Wireless Device Location Sensing In a Museum Project

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Abstract

Indoor navigation can be implemented with Bluetooth technology as sensors. We use RTT (Round Trip Time) as an attribute towards the navigation of an object. Designing the scheme for indoor networks with the introduction of pre-fixed co-ordinates has been used as a database. This paper presents a new algorithm that incorporate real life signal strength measurement from access point and peers to estimate position and distance using Bluetooth sensor network. The main feature of this paper is to see how RTT behaves with distance and then what approach we must take to make RTT more robust. We conducted several experiments to validate our proposed algorithm and study RTT behavior in real life application.

Keywords: Round Trip Time (RTT), Receive Signal Strength Indicator (RSSI), Bluetooth tags, Sensor

I. INTRODUCTION

Location awareness is becoming the most important issue in many cases, such as when an urgent accident needs the nearest doctor in the hospital, or in the university the staff members want to check available members for a quick meeting, or even to track an object. These are some of the important questions which certainly need fast, reliable answers by keeping the privacy as a priority. For various reasons localization is rapidly growing and context awareness consists of six questions involving what, who, where, when, why and how? Location awareness mainly tries to answer two of them: "where" and "who". Location sensing can be divided into indoor and outdoor awareness. Indoor systems mainly contain a set of antennas with wireless tags. The antennas communicate wirelessly with tags, which are attached to humans, or to desired position of the objects. Mobile handsets are also often personal in nature, so the statistics related to measurements reflect behavioral patterns of the user or object. We demonstrate how prototypical patterns of behavior may be found in data produced by Bluetooth scanning. It appears that cyclical nature of the patterns reflects well various daily routines of test objects. The scanning results are then sent via GPRS/AP to a backend server for further processing for a fixed duration of time. In this project we monitor various data received to ensure that all palmtops and Bluetooth dongles attached to every item of the museum are operating properly. The data set consists of phone ID, timestamp, and MAC address. Some of detected MAC address corresponds to known locations (location of every items of museum). Location evaluation is performed by sensing Bluetooth signal strength with a reference model based approach. We discuss problems which arise when the Bluetooth Received Signal Strength Indicator (RSSI) is used as a measurement of signal strength and propose a novel access point technique based on such data. This access point allows the reading of a wider range of signal strengths using RSSI [1] [2].

This paper is organized into seven sections. Section I gives the introduction. Section II presents an overview of the architecture while section III identifies parameters making RTT as a strong candidate for improvement on localization technique. Section IV and V presents various aspects of Bluetooth protocol and how the database can be accessed. Our proposed algorithm and results of the experiments are given in Section VI. We conclude our work in Section VII.

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II. SOFTWARE ARCHITECTURE AND IMPLEMENTATION

Our architecture is inspired by the location stack and reduce the interaction between separate layers.Figure-1 below illustrates the architecture.

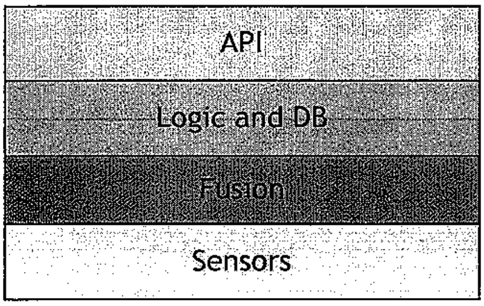

Figure1: Schematic diagram of the layered Architecture

A. *Sensor layer*

This layer is divided into two modules: sensor driver and sensor data abstractor. The former provides low-level software that gathers raw sensor data from the corresponding sensor hardware. The native sensor data is sent to a sensor abstractor, which runs in location server process. These abstractors optionally have access to a database to query the physical or semantic location of a Tag reader or a Bluetooth host [6].

B. *Fusion layer*

The fusion layer takes data from all sensors in the uniform format used by the sensor layer and calculates a single resulting position. This layer can implement algorithms based on individual requirements. Algorithms with very high precision and high requirements in computing power are available, as well as simpler and faster algorithms, which can handle a much higher number of simultaneous tracked clients.

C. *Logic and database layer*

The logic and database layer maintains databases for all tracked objects and their environment. It can store the actual semantic or geometric position and the history of locations (if desired) of the tracked objects. Contextual information like names, room numbers and other properties are also located at this layer. Digital representations of the environment are stored as a hierarchal zone model, whereas the logic layer can look up a geometric or semantic position in the zone database to get additional symbolic information like the room or area in which the position is located [6].

D. *API layer*

The API layer describes the interface of our service used, to obtain position and contextual information as well as basic relationships like containment, and proximity, which we implemented as common and expandable set of features. The API is used both for client/server communication and for communication between the servers [6].

III. ROBUSTNESS OF RTT

We used RTT, the time a packet takes to travel to the receiver and then to come back to the transmitter. Three main components of RTT consists of: processing time, flight time and serialization delay. In Bluetooth devices we have several layers. In order to make Bluetooth working as a good navigator the link manager protocol, L2CAP layer and BNEP are being used.

The link manager protocol that is stored in the firmware of the Bluetooth holds protocols of inquiry, inquiry scan paging and few other necessary uni-directional protocols. They are needed to discover the device present in the range of Bluetooth and then create the link among the Bluetooth enabled devices. According to the standard, one of the available Bluetooth enabled devices, has to agree to be a master of the piconet (one piconet can have maximum of one master and seven slaves). Once the link is established, the immediate higher layer L2CAP protocols are implemented. This layer does the function of data management. The size of packet, the sequence of transmission, encapsulation of higher layers, are taken care of in this L2CAP section. The size of the packet, serialization delay and the speed of the packet transmission are closely related to the media of packet transmission.

Though, with the available mathematical and logical knowledge, we can draw conclusions of the performance of the above parameters, yet the theoretical facts can be established through experimental observations [3] [4]. The readings of RTT versus distance inside and outside the lab help us analyze the nature of transmission for the packets of fixed size.

What is prominent in the readings is the absence of RTT values for some distances. As mentioned before, RTT is nothing but, the time taken for packets of a fixed size, to travel from the source to the destination and back to the source. The absence of RTT, in the readings does not establish this fact, because packets are lost. The inconsistency of RTT with distance is also conspicuous from the graph. To increase the robustness of the data (RTT), we only consider the cluster of readings very close to each other and get rid of the abnormal readings with high variance, from the cluster of ten sampled readings for each distance. The reading which has a high variance, and is very far from the cluster will have bad effects on the rest of the readings of the specified cluster.

Like GSM system for mobile, interior Bluetooth location sensing system network also consists of many small cells. We make each cell as one piconet, having one master/Gateway to the rest of the network (in our case, Bluetooth enabled network access point) at the centre of each cell and many other slaves (any other mobile Bluetooth enabled devices).

IV. DATABASE IN BLUETOOTH

Unlike the home agent in mobile networks, the home agent in Bluetooth networks mostly involves handling of the database and the hand-over process. To present the information

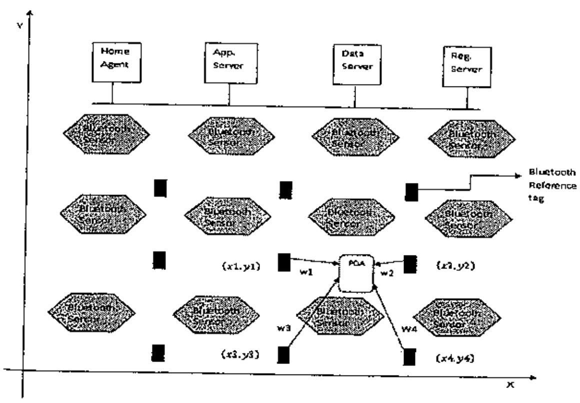

Figure 2: The scheme with tags and sensors

(in our case, the information of different objects in the museum) in the best possible way, the management of the database within the system is taken care of very delicately. To build our database we need to start with an experiment with predefined co-ordinates for some Bluetooth enabled devices considered as reference tags constantly emitting packets to travel to the nearest access point (in our case, sensors). The sensors are also located at a fixed co-ordinate. Though these packets emitted from one such tag are received by many sensors, yet we will be able to come up with a limited number of neighboring sensors by setting a common threshold E value(see the Euclidian distance formula) for every bluetooth enabled tag. The scheme is presented in Fig 2.

We created a sample database called "Museum Database" with attributes describing: object number, corresponding co-ordinate of the object and related information of the object. RTT (Round Trip Time) of each tag is sensed by four nearest neighbors (combination of four neighboring sensors each with a RTT value above a certain high threshold corresponds to one reference tag). The correlation between the mobile Bluetooth enabled device and the reference tag is calculated using the Euclidian distance formula [3].

$$E_i = \sqrt{\sum_{k=1}^{n} (r_{i,k} - u_k)^2}$$

The least value of E allows us to find the closest reference tag to the mobile Bluetooth device. The location of the reference tag is the location of the object in the museum. In the formula r and u are the RTT (Round Trip Time) values of reference tag and the mobile Bluetooth enabled device respectively. Every sensor in the network senses these RTT values of the reference tags [3]. Ethernet header is replaced with a BNEP header at the interface.

V. BLUETOOTH LAYER PROTOCOLS

As shown in Figure-2, two different kinds of communication are established involving the device. The first one is wireless (between two Bluetooth enabled devices) and the second one is wired. In terms of protocol layer, in wireless communication it is the BNEP header which holds the Ethernet payload, whereas in wired communication it is the Ethernet header that holds the Ethernet payload. So whenever we have packets transferred between two Bluetooth enabled devices it is the BNEP header that holds the payload, otherwise it is Ethernet header for conventional communication. We present the network infrastructure implemented in the lab with the following example. A wired networked device (Device C)communicates with a mobile Bluetooth enabled device(Device A) via a Bluetooth enabled NAP (Device B) , Device B will act as a NAP (Network Access Point) and remain as a piconet master for the Bluetooth network, which is connected via a wired network to Device C.

For every network communication irrespective of the wire, before a packet can be transferred between two devices, a bridge is made and the Bluetooth packets are divided into several smaller baseband packets before they can be transmitted. Such task is performed by the L2CAP protocol layer. L2CAP provides connection oriented or connectionless data channels. The physical link is the link that is established between the master and slave units. There are two different kinds of link defined in the Bluetooth specifications:

- Synchronous Connection-Oriented link, or SCO –link
- Asynchronous Connection-Less link, or ACL-link

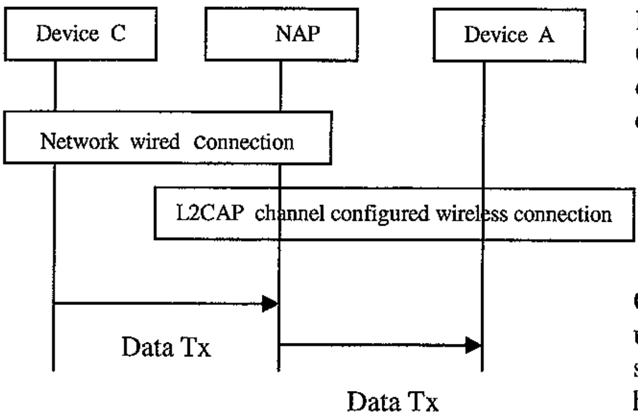

Figure 3: Wireless Device Protocol stack (Network Access Point)

The functional requirements for Bluetooth Network Encapsulation protocol (BNEP) include the support of Personal Area Networking (PAN) profile.

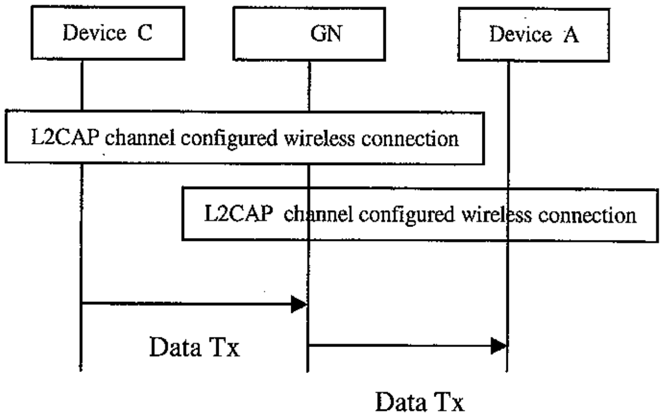

Figure 4: Wireless Device Protocol stack (Gateway Network)

There are three kinds of PAN profile and they entirely depend upon the topology in which the personal area network is setup. Each of these three profiles has different roles. A simple mobile Bluetooth enabled device in a piconet that avail the network wirelessly through either a Bluetooth Network Access Point connected to internet or a central home agent or through a Group Ad-Hoc Networking Controller called PANU. So PANU is a client. GN and NAP are service providers. But there is a basic difference between these two. NAP is connected to the larger network infrastructure with wire whereas, GN is like any other mobile Bluetooth enabled device acting as a packet forwarding node that can serve up to seven slaves[5][7][8].

VI. BLUETOOTH NAVIGATOR ALGORITHM AND RESULTS

Collecting all the RTT values of one moving unknown tag sensed by all the neighboring sensors to a server called main server which holds the program to manipulate this database of RTT values with the already existing database of RTT values of all the reference tags. These RTT values will be stored into a file where my program will fetch the value from when necessary. There is a file containing the co-ordinate values and their corresponding reference tag RTT values. After this we calculate all the E values implementing the equation mentioned above between one unknown tag against every other reference tag. Then we set a threshold value k (k is a very small number and is small enough to satisfy our criteria.). Any E value below k is to be taken into account and others are to be discarded. Now we can fetch the co-ordinate of the reference tags associated with those E values that are below a certain threshold value k.

We calculate the weights associated only with those reference tags whose E values are below the threshold value k. Finally we calculate the co-ordinate of the moving palm top device. Unknown tag using the co-ordinate geometry formula is presented below [3].

$$x_{unknown} = \frac{1}{2}(x_{nearest1} + x_{nearest2})$$

$$y_{unknown} = \frac{1}{2}(y_{nearest1} + y_{nearest2})$$

$$(x,y) = \frac{1}{k}\sum_{i=1}^{k}(x_{ri}, y_{ri})$$

$$(x,y) = \sum_{i=1}^{k} w_i\,(x_{ri}, y_{ri})$$

W_i is the function of the E of all K nearest neighbors. Our approach of the weight depends on the E as:

$$w_j = \frac{\frac{1}{E_i}}{\sum_{i=1}^{k}\frac{1}{E_i}}$$

In this approach, the reference tag with the smallest E value has the largest weight.

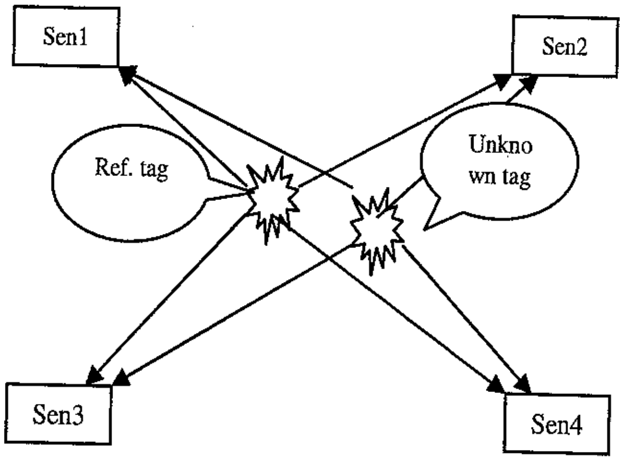

Figure 5: Algorithm implemented to locate unknown tag

Experimental results for inside lab:

Dist(m)	seq.	Time(ms)	Avg(ms)
1	1	3908	6617
	2	4770	
	3	5553	
2	1	2770	5171
	2	3481	
	3	4124	
3	1	1967	3518
	2	2997	
	3	3196	
4	1	2024	3754
	2	3151	
	3	3337	
5	1	3025	6098
	2	4153	
	3	4786	
6	1	9120	12301
	2	10834	
	3	13152	
7	1	2906	5491
	2	3716	
	3	4273	
8	1	4161	7998
	2	4998	
	3	6667	

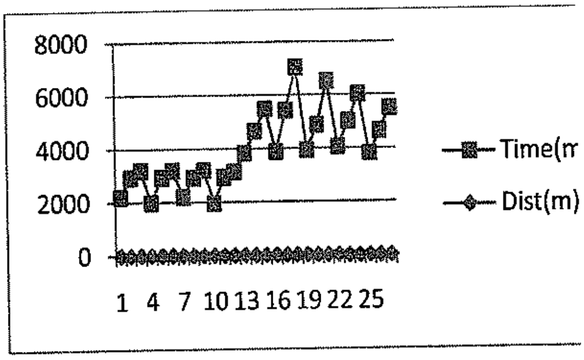

Figure 6: RTT vs Distance (inside lab)

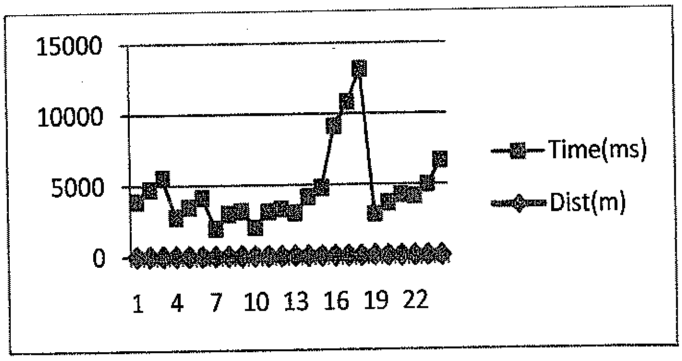

Figure 7: RTT vs Distance (outside lab)

Experimental results outside Lab:

Dist(m)	Seq	Time(ms)	Avg(ms)
1	1	2204	2050
	2	2940	
	3	3188	
2	1	1985	3413
	2	2931	
	3	3190	
3	1	2192	3441
	2	2923	
	3	3197	
4	1	1956	3027
	2	2942	
	3	3140	
4.5	1	3824	6513
	2	4651	
	3	5487	
6	1	3879	7752
	2	5429	
	3	7039	
6.5	1	3924	7967
	2	4879	
	3	6516	
7	1	4043	7148
	2	5015	
	3	6028	
7.5	1	3805	6651
	2	4655	
	3	5497	

VII. CONCLUSION:

The experimental results suggest it is possible to use RTT based measurements for location based services using Bluetooth. Though our result is not linear, yet such variation with distance can be of great use. More work can be done on data link layer to acknowledge the packet received or make the payload shorter to make RTT even more robust in location based navigation system.

ACKNOWLEDGMENT

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[8] Bluetooth Protocol stacks Overview, Palo Wireless, Bluetooth SIG Inc, Tutorial 2001

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Date: Mon, 11 Oct 2010 18:39:05 +0800
To: tanvir.anwar.australia@gmail.com, Priyadarsi.Nanda@uts.edu.au

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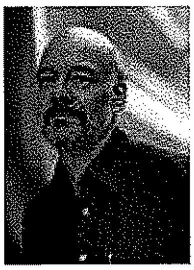

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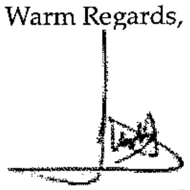

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Some set of experiments and readings.

No Experimentation Details given.
No Research Novelty.
Many references are not in complete format, some are missing publisher, some date and venue

Areas of improvement:
Research Inclination is required.
Proper Experiment platform and framework should be discussed.
Lot of sentences need to be revised

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Preface

We are proud to welcome you to the proceedings of the Annual International Conference on Information Technology Security (ITS) 2010, Annual International Conference on Advanced Topics in Artificial Intelligence (ATAI) 2010 and Annual International Conference on Network Technologies & Communications (NTC) 2010 held on 29–30 November 2010 at the Hilton Phuket Arcadia Resort & Spa, Thailand.

The ITS, ATAI and NTC 2010 Conferences continuously aim to foster the growth of the Information Technology industry and its benefits to the community at large. The scientific content of the conference has attracted immense attention and the wealth of information spread across the papers would be extremely useful to the professionals working in the related fields.

It is with great pride and honour that I announce the participation of expert speakers from various countries in this two-day event. This truly is a unique platform for all stakeholders such as researchers, users, technology developers and distributors, and policy makers to discuss, deliberate and exchange experiences.

The Conference Proceedings documents the presentations made at ITS, ATAI & NTC 2010 and in total this volume contains nearly 50 papers, the end result of a tremendous amount of creative work and a selective review process. We have received research papers from distinguished participating scientists from various countries.

As we have been receiving notable contributions this year, there will be a "2010 BEST PAPER AWARD" and "2010 BEST STUDENT PAPER AWARD" for each of the co-located conferences to recognize outstanding contributions and research publications.

I want to thank all the authors who submitted papers for their participation. They contributed a great deal of effort and creativity to produce this work, and I am happy that they chose ITS, NTC and ATAI 2010 as the place to present it. Credit also goes to the Program Committee members, who donated enormous blocks of time from busy schedules to carefully read and evaluate the submissions.

I would also like to thank the Conference Chair, Professor the Hon. Dr. Stephen Martin the Editors in Chief of ITS, NTC and ATAI, respectively, for contributing towards the success of the conference.

The Organizing Committee would like to take this opportunity to extend our sincere thanks to the Supporting Organizations for their support and encouragement to make the event a success.

Mr. Anton Ravindran
ITS, ATAI & NTC 2010 Conference Organizing Chair

Foreword

This volume of conference proceedings contains a collection of technical research papers presented at the Annual International Conference on Information Technology Security (ITS) 2010, Annual International Conference on Advanced Topics in Artificial Intelligence (ATAI) 2010 and Annual International Conference on Network Technologies & Communications (NTC) 2010 held on 29–30 November 2010 at the Hilton Phuket Arcadia Resort & Spa, Thailand.

The ITS, ATAI & NTC 2010 Conferences are international events for the presentation, interaction, and dissemination of new results relevant to IT security, network technologies and artificial intelligence, and related areas. As Conference Chair of this event, I would like to express my sincere thanks to all those who submitted papers for review and those who provided manuscripts for publication in these proceedings.

A special thanks to all our speakers and attendees for making ITS, ATAI and NTC 2010 a successful platform for the industry, fostering growth, learning, networking and inspiration.

We sincerely hope you find the conference proceedings to be enriching.

Professor the Hon. Stephen Martin
ITS, ATAI & NTC 2010 Conference Chair

Annual International Conference on

Network Technologies & Communications

(NTC 2010)

Editorial

It is our pleasure to present to you the Proceedings of the Annual International Conference on Network Technologies & Communications (NTC 2010).

The goal of the NTC 2010 is to provide opportunities for academics, researchers, experienced professionals and business people to share their knowledge of network technologies and communications. Networking should be on-demand, with whomever or whatever they want, regardless of time or location. To meet these requirements, industry has invested heavily in a variety of wireless and wireline communications technologies, each with its own strengths and weaknesses. In recent times, we have seen the emergence of 3G and 4G, WiFi and WiMax, Bluetooth and Zigbee, Ultrawideband and TV-band, Powerline and Free space optical.

Next-generation services require unified and scalable technologies spread across the network protocol layers facilitating a converged service model across all partitions of the network. Because of the importance of this technology, decisions of purchase, structure, and operation of networks, management has a critical need for understanding the technology of networks and communications.

The novelty of this conference manifests both in its context as well as content. In terms of the content, this conference certainly merits a leading position as most up-to-date research results using cutting-edge technologies were presented.

I would like to take this opportunity to thank the authors for the care with which they prepared their papers. Finally we would like to thank all our speakers, partner universities, review committee members, organising committee members and especially all the conference participants for making this conference a success. We hope you enjoy reading the proceedings of NTC 2010.

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