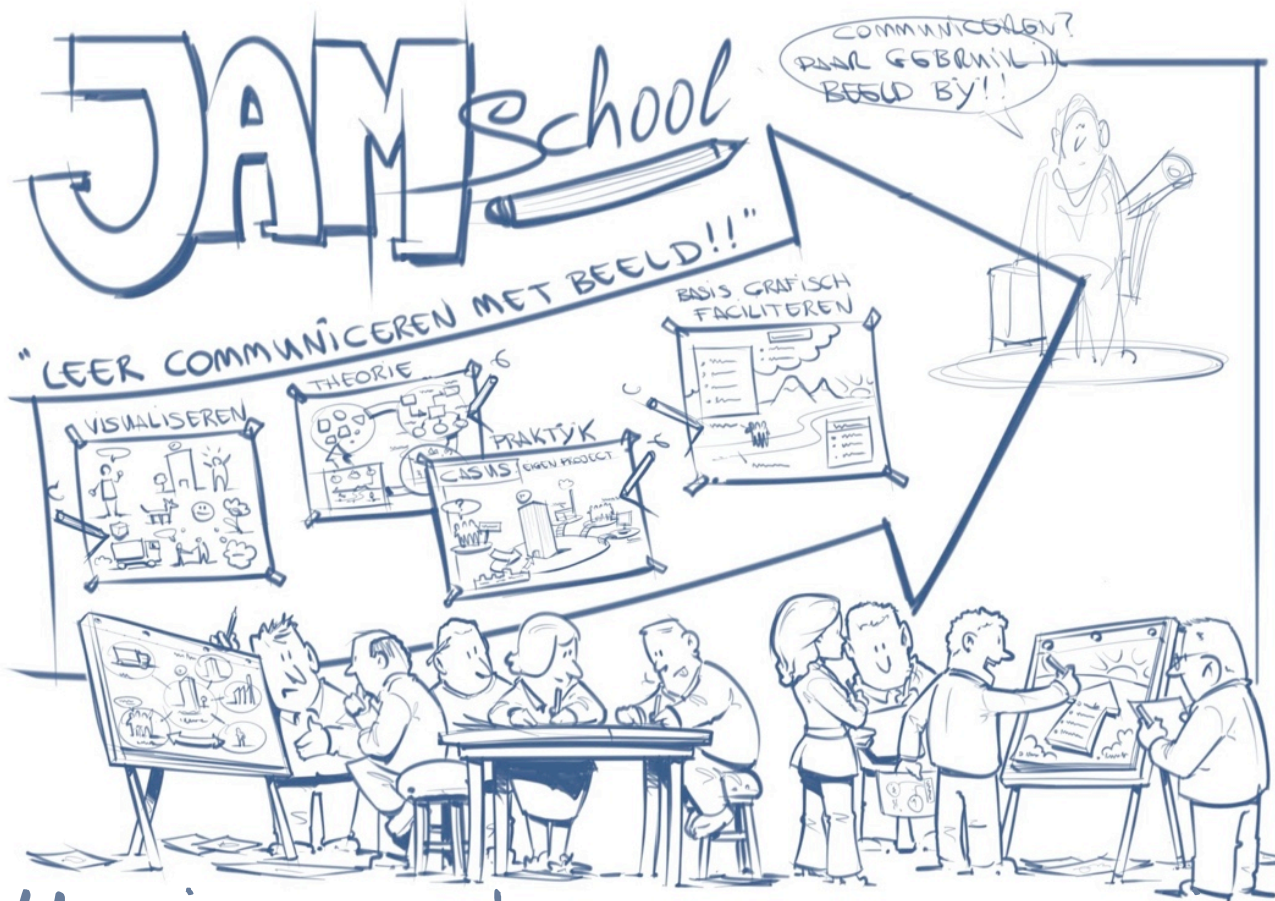

how to ...


...mind map

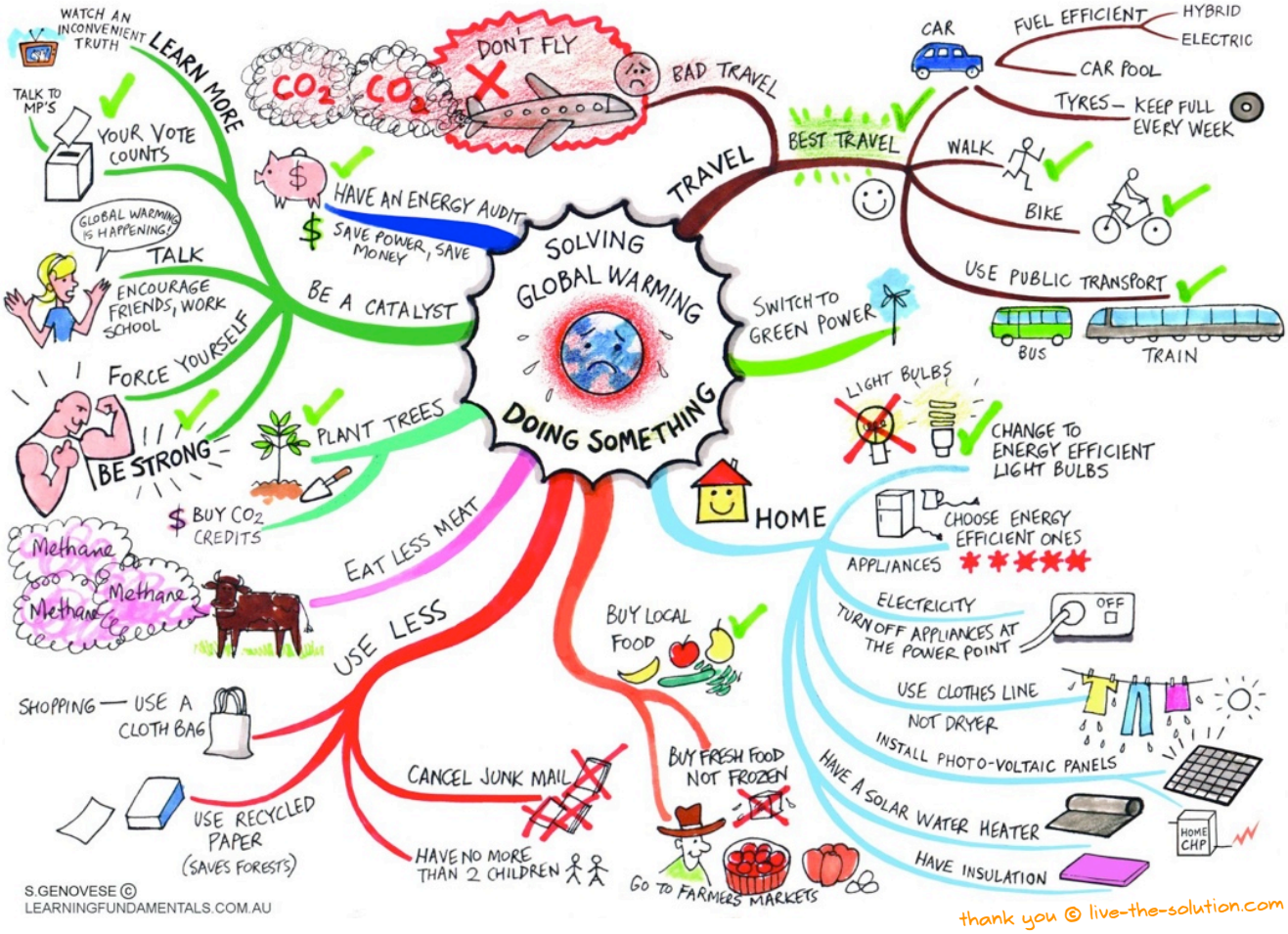

Use colors to add context


Use size to
show impact

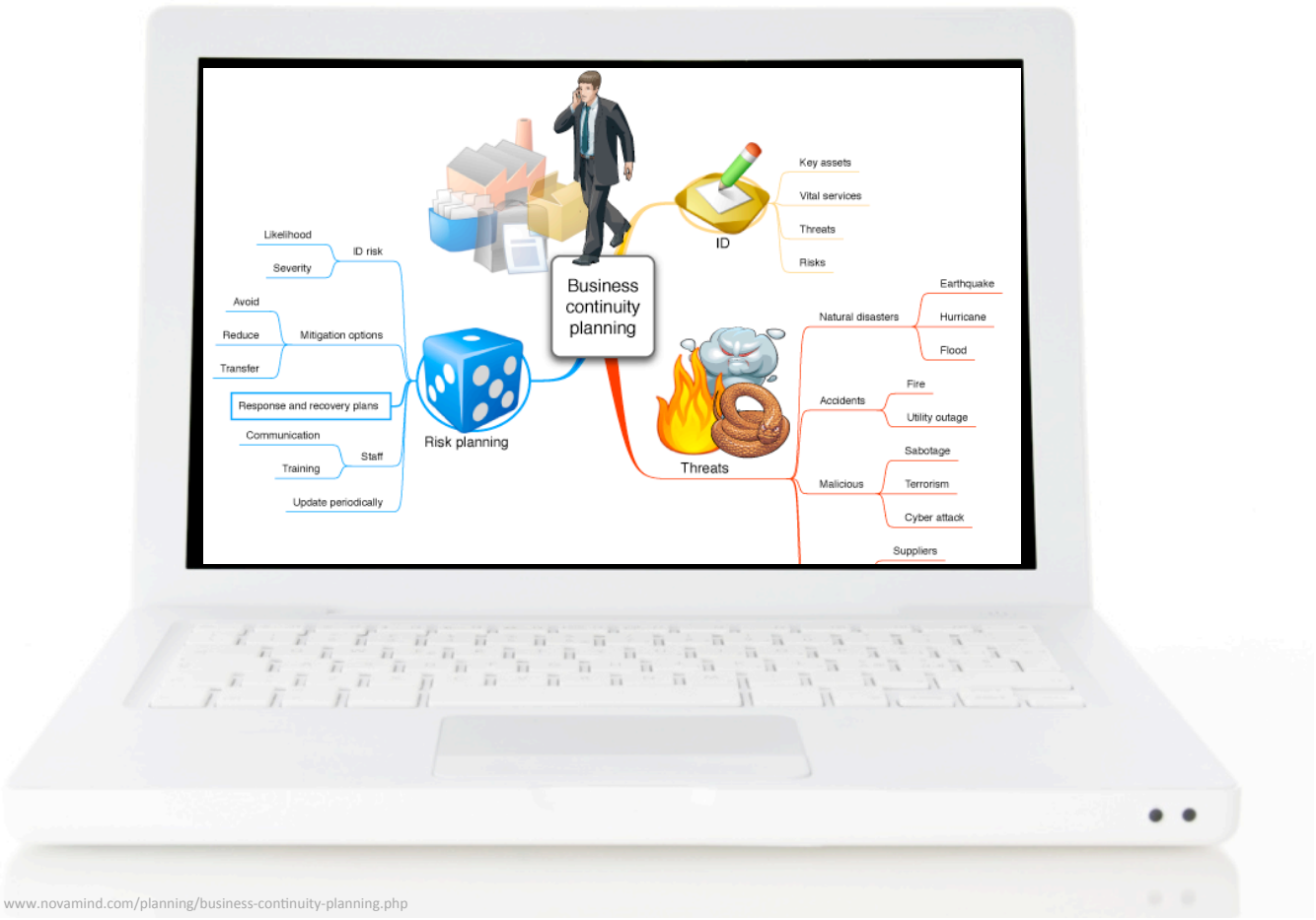
Use lines between topics
to reinforce associations



Use images to engage your mind


SOLVING GLOBAL WARMING
DOING SOMETHING
LEARN MORE
WATCH AN INCONVENIENT TRUTH
TALK TO MP'S
YOUR VOTE COUNTS
BE A CATALYST
HAVE AN ENERGY AUDIT
SAVE POWER, SAVE MONEY
TALK
GLOBAL WARMING IS HAPPENING!
ENCOURAGE FRIENDS, WORK SCHOOL
FORCE YOURSELF
BE STRONG
PLANT TREES
BUY CO_2 CREDITS
EAT LESS MEAT
Methane
USE LESS
SHOPPING — USE A CLOTH BAG
USE RECYCLED PAPER (SAVES FORESTS)
CANCEL JUNK MAIL
HAVE NO MORE THAN 2 CHILDREN
BUY LOCAL FOOD
BUY FRESH FOOD NOT FROZEN
GO TO FARMERS MARKETS
TRAVEL
DON'T FLY
BAD TRAVEL
BEST TRAVEL
CAR
FUEL EFFICIENT
HYBRID
ELECTRIC
CAR POOL
TYRES — KEEP FULL EVERY WEEK
WALK
BIKE
USE PUBLIC TRANSPORT
BUS
TRAIN
SWITCH TO GREEN POWER
HOME
LIGHT BULBS
CHANGE TO ENERGY EFFICIENT LIGHT BULBS
CHOOSE ENERGY EFFICIENT ONES
APPLIANCES
ELECTRICITY
TURN OFF APPLIANCES AT THE POWER POINT
OFF
USE CLOTHES LINE
NOT DRYER
INSTALL PHOTO-VOLTAIC PANELS
HAVE A SOLAR WATER HEATER
HOME CHP
HAVE INSULATION
S.GENOVESE ©
LEARNINGFUNDAMENTALS.COM.AU
thank you © live-the-solution.com


use computer to mind map



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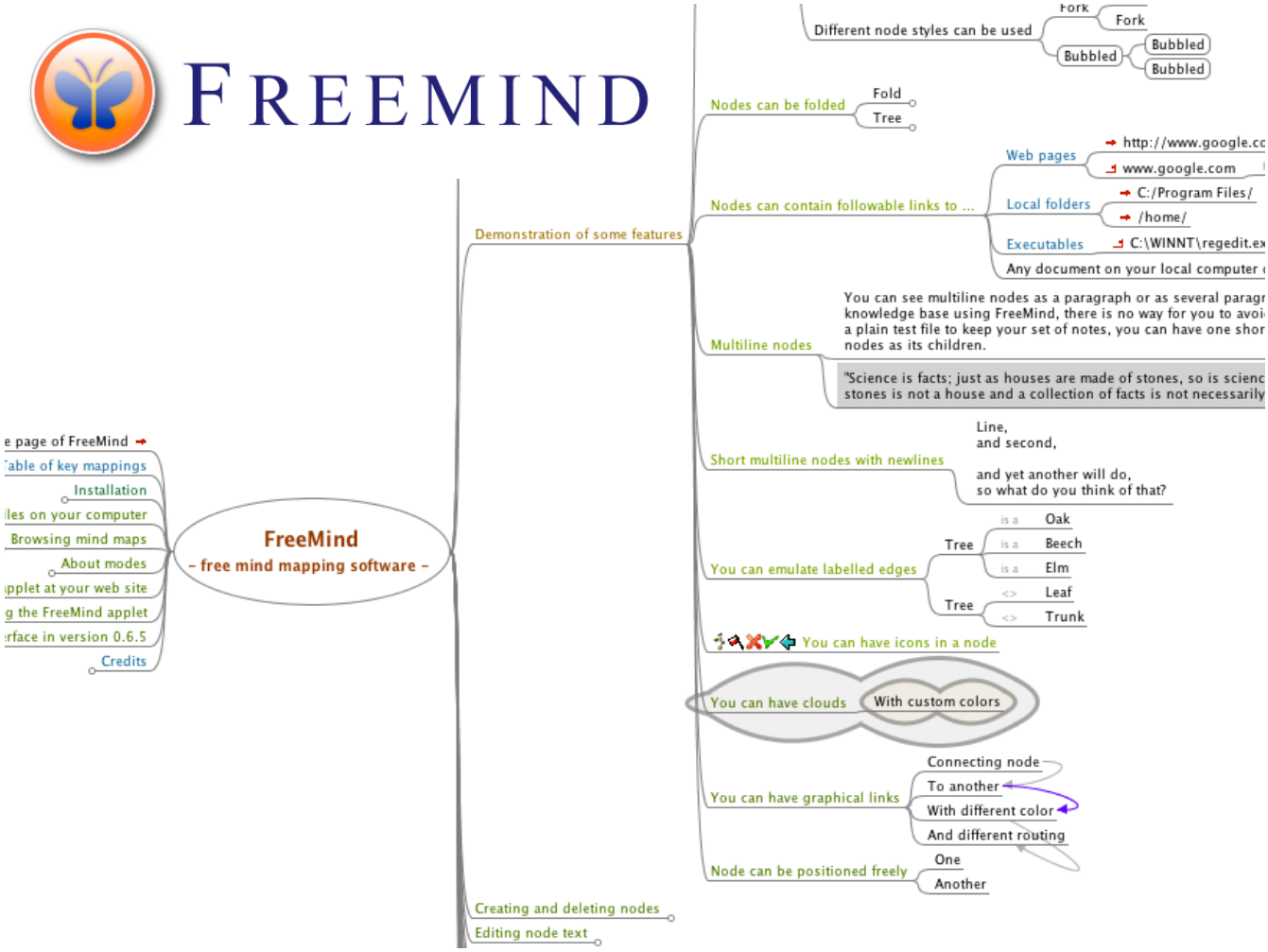
FREEMIND


FreeMind
– free mind mapping software –
e page of FreeMind
able of key mappings
Installation
iles on your computer
Browsing mind maps
About modes
pplet at your web site
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rface in version 0.6.5
Credits
Demonstration of some features
Different node styles can be used
Fork
Fork
Bubbled
Bubbled
Bubbled
Nodes can be folded
Fold
Tree
Nodes can contain followable links to ...
Web pages
http://www.google.co
www.google.com
Local folders
C:/Program Files/
/home/
Executables
C:\WINNT\regedit.ex
Any document on your local computer
Multiline nodes
You can see multiline nodes as a paragraph or as several paragr
knowledge base using FreeMind, there is no way for you to avoi
a plain test file to keep your set of notes, you can have one shor
nodes as its children.
"Science is facts; just as houses are made of stones, so is scienc
stones is not a house and a collection of facts is not necessarily
Short multiline nodes with newlines
Line,
and second,
and yet another will do,
so what do you think of that?
You can emulate labelled edges
Tree
is a
Oak
is a
Beech
is a
Elm
Tree
<>
Leaf
<>
Trunk
You can have icons in a node
You can have clouds
With custom colors
You can have graphical links
Connecting node
To another
With different color
And different routing
Node can be positioned freely
One
Another
Creating and deleting nodes
Editing node text


中華文明史
History of Chinese Civilization
中国 • 上海
use posters to communicate
enchiel.blogspot.com/2008/07/el-libro-de-los-mapas-mentales.html

Getting the Most out of Mapping

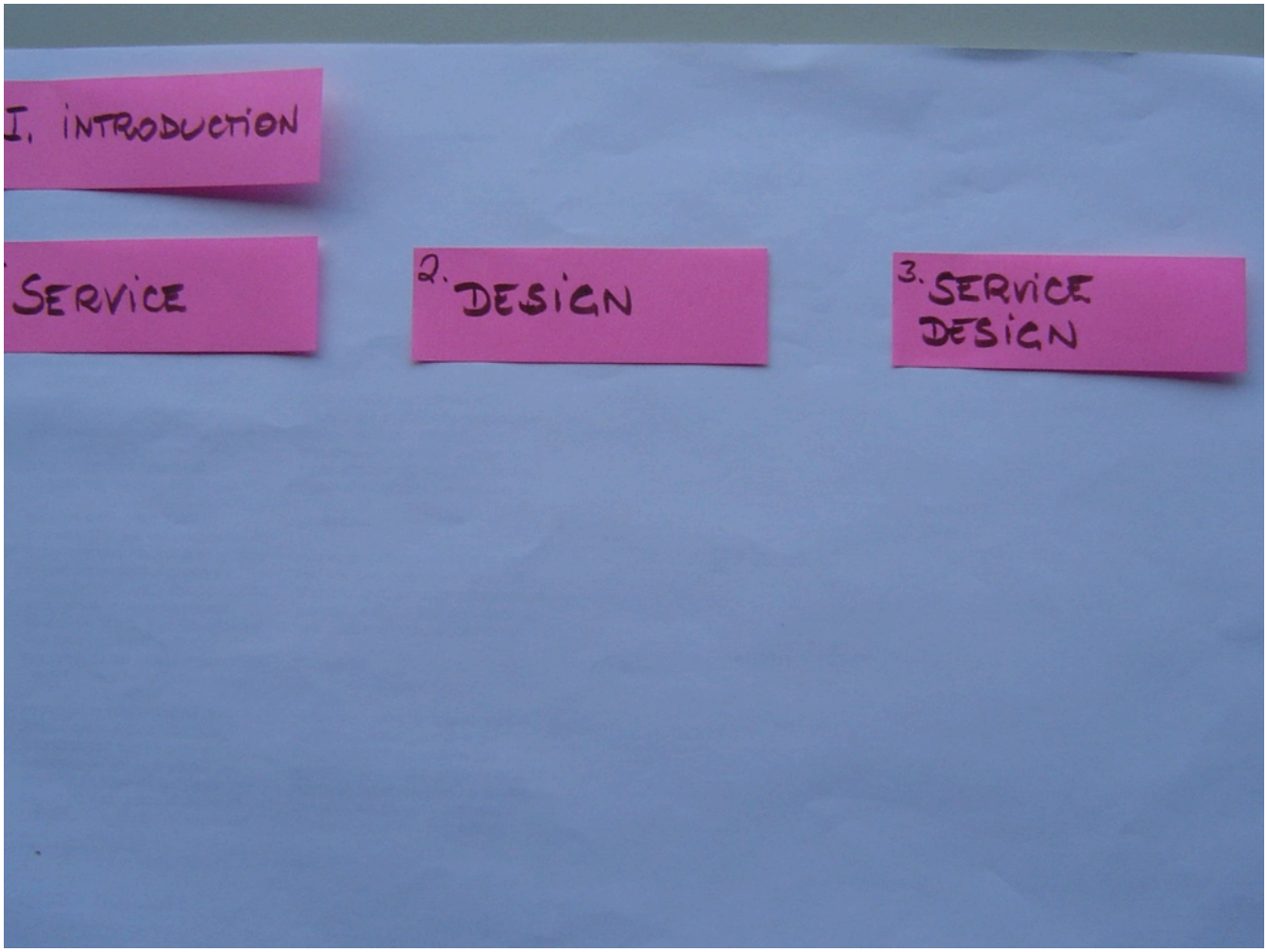
A GTD® Connect Special Presentation

thank you
Michael Deutch

http://www.slideshare.net/michaeldeutch/getting-the-most-out-of-mind-mapping

service design

making of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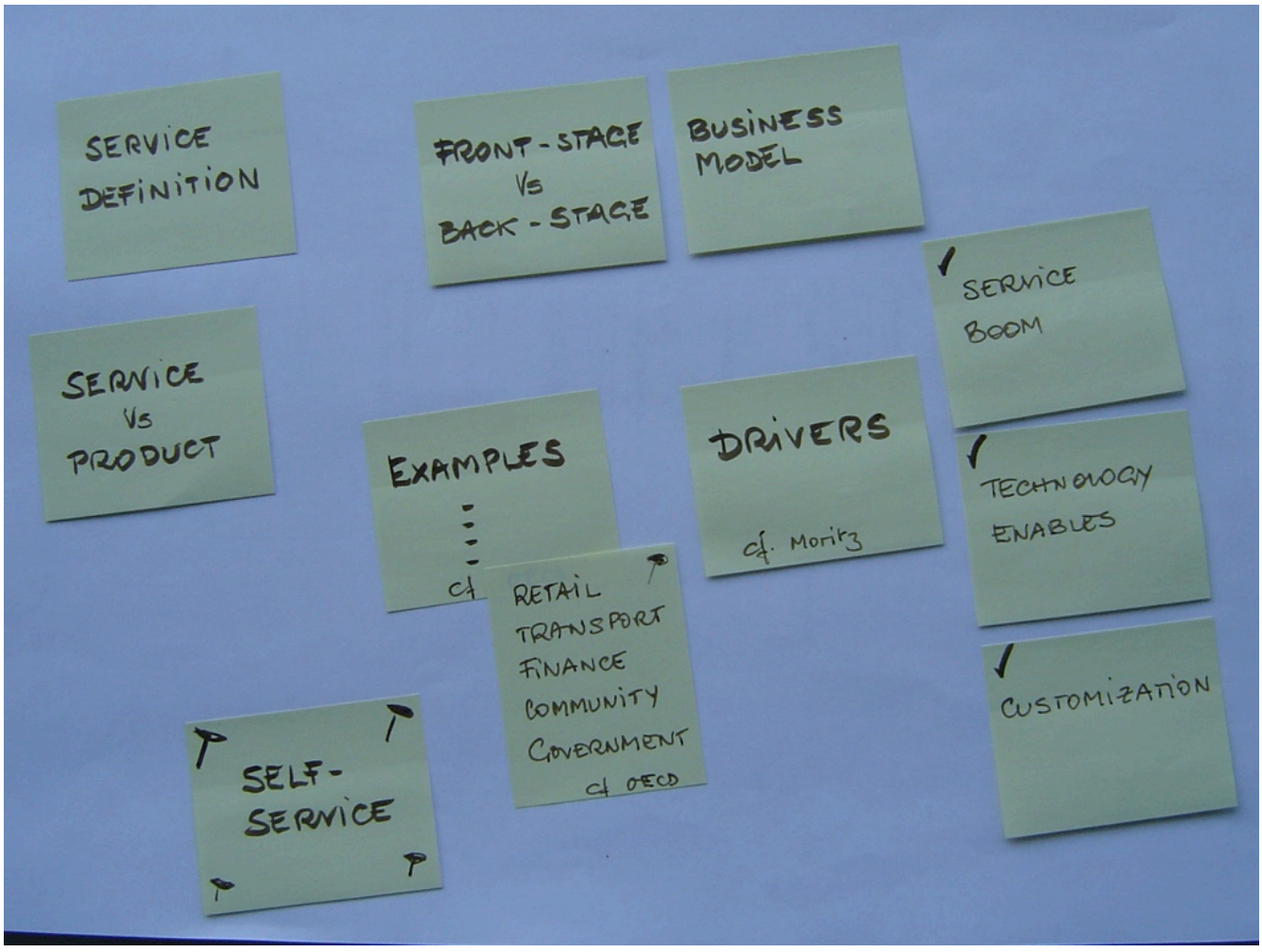
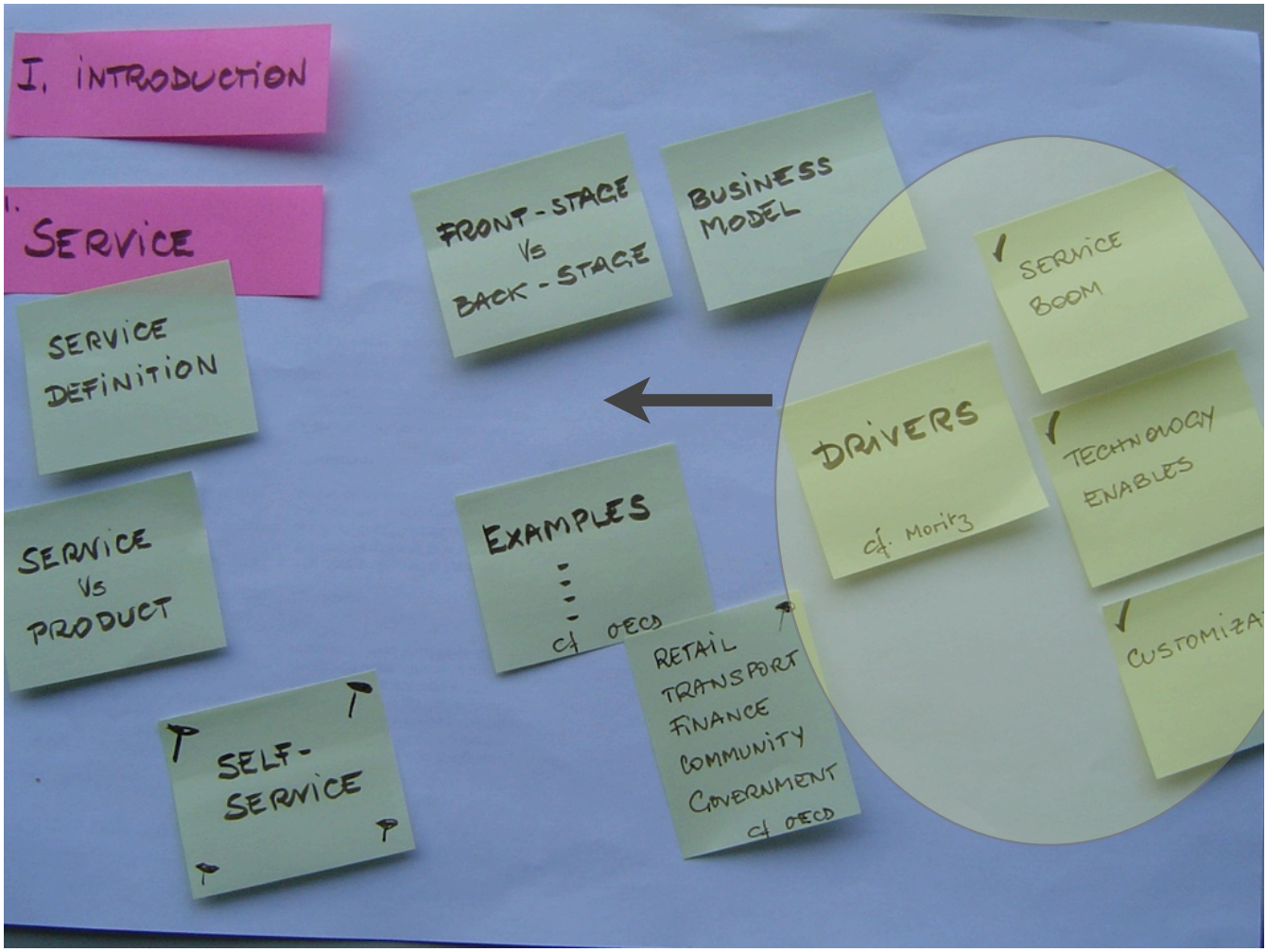
SERVICE
2. DESIGN
3. SERVICE DESIGN


SERVICE DEFINITION
FRONT - STAGE Vs BACK - STAGE
BUSINESS MODEL
SERVICE Vs PRODUCT
SERVICE BOOM
EXAMPLES
cf
DRIVERS
cf. Moritz
TECHNOLOGY ENABLES
RETAIL
TRANSPORT
FINANCE
COMMUNITY
GOVERNMENT
cf OECD
CUSTOMIZATION
SELF-SERVICE


I. INTRODUCTION
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FRONT-STAGE Vs BACK-STAGE
BUSINESS MODEL
EXAMPLES
cf. OECD
RETAIL
TRANSPORT
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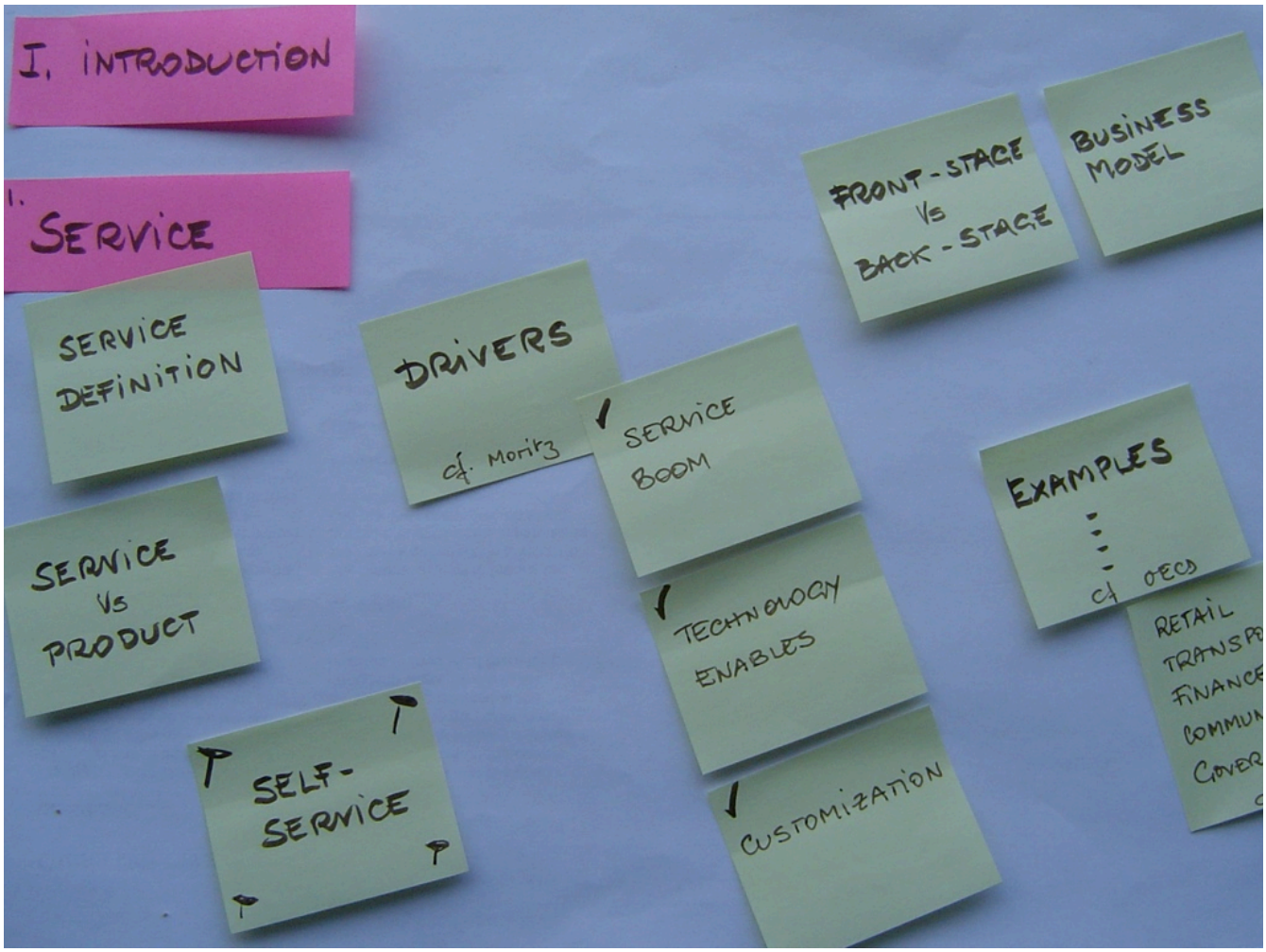
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CUSTOMIZATION
FRONT-STAGE Vs BACK-STAGE
BUSINESS MODEL
EXAMPLES
cf. OECD
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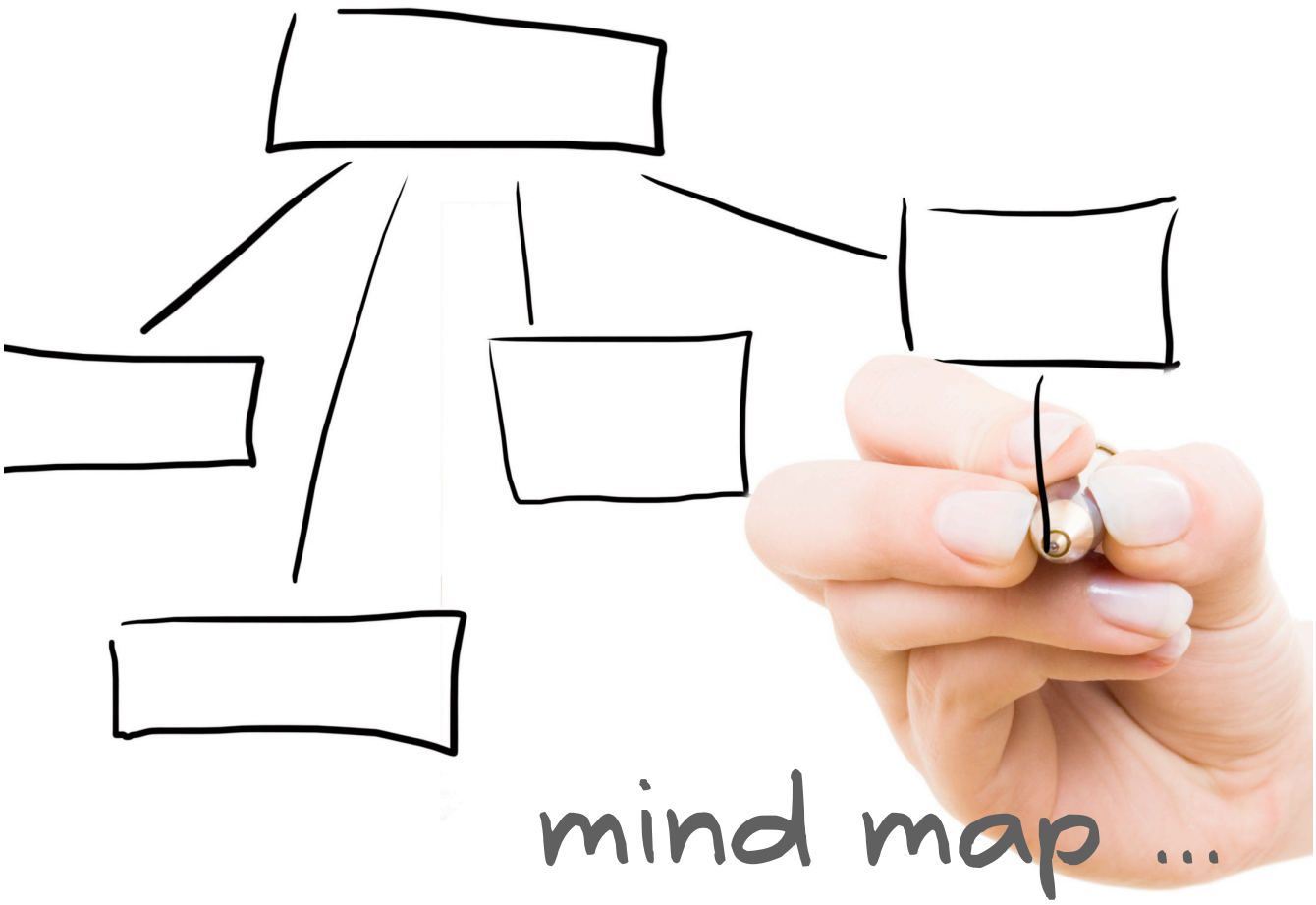
service design

- service
  - definition
  - product Vs. service
  - main drivers
    - service growth
    - technology enables
    - customization
  - examples
  - frontstage Vs. backstage
  - business model
- design
- service design
  - service system & scenario
  - task analysis & use case
  - prototyping services
  - service quality

practice practice practice




the concepts of ...


your own research

title

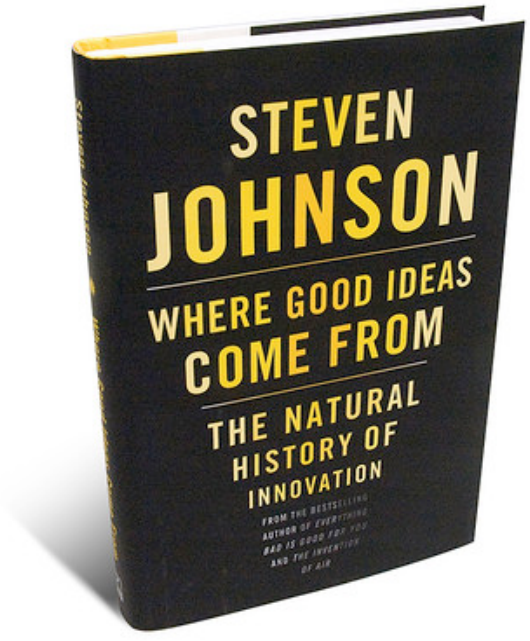
Main research question

First sub-question

Second sub-question

Third sub-question

based on your research question



http://bernardlherbier.unblog.fr/2010/05/12/discours-de-socrate-diotime/

2

design rationale

design rationale ...

“ ... a framework of the reasons behind decisions made when designing a system or artifact.

An understanding of the design rationale, or the justification for design decisions made throughout the design process, is necessary in order to understand, recreate, or modify a design ”

- wikipedia

wikipedia

design rationale research ...

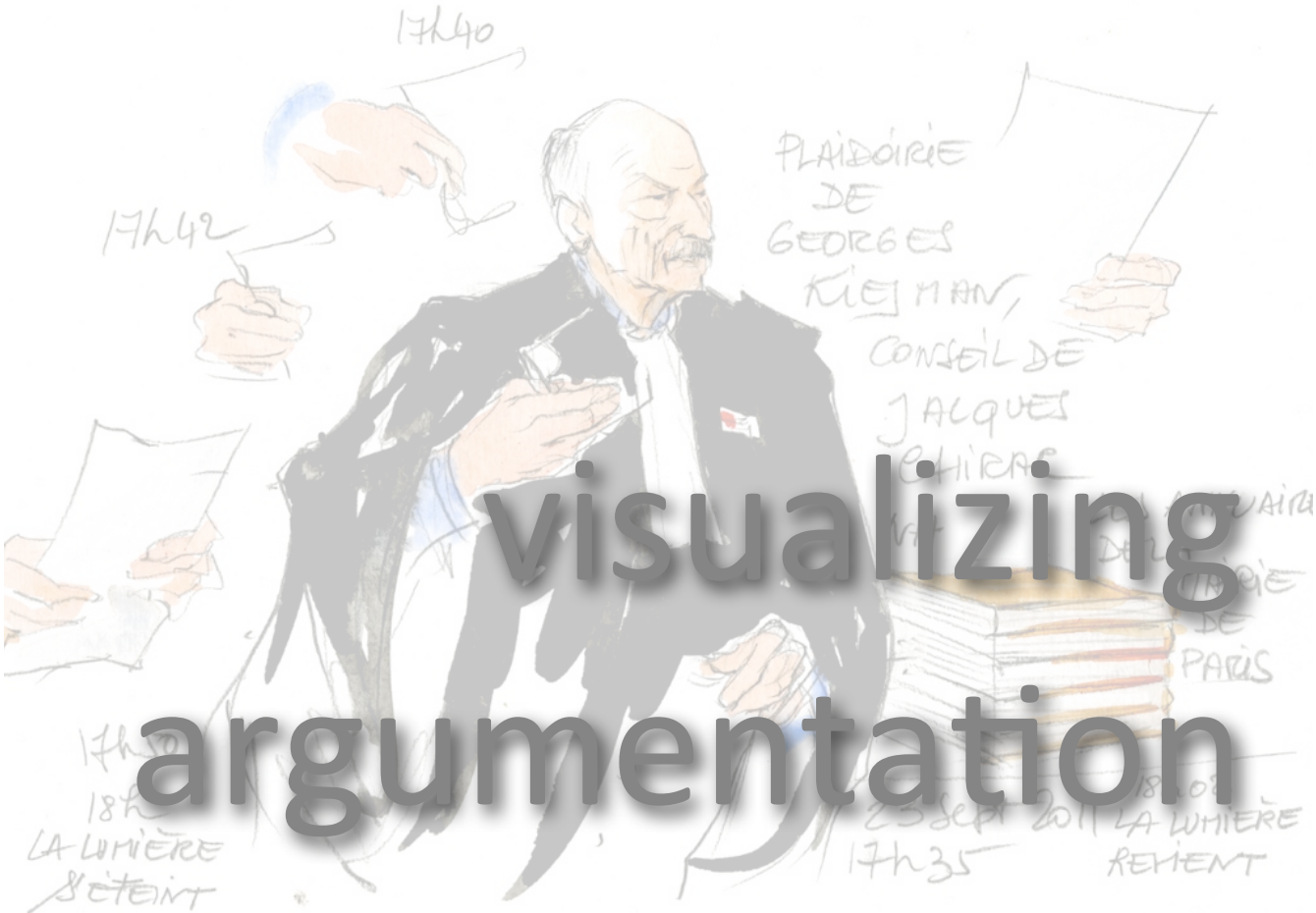
- effective methods and computer-supported representations
- for capturing, maintaining and re-using records of ...
- why designers have made the decisions

compendium

design rationale research ...

- the challenge is to make the effort of recording rationale worthwhile and not too onerous for the designer,
- but sufficiently structured and indexed that it is retrievable and understandable to an outsider trying to understand the design at a later date,
- and offers computational services that make the effort worthwhile

compendium



visualizing argumentation

argumentation-based design rationale

- decisions in teams/organizations are invariably made through debate and discussion
- but a lot of the effort and reasoning invested is often then lost, or locked in particular individuals' heads

compendium

dialogue mapping

- a facilitation process that creates a diagram or 'map' that captures and connects participants' comments as a meeting conversation unfolds
- especially effective with highly complex or “wicked” problems that are wrought with both social and technical complexity, as well as a sometimes maddening inability to move forward in a meaningful and cost effective way

issue-based information systems (IBIS)

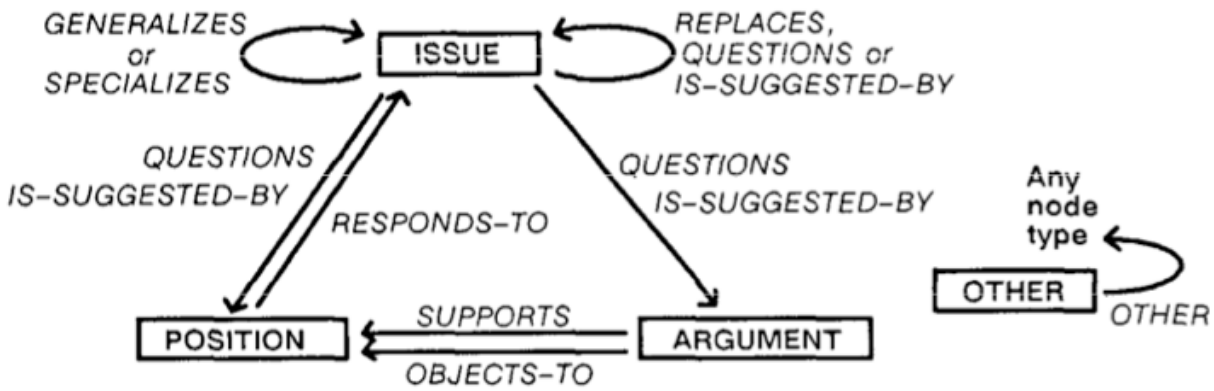
- a design rationale
- used to support group discussion
  invented by Werner Kunz and Horst Rittel in 1970
- adapted by Conklin et al. for use in software engineering in
  gIBIS a hypertext tool for exploratory policy discussion

IBIS elements

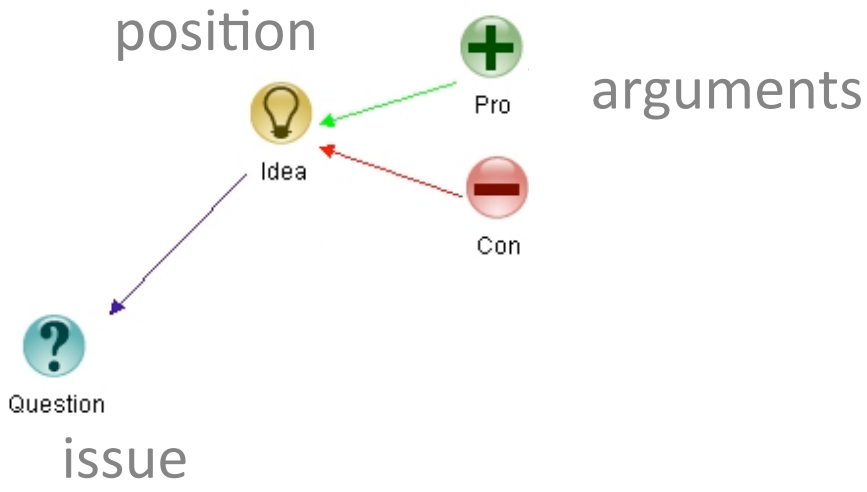
- issue (question)
  being discussed or analyzed

- position (idea)
  a response offering a potential resolution or clarification of the question.

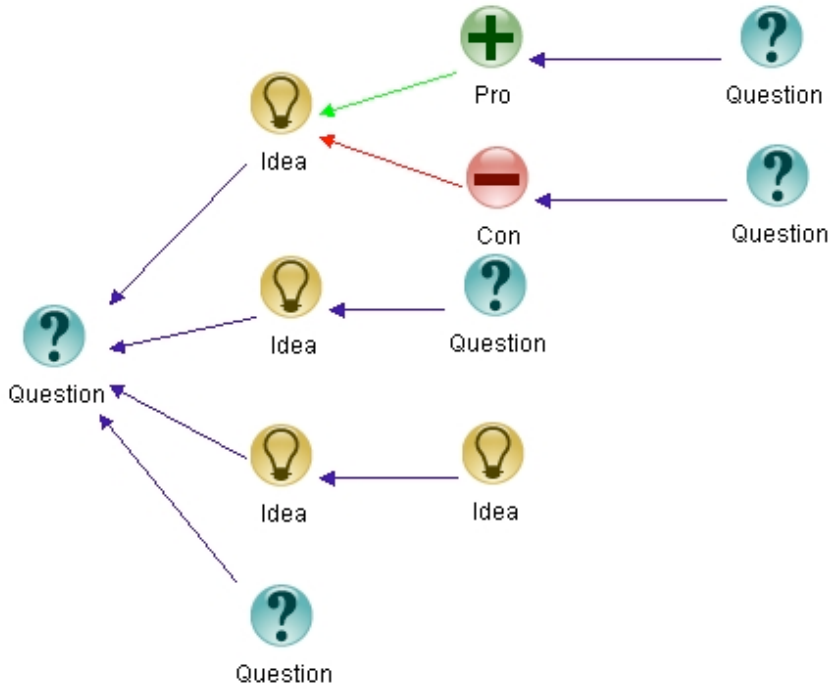
- argument
  in favor (pro) of or against (con) an idea



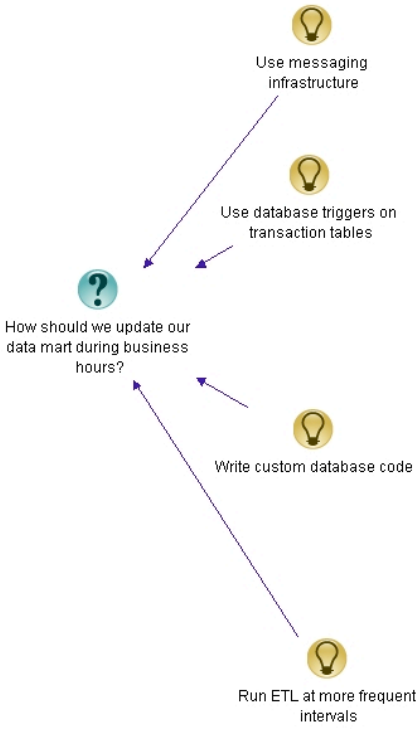
gIBIS model



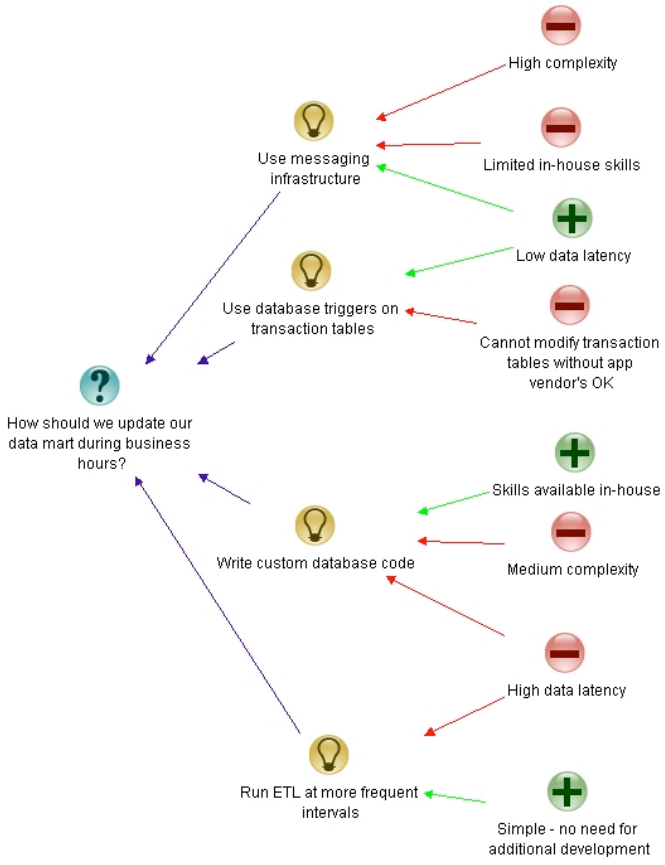
gIBIS (using Compendium)



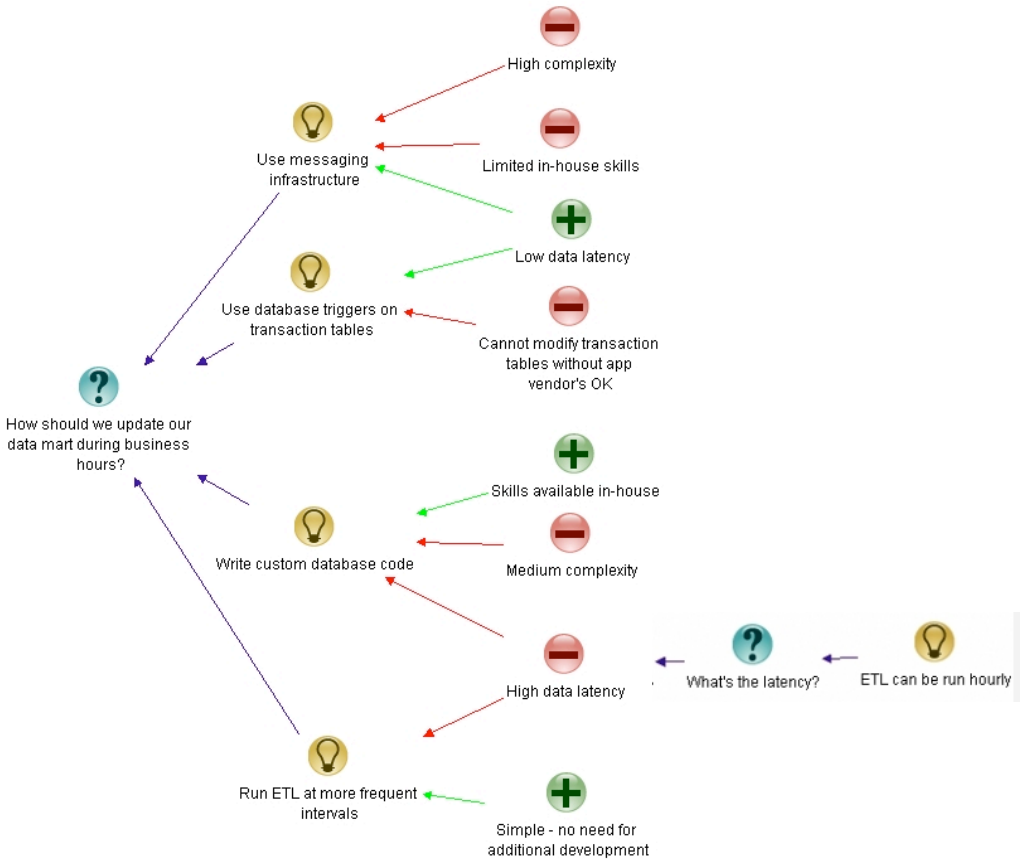
gIBIS (using Compendium)



Compendium



Compendium



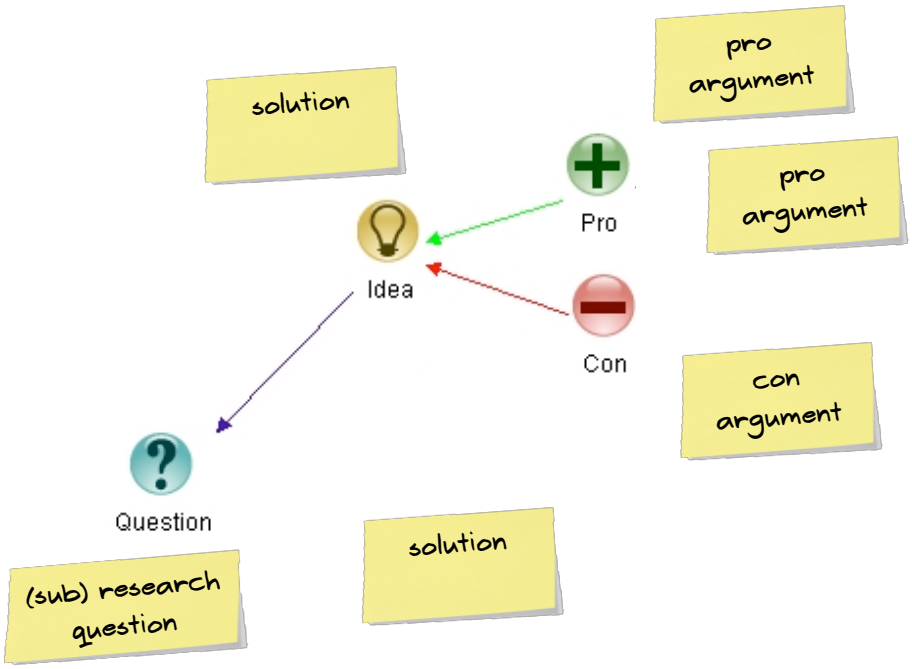
Compendium

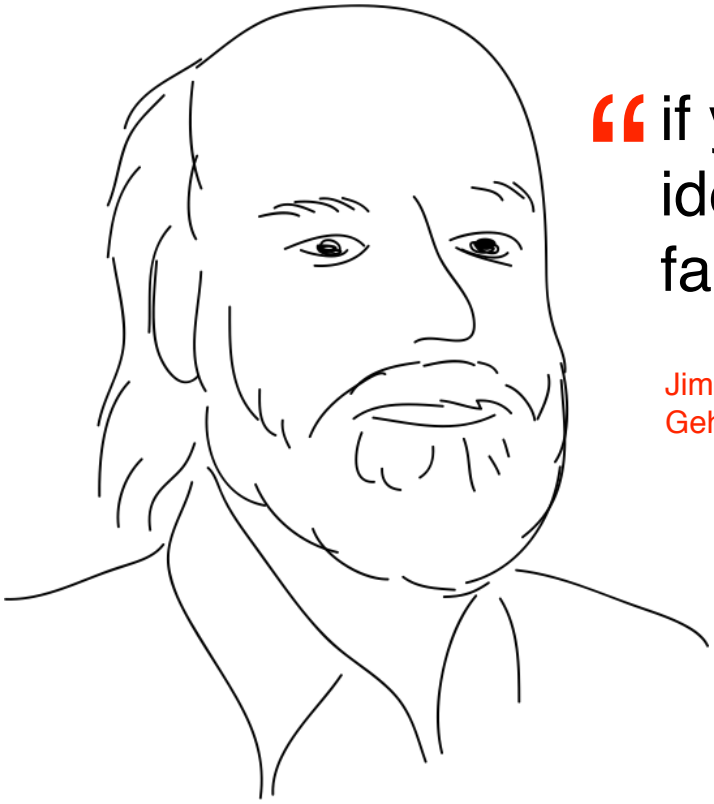
practice practice practice

design rationale ...

# of an artifact in ...

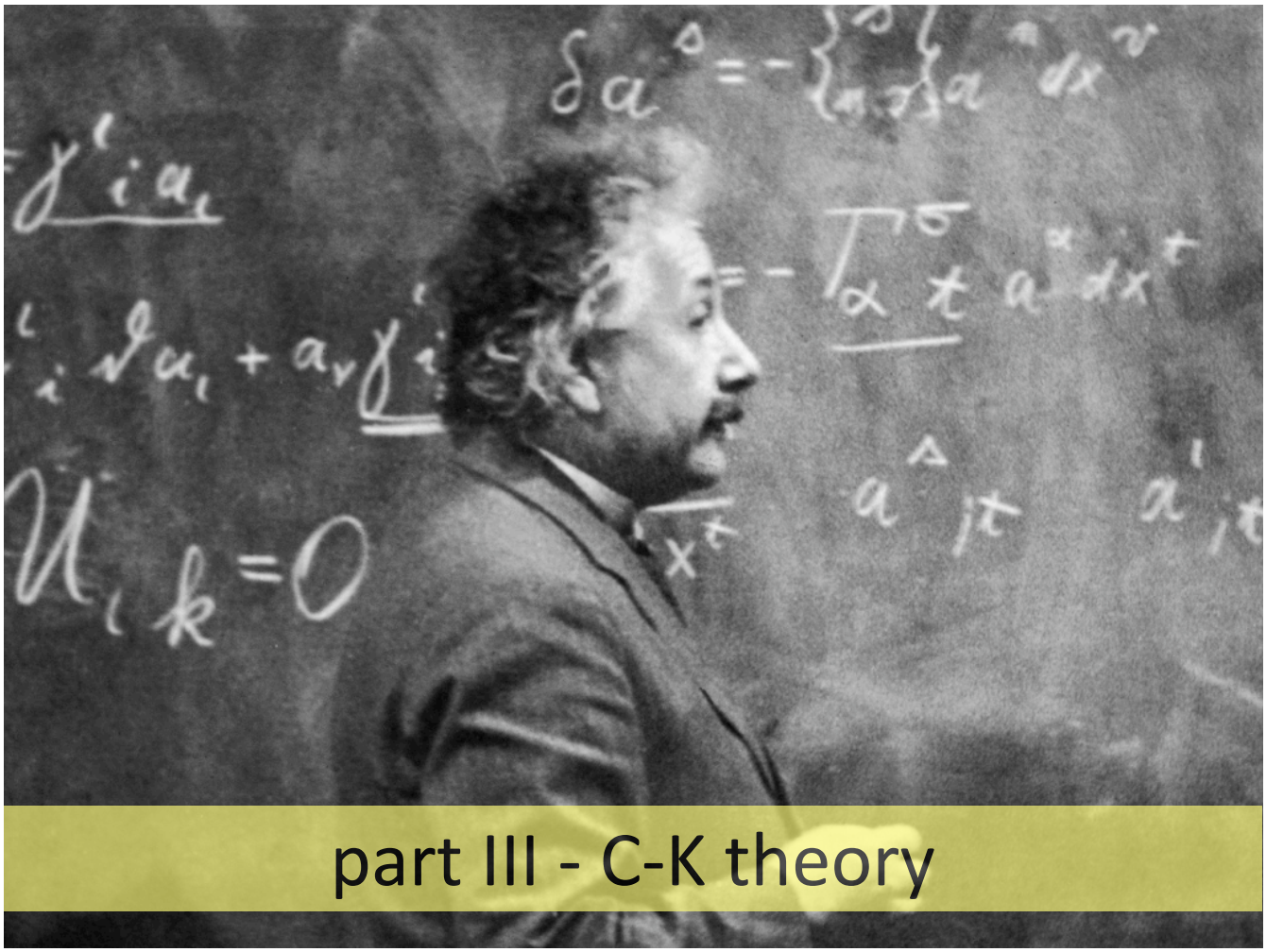

your own research


solution
pro argument
pro argument
Pro
Idea
Con
con argument
Question
(sub) research question
solution



“if you freeze to an idea too quickly, you fall in love with it ...”

Jim Glymph,
Gehry Partner



part III - C-K theory

3

C-K theory

C-K design theory: an advanced formulation

Armand Hatchuel and Benoît Weil (2009)
Research in Engineering Design, 19(4):181–192.

(Ondrus and Pigneur, 2009) *C-K Design Theory for Information Systems Research*

questions

what is the objective of the article?

what are the design theories?

why C-K theory?

design and knowledge

> “ ... design cannot be defined without a simultaneous knowledge expansion process. ”
>
> - Armand Hatchuel and Benoît Weil

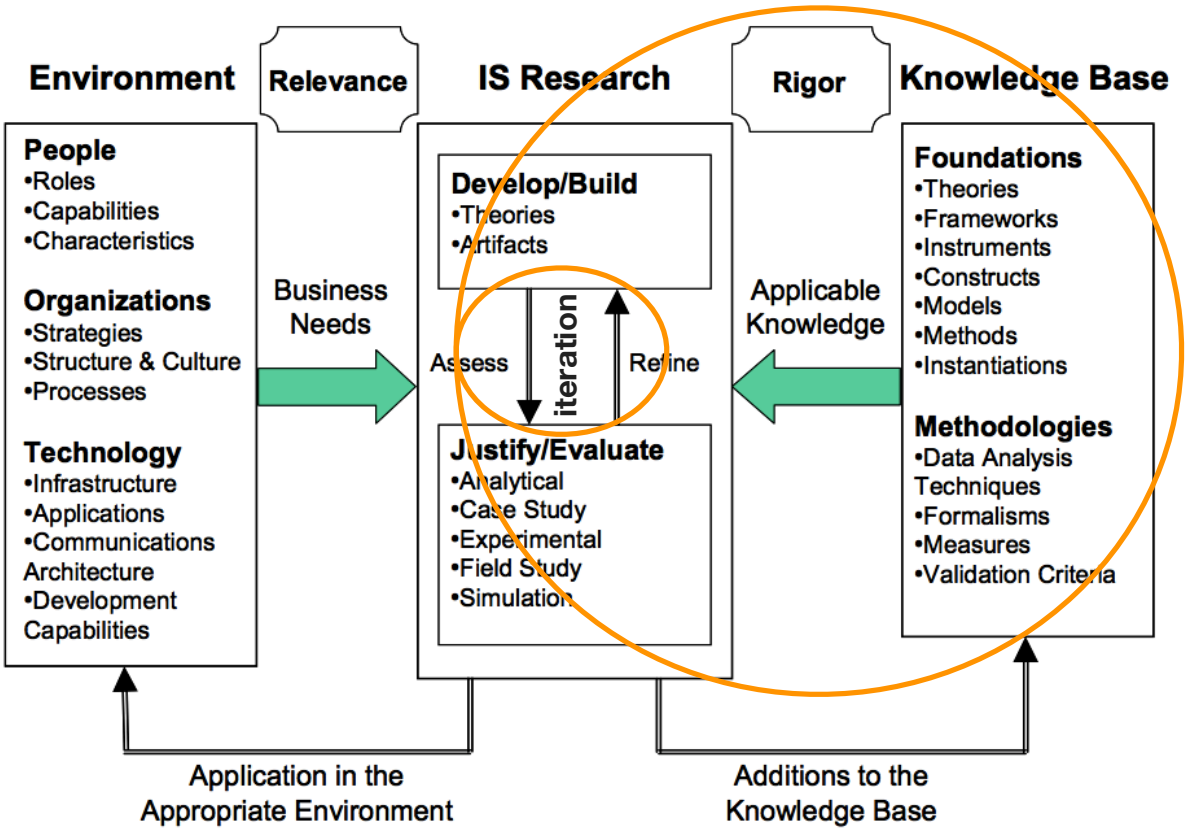


Figure 2. Information systems research framework

Component	Description
Core components	
1) Purpose and scope (the *causa finalis*)	"What the system is for," the set of meta-requirements or goals that specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundary.
2) Constructs (the *causa materialis*)	Representations of the entities of interest in the
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Additional components	
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8) Expository instantiation	A physical implementation of the artifact that can assist in representing the theory both as an expository device and for purposes of testing.

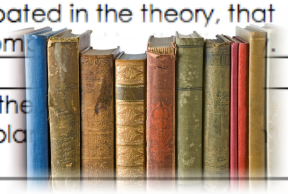


Table 2: Eight components of an IS design theory

C-K theory

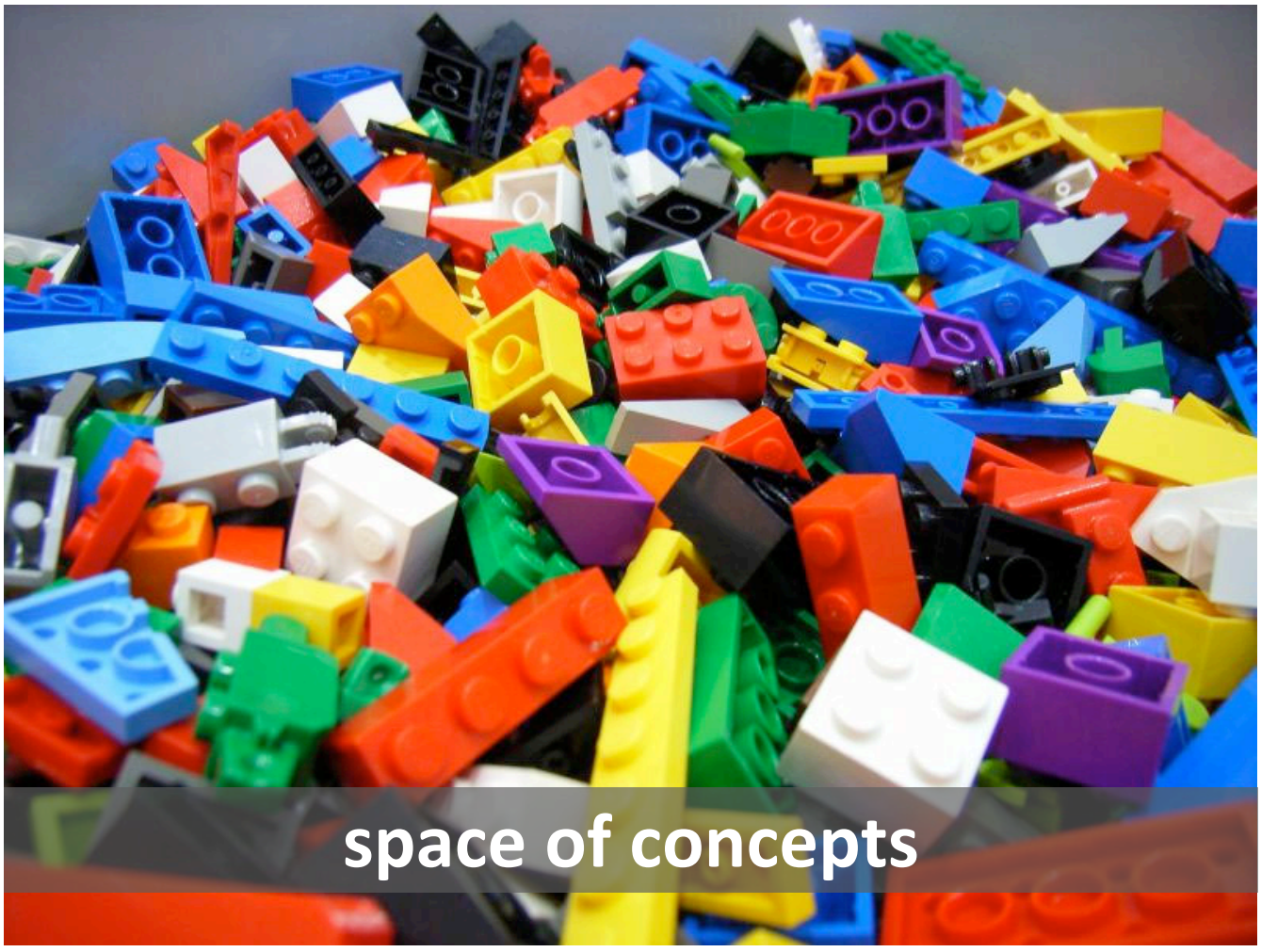
- a unified design theory introduced in engineering
- assumption that design can be modeled and analyzed as the interplay between two interdependent spaces: the space of concepts (C) and the space of knowledge (K).
- importance to capture the generation of new objects and new knowledge, which are distinctive features of design.

space of knowledge (K)

- the theory assumes a space of knowledge (K), which is the established knowledge available to a designer and contains propositions about partly known objects as well as relations between these objects

- proposition have a logical status (true or false in classic logic, but non standard logic could be adopted)

- K is expandable since its content changes over time



space of concepts (C)

- a concept is a proposition saying that *“an object verifies a group of properties”*

- a concept has no logical status in the space of knowledge (K): when a concept is proposed, it is not possible to prove this is a proposition of K

- concepts are considered as sets that can only be partitioned or included (not searched) ...

space of concepts (C)

- concepts are considered as sets that can only be partitioned or included (not searched):

✓ If a property is added, the set is partitioned in subsets

✓ If a property is removed, the set is included in a set that contains it.

- The space of concepts (C) has a tree structure based on these partitions and inclusions

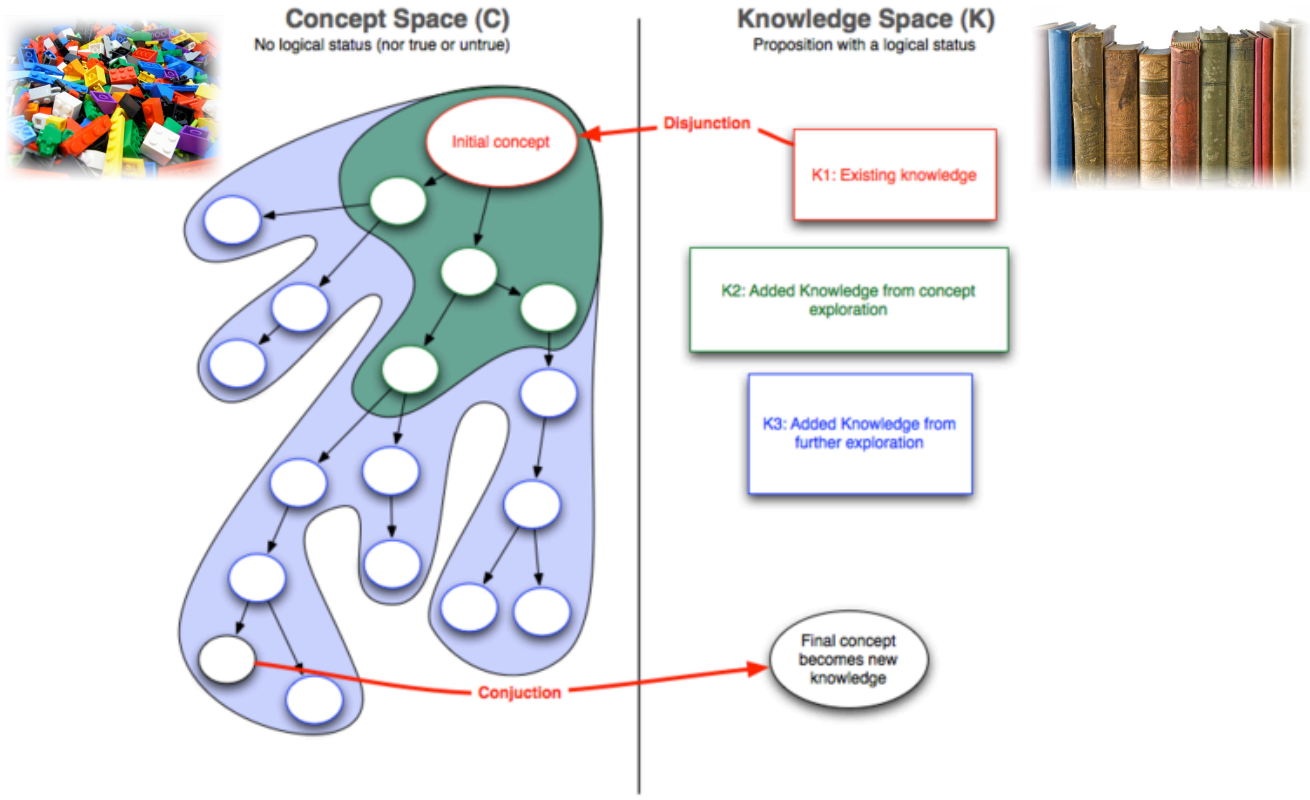


Figure 2. C-K dynamics

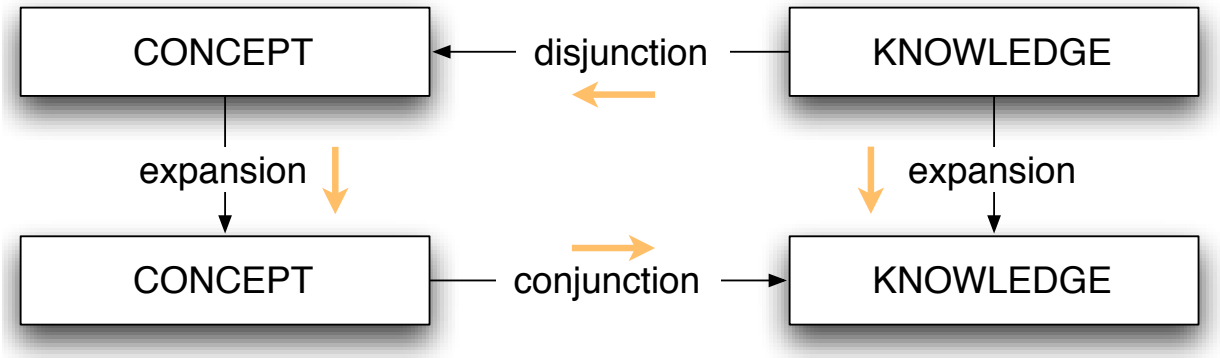
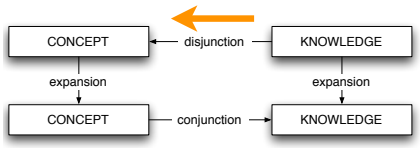


Figure 1. the design square

[Hatchuel et al., 2003]

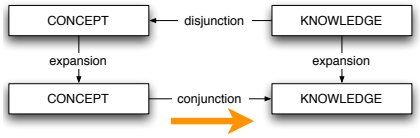
K→C operator

- this operators adds or removes properties from K to concepts in C
- it creates “disjunctions” when it transforms a proposition into a concept
- it corresponds to the generation of alternatives
- it expands the space C with elements from K



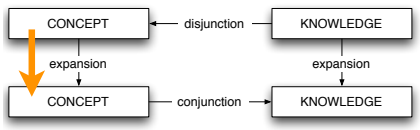
C→K operator

- this operator seeks for properties in K that could be added or removed to reach propositions with a logical status
- it creates “conjunctions” which could be accepted as finished design
- this corresponds to evaluation using an experimental plan, a prototype, or testing
- it expands knowledge with the help of concepts



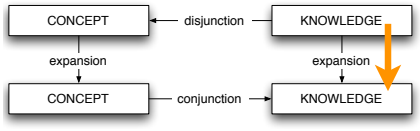
C→C operator

- this operator controls the expansion of the space or tree of concepts, by partition or inclusion



K→K operator

- this operator allows to expand the space of knowledge using logic and proving new theorems



expansion mechanism ...

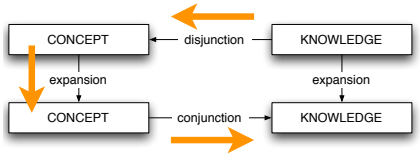
> “ ... helps to define design as the reasoning activity which starts with a concept about a partially unknown object and attempts to expand it into other concepts and/or to generate new knowledge. ”

- Armand Hatchuel and Benoît Weil

co-expansion ...

> “ design is the process by which K→C disjunctions are generated, then expanded by partition or inclusion, to reach C→K ”

- Armand Hatchuel and Benoît Weil



C-K theory illustration

research question ...

Is a theory developed in the engineering field, the *"C-K theory"*, a good candidate for dealing with design reasoning, and the relationship between design and knowledge in IS design research?

story of a design science research (with Jan Ondrus) ...

research objectives

- design a systematic approach to analyze rigorously the mobile payment market and its potential disruptiveness
- explore the hypothesis that multi-criteria decision-making (MCDM) methods are suitable for technology foresight
- represent the situation in the Swiss mobile payment market and reveals previously undiscovered weak signals for future trends

environment > the m-payment landscape (2005)

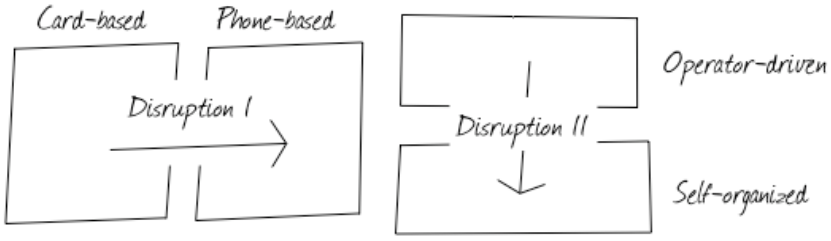
- Mobile payments were predicted to be successful
- Asian countries are in advance compared to the rest of the world
- Uneven developments in Europe (e.g., Austria)
- The U.S. market is lagging behind too
- The Swiss market is still immature

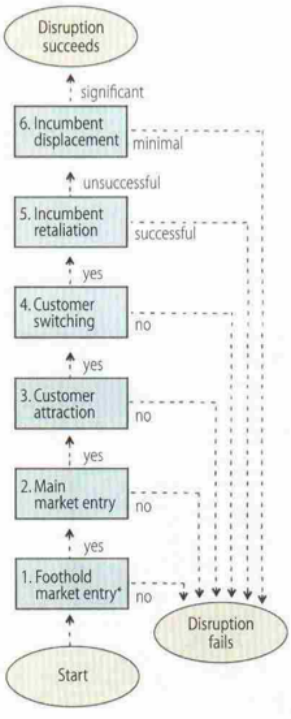
knowledge > state of the art

- m-payment is an emerging research topic but literature review revealed several gaps
- m-payments could be considered as a disruptive innovation but few approaches have been proposed to detect disruptions “ex ante”
- MCDM methods have been seen as possible candidates for technology foresight (Salo, 2003)

first sketch

1



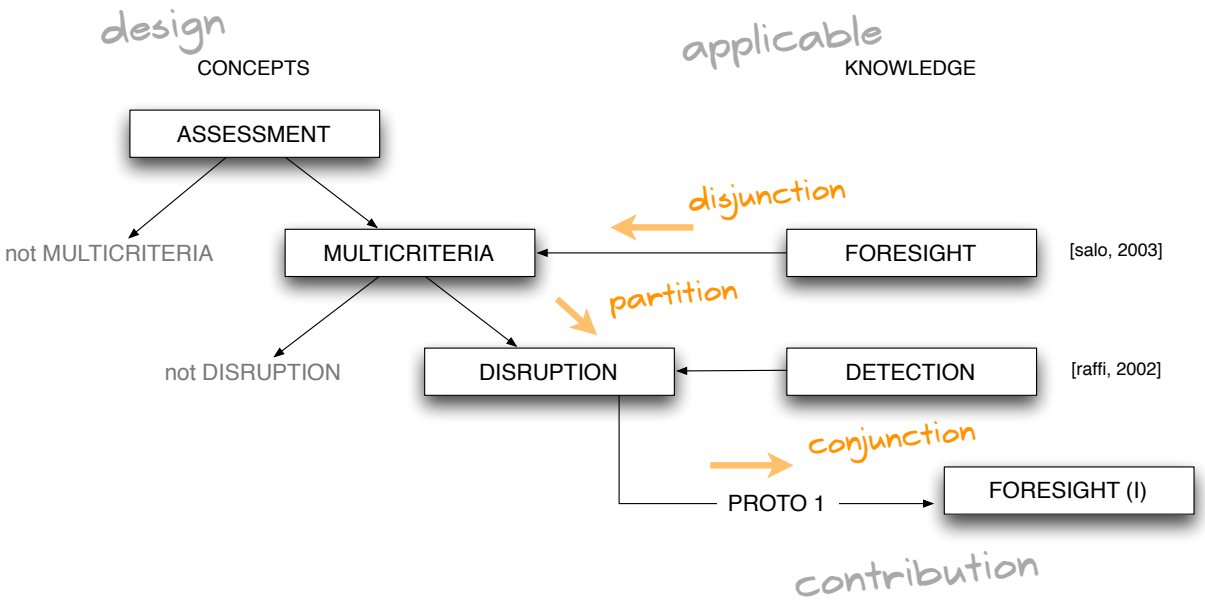


phase 1 > m-payment assessment using (Rafii, 2002)

Disruption I: From card-based to phone-based schemes			
Stage	**Forces disabling disruption**	**Evaluation**	**Forces enabling disruption**
1. Foothold market entry	- Required: large scale scheme and high volume of transactions	➡	- Generate extra revenue - Enable new services - Existing large customer base
2. Main market entry	- Legal concerns (prepaid) - Financial risks - Strong position of banks	➡	- Gray area for postpaid scheme - Possibility to acquire a bank
3. Customer attraction	- Education of users - Cost of mobile payments	=	- Better performance in specific industries
4. Customer switching	- Behavioral issues - Cultural issues - Better user interface needed	⬅	- Payment of new digital content mainly adopted by youths
5. Incumbent retaliation	- Bank's strong brand names - Loyalty and trust in banks	⬅	
6. Incumbent displacement	- MNO's dependence on banks - MNO's preference to collaborate with banks	⬅	- Market segments (micro vs macro)

Disruption II: From operator-driven to self-organized schemes			
Stage	**Forces disabling disruption**	**Evaluation**	**Forces enabling disruption**
1. Foothold market entry		➡	- Existing demand for personalization
2. Main market entry	- Large customer base missing - Cannot manage a global implementation alone - Legal issues (prepaid)	⬅	- Independent payment systems are already widely used in specific contexts
3. Customer attraction	- Not a standard means of payment	➡	- No commissions - Benefits due to personalization - Operator independent - Fast clearing
4. Customer switching	- Registration process	⬅	- Device not necessarily expensive (can be free)
5. Incumbent retaliation	- Bank's strong brand names - MNOs margin - MNOs control the SIM card	⬅	
6. Incumbent displacement	- Complements and not substitutes - No global solutions	=	- Transaction volume can be threating

m-payment assessment using (Rafii, 2002)



SYMBOL	Definition
ASSESSMENT	IS for assessing a technology landscape such as m-payment.
MULTICRITERIA	... using a multi-criterion approach
DISRUPTION	... with a predefined set of criterion for detecting a disruptive technology
FORESIGHT ←	Multi-criterion methods are appropriate for technology foresight (belief) [Salo et al., 2003].
DETECTION ←	A disruptive profil could be detected using a simple multi-criterion approach [Rafii and Kampas, 2002].
FORESIGHT (I) →	A simple multi-criterion approach is appropriate for simple technology foresight and disruption analysis [Salo et al., 2003] confirmed by [Ondrus and Pigneur, 2006], but limited explanation power.

Phase 1- Multi-criteria technology foresight > terminology

first sketch evaluation

- Exploratory interviews with Swiss industry experts
- Assessment of the two disruptions
  No Disruption I: Card-based systems are still dominant
  No Disruption II: Unlikely to happen due to barriers
- weaknesses ...
  only a broad overview
  need for a finer granularity to grasp the phenomenon

initial design

2

initial design > a MCDM approach

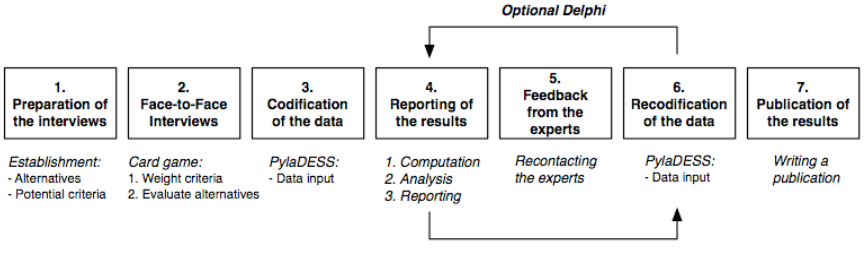
- Use of a more formal and structured MCDM method ...
  ELECTRE I & Group decision feature
- Multi-actor approach is possible
- Comparison of several alternatives
- Finer granularity of analysis ...
  Nature of the data collected
  Outcome is more formal and precise

Alternatives	Criteria
Money Regular cash (i.e. coins, bills)	**Ease of use** This criterion refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis 1989).
Magnetic card Plastic card with a magnetic stripe	**Cost** It regroups direct costs (e.g. cost of the technology, cost of implementation) and indirect costs (e.g. infrastructure operation and maintenance).
Smartcard Plastic card with a chip	**Reliability** The purchase process should be flawless as it involves a financial transaction.
Contactless card Plastic card equipped with an RFID chip	**User/Market Acceptance** This criterion represents the degree to which the user and the different stakeholders are already consenting to accept a technology for payment purposes.
Mobile phone "remote" Mobile phone using a remote network (e.g. GSM, GPRS, UMTS). The payment transactions transit through a telco mobile network infrastructure. This could be done using SMS, Premium SMS, USSD, WAP.	**Security** Implicit security features (e.g. embedded encryption) and ease of securing the implementation of the technology.
Mobile phone "proximity" Mobile phone using a proximity network (e.g. Bluetooth, Infrared, RFID). The payment transactions transit through a locally established wireless network.	**Flexibility** Degree to which the technology can be adapted in many different applications.
	Value proposition improvement Improvement in value a technology could bring to the customer.
	Maturity Development state of the technology.
	Speed Implicit speed of the technology for payment processes.
	Scalability Ability to grow. Usability in small and large environment.

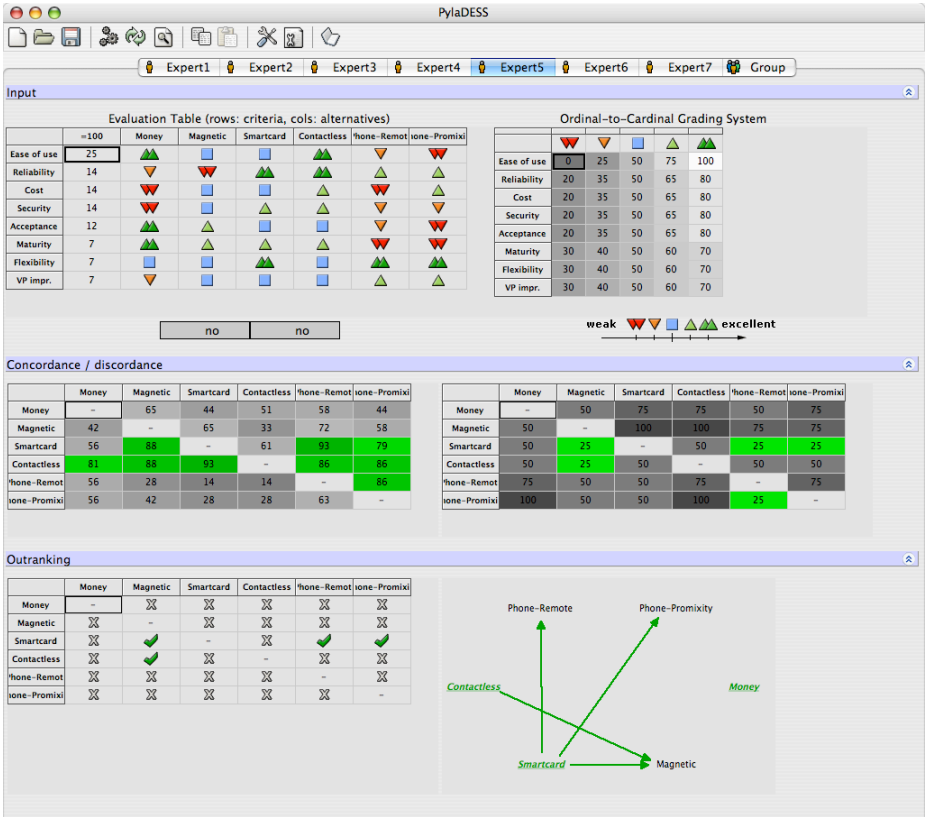
disruption I > alternatives and criteria

phase 2 > Electre model

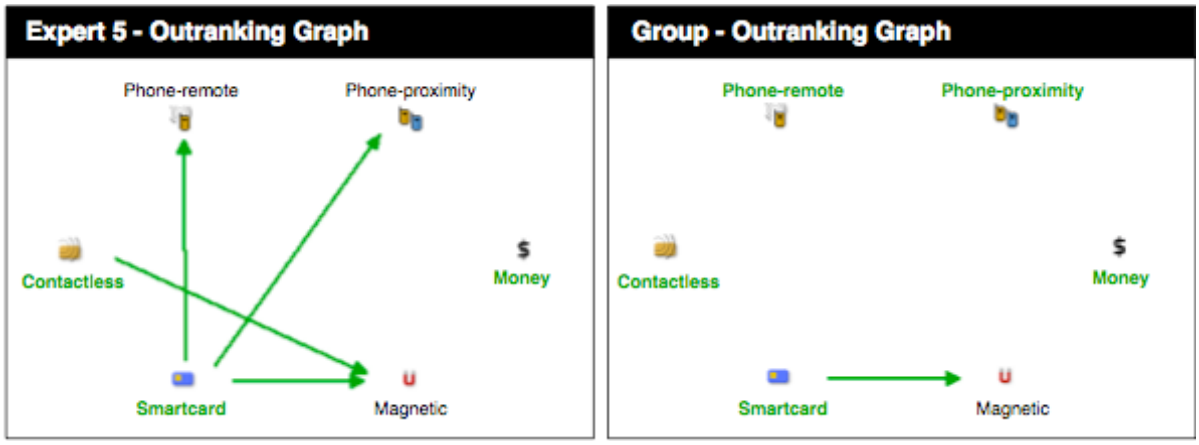
- [Constructs]
  Alternatives, criteria, weights, evaluations, and actors
- [Model]
  ELECTRE I algorithm + group decision feature
- [Method]



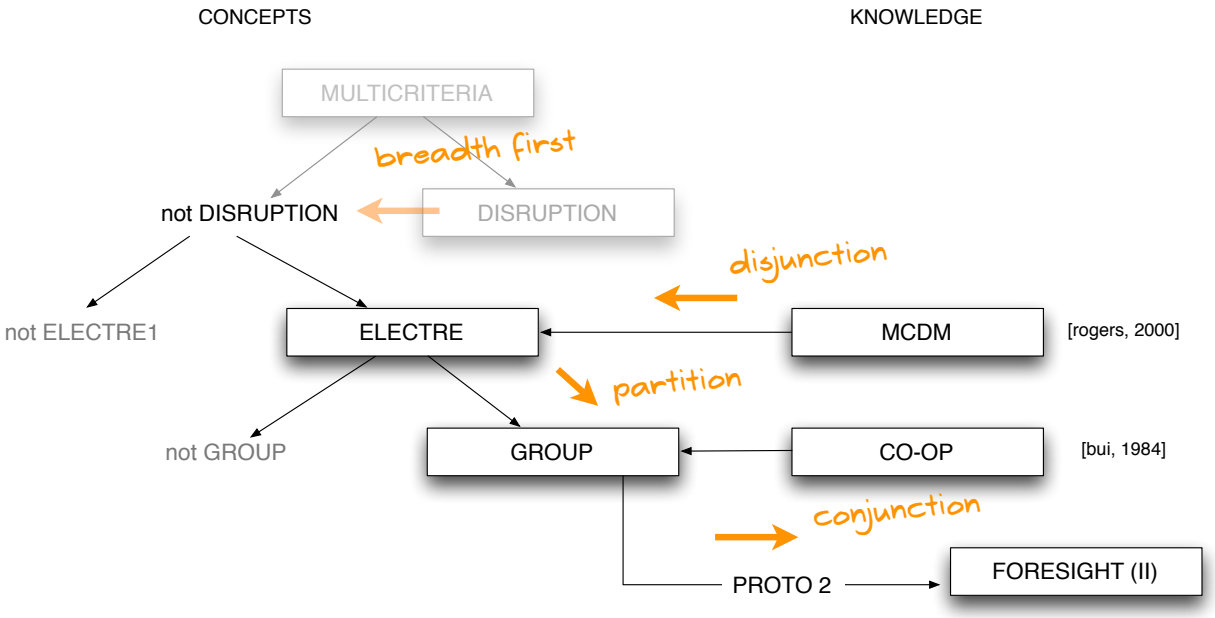
- [Instantiation]
  First version of *PylaDESS*



PylaDESS v1.0



outranking graph using Electre



Phase 2 - Electre technology foresight

phase 2

SYMBOL	Definition
ELECTRE	... using *Electre I* as a more powerful multi-criterion approach
GROUP	... with group decision (GDSS) features
MCDM	*Electre I* is an MCDM method that gives the possibility to model a decision making process by using the concordance and discordance indexes, and the outranking relations [Rogers et al., 2000].
CO-OP	Group decision features can be added to MCDM methods for supporting cooperative decision making, based on the min-max concept in game theory [Bui and Jarke, 1984].
FORESIGHT (II)	An *Electre I* multi-criterion approach, with a group decision feature, is appropriate for technology foresight [Salo et al., 2003] confirmed by [Ondrus and Pigneur, 2007].

Phase 2 - Electre technology foresight > terminology

initial design evaluation

- Structured interviews with Swiss key experts, with “Pack of Cards” technique
- Individual outranking graphs for 6 experts
- A consensus on one outranking relation
- No Disruption I: Cards-based systems are still dominant

initial design weaknesses

- Insufficient exploitation of the richness of the data
- Lack of explanation of the non-consensus
- Limited scalability of the data collection process
- Minimal visualization of data and outcome

refined design

3

refined design

- many improvements in *PylaDESS* ...
  development of computerized “Pack of Cards”
  addition of another MCDM method (WSM)
  enhanced visualization (e.g., proximity maps)

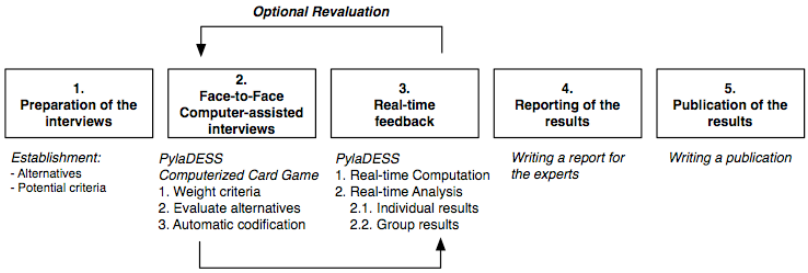
- More experts involved to ...
  increase the relevance of the study, and
  provide a good representation of the whole industry

phase 3 > a mixed MCDM approach

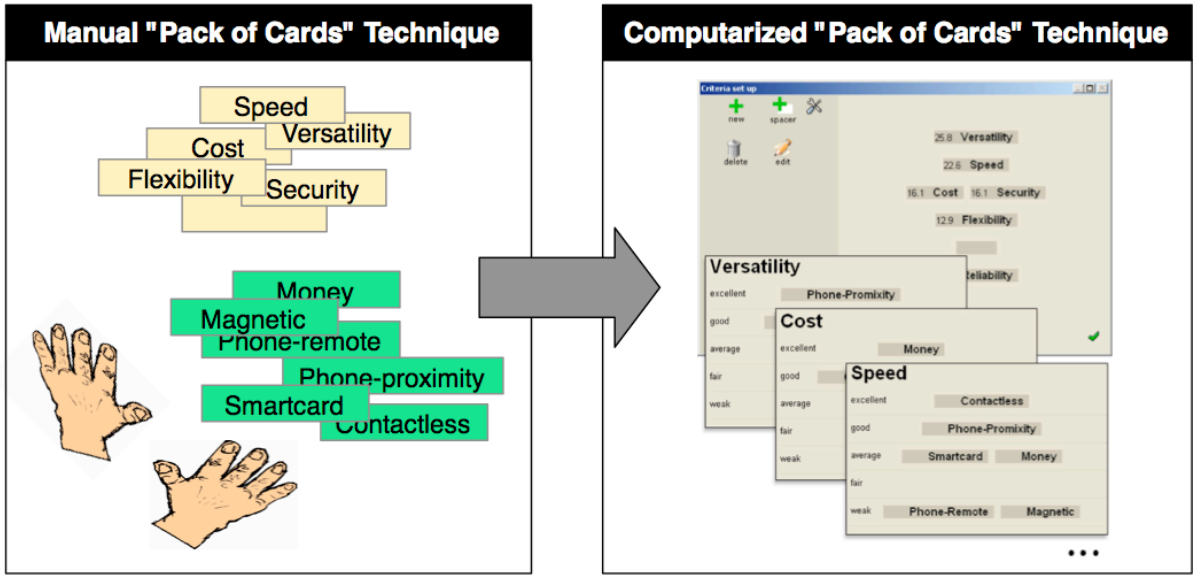
- [Constructs]
  Alternatives, criteria, weights, evaluations, rankings, distances and actors

- [Model]
  ELECTRE I algorithm + group decision feature, WSM, proximity maps

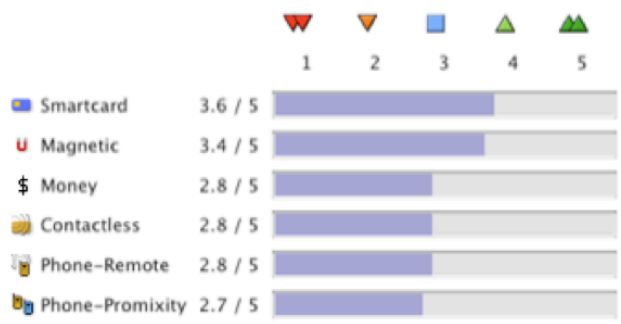
- [Method]



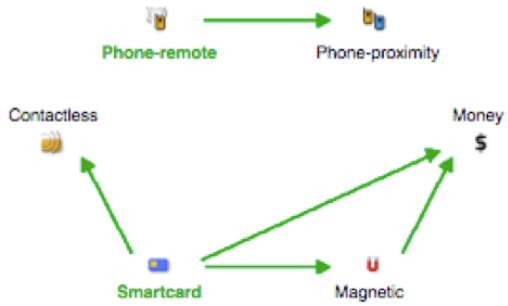
- [Instantiation]
  refined version of *PylaDESS* with ”pack of cards” and other features



PylaDESS v2.0 > pack of cards

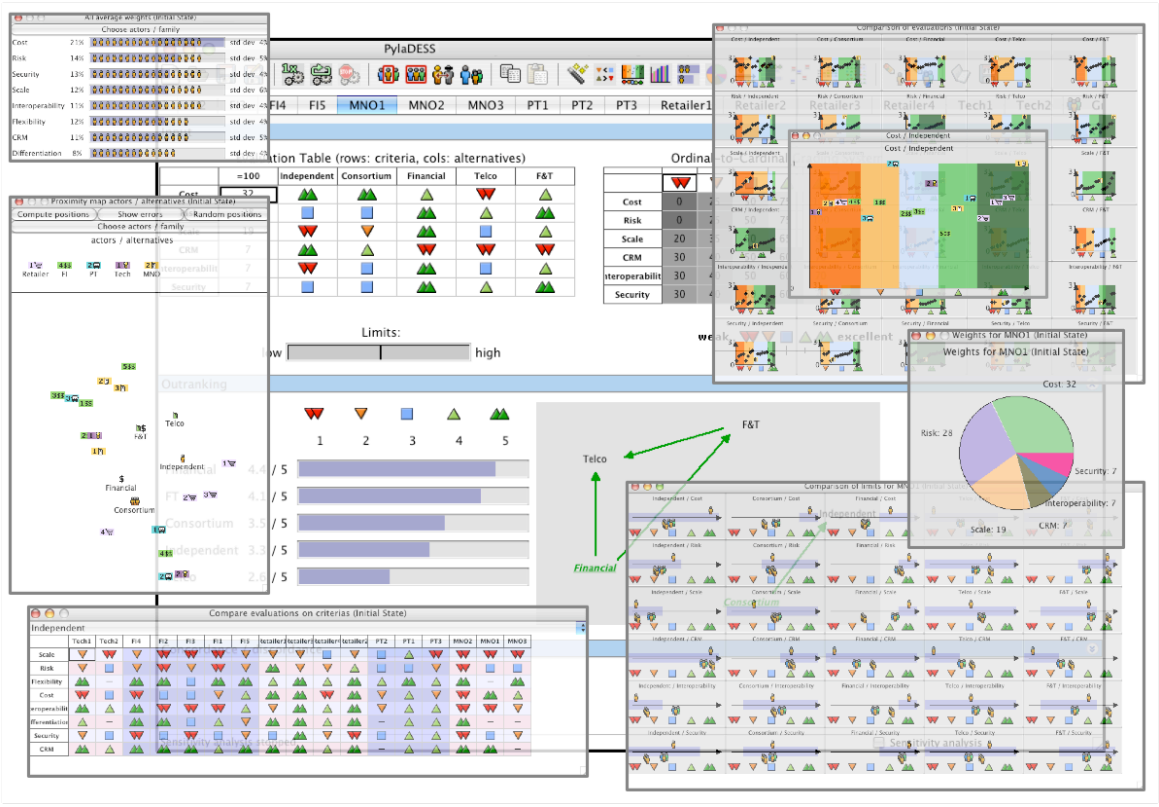


Weighted Sum Model

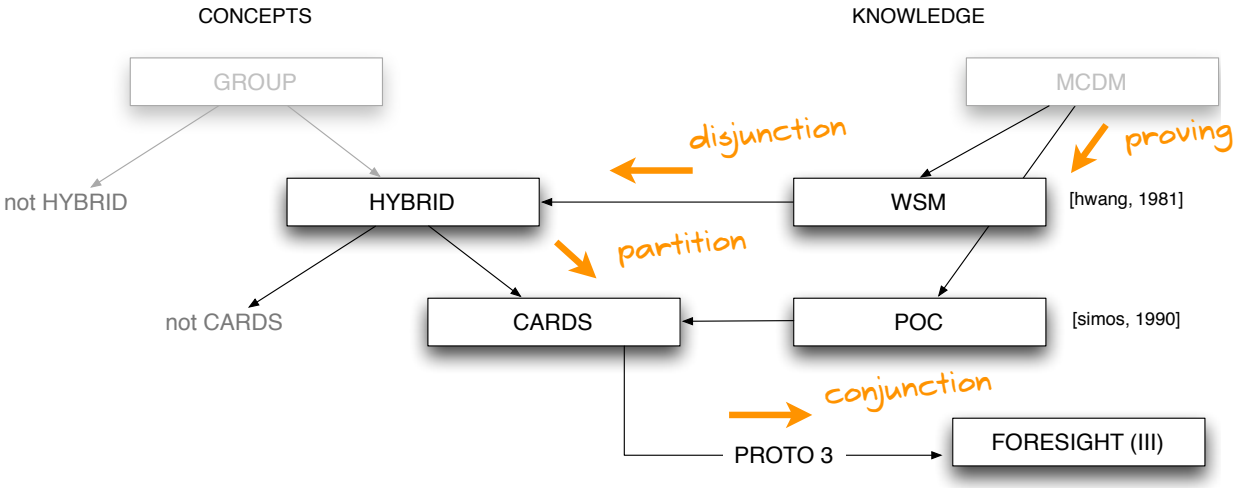


ELECTRE I

PylaDESS v2.0 > mixing WSM & Electre



PylaDESS v2.0 > visualization



Phase 3 - Hybrid technology foresight

phase 3

SYMBOL	Definition
HYBRID	... using a mixed approach combining *Electre I* and *WSM*
CARDS	... using a computerized *Pack of Card* technique
WSM	*Weighted Sum Model (WSM)* enables the computation of a ranking of the best alternatives based on the preferences collected [Hwang and Yoon, 1981].
POC	The *"Pack of Cards"* technique replaces the rankings by cards for weighting criterion and ranking solutions [Simos, 1990].
FORESIGHT (III)	An extensive multi-criterion approach, with group decision and highly interactive features, is clearly appropriate for technology foresight [Salo et al., 2003] confirmed by [Ondrus and Pigneur, 2007].

Phase 3 - Hybrid technology foresight > terminology

refined design evaluation

- 20 representative companies of 5 industries in the mobile payment market
- Active use of *PylaDESS* during the interviews: computerized “Pack of Cards” and real-time feedback
- Assessment of the two disruptions ...
  No signs of Disruption I
  Weak signals of Disruption II

Financial Institutions	**Mobile Network Operators**	**Retailers**
Credit Suisse Corner Bank Datatrans PostFinance Telekurs Multipay UBS Viseca	Orange Sunrise (TDC) Swisscom Mobile	Coop McDonald’s Migros MyOne
	Public transportation	**Technology Providers**
	SBB (National Railways) TL (Lausanne) ZVV (Canton of Zurich)	Crealogix link-u Polyright (Kudelski group)

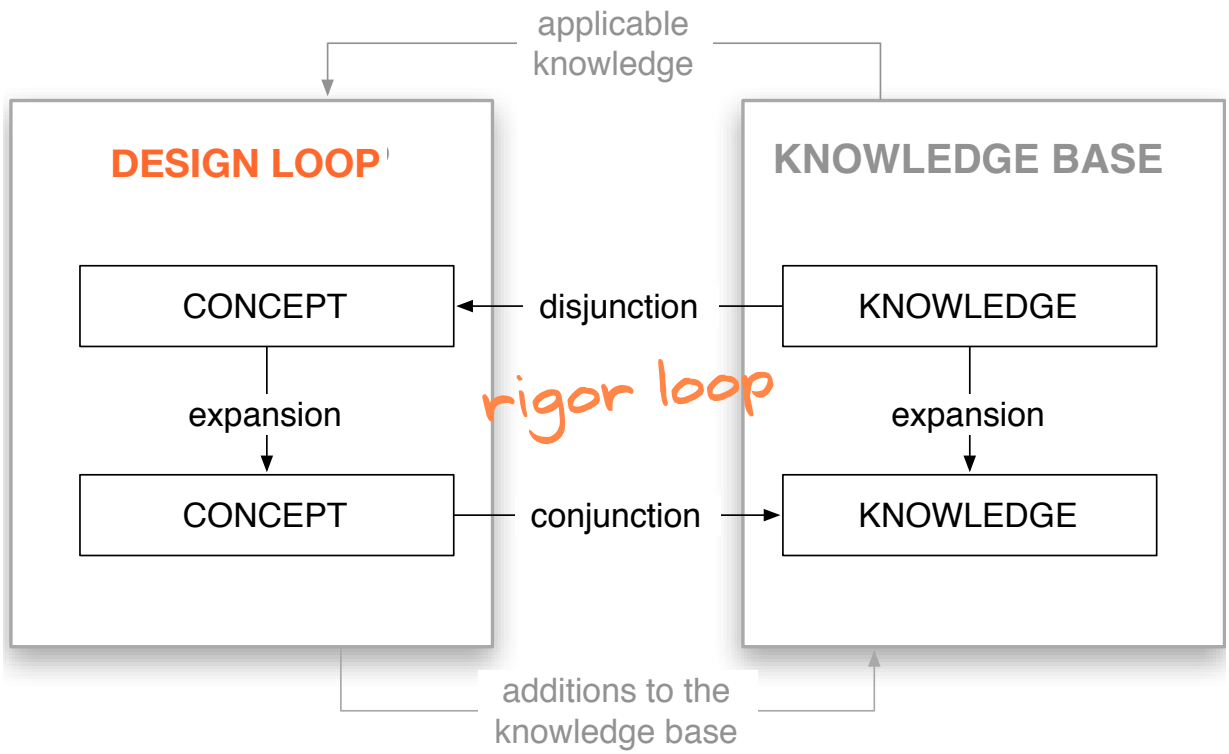
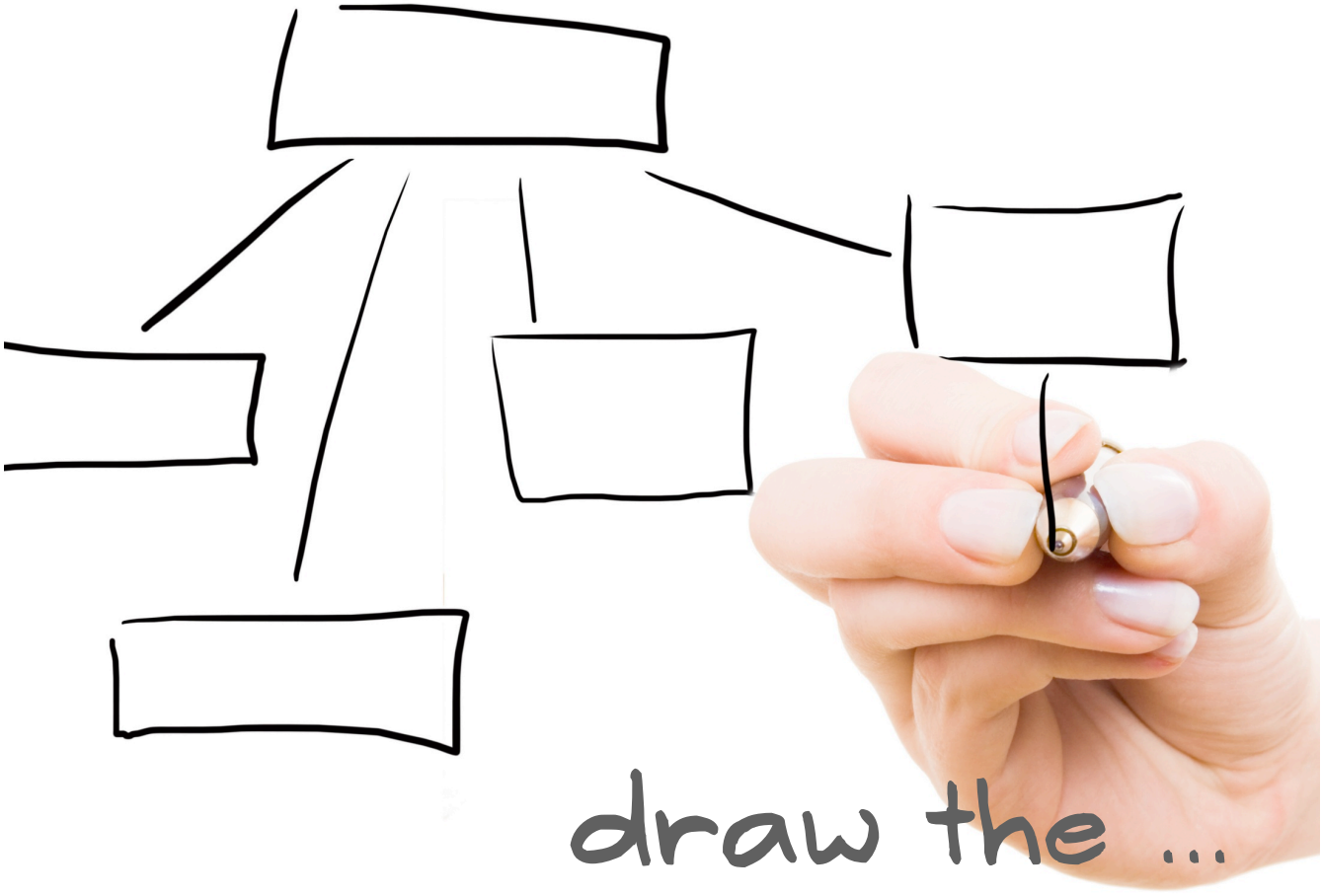


Figure 1. the design square & Hevner's framework


draw the ...


concept space &


knowledge space of


your own research