A Framework for Designing UX of Sharing 'Internet of Things (IoT)' System and Service: Case Study of UX Development of Community Laundry Machines

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Abstract. The objective of present case study is to design user experience (UX) of an IoT system and service for sharing devices, community laundry machine. Due to distinctive usage situations of the system such as community machines, multiple users, and use of IoT technology, it was identified that a distinctive usage model and design framework are required rather than conventional UX design frameworks. Based on the unique usage model, a series of UX design process was performed including an interactive prototype as conceptual design. We expect the framework and process of the study would provide UX designers with insights to design such novel system/service environments.

Keywords: UX design · Community system and service · Multiple users · IoT

1 Introduction

The life style using products and services is being transformed to a new aspect using more emerging technologies including mobile devices and 'internet of things' (IoT). In addition to this, a concept of 'community products' in terms of 'sharing economy' has been expected to be an important trend of the new life style in near future, such as 'Uber' and 'AirBnB.' Even though many companies and researchers have developed various products and services that use the concept of IoT, most of them seem to focus on implementation of technologies such as sensors and network, rather than active efforts to consider and reflect the users' needs in terms of the principles of user-centered design and UX design.

Historically, a model of computer-supported cooperative work (CSCW) was used to identify such interactive systems used by multiple users, since various users access the system and communicate information regardless of time and space [1, 2]. However, we initially expected that the UX development for the 'community product' would require a different design framework beyond traditional interactions for single user or, even, multi-user situations (CSCW), due to a different usage model.

A. Marcus (Ed.): DUXU 2016, Part III, LNCS 9748, pp. 365–372, 2016.
DOI: 10.1007/978-3-319-40406-6_35

With this in mind, the objectives of this study were to conduct a UX design development for a community product integrated with IoT as well as to identify different design and development framework for the system and service. A series of user requirements analyses and conceptual design including development of usage model, framework, and task flow were conducted to achieve the objectives. A facility of community laundry machines in a University dormitory was used for the UX development including user requirement analysis, system and service design, and prototyping and user interface (UI) design in a mobile device.

2 User Requirement Analysis

A facility of community laundry machines in student dormitory of Handong Global University in South Korea was selected for the target system. The dormitory consists of seven buildings with 3-5 stories in each building. Approximately 90 students reside in a floor and they share one or two laundry machines in each floor. Thus there are about 5 machines in each building.

In order to collect and analyze users' implicit/explicit requirements for the system and service in the situation, various methods were employed. Since the service and system using IoT for the community machine has not introduced in the market, the user requirement analysis was focused on understanding current users' usage model and explicit concerns as well as on developing new system/service framework to resolve their concerns on the system. Conventional methods to capture user requirements in terms of user studies were used including focus group interview, contextual inquires, in-depth interview, video ethnography, and survey using actual target users [3].

In this section, interesting results of the user requirement analysis in the study is provided along with unique usage model for the community IoT system.

2.1 Current Users' Explicit Concerns and Behaviors

The analyses of user studies revealed several general issues on current system. In general, the primary concerns were inefficient waiting time due to messed order of the machine use among multiple users and a lack of confidence to other unknown users in a same community such as invasion of privacy.

As examples of inefficient waiting time, a current active user (a user in use) who was waiting the completion of his/her laundry showed frequent movements between his/her room to the laundry machine to check the completion or spent meaningless time near the machine because there is not a substantial way to monitor current status of washing or drying from the machine in own room. Other users who are waiting his/her turn for use of the machine also had to frequently check the completion of current use by physical movements between rooms. Even other waiting users for second or later had to spend substantial efforts to check the completion of current and previous uses of the machine. Many actual users complained the problems during the user studies.

If a current user missed picking up his/her laundry right after the completion, a next user who had waited his/her turn had to wait another time until the current user's pick

up. If the current user did not appear to pick up on time, the next user moved the current user's completed laundry to other places (e.g., shelves) to start his/her laundry. In this case, the current (or previous) user would feel unpleasant experience such that other unknown person touched his cloth, sometimes, including underwear. The students in the study also expressed a concern of a lack of communication between users in the community for the use of machine. Therefore, we initially thought that the issues could be resolved using new service and system design in terms of UX, especially using network between laundry machine and personal device (e.g., smartphone), which is a basic concept of IoT. That is, the laundry machine has own function to detect the current status and expected completion (or waiting) time for multiple users as well as notify them to multiple users. Each user in current use and a line also can check the status and receive messages from the machine, using individual device such as smartphone.

2.2 Development of a Usage Model

Based on the analysis, a usage model was developed for the system and service. Since the use situation between system and users are different to the conventional single user system, a use model for multiple users was attempted to generate. Initially, a conceptual use model of CSCW was considered to apply, which represents the use of system for multiple user. Figure 1 shows the historical categories of CSCW system and instance applications of each category, identified by Shneiderman and Plaisant [2]. As shown in the Fig. 1, the CSCW systems are categorized by time of use (synchronous vs. asynchronous) across space of use (remote vs. co-located) among users.

However, we realized that the framework for CSCW was not applicable to develop a usage model for the present study. We could identify the primary reasons of this mismatch. First, while the users in CSCW are cooperating for achieving a common goal (e.g., completion of discussion for decision making or document preparation),

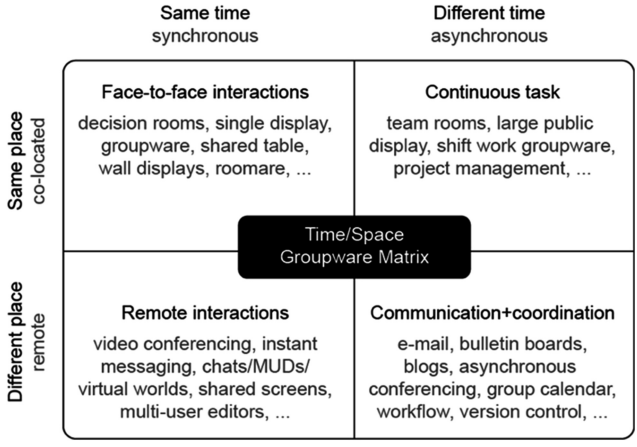

Fig. 1. Time/space four-quadrant matrix model of group-supported work [2]

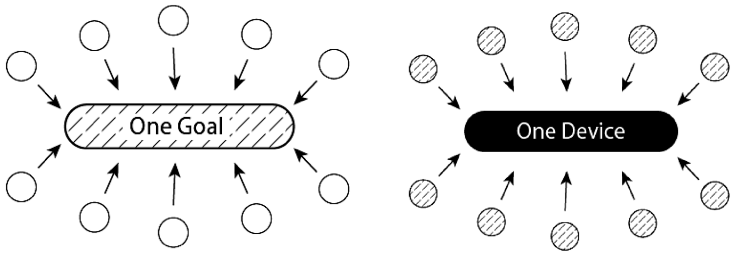

Fig. 2. The traditional CSCW usage model(left) and the Community IoT Product Usage Model (right) (Note: blank item represents personal devices, slash textured item represents goals to achieve, and solid filled item represents a IoT device)

the users in the present study have own goal (e.g., "completion of laundry of my clothes," "reservation for next use") regardless of other users. Second, while the CSCW users use their own device to complete the common goal, the users in the present study use own personal device (e.g., smartphone) to access the main device (e.g., laundry machine). Figure 2 shows the conceptual differences in usage models between traditional CSCW system and the present study, community IoT service and system. Consequently, the multiple users in CSCW works together with distributed cognition [4] while the multiple users in the present community system/service share specific system across time and space.

In addition to this, as a result of usage model development for the present study, four main agents were observed and identified, including: a present user who is currently using a laundry machine, the laundry machine with IoT equipment, a first waiting person of the machine, and other waiting persons. However, it was assumed that every human user has own mobile device to communicate between agents such as human users or the machine. Figure 3 shows general relations among the four agents in the service.

Based on the usage model, a list of general user tasks was identified, which are expected to implement as functions in the system/service. The tasks were identified two dimensions, the space and time of interactions between main device (laundry machine) and personal device (smartphone). Two possible use contexts were identified for the space category (see Table 1). First, the interaction could be done where the main and

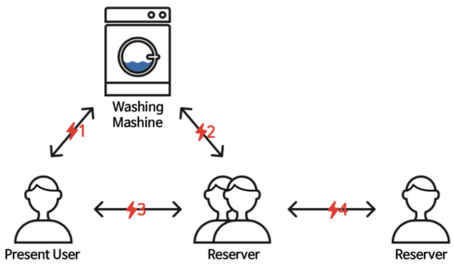

Fig. 3. Four agents (users and device) consisting the service

Table 1. Time/space matrix model of community laundry system

		Time		
		Before Reserved time	**On Reserved time**	**After Reserved time**
Space (main and personal devices)	**Same Place**	(no interaction but physical interaction between user & machine)	Authentication	(no interaction but physical interaction between user & machine)
	Remote Place	Check availability, waiting line, etc. Make reservation	Evaluation of previous users	Pick-up message

the personal device are in the same place such as in the laundry room. In this case, along with a long-distance network such as internet protocol through Wi-Fi or data service for smart phone, a simple short-distance network such as Bluetooth or Near Field Communication (NFC) could be used for the authorization. Second, the user can access the main device using his/her personal device in a remote place (e.g., own room or outside of building) to check the status of the main device like a typical IoT system. In this case, a long-distance network would be needed to connect the devices.

Three possible use contexts were identified for the time dimension in perspective of user to complete own purpose, including: (1) Before reserved time: because the laundry machine is being used for previous user's purpose, he/she would check the expected completion time for previous user and the number of previous users in the waiting line, and reserve his/her order on the specific machine; (2) On reserved time: when the user starts using the machine. The user needs to authorize him/herself in front of the main machine as well as evaluates previous user's manner for the community system; and (3) After reserved time: when the laundry machine is finishing the washing. The user would receive a push message to pick up the laundry few minutes earlier its completion.

3 Development

3.1 Task Flow Chart

Based on the usage model and the general tasks list, detailed problems and requirements for each agent as well as what kinds of information need to be delivered between agents to resolve the problems were identified, along with considerations of personal privacy. Then a conceptual service model was developed in forms of UX service flow chart. Figure 4 shows a sample of the service flow chart. The service chart was used to identify groups of features and functions of the service. The three main features were: (1) 'washing reservation' to determine the order of the laundry machine use among

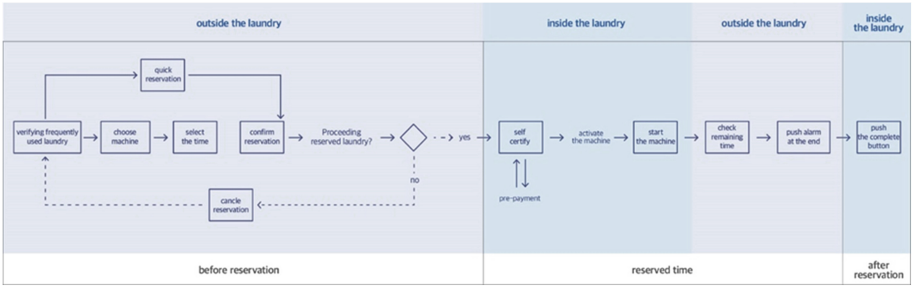

Fig. 4. A sample of service flow chart

users; (2) 'self authentication' to check the present user at his/her reserved time, and (3) 'laundry monitoring' to provide users with current status of the washing in real time. Some distinctive functions for the service also were identified including, for example, 'poke' to send an anonymous push notification for the previous user to pick up his/her completed laundry and 'manner evaluation' to evaluate other users' manner to the community machine.

3.2 Concept UI Design

In order to validate the suggested UX design along with features and functions, a prototype of user interface in a mobile phone was developed. Figure 5 shows 3 sample screenshots of the smartphone application UI. (It should be noted here that the UI was designed in Korean.) Figure 5 (a) is a 'Reservation' screen which shows current status of laundry machines in each building with multiple floors. A user can check which machine is being currently available, otherwise, when the current use for previous user

Fig. 5. Sample screen shots of UI prototype: (a) Reservation; (b) Authentication; and (c) Status Monitoring

would be finished, and how many users are waiting the machine in the line for each machine. Finally, the user can select and reserve a specific laundry machine which seems to be most feasible. When a user received a message from system notifying that his/her order becomes to ready, the user needs to authorize himself/herself in front of the reserved machine using own smartphone application depicted in Fig. 5 (b) ('Authentication'). After the user starts his laundry, the user may check the status of the machine washing his/her laundry in a remote place, using the UI screen shot in Fig. 5 (c). As shown in Fig. 5 (c), the UI provides the user with remained time to complete the laundry using various ways such as clock and progress bar.

3.3 Concept System Development

A hardware prototype of laundry machine integrated with IoT device (Raspberry Pi) also has been developed to build and aggregate the comprehensive system including the laundry machine and smartphone application. However, due to the limited time and resource, a series of evaluations by experts (e.g., walkthrough and heuristic evaluation) has been conducted for usability evaluation to revise the UI. More elaborative usability test using actual users for evaluating aggregated UX service will be conducted in near future in more realistic situations.

4 Discussion and Conclusion

The present research shows a case study to design a comprehensive UX for community system with IoT, which is a laundry system in a dormitory. Through the study, it was able to confirm that:

First, UX development of communal environment revealed respectively unusual usage models as it must consider multiple user UX simultaneously. During developing the usage model and its framework, it was identified that the model of CSCW was not applicable to the current study due to differences in purposes among users toward the sharing system, even though multiple users need to access the system regardless of space and time. Second, some unique features, such as push alarm or manner evaluation, were needed to enhance the inter-user credibility to serve as differentiated using models. Third, the development of higher fidelity prototype including hardware, software, network, and service seems to be necessary to reflect users' potential and tangible needs.

The primary limitation of this study is that the comprehensive system was not evaluated in terms of usability test and acceptability. As mentioned, even though several expert evaluations were conducted for the UI of the smartphone application, it would not represent actual acceptability for overall UX of the system to be perceived by actual target users. Therefore, it would be desirable to assess overall system/service through appropriate evaluation methods, rather than traditional heuristic methods or usability tests for simple UI with a single user.

Finally, the present study itself is expected to provide a better UX environment to the dormitories and community laundries, the typical environment of communal

washing. Also, we expect that the study could be a precedence case of UX development and framework research for the new communal usage environment. The study would serve as a preliminary case of an application of the IoT technology to the sharing economy as well.

Acknowledgement. This study was supported by a 'University for Creative Korea' Grant to Handong Global University through the Ministry of Education, South Korea. We would like to thank professors InWook Choi and Sang-Hwan Kim for advising the study and manuscript preparation.

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