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A Self-Adaptive Software for Connection of Things: An IoT based Application Study

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Abstract: Internet of Things (IoT) is a new trending phase of technology. IoT refers to communication and connectivity between things such as technological devices, actuators, sensors, and people or processes with unique identifiers. The importance of IoT is to improve the daily living standards of an average user. IoT is made for the people and used by the people for many reasons such as improved health, business innovations, and personal health trackers. Examples of IoT applications and services today include Smart thermostats like NEST, connected cars like Car2Go, activity trackers like BASIS, smart outlets like Belkin, Parking sensors like street line and so much more services being developed. The main goal of this study is to identify the challenges users face in understanding IoT and monitoring it as it undergoes change through self-adaptation. In this paper, an observational study is conducted. Within the study, two data collection methods were used; observational of the users and post observation questionnaires. The observational study was done by video recording users while using the IoT application. This was to obtain information about the IoT.

Keywords: User requirements, Internet of Things, Observational study, Software engineering

[1].INTRODUCTION

The Internet of Things (IoT) is a system in which objects, animals or people are provided with unique identifiers. It allows the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [1]. Sensors are like the digital nervous system [22]. Sensors are the ears and eyes of a camera or proximity and position of GPS[22]. For example a smartphone's range of sensors (GPS, campus, accelerometer, video, proximity, electric/magnetic, temperature or sound) and connectivity (NFC, Bluetooth, Wi-Fi, Cell or printed Ethernet Powerline) [22]. These features make a smartphone a well-equipped IoT device that can automatically monitor your locations, movements and workout throughout the day. IoT promotes a heightened level of awareness about our world [1]. For example smart natural disaster management that allows us to predict with accuracy before natural disasters such as earthquakes or tsunamis happen [1]. This allows quick response through evacuation or hazard preparedness. It also gives a platform to monitor the changes brought about by this awareness [1]. For instance wearables [6] such as wristbands provide a platform for health tracking. These detect health problems before they occur. Then deploy emergency respondents or family members ahead of time with the exact location of the wearer. In Today's technology, IoT applications can adapt themselves into different conditions through change by self-adaptation. For example, a wearable health tracker will immediately inform the emergency contact in case of a very low heart pace of the wearer. Self adaptation is important as the network is undergoing continuous change [2]. IoT applications are able to adapt to change through their different dimensions. For instance, Dropbox [3] has a data size dimension. Here, different sizes of data are always being transferred from one point to the other. Also, Dropbox is able to measure and monitor the data transferred according to its size or form. Self-adaption [2] [4] [5] [17] is important for the software to be able to monitor changes around and reconfigure itself accordingly. One of the key problems in the context of IoT through self-adaptation, is how the user will understand and maintain the knowledge of IoT amidst the occurring changes. But before the user understands and maintains the IoT knowledge, the users need to learn about the IoT.

[2].BACKGROUND AND RELATED WORK

The researcher conducted a literature review in the following databases; Inspec, Scopus and ACM digital library. She used keywords from the research questions as a basis of the search strings. The keywords were supplemented with their synonyms and related words using Boolean AND, OR constraints. The search string generated a lot of results and the researcher used inclusion and exclusion criteria. This was based on the year of publication, type of publication and the language of publication. Few articles were chosen with respect to their title and abstract. And from these, snowball

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sampling [11] was conducted, articles were chosen according to their relevance of information in regards to the search topic. The articles chosen were further analyzed and their references checked to see if they could lead to articles of great relevance. After exclusion and inclusion of the search string using snowball sampling, the research did not find any article on the user requirements of IoT applications. This is when the researcher found a big knowledge gap and the main reason for this paper to fill that knowledge gap. In the articles found, many of them talked about how to make IoT application and even some went ahead to write on user roles as shown in the examples below. But none of the papers talked about IoT applications from the user perspective. Many studies focused on how to design an automated IoT system using different methodology. Take an example of Yuan Jie Fan et al, they talk about how to design an automated IoT-based system using an ontology-based methodology [8]. They further explain how IoT can provide an effective platform to interconnect all resources, but there is no mention of the users [8]. Even though the system is being made to help with the rehabilitation of the elderly, therefore, making the elderly the users in this case. "IoT systems can benefit from a process model based on principles derived from psychology and neuroscience of human behavior that emulates how humans acquire task knowledge and learn to adapt to changing context" [9]. This is maybe correct but before the model is designed, it is important to know what the users think of the IoT application before insinuating how the user is expected to react while operating the IoT systems from the psychology and neuroscience view.

Many IT industries are coming up with complex systems of IoT applications. For example, the IoT application used in this study is complex because the devices have their own lifecycle but need to interact with each other to fulfill the user goals. These systems are being made for the users to improve their daily living standards. For instance, Smart Cities is one example of providing parking space for drivers in cities or Smartwatch such as iWatch [6] whose main focus is business and innovation. A person can do almost all the mobile phone tasks on this iWatch i.e. read emails, send messages, view pictures and so forth. But what the developers are ignoring is the user perspective to these systems. The user population for the IoT application is spread out across age, gender, race, and knowledge background. Also, users are the main entity for the IoT applications. Therefore, it is important to see that users are able to operate these IoT applications with as little effort as possible. Without my work of bridging this knowledge gap, then the complex IoT applications would fail.

One of the main reasons we need self-adaptive software is the increasing cost of handling the complexity of software systems [5]. An example of a self-adaptive software is Internet of Things (IoT) applications. IoT applications include smart watches such as Apple's iWatch [6] whose main focus is health &training, innovation, and business; The Automated Home such as Smart Home Starter kit. It provides overall security through different sensor functions. The Smart Home starter Kit as an IoT, it is able to adjust the temperature of the room according to the user's preferences. Also, the Smart Hub can be connected to the room thermostat where it can adjust the temperatures to suit the user's selected range. This shows IoT's self-adaptive capability, it is able to reset to the user's preferred temperature amidst the temperature being recorded.

[3].RESULTS

The results below were as observed and reported by the researcher as the users were setting up the security of the room used. A total of 5 users took part in the study. The number of users was stopped once the users started giving the same results or no new relevant information was being recorded by the researcher. The observational study was first carried out on 2 different participants. 2 participants were chosen to be able to cover a wide scope but also mainly for comparison purposes. If only one user had taken part in the study, then there would be no scale for relationship of results. Also because of limited resources, that is, the researcher couldn't be in more than one place to see the observational study through. So it was limited to 2 and not more. The two participants were chosen through convenient sampling by stopping random people. Convenient sampling [11] is helpful for pilot study and generation of hypothesis. It is also cost effective. The study aims to put no limitation to the participant population. Later on, judging from the user feedback, more users would be selected for the observational study. If user feedback became similar i.e. the users were starting to face the same challenges, then recruitment of new users will have to stop. This is because the study is not giving the researcher any new relevant information other than the one from previous users. The goal of this study was to observe the user's understanding of the IoT applications and being able to monitor it as it goes through change. The participants were to secure the office room J2318 at Blekinge Institute of Technology using the smart home starter kit presented to them by the researcher. The Smart Home Starter Kit [21] was the researcher's choice of IoT application. This was because it was flexible, portable and did not require installation, therefore appropriate for the observation study. It contained 3 devices with different roles in securing the room. The devices included a SmartSense Motion detector, SmartSense Open/Closed and a SmartSense Presence. The Kit also contained a Smart Hub which is the central configuring port for the device.

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[4].ANALYSIS:

This section outlines the analysis of the results from the observational study. An editing approach [19] and conventional content analysis [23] was used to analyze the data collected and thereby coming to the conclusions below. This is done through the following steps. An editing approach was done through the collection of all the user post observational questionnaires, the researcher together with her supervisor categorized the different answers. • The data collected from the user feedback is analyzed to understand what happened in the study by the researcher. • The researcher then forms codes from different segments where a hypothesis is made. Coding was done through categorizing the data collected from the users. Below is a table showing the codes formed from the data collected.

TABLE 1: DEVELOPING CODES FROM THE USER DATA COLLECTED.

Research Questions	Elements to be coded	Codes
RQ1	User challenges	• IoT unawareness by user • "Where can I start from?" • New IT terms used in manuals. • No pictorial descriptions in manuals • No video illustration. • Missing information in the manuals • Guess work while setting up
RQ2	User expectation of the IoT application	• Glossary list of terms. • A list of expected outcomes. • How to troubleshoot errors generated. • Video illustration for users. • Developers not to assume that all users have an IT background. • Mobile application for the IoT application to be stated. • Specifically outline what different buttons the manuals refer to.
RQ3	Elicitation of User requirements	• A user experience design for the IoT application to be elicited that interacts with the user irrespective of their background.

The researcher then formed a set of generalization that led to a pattern or a theory concluded from the data collected [13]. This was done through analytical and critical thinking skills exhibited by the research to form patterns from the codes. The technique used was word and phrase repetitions. This analysis of the data is important as it may reveal the need of collecting other data [13]. This can be due to the new insights discovered after analyzing the data. • Thereafter the data was summarized by mapping the research findings to the research aim and objectives through answering the research questions by the users.

[5]. DISCUSSIONS AND FUTURE WORKS

In this section, the researcher discusses the findings of this results. Also, he recommends future works for researchers that will proceed with the research topic. This is important as the new researchers know about the old findings giving them a starting point in their research. It also covers an area that may not have been covered by the researcher due to one reason or the other such as time, resources even the research scope. The following sections summarizes discussion, conclusion, and future works.

This paper decided to bridge this research gap. By knowing what users know of IoT or what would facilitate them in knowing IoT, this would bridge the gap between the system requirements and user requirements. When the gap has been bridged, this would indicate user empowerment leading to an increase in users. This in turn would lead to an increase of IoT applications and services. An observation study [13] was carried out and the researcher deduced that the biggest challenge of IoT applications that many users face is learnability. Since IoT is a whole new technology, it is yet to become common among the people. Therefore, there is a need for users, in this case, everyday people, to learn what it is, what it can accomplish and how it does that. Also, the user needs to be able to understand how it operates after learning about IoT. And if the user is able to understand IoT, the next step would be to monitor it as it goes through change and self-

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adaptation. More about self-adaptation of IoT is discussed in section 2. The results from this study indicated that many users are excited to try out IoT applications and services, but the systems are too complex and not user-friendly. This can be improved by the application designers and developers through making simple and interactive user experience interface designs for the IoT applications and services. This will facilitate quick and interactive learning and awareness for the users. From this research, we were able to learn that IoT is very complex technology and therefore the developers need to consider requirements engineering to enable them help the users to acquire more knowledge and awareness about it. The devices used in this study are complex. They cannot work alone, they interact with each other in order to fulfil a user goal.

IoT is a very fascinating new developing technology and there is still a lot of work to be done by researchers. Hopefully, they can try and find solutions to the missing research areas of IoT in the future works. Many studies or surveys can be conducted with a particular population sample of users or random. These will lead to different areas of research and new discoveries. The new researches and discoveries would lead to new user-friendly IoT applications or even ways in which users are trained to use the IoT systems. This would lead to an increase in the deployment of the IoT systems and the increase in users achieving the goal of meeting user standards. Another area for future works would be how to make a relation of different IoT applications with users. Each IoT system has a different goal and objective meaning also the way the users will view it will be different. This would be another interesting topic of research. Also for future researchers conducting this observational study, most users are conscious when it comes to cameras and videos and, therefore, will not be fully participatory in the study as they are aware of the camera. It is important the user feels comfort and secure while carrying out the study. So a research like this an observational study conducted with no camera together with a post observational questionnaire and in-depth interviews would generate more results. Another area for future works that is not related to user requirements are the system requirements. There is still more to be done with the systems that concern the way the system functions, including the privacy of the IoT systems as it deals with very important details of the users. Therefore, it is important that the IoT system is 100% reliable and not just 90% reliable. Finally, this thesis is the beginning of something big and great. It will be of great benefit if this thesis could be extended in terms of research such as User requirements and big data or a specific classification of users. This would be of great beneficial to IoT industries and developers as this would provide insight to what is required to expand IoT in many sectors.

[6].CONCLUSION

In conclusion, this study aims to find what the users require in understanding IoT and maintain this understanding of IoT through self-adaptation. This is done by understanding the users' challenges in operating and monitoring IoT application. This helps bridge the gap between system requirements and user requirements of the IoT application. The study was done by conducting an observational study. 5 users were observed while setting up a room to ensure that the user can get a notification in case of motion, if a door is opened, and if someone came in and out of the room is detected. This was done by using the IoT application of the researcher's choice-SmartThings Home Starter Kit together with its mobile application. The data was collected through video recording and/or scribbling of notes depending on the user's consent. The users were also presented with post observational questionnaires to collect any data that may have been left out during the observational study. Data analysis was done through snowballing analysis, editing approach and a conventional content analysis method by forming codes of data and thereafter patterns to make conclusive findings. From the observation study, I noted that the IoT is an exciting technology that many people want to experience but little knowledge and unawareness is so far a huge obstacle standing in their way. The users find IoT very complex even though they want to exactly know how it operates. This problem can be solved by doing requirements engineering of user needs. These needs can then be used for elicitation by the system designers and developers to make user-friendly interfaces from user experiences. There were mainly 3 challenges being faced by the IoT users. These included learnability, awareness and monitoring of the IoT. These challenges being faced by the users indicated there is limited understanding on how IoT applications work. This is due to the fact that the users have not learned what IoT is, what it does under what circumstances. The users need to learn what IoT is prior to becoming aware and understanding how IoT operates.

This study can also be used by the IoT developers to modify the designs of the complex systems making the user the most important priority of all the entities. The IoT developers can come up with simpler online tutorials to teach the user on how to use their product. This is important as it would bridge the gap between system requirements and the user requirements.

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REFERENCES

[1]. Minoli, D. 2013, Building the internet of things (IoT) with IPv6 and MIPv6
[2]. Cheng, B., Finkelstein, A., Becker, B., Grassi, V., Mirandola, R., Park, S., Malek, S., Lemos, R., Gacek, C., Kramer, J., Tichy, M., Tivoli, M., Inverardi, P., Brun, Y., Giese, H., Müller, H., Serugendo, M., Dustdar, S., Geihs, K., Whittle, J., Shaw, M. Karsai, G., Andersson, J., Kienle, H., Bencomo, N., Litoiu, M., Cukic, B., Weyns, D., Magee, J., Fakulteten för matematik/naturvetenskap/teknik, Växjö universitet & Matematiska och systemtekniska institutionen 2009, "Software Engineering for Self-Adaptive Systems: A Research Roadmap" in, pp. 1
[3]. Dropbox, 'Dropbox'. N.p., 2015. https://www.dropbox.com/Web. 25 May 2015
[4]. Xiao, G., Guo, J., Xu, L.D. & Gong, Z. 2014, "User Interoperability with Heterogeneous IoT Devices Through Transformation", IEEE Transactions on Industrial Informatics, vol. 10, no. 2, pp. 1486-1496.
[5]. Laddaga R 2000 Active software. In Proc. Of Int. Workshop on Self-adaptive, 11-26
[6]. Apple Watch 'i Watch'. N.p., 2015. http://www.apple.com/watch/technology/ Web. 12 August 2015
[7]. Atzori, L., Iera, A. & Morabito, G. 2010, "The Internet of Things: A survey", Computer Networks, vol. 54, no. 15, pp. 2787-2805.
[8]. Fan, Y.J., Yin, Y.H., Xu, L.D., Zeng, Y. & Wu, F. 2014, "IoT-Based Smart Rehabilitation System", IEEE Transactions on Industrial Informatics, vol. 10, no. 2, pp. 1568-1577.
[9]. Lee, S.W., Prenzel, O. & Bien, Z. 2013, "Applying Human Learning Principles to UserCentered IoT Systems", Computer, vol. 46, no. 2, pp. 46-52.
[10]. Moreno, M.V., Ramos, J.L.H. & Skarmeta, A.F. 2014, "User role in IoT-based systems", IEEE, pp. 141.
[11]. C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén, Experimentation in software engineering: Springer, 2012.
[12]. Dybå, T., Prikladnicki, R., Rönkkö, K., Seaman, C., Sillito, J., School of Computing, Blekinge Tekniska Högskola, Blekinge Institute of Technology & Sektionen för datavetenskap och kommunikation 2011, "Qualitative research in software engineering", Empirical Software Engineering, vol. 16, no. 4, pp. 425-429.
[13]. Runeson, Per, Host, Martin. Rainer, Austen. & Regnell, Bjorn. (2012). Case Study Research in Software Engineering [Elektronisk resurs]: Guidelines and Examples. Hoboken: John Wiley & Sons
[14]. B. Flyvbjerg. Five misunderstandings about case-study research In Qualitative Research Practice, concise paperback edition. Sage, 2007, pp.390–404.
[15]. C.Robson.Real World research 2nd edition.Blackwell, 2002.
[16]. Firschein, O. & Laddaga, R. 1997, "IEEE intelligent systems coming on line", IEEE EXPERT-INTELLIGENT SYSTEMS & THEIR APPLICATIONS, vol. 12, no. 4, pp. 2-3.
[17]. Laddaga, R. 1999, "Creating robust software through self-adaptation", IEEE INTELLIGENT SYSTEMS & THEIR APPLICATIONS, vol. 14, no. 3, pp. 26-29.
[18]. J. Corbin and C.Strauss. Basics of Qualitative Research, 3rd edition. Sage, 2008.
[19]. C. Robson. Real world research 2nd edition. Blackwell, 2002.
[20]. Silva Souza, V., Lapouchnian, A., Robinson, W. & Mylopoulos, J. 2011, "Awareness requirements for adaptive systems", ACM, , pp. 60. 28
[21]. Smart Kit 'Smart home starter kit'. N.p., 2015. http://www.smartthings.com/getstarted/kits/?gclid=CI-Hl6qvwcECFYVffgodU3UAJA Web. 06 November 2015
[22]. Pinterest.com, 'What exactly is the "Internet of Things"?', 2015. [Online]. Available: https://www.pinterest.com/pin/494551602804570084/. [Accessed: 13- Nov- 2015].
[23]. Hsieh, H. & Shannon, S.E. 2005, "Three Approaches to Qualitative Content Analysis", Qualitative Health Research,vol. 15, no. 9, pp. 1277-1288.