International Conference on Information Engineering, Management and Security
2015 [ICIEMS 2015]

ISBN	978-81-929742-7-9	**VOL**	01
Website	www.iciems.in	**eMail**	iciems@asdf.res.in
Received	10 - July - 2015	**Accepted**	31- July - 2015
Article ID	ICIEMS015	**eAID**	ICIEMS.2015.015

Bluetooth to Bluetooth RSSI estimation Using Smart Phones

Kumareson.P[1], Rajasekar.R[2], Prakasam.P[3]
[1]PG scholar/CSE, Tagore Institute of Engineering and Technology, Salem, India.
[2]Associate Professor/CSE, Tagore Institute of Engineering and Technology, Salem, India.
[3]Professor/ECE, United Institute of Technology, Coimbatore, India.

Abstract: *Mobile computing is one of the most advanced computing models used in scientific research applications. Although the foundation of the proximity estimation model was laid by past generations only the recently advances opened on expanding proximity estimation application range and its research implementation. Existing approaches used such as GPS and WIFI triangulation are more complicated to find the accurate extraction of proximate location and it insufficient to meet the requirements of flexibility and accuracy. In nowadays the Bluetooth which is commonly available on most modern Smartphone's. And it finds the exact location of any Bluetooth users only in a certain limit. By pairing the key in their mobile of one Bluetooth users to any another Bluetooth users. This paper proposes a proximity estimation model to identify the distance based on the RSSI values of Bluetooth and light Sensor data in different environments. And also state Bluetooth proximity estimation model on Android with respect to accuracy and power consumption with a several real world scenarios.*

Keywords: Bluetooth, RSSI, proximity estimation model, smartphone, face-to-face proximity

I. Introduction

In recent years, the mobile phone market has increasingly used Bluetooth as the preferred method of device communication, data exchange, and accessory pairing. Many PC accessories including mice, keyboards, headsets, and printers also employ the Bluetooth standard for wireless communication.Bluetooth is an industrial standard for wireless personal area networks. It is primarily designed for low power consumption and short range operations among several mobile and embedded devices.. Bluetooth provides connection management and data exchange among devices that are within close proximity and do not require high bandwidth data links. The technical challenge is how to measure face-to-face interactions.In Bluetooth the rssi signals range between two or more individuals within a certain distance that could afford those interactions.The previously mentioned schemes used as to determine the proximity estimation is GPS and WIFI are not such efficient,because its suffers from accuracy shortcoming and lack of viability indoors.

With the important shift of the problem statement, Bluetooth emerges as a straightforward and Alternative approach used as offering both accuracy and ubiquity (most modern smartphones come with Bluetooth) Although some prior work has attempted to use the detection of Bluetooth to indicate proximity nearness, it is not enough for the face-to-face proximity estimation. This paper describes to extent the range of Bluetooth and it can be an accurate estimator of such proximity.

Cite this article as: Kumareson.P, Rajasekar.R, Prakasam.P. "Bluetooth to Bluetooth RSSI estimation Using Smart Phones." *International Conference on Information Engineering, Management and Security (2015)*: 92-97. Print.

To summarize, our work it makes the following contributions:

- To explore the viability of using Bluetooth for the purposes of face-to-face proximity estimation and propose a proximity estimation model with appropriate smoothing and consideration of a wide variety of typical environments.
- To Identifying the relationship between the value of Bluetooth RSSI and distance based on empirical measurements and compare the results with the theoretical results using the radio propagation model.
- To explore the energy efficiency and accuracy of Bluetooth.

The remainder of the paper is organized as follows.In Section II the problem identification is described. In Section III, the introduction about related approaches to get relative distance determination in proximity estimation. In Section IV the data collecting system built on smartphones is documented.In Section V the proximity estimation model with smoothing and environment differentiation is proposed. Finally, we suggest ways to extend this work to future communication research in Section VI.

II. PROBLEM IDENTIFICATION

Bluetooth -to- Bluetooth interaction does not demand an absolute position as offered by the previously mentioned schemes like GPS and WI-FI but rather it requires a determination of proximity.

With that above important shift of the problem staement .Bluetooth emerges as a straightforward and alternative approach to offering both accuracy 1-1.2 m and ubiquity (most latest smart phones come with Bluetooth). Although the prior work has attempted to use the detection of Bluetooth to indicate nearness, it is not enough for the Bluetooth -to- Bluetooth proximity estimation.

Data values reported by light sensor is not reliable. Determination of proximity within a limit(coverage).Each RSSI value was not allow for environmental fluctuations.

The critical challenge is how to measure face-to-face interactions Two or more individuals within a certain distance that could afford such interactions .Interactions are not limited to any particular area and can take place at a wide variety of locations, ranging from sitting and chatting in a Starbucks coffee shop to walking and chatting across a college campus

III.RELATED WORK

Over the past years, there has been a number of technologies proposed for proximity detection. The approach used such as meme tags,active badge,place lab,zigbee techonology,location based services,3-D optical services…etc

A)Meme Tags

The Meme Tag event took place over a period of October 1997. The event was designed by MIT Media Lab's *Digital Life* (DL), *Thing That Think* (TTT), and *News In the Future* (NIF) consortia sponsor meetings

Meme Tags [12] provide good accuracy but require line of sight.

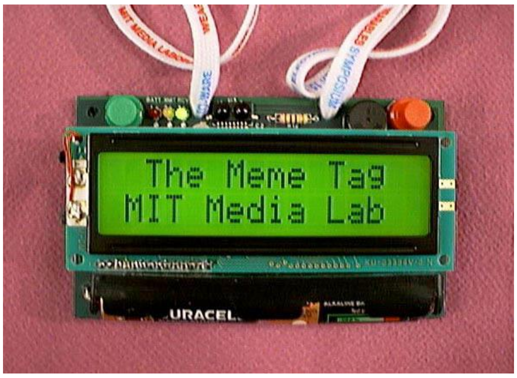


figure 1: The Meme Tag. Worn around the neck, the

Meme Tag includes a large, bright LCD screen, green

and red pushbuttons (for accepting or deleting memes), a knob (not visible) for reviewing and choosing memes to offer, and a bidirectional infrared communications device

B)Active Badge

Cite this article as: Kumareson.P, Rajasekar.R, Prakasam.P. "Bluetooth to Bluetooth RSSI estimation Using Smart Phones." *International Conference on Information Engineering, Management and Security (2015)*: 92-97. Print.

Ultrasound approaches used such as Activebadge also provide good accuracy but they require infrastructure support. Goal of active badge is to find efficient location and coordination of workers in a large organization. Existing Solutions used as Broadcasting a phone to call several possible numbers a beeper with audible signal or call-back number

Ex: location of doctors, staffs, and patients in a hospital.

C)Zig Bee technology

ZigBee technology is widely used in wireles

sensor network to provide radio proximity estimation in the environment where GPS is inoperative. Proximity can also be reported by sounds, and past work has shown audio to be effective for delivering peripheral cue. However,it is untenable to expect the use of smartphones to reduce the unobtrusiveness of cues or increase comprehension However,it is untenable to expect the use of smartphones to reduce the unobtrusiveness of cues or increase comprehension

For the purposes of this paper, we are interested in techniques that are based on commonly available technologies in smartphones,i.e., GPS, Cell, Wi-Fi and Bluetooth. Particularly, we are interested in techniques that can be applied at the smartphone itself without significant changes to the infrastructure.There are some proximity detection works using Bluetooth signal. From a specific work perspective, the works of Eagle etal. are highly relevant to this paper. In those studies, the authors use the ability to detect Bluetooth signals as indicators for people nearby within the Bluetooth range However, such indication does not meet the requirement of face-to-face proximity detection. In class, a student may discuss with others sitting beside him/her, butface-to-face talk is difficult with the students on the other side of the classroom even they are still in the Bluetooth range. Different from the above proximity detection method, our method is a fine grain Bluetooth-based proximity detection method which can provide adequate accuracy for face-to face proximity estimation without any environment limitations.

D)location based systems

Proximity detection is one of the advanced Location based Service (LBS) functions to automatically detect when a pair of mobile targets approach each other closer than a predefined proximity distance (as in Location Alerts of Google Latitude and longitude). For realizing this function these targets are equipped with a cellular mobile device with an integrated GPS receiver, which passed position fixes obtained by GPS to a centralized location server. Most proposals for such services give low accuracy and its guarantees to incur high communication costs

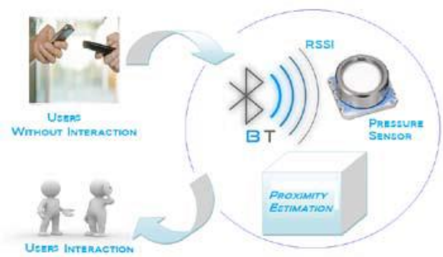
E) 3-D optical approach

3-D optical wireless based location approach is proposed which it is based on both GPS and triangulation technologies. It is another feasible way of utilizing GPS to get relative distance among objects.Some proximity estimation methods are based in Cell or WiFi signal. Using Place Lab cell phones listen for the MAC address of fixed radio beacons such as cell tower ,wireless access points, and reference the beacons positions in a cached database. It provides adequate accuracy for detecting something like buddy proximity (e.g., median accuracy of 20-30 meter)

IV.SOFTWARE DESING FOR BLUETOOTH SMARTPHONE'S

A)System Architecture

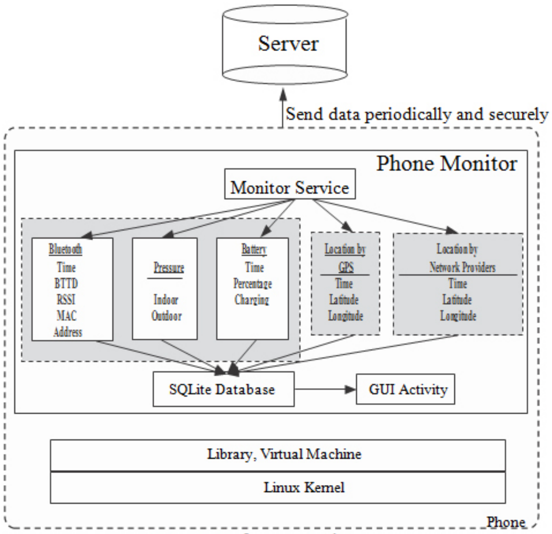
The smart phone is taken and the application for it is modeled.The first one is to enable the application and it will turn on the Bluetooth application then it asks whether to display the listed pair device. If list paired device button is pressed then the list of paired device is displayed. Then select one device and if the device is near the coverage area then it displaces the RSSI value i.e., distance between the devices. The obtained RSSI value is calculated by using the propagation formula. After that in future the pressure sensor is used to detect whether the smart phone is in indoor or outdoor location



B)Data Collection System

Cite this article as: Kumareson.P, Rajasekar.R, Prakasam.P. "Bluetooth to Bluetooth RSSI estimation Using Smart Phones." *International Conference on Information Engineering, Management and Security (2015)*: 92-97. Print.

The application named Phone Monitor collects Bluetooth data including the detailed values of RSSI, MAC address, and Bluetooth identifier (BTID). The data is recorded in SD card once the phone detects other Bluetooth devices around. In addition to Bluetooth, data points from a variety of other subsystems (light sensor, battery level and etc.) are gathered in order to compare and improve the proximity estimation. Separate threads are employed to compensate for the variety of speeds at which the respective subsystems offer relevant data. It also record the location data reported by both GPS and network providers (either WiFi or cell network). In order to determine whether the phone is sheltered (e.g. inside a backpack or in hand) and the surroundings (e.g.inside or outside buildings) during the daytime, we keep track of the light sensor data values. The battery usage of the percentage is recorded for the energy consumption comparison.



V.BLUETOOTH PROXIMITY ESTIMATION MODEL

In this section, we explore the relationship between Bluetooth RSSI and distance in real world scenarios. The first method is using RSSI value threshold to determine whether two phones are in proximity or not. The second method introduces the light sensor data to determine whether the phone is indoors or outdoors, inside the backpack or in hand. By differentiating environments and smoothing data, a face-to-face proximity estimation model is outlined to improve the estimation accuracy in general scenarios. At the end of this section the proximity accuracy of Bluetooth, WiFi and GPS are analyzed and compared.

A) Bluetooth RSSI vs. Distance

Anti et al. presented the design and implementation of a Bluetooth Local Positioning Application (BLPA) in which the Bluetooth received signal power level is converted to distance estimate according to a simple propagation model as follows:

$$RSSI = PTX + GTX + GRX + 20 \log (c\ 4\pi f) - 10n \log (d)$$
$$= PTX + G - 40.2 - 10n \log (d)$$

where PTX is the transmit power; GTX and GRX are the antenna gains and G is the total antenna gain:
$G = GTX + GRX$, c is the speed of light ($3.0*108m/s$), f is the central frequency (2.44 GHz), n is the attenuation factor (2 in free space), and d is the distance between transmitter and receiver (in m). d is therefore:
$d = 10[(PTX-40.2-RSSI+G)/10n]$
However, such a model can only be utilized as a theoretical reference. Due to reflection, obstacles, noise and antenna orientation, the relationship between RSSI and distance becomes more complicated. Our challenge was to assess how much impact these environmental factors have on Bluetooth RSSI values. Therefore, we carried out several experiments to understand how the Bluetooth indicators fade with distance under these environmental influences.

B)Single Threshold

RSSI value (-52dBm) of direct communication distance (152cm) based on the indoor measurements was used as a threshold to estimate whether the individuals were in proximity. Accordingly,values less then -52dBm were considered as not in face-to-face proximity and labeled as a wrong estimation. It was found that both of the outdoor and backpack parts have extremely high error rates.After switching the threshold value to -58dBm which is the outdoor RSSI values with 152cm distance, the error rate was improved but still high. To reduce the error rate we go multiple thresholds with data smoothing and different environmental effect.

Cite this article as: Kumareson.P, Rajasekar.R, Prakasam.P. "Bluetooth to Bluetooth RSSI estimation Using Smart Phones." *International Conference on Information Engineering, Management and Security (2015)*: 92-97. Print.

C)Multiple Thresholds

According to the reasons for high error rate then we introduce the proximity estimation model which is a multiple threshold-based method with the consideration of data smoothing and different environmental effects.

i)Data Smoothing

. Since there is time delay during the data collection,then do smoothing on the data collection to avoid environmental fluctuation effects and there are several ways to achieve it. using simple window function and each value RSSI(i) at time (i) is modified using the following function:

$$RSSI(i) = a * RSSI(i-1) + b * RSSI(i) + c * RSSI(i+1)$$

Another one smoothing method is to utilize EWMA (exponentially weighted moving average) to analyze the dataset. Let the Ei be the EWMA value at time (i) and (s) be the smoothing factor.

The EWMA calculation is as follows:

$$Ei = s * RSSIi + (1 - s)Ei-1.$$

Measureing the possible face to- face interaction distances across the campus (such as diagonal of desk in dinning hall and distance between desks in classrooms and etc.) and the average value is equal to1.52 (m.)Base assessment: the whole process took 30 minutes and individuals were always within the distance for face-to-face communication. After the data collection, the corresponding RSSI value (-50dBm) of direct communication distance (152cm) was used as a threshold to estimate whether the individualswere in face-to-face proximity or not

ii)Light Sensor Data

The Bluetooth RSSI values are much smaller than the indoor ones when the phone is in the backpack or outdoors. One of our observations is that it is possible to treat the light sensor data as an indicator of the environment

VI.ACKNOWLEDGEMNT

This work was funded in part by the National Science Foundation through grant IIS-0968529.

VII.CONCLUSION AND FUTURE WORK

I have analyzed several proximity estimation model by combining Bluetooth RSSI value, light sensor data as well as data smoothing together and understanding with the method of collecting all devices around, the accuracy of utilizing proximity estimation model to estimate whether two devices are in a Direct communication distance is improved dramatically. I also analyzed and studied the battery usage and accuracy of Bluetooth method with other different location methods such as WiFi triangulation and GPS. Finally it demonstrates that Bluetooth offers an effective mechanism that is accurate and power-efficient for measuring face-to-face proximity to increase Bluetooth signal Strength level and its coverage range.Another promising method for Improving the threshold algorithms w ith data mining. The thresholds used in the proximity estimation model are based on the experiment results on android phones. For different phones, such thresholds may be different. Therefore, a more general method is necessary to determine the relationship between Bluetooth RSSI values and the face-to-face proximity. With more data reported in the next following years, a more efficient data mining algorithm is needed to analyze the data. During the nighttime, only the data reported by light sensor is not efficient. The possible method to solve this problem is to taking atmospheric pressure into consideration to determine whether the phone is indoor or outdoor.

REFERENCE

[1]Yang-Hang Lee , Kuo-Wei Ho, Hsien-Wei Tseng," Accurate Bluetooth Positioning Using Large Number of Devices Measurements", IMCES ,Vol.2,No 4, PP.381-394 March 12 - 14, 2014,
[2] M. R. Friesen & R. D. McLeod," Bluetooth in Intelligent Transportation Systems: A Survey",Springer,vol 10,No 15,pp.107-112, May .2014
[3] Dae Wook Kim and Mehmet M. Dalkilic," Analysis of Proximity Networks from Multiple Mobile Sensor Data", International Journal of Future Computer and Communication, Vol. 2, No. 3,pp 134-139, June 2013
[4] Avik Ghose,Chirabrata Bhaumik," BlueEye – A System for Proximity Detection Using Bluetooth on Mobile Phones", UbiComp'13, Vol 5,No 7,pp.8-12,September 2013
[5] Julian Benavides,"Smartphone techonologies for social network data generation and infectious disease modeling", Journal of Medical and Biological Engineerin,,Vol 32 ,No 4,pp. 235-244,jan 2012.
[6] Trinh Minh Tri Do,Daniel Gatica-Perez," GroupUs: Smartphone Proximity Data and Human Interaction Type Mining",Vol 5,No 2,pp 8-5, feb 2011
[7]M. N. Juuso Karikoski, "Measuring social relations with multiple datasets," International Journal of Social Computing and Cyber-Physical Systems, vol. 1, no. 1, pp. 98–113, November 2011.
[8] Ling Pei, Ruizhi Chen," Using Inquiry-based Bluetooth RSSI Probability Distributions for Indoor Positioning", Journal of Global Positioning Systems ,Vol.9, No.2,pp.122-130,march 2010
[9]H.Falaki,R.Mahajan,S.Kandula,D.Lymberopoulos,R.Govindan,and Estrin,"Diversity in smartphoneusage,"inProceedingofthe8thinternationalconferenceonMobilesystems,applications,andservices. ACM,2010, pp. 179–194
[10] Chakib Baouche, Antonio Freitas," Radio Proximity Detection in a WSN to Localize Mobile Entities Within a Confined Area", JOURNAL OF COMMUNICATIONS, VOL. 4, NO. 4,pp.132-138, MAY 2009
[11] Mika Raento, Antti Oulasvirta," Smartphones: An Emerging Tool for Social Scientists", Sociological Methods & Research,Volume 37 Number 3, pp.426-431,February 2009
[12]A. P. Nathan Eagle and D. Lazer, "Inferring social network structure using mobile phone data," Proc. of the National Academy of Sciences (PNAS), vol. 106, no. 36, pp. 15 274–15 278, September 2009
[13]Kevin A. Li, Timothy Y. Sohn," PeopleTones: A System for the Detection and Notification of Buddy Proximity on Mobile Phones", ACM,vol 2,No 8,pp-978-982,June 2008
[14] Aswin N Raghavan1 Harini Ananthapadmanaban,"IIT,Vol 10,No 3,pp 123-128,feb 2007
[15] Fernán Izquierdo, Marc Ciurana," Performance evaluation of a TOA-based trilateration method to locate terminals in WLAN",IEEE,Vol 5,No 3,pp. 132-140,jan2006.
[16] Georg Treu and Axel K¨upper," Efficient Proximity Detection for Location Based Services," (WPNC'05)& (UET'05),Vol 12,No 24,pp.567-572,june 2005.
[17] N. Eagle and A. Pentland, "Social serendipity: Mobilizing social software," IEEE Pervasive Computing, vol. 4, no. 2, pp. 28–34, 2005.
[18] V. Otsason, A. Varshavsky, A. LaMarca, and E. De Lara, "Accurate GSM indoor localization," UbiComp 2005: Ubiquitous Computing, pp. 903–921, 2005
[19] A. Kotanen, M. Hannikainen, H. Leppakoski, and T. Hamalainen,"Experiments on local positioning with Bluetooth," in ITCC 2003:Information Technology: Coding and Computing, april 2003, pp. 297–303
[20].V. Zeimpekis, G. M. Giaglis, and G. Lekakos, "A taxonomy of indoor and outdoor positioning techniques for mobile location services," SIGecom Exch., vol. 3, pp. 19–27, December 2002.

Cite this article as: Kumareson.P, Rajasekar.R, Prakasam.P. "Bluetooth to Bluetooth RSSI estimation Using Smart Phones." *International Conference on Information Engineering, Management and Security (2015)*: 92-97. Print.