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The Internet of Things for the Open Sharing Economy

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Abstract
In this paper we raise the question of how to enable groups of individuals to collaboratively design, implement and maintain IoT-enabled sharing economy services. We argue that there is a need for HCI research to engage with the whole lifecycle of sharing services, from inception and design to operation and use. In particular, we motivate the need for an open design approach for IoT-enabled sharing services that fosters intelligibility, accountably and control with respect to the mechanisms and algorithms that govern a sharing service.

Author Keywords
Internet of Things; Sharing Economy; Open Design; Collaborative Design; Human-Computer Interaction.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction
The Internet of Things has become an important infrastructure for the sharing economy, a term used to describe a class of socio-economic services based on the sharing of underutilized assets and resources (e.g. bikes, cars, energy, food, clothing, and waste). In such services, sensor data streams and coordination

Figure 1: Energy sharing within a household

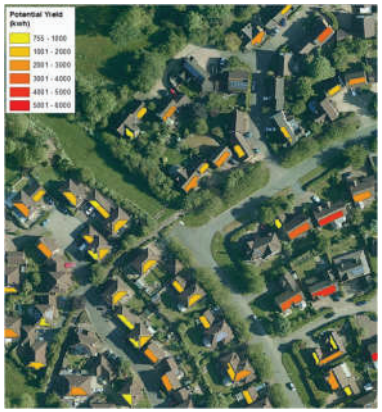

Figure 2: Aerial image data indicating potential yield from solar electricity potential

mechanisms make it possible to determine the availability and state of assets, and match demand and supply in real-time.

However, the initial excitement about the sharing economy has recently been dampened by the realization of the potential negative social and economic implications of commercial sharing services such as where a company exercises tight centralized control and does not disclose its sharing algorithms. This in-transparency gives companies leverage to tilt the playing field in their favor and extract maximum economic value from their ecosystem. Local community-based sharing services (such as seed banks [1] and local distribution of renewable energy [2]), on the other hand, tend to be value-driven [3] and more equitable.

In this paper we raise the question of how to enable groups of individuals or small organizations to collaboratively design, implement and maintain IoT-enabled sharing services. Using two case studies from the energy sector we argue that there is a need for HCI research to engage with the whole lifecycle of sharing services, from inception and design to operation and use. In particular, we motivate the need for an open design approach for IoT-enabled sharing services that fosters intelligibility, accountably and control with respect to the mechanisms and algorithms that govern a sharing service.

In the following we will describe observations on energy sharing from two case studies, and outline the case for an open design framework for IoT sharing services.

Case studies

This research is informed by research in progress that is we conduct in two energy-related research projects, one focused on domestic energy generation [4], and the other focused on community energy initiatives [5].

Energy Sharing within a Household.

The first case study investigates sharing of self-generated solar energy *within a family household*. This is an extreme case of a very small and close-knit group of individuals who make decisions about the use of a shared asset *(Figure 1)*. With the right mix of IoT technologies, solar energy can be divided in a flexible manner among a number of energy consuming devices (e.g. electric oven, electric vehicle, entertainment devices) or exported to the grid. The strategies for how this is done are decided upon by the family members, according to economic and environmental preferences, and based on information about current and predicted energy supply and demand.

Community Energy Platform

The second case study is focused on developing an urban energy platform to help community groups, city authorities and companies to collaboratively design, run and monitor community energy projects, such as shared solar and ground-heat installations or energy savings measures. The platform combines offline building data (for example heat loss and potential for solar (Figure 2) and ground-heat installations derived from aerial surveys) with real-time building energy data from smart meters. This case study is an example of a sharing economy service as it allows groups of home owners to share and utilize their collective building portfolio as a shared asset for energy generation and efficiency gains.

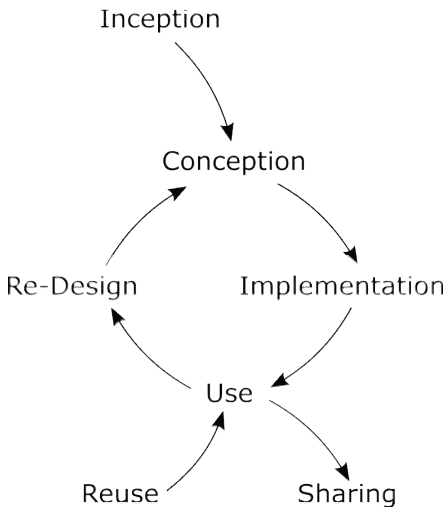

Figure 3: Open design approach for IoT-enabled Sharing Economy Services

Observations

During our research on these cases we made several observations about the nature of sharing economy services, three of which we highlight here.

Resource Sharing: Transactions vs Pools
Many existing sharing economy services, such as AirBnB, Uber, and TaskRabbit, follow a transaction-based model: they function by matching and facilitating transactions between individuals who supply an asset and individuals who demand an asset. Our case studies in contrast demonstrate a pool-based model: they function by aggregating a pool of assets and sharing the pool among participants. In the home, householders access a pool of limited local electricity to supply their shared or individual activities. The energy community members contribute assets for energy generation (e.g. roofs for solar panels or gardens for ground-heat pumps). In this context, sharing increases the overall value of the pooled assets.

Governance and Control: Open vs Closed
Many sharing economy services exhibit a sharp separation between those who operate and control the service (e.g. a commercial company) and those who merely participate. In our case studies there is no such in-built distinction, all actors (family members and community members) participate in a similar way and their interests are more or less aligned. Moreover, in our case studies the design of the sharing mechanisms is the result of a community-driven process. This is in contrast to many services where sharing mechanisms are designed by experts without involvement by participants and are not subject to outside inspection, control or governance.

Continuous Redesign and Adaptation
In our case studies we have highlighted the importance of redesign and adaptation of sharing mechanisms to reflect the changing attitudes and preferences of actors. For example, in the household case study we noticed that household explore various strategies, some favoring economic or and others favoring environmental concerns. Similar, in the community energy case study we noticed that ideas about the community energy scheme evolve over time as result of changes in energy technologies and the economic environment, or because of an improved understanding by participants about the potentials community energy.

Open Design Approach

From these observations we derive two conclusions:

1. There is a need for an *open design approach* for the collaborative design, control and governance of sharing mechanisms, that allows groups of individuals to design, test, critique, refine, share and enact the rules, mechanisms and algorithms that govern a sharing service.
2. There is a need for technology support of sharing services that goes beyond interaction and use, but covers a *circular lifecycle* that includes inception, design, implementation, use and re-design (Figure 3).

We will now look at 4 of the lifecycle stages of a sharing service in more detail and explore how IoT technologies might support these stages.

Inception:
Inception, or ideation, refers to the stage of the design process where potential participants come together,

identify the potential benefits of a sharing services and formulate the intent to set up a sharing service. From our case study experiences we have learned that data visualizations (for example about potential solar generation as shown in Figure 2) are a powerful means for attracting potential participants and idea generation.

Conception: Sharing Mechanism
The conception stage refers to the design of the rules and mechanisms that govern a sharing service (for example, how available energy is shared between households). This requires the ability to compare the impact of different rules and mechanisms wrt the benefits accrued to participants. In other words, this requires a simulation environment that can predict actual behavior based on historical or live sensor data.

Use
During operation and use of a sharing service two aspects are important: 1) Proactive information to enable participants to take part in the sharing service and 2) Tools to monitor the dynamics of the sharing service as a whole to understand appropriateness of rules and mechanisms and to evaluate the outcomes (for example in terms of fairness).

Re-design
The re-design stage refers to the reshaping of the rules and mechanisms govern the sharing community. This is needed to support changing needs and values of participants, or in case the dynamics of the sharing service do not conform with participants' intention.

In all these stages the key goal is to foster intelligibility, accountably and control: participants must be able to understand the impact of rules and mechanisms; those who define the rules must be able to vouch for the correctness wrt intended outcomes; and a community of participants as a whole must be able to define the dynamics of the sharing economy service. These are important HCI research topics that must be addressed to make the idea of an open design approach for sharing economy services possible.

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