Augmenting Requirements Gathering for People with Special Needs using IoT: A Position Paper

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ABSTRACT
Requirements gathering are an important aspect of application development, especially when users are people with special needs. Traditionally, this process is being conducted using conventional methods, such as interviews, workshops and questionnaires. These approaches, however, are unable to grasp the full context when collecting data from the communities of people with special needs, mainly because of the difficult access to participants and incomprehensiveness of the data gathered. To mitigate such issues, in this position paper, we argue that existing traditional methods could be complemented by means of Internet of Things. The immense amount of data gathered from various devices interconnected could help generate meaningful data that will complement the usually insufficient amount collected using traditional methods. This new approach is, however, associated with challenges that are discussed along with a possible scenario on how data complementing from traditional and the indirect method could be done.

CCS Concepts
• **Human-centered computing~Accessibility systems and tools**
• **Software and its engineering~Requirements analysis**

Keywords
Requirements Gathering; Accessibility; Internet of Things, IoT.

1. INTRODUCTION AND MOTIVATION
The majority of failures in the software design and development are due to inadequate requirements specifications. Research suggests that one way to mitigate these risks is stronger user involvement [23]. The user-centered design process is where user requirements present an overarching focus and guidance to software design and development cycle [15]. An important aspect to this process is the requirements gathering phase where designers learn about users' needs, abilities and limitations. Requirements gathering are usually done by meeting and actively engaging with users. Active user involvement becomes particularly important when designing applications to be used by people with special needs, because of their specialized requirements [3].

Understanding requirements of the people with special needs is difficult process and the user-centered design provides only little guidance on how to design for such community [4]. Researchers adopt various methods and techniques to understand such user needs, abilities, and limitations. Research usually relies on techniques such as questionnaires [5], interviews [6], workshops [7, 8] and scenario-based methods in theatrical setting [3]. These approaches require direct communication and access to participants. However, in the case of disabled users this usually becomes troublesome and is limited. This limitation is because this community of users is dispersed and it is difficult to gain access to them for longer period of time. Typically, the access is limited to the time of the workshop or the time needed to conduct an interview. These limitations usually create a challenge of insufficient data to understand the needs and requirements of the people with special needs.

At the same time, we are experiencing a tremendous growth in the usage of different sensors, smartphones, wearables and web technologies in general, all as a part of Internet of Things (IoT). All these technologies are becoming ubiquitous and immersive in people's everyday life. IoT technologies are generating huge amount of data that enable new ways of communication between people and objects as well as objects themselves [2]. Different scenarios, such as shopping, at school, and in the home environment, show how using IoT (sensors, smartphones, wearables, etc.) can improve the lives of people with special needs [1]. These devices actually capture a lot of data regarding the user context and daily activities that could be used in the process of requirements gathering. This position paper argues on the need for a complementary approach for requirements gathering to augment the traditional methods. This approach would constitute the streams of data collected by IoT devices in order to make the requirements gathering richer. We believe that this approach would shorten the time to address the very basic necessities of the people with special needs from everyday situations and contexts.

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Table 1. Overview of user requirements methods based on disability type (modified from [4]).

User requirements elicitation methods and techniques	Disability			
	Motion	Vision	Hearing	Cognitive / Communication
Brainstorming	√	√	!	!
Direct observation	√	√	√	√
Activity diaries and cultural probes	!	!	√	!
Survey and questionnaires	!	!	!	X
Interviews	√	√	!	X
Group discussions	√	√	!	X
Empathic modeling	√	√	√	X
User trials	!	!	!	!
Scenarios and personas	√	√	√	√
Prototyping	√	√	√	√
Cooperative and participatory design	√	√	√	!

√ – Appropriate
X – Not recommended
! – Needs modification and adjustment

2. INSUFFICIENCIES OF CURRENT APPROACHES

Current requirements gathering methods require direct communication with participants and this often introduces two important issues: difficult access to participants and incomprehensiveness of the gathered requirements.

2.1 Difficult access to participants

People with special needs usually represent a frail group of users that requires a particular attention when gaining access to. Recruiting people with special needs is a lengthy and difficult process. Gaining access to this user group is typically done by contacting organizations that maintain connections with them as their members. Thus, in itself this process is very formal and requires reliance in an institution to contact members willing to participate in a study. In one hand, it seems positive that one can gain access to participants using a single channel, but on the other hand, this introduces new steps, as the institution might ask for detailed information about the study before forwarding it to its members. While this is a necessary action to protect people with special needs, who in many cases need such protection, it makes the process of recruitment lengthy and troublesome. To make things more difficult, even after participants are found, issues with obtaining the consent forms could arise [4]. Sometimes this occurs even in cases when informally people might agree to participate, but either they do not show up or fail to provide the consent form. These difficulties with participant recruitment typically result in low number of users participating in data gathering sessions, which consequently generates limited data making it insufficient to comprehensively represent their needs.

2.2 Incomprehensiveness of the gathered requirements

Deciding the appropriate data gathering method influences greatly the quality of the data, which becomes even more relevant when users are of various special needs. A comprehensive list of suitable methods depending on the disability is given in Table 1, which is modified from study [4]. For instance, according to [10] even traditionally structured focus groups present a challenge when meeting people with special needs. To avoid such issues, several studies have conducted in-home interviews and observations to provide the natural settings [11, 10]. They also argue that in-home interviews are favored considering that participants are familiar with the environment, which is highly important for the disabled as they might be using various assistive devices at their home. Additionally, being in someone's home as a guest rises the host's authority and may increase the quality of the data gathered as well as helps the researcher to better understand the connection between technology and environment [10].

Besides the small number of participants [13], the comprehensiveness of the data typically also suffers from the limited time there is to spend with participants. This is significant when considering that people with special needs get fatigued faster, thus imposing the need to make the study sessions shorter. While these elements negatively influence the statistical power and generalization of the findings, it becomes even more difficult when users might have very specialized requirements [4], when recruiting people with insufficient technical expertise [10], or having various cultural backgrounds [7].

These insufficiencies of traditional requirements gathering methods could be mitigated using a complementary approach involving IoT. This indirect approach does not require changing existing traditional methods, but provides help in discreetly gathering high volume of data from participants, thus ensuring higher comprehensiveness of the requirements gathered.

3. REQUIREMENTS GATHERING USING INTERNET OF THINGS

Considering the various discussed insufficiencies related to existing requirement gathering methods—at least when used in isolation and also when a target group are people with special needs—we propose complementing these traditional methods with a new approach that requires no direct communication with participants. Such new approach will require leveraging the IoT platform (smartphones, wearables, and sensors) that will generate large and contextual amount of data making the requirements richer.

3.1 Internet of Things (IoT)

The connection of physical objects to the Internet opens new opportunities to sense data and control the physical world from the distance. The mashup of acquired data together with data retrieved from other sources provides new synergistic services that outperform and surpass those provided by standalone and isolated embedded services [14].

IoT is already considered as the next evolution in terms of smart grids, healthcare and education [12]. The latest advances in technology, such as affordable electronics, mobile devices, and connectivity costs, as well as an increased use of distributed applications, are transforming the industry and society [17]. Moreover, IoT systems could provide new possibilities for augmenting daily activities of the disabled people, which can be embedded in different settings and across contexts. We believe that the next evolutionary step of IoT is to move from smart objects to social objects [16]. These social objects could interact in an autonomous way with respect to the users with special needs. Thus, IoT already started to move towards the notion of Internet of People (IoP) [19]. In this sense, IoT should not only be about "integrating technology into everyday lives", but rather "adapting to the user's context changes" (in this case to people with special needs). Thus, one of the main challenges and values to be realized from IoT is when physical contexts are derived from the gathered sensor data [20].

Smartphones nowadays are equipped with many sensors that capture and generate various data regarding device location, orientation, lighting, etc. Smartphones are also becoming very

preferred devices to people with special needs as it helps them independently conduct daily work or leisure activities. The greatest advantage to using smartphones for data gathering is the assumption that almost all individuals have one in possession and carry with themselves most of the time. Considering that over a billion people (15% of population) are estimated to suffer from some kind of disability, IoT devices can substantially contribute in improving the quality of life for this group by offering the assistance and support they need [1]. Hence, contextual aspects to be included in our approach are extremely important for people with special needs.

Wearables, such as Apple Watch, Android Wear and specialized monitoring devices, are another good source of data that users are increasingly adopting. One of the advantages of these wearable devices is that those could be an intrinsic and inseparable part of people with special needs. The other aspect is the unobtrusive nature of these wearables, which can stream data without hindering the everyday activities of the people with special needs. Examples, such as neuromuscular bions for para- and tetraplegics and RFID canes or specialized eyeglass cameras for the blind, represent small devices that could stream in real time huge amount of data to various relay and control stations. The collected data captures the everyday activities of these people, however, this poses some challenges that will be elaborated in section 4.

3.2 An illustrated example in a library context

Suppose we need to build an application to help blind and visually impaired people navigate through a library and find suitable resources. Among other things, the application should help users easily locate a desired book through the many shelves, checking in and out a book, or locating a computer that has assistive software installed in it.

In order to gather the requirements for such application, we could leverage the IoT approach to complement the traditional methods. Using IoT enabled devices, the gathered data could reveal patterns that will help researchers understand people's activities inside a library. For example, how they find a book; do they ask for help from the library workers or try to locate it on their own.

Using participant's smartphone, researchers can monitor their navigation and behavior using sensors and beacons installed in the library. This data gathering activity could span for many days and help researchers collect great amount of data that will ultimately translate into features of the application. For example, the collected IoT data reveals that although inside the library there are computers with assistive software, such as a screen-reader, or equipped with Braille embossers, users rarely use them. Considering this, it is relevant to know whether the blind people go near those resources and if they do, how much time they spend in that location. Perhaps people are not aware of such services if the collected data reveals no or minor activity near the places where the resources exist. Or, people might approach, but leave shortly, indicating that they are not able to use such resources for various reasons, despite being aware. These kind of data will motivate application designers to add features that will suggest users the availability of appropriate devices and services based on their disability and proximity to the resources point. While arguably this data gathering activity can also be accomplished using observation, it will be extremely costly in terms of research time. The purpose of this example is to illustrate how IoT could be used to help researchers gather requirements data, but not how it will help users find a book.

4. CHALLENGES

The data collection using IoT for requirements purposes comes with several challenges. One crucial challenge is contextualizing the stream of collected data and the ability to transform it into meaningful requirements [24, 20]. Another challenge is the security and privacy issues linked with the process of gathering large amount of data from various distributed IoT objects [18]. This challenge becomes even more relevant when participants are people with special needs, who are especially vulnerable [27]. More importantly, some specific challenges when collecting data from people with special needs are the level of acceptance of IoT by this community and the need for customization to ensure uninterrupted data gathering process.

4.1 Acceptance of IoT by people with special needs

Participants with special needs are very sensitive to data gathering using technology. A study conducted with participants having Alzheimer's shows the unwillingness of these participants to be video recorded [25]. Consequently, it will be difficult to persuade these participants to allow data gathering using IoT. This is further made difficult considering that laws regulating access to participants with special needs are more stringent. A possible solution to mitigate this challenge is by providing detailed information to the user for the type of data the IoT are collecting, which will increase participant's trust on IoT [21]. This, however, presents a challenge in determining the best modality to communicate to the participant based on their disability.

4.2 Customization for uninterrupted process

Gathering data using IoT should be adapted and customized to people with special needs and their abilities and circumstances [1]. This is particularly important to ensure uninterrupted operation of the data gathering process. By accident, participants with special needs could disable the IoT devices, and they might not be aware of it. Such an example could be a visually impaired person unable to perceive whether the wearable device is on and collecting data. Or a person with cognitive impairment could unintentionally disable the device's normal operation and unable to communicate such problem. This challenge raises the need for IoT to manage themselves without human intervention, such as, self-healing and self-protection capabilities [26].

5. CONCLUSION

Identifying requirements is usually the initial and most important process of software design and development. The importance of the proper requirement gathering increases especially when we deal with people with special needs. The current body of knowledge regarding requirements gathering provides limited insights concerning the approaches for handling the specificities of this frail group of users. Applying traditional methods for requirements gathering with this group of users becomes troublesome especially due to limited access and geographical dispersion of these users. Faced directly with these challenges in our previous work [7, 22], in this paper we propose an approach for leveraging contextual data gathered through IoT as a part of a requirements gathering phase. As IoT technologies are becoming immersive in our everyday life, we argue that they provide a very good source for enriched depiction of the user context. Complementing traditional methods for requirements gathering with the immense amount of data generated from IoT, will increase the comprehensiveness of the data gathered. To describe the usefulness of our suggested approach, we presented a scenario

on how the traditional approaches could benefit by being complemented using the data collected using IoT.

With the current trends of technological innovation and exponential growth of the numbers of the connected devices, we consider that there will be a need to reflect upon the way the requirements gathering is done. As the society is in the brinks of the fourth industrial revolution, we must strive to make the community of the people with special needs part of it from the beginning. Inclusivity of the technology combined with the principles of the universal design will represent the way forward on handling the requirements gathering of the people with special needs. IoT as representative of the current technological trends brings new possibilities for including user context as a part of the design process. The contextual streams of data will enrich requirements gathering, thus leading more towards an "augmented" ethnography where user's needs will be better understood leading toward increased usability of the artifacts.

Nevertheless, despite the vast amount of opportunities that IoT brings to the requirement gathering, it also brings some challenges. As the amounts of data generated by the means of IoT will continue to increase, there is a need for further research efforts that will shed more light in the way of how these data can augment the requirements gathering. Especially focus should be put in how the security and privacy of the users with special needs is respected, while aiming for increased acceptability and usability.

6. REFERENCES

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