Research & industry workshop - *ICT with Industry* - TNO & Océ case

Title: Architecting support using system architecture knowledge graphs and expert systems

Workshop aim: Researchers and industry experts meet to find directions for co-innovation. The workshop aims to find innovative directions for research to exploit the knowledge graph to support the system architect: e.g. notification for inconsistencies or incompleteness, suggestions for analysis, generation of relevant questions, suggestions for 'thinking tracks', analysis or synthesis elements using expert system reasoning. These options should be of great value to system architects, and are intended as an add-on (not replacement) to the 'human way' of working.

Date, location: 27 november to 1 december 2017 in the Lorentz Centrum, Leiden. The workshop and accommodation near the Lorentz Centrum is provide free of charge. Participants are expected to stay for the entire workshop week, although exceptions can be made. Participants can stay in the nearby hotel Van der Valk. Your accommodation will be covered. Participants will share a room with another person. Single rooms are available, upon payment of extra cost and will be charged on own account.

More information & registration: http://tinyurl.com/y7jxoans

ICT With Industry 2017 poster: http://www.lorentzcenter.nl/lc/web/2017/952/poster.pdf

Current participants:

- Richard Doornbos, TNO-ESI, Rondom 1, Eindhoven, Richard.doornbos@tno.nl, 0888665421
- Alex Telea - Johann Bernoulli Institute, University of Groningen

Academic team leaders:

- Alexander Serebrenik - Technische Universiteit Eindhoven
- Klaas Andries de Graaf - Vrije Universiteit Amsterdam - ka.de.graaf@vu.nl

Company information:

- TNO-ESI
- Océ, Venlo, R&D department of Professional Printing.

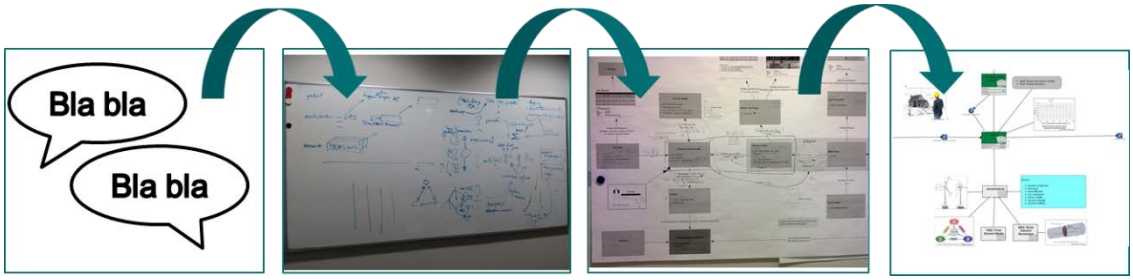
Description of the ICT related challenge:

- Context: The complexity in high-tech systems is increasing rapidly, therefore development of these systems is becoming a huge challenge. The role of a system architect in a company that is developing complex systems is becoming increasingly hard. It is difficult to identify and manage all system aspects that are relevant for stakeholders, such as customers, senior management, on one hand and the technical solutions worked on by the development organization on the other hand. The current situation is that large and complex it is nearly impossible for a system architect to stay in control.

- It is clear that there is a great need for overview and a mutual understanding of the problem area, the system concepts and agreement in approach. This means that here should be significant attention for internal communication and clear architectural and design artefacts.

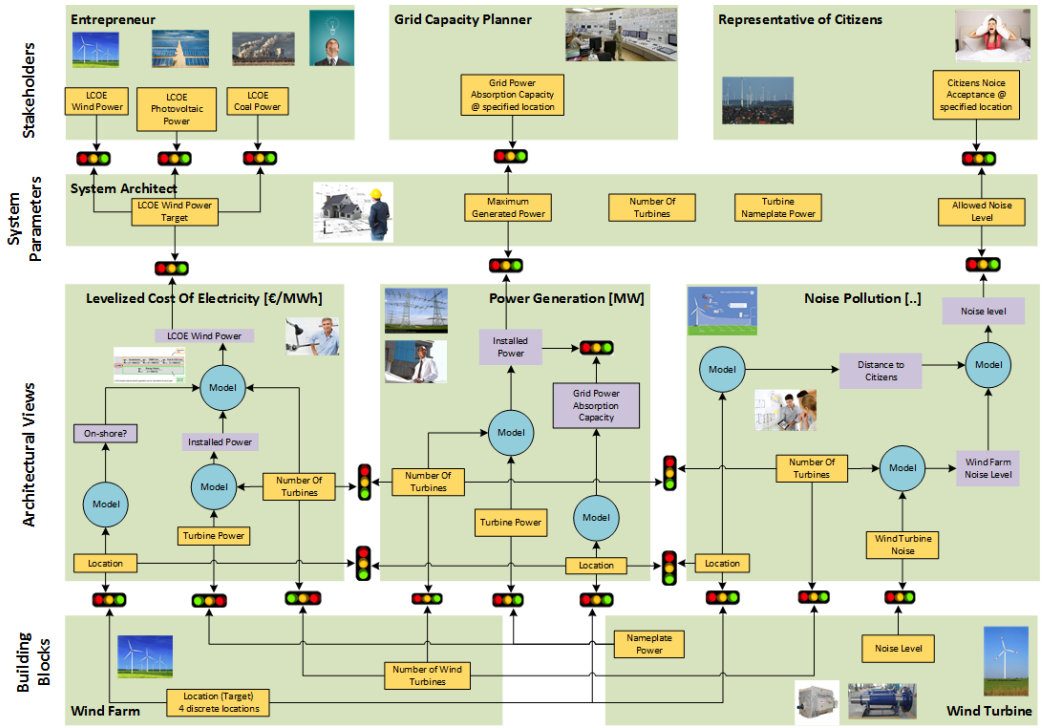
This helps a lot in making of trade-offs in the early phases of development and well-founded decisions by architects and management. Having clear architectural and design models and other artefacts is also crucial for the development of next systems and products, therefore can be seen as core assets of the organization/company.

- Consolidation of architectural knowledge is essential for development of complex systems (large professional printers) in complex environments (by multi-architect teams at multiple sites). Our way of working is to develop simple models as early as possible, even if the accuracy is very low. In making these models and sharing and explaining them in the team a shared language is being developed. Talking about system parameters and concrete models, preferably quantitative, things become clear very quickly. In practice we see often the phases shown in figure 1: it usually starts with talking in vague notions and abstract concepts, next more concrete discussions appear and on whiteboards or on paper the first models appear. After that some clean-up and digitization leads to more formal artefacts, e.g. in the form of A3 architectural overviews. Many existing architecting methods (CAFCR, 4+1, etc.) are being used in these phases.



Figuur 1 Typical phases in early architectural modeling.

- But the last step is crucial in our model-based architecting approach: defining the various domains (indicating the responsibility areas of actual persons), clearly showing the relations between the domains (expressed in parameters which are being used in multiple domains, and using 'traffic lights' to indicate discrepancies), going from qualitative relations between concepts to low-fidelity quantitative models (when needed), realizing the set of concepts and models in a multi-user tool (TNO-ESI Design Framework).
- The visual structure of the (possibly large) set of models is also very important to achieve a good overview. In figure 2 we show an example of a well-organized structure, that performs well in industrial practice.



Figuur 2 Architectural overview.

- State of the art tools provide support in capturing this knowledge in qualitative and quantitative models. In Figure 3 an example is shown of the network of quantitative relations between system parameters: simple numerical functions represented by the green circles, parameters are shown as yellow rectangles. This network of models and concepts can be considered a knowledge graph. The meaning of the relations and concepts vary significantly, and is depending on the needs of the system architect. Typical models a system architect creates: stakeholder overviews (names, roles, concerns in plain text), important high-level system parameters and their links to detailed-level parameters (numbers and values), system decompositions (functional, structural, organizational, behavioral, etc.).
- These models are possibly linked to ‘engineering-level’ models containing more detail (single discipline, numerical, high accuracy and typically created in Matlab, Python, etc.). This category should however not be considered in this challenge.
- When we consider this architectural knowledge represented as a knowledge graph, we expect that computing science may provide useful mechanisms and algorithms to support the system architect as a user in the role of model creator, analyzer, reasoner, etc.

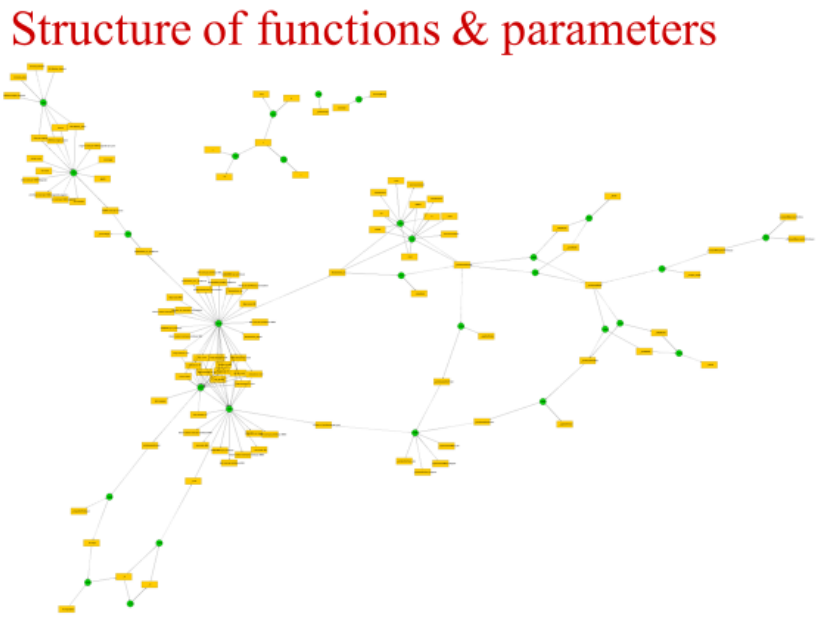


Figure 3 Example of an architectural knowledge graph.

- Workshop aim: find innovative directions for research to exploit the knowledge graph to support the system architect: e.g. notification for inconsistencies or incompleteness, suggestions for analysis, generation of relevant questions, suggestions for 'thinking tracks', analysis or synthesis elements using expert system reasoning. These options should be of great value to system architects, and are intended as an add-on (not replacement) to the 'human way' of working.
- We should also consider the eventual goal of integration into architecting support tooling (e.g. into the TNO-ESI Design Framework).
- Possible research directions include: search heuristics, architecture knowledge management, text and data mining, machine learning, architecture documentation theory and practice, expert systems, semantic web & linked data, natural language processing, information retrieval, agent-based systems, (data/graph) visualization techniques, time-series analysis, and sentiment analysis.

Input provided for workshop participants:

- Industrial system architects can provide information about the way of working.
- Illustrative and representative industrial cases.
- Academic leads and other researcher can point to technologies and research directions that could work towards achieve goals of industry participants.

Input requested from workshop participants:

- Sample knowledge graphs, or data that can be converted into a knowledge graph.
- Questions that you like to see answered from your data
- Possible visualisations of your data that you would like to see

- List of tools and systems in which the knowledge graphs should be integrated