Users' Position Detection Based On Bluetooth Technology Supported Of M-Commerce Applications

John Garofalakis[1,2], Christos Mettouris[1,2], Vasilios Stefanis[1,2]

[1]Research Academic Computer Technology Institute
N. Kazantzaki str. 26504 Patras, Greece

[2]University of Patras
Computer Engineering & Informatics Dept
26500 Patras, Greece

E-mail: garofala@cti.gr, mettour@ceid.upatras.gr, stefanis@ceid.upatras.gr

Abstract

While wireless technologies continue to evolve, they are met in many different applications. Among other, Bluetooth is used today for user positioning as well. However, user positioning applications are focused mainly on providing users with exact location information, making them computational heavier and often demanding specialized software and hardware from mobile devices. In this paper we present a user positioning application intended for use with m-commerce. The application is based exclusively on Bluetooth. It uses a simple and efficient positioning method for locating users and sending them m-commerce based messages, which can be received without additional software or hardware installed. We focus on implementation issues and evaluate our application after testing it. Finally, conclusions are extracted and future work is proposed.

Keywords: Bluetooth, user positioning, triangulation method, m-commerce

1. Introduction

Wireless technologies have become a very important part of today's life. Bluetooth, WiFi and Infrared are three examples of such technologies with a variety of usages each. Wireless technologies can be used to form wireless networks among computers themselves and among computers and mobile devices. These wireless networks can be used for many applications including exchanging data and accessing the internet from mobile devices. These potentials gave ground for m-commerce to grow to a very profitably field of the business world [Ding Xiaojun et. Al. (2004)].

During the past few years, the Bluetooth technology has really conquered the world of wireless technologies. It's low cost and low power consumption have made it ideal for use with small, low powered devices such as mobile phones and PDAs. Apart from forming wireless ad-hoc networks for sending and receiving data among

Bluetooth enabled devices, wireless voice transferring, wireless printing, object exchange (such as business carts and messages) and many more applications. Bluetooth technology is also ideal for user location detection applications, mainly for two reasons: The first is that the technology itself provides ways for a variety of positioning methods to be efficiently implemented, like the triangulation and RX (Received X) power level methods [Kotanen et. Al. (2003)]. Second, almost everyone possesses at least one Bluetooth device that can be used by a positioning application.

User positioning is the technology used to detect the location of a user. This detection can be done according to some stationary points, which are usually called base stations. The location of a user arises when his distance from every base station becomes known. Then, two techniques can be followed: the first uses a central stationary point (server) that analyzes the data (distances) that come up from the base stations, resulting the location of the user. The result is then sent to the user. The second technique on the contrary does not use any central stationary point. Instead, the data that come up from the base stations are sent directly to the user's device to be processed there. This means that the user's device must be equipped with the necessary software to process the data to find the users position, hence become software depended, something not desirable.

User positioning can be global or indoor. Global positioning is the technology used to detect the geographic location of a user. GPS is a very well known and efficient global positioning system that uses satellite links to detect the location of a GPS device worldwide. Indoor positioning is the technology used to locate a user inside a building. Global positioning cannot be used for indoor positioning because the latest needs more accuracy than the first can achieve and because the building walls block the satellite signal.

On the other hand, mobile commerce (m-commerce) is a rather new field in the business world. It depends on wireless networks for accessing the internet from mobile devices and for exchanging data between such devices. There are similarities between m-commerce and e-commerce, such as being able to purchase products and services from the internet, but m-commerce is not just another application of e-commerce: it combines the advantages of mobile communications with existing e-commerce services [Ding Xiaojun et. Al. (2004)].

In this paper we present a User Positioning Application based on Bluetooth technology for use in m-commerce. The application utilizes the solutions that wireless technologies and more specific Bluetooth offer, in such a way that they can be used in m-commerce. The application uses exclusively the Bluetooth technology to detect the position of all nearby users and send them advertising, informative and other kind of messages related to m-commerce. After comparing Bluetooth with other wireless technologies, we explain why we used Bluetooth. Next, we discuss briefly all available positioning methods that can be used with Bluetooth technology. A preview follows of the related work that has already been done regarding Bluetooth positioning and how our work differentiates from them. We show that Bluetooth technology is the best technology to be used for indoor positioning and that the triangulation method gives very good results for positioning applications that don't need very high accuracy. In chapter 5 we talk about our positioning method, which is derived from the triangulation method and the implementation issues regarding the application. A relatively low accuracy but reliable end efficient application such as the one we present in this paper can be used with very good results for the needs of m-commerce. This is indicated by our test that shows how the application functions and what its strong and weak points are. Finally we discuss our conclusions from our work and what future work can be done for further improvements.

2. The ideal Wireless technology for user positioning applications

In a comparison between 80211.b (Wi-fi) [David Coursey (2002)], IrDA (Infrared) [Marcus Nilsson et. Al. (2002)] and Bluetooth [The official Bluetooth Web site], we concluded that Bluetooth is the ideal technology to be used for indoor user positioning. 802.11b can be used as well for a user positioning application, but because of its need of high power, not all mobile devices will be able to be used by such an application. Moreover, a line of sight is not required (IrDA), making it possible for the user to be able to be detected and receive messages from our application just by possessing a Bluetooth enable device and having the Bluetooth turned on. Such a device may be any common Bluetooth enabled mobile phone. Bluetooth is so popular a technology that almost all mobile phone manufacturers include it in the basic features of their phones, making it easy and cheap for anyone to possess a Bluetooth mobile device. For more information on Bluetooth technology, the reader is referred to [Specification of the Bluetooth System (2003)] and [Qusay H. Mahmoud (2003)].

3. Positioning methods that can be used with Bluetooth technology

There are many positioning methods to be used with the Bluetooth technology [Kotanen et. Al. (2003)]. Angle of Arrival, Cell Identity, Time of Arrival, Time Difference of Arrival, the RX power level method and the Triangulation method are among the available options, all of which may be used in a positioning application. The choice of the appropriate method must be made according to the purpose of the application. Hence the RX power method is suitable for positioning applications needing high accuracy, since it uses measurements of the signal strength of the participant Bluetooth devices and conversion of these measurements to distances of the devises from stationary points. For our application purposes we chose the

Triangulation method [Hallberg et. Al. (2003)] not only because a high accuracy is not needed in our application, but also due to the methods simplicity.

4. Related Work

In the bibliography, there are many positioning systems based on the Bluetooth technology. The *Alipes* [Hallberg et.Al. (2003)], the *BLPA* (Bluetooth Local Positioning Application) [Kotanen et. Al. (2003)], the *B-MAD* (Bluetooth – Mobile Advertising) [Lauri Aalto et.Al. (2004)], the *Novel Location Sensing System* [Udana Bandara et. Al. (2004)] and the *BIPS* (Bluetooth Indoor Positioning Service) [Anastasi et. Al. (2003)] are some of the many positioning systems that effectively use the Bluetooth and other wireless technologies to detect the position of mobile devices. Despite the fact that most of the systems mentioned in the bibliography are positioning systems that inform the users of their location mainly by sending them location data, only one of them sends messages not related with the location itself. B-MAD sends advertising messages to the users, informing them not about their location, but about products and services. We differ from that system as well in the aspect of how the user receives the messages. We don't use technology not available to all users like GPRS and XHTML browsers on mobile devices. Instead, our approach supposes a system depending exclusively on the Bluetooth technology to detect the position of all nearby users and send them messages. Our purpose is to make it possible for any user entering our system's coverage area with a common mobile Bluetooth enabled device to be able to receive messages related to m-commerce, like ads, with the least possible effort on behalf of him. User's Bluetooth mobile device does not need any specific hardware or software installed to interact with the system. The only requirement is that the device implements the Obex Object Push Profile (OPP). Obex (Object Exchange Protocol) is a protocol for exchanging objects among Bluetooth enabled devices. These objects can be file, pictures, vCarts e.t.c. The Obex OPP is implemented mainly in all new mobile phones and PDAs.

5. A User Positioning Application based on Bluetooth technology for use in m-commerce

In this section we discuss the positioning method and implementation issues regarding our application. We also provide the architecture of the application schematically.

5.1 Our positioning method

Our positioning application is meant to be used by m-commerce. Such an application does not demand the exact location of the user. We can apply a method that provides the location of the user approximately, in respect to the stationary points.

Our approach suggests three base stations. These stations are stationary points that are placed in a way to form a triangle (white dots in Figure 1). The distances between the stations depend on the given location. Each station's coverage area should be in partial mutual coverage with the coverage area of the other two stations, so that our application comprises of more sub-areas (seven) than just three. The coverage area of the three base stations together is the coverage area of our positioning application. In Figure 1, the coverage area of the application is the entire square room, excluding the light grey area surrounding the three circles.

Our method is derived from the triangulation method and it depends on which of the three base stations will detect each mobile device. If all three stations detect a device, according to the triangulation method, the location of that device is the black centered area in Figure 1. If only two stations detect a device, then the device's location is somewhere in the area of intersection of the two circles corresponding to the two stations, excluding the area of intersection with the third station. Finally if only one station detects a device, the later is located to be somewhere in the area formed by the circle corresponding to the station, excluding the areas of intersection with the other two circles. Figure 1 shows these areas in different colors.

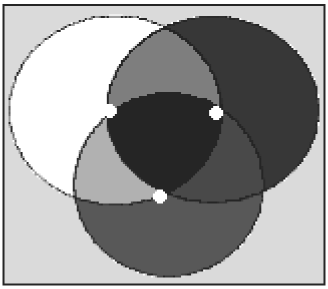

Figure 1. *The seven sub-areas of our application are shown in different colors*

5.2 Implementation Issues

Our application consists of four modules: 1. three base stations, 2. a central server, 3. a database and 4. an interface to administrate the database. The stations and the server are Java programs, the database is implemented using mySQL and the interface is written in php.

The java programs use the JSR 82 [JSR-82 Specification Version 1.0a (2002)], also known as JABWT (Java API for Bluetooth Wireless Technology). JSR 82 is a standard used for implementing Bluetooth applications in java. It contains a set of java APIs which we used for implementing our application. We used BlueCove's implementation of JSR82 [Blue Cove] and Avetana's implementation of Obex [avetanaOBEX-1.4]. These software packages work well with Win XP SP2 Bluetooth Protocol stack.

The application works in loops. In each loop, the stations detect mobile devices, send their addresses to the server and then the server sends the corresponding messages to the devices.

The three base stations are programmed to: a) Scan the area for mobile Bluetooth devices, and retrieve their Bluetooth addresses, b) Find the central server and provide it with the Bluetooth addresses of the detected mobile devices and c) give time to the server to process the data and send the messages. These three phases are executed identically by all stations at about the same time. The main idea is to scan only for mobile devices and to retrieve their Bluetooth addresses. A station after detecting a mobile device, it examines if the device implements the Obex Object Push Profile service. If it does, the station finds the channel that corresponds to that service, which must be given with the Bluetooth address to the server. These addresses with the given channel will be used afterwards by the server for sending the messages related to m-commerce to the corresponding mobile devices.

The central server, having a mobile's device Bluetooth address, is able to send a message to that device. As said, this is done by using the Bluetooth OBEX Object Push Profile. The main work of the server is to receive data from the base stations. When all three stations provide him with their data, the server runs an algorithm which distinguishes which mobile devices were discovered by each station, by any two of them and by all three of them. In this way, the server knows how many and which stations detected each mobile device, hence where in the area of coverage of the application (Figure 1) the mobile device is located. Next, the server sends to each mobile device a message corresponding to its location.

In addition to the above, the server interacts with the database as well. It registers in it the Bluetooth addresses of the users' mobile devices discovered by the application, how many times were they discovered and other useful data.

Along with the database, we implemented an interface for the administrator to be able to supervise the operation of the application and to be informed at the same time about the Bluetooth addresses of the users detected and other information concerning the application and the detected users.

Figure 2 shows the four modules of the application and how they interact.

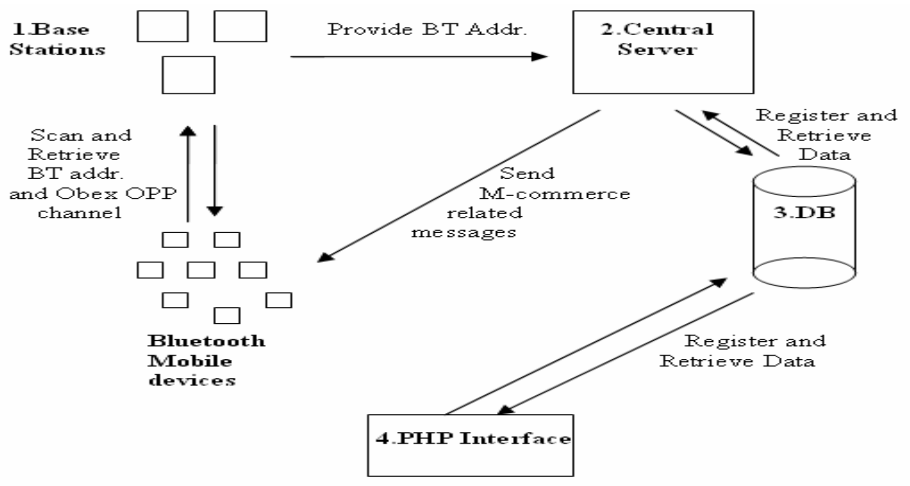

Figure 2. *Application's architecture: The four modules*

5.3 Application's topology

Topology is very important for the proper operation of our application. The central server must be situated in a spot so that it can communicate with all stations at any time. We positioned the server in the middle of the coverage area of the application. That position is shown in Figure 3 as the central dot. The other three dots forming a triangle designate the stations.

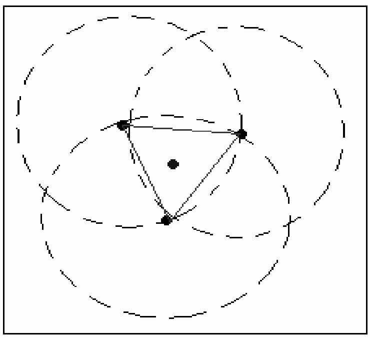

Figure 3. *The application 's topology*

The Bluetooth range of the most common Bluetooth enabled devices is 10m. This constrains the functionality of our application in a way that we are going to describe next. A Bluetooth device of range 100m is able to detect another mobile device within its coverage area, under the condition that the latter is able to detect the first one as well. If the second device has a Bluetooth radio of 10m range, then the two devices must be in 10m distance or less for each one to detect the other one. This forced us to use Bluetooth radios of 10m range (and not 100m) to implement our application (stations and server). This means that in Figure 1 the radiuses of the three circles are 10m. Since this positioning application is destinated to be used in real m-commerce scenarios, one may say that the sub-areas created by the application are small in comparison to the sections of a supermarket or a museum. This is just a minor drawback of our application.

6. Testing the application

We tested our positioning application in our offices building (Figure 4).

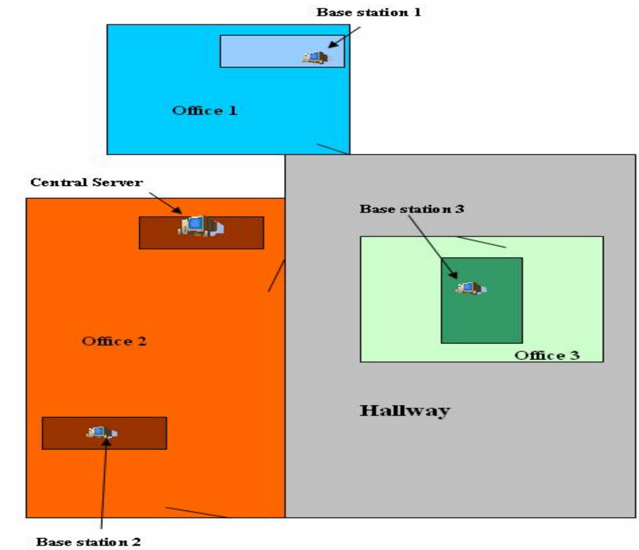

Figure 4. *The building used for testing the application*

For the purposes of this application test, we supposed that this area belonged to a supermarket. Figure 5 shows in different colors the seven different sub-areas in which our application was able to divide the whole coverage area. We let each sub-area of different color be a unique section of the supermarket.

Figures 6 and 7 show the interface of the application. By using this interface one is able to administrate the database in such a way to be suitable for use with the supermarket.

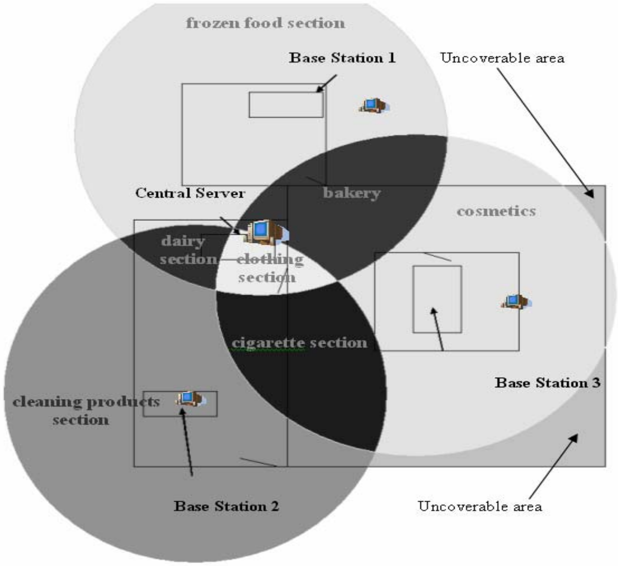

Figure 5. *In different colors are shown the seven different sub-areas in which the application was able to divide the whole coverage area*

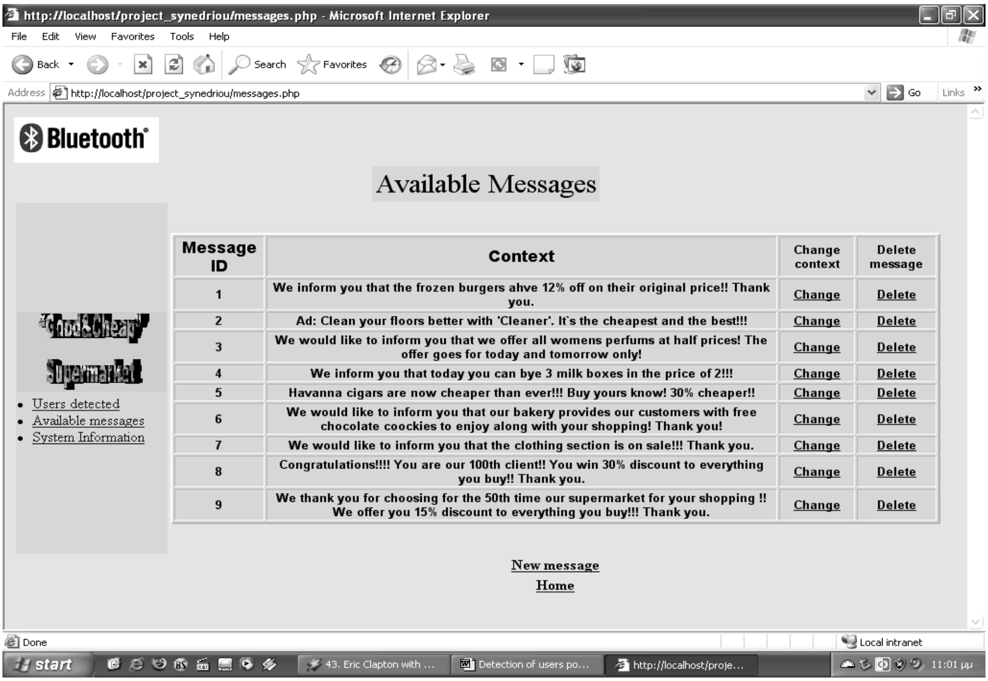

Figure 6. *The m-commerce related messages of the application*

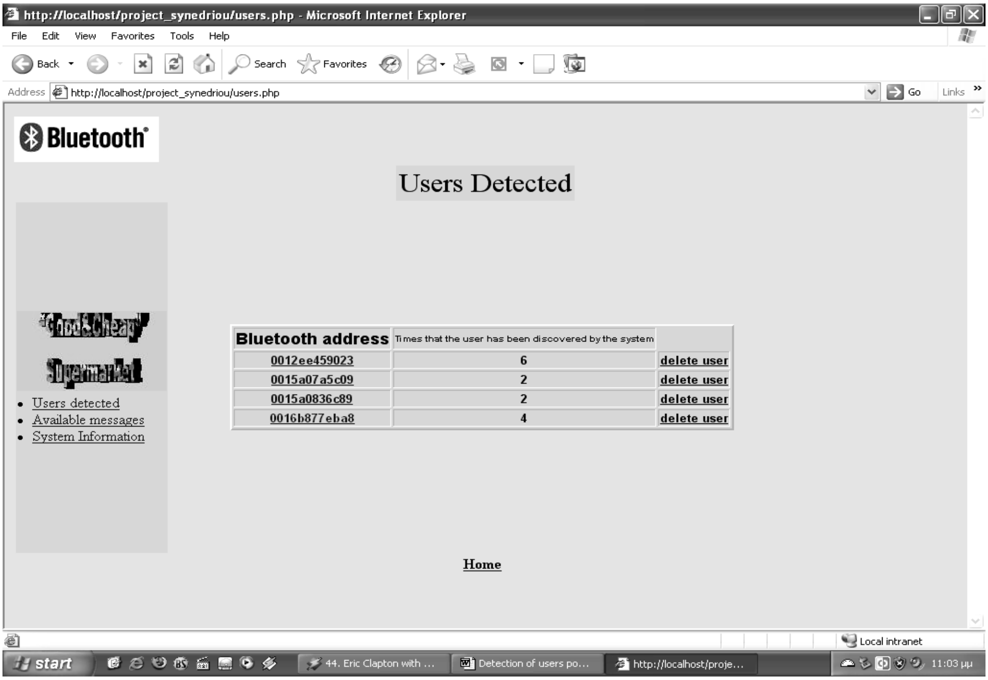

Figure 7. *Users detected by the application during the tests*

During the tests, the application could detect in which one of the sub-areas shown in Figure 5 each Bluetooth mobile device was located and send it the corresponding messages. These messages are related to m-commerce and are shown in Figure 6. Such messages inform the users about product discount offers in the area they are currently located and advise them about smart purchases. The application is also provided with special messages to send to clients in special occasions.

For the tests of the application we used relatively new Bluetooth enabled mobile phones such as Sony Ericsson V800. The application was running in a continual loop, detecting all devices and sending them messages. The messages were not sent to mobile devices not implementing the Obex OPP. Also, a mobile device could fail to receive the message, if its Bluetooth radio was busy by another connection at the same time.

Our application needs approximately 40-50 secs, according to the number of the mobile devices to be discovered, to detect these devices and send them messages, thus to finish a loop. Each base station needs 20 to 30 secs to detect all mobile devices within its coverage area, check each one for the Obex OPP service and then send their Bluetooth addresses to the server, after detecting it. If a station does not detect any devices, then it needs approximately 10 secs to scan and return ‘null’ to the server. The three stations function at the same time, thus in a period of 30-40 secs the server will possess their results. The central server needs very little time to send the messages to the detected devices, if the users accept them immediately. After sending a message, it waits for the user to accept it. When he does so, the server needs a second or two to send it, depending on the distance of the user. If the user does not accept the message, the server waits for approximately 8 secs and then times out and continues its work.

The above timings suppose that the stations start simultaneously. If they don't, the application takes longer to finish a loop. Let's assume that the stations start with 20 secs of time difference from one another. The stations will have transmitted the data to the server in 20+20+40=80 secs instead of 40. As we notice, the duration of a loop has doubled.

Discussing the timing of the application, we mention that a period of 50 secs is satisfactory. Users in supermarket take quite some time for their shopping, spending several minutes in their favorite sections of the store, giving our application the time to locate them. But even if a user spends less time in a section, the application, needing only 10 secs to detect him, will locate and send him the informative message, even if he goes to a different location at that time.

A user will miss a message if he passes through a section during the period of time starting when the stations finish the scanning and finishing just before the stations start scanning again. This period takes about 30-40 secs.

7. Conclusions and future work

In this paper we presented a User Positioning Application based on Bluetooth technology for use in m-commerce. The application uses a positioning method that is based on the triangulation method. The method's simplicity does not affect its efficiency, meaning that we don't use complex high precision positioning methods like measuring the signal strength of the Bluetooth connections but a simpler method giving the amount of precision needed for m-commerce applications.

The positioning method provides the application with information about users' location, making it possible for the latter to send the appropriate messages to them. The application needs the tolerable time of 40 to 50 secs to send the messages, meaning that almost every user will receive the messages on time. The application expects no additional software or hardware from the users' devices.

Such an application could be upgraded in the future using cabled LAN like Ethernet. The Ethernet can make the stations-server connections quicker as it is faster than Bluetooth. The drawback of Ethernet is the cables, making the application less flexible for use outdoors. This is why we used Bluetooth for all our connections. Also, other wireless LAN technologies can be used for the connections we mentioned, like 802.11b.

By having the server send the messages, a device being in the edge of the coverage area of the application might not receive the messages. This happens because the server has range only 10m (in fact he can send messages to devices at distances 12-13m. Figure 8). Increasing the range of the server will not solve the problem, since the users' devices will still be of 10m range. An upgrade is to let the stations send the messages to the users and not the server. This will increase the number of messages in the application, but the mobile devices will be able to receive the messages anywhere in the coverage area of the application. In addition to this, the problem would also be solved if Bluetooth mobile devices were of 100m range instead of 10m. In this case, the server would also have to be of 100m range, but the stations would have to remain at 10m of range.

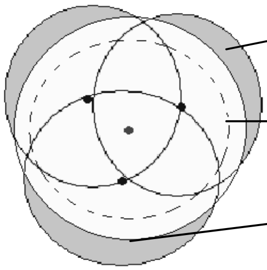

Figure 8. *The server with range 10m can send messages to devices at distances 12-13m*

References

Anastasi, G., Bandelloni, R., Conti, M., Delmastro, F., Gregori, E. & Mainetto, G. (2003), *Experimenting an Indoor Bluetooth-Based Positioning Service*, Distributed Computing Systems Workshops, 2003. Proceedings. 23rd International Conference

AvetanaOBEX-1.4, *http://sourceforge.net/projects/avetanaobex/*

Blue Cove, *http://sourceforge.net/projects/bluecove/*, *http://bluecove.sourceforge.net/*

Ding Xiaojun, Iijima Junichi, Ho Sho (2004), *Unique Features of Mobile Commerce*, Journal of Business Research, Elsevier Inc, 2004 Dempsey

David Coursey, Bluetooth vs. WiFi: Why it's NOT a death match (2002), *http://reviews- zdnet.com.com/4520-6033_16-4207317.html*

Hallberg, J., Nilsson, M. & Synnes, K. (2003), *Positioning with Bluetooth*, Telecommunications, 2003. ICT 2003. 10th International Conference.

JavaTM APIs for BluetoothTM Wireless Technology (JSR-82), Specification Version 1.0a ,JavaTM 2 Platform, Micro Edition (2002)

Kotanen, A., Hännikäinen, M., Leppäkoski, H. & Hämäläinen T. (2003) *Experiments on Local Positioning with Bluetooth*, Information Technology: Coding and Computing [Computers and Communications], 2003. Proceedings. ITCC 2003. International Conference.

Lauri Aalto, Nicklas Göthlin, Jani Korhonen, Timo Ojala (2004), *Bluetooth and WAP Push Based Location-Aware Mobile Advertising System*, International Conference On Mobile Systems, Applications And Services, Proceedings of the 2nd international conference on Mobile systems, applications, and services, Boston, MA, USA

Marcus Nilsson, Josef Hallberg (2002), *Positioning with Bluetooth, IrDA and RFID*, master thesis Lulea University of Technology, Department of Computer Science and Electrical Engineering.

Qusay H. Mahmoud (2003), *Wireless Application Programming with J2ME and Bluetooth*, http://developers.sun.com/techtopics/mobility/midp/articles/bluetooth1/

Specification of the Bluetooth System (2003), *Wireless connections made easy*, specification Volume 0, Covered Core Package version: 1.2

The official Bluetooth Web site, *http://www.bluetooth.com/bluetooth/*

Udana Bandara, Mikio Hasegawa, Masugi Inoue, Hiroyuki Morikawa, Tomonori Aoyama (2004), *Design and Implementation of a Bluetooth Signal Strength Based Location Sensing System*, Radio and Wireless Conference, 2004 IEEE