Indoor Positioning System using Bluetooth

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Abstract:This Paper on Bluetooth Indoor Positioning System is the intersection of Bluetooth Technology and Indoor Positioning Systems. Almost every smartphone today is Bluetooth enabled, making the use of the technology more flexible. We aim at using the RSSI value of Bluetooth signals to track the location of a device.

Keywords— Bluetooth-Android-Indoor Positioning

I. INTRODUCTION

An indoor positioning system (IPS) is a network of devices used to wirelessly locate objects or people inside a building. Instead of using satellites, an IPS relies on nearby anchors (nodes with a known position), which either actively locate tags or provide environmental context for devices to sense. The localized nature of an IPS has resulted in design fragmentation, with systems making use of various optical, radio, or even acoustic technologies[1]. IPS using Bluetooth technology is a relatively new field and has not been worked upon seriously. Though Google has tried to improve its IPS for android smartphones, accurate positioning still remains an open field for programmers to explore.

The paper aims at providing correct and precise information regarding the location of a Device using BTM 222 Bluetooth Modules and Android Smartphones. We aim at using Strong Bluetooth Signals from the BTM 222 module and using its RSSI (Received Signal Strength Indicator) to track a particular Device.

II. ANDROID AND BLUETOOTH

A. Android

Android is a Linux-based operating system designed primarily for touchscreen mobile devices such as smartphones and tablet computers. Initially developed by Android, Inc., which Google backed financially and later bought in 2005.
We work on our research using various packages and methods provided in the Bluetooth API which are stated below (All of the Bluetooth APIs are available in the android.bluetooth package.)

B. Bluetooth and BTM222

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security. The DW- BTM-222 is a small form factor, low power, simple to integrate Bluetooth radio for OEMs adding wireless capability to their products[2]. In the USB mode, the DW-BTM-222 is interfaced to the external processor using a USB interface. The DW-BTM-222 acts as a USB slave (not a USB host). The key advantage of HCI mode is that it allows customers to run custom profiles on their processor. It also provides fast data rates (up to 3 Mbps).
In our research we embed the BTM-222 Module using the UART and use it by connecting to a DC Power Supply 40V-1A [3].
To use the BTM222 you need to hook up 11 pins. 6 of them should have the GND signal. It is very important to tie every single one of the GND pads to the GND-signal because in the mysterious world of high frequency applications devices don't work when they are not properly grounded. Also remember that the BTM222 needs a supply voltage of 3.3 V when hooking up the module. Of the three remaining pads of the module there are two used for UART communication and one for the antenna.

Fig. 1 BTM 222   Fig. 2 Power Supply

C. API connecting Bluetooth and Android

Though JSR 82 implementations for Java 2 Platform Standard Edition (J2SE) are available, We use the Bluetooth API provided by Google Android because of its ease of use, large library and methods, Plugin capabilities and integration with Eclipse IDE.

At first we paired the mobile phone with the BTM222.

Activated our Bluetooth and searched for devices. The default name of the module is "Serial Adapter". We use the default pin "1234″ for pairing.
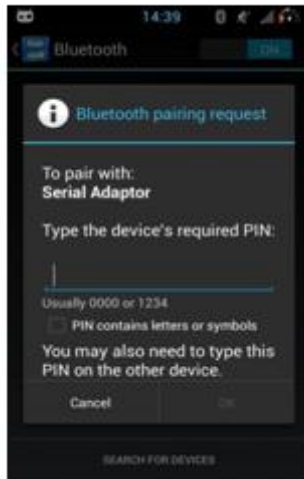

Fig3. Connection to Serial Adapter BTM 222

III. PHYSICAL IMPLEMENTATION

A. First Application

We wanted to test the accuracy and limitations of the Bluetooth Positioning System and hence proceeded with creating our first application to discover the Bluetooth devices around an Android Device, retrieve its name, address and RSSI value.
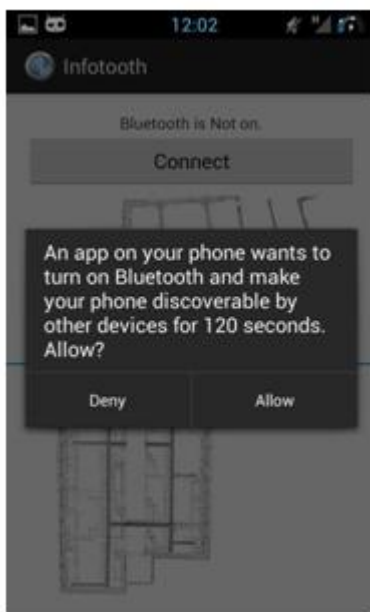

Fig 4.Application for Bluetooth Connection

We then refreshed our Device Application after 'n' seconds to check the least value of 'n' which would be suitable to detect all devices in the vicinity. We discovered that the value depends on

the range we are testing, hence if we fix a value for the range only then can we manage to get a suitable value of 'n'.

For an Indoor Positioning system, we decided to set the value of our range for testing purposes as 10 meters based on the Bluetooth specifications of range.

TABLE I

Test No.	No. of BT Devices	BT Devices Discovered	Time Set	RSSI
1	6	1	3	-34
2	6	3	4	-42/-49/-68
3	6	3	5	-36/-45/-62
4	6	4	6	-35/-45/-88/-72
5	6	4	7	-47/-56/-94/-89
6	6	5	8	-44/-52/-66/-69/-85
7	6	5	8	-37/-45/-64/-72/-95
8	6	6	9	-39/-45/-62/-67/-75/-81
9	6	6	9	-47/-55/-59/-82/-85/-91
10	6	6	10	-32/-47/-58/-71/-83/-87
11	6	6	10	-51/-55/-74/-82/-85/-74
12	6	6	11	-41/-48/-59/-72/-65/-71

SOFTWARE TEST RESULTS

With the help of the above mentioned results we estimated the correct refresh time for the Bluetooth in Android Devices to discover all devices in its vicinity of 10 meters to be 9 seconds which works perfectly fine with all android devices.

We faced the Problem of this huge time interval of 9 seconds and hence decided to restrict the Bluetooth devices that were to recognize by the Bluetooth smartphone to only the Bluetooth Modules that were to be used for Location Detection i.e. the Serial Adapters. This helped us reduce the refresh time to 7 seconds as only a maximum of 2 Bluetooth Adapters were to be placed in each room of the Communications department, which would lead to an estimated 6 BTM 222 modules including the surrounding 2 rooms in the vicinity of 10 meters.
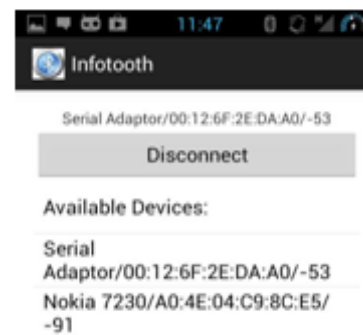
Fig. 5 List of BT Devices Captured

Final Application

After the creation of the Application where we had estimated the refresh time of the Bluetooth Device for discovery of the required Bluetooth modules in the vicinity our next task was to use these Bluetooth beacons to identify the location of the Android Smartphone.

The first requirement for this application is the Map on which the smartphone needs to be implemented. We managed to acquire a marked soft-copy of the Department of Communication, FernUniversitat in Hagen Map which we used to apply the fingerprinting technique on to get the location of the user.(The map was cleaned using Adobe Photoshop CS5.5).

B1. Location Fingerprinting

Radio/Location fingerprinting is a process that identifies a cellular phone or any other radio transmitter by the unique "fingerprint" that characterizes its signal transmission. An electronic fingerprint makes it possible to identify a wireless device by its unique radio transmission characteristics.
We have specified a location fingerprint for each room (or rather the a few test rooms).These location fingerprints are our BTM 222 modules which have a unique address and the beauty of the Bluetooth modules is that the nearer you are to the beacon the more powerful signal you'll receive through the transmitter.
Hence, we use this property of directly proportionality of Signal Strength with distance to determine which location fingerprint to activate and thus show the position of the device.
Now the question arises as to why not use triangulation method of distance measurement and use it to implement location based services?
The answer is simple:
• Location Fingerprinting is more accurate than triangulation implementation.

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Fig 6. Location Fingerprints

B2. Finding the Location:

Every room had been designated a Serial Adapter BTM 222 Module which sends out Bluetooth Signals. These Signals are caught by the Smartphone. As the smartphone has the capability to catch more than one signal, we arrange the signals received in decreasing order of their RSSI value i.e. the Signal strength value. According to the highest signal Strength received the position of the smartphone is shown on the map.

Every 7 seconds the application is refreshed and it searches for the Bluetooth module having the largest value of strength and display the position.

According to the tests carried out, if a refresh time of 9 seconds is provided a 90% accuracy rate is achieved which comes at the cost of delayed current position.
At 7 seconds refresh rate we achieve 80% accuracy, but current position gets updated earlier and much faster.

The following table explains the observations of Indoor positioning using Bluetooth when the Bluetooth modules are kept at relatively large distances from each other i.e. greater than 10 meters from each other.

TABLE II
ACCURACY AND OBSERVATIONS

Test No.	Actual Location	Location Detected	Refresh Time
1	Room 143	Room 143	7 sec.
2	Room 158	Room 158	7 sec.
3	Room 143	Room 143	6 sec.
4	Room 158	Room 153	6 sec.

C. Google Drive Plugin and Connectivity

We decided to track the Android user, its current and previous locations by automatically updating the Timestamp, Device name and Location to the Google Drive Spreadsheet using a simple google form creation which acts as the HTTPRequest platform Now, the question is why not put the data in a centralized database on a computer and why on the Drive?
A Smartphone can be connected to the internet but its distance from the central computer may not be in the range of the Bluetooth of the smartphone. To have a centralized database and UI on a computer the device always has to be within a short Bluetooth range of the computer so that all its locations can be stored, which is not possible due to the indoor space being greater than the Bluetooth range. Google provides us within the Google Drive API which helps us store the location of the device from anywhere in the surroundings regardless of the Bluetooth connection (Only requirement being an internet connection).

Fig 7. Google Drive Connectivity

IV. CONCLUSIONS

With the help of the faculty at the Communications department of the FernUniversitat in Hagen, it has been possible to create an Indoor Positioning system using Bluetooth using its features of Signal Strength.

We have been successfully able to test the System for the 1st floor of the Department and maintain a database of the activities carried on by the user and maintain a track of its movements on the floor.

We hope that our research and work can be put to use on a bigger platform at that it helps with the advancements in the field of indoor positioning.

The following may be implemented in the future using this research:
• Decrease in Refresh Time: The application needs a refresh time of 8-9 seconds for small distance evaluation of position, if stronger Bluetooth signals are produced it is possible to reduce this to 5 seconds, but that might be being too optimistic.

• Customized Maps for Users: In the future the application may be enhanced in a manner that users can upload their own maps, set up their own fingerprints and completely customize it according to their own surroundings and locality.

ACKNOWLEDGMENT

REFERENCES

i.   Wireless Indoor Positioning Techniques, R. Ballazhi, 2012
ii.   www.bluetooth.com
iii.   Rayson BTM 222 Datasheet