Embedding IoT in Large-scale Socio-technical Systems: A Community-oriented Design in Future Smart Grids

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Abstract In traditional engineering, technologies are viewed as the central piece of the engineering design, where the physical world consists of a large number of diverse technological artifacts. The real world, however, also comprises a huge amount of social components – people, communities, institutions, regulations and everything that exists in the human mind – that have shaped and been shaped by the technical components. Smart urban ecosystems are examples of such large-scale socio-technical systems that rely on technologies, particularly IoT, within a complex social context where the technologies are embedded. Despite that the two aspects are deeply intertwined, designing applications that embed IoT in large-scale socio-technical systems is slowly transitioning from a traditional engineering approach towards a socio-technical approach. The latter has not yet entered the mainstream of design practice. In this chapter, we present our experience of adopting a socio-technical approach in designing a community-oriented smart grid user application. The challenges, implications and lessons learned are discussed. The chapter is concluded by offering a set of good design principles derived from this experience, which are also relevant to the design of other smart urban ecosystems.

1 Introduction

The traditional science and engineering philosophy is dominated by technological determinism, the idea that technology determines societal development [7, 10, 12]. Within this reductionist view, technologies are the central piece of the engineering design, where the physical world consists of a large number of diverse technological

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artifacts. The plausibility of this view is challenged by the socio-technical systems view [13] which argues that technological and social development form a "seamless web" where there is no room for technological determinism or the autonomy of technological systems [2]. The latter view is premised on the interdependent and deeply linked relationships among the features of technological artifacts or systems and social systems [10], since the man-made world also comprises a huge amount of social components – people, communities, institutions, regulations, policies and everything that exists in the human mind – that have shaped and been shaped by the technological components [4, 13]. Engineering design is hence identified as a process through which technologies materialize into products, a process that substantively shapes and reshapes our lives and societies and vice versa [5]. This focus on socio-technical interconnectedness becomes even more visible in designing new emerging technologies [5].

Smart cities, for example, use technologies such as Internet-of-Things (IoT) within a large complex social context where they are embedded. The goal is to facilitate the coordination of fragmented urban sub-systems and to improve urban life experience [3]. The rise of the IoT has important socio-technical implications for people, organizations and society – it is obvious that connecting devices is possible, we yet know little about its implications [11]. A socio-technical perspective can be insightful when looking at dynamic technology development and when considering sustainable development [11]. Although socio-technical systems have been studied for decades, socio-technical approaches are relative new to the design and systems engineering communities [1, 9, 10]. Such approaches are not widely practised despite growing interests [1].

In this chapter, we review the literature and present our experience of adopting a socio-technical approach in designing a community-oriented smart grid user application. We discuss the challenges, implications and lessons learned from this design experience, and conclude the chapter by offering a set of good design principles which are also relevant to the design of other smart urban ecosystems.

2 Design in Large-scale Socio-technical Systems

The socio-technical perspective has a number of implications for (1) the formulation of the design problem, (2) the product of the design process, and (3) the design process itself (BootCamp, BC).

Large-scale socio-technical systems are often not designed as a whole but incrementally "piece by piece" evolving from legacy systems (BC). Designers are therefore working *in* the context of some socio-technical system with the intention of changing or improving some part of that system [BC]. This means that what matters more in the design is the design process itself, more than the “final status” of the system [11, **?**] because the socio-technical system keeps evolving and exhibits emergent behaviour [8]. An important goal of the design process is to make the design (a product or system) relevant to the evolving context [11, **?**] as social and technical artifacts exist within their socio-technical context [BC].

The socio-technical view can be articulated as the recognition of (1) the mutual constitution of people and technologies, (2) the contextual embeddedness of this mutuality, and (3) the importance of collective action [10]. Those who hold this view examine more than just the technological system, or just the social system, or even the two side by side, but also the phenomena that emerge when the two interact [6].

Use and combine content in:

1. [9] (design problems in large-scale socio-technical systems) and
2. [1] (socio-technical approach to systems engineering)
3. [14] (four system levels of Socio-tehnical systems);
4. [11] (a very good article about IoT, socio-technical perspective)
5. see also https://medium.com/rettigs-notes/notes-on-sociotechnical-systems-design-178f161bc9e8

3 YouPower

Use the YouPower paper as much as possible.

4 Lessons Learned / Design Guidelines

5 Conclusions

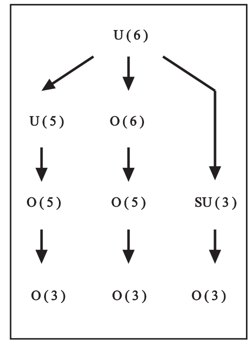

Fig. 1 If the width of the figure is less than 7.8 cm use the `sidecapion` command to flush the caption on the left side of the page. If the figure is positioned at the top of the page, align the sidecaption with the top of the figure – to achieve this you simply need to use the optional argument `[t]` with the `sidecaption` command

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Table 1 Please write your table caption here

Classes	Subclass	Length	Action Mechanism
Translation	mRNA[a]	22 (19–25)	Translation repression, mRNA cleavage
Translation	mRNA cleavage	21	mRNA cleavage
Translation	mRNA	21–22	mRNA cleavage
Translation	mRNA	24–26	Histone and DNA Modification

[a] Table foot note (with superscript)

Type 1 That addresses central themes pertainng to migration, health, and disease. Blablabla

Type 2 That addresses central themes pertainng to migration, health, and disease. Blablabla

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References

1. G. Baxter and I. Sommerville. Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, 23(1):4–17, 2011.
2. L. Fleischhacker. *Evandro Agazzi: Right, Wrong and Science The Ethical Dimensions of the Techno-Scientific Enterprise*, chapter Commentaries: The non-linearity of the development of

technology and the techno-scientific system, pages 301–310. Monographs-in-Debate. Brill, 2004.

3. A. Glasmeier and S. Christopherson. Thinking about smart cities. *Cambridge Journal of Regions, Economy and Society*, 8:3–12, 2015.
4. Y. N. Harari. *Sapiens: A Brief History of Humankind*. Harvill Secker, 2014.
5. P. Kroes, P. E. Vermaas, A. Light, and S. A. Moore. *Philosophy and Design: From Engineering to Architecture*, chapter Design in Engineering and Architecture: Towards an Integrated Philosophical Understanding, pages 1–17. Springer, Dordrecht, 2008.
6. A. S. Lee. Mis quarterlys editorial policies and practices. *MIS Quarterly*, pages iii–vii, 2001.
7. C. C. Mody. *Nanotechnology Challenges: Implications for Philosophy, Ethics, and Society*, chapter 5 Small, but Determined: Technological Determinism in Nanoscience, pages 95–130. World Scientific, 2006.
8. I. Nikolić. *Co-Evolutionary Method For Modelling Large-Scale Socio-Technical Systems Evolution*. PhD thesis, Delft University of Technology, 2009.
9. D. A. Norman and P. J. Stappers. Designx: Complex sociotechnical systems. *She Ji: The Journal of Design, Economics, and Innovation*, 1(2):83 – 106, 2015.
10. S. Sawyer and M. H. Jarrahi. *Computing Handbook: Information systems and information technology*, chapter 5 Sociotechnical Approaches to the Study of Information Systems. Taylor & Francis, 3rd edition, 2014.
11. D. Shin. A socio-technical framework for internet-of-things design: A human-centered design for the internet of things. *Telematics and Informatics*, 31(4):519 – 531, 2014.
12. M. R. Smith and L. Marx, editors. *Does Technology Drive History?: The Dilemma of Technological Determinism*. MIT Press, 1994.
13. K. H. van Dam, I. Nikolic, and Z. Lukszo, editors. *Agent-based modelling of socio-technical systems*. Springer Science & Business Media, 2012.
14. B. Whitworth. *Encyclopedia of Information Science and Technology*, chapter 66 A Brief Introduction to Sociotechnical Systems, pages 394–400. IGI Global, 2nd edition, 2009.