Int. J. Human-Computer Studies 80 (2015) 24–35

Contents lists available at ScienceDirect

Int. J. Human-Computer Studies

journal homepage: www.elsevier.com/locate/ijhcs

Exploring interactive style and user experience design for social web of things of Chinese users: A case study in Beijing ☆

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ARTICLE INFO

Article history:
Received 8 April 2014
Received in revised form
18 January 2015
Accepted 18 February 2015
Communicated by E. Motta
Available online 26 February 2015

Keywords:
Social web of things
Chinese user
Internet of things
User experience
Service design
Social network

ABSTRACT

This study designed an interactive IoT (Internet of Things) service on mobile devices based upon the concept of Social Web of Things (SWoT), with which users can interact with IoT in the same way they use the social network services. In order to integrate IoT into Chinese daily use, this study also investigated how Chinese users interact with things and IoT technologies. A four-phase study among users living in Beijing was conducted with a lifecycle of user-centered design. Results revealed that SWoT could activate users' intuitive understanding of social network services, and make the interaction with SWoT natural in their own ways. Users living in Beijing tended to be utility-oriented and highly emphasized efficiency; they were distinctive in uncertainty avoidance and preference of hierarchical way of managing things. Our results suggested implications for the design of user-centered IoT systems in China, and shed light on improvements for the performance of IoT systems and balance of requirements between users and system design.

1. Introduction

Internet of Things (IoT) was first proposed in the paper "Making Reality a Cyberspace" by Kellogg et al. (1991) at the first Cyberspace Conference in 1990. With the potential impacts on a nation's power, IoT was recognized as a "disruptive civil technology" by US National Intelligence Council. The concept refers to pervasive presence of smart objects that are connected in an internet-like structure so as to interact and cooperate with each other. Chinese former Premier Wen proposed the concept of "Perception of China" in 2009, which was the first time that Chinese government supported developing IoT in China. According to the estimation by Chinese government, the scale of IoT related industries in China will reach RMB 750 billion (USD 117.91 billion) by the end of 2015 (Huang et al., 2011). Before practical IoT services can be fully implemented, researchers and practitioners are exploring proper interactive styles and user experience design for it. Future objects will become smart autonomous artifacts that can communicate, collaborate to pursue appropriate behavior through the Internet (Kortuem et al., 2010; Vazquez and Lopez-De-Ipina, 2008). Therefore, it is important to make sure that users understand the totality of the interconnections between things before manufacturers carry out designing Internet of Things (Formo, 2010).

Realizing that most users hardly have a clear and well-organized understanding of IoT-they understand the wireless network as series of A-to-B connections instead of interconnections (Formo, 2010). The concept of Social Web of Things (SWoT), proposed by User Experience Lab at Ericsson Research, attempts to utilize users' intuitive understanding of social networks to make the interconnected nature of IoT understandable and acceptable (Formo et al., 2011). SWoT is an innovative concept aiming to help people to establish a correct enough mental model of IoT. In SWoT, devices are presented as "beings" in social networks, with their interconnections compared to social relations, and their communications compared to social interactions.

Following this trend, a collaborative research project has been initiated together with Ericsson in Beijing, China. Building upon compatible user studies conducted by Ericsson in North Europe and North America, this study focused on exploring Chinese users' perception of SWoT and designing localized SWoT services for users in China. However, services in the pursuit of SWoT have not been put into practical use yet, and a minuscule amount of published research has been devoted to assessing user requirements of IoT services. For this reason, we conducted a four-phase study based on the process of user-centered design. In the first phase, we explored factors influencing users' mental model of SWoT: their decision-making when purchasing products, perception of things, and understanding of

☆This paper has been recommended for acceptance by E. Motta.

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http://dx.doi.org/10.1016/j.ijhcs.2015.02.007
1071-5819/

their relationship with things and interconnections between things. In the second phase, we examined users' real-time interaction feedback when interacting with the preliminary SWoT demo and explored their interaction needs of SWoT with a depth interview. Based on the findings of Phase One and Phase Two, conceptual design and prototype implementation were introduced in Phase Three. In the fourth phase, we evaluated the SWoT prototype with usability testing and heuristic evaluation. The intended contribution of this research is to provide a richer understanding of requirements that users have when using IoT systems, and to inform the service design of IoT and other ubiquitous technologies in the future.

2. Theoretical background

2.1. Interacting with IoT

A wealth of IoT-related research focuses on technical feasibility and scenarios of application. Both physical User Interface (UI) based on Near Field Communication (NFC) and Radio Frequency Identification (RFID) and mobile interaction applications have been developed for commercial use, especially in ticketing, payment, smart home care, access control, logistics as well as entertainment (Hang et al., 2010). Users can interact with smart objects directly or indirectly-via clients such as PC or smartphone (Rukzio et al., 2006). Elderly people's living is assisted by home care services based on NFC-equipped cell phones (Sidén et al., 2011). Unlike Google for searching in the virtual world, a real world search system called MAX can fulfill on-demand search and location of physical objects with RFID tags in smart domestic settings (Yap et al., 2005).

Despite the increasing popularity of IoT systems, most users are still unfamiliar with this new technology (Hang et al., 2010). Even though there were technology-oriented research studies dealing with security and privacy, few of them concerned IoT from a comprehensive perspective of users' mental model and actual usage requirements. For instance, users using NFC-enabled applications are still confused with how to initiate the interaction between humans and smart objects (Broll et al., 2009). Also, as for user perception of the novel "network of things", Boussard and Thébault (2010) found that distinguishing web-enabled objects from non-connected objects made objects' behaviors understandable through a study involving a smartphone, a web tablet and a desktop web browser. However, the arrangement of the structure of numerous daily objectives in a smart environment warrants further exploration.

Another issue in accepting IoT is enhancing control. During the interaction with technology, users need to perceive control over things to avoid uncertainty. A study by Zander et al. (2010) derived a framework of computation of things, in which decision support is provided based on geographic positions, activity patterns, and human state patterns, to reduce fear and to enhance awareness of appropriate responses.

To this end, Social Web of Things (SWoT) consists of the social web and the IoT, which means that people can connect with devices and services in a social network service, where they can say what they do, what they want, follow others, discuss with each other, complete tasks together, or even just "like" or "re-tweet" each other (Formo, 2012). Introducing familiar concepts such as "friendship" and "social relations" to the abstract "IoT" based on users' jobs, workplaces and hobbies may probably help users better understand the network of people and things (Breslin and Decker, 2007). Actually, this "natural" interaction is now feasible in technology. For instance, people can have conversations with their TV, smart meter or refrigerator as they talk to their friends on Facebook, and then the devices will give people corresponding feedback such as the current state of energy saving at home. Recently, Kamilaris and Pitsillides (2010) proposed interacting with smart home using Facebook and evaluated its technical feasibility; Guinard et al. (2010) proposed a platform to share devices with other people in an existing social network; other researchers even offered proper policies for social relationship management in such a Social Internet of Things system, and analyzed characteristics of the structure via simulation (Atzori et al., 2012).

2.2. Culture theories

Cultures, societies and policies form people's values and attitudes, and as a result shape their perception and cognition specifically towards novel concepts and technologies: how they manage time and money to buy products, how they regard uncertainty along with new technology, how they perceive their relationship with things and people, how they tend to structure network of things. Due to the unique characteristics of Chinese culture and rapid changes of society, it is hard to generalize Chinese consumers' behavior solely based on Western culture dimensions. An emerging stream in consumer behavior research takes Chinese traditional cultural values, social reforms, policies and Western culture theories into consideration. In the present study, we focus on four cultural dimensions related to social networking and IoT: perspective of time, uncertainty avoidance, power distance and cognitive style.

One interpretation of the perspective of time is from Trompenaars and Hampden-Turner's (1998) model. The perspective of time depends on whether a culture is short-term (present) or long-term (future) oriented. Cultures emphasizing short-term orientation stress more on short-range goal of profit and efficiency while cultures emphasizing long-term orientation stress more on long-range gain and loss of profit. Another interpretation is whether cultures treat time as scarce or plentiful resources (Wilson et al., 1996). People living in some cultures treat time as scarce resources, so they have a fast pace of life and work; whilst in some other cultures treat time as plentiful resources, so they live a leisurely life. The way people treat time might influence their perception of things and requirements of IoT service.

Uncertainty avoidance, which is defined as how people feel threatened by uncertain situations, comes from Hofstede's (2001) four-dimension model. Cultures with high uncertainty avoidance tend to have a higher need for security and a stronger belief in experts and knowledge. Especially in the IoT, uncertainty of information and functionality increases because the interoperate system can be hidden in pervasive objects and even small interconnected everyday devices. Apart from user privacy, easy and safe user control of IoT services is also a significant design aspect confronting uncertainty.

Power distance in Hofstede's model is defined as the degree to which less powerful members of organizations accept the unequally distributed power (Hofstede and Bond, 1984). In Eastern cultures such as China and Korea, the Confucianism seeks a stable and tight hierarchy in interpersonal relationship, and strict obedience can be easily found (Huang and Deng, 2008). The high power distance may influence the way Chinese people regard their relations with things and then influence how they understand and manage the interconnections between things in SWoT-based services.

Regarding cognitive styles, East Asians have holistic cognitive styles rather than analytic (Rau et al., 2004), due to the remarkable differences in social systems (Nisbett et al., 2001). Therefore Chinese may understand IoT in a holistic manner so that they may have a different understanding of the state or feedback of IoT systems.

As for target users of SWoT in China, users living in Beijing not only share similar values and lifestyles with users from Western cultures due to the rapid pace of urban life, but also maintain

distinctive characteristics of Chinese cultural in their values and motives. These characteristics add to the complexity of localizing the concept of SWoT. We therefore proposed a qualitative user requirement gathering approach as part of the User-Centered Design (UCD), in order to understand the requirements, preference and mental models of this special group of users who do not have practical experience with SWoT or IoT, and to discover design implications for IoT service in China.

3. Phase One: Exploring the mental model of SWoT

A self-reported photo-diary was conducted to gain insights into how potential users perceive things around them and their mental model of SWoT. The photo-diary method served as a reflective technique for uncovering users' experience with technologies, life scenes, and hidden ideas of human–thing relationship.

3.1. Participants

As the first stage of exploring SWoT service design in China, we focus on target users of SWoT in Beijing. We recruited seven pairs of participants ($n=14$, ages 23–55, 5 males) living in Beijing in the study. Each pair should know each other but not live in the same household, because the photo-diary should be done independently. They were either causal acquaintance of the researchers or recruited from online forums. The sample covered diverse occupations, different family situations (e.g., single, married, and divorced) and different living arrangements (e.g., single member household, living with partner and/or children household, and three-generation household). Most of the participants had home network and prior experience of Social Network Services (SNS) (see Table 1).

3.2. Method and tasks

The present photo-diary study was inspired by the design methodology of "cultural probe", whose premise is that user behavior can be better understood by being studied in their own environment (Gabridge et al., 2008). The rationale underlying photo-diary is that consumed or conserved goods can partially indicate how one's "self" is formed and maintained (Dwayne Ball and Tasaki, 1992) and they can reflect one's values and attitudes towards things. The photo-diary method, as a projective technique, is useful for exploring hidden ideas of how people perceive things in their daily lives. As Chinese users tend to express their points implicitly in usability evaluation (Clemmensen et al., 2009), the self-reported photo diary makes it easier to collect personal data and opinions that are otherwise difficult to get in a direct manner.

At the beginning of the photo-diary, participants were given a booklet containing 26 tasks and were asked to complete all the tasks in two weeks, in an arbitrary order. The tasks were about asking about participants' decision making, perception of things, relationship with things, understanding of relationship between things, expectation of the intelligence level of things, or expectation of future scenarios of IoT (see Table 2). Each task asked the participants to take photos of one or several objects, to make a brief description in text, and to email the photos and texts to the email address of the research team. To ensure validity, we told the participants that there was no right or wrong answer to each task, and that all personal information would not be disclosed. During the two weeks, they were reminded if their progress was left behind. After two weeks, the photos and corresponding descriptions generated by participants were collected, summarized and analyzed. For each participant, questions that were not explained clearly or needed further elaboration were summarized and asked about in the next phase.

3.3. Data analysis

The photo-diary results were analyzed through a modified grounded theory method (Strauss et al., 1990). At the first stage, we conducted open coding. The cultural dimensions from prior literature served as priori codes to guide the coding process. Each researcher coded the diary notes and photos independently, and then a joint discussion was held to resolve differences and to clarify ambiguous

Table 1
Overall background of participants.

Criteria	Overall background
Occupation	Automobile manufacturing (2), education (1), business (1), management consulting (3), information technology (2), healthcare (2), transportation (1), agriculture (1), advertisement (1)
Family situation	Single (4), married (8), in a relationship (1), divorced (1)
Living arrangement	Living with parents (1), living with friends (3), living with partner with/without children (7), Living by oneself (2), Living with partner, children and parents (1)
Income	Personal monthly income ranges from RMB 4000 to RMB 20,000
Home network	Having home network (10), not having home network but interested in having one (4)
Prior experience of SNS	Having prior experience about SNS (11), not having prior experience but having heard of it (3)

Table 2
Example tasks of photo-diary.

Category	Representative tasks
Decision making	Take a picture of something that you are really happy that you bought and that you are still happy with
Perception of things	Take a picture of something beautiful (old; important; having personality; and having a story)
Relationship with things	Take a picture of something that is partly broken, but still in usage (that replaced another thing; that you hope you will still own 10–20 years from now; that you most/least trust)
Understanding of relationships between things	Take a picture of things that belong together where you cook (relax, sleep, watch TV) Imagine what things would say if they can speak
Expectation of the intelligence level of things	Take a picture of a thing that actively communicates with you (does something automatically)
Expectation of future use scenarios of IoT	Take a picture of something that you would like to remote control but that is however not possible to be remote controlled today (something that you own that you often share with others)

codings. At the second stage of analysis, axial coding was performed. All researchers discussed the content of coded transcripts, and independently wrote memos concerning connections between codings, grouping of similar concepts. Then all the memos were collected and discussed within the whole research group to cluster them into themes. At the same time, themes were combined or divided into core categories in order to uncover patterns of user perception and motivation. Ambiguous themes and discrepancies in ideas were solved with the iterative memo writing process involving individual memos and original photos and notes. Finally researchers came to the consensus of four core categories of participants' perception of things: purchase decision of things, perception of owned things, relationship with things, and the perception of thing–thing relationship. Then the researchers refined the themes by comparing them with results of compatible studies in North America and North Europe.

3.4. Results: factors influencing Chinese users' SWoT mental model

From the transcripts of photo-diary and four core categories we have identified, we gained some insights into Chinese users' mental model towards the interconnected nature of humans and things. We organized our findings into four sections: (1) utility-oriented perception in making purchasing decisions, (2) relationship with things: uncertainty avoidance, (3) thematic hierarchy among things, and (4) attachment to things.

3.4.1. Utility-oriented perception in making purchasing decisions

Users in Beijing were utility oriented in making purchase decisions, and the benefit-to-cost ratio was among the most important considerations. This practical view was found to influence their acceptance of new technology and requirements of interface design. Benefits mentioned by users included: usefulness (3 participants), good quality (3 participants), reliable performance (3 participants), and novel or multiple functions (2 participants). The costs mentioned were fixed cost, price (12 participants), and variable cost-one participant mentioned explicitly that he would consider the variable cost when making purchases, such as energy consumption and maintenance cost. It seemed that most participants in this study intuitively did benefit–cost analysis before making every purchase decision. In this interview, 12 participants naturally performed benefit–cost analysis when they were asked about the considerations when making purchases. To acquire the thing with the best benefit-to-cost ratio, some said that they did a lot of research to become "experts" of certain types of product before purchasing, so that they could make comprehensive comparisons among similar products and choose the best offer. One participant mentioned the following words when making the decision to buy a water heater:

On one hand, [I] would consider the benefit-to-cost ratio of the water heater itself, and on the other hand, consider the benefits-to-cost ratio of using gas or electricity. After that, I will take the overall benefit-to-cost into consideration to make an optimal decision finally (#4a, 36, male).

The perception of gaining the highest benefit-to-cost ratio can increase users' satisfaction. Participant #5a expressed her satisfaction when making a wise decision with a high benefit-to-cost:

It took only RMB 3,000 [USD 475.2] to buy this wine cabinet, the table and the six chairs. Don't you think I am happy? I am very, very satisfied with them! (#5a, 55, female).

Users living in Beijing emphasized functionality and tended to express their utility-orientation. There was a question asking participants to list things that were important to them. Among all the important things mentioned, most were regarded as important for their functional value (9 out of 14), including things that were essential for human physiological needs (e.g., water) or safety needs (e.g., mobile phone and electronic razor). Others were regarded as important for their emotional values (5 out of 14), including things that related to belongingness and love (e.g., photo of mother) and self-fulfillment needs (e.g., digital camera used for years by a photographer). This finding was supported by service research studies in which users were typically goal oriented, and entertainment-related criteria of online services were not relevant to purchasing strategies (Zeithaml et al., 2002). However, the difference between age groups was distinct in terms of what they valued about things. For instance, four fifths of participants born after 1980 perceived emotional values as important, and they were more prone to attaching emotions (e.g., interest, love, self-esteem) to things; while two thirds of those born before 1980 perceived functional values as important. This difference maybe partially results from the one-child policy in China. Falbo (1987) concluded that the only children in China were superior to those with siblings in intellectual abilities, imagination, and emotional health.

As for the question asking participants to list things that were beautiful, it seemed that for Chinese the functional values and aesthetic values of things were considered separately; therefore the aesthetic values of practical products may be less important than their function and performance. About half of beautiful things mentioned were purely decorative things (e.g., painting and home plants), whereas nearly no high-tech products or home appliances were perceived as beautiful. The elements of beauty mentioned by participants were: design (e.g., Chanel handbag), nature (e.g., home plants), culture (e.g., blue-white porcelain) and emotional attachment (e.g., photo of a child). In addition, participants' attitudes towards the beauty of things were gendered. For example, female participants (7 out of 9 female) tended to regard things with natural, Chinese cultural or artistic elements as beautiful things. One female respondent thought the five-color hanging bag was beautiful since it represented a Chinese traditional aesthetic feeling. The iPhone was mentioned because of its elegant design features. On the contrary, male participants (4 out of 5 male) were more likely to perceive beauty in things with practical functions than female. One respondent regarded a 100 CNY note as one of the most beautiful things that he has ever had. Devices with practical functions like electrical shavers were also thought to be beautiful, according to one male participant. These differences in gender might be related to the orientation of aesthetic perception of everyday things such as hedonic-orientation or utility-orientation.

Except for benefit-to-cost ratio, appearance (5 participants), brand (4 participants), and ease of use (2 participants) were mentioned as secondary considerations. It was noteworthy that Chinese users' consideration of brand was also utility-oriented. Brand was seen as an indicator of quality. If the purchase was big (e.g., the price of the item is high), choosing international and well-known brands (often with higher price) was a strategy for decreasing risk and saving information searching effort. One participant demonstrated strong propensity for foreign brands in preference to domestic brands, and she explained that:

It takes too much effort to buy domestic-made product - you have to do a lot of research among different types, functions, and brands I don't quite trust domestic brands I am afraid that I have to repair them all the time (#6a, 31, female).

In comparison, she regarded most foreign brands as more trustworthy and reliable. Moreover, the effect of country of origin was sometimes taken into account together with brands, that is, foreign brand products made in its country of origin were perceived to be more reliable than those made in other areas. One participant mentioned that she would like to buy Samsung products made in Korea rather than those made elsewhere, because she thought the country of origin strongly affected quality of goods.

3.4.2. Relationship with things: uncertainty avoidance

In this study, Chinese participants tended to apply personalities to low-intelligence things, and they were prone to appreciating modest

personalities. Most of the things that were thought to have personalities were of low-intelligence level (e.g., bookshelf and antique chair), and few technical things were mentioned (only the washing machine and rice cooker). Half (7 out of 14) of the personalities they applied to things were modest ones such as "lovely", "obedient", "helpful", "gentle", "docile" and "devoted". Other personalities tended to express the participants' appreciated characters such as "unique" (e.g., punk bracelet and antique artifact), "special" (e.g., small home plants). In Chinese culture, modest personalities are generally more accepted, and people tend to assign their expected personalities to things.

Low-intelligence things were generally perceived relatively trustworthy (11 out of 14), probably because people perceived higher level of dominance and control over things. Participants trusted things that were frequently used, reliable in quality or performance, or were attached with firm emotions. Four participants regarded all things as reliable because they bought the things by themselves. On the contrary, things with high-intelligence level were more likely to be considered as untrustworthy (6 out of 10). Things were untrustworthy mainly because they were broken easily (e.g., PC and TV), of poor quality (e.g., electric kettle and telephone), easy to be out-of-date (e.g., laptop computers), invisible (e.g., wireless network), or related to the third parties such as manufacturers or government (e.g., food and electric indicator). Chinese culture is characterized high on uncertainty avoidance, and Chinese people tend to seek results that are compatible with their affirmative knowing. When things in the IoT system behave in a way that are compatible with Chinese people's perception of ordinary things, it reduces uncertainty, thus may lead to greater comfort and acceptance (Mao and Palvia, 2006). Since users' trust is critical for their acceptance of technology. Things that are trustworthy can be good candidates to be included in SWoT and be given more autonomy and flexibility.

3.4.3. Thematic hierarchy among things

Users living in Beijing tended to perceive the relationship among things with a thematic structure, reflecting their holistic thinking style (Rau et al., 2004). Most participants grouped things together if the things were used for performing certain activities. For example, TV, remote controller and set-top boxes were grouped together because they were used for watching TV; tea table, sofa and snack food were grouped together because they were all for relaxing oneself. Another grouping strategy identified in the photo-diary was the function-based categorization. In the task of "listing things that belong to the kitchen", most participants gave answers such as things using/not using power, and things for cooking/eating.

Additionally, participants had difficulty in imaging how things could interconnect or interact with each other. All of them regarded the task asking about "things that belong together" as difficult. When they were asked to imagine what things would say if they could talk, they intuitively thought about "things talking to people"; only one of them mentioned "a thing talking to another thing".

3.4.4. Attachment to things

We are also interested in exploring Chinese people's attachment to things. There were three tasks in the photo-diary to examine their attachment to things: expectation of products' life, attitudes towards old things, and replacement strategy of things.

Chinese hold low expectations for lasting things that can be used for decades. When participants were asked to picture a thing that they would like to use for another 10–20 years, two of them could hardly imagine using something for such a long time at all. In general it was difficult for everyone to find such a thing. The main reasons for expecting to use things for another 10–20 years proposed by participants were firstly, that the thing was newly bought and with the latest technology (5 participants), for example, an expensive TV with advanced features, and secondly, that the thing had an emotional meaning (2 participants), for example, lovers watches. Otherwise, Chinese hardly expected using lasting things for decades. One reason of this may be that products upgrade very quickly and people have the intent to replace out-of-date things. Another reason may be that due to the lack of technology and management, many products in Chinese market are of relatively low quality, and consumers therefore have low expectation of products' life due to their prior experience.

Chinese have more negative than positive attitudes towards old things. Ten of the fourteen participants expressed negative attitudes towards old things sending in descriptions such as "worn-out", "old-fashioned", "limited function", or "poor performance"; only two expressed positive attitudes towards old things for their emotional values (e.g., a camera used for years) or collection values (e.g., an ancient antique chair).

The questions about a thing that is partially broken but still in use and a thing that replaced another thing aimed to investigate participants' replacement decision. Partially broken things were mainly kept when main functions still remained (11 participants), for example, a telephone which could still make and receive calls, or when replacement was costly (1 participant). Only a few (2 participants) referred to emotional reasons for keeping partially broken things. For example, one participant kept using a partially cracked glass plate because she liked it very much. Users often replaced things with upgraded products (8 participants) to improve their quality of life. For example, the stove was replaced by a microwave oven for cooking. Therefore it could be concluded that the main motivation of replacing things was to get better, more, or newer functions provided by upgraded products. As a result of the rapid development of China's economy over the recent 30 years, products have been upgrading frequently with emerging techniques, which motivates consumers' frequent replacement behavior.

4. Phase Two: interaction needs of SWoT

As the second part of qualitative user requirement gathering method, this phase aimed at obtaining users' real-time interaction feedback and distinctive interactive needs by the Wizard-of-Oz studies followed by depth interview.

4.1. Apparatus

After finishing the photo-diary, each pair of participants was invited to the lab to interact with a preliminary mock SWoT prototype developed by Ericsson User Experience Lab (see Fig. 1), and to be interviewed in-depth afterwards. The mock SWoT prototype resembles the look of social network applications in a cellphone, while the "friends" on the platform can be both objects and people. Like friends in SNS, the objects on the prototype update their status and send messages to the user in the "Newsfeed" tab. Users can comment on the messages with natural language. Outside object sends a request to "add as friend" to the user for confirmation to get into the network. Throughout the study, a member in the research team simulated the system's intelligence by "acting" as things and interacted with the invited user pairs in the observing room (Masthoff, 2006). The duration of each paired interview was 2–3 h. Before letting users interact with the prototype, profiles of participants were set up in the prototype using their photos submitted in the phase of photo-diary.

4.2. Procedures and tasks

The interview was semi-structured and consisted of two parts. The first part was conducted before participants interacted with the preliminary SWoT prototype. This part included structured warm-up questions on general perception of things, as well as

Fig. 1. The web-based prototype used in the study.

questions extended from the photo diary (e.g., what is the main consideration when making a purchase). The second part consisted of seven use scenarios, and in each usage scenario the participants interacted with the SWoT prototype to accomplish one or several tasks. The use scenarios are as follows:

- Overview of the SWoT prototype.
- Accepting the request from an object to be added as a friend.
- Giving orders to and communicating with objects in a conversation manner.
- Reacting to the inter-dependence of things.
- Reacting to an object's request to be repaired.
- Adding the other participants as a friend; adding the other participant's object as a friend.
- Adding a public object (a hotel room in this case) as a temporary friend.

Since the prototype was personalized for each participant before they interact with it, the participants could get more real experience. Each of the tasks started with a status update message from one object in the "Newsfeed" tab, and the participants then interacted with the objects by replying in the natural language. How the participants interacted with the prototype in each task was observed, recorded and semantically analyzed afterwards.

The interview data were recorded, transcribed and translated into English. Similar with analysis in phase one, we performed qualitative data analysis based on the grounded theory. Researchers acted as independent coders to code transcripts, in order to identify users' attitudes and behaviors when interacting with SWoT. After clustering similar concepts and connections into themes, we tried to use the cultural dimensional theory and factors influencing users' mental model of SWoT that we obtained from Phase One to explain them. We also borrowed ideas from IoT technology and applications to select corresponding user requirements to further facilitate the following SWoT design phase.

4.3. Results: interaction needs with preliminary SWoT prototype

4.3.1. General acceptance: utility-oriented

Users in this study accepted SWoT as a pragmatic tool, and they frequently emphasized characteristics such as perceived usefulness and efficiency while interacting with the preliminary SWoT prototype. In the first use scenario, each participant added an object into his/her network of things. At the first impression, most participants demonstrated interest and happiness with the prototype. One participant expressed that:

It [SWoT] is friendly and personalized when you realized that home appliances have personalities, you'll love them more (#7a, 43, female).

However, with the interaction moving on, participants started to express doubts and unease. The primary sources of unease were the lack of dominance resulting from a too high level of intelligence, and the unnecessary empathy towards things resulting from emotions of things.

How terrible it is! It seems that everything is alive, even though they are under my control at the beginning, they are sure to lose control of mine one day (#1a).

In the post-interaction interview we found that the primary consideration of accepting SWoT was whether the platform could be practically beneficial and whether the interaction was efficient enough. Perceived usefulness was most critical to users' adoption than any other characteristic that users experienced during the interaction (e.g., fun and engagement). As one participant put it,

All functions provided should facilitate human's life (#2a, 27, female).

After all, users accepted SWoT as a pragmatic tool. Users' concern about practical benefits was connected to their perceived usefulness of the new system. In prior literature, perceived usefulness is defined as "the prospective users' subjective probability that using a specific application will increase their job performance within an organizational context" (Davis et al., 1989). According to the Technology Acceptance Model (TAM) proposed by Davis et al. and further replicated studies, perceived usefulness is a strong influencing factor

to people's intention to adopt new technologies (Zeithaml et al., 2002). Users' propensity of making practical benefits clear also corresponded to the observed results in Phase One, in which utility-oriented decision making and emphasis on function were among the most important considerations. Considering the findings in the first two phases, we thought that SWoT could be accepted as a pragmatic tool for Chinese users. Then, it is of great significance for the success of the SWoT concept to understand users' practical needs and to explicitly demonstrate the accessible benefits.

SWoT is perceived differently from the SNS. First, users have the ownership of things but cannot have the ownership of their friends; therefore SWoT should be more controllable. Second, things' network on SWoT is more stable than human's network, for most objects in one's home are there for years. As one participant explained,

I will use it [the SWoT platform] more often than social network services, because it is part of my life and these things are mine (#4a, 36, male).

4.3.2. Dominance and control: uncertainty avoidance

The prospective users of SWoT in Beijing needed to perceive dominance and control over things to avoid feeling in an uncertain environment. Their uncertainty avoidance lay in four aspects: intelligence and personality of things, linking to other people, linking to the third party, and building temporary relationship.

There were tradeoffs between expected intelligence level and personality of things. In the third use scenario, the object failed to understand the users' comment. Then the users were asked about their experience with the interaction and expectation of the intelligence level of things. All participants were confused if the objects' intention was not clearly indicated, and expected things to be smart enough to understand human's demands and to perfectly fulfill their intended functions. However, users' requirement for objects' obedience dominated the requirement for objects' intelligence. Most (8 out of 14) participants reported that things should not be too smart, even if they might have to spend more time communicating with the objects that were not smart enough. When asked about reasons, participants thought that it was not necessary for things to have too high level of intelligence; while two participants thought that they would be "scared if it were too intelligent" (#6a, 31, female; #6b, 32, female). Thus, rather than treating things like friends, users in this study would be more comfortable when things had modest personalities, and behaved as "smart subordinates who can just strictly comply with the orders of their boss", clearly reporting their status, providing information for users' decision making, and always asking for permission when decision-making was needed.

SWoT was perceived as a private network rather than a public one. The sixth use scenario asked users to add other people into their SWoT network, aiming to explore whether the participants accepted other humans entering their private web of things or not. From the observation during paired interaction, we found that all of them naturally accepted the friend request from the other participant, but at the same time felt vigilant and unsure about the intention of their paired participants who asked to connect to their things. When the other participant looked up the profile of the thing, most (9 out of 14) apparently felt invaded and showed an opposing attitude towards adding other humans in the network. When asked about reasons and considerations, four participants stated that they would be more likely to accept intimate others such as family members as friends in SWoT. Six participants completely opposed to having other people connected to their own network:

I do not accept to add others as my friends [on SWoT], because this is my private space. (#1a, 23, male)

All participants thought that compared with SNS in which much information can be shared, SWoT was a network in which limited information can be shared to other people. Possible motivations of sharing information of things to other people were: feeling proud of owning a thing, sharing similar interests with others, seeking help, or temporary authorization. The type of information that can be shared is also limited: only public information can be shared, and the information should not include any private information of the owner. Thus there are "boundaries" between the network of things and network of humans, and the boundaries vary with personal privacy preference and cultural backgrounds.

Participants in this study needed to keep control over things and their activities when they linked to the third party. In the fifth use scenario, one thing had a status saying something about needing a repair, and it asked if it could contact the manufacturer to book a service repair. At first, the participants perceived benefits for the convenience it would bring, because if the device itself connected the third party, the user would not need to do so. However, they were very discreet when the device suggested contacting the third party without supervision and control of the users. The reasons were threefold. First, they were suspicious towards the capacity of the technology to make the best choice and do good bargain with the third party. One participant said "*Perhaps the repairing fee is very high and I don't need to repair it, so it should always ask me first before taking actions*" (#1a, 23, male). Second, they did not fully trust the integrity and service quality of the third party, and were worried that the third party would not provide the best service without the supervision of people. Third, they were concerned about the risk of disclosing private information. Therefore the SWoT platform should only support users' decision making by providing information and suggesting solutions; decision and external negotiations should be made by users themselves.

Users would like to evaluate and control the risk of building temporary relationship before accepting the request. In the last use scenario, the participants received requests from an outside entity as "temporary friend". In this case, the temporary friend was the hotel room they booked during a business trip. Participants were very discreet towards the request. Most of them (9 out of 14) opposed to the connection in consideration of protecting privacy or avoiding the risk of leaking information or coming across fraud. As one participant put it, "*I do not accept the connection, because I don't want to leave my footprint*" (#5a, 55, female). A few hesitated at the beginning but finally accepted the request considering the benefits provided by this temporary relationship (in this case, the room claimed that it could provide internet service and make the hotel more cozy). It implied that users would only accept temporary relationship with things when they saw benefits. Therefore, SWoT should provide users with enough information of the benefits and possible risks, and to clearly show the benefits of the connection and reduce the perception of risks caused by lack of knowledge in order to promote the functionality of temporary connection.

In sum, participants' uncertainty avoidance generally involved maintaining moderate tradeoff between personality and intelligence level of things (e.g., smart and obedient); the connection linking to outside companies and people should be built based on minimal risks. As one participant concluded, "*the platform should be under the control of people*" (#4b, 36, male). Participants sought to protect themselves from uncertainties such as being exposed to people other than families, generating unwanted costs, disclosing private information, and being overwhelmed by technology. Users' emphasis on dominance and control over things, relationship and information is identical to previous studies of online service evaluation (Zeithaml et al., 2002): perceived control over system can motivate users to embrace and use SWoT to accomplish goals in their home lives. For example, when things present a too high level of intelligence, users will feel worried.

I'm worried that things will be out of control one day by this way (SWoT) (#6a).

Compared with identical studies in North America and North Europe, users in Beijing are more sensitive in building "boundaries" (e.g., SWoT is a private network that can be only shared among intimate family members) when privacy needs to be clarified during interaction. Chinese users' concerns of the "circles" (e.g., family versus friends, third-party companies, and temporal relationships) in SWoT indicate that they are more protective in dealing with their "boundaries" (Rosinski, 2003). We speculate that the evaluation of benefits when users are dealing with external relationship might be more important for Chinese people than Western users, consistent with the literature on collectivism and uncertainty aversion in Eastern cultures (Hofstede, 1983). Therefore the design implication is that social web of things should be separated from the social network of humans. If sharing information is needed, users should have full control over the whole process and details of sharing.

4.3.3. *Efficiency*

Efficiency is an important consideration for the interaction; straightforward and clear communication between humans and objects is preferred. There were two cases concerning human–object communication. In the first case, one device reported that it was still on although it was probably supposed to be off, and it asked if it should switch itself off; in the second case, another device reported its abnormal condition in an ambiguous manner, and it did not understand the user's complex input. All participants showed positive attitudes towards the first case because the interaction was simple and clear. While in the second case, when the user did not understand the objects' ambiguous statement and the object failed to understand the user's complex input, many participants turned to be doubtful, and one even said that he would give up the communication immediately.

The different responses in the two cases highlighted the importance of efficiency in interacting with SWoT, and suggested that prospective users would show positive attitudes towards a new technological system when they can get access to their desired goal directly and easily, and find their desired information (status of devices and solutions if something abnormal occurs). The literature on e-service quality has described efficiency as one key dimension of measuring the customers' perception of service quality, suggesting that our results about the role efficiency played in the acceptance of SWoT system is in accord with the criteria of evaluating e-service quality.

Interaction style and communication style of SWoT also reflected users' propensity of efficiency. As for interaction styles, users in this study were more familiar with sending and receiving SMS than using cellphone applications. Interacting with a digital TV and a remote control was another frequently used interaction approach. As for communication styles, participants showed little interest in natural language because they concerned about extra communication efforts to make things work. The function of human–object communication would only be perceived beneficial when users can easily find out which object is talking and what the current situation is. Even though the attitudes towards natural language vary with each individual, communication should be logical enough to assist efficient interaction.

To enhance the efficiency of the interaction, several solutions were mentioned: (1) limiting the ambiguity of conversation (e.g., giving multiple choices instead of asking open questions); (2) presenting only information useful for actionable goals; (3) presenting information in a logical sequence (e.g., What is the problem? What are the potential solutions? What are the costs and benefits of each solution?); (4) simplifying the steps of operations especially when using natural language; and (5) providing personalization of communication patterns.

4.3.4. *Hierarchical structure of things*

Hierarchical organization for things was widely preferred than flat organization; and things can be connected only if explicit benefits were declared. It was mainly because hierarchical structure enhanced perceived control and made the management of things easier. Thus users could ensure their status and responsibility over things and power distance was maintained. An appropriate organizational structure of things would resemble the organization of a company, where the user is "the boss" and things are "obedient and smart subordinates" that can provide support to the user and ask for their permissions. Hierarchical relationship among things was also necessary to reduce information overload by only allowing the things at higher levels to report to the user, or by reporting summaries of information to users.

5. Phase Three: SWoT prototype design

After gathering user requirements towards SWoT, an interactive IoT system based on this concept (also named SWoT) was designed based on design implications obtained from previous phases.

5.1. *Conceptual design*

Potential use cases were originally generated from participants' brainstorming and further refined with market consideration and feasibility, and could be categorized into four groups: (1) managing relationships with things, (2) connected home, (3) reminding events, and (4) tracking valuable things. Setting room manager satisfies all distinctive characteristics in SWoT design, and it is useful in forming a social network. The natural way of organizing and managing relationship with things makes SWoT a social tool. It enables users to manage properties and relationships among things according to their own interests in the same way as they do in SNS. Remote control satisfies users' utility-oriented decision making by ensuring security and saving time, especially in emergent situations. Moreover, interacting with a cellphone or a PC is proper for remote control. Things in this feature should act as smart and obedient assistants or subordinates to ensure users' feelings of dominance, so as to avoid their uncertainty and maintain the power distance. Assisting living of the elders is of great market potential in the aging society. The potential interaction model allows users to minimize uncertainty: Chinese are quite familiar with SMS (Short Message Services), TV and phone rings. For the elders, they are more likely to use SMS or phone calls to communicate with their families. They also frequently use TV because of its large screen size and central position at home. Voice and rings are very useful to attract the attention of the elders, since they seldom use complex intelligent devices. Tracking agent is new to Chinese users, but it has eminent benefits for Chinese users in finding their lost things. The biggest problem for Chinese when losing things is that they do not know where to ask for help and how to obtain useful information. Thus this feature is especially designed for users facing this problem. What's more, if SWoT provides meaningful suggestions and solutions towards serious contexts to support users' decision making, it helps a lot in saving time and avoiding uncertainty, which is highly valued by Chinese users. The four use cases and corresponding characteristics are depicted in Fig. 2.

5.2. *Integrating design implications into prototype design*

SWoT prototype is an Android-based mobile application, which was developed with Adobe Illustrator CS4 and Adobe Flash Professional CS4. There are five features that make the prototype design of SWoT innovative and distinctive:

First, different from the regular SNS, the social network in SWoT is narrowed down to a private "family network" (see Fig. 3a),

including only intimate family members (e.g., father, mother and child). According to Chinese users' perception of SWoT, they prefer a private "social relation" in SWoT, meaning that only intimate family members can be involved into the network. In addition, users need to remain dominative over all devices in the network, thus SWoT was designed to be a private family network in which the user dominates all the objects.

Second, all the functions in SWoT are related to practical use, such as finding lost things and dealing with urgent situations of devices. This design is helpful for explicitly demonstrating SWoT as a useful tool with various pragmatic functions. In addition, we integrate a control panel of things with a GUI (Graphical User Interface) into the SWoT prototype (see Fig. 3c), which is primarily based on a social network service. The control panel allows users to manipulate things and strengthens the practical value of SWoT.

Third, all things in SWoT are generally set as modest beings with low-intelligence so as to highlight users' dominant role in the network. Specifically, things in SWoT always provide practical suggestions and ask the users to make decision in a subordinate way. This is because by investigating their perception of relationship with things, users would feel comfortable with things acting as "smart subordinates" rather than being friends the way in Facebook. In addition, things are designed to be smarter in emergent situations, when devices automatically execute some actions for security (e.g., "urgent power off" is automatically executed when the gas stove is detected not working).

Fourth, the form of multiple-choice questions with which things stating situations and providing suggestions enhances the efficiency of SWoT. When the system gives suggestions to users in urgent situations, their suggestions are presented as a multiple-choice question, with which the users can make a selection quickly. Of course, the contents and sequences of these solutions are presented in a logical way for users to quickly catch the meaning. For example, "power off urgently" should always be the first choice in such questions. Fifth, in the culture emphasizing power distance, users need to see the relation network in a hierarchical way not only between the user and things, but also among things. Not every device has the right to directly talk to the user. That is why in SWoT prototype things are originally grouped by rooms or activities they belong to (see Fig. 3b), and in each group one of them is chosen to be the "room manager" to report updated events to the ultimate boss – the user.

	1	2	3	4	
Use cases	Utility-orientation	Uncertainty Avoidance	Efficiency	Power Distance	Interactive Models
Setting Room Manager	✓	✓	✓	✓	Mobile app
Remote Control Connected home	✓	✓	✓	✓	Mobile app, PC app
Reminding Assisting the living of the elders	✓	✓	✓	✓	SMS, TV, voice & ring
Tracking Finding lost things	✓	✓	✓		Mobile app

Fig. 2. Target use cases and interactive models.

5.3. Overview of functions

5.3.1. Management

"Management" deals with managing things' attributes and relationship with people. After choosing a certain role of a family (see Fig. 3a), the user is presented with the SWoT default screen "Express", where shortcuts of items for quick access are displayed. Another related tab "Management" includes functions of defining the hierarchical structure (see Fig. 3b), setting the room manager, adding/deleting items, managing things' profile, history record, and users' authorization (e.g., the father can take full control of things while the son can only see his toys). The room manager can be set and changed according to users' own preference. Users can approach management from the "menu" button on the bottom of the screen.

5.3.2. Remote control

Remote control includes setting/changing parameters of things to let the device work (see Fig. 3c), dealing with urgent tasks (e.g., abnormal status of gas stove). Normally the control panel is accessed when the user enters the screen of the things in "Management" tab. GUI is used for control panels to enhance efficient interaction, perceived control, usefulness and effectiveness, which are all explicit benefits to users. GUI is also helpful for avoiding uncertainty brought by natural language interface.

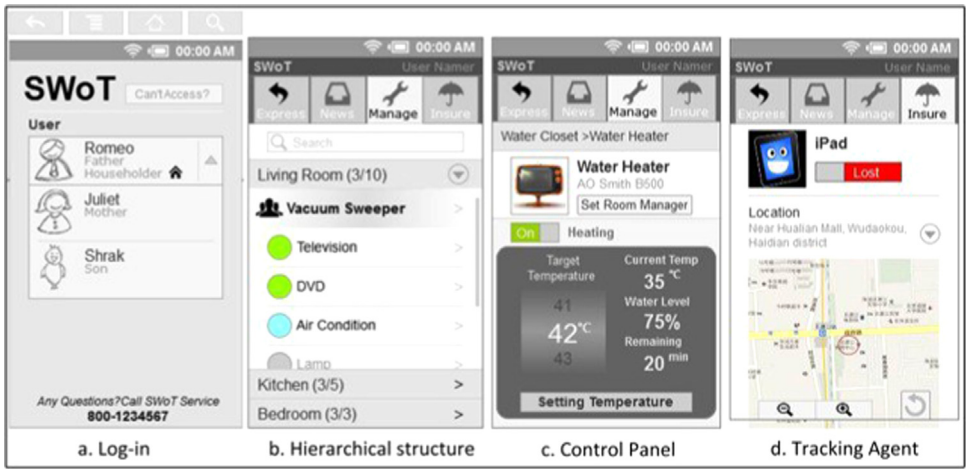

Fig. 3. The low-fidelity SWoT prototype.

5.3.3. Messages

"Messages" contains messages between users and things. Messages are presented when users enter the "News" tab with a cellphone, and messages can also be sent to TV screens to catch users' attention. In mobile apps, two types of messages are displayed in "News" section: events reports and requests. Important messages (e.g., exigent messages) are always with higher priorities. When TV are connected in the network, users can receive reminders from the screen of TV, and send feedback with a remote control, such as choosing from "remind me 30 minutes later" or "OK, I know", etc.

5.3.4. Insure

This module aims at providing a tracking agent enabling users to find their lost, valuable things. If a device is lost, SWoT will notify the user. By entering the "Insure" tab, users can find the current status of the lost things or other insured ones. Then the current location and situation of the things can be detected (see Fig. 3d). Users can also find all possible solutions to find the lost things.

6. Phase Four: evaluation

This phase aimed at exploring to what extent the concept of SWoT was accepted and how Chinese characteristics were integrated to design through a combination of a usability testing and a heuristic evaluation.

6.1. Methodology

6.1.1. Usability testing

We recruited seven representative users (3 males and 4 females) in Beijing, and five of them had taken part in previous photo-diary and interview. Their ages ranged from 23 to 46 years old, and nearly all of them had used social network and online mobile services. Evaluation was conducted on an Acer ACONIA A500 tablet, because its larger screen size (10.1 in) made it easier for observers to catch users' interactive behavior. The testing consisted of tasks and post-test interview and questionnaires. The four tasks were designed based on user study implications and major functionality: (1) authority management of rooms: setting TV as the room manager of the living room; (2) remote setup of a water heater through a mobile phone; handling an emergent situation of the gas stove; (3) reminding old people to take medicine by setting a reminder on the TV; and (4) finding the lost iPad with the help of SWoT tracking agent. The interview aimed at understanding users' subjective experience of interaction and reasons contributing to confusion and mistakes. The questionnaire addressed subjective measures of satisfaction (overall reactions, satisfaction towards learning and screen display) and usability (compatibility, consistency, learnability, minimal actions, minimal memory load, perceptual limitation, and user guidance) in a 7-point Likert scale. When interacting with the prototype, user behavior (e.g., number of making the same mistake, times of asking for help, and retention overtime) was recorded.

6.1.2. Heuristic evaluation

Three experts, who had more than 3 years' experience in user interaction design, were invited for heuristic evaluation. Experts were asked to explore the prototype freely and find usability problems through a modified heuristics checklist based on Jacob Nielson's heuristic evaluation guidelines (Nielsen and Molich, 1990; Nielsen, 1994). Three levels of guidelines were provided: information architecture (including classification, sequence, completeness and redundancy of information), interaction process (covering the rationale of hints, operation process, recovery from errors, and flexible and alternative access to some important functions) and visual design (including whether texts and icons are easy to understand, whether the UI layout is consistent, and whether users can clearly know current status of the system).

6.2. Results

6.2.1. Overview

After analyzing results, we grouped all 36 identified issues into five major categories: issues related to SWoT concept, utility-oriented, uncertainty avoidance, efficiency, and power distance. The most serious ones were selected and modified. As for usability, SWoT scored an overall 6.34 indicating positive attitudes towards it. Evaluation of compatibility (mean=6.48), minimal action (mean=6.52) and user guidance (mean=6.50) were higher than the average level, indicating that users thought SWoT was compatible, easy to return to the last level of menu, and the "cancel" action worked well. However, scores of consistency (mean=6.07) and learnability (mean=6.14) were comparatively low. As for satisfaction, the overall average grade was 6.07, indicating that the design and functionality of SWoT was satisfactory for users. Among dimensions of satisfaction, grades of usefulness (mean=6.57) and controllability (mean=6.71) were higher than the average level, which indicated that the functions provided were considered useful, and participants had enough efficacies towards SWoT. However, the evaluation of ease of use (mean=5.71), organization (mean=5.86) and location (mean=5.57) of screen display were relatively low.

6.2.2. Validation results of design implications

For the concept of SWoT, the natural way of interaction with things presenting as "subordinates" in a network was novel and acceptable for all users. All participants mentioned they liked the concept of SWoT and would use it and recommend it to their families when SWoT services were within an "*acceptable price*" (26, female). The utility-orientation of SWoT was supported because users saw the benefits of SWoT. Users thought the SWoT prototype was "*exquisite and convenient*", and "*easy to understand and manipulate*" (36, male). Moreover, GUI-based interface was preferred to the "*previous human-like one*" (24, male). The characteristic "uncertainty avoidance" was validated because things in SWoT system were thought to be smart and obedient for users to control. However, higher intelligence level was preferred in emergency cases, such as the emergency situation of gas stove. "*If the situation is related to the security of my family, it is better for the gas stove to judge the situation and take measures in the first place*" (31, female; 26, female). In addition, SWoT did well in enhancing perceived privacy when user information was well protected by connecting to family members only and blocking the third party entities. SWoT was proved efficient because of useful information it provided. Even if users' attitudes towards natural language varied a lot, they came to the agreement that things should clearly indicate their status and provide feasible and effective solutions without ambiguous expressions. However, low ratings of learning (mean=6.07) and learnability (mean=6.14) indicated the illogical layout of menu items in "tracking" screen. Low scores of consistency (mean=6.07) and screen display (mean=5.86) reflected issues on work flow design of SWoT. All users advocated the hierarchical way of manipulating things in the interconnected world, yet the value of "room manager" was not well understood. Even though users understood the functionality of the room manager, they still felt confused and doubted the value when were asked to set a device as the room manager. In summary, the greatest advantages of SWoT were thought to be the ability to:

- Help users to understand IoT in a natural way of interaction.
- Provide practical ways to control devices easily and help to find lost things.

- Let users dominate things with their privacy protected.
- Enhancing the efficiency of communication with things.

Issues in great need of consideration were:

- The work flow design of accessing the control panel of a certain device was too complicated.
- There were too many solutions presented in the page of "tracking" and the order of solutions made no sense.
- The explicit benefits of "room manager" were difficult to understand.

7. Discussion

7.1. SWoT is accepted as a private family network

The concept of utilizing "friendship" or "social relations" to understand the interconnected nature of things in IoT is accepted by prospective users living in Beijing. Compared with a general social network, users prefer the network of things to be a private, domestic one by sharing it with their intimate family members. The discrimination of priorities among different family members is also necessary in enhancing perceived status and security of the user. As for the relationship between the user and things, a hierarchically "company-like" structure works well. This is mainly because users want to be dominative over things, and the hierarchical structure satisfies their culture background in seeking high power distance. With the well-defined hierarchical structure, users only need to deal with useful information by reading reports from things or "room managers" that they trust, as a result they perceive efficiency and possibly cultivate attachment to the SWoT system.

7.2. Characteristics of designing IoT services

Similar to studies in North America and North Europe carried out earlier, efficiency and consistency should always be the critical considerations when designing interaction systems like SWoT. Every interaction detail (e.g., the work flow, and meanings of elements) should be clear and simple enough to effectively solve the problem and help users' decision making. It is worth noticing that users in the three studies all come from big cities, and they are influenced deeply by the rapid pace of urbanization. Thus they all regard time as scarce resource (Wilson et al., 1996) and wish the IoT application to be efficient. On the contrary, Chinese rural users may not value efficiency so much when using technology (Liu et al., 2010). Thus we should be careful when generalizing this characteristic among people in China.

Both users from East Asia and North America regard IoT applications as private tools, since privacy is important for them. In modern society, more information means more opportunities and advantages. Thus people would like to protect their important information rather than to share with other people or entities, in order to stay in a preponderant place. Like users from other cultures, Beijing users' perception of things is basically utility-oriented. As a consequence of the pragmatic orientation, SWoT is accepted as a pragmatic "assistant" that helps make life more convenient, not as a social network service or a way of entertainment. User needs are also influenced by this belief: only beneficial and useful functions and information should be provided, and the benefits and usefulness should be demonstrated to users explicitly. For Chinese users, the practical value of things is considered more important than other features such as the emotional value, aesthetics or personality. Although in this study people living in Beijing have several characteristics similar to users from other countries, they are distinctive in uncertainty avoidance. Users need to perceive control over things to avoid uncertainty, and they expect things in SWoT to be obedient and helpful. Hence, objects in IoT applications should clearly indicate their status to users, and always ask for users' permission when decisions are needed, especially when the decision involves the third-party entities. Users in China have low attachment to things because they are more likely to avoid uncertainty. In addition, users also concern a lot about the transparency and credibility of the platform. They have an aversion towards monopoly companies; some users would like to have several companies competing so that the consumers get better services. Chinese users, especially the elders, are familiar with SMS (Lu et al., 2010) and TV. This is quite different from previous studies elsewhere, where smart phones and network has already become essential in daily life. These two interactive models have large market potential before smart phones and wireless network are widespread. Even if the young generation is quite familiar with smart phones and social network, developing IoT products based on SMS and TV will considerably increase the market scale in China and be accepted by Chinese users.

7.3. Tradeoff between design implications and implementation

Some deviations between evaluation results and design implications were found in this study. According to one of the most frequently mentioned issues, there are too many steps to approach the control panel of the water heater, and it is difficult for users to find a certain term through the long list in the profile page of the water heater. This issue indicates that efficiency we implemented in current design is not enough for users. In order to address it, designers should: (1) present the control panel in the first page of its profile, and group less important items into a tab as "other settings", (2) add normal functions into the tab "Express" for quick access. Another issue related to efficiency is too many solutions to choose in "tracking" page and their illogical sequences, which makes users (5 out of 7) "get lost". In order to improve this, the items "remote lock", "locate it" and "insured thing settings" should be integrated into one group and "Find" should be the only option left in this page.

The issue related to the understanding of "room manager" is noteworthy. Users (4 out of 7) had difficulties in understanding this concept. Room manager was only thought useful in "*reporting information*" (23, male), but it hardly had other advantages "*unless there are a great number of things in the network*" (23, male; 36, male). Even when explained, users still did not think it necessary to let a certain thing to report status of other things. Thus it is possible that "room manager" may mislead users at the first sight, because the name does not match its real function. As a result three possible solutions are provided: (1) renaming "room manager" to other terms which are easier to understand (e.g., "room reporter" or "message manager"), (2) letting a virtue "person" be the manager instead of a thing, (3) weakening the concept and presenting messages in a clear and laconic way. Although these modification strategies help to improve current issues, it cannot certainly satisfy a wider population. Thus these issues still remain challenging in SWoT prototype design.

8. Conclusions and future work

The innovation of SWoT is the first trial in IoT system development, and interaction with IoT is still a significant and challenging topic. By carrying out a four-phase study with the process of user-centered design, the concept of SWoT was shown as a prominent and feasible idea in helping people to interact with things and IoT technology more naturally. Potential Chinese users accept SWoT as a private family network; and this viewpoint provides insights on how to make the interconnections understandable. The impact of culture, societies and policies on users' experience and interactive

needs towards IoT products is significant and challenging as well. Similar user needs, such as efficiency, consistency and perceived privacy among worldwide users, help products be accepted widely. Moreover, as the first study that explored users' experience and interactive needs towards SWoT in China, distinctive Chinese characteristics and interactive models also help to better integrate and localize IoT in the emerging market of China. Thus developers and researchers can gain benefits and inspirations by considering cultural influences.

Acknowledgment

This study was funded by National Natural Science Foundation China Grant 71188991 and State Key Lab of Automobile Safety and Energy.

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