Open Innovation Platform
University - Enterprise Collaboration

Hands on Problem Solving
LUT Summer School
July 25-29, 2016

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WHERE ARE WE NOW?

Design Task
Clarification

Problem Framing
and Idea Generation

Concept Formulation
and Assessment

Introduction
Outline

• Problem Framing
  • Network of Problems and Partial Solutions
  • Exploring the design space with the System Operator (multi-screen)
Outline

- Problem Framing
  - Network of Problems and Partial Solutions
  - Exploring the design space with the System Operator (multi-screen)
(Some) characteristics of design problems

- **There is no definitive formulation of the problem**
  - Temporary formulations are unstable and can change as more information becomes available

- **Formulations of the problem are solution-dependent**
  - The way the solution is conceived influences the way the problem is conceived

- **Any problem formulation may embody inconsistencies**
  - Many conflicts and inconsistencies emerge in the problem-solving process and have to be resolved in the solution

Source: Cross (2008)
Problem Framing

• (Some) characteristics of design problems (continued)

❖ Proposing solutions is a means of understanding the problem
  − Many constraints and criteria emerge as a result of evaluating solution proposals

❖ There is no definitive solution to the problem
  − Different solutions can be equally valid responses to the initial problem

Source: Cross (2008)
Problem Framing

Conceptual Maps

- Concept maps are graphical tools for organizing and representing knowledge.
- A concept map is a 2-dimensional node-link representation that depicts the most important concepts and relationships.

Steps in Concept Mapping

1. Prepare Project
   - Focus
   - Participants
   - Schedule

2. Generate Ideas

3. Structure Ideas
   - Sort
   - Rate

4. Compute Maps
   - Multidimensional scaling
   - Cluster analysis

5. Interpret Maps

6. Utilize Maps
Network of Problems and Partial Solutions:

- Pb 1
  - S 1.1
  - Pb 3
    - S 1.3
    - S 2.3

- Pb 2
  - S 1.2
  - S 2.2
  - Pb n
    - S 1.n
    - S 2.n
    - S 3.n
Problem Framing

Network of Problems and Partial Solutions:

- Nodes:
  - Problems (Pb)
  - Partial Solutions (PS)
  - Questions to Experts (QE)
  - Constraints (Cnstr)
Problem Framing

Network of Problems and Partial Solutions:

- Nodes:
  - Problems (Pb)
    - whatever we are not comfortable with
    - whatever objective we would like to achieve
  
  - Describe it with a statement about what we don’t like:
    - How to... (Useful Function)?
    - Insufficient performance of a desired function
    - Undesired side effect of a design choice
    - Excessive consumption of a resource
Network of Problems and Partial Solutions:

- Nodes:
  - Partial Solution (PS)
    - whatever we know that at least partially addresses a problem
    - whatever we suppose that at least might address a problem
    - whatever details a more specific way to implement a PS
Network of Problems and Partial Solutions:

- Nodes:
  - Questions to Experts (Information need)
    - Whatever info need emerges within the problem solving process
  - Typical sources of information:
    - Information Retrieval within the Company
      - Other divisions/departments/colleagues
      - Past experiences
    - Information Retrieval from Outside the Company
      - Patents, Technical/Scientific Papers
      - Customers, Market, Benchmarks
Network of Problems and Partial Solutions:

- Nodes:
  - Constraint
    - Whatever feature that cannot be modified to any extent, but should be taken into account
      - Standards and rules
      - Contract specifications
      - Physical Laws

- Warning:
  Don’t confuse problems with constraints!
  Double check if what you are describing as a constraint can be transformed into a further problem to address (e.g. through 5 Whys)
Network of Problems and Partial Solutions:

- Links:
  - $\text{Pb} \Rightarrow \text{Pb}$ (cause-effect relationships, decompositions)
Problem Framing

- Network of Problems and Partial Solutions:
  - Links:
    - Pb $\Rightarrow$ PS
    - PS $\Rightarrow$ Pb
Building a Network of Problems and Partial Solutions (excerpt from Tutorial 1, continued):

<table>
<thead>
<tr>
<th>NEED (TF)</th>
<th>STAKEHOLDER(s)</th>
<th>REQUIREMENT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearable</td>
<td>-FITMI</td>
<td>Lightweight: &lt; 30g</td>
</tr>
<tr>
<td></td>
<td>-RUNNERS</td>
<td>Easy to wear (max. 2 actions required)</td>
</tr>
<tr>
<td>Long battery</td>
<td>-RUNNERS</td>
<td>Max. 1 recharge/week with all tracking features in active mode</td>
</tr>
<tr>
<td>life</td>
<td>-FITMI</td>
<td></td>
</tr>
</tbody>
</table>

- **Pb: 30**
  - The device should be lightweight (30g or less)

- **Pb: 2**
  - The device should be easy to wear (less than 2 actions)

- **Pb: 1**
  - The device should last long without recharging with tracking features on (at least 1 week)
Building a Network of Problems and Partial Solutions (excerpt from Tutorial 1, continued):

- **Pb: 1**
  The device should last long without recharging with tracking features on (at least 1 week)

- **PS: 2**
  Add extra battery for extended duration

- **Pb: 2**
  Add extra battery for extended duration

- **Pb: 30**
  The device should be lightweight (30g or less)
Problem Framing

Pb: 1
The device should last long without recharging with tracking features on (at least 1 week)

PS: 2
Add extra battery for extended duration

Pb: 3
The device should be water proof

PS: 4
Increase sealing with double gasket

Pb: 30
The device should be lightweight (30g or less)
The device should be lightweight (30g or less)

Pb: 30

The device should last long without recharging with tracking features on (at least 1 week)

Pb: 1

The device should be easy to wear (less than 2 actions)

Pb: 2

Add extra battery for extended duration

PS: 2

Increase sealing with double gasket

PS: 4

The device should be water proof

Pb: 3

The device should be resistant against scratches

Pb: 6

Use plastics for the case

PS: 5

Use lightweight metal alloys for the case

PS: 8

High cost of materials for the case

Pb: 9

The device should have a nice look

Pb: 7

Problem Framing
Problem Framing

- Exemplary Network of Problems and Partial Solutions after a half-day workshop in industry
Problem Framing

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Problem Framing

Network of Problems and Partial Solutions:

- How to build them
Outline

• Problem Framing
  • Network of Problems and Partial Solutions
  • Exploring the design space with the System Operator (multi-screen)
Exploring the Design Space

PAST
SUPERSYSTEM
SYSTEM
SUBSYSTEMS

PRESENT

FUTURE

ANTI-SYSTEM Layer
SYSTEM Layer
SUBSYSTEMS Layer

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Exploring the Design Space

Different meanings of time

- Meaning #1: Technical Evolution (Historical Time)
  - What principle was used in the past to deliver the function of the system? How was the system like in the past?
  - What principle is currently used to deliver the function of the system? What is the current structure of the system?
  - What principles might be used in the future to deliver the same function? What is the ideal system?
Different meanings of time

- Meaning #2: Phases of a Process
  - What phases precede the activity under analysis? What actions does the object of the function undergo before the current one?
  - Concurrent actions; simultaneous auxiliary functions
  - What phases will follow? What further actions will the object receive after?
Different meanings of time

- Meaning #3: Cause and Effect Chains
  - Root Cause: What event or situation did create the conditions for the appearance of our problem?
  - Failure Mode: What is the manner in which the failure of our system can occur?
  - Failure Effect: What are the undesired consequences of the failure?
The System operator can be used as a tool by itself with different functions within the problem solving process:

- **During the preliminary stages of the problem solving process**, while looking for roundabout problems whose solution allows to obtain the same overall goal, a multi-screen view helps orienting the thought from cause prevention to effects compensation or mitigation, as well as a means to change the scale of the solution space in order to avoid psychological inertia.

- **While looking for resources**, the System Operator helps focusing the attention on every relevant aspect of the system and its environment, by analyzing any time stage at any detail level with a systematic approach.
Exploring the Design Space

The «screens» are more than 9!!
Task for Today Afternoon Session

1. Revise and complete your stakeholder analysis; formulate a comprehensive design specification
2. Build your Network of Problems and Partial Solutions
   • Check coherence with the list of requirements you identified
   • Propose your first ideas to explore the design space and apply System Operator to enrich the map
   • Manage your time and competences properly!
3. Prepare the presentation of your partial results
   • Deliver a PPT to gaetano.cascini@polimi.it by 16:15
   • Put the names of your team-members in the first slide
   • At least 2 team members speaking
   • The presentation should last 7 minutes (or less)
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