Multi-Purpose Permission-Based Bluetooth Advertising System Based on SDP, RFCOMM, and OBEX

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Abstract—**Mobile advertising is being addressed more and more in regards to the recent rapid advancement in mobile devices and smart phones and ubiquitous use of these gadgets. In this article we introduce the concept of a permission-based mobile advertising system which uses Bluetooth technology and SMS text messaging. These kinds of advertising may have different names according to the applied technologies; hence, in this article we call it permission-based Bluetooth advertising system. This advertising system is not a new concept; however, the main purpose of this article is introducing a different approach, using common methods, like pushing Bluetooth advertising messages, which are not widely used; however, they can facilitate the process of advertising on mobile devices and provide the advertisers with valuable data which can be applied to their advertising plans.**

Index Terms—**Bluetooth, mobile advertising, software architecture and design.**

I. INTRODUCTION

Mobile advertising could be designed and implemented using variety of mobile technologies such as wireless, Bluetooth, and many others according to the deciding factors by which advertisers' requirements are met. In this paper we focus on the kind of mobile advertising in which the advertisements are sent to mobile devices which support Bluetooth technology, e.g. smartphones, and tablets. According to the nature of Bluetooth technology this kind of advertising is permission-based.

In this paper we introduce a mobile advertising system based on Bluetooth technology and SMS text messaging. This system benefits from a different method rather than the same purpose Bluetooth advertising systems with which advertisers are able to access to the phone number of customers with their permission, deliver advertisements through a Bluetooth connection, and many other benefits that are quiet dependent on their business models and some of them will be elucidated. In this paper we only focus on technical issues and avoid addressing and evaluating business models. Only a simple scenario would be discussed as an example to delineate the purpose and application of this system. According to the key role of Bluetooth technology in this system, it would be called permission-based Bluetooth advertising system (P.B.A.S) from now on.

The organization of this paper is as follows: In Section II we briefly address the architecture of Bluetooth technology and its important protocols which play a vital role in this system. In the next part of this paper, Section III, the architecture of this system is introduced and all of the procedures are described respectively. The Section IV is allocated to existing challenges and ways to overcome them. In Section V we try to present the advantages of this Bluetooth advertising system. In the next Section VI an advertising scenario is discussed. Finally Section VII is allocated to conclusion and future works.

II. BLUETOOTH TECHNOLOGY

In this section we are going to have a brief introduction to Bluetooth technology and its applicable profiles which are so vital in the system we are discussing about.

A. What Is Bluetooth?

Bluetooth is a standard base on which variety of devices are able to communicate to each other over a wireless radio connection. In fact, various devices can benefit from this cost effective technology as a replacement for serial data cables in that it minimizes the complexities of establishing a connection between them.
Here is a list of key features of Bluetooth which justify using this technology in a mobile advertising system:
- "Ad hoc
- Small Size
- Low Cost
- Low Power
- Short Range
- Secure
- Interoperable
- Global Standard
- Ease-of-use
- Does not require line of sight
- Does not suffer from interference from obstacles like walls
- Can co-exist with other wireless technologies
- Big set of profiles already available to address real world scenarios." [1]

B. Bluetooth Protocols and Architecture Overview

"Bluetooth has a layered architecture" [1]. We are not going to describe the Bluetooth architecture in depth because it is beyond the purpose of this paper. Hence, we try to mention a general overview of its architecture and most important protocols.

The Bluetooth architecture consists of different protocols. As other networking aspects, this set of protocols related to Bluetooth technology is also called protocol stack. Fig. 1 depicts the Bluetooth protocol stack. These protocols are lodged in different groups according to their functions. Here

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is the classification of aforementioned protocols:

- *"Bluetooth Core Protocols:* the Baseband, LMP, L2CAP, and SDP
- *Telephony Control Protocols:* TCS Binary and AT-Commands
- *Cable Replacement Protocol:* RFCOMM
- *Adopted Protocols:* PPP, UDP/TCP/IP, WAP, OBEX, IrMC" [2]

Here is a brief definition of the Bluetooth protocols; protocols which are widely used in this system:

- *Service Discovery Protocol (SDP):* This protocol provides the Bluetooth device playing client role with information about the services which the other device, playing server role, presents. It also makes the client device able to detect when the server device stops presenting a specific service.
- *RFCOMM:* This protocol enables the device to transfer data via Bluetooth. Actually, it emulates a RS-232 serial port in order to bring this capability
- *OBEX:* This protocol has a client-server architecture and originates from the IrOBEX protocol. Another important point about this protocol is that it is totally independent of transport mechanism and API.
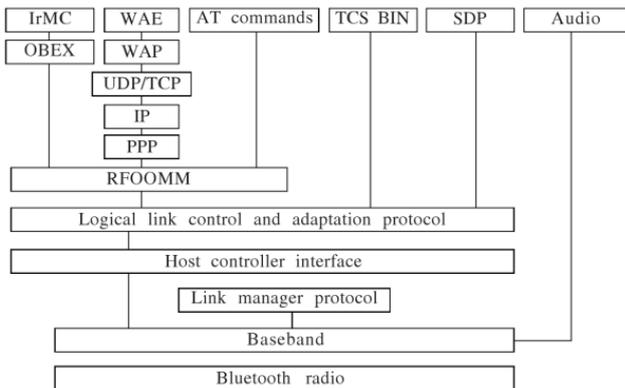

Fig. 1. Bluetooth protocol stack [2].

C. Bluetooth Profiles

"Bluetooth profiles define standardized approach in using specific subsets of protocols and their features to implement different applications" [2].

Here is the definition of the most important Bluetooth profiles which play an indispensable role in P.B.A.S:

- *Service Discovery Application Profile (SDAP):* This profile is based on service discovery protocol (SDP) and its functionality pursues the purpose of this protocol. "SDAP defines procedure for investigation of services available in a Bluetooth unit" [2]
- *Serial Port Profile (SPP):* This protocol is based on RFCOMM protocol and defines the rules of establishing a virtual serial port between two Bluetooth devices and the way of connecting them to each other.
- *Object Push Profile (OPP):* Generic Object Exchange Profile (GOEP) is dependent on serial port profile. GOEP has some procedures to handle (establish/close) OBEX connections and for this purpose it has some usage models one of which is object push. The main purpose of object push profile (OPP) is defining some requirements to bring the object push usage model to the applications willing to use it.

III. DESCRIPTION OF P.B.A.S

This system consists of four main modules:

- Discovering the nearby Bluetooth-enabled devices and their unique Bluetooth addresses.
- Saving the discovered Bluetooth addresses to the database.
- Sending kinds of advertisement over Bluetooth using object push profile (OPP).
- Interacting with customers to check if they want to register their phone number in the system for further contacts.

All of the mentioned modules, their components and procedures are explained in this section respectively.

Before discussing the rest of this part, there is an important concept in the system, namely address pool, which should be articulated.

Address pool is a set of Bluetooth addresses loaded from the database when the system starts to work. The process of loading Bluetooth addresses is totally independent of other modules of the system. It is clear that the address pool is empty when the system starts working for the first time. This mechanism is considered in order to facilitate and precipitate the access of Bluetooth addresses in that connecting to the database in order to access Bluetooth addresses, whenever needed, is a time-consuming task. Note that if P.B.A.S is applied to a centralized system like what we will discuss in section 7, the address pool should be synched with central database periodically; otherwise new Bluetooth addresses are stored in the local database by the independent module which is considered for this purpose.

A. Discovery

This module is responsible to discover the nearby Bluetooth enabled devices and find their unique Bluetooth addresses (BD_ADDR). As you can see in Fig. 2 and Fig. 3, Bluetooth sensor(s) discover(s) nearby devices which are discoverable, find(s) their Bluetooth addresses, and add(s) them to the address pool.
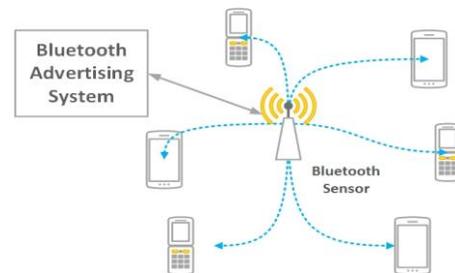

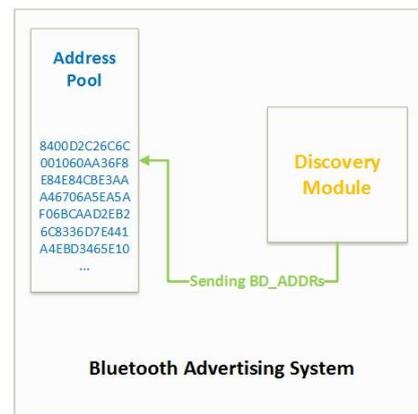Fig. 2. The Bluetooth sensor is discovering nearby devices.

Fig. 3. Discovery module is adding Bluetooth addresses to the address pool.

B. Bluetooth Advertisements

As it was mentioned in Section II, OBEX protocol is used in profiles involving data exchange. Object Push Profile (OPP) is one of the profiles based on OBEX protocol from which we benefit in this part of the system. This module of P.B.A.S is responsible to push advertisements (picture, text, video, pdf) to mobile devices. This means that all of the devices in vicinity of Bluetooth sensor can receive the advertisements if the customer accepts this connection. Following procedure illuminates the details of this module:

1) When Bluetooth sensor discovers a mobile device which is discoverable and its Bluetooth address exists in the address pool and the database, Ad Server checks if there is any new advertisement for the target device which can be sent. [3]
2) System searches the target device whether it supports the object push profile (OPP) or not.
3) Related advertisement is pushed to the target device.
4) If the customer accepts the received message, target device will start receiving the advertisement.

C. Interacting with Customers

This module gives the advertiser the ability to interact with customers: the advertiser can ask the customer to register their phone numbers on the system. This opens another way of advertising using text messaging (SMS). Before addressing the operation sequence of this module, we try to have a brief definition of AT Commands which are used in this module to deliver SMS from the target device to the Ad server.

"AT Commands are simple orders, used to control the computer modem. From example, the ATH command means that the computer sends to the modem (or more specifically, to the COM port) and ATH string. The modem then interprets the ATH string as a command" [4]. In this system, the target mobile device plays the modem role and AT Commands are sent to it in order to send a SMS containing the BD_ADDR from the target device to the Ad Server.

This module benefits from Bluetooth serial port profile (SPP) to send AT Commands to the target device. According to the previous definition in Section II, SPP is based on RFCOMM protocol and simulates COM port through which the system is able to send AT Commands to the target device.

Hence we can fetch the sender's phone number from the received message.

Here is the detailed procedure of this module:

1) System searches the target device whether it supports serial port profile (SPP) or not.
2) System tries to access the target device. The device alarms the user and if they accept the connection, the system can connect to the target device over the RFCOMM.
3) Related AT Commands are sent to the target device by which it is able to send SMS. Through this process the device sends its Bluetooth address to the Ad Server using a text message.
4) The Ad Server receives the message and fetches the phone number and Bluetooth address.
5) The System searches the database for the received Bluetooth address then maps the phone number to the existed Bluetooth address.

In this way we will have pairs of phone numbers and Bluetooth addresses which can be useful for advertisers for further contacts with customers. Fig. 4 and Fig. 5 show the outline and flow chart of this process respectively.
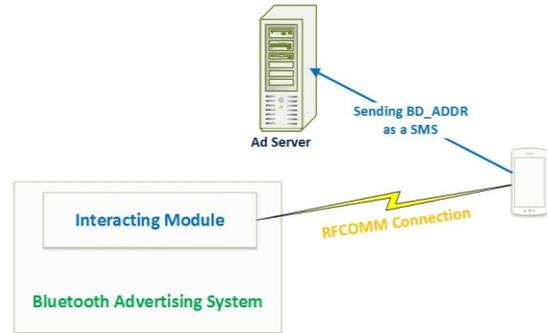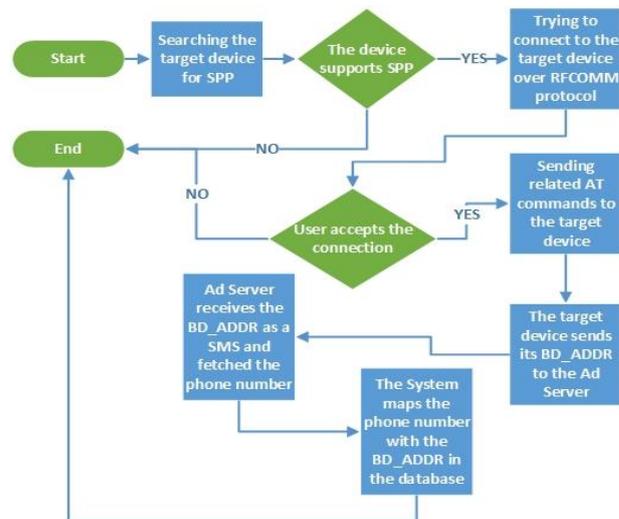

Fig. 4. The outline of interacting module.

Fig. 5. The flow chart of interaction module.

IV. CHALLENGES

This system may encounter some challenges affecting on number of recipients which this system can target and time of delivering advertisements. In what follows, the two most important ones among these challenges would be discussed.

A. Bluetooth Profiles Supported by Mobile Operating System

The first challenge in this system is a variety of smart phones and their operating systems each of which only supports different Bluetooth profiles that may differ from those the other one supports [5]-[7]. They also differ in the policy by which they handle Bluetooth connections. For instance iOS devices such as iPhone, iPad, and iPod, are not discoverable by other devices; they also do not support some functional Bluetooth profiles such as OPP (OBEX Object Push) and SPP (Serial Port Profile). This can become a bottleneck in the system we are discussing.

Reference [5] shows that iOS devices support a limited group of Bluetooth profiles. As it was mentioned formerly, if they use the standard version of iOS, they are not even discoverable for other devices. Hence, the only solution for these kinds of devices which can be involved in our advertising system is registering their numbers manually in

system to deliver text messages to them.

B. Multiple Bluetooth Devices

Unlike the previous challenge affecting the number of devices, this one affects the time of delivering advertisements. Suppose that there is a large number of devices in the proximity and their Bluetooth status is discoverable. In such a situation, if the number of devices exceeds the maximum multiple devices which the Bluetooth sensor can handle, some devices should wait in the queue to receive the advertisements and this protracts the process of advertising. In the meantime, the customer may exit the proximity and the process fails.

Overcoming this challenge depends on implementing the system and using the proper Bluetooth marketing devices for this purpose. It is clear that it should be chosen according to the advertising area and estimate of maximum people visiting the area.

V. Advantages

In this section we address some advantages of the system which discriminate it with existing identical mobile advertising systems.

Functionalities of the system were previously discussed in section three. Each part of the system which has a specific responsibility, has been considered as an independent module. This makes this system so flexible in a way that, each of the parts mentioned in section three can be changed or even eliminated without affecting other modules; according to this point the system is loose coupling. Each module is responsible for a simple task. For instance, Discovery module does not have to store the Bluetooth addresses in the database. This makes the system highly cohesive. Hence, the system has flexibility while advertisers decide to change their advertising plan and use only one of the aforementioned modules.

Unlike the advantage previously discussed, this one is not related to design of the system; it concerns the extra features rather than identical advertising systems. This system gives the ability of interacting with customers and collecting their phone numbers through a legal and permission based process. With this capability, advertisers are able to deliver the advertisements using the text messages to the customers whose Bluetooth addresses has not been detected in the advertising area, such as airport, supermarket, gas station, and pharmacy, for a period of time.

VI. A Scenario to Depict the Application of P.B.A.S

In this section we are going to review the outline of a practical scenario, to which our Bluetooth advertising system can be applied, in order to depict how this system helps the advertisers and business owners to achieve their marketing and business purposes.

Suppose that a department store, which has three branches, decides to have a mobile advertising system being applicable in all of the branches. Owners of the department store intend to have a close contact with their customers; they want to apprise them of the information such as the newest products,

special offers, and opening of new branches. They also need to have the contacts of the customers willing to be aware of the aforementioned information. They only want to concentrate on those kinds of customers who come to the stores to purchase their requirements, not those doing online shopping. Fig. 6 depicts the outline of the suggested architecture of the aforementioned system.

As it is clear in the Fig. 6 all of the branches, according to their area and estimates of customers, should be equipped with one or more Bluetooth marketing devices. There is a further subtle point in this architecture which should be considered. As Fig. 6 shows, this is a centralized system. This feature can be useful in that the list of the delivered advertisements to each customer exists in the database. Hence if the customer refers to the other two stores in a day, they will not receive an advertisement twice or more. As it is mentioned in Fig. 6, the main automation software, which the stores already use, can access to the database of P.B.A.S using the web service. The web service is an optional part of P.B.A.S whose methods and functionalities are dependent on requirements and data which automation system needs to retrieve from P.B.A.S.

Suppose that P.B.A.S has been deployed in these stores. Not only are owners of the department stores able to use the basic functionalities of the Bluetooth advertising system, but also they can add some other functions by their automation software. For Instance, they can deliver a text message (SMS) to the old customers entering the store using the facilities the Bluetooth advertising system provides. They can also gather a bunch of valuable data such as date and time in which a registered customer has referred to a store, the extent of traffic each store has, and many other reports which can be extracted according to their business and advertising plans.
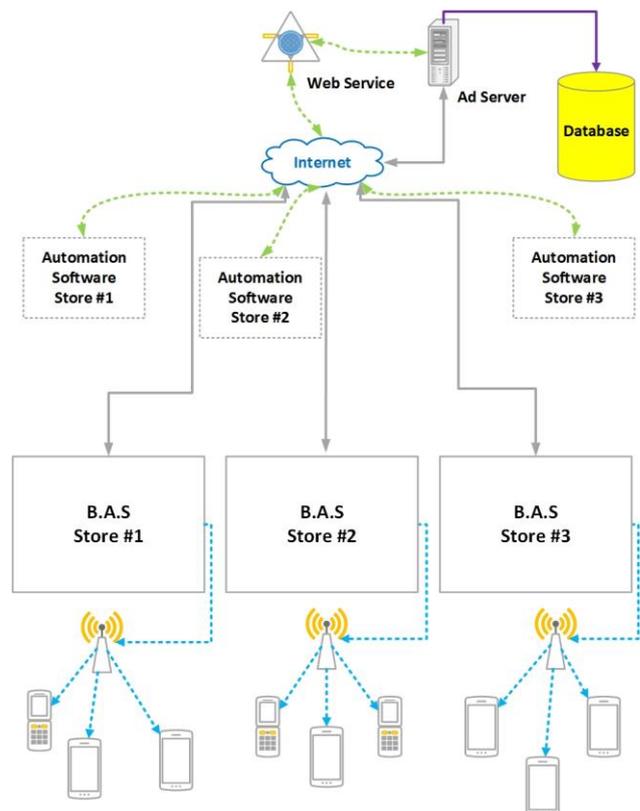

Fig. 6. The outline of the suggested architecture of the system which the owners have offered.

VII. CONCLUSION

As it was mentioned formerly, the purpose of this paper is introducing the concept of a mobile advertising system, using the Bluetooth technology and its applicable profiles, with a new practical approach focusing on improvement of functionalities which old identical systems had and adding new features to them. However the most important aspect in this point, which should be done in the future, is implementing such a system. According to the variety of technologies of software development and programming languages, implementation of this system becomes more important in that choosing an appropriate solution among them is the matter of research and spending time and can considerably affect the performance of the system and choosing wrong technologies and development tools may lead to low performance or even having counterproductive effects on customers.

Another aspect which can be considered in future, is designing mobile applications by which geographical information of customers, their fields of interest, and many other factors which are essential in advertising can be accessed. Moreover, it can facilitate the procedures of advertising, solve important challenges mentioned before, and add many other functionalities. Actually this broadens the scope of this advertising system and needs more researches in related fields.

ACKNOWLEDGMENT

REFERENCES

[1] N. Gupta, *Inside Bluetooth low energy*, 1st ed., London, U.K.: Artech House, 2013, ch. 2.

[2] C. S. R. Prabhu and A. Prathap Reddi, *Bluetooth Technology and Its Applications with Java and J2ME*, 1st ed., New Delhi, India: Prentice-Hall of India, 2004, pp. 20-92.

[3] L. Aalto, N. Göthlin, J. Korhonen, and T. Ojala, "Bluetooth and WAP push based location-aware mobile advertising system," *MobiSys '04 Proceedings of the 2nd international conference on Mobile systems, applications, and services*, pp. 49-58, New York, NY, USA: ACM, July 06, 2004.

[4] L. Dostálek and A. Kabelová, *Understanding TCP/IP: A Clear and Comprehensive Guide to TCP/IP Protocols, Birmingham*, U.K.: Packt Publishing, 2006, ch. 3.

[5] iOS: Supported Bluetooth profiles. (October 2014). [Online]. Available: http://support.apple.com/kb/ht3647.

[6] Bluetooth for Windows Phone 8. (March 2014). [Online]. Available: http://msdn.microsoft.com/en-us/library/windowsphone/develop/jj207007(v=vs.105).aspx.

[7] Android Developers. (March 2014). [Online]. Available: https://developer.android.com/reference/android/bluetooth/package-summary.html.

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