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A socio-technical framework for Internet-of-Things design: A human-centered design for the Internet of Things

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ABSTRACT

This study presents a case application of a socio-technical framework to assess and predict the development of the Internet of Things (IoT) in Korea. Applying a socio-technical system approach to the IoT, this paper seeks a clear understanding of how the IoT will evolve and stabilize in a smart environment. It investigates the complex interaction between social and technical aspects of the IoT, by highlighting the co-evolution, interaction, and interface, which constitute the next generation network environment. It describes the challenges in designing, deploying, and sustaining the diverse components of the IoT, and provides a snapshot of Korea's current approach to meeting this challenge. Finally, the findings of this study provide insights into these challenges and opportunities, by offering a socio-technical analysis of IoT development. The insights help to conceptualize how the IoT can be designed and situated within human-centered contexts.

1. Introduction

With the explosive growth of smart phones and tablets, wireless technologies have become a fundamental tool for everyday life around the world. The coming wave of connected devices, appliances, vehicles, sensors, meters and countless other "things" represents the next generation of a hyper-connected world, the Internet of Things (IoT). The IoT aims to extend the benefits of the regular Internet—constant connectivity, remote control ability, data sharing and so on—to goods in the physical world. All would be tied to local and global networks, through embedded sensors that are always on. Often called the Internet of everything, the term IoT was coined in 1999 by Kevin Ashton, who dreams of a system where the Internet is connected to every physical object, via ubiquitous sensors.

Recently, building the IoT has become a global trend of governments across the globe. As the government initiatives form the foundations in creating a smart infrastructure, governments initiate projects to improve infrastructures, and to construct new channels that are more advanced and accessible. Governments and industry worldwide are investing billions of dollars to develop IoT computing. Such projects include Japan's u-Strategy, China's National IoT Plan by the Ministry of Industry and Information Technology, the Italian National Project of Netergit, the European Research Cluster on IoT (IERC), and the UK's Future Internet Initiatives. As IoT is increasingly seen as a priority in national ICT strategies, the IoT is being planned to develop an advanced computing environment, to pool computer resources to process, store and access large amounts of data (Gubbi et al., 2013).

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While the IoT is expected to have a massive impact on society and wider cultural milieu, these are still early days, and many challenges lie ahead. There is no standard definition of the IoT as of yet, and protocols and standards are still in early development. Questions arise such as what will the IoT landscape look like, and what will its impact be? As the IoT rapidly develops, it sheds light on serious problems. For example, as the IoT expands the number of connected devices integrated into our everyday lives, they have the potential to allow cyber attackers into the physical world in which we live, as they seize on security holes in these new systems. As Winter (2013) points out, the discussion of the IoT so far has been predominantly focused on the technical aspect of design, such as network development. This may be even more true of Korea, where IT has been the key national agenda, and the IoT is considered as one kind of IT. Up to the present, most IoT efforts have been focused on the development and integration of IoT technologies and resources. Fewer efforts have focused on the immense repercussions of the social dynamics and organizational, policy, management and most importantly user issues inherent in developing and deploying the IoT. Such choices, and the social, cultural and behavioral impacts of how we develop, manage and evolve the IoT, will be critical to its success. This study argues that the IoT is a socio-technical ensemble (Bijker, 1995), and thus its design and development should be based on human needs, and its ultimate status should accordingly be a human-centered system. This argument supports the idea that the analysis of infrastructure should be based on contextual analysis (Shin, 2010). According to Holtzblatt, Wendell and Wood (2005), contextual analysis examines the processes of technology development, offers heuristics to improve problem formulation, and equates better designs with improved problem formulation, improved understanding and improved communication. These approaches are indeed *in situ* contextual, in the sense that they heavily scrutinize local features of the decision situation. They argue that the very meaning of a real environmental problem is anchored in a place, which includes the physical features of a geographic location, and also the users who live there, and their institutions and politics.

Because the notion of the IoT has evolved from a different context, it is essential to investigate the IoT within the context where such IoT is being placed and used. Thus, contextual analysis is a particular imperative in this study. With the contextual analytical focus, this study attempts to identify opportunity, prospectus, limitation and risks embedded in the IoT design in Korea. By identifying such socio-technical challenges, this study conceptualizes a human-centered IoT that finds an optimal point among appropriate regulation, industry dynamics, and market receptiveness, addressing issues such as how the IoT should be developed and stabilized in Korean society, and what its social and regulatory issues are. To this end, a socio-technical approach is used to uncover the underlying ongoing IoT issues, which in turn help to design a human-centered IoT. The Korean IoT has a tendency to be designed in a technology-oriented fashion, as its name implies. A socio-technical perspective can provide an integrative and comprehensive framework, to reflect diverse human-technology interaction in the IoT. The socio-technical framework used in this study is to drive a wedge between the technical and social understanding of the IoT (Shin, 2012). This relationship, between technology and society, between technical artifact and the context that surrounds it, provides an essential insight into the way infrastructure has been designed, deployed, and developed (Sawyer and Eschenfelder, 2005). In particular, the Korean Internet case offers an excellent example of such socio-technical interaction. Since Korea has been pioneering the development of IT infrastructure and services, it has become a leading country in the world in introducing a series of advanced smart technologies (Shin and Jung, 2012).

While the development of IT hardware has been very actively pursued in Korea, other non-hardware aspects have not been so well developed, compared to those of hardware. Such contrasts provide nice analytic materials for the IoT, where a large part of socio-technical interface and interaction issues arise. In this light, it is worthwhile to see how Korea develops the IoT and what might affect its IoT design. The following research questions guide this study:

1. What socio-technical obstacles and problems are encountered in the attempts to develop the IoT in Korea?
2. How can the IoT be designed as a human-centered system, as opposed to a technology-oriented one?
3. What elements may be considered to be constitutive for the IoT as a human-centered system?

With these inquires in mind, this study delves deeply into Korea's IoT development, by tracking the ongoing activities and discourses for infrastructure, and examining the social trends building around the IoT, and the future demands they will meet. In the road to the IoT, a number of socio-technical challenges are being identified (Winter, 2013). This study focuses on an evolving vision of what IT can do, and the challenges of sustainability, openness, integration and control that it presents. The approach allows a prospective analysis regarding future uses of IoT in a socio-technical system, satisfying the call for more prospective and prescriptive research into the use and acceptance of the IoT (Boos and Grote, 2012). The findings in this study give the implications of designing an optimal ecology for humans and the IoT, drawing on what can be done with technology, software, organizations, and policy.

This study is structured as follow: Section 2 provides a literature review on socio-technical theory and approach, followed by the definition and trends of the IoT; Section 3 then describes the method used in this study; Section 4 introduces and traces the history of Korean information infrastructure development; Section 5 presents critical socio-technical insights; Section 6 draws on the Korean model for IoT architecture, and Section 7 discusses some implications for practitioners; Section 8 presents topics for future studies; and finally, Section 9 ends with the conclusion of this study.