



A Socio-Technical Framework for Internet-of-Things Design:

A Human-Centered Design for the Internet of Things

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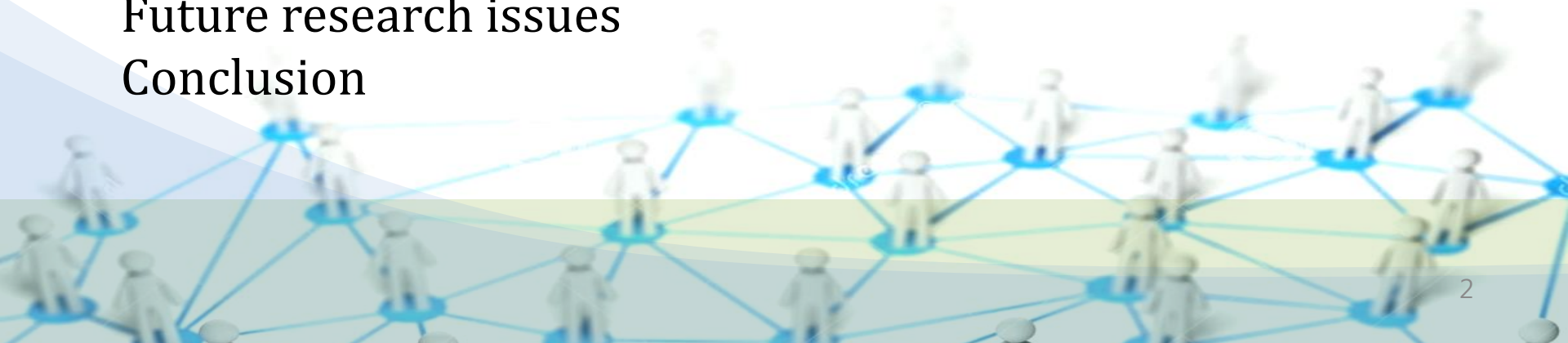
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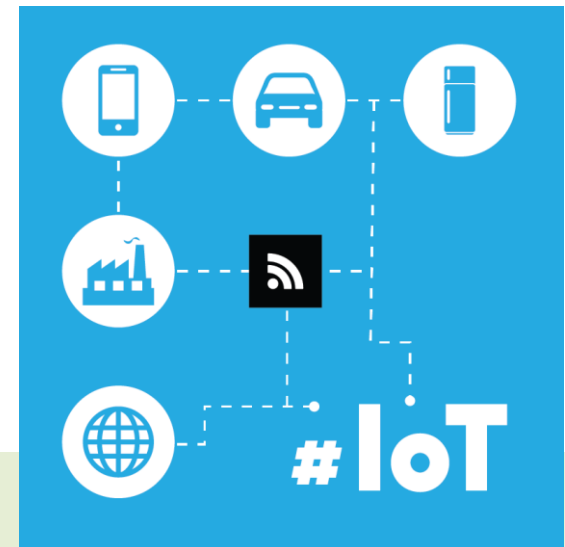
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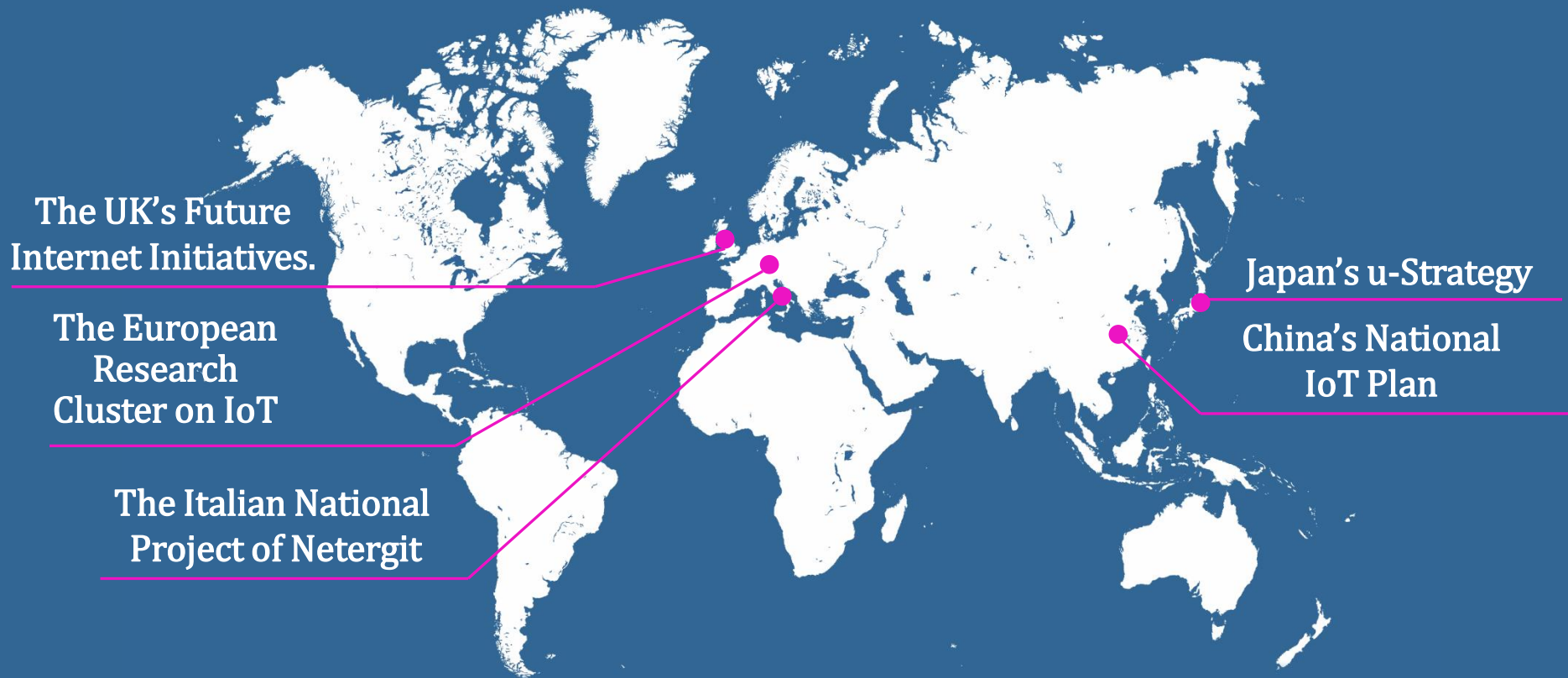
Internet of Things (IoT)

- The term was coined by Kevin Ashton, who dreams of a system where the Internet is connected to every physical object, via ubiquitous sensors.
- The coming wave of connected devices, appliances, vehicles, sensors, meters, and countless other - “things” represents the next generation of a hyper-connected world.
- It 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.



IoT as Government Initiatives

Building the IoT has become a global trend of governments across the globe.



International trends

Large scale initiatives are underway in Korea, Japan, the US and Australia, where industry, associated organizations and government departments are collaborating on various programs, advancing related capabilities towards an IoT.

In China, the IoT has been developed with M2M with smart meters and smart grid being a significant portion of the market.

In Europe, extensive effort is underway to consolidate the cross-domain activities of research groups and organizations, spanning M2M, WSN and RFID into a unified IoT framework.

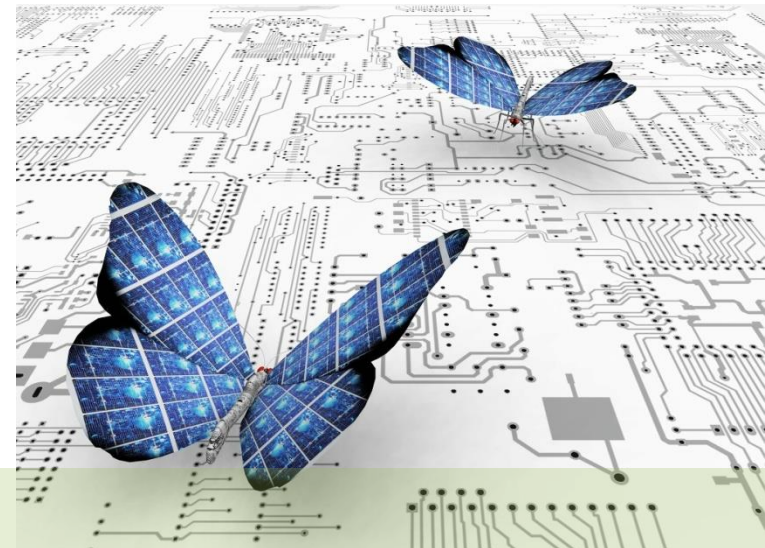
The Problems of IoT

- No Standard definition of the IoT
- Focused on the technical aspect of design.
- Fewer efforts have focused on the immense repercussions of the social dynamics, and most importantly user issues inherent in developing and deploying the IoT.



IoT in South Korea

- It has a tendency to be designed in a technology-oriented fashion.
- Non-hardware aspects have not been so well developed, compared to those of hardware.
- Korean internet case offers an excellent example of socio-technical interaction since Korea has been pioneering the development of IT infrastructure.
- It is worthwhile to see how Korea develops the IoT and what might affect its IoT design.



Research Goal & Questions

The goal of this study is to clarify a practical and theoretical point of view of the conceptualization of the IoT as a human-centered system.

RQ1: What socio-technical obstacles and problems are encountered in the attempts to develop the IoT in Korea?

RQ2: How can the IoT be designed as a human-centered system, as opposed to a technology-oriented one?

RQ3: What elements may be considered to be constitutive for the IoT as a human-centered system?

Theory of socio-technical systems

Holistic approach to system analysis is central, since all the layers together define the overall performance of the system.

- Shin (2010)

It has been frequently used in the research of information infrastructure.

- Mumford (2006)

Socio-technical systems can show a specific kind of complexity, because these systems are of a hybrid nature.

Definition and scope of the IoT

A future computing scenario, where everyday physical objects will be connected to the Internet, and will be able to identify themselves to other devices.

- Chen (2012)

The IoT can be viewed as an extension of information infrastructure that has been implemented for decades.

It examines the direction, nature, and future of the IoT, by focusing on the human, social, and political economy of informatization.

Method

- Qualitative data analyses : content analysis, key informant interviews and a survey. Participants were government officials, industry representatives, and academic researchers.
- Archival materials, such as industry reports, government publications, were collected and analyzed.
- Computer-assisted qualitative data analysis software, Atlas.ti, was used to explore complex data.



71 in-depth
interviews



33 questionnaires
(among 147 of them)

Data Collection

Sectors		Methods		Responses
Government		Face-to-face	5	22
		Phone	8	
		Email interview	5	
		Mail survey	4	
Industry	Content/Service provider	Face-to-face	6	27
	System/Telecom	Phone	6	
	Electronics	Email interview	10	
	IT manufacturing	Mail survey	5	
Academia		Face-to-face	7	22
		Phone	8	
		Email interview	3	
		Mail survey	4	
Total				71

Korean history of building the IoT

Historic reviews reveal how current technologies are contextually linked to past, and also show future trajectories(Bijker, 1995).

Date	Event – time line
1984	Korean government started the first national IT project
1987-1991	National Basic Information System (NBIS)'s early stage
1993	Korea Information Infrastructure (KII) was started
1995	The first effort building Internet infra was launched in 1995, with the Very High Speed Information Network (VSIN)
2002	the Korean National Grid Infrastructure (K-Grid)was began
2004	the government announced a new strategy called IT 839 Strategy

Korean history of building the IoT

NBIS - the National Information System for Administrations, Financial, Education and Research, Defense, Security.

- Aimed at promoting IT use in Korea
- The government maintained leadership in the process, but project was largely a supply-push enterprise that did not account for demand.

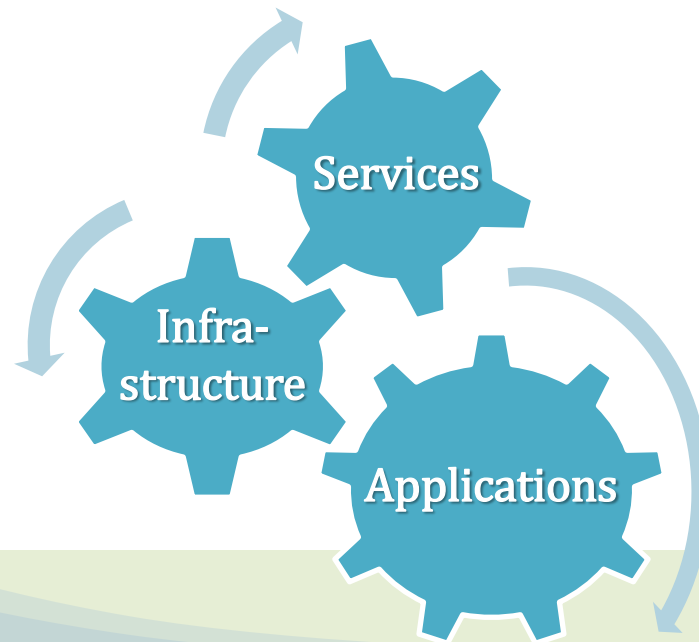
Grid-infrastructure

- Aimed to build a nation-wide optical communication cable infrastructure
- The government built Internet services upon the infrastructure, which enabled e-government services, e-commerce services, and other IT application services with low cost and high quality.

Korean history of building the IoT

IT839

- The government seems to realize that infrastructure would be ineffective, without proper applications.
- IT839 has a more comprehensive view, focusing on interconnectivity among infrastructure, services and applications.



The IoT as a socio-technical artifact: Applying a socio-technical perspective

This study contributes to the design of the IoT as a socio-technical artifact, and to the ongoing political and legal debates surrounding its continued move towards ever-increasing ubiquity in culture, politics, commerce, and society.

An information infrastructure has been defined as a socio-technical system (Hanseth & Lyytinen, 2004; Hanseth & Monteiro, 2000; Shin & Jung, 2012) that comprise networks of technology, information, people, rules, and practices.

The socio-technical model presented in this study is a comprehensive framework, which addresses environmental, social, content, and technical aspects of the information infrastructure.

The IoT as a socio-technical artifact: Applying a socio-technical perspective

Technology issues - Architecture

Layer]	Legend	Description
Layer 1	Sensing and control layer	This the foundation of the development and application of the IoT, including RFID readers, smart sensor nodes and access gateways, etc.
Layer 2	Networking layer	This is mainly responsible for the different types of networks integration, such as the Internet, Mobile Communications Network, and Broadcast Television Network.
Layer 3	Resource management layer	This will provide the initialization of resources, monitoring the operation status of resources, and coordination of work between various resources, and achieve cross domain interactions between resources.
Layer 4	Information processing layer	This layer realizes the reasoning and semantic understanding of sensing data; it also provides data query, storage, analysis, mining, etc.
Layer 5	Application layer	After analyzing and processing the sensing data, this application layer uses the data to provide users with a variety of different types of services. The IoT should also include some support technologies, such as network security, fault-tolerant mechanism and quality control throughout all levels, to provide application support.

The IoT as a socio-technical artifact: Applying a socio-technical perspective

The key technologies for the IoT include

- IPv6**, which is responsible for things' identification
- sensor technology**, which is responsible for dynamic information sensing
- communication technology**
- network integration technology** which realizes information transmission and intelligent information processing technology



The IoT as a socio-technical artifact: Applying a socio-technical perspective

Service and applications of IoT

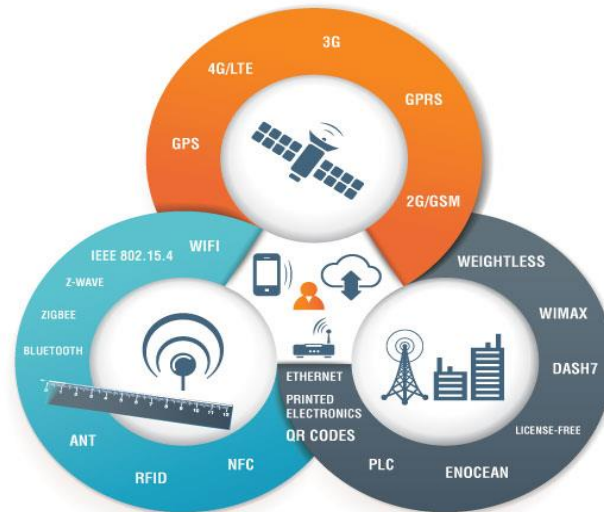
Services	Descriptions
Smart Cities	Songdo is planned to be wired, connected, and turned into a constant stream of data that would be monitored and analyzed by an array of computers, with little, or no human intervention.
Smart Energy & the Smart Grid	There is increasing public awareness about the changing paradigm of our policy in energy supply, consumption and infrastructure. In consequence, future energy supply needs to be based on renewable resources.
Smart Transportation & Mobility	The connection of vehicles to the Internet gives rise to a wealth of new possibilities and applications, which bring new functionalities to the individuals, and/or the making of transport easier and safer.
Smart Home, Buildings & Infrastructure	The rise of Wi-Fi's role in home automation has primarily come about due to the networked nature of deployed electronics, where electronic devices have started becoming part of the home IP network, and due the increasing rate of adoption of mobile computing devices.
Smart Factory & Manufacturing	The role of the Internet of Things is becoming more prominent in enabling access to devices and machines, which in manufacturing systems, were hidden in well-designed silos.
Smart Health	The market for health monitoring devices is currently characterized by application-specific solutions that are mutually non-interoperable, and are made up of diverse architectures.
Food & Water Tracking and Security	Organic food produced without the addition of certain chemical substances, and according to strict rules, or food produced in certain geographical areas will be particularly valued.

The IoT as a socio-technical artifact: Applying a socio-technical perspective

A few of the socio-technical issues for the IoT include standard, security and privacy.

To be an effective IoT, it should

- (1) be accessible as a public good;
- (2) be sustainable;
- (3) provide interoperability;
- (4) facilitate collaboration;
- (5) support experimentation.



So far, there seems to be not enough efforts on social issues regarding Korean IoT projects.

Korea appears to overestimate the near-term effects of technology, and to underestimate its long-term consequences

The IoT as a socio-technical artifact: Applying a socio-technical perspective

Government

- The government has taken a highly proactive role in promoting the IoT.
- Ambitious technology-driven programs have already led to a number of remarkable R&D and technology demonstrations. The government has laid the foundation for a technological approach towards complete IoT systems and networks.
- Goals of Korea's R&D activities on the IoT are to take global leadership in ubiquitous computing, and to establish the world's first Broadband Convergence Network-based infrastructure that can converge wired, wireless and broadcasting systems.



The IoT as a socio-technical artifact: Applying a socio-technical perspective

Industry

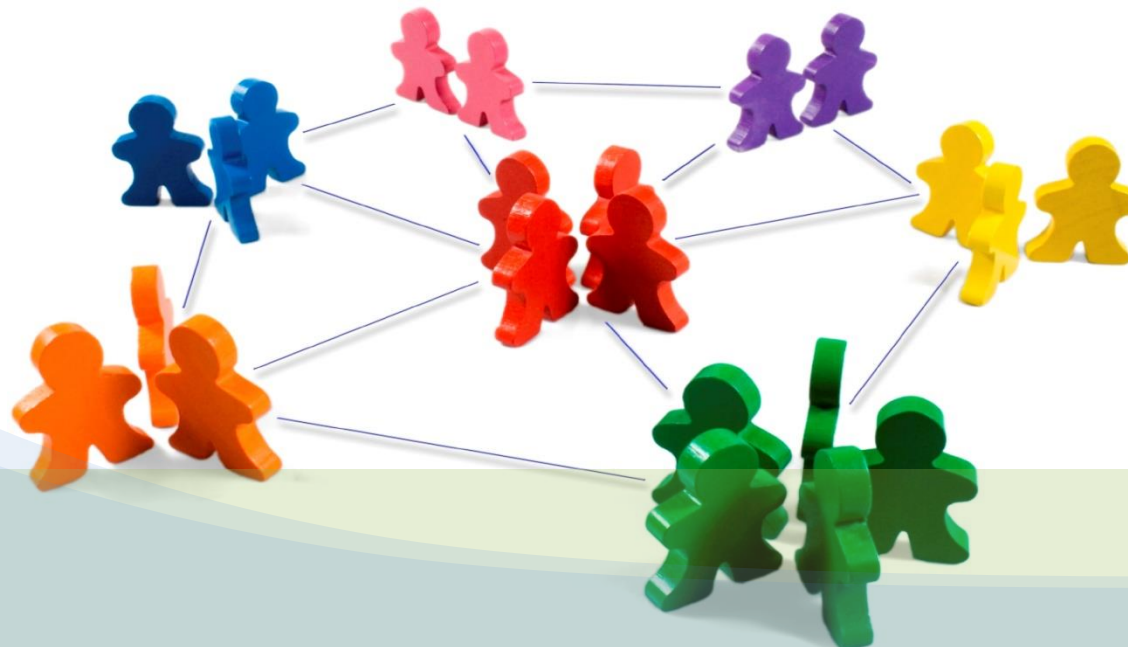
-The IT Industry has been actively working with the government in the area of technologies and equipment. Participating industrial leaders include Samsung, LG, Korea Telecom, and SK Telecom, which all regard IoT as an opportunity to develop new markets, particularly killer applications. These industries have received governmental support, or a subsidy to develop new technologies for the IoT.



Discussion

The challenge of the IoT is to enable diverse and disparate components, services, and technologies to work together. Moreover, these pieces are operated and supported by users across multiple groups.

The IoT is not a one-way initiative or one-off event by government, but rather a massive interaction, and participation of numerous parties.



Practical suggestions

The government should support a meaningful IoT literacy program and awareness-raising, to empower self-regulation, and enhance individual interaction with the IoT

The government should support and promote knowledge sharing, research and social projects, constant debate and policy articulation, especially on security, privacy and ethics in IoT environments



Practical suggestions

Social demands should not be identified and addressed solely by the market. The boundary between the social and the economic has to blur, and society has to be reshaped into a more participatory arena.

Users have to be empowered to utilize the IoT technologies to turn the physical environment into a socio-technical environment. Designers working with the IoT should be thinking from a human-centered perspective.

Future research issues

- Future research can explain how technological change occurs, and how a new technology is evolved.
- Future research will extend the integrated perspective of the socio-technical system, looking at future IoT infrastructures.
- Future studies may draw on some examples from an empirical case study on the development and use, to illustrate the conceptualization of the IoT.

Conclusion

- For the upcoming IoT, Korea may need a series of socio-technical experiments that emphasize both the sociological, and the technological aspect of a development.
- Korea needs an ethnographic perspective, when designing and deploying the IoT - identify different narratives used by users, explore how users will use the IoT, and investigate paradoxes in the upcoming IoT.
- What is most needed is not an Internet of Technologies, but an Internet of Humans.

