JOURNAL OF SOFTWARE ENGINEERING & INTELLIGENT SYSTEMS
ISSN 2518-8739
30th April 2018, Volume 3, Issue 1, JSEIS, CAOMEI Copyright © 2016-2018
www.jseis.org

Indoor navigation to estimate energy consumption in android platform

[1]Hasan Sajid Atta Al Nidawi, [2]Ammar Khaleel, [3]Kareem Abbas Dawood
[1,3] Department of Software Engineering and Information System, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, Malaysia. [2]Department of Computer, Faculty of Education for Girls, University of Kufa, Iraq.
Email: [1]hassan.sajid44@yahoo.com , [2]ammar.khaleel@uokufa.edu.iq , [3]kareem.a.it@gmail.com

ABSTRACT

Consumption of a mobile application energy (battery and data traffic) is still a primary concern to mobile manufacturers. It has been noted earlier that the consumption of a particular mobile application depends heavily on its software architecture. Therefore, mobile developers can make necessary design decisions based on the comparative study performed on different software architectures. This work presents the consumption analysis of two different software architectures: server-centric architecture and mobile-centric architecture, in order to show the least energy-consumption in Android-mobile application which is implemented to execute effectively the primitive operations for indoor navigation. To do so, either PowerTutor1.4 or Trepn Power Profiler will be applied to estimate the energy consumption. Ultimately, this application will be implemented on indoor navigation environment of first floor - IMAM HUSSEIN LIBRARY (IHL) at Imam Hussein Shrine, Karbala, IRAQ.

KEYWORDS: software architecture; energy consumption; android mobile application; indoor navigation;

1. INTRODUCTION

The popularity of smartphones and mobile apps has been increasing since the beginning of this century. According to [1] the number of mobile-cellular subscriptions increases from 738 million to about 7 billion currently. The energy conservation of mobile application relies heavily on its resource consumption such as battery use and network traffic [2][3] these two elements are considered as factors to determine the success of mobile applications. The resource consumption of mobile devices and their applications is a topic that has garnered significant attention recently [4]. Most researches have focused on optimizing the consumption of applications after they have been developed. Due to the limited resources of mobile devices, conducted industrial context studies are increased. This increase makes them an interesting subject of study in terms of consumption efficiency. Mobile applications that drain the device's resources are soon rejected by their users [5]. Therefore, the development of a mobile application should include analysis of consumption patterns. These consumption patterns are determined primarily by software architecture [6]. The most established architecture for mobile apps is the server-centric approach [7], whereby mobile devices are acting as simple clients and tasks such as information storage, processing, and communication tasks are delegated in the cloud. However, there are other emerging mobile-centric architectures [8] inspired by distributed processing which are gaining in relevance for mobile-to-mobile service provisioning. Resource consumption is also a concern for these architectures. In this context, there has been no work assisting developers in choosing the most suitable software architecture for their applications in terms of resource consumption except [9], and their work still limited to a number of case studies, architectures, and real applications. Thus, in this research the authors aim to present analysis of two architectures (server-centric architecture and mobile centric architecture) to show which of these architectures is less demanding for energy consumption in mobile devices. Generally, wireless technology oriented indoor navigation application will be deployed at first floor of *IMAM HUSSEIN LIBRARY (IHL), Karbala* as the case for this study.

Wireless technologies such as Bluetooth, Wi-Fi, signals of cellular towers and ZigBee are common. Amongst these technologies, Wi-Fi is the most popular one because it does not require additional location of each mobile device. Therefore, "Wi-Fi trilateration approach" will be used in our indoor navigation application. This approach uses the signal strength to estimate the distance between user and each transmitter. Moreover, the Spherical Trilateration Algorithm that uses the parameters of known Wi-Fi network such as frequency, signal strength, network MAC address and real coordinates of Wi-Fi access points will be implemented in this work.

This research presents the consumption analysis of navigation for localization within the indoor environment of first floor of *IMAM HUSSEIN LIBRARY (IHL), Karbala, Iraq*. An effective application (used in Android smartphones) will be implemented to execute primitive operations (like post, get) for indoor navigation. This application will be built by two different architectures (server or mobile-centric) in order to identify the least energy-consuming architecture. In addition, The PowerTutor1.4 or Trepn Power Profiler, one of them it will be used to estimate the energy consumption [10]. The remainder of the paper is organized as follows: Section 2 describes the related work, Section 3 presents the Method, Sections 4 discusses the limitations and finally, section 5 concludes the paper.

2. RELATED WORKS

Resources of mobile devices are generally limited. One of the most important resources in mobile devices is energy recourse (battery). Various strategies have been proposed by [11] to reduce battery consumption. Technique off-loading resource-consuming tasks to cloud servers, for example, has been adopted by commercial mobile applications. However, it is not applicable for application that is processing data stored locally (not on server). Besides, managing resource consumption at the level of the device's operating system has been proposed; however, most developers found that it is challenging to perform this task. Studies such as [12][13] focus on the battery consumptions of different mobile networking technologies including Wi-Fi and 3G and the authors have proposed a new communication protocol to reduce energy consumption by delaying some communications or increasing data traffic through pre-fetching information.

Various energy-saving methods such as scheduling data transmission between mobile devices and cloud servers are reported by [14][15]. In order to characterize the energy consumption, energy demands of mobile devices are determined from both hardware and software [13]. Their study has led to the creation of an energy-aware operating system for mobile devices designed to reduce the energy consumption of mobile applications.

The resource consumptions within specific applications are studied by [16]. As reported, a fine-grained energy profiler for smartphone applications is applied to measure the energy spent within an application in performing tasks such as rendering images on the screen or building an internal database for the application. While this information is beneficial for developers seeking to improve resource consumption, the application must be built before the analysis can be executed. Thus, this strategy is not useful at the design stage of a mobile application [16]. The resource consumption of a wide array of sensors embedded in mobile applications has been studied by [17], They have proposed a solution to manage the sensing requirements of all the applications running on a mobile device in order to reduce the energy consumption. However, detailed information is not provided on how to design the least-consuming application.

While, a set of indicators has been proposed in [18] to measure power consumption. The authors concluded that McCabe cyclomatic complexity, weighted methods per class, nested block depth, number of overridden method, number of methods, total lines of code, method lines of code and number of parameters have strong bivariate correlations with the power consumption. Therefore, these metrics can be adopted as indicators to estimate the power consumptions of mobile applications.

So far, various techniques have been proposed to measure energy consumption such as external power monitor [19][20]. Also, the consumption information from the battery and the modified kernel has been evaluated by [21]. In general, consumption information obtained from the devices is reliable for different types of analyses and experiments such as those proposed in the present work. A conceptual framework has been proposed by [9] to help mobile developers during the architectural decision making process. By estimating the energy consumption of mobile applications constructed under different software architectures, the proposed framework allows developers to analyze the resource consumption and its variations as the applications are scaled up. To that end, the framework analyzes the consumption of a set of primitive operations that can be used to compose complex social applications.

In short, topic such as resource consumption of mobile devices has garnered significant attention in recent years [22]. Most of the studies focus on optimizing the consumption of applications upon the development stage. However, to the best of the authors' knowledge, work related to choosing the most suitable software architecture for mobile applications in terms of resource consumption is rather limited [6].

3. METHODOLOGY

The main concern is to identify which approach; server-centric architecture or mobile-centric architecture, is going to consume less energy in android mobile applications to execute primitive operations for indoor navigation of IHL, Karbala. Due to the fact that there is no useable map within (IHL), an indoor map is created as well in the current work. This map (include all rooms and exits) can be assessed near the emergency exits. After the structure of the inner first floor-IHL building is modeled, walkable area inside the floor is then defined which is essential for route calculation. The indoor localization method based on Wi-Fi signal strength trilateration technique is considered. It is simple in realization and estimation and can localize position of a mobile device within building. The methodology focuses on many activities to achieve analysis of these two architectures (server and mobile-centric architecture) for energy consumption as shown in Section 3.1.

3.1 Wi-Fi trilateration approach

In this approach, signal strength will be used to predict the distance between user and three access points. Here, the Spherical Trilateration Algorithm will be implemented whereby the distance is estimated by the signal strength which is presented as a circle centered at each access point. The three circles may intersect to form a point or an area of receiver. Figure 1 shows indoor localization area provided by the trilateration approach.

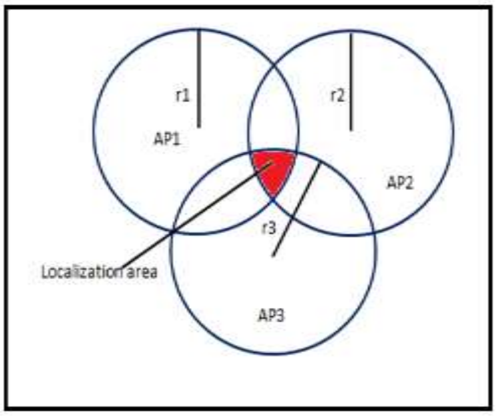

Figure. 1 Indoor localization area provided by the trilateration approach

3.2 Application architectures

Indoor navigation application can be implemented by applying either the server-centric (SC) or the mobile-centric (MC) architectures, but its behavior differs depending on which architecture is used. With a server-centric architecture (See Figure 2), the users' location is stored on a server. Thus, the client (mobile device) supposedly has Wi-Fi connection capabilities, where Wi-Fi connection is turned on automatically as the application starts. By using the Android's Wi-Fi Manager API, the device scans for all available connections. This information contains Service Set Identifier (SSID), Received Signal Strength Indicator (RSSI) and MAC address of each access point. The current module selects only the pre-defined SSIDs and plugs the corresponding RSSIs into the Wi-Fi Localization algorithm. The resulting coordinates (X, Y) are used in the server. Therefore, RSSI must be posted to the server in order to obtain the user location from the server. On the contrary, with a mobile-centric architecture (See Figure 3), the user location is kept internally inside the client (mobile device) and provided as a service for this application.

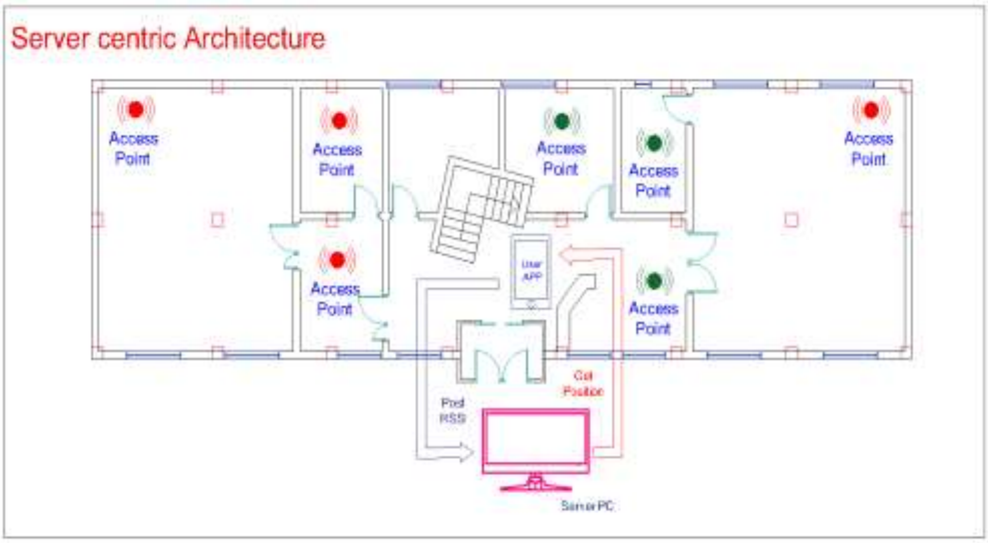

Figure. 2 Server-centric architecture for IHL

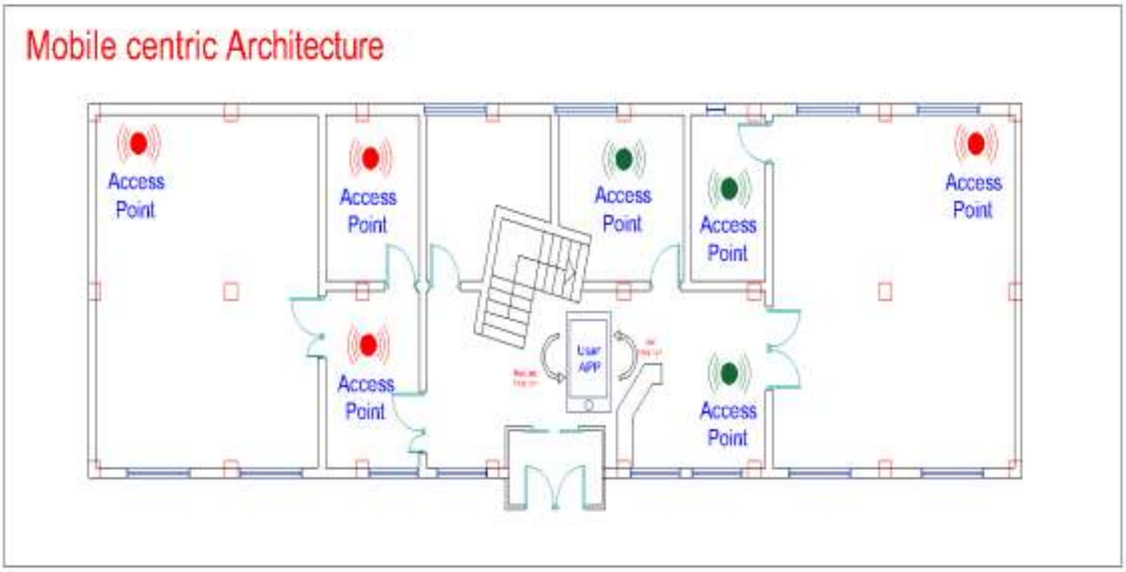

Figure. 3 Mobile-centric architecture for IHL

3.3 Experimental setup

Predicting the resource consumption of an application is not a simple task and trying to estimate that consumption under different architectures is even harder. To get the most accurate measurements, a prototype including the most significant functionalities would have to be built for each architecture. However, this is generally unfeasible because of the cost and effort required. To this end, We plan to apply the new approach (framework) presented by [9] via identifying the commonest operations like *(post, get)* of an app and measures its consumption. Then, the important functionalities of an app can be composed from these primitive operations, and the expected consumption of an app can be extrapolated based on the consumptions of the primitives. This method has been used at high abstraction levels on social network case study [9]. In the current work, we aim to develop an application indoor navigation applying the same technique utilized in social network on indoor navigation case study to identify the least energy-consuming architecture. The consumption of the battery and the data traffic (either received or transmitted) can be measured with each primitive operation executed and registered by the PowerTutor1.4 or Trepn Power Profiler. To ensure measurement accuracy, this indoor navigation app must be executed without relegating to the background by the operating system. Also, the executions of other applications are not permissible during the measurement. Finally, based on the analysis of the two architectures, a decision should be made to conclude: under which architecture (server or mobile-centric architecture) this application will be less energy-consuming for battery life in an indoor navigation.

4. LIMITATIONS

Due to the fact that there are no useable maps within IHL, an indoor map should be created as well in the current work. Also, to get the most accurate measurements, a prototype includes the most significant functionalities would have to be built for each architecture. These map and prototypes would then be used to perform different simulations in conditions close to the real execution environments [23]. However, this is generally unfeasible because of the cost and effort required. Furthermore, the efforts put in would not be reusable for measuring the consumption of other applications since these would also require their own prototypes with which to compare the different architectures.

5. CONCLUSION

The study focuses on the analysis of two architectures (server and mobile-centric architecture): which of the two architectures (server or mobile-centric) is less demanding for energy consumption in mobile devices. Generally, wireless technology oriented indoor navigation application will be deployed at first floor of Imam Hussein Library, Karbala as the case for this study. In this research, some facts will be found out that contribute to the body of knowledge and this expected fact can be summarized as such: firstly, this research will detail up and conclude which architecture; server centric architecture or mobile-centric architecture consumes less energy in android mobile applications (indoor navigation). This fact at the design phase is crucial for developers to be able to reduce resource consumption and hence, increase the likelihood of success of their apps. Secondly, to develop a prototype to implement the aforementioned two architectures by executing primitive operations for indoor navigation of first floor- IMAM HUSSEIN LIBRARY (IHL) at Karbala, IRAQ.

ACKNOWLEDGMENT

Authors owe the Imam Hussein Library Management Centre and a great debt of gratitude for their indispensible support and cooperation. Sincere gratitude also extends to students and other individuals who are either directly or indirectly involved in this project.

REFERENCES

1. B. Sanou, *"Facts & Figures,"* 2015.
2. A. Merlo, M. Migliardi, and L. Caviglione, "*A survey on energy-aware security mechanisms*," Pervasive Mob. Comput., vol. 24, pp. 77–90, 2015.
3. K. Lee, A. Member, J. Lee, S. Member, and Y. Yi, "*Mobile Data Of fl oading : How Much Can WiFi Deliver ?*," vol. 21, no. 2, pp. 536–550, 2013.
4. R. Hans, D. Burgstahler, A. Mueller, M. Zahn, and D. Stingl, "*Knowledge for a Longer Life : Development Impetus for Energy-efficient Smartphone Applications,*" 2015.
5. C. Wilke, S. Richly, G. Sebastian, C. Piechnick, and U. Aßmann, "*Energy Consumption and Efficiency in Mobile Applications : A User Feedback Study,*" 2013.
6. A. Khaleel, "*ENERGY CONSUMPTION PATTERNS OF MOBILE APPLICATIONS IN ANDROID PLATFORM : A SYSTEMATIC LITERATURE REVIEW,*" vol. 95, no. 24, 2017.
7. W. Xu, Wu, Daneshmand, Liu, "*A data privacy protective mechanism for WBAN,*" Wirel. Commun. Mob. Comput., no. February 2015, pp. 421–430, 2015.
8. J. Guillen, J. Miranda, J. Berrocal, J. Garcia-Alonso, J. M. Murillo, and C. Canal, "*People as a service: A mobile-centric model for providing collective sociological profiles,*" IEEE Softw., vol. 31, no. 2, pp. 48–53, 2014.
9. J. Berrocal et al., "*Early analysis of resource consumption patterns in mobile applications,*" 2016.
10. J. Bornholt, T. Mytkowicz, and K. S. McKinley, "*The model is not enough: understanding energy consumption in mobile devices,*" Power (watts), vol. 1, no. 2, p. 3, 2012.
11. N. Vallina-rodriguez and J. Crowcroft, "*Modern Mobile Handsets,*" pp. 1–20, 2012.
12. N. Balasubramanian, "*Energy Consumption in Mobile Phones : A Measurement Study and Implications for Network Applications,*" pp. 280–293, 2009.
13. N. Vallina-rodriguez, P. Hui, J. Crowcroft, and A. Rice, "*Exhausting Battery Statistics,*" no. February, pp. 9–14, 2010.
14. M. B. Terefe, H. Lee, N. Heo, G. C. Fox, and S. Oh, "*Energy-efficient multisite offloading policy using Markov decision process for mobile cloud computing,*" Pervasive Mob. Comput., vol. 27, pp. 75–89, 2016.
15. T. Shi, M. Yang, X. Li, Q. Lei, and Y. Jiang, "*An energy-efficient scheduling scheme for time-constrained tasks in local mobile clouds,*" Pervasive Mob. Comput., vol. 27, pp. 90–105, 2016.
16. A. Pathak and Y. C. Hu, "*Fine Grained Energy Accounting on Smartphones with Eprof,*" pp. 29–42, 2012.
17. A. A. Moamen, "*ShareSens : An Approach to Optimizing Energy Consumption of Continuous Mobile Sensing Workloads,*" 2015.
18. C. K. Keong, K. T. Wei, A. Azim, A. Ghani, and K. Y. Sharif, "*Toward using Software Metrics as Indicator to Measure Power Consumption of Mobile Application : A Case Study,*" pp. 172–177, 2015.
19. L. Zhang, R. P. Dick, Z. M. Mao, Z. Wang, and A. Arbor, "*Accurate Online Power Estimation and Automatic Battery Behavior Based Power Model Generation for Smartphones,*" pp. 105–114.
20. W. Jung, C. Kang, C. Yoon, D. Kim, and H. Cha, "*DevScope : A Nonintrusive and Online Power Analysis Tool for Smartphone Hardware Components,*" pp. 353–362, 2012.
21. C. Yoon, D. Kim, W. Jung, C. Kang, and H. Cha, "*AppScope : Application Energy Metering Framework for Android Smartphones using Kernel Activity Monitoring.*"
22. R. Hans, D. Burgstahler, A. Mueller, M. Zahn, and D. Stingl, "*Knowledge for a Longer Life : Development Impetus for Energy-efficient Smartphone Applications,*" no. June, 2015.
23. R. Mittal, A. Kansal, and R. Chandra, "*Empowering developers to estimate app energy consumption,*" Proc. 18th Annu. Int. Conf. Mob. Comput. Netw. - Mobicom '12, p. 317, 2012.

AUTHORS PROFILE