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GPS based Bluetooth Broadcasting – Long Range Solution

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Abstract: ***In this paper, GPS based Bluetooth broadcasting for long range is proposed. System model for Long range broadcasting of messages with multiple piconets and dynamically created threshold devices, based on GPS information is presented. Our simulation results have shown that, message can be received by those devices which are out of the initial Bluetooth range in reasonable time. Flooding of multiple messages could be avoided by applying hash function. With this solution, long range data and voice communication could be done with free of cost also can be used for commercial advertising purpose.***

Keywords: Broadcasting, TDD, Hash, Flooding

1. Introduction

Bluetooth technology (IEEE 802.15.1) was developed for wireless short range communication purpose and many marketing agencies are utilizing it to market the latest products and available offers to the nearby bluetooth mobile holders and customers moving around within the range. Transferring the short messages and images to different bluetooth enabled devises are most commonly used among the people, which is the basic application of Bluetooth technology. From the time bluetooth technology has been launched, not much research work has been done on bandwidth problem and range improvement problem. Some companies have developed certain products, which could be attached additionally and could be used to increase the bandwidth up to certain extent and solutions have not been provided to solve geographical range problem. There are two challenging issues in bluetooth technology need to be seriously addressed, one is Bandwidth problem, that's is increasing the nodes in bluetooth network range and another one is geographical range problem, which is related to broadcasting problem. Broadcasting problem is concerned issue focused and discussed in this paper. In [1] bluetooth technology overview is presented where author studied the possibility of bluetooth broadcasting and the available hardware and software products are discussed, which can be used to broadcast within bluetooth range also problems discussed in broadcasting to target audience. Possibility of more than seven connections for bluetooth network are proposed and ongoing research projects are briefly shown in [2]. Creating bluetooth network, its operation and managing the bluetooth devices is presented in [3], where authors proposed the simple algorithm in selecting the masters, slaves and bridges in bluetooth network. Real time video broadcast application is proposed in [4] where authors modified the receiver in their solution. Performance issues for Bluetooth for long and short range communications are addressed in [5], where authors suggested that over all performance of Bluetooth network could be upgraded with error correcting techniques. Proposed interference range model in [6] will allow the user to determine acceptable range of interference in environment. It is a simulation model, can be used for wireless and piconet in Bluetooth. Scatter net route structure defined in [8] will provide efficient channel utilization in piconet. Adhoc network formation is proposed in [9], where authors established and studied the performance of adhoc network. Attack detection system is proposed in [10] to make the scatter net more secure. MMTT tool [11] which is permission based advertising to mobile phones target huge number. Remote Bluetooth computers are controlled by attackers without any security software is proposed in [12], in which data could be easily transported out of Bluetooth network.

This paper is organized as follows. Section 2 will briefly discuss the Bluetooth technology and its limitations. Section 3 talks about usage of

GPS application in mobile nodes and to integrate with bluetooth technology. Proposed System Model is presented in section 4 followed with proposed algorithm in section 5. Section 6 presents the analytical evaluation and simulation results. Finally we have drawn our conclusions in section 7.

2. Bluetooth Technology & Limitations

Bluetooth technology is low power, short range, low cost technology which provides radio link for bluetooth enabled devices to communicate in wireless environment. Core Bluetooth architecture consists of RF transceiver, base band and a protocol stack. In Bluetooth technology, communication channel can support Asynchronous (data) and Synchronous (voice). It works on unlicenced 2.4GHZ Industrial, Scientific and Medical (ISM) band. This operating band is divided into 1MHZ spaced channels, signaling data rate (total bandwidth) up to 1Mb/s is achieved by using GFSK (Gaussian Frequency Shift Keying) modulation scheme. Frequency hopping technique is applied to reduce interference and fading. Every 625 μsec the channel will hop to another frequency within the 2402 to 2480 MHz range, 1600 hops every second. Time Division Duplex (TDD) is used for full duplex communication, even and odd time slots are allocated to communicating devices. One device transmits during even time slots and another one uses odd time slots for data transmission. Bluetooth devices are classified according to three power levels. Class – I device with power 100mw (20 dBm) can cover geographical area up to 100meters. Class – II device with power 2.5mw (4 dBm) can cover geographical area up to 10meters. Class – III device with power 1mw (0 dBm) can cover geographical area of 1meter. Bluetooth devices are organized as sets called piconets, in which one device acts as master and one or more than one devices act as slaves.

Channel is shared among all the devices. One device can be master for only one piconet and slave can be shared by more than one piconet and this shared device is called bridge. Total devices allowed are maximum 8 in a piconet including one master and 7 slaves. Each bluetooth device got assigned unique BD_Address from manufacturer. In piconet each slave is assigned 3 bit active member address ie. AM_Address. Other devices synchronized but not assigned AM_Addresses are called paked devices. These parked devices are assigned 8 bit parked member address PM_Address and maximum parked devices allowed are 256. Also there are few standby devices. In piconet, bandwidth is limited and geographical coverage is is also limited and restricted to maximum of 8 active devices.

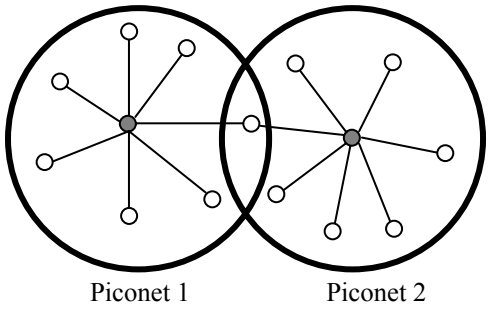

Figure1. Piconet

3. GPS Application

Global Positioning System (GPS) network provides information about position and time to receiving devices. There are 24 satellites actively involved in this network and continuously transmit position information through spread spectrum signal. In order to obtain the accurate location and time, there must be four satellites in receiver range. In this paper location information is considered to calculate the threshold distance, to extend the number of piconets and to broadcast the message. Reference point could be the position of master, approximate coverage area of master is known and these will help to evaluate the threshold distance.

4. Proposed System Model

In general, bridge devices are used to transmit messages from one piconet to another. In this solution, if bridge device got problem then message could not be transmitted further. In our proposed solution, there are more than one threshold device is dynamically created to broadcast message and explained as follows.

In our proposed scheme, bluetooth enable devices such as mobile nodes, laptops and PDAs are grouped together to form a piconet. We are assuming that all devices in piconet are GPS based. Each device knew its location and distance from it's master. Initially piconet is formed with one master and seven slaves.

Geographical coverage area of master is fixed and minimum distance that is threshold distance (radius) which is very near to boarder coverage area is maintained, which is less than geographical radius. We refer in this paper hereafter, D is geographical distance of master, d is the distance from slave to master and δ is threshold distance. Always $D > \delta$.

Another piconet with threshold device is created if condition $D - d \leq \delta$ meets. D is approximately 100meters.

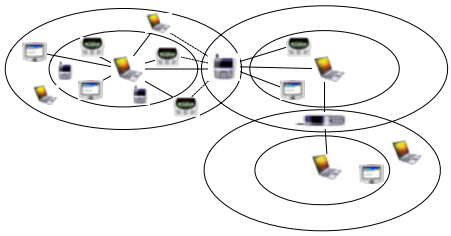

Figure2. Proposed System for Message broadcast

Short message is prepared and its hash value is calculated. Message is broadcasted to slaves in piconet along with its hash value, shown in figure3. Slaves receive this message and hash value and store in respective database. After receiving the message, device will calculate the threshold distance, reference point to its master. If any of the devices are within the threshold range, they will form new piconets, assigned themselves as a master and broadcast the same received message and hash value to respective slaves in their vicinity. If the device is not within the threshold range, it will only just receive the message and threshold value and store in its database.

There is possibility of devices connected to multiple piconets will receive the duplicate messages again and again. To solve this problem of flooding of duplicate messages and to avoid unnecessary memory occupation, hash function is used and it works as follows.

Whenever a device receives a message and hash value, initially device will accept the hash value and compare it with the stored one. If both values are same, then it will reject the message, otherwise it will accept. With this procedure flooding of messages could be avoided.

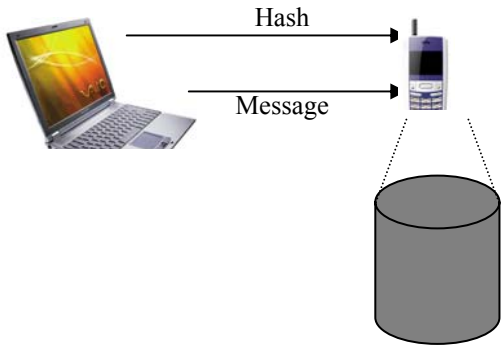

Figure3. Flooding avoidance

5. Algorithm

1. Begin
2. Create a piconet
3. Find the threshold device
4. Make the threshold device as master
5. Send message along with hash value
6. Compare hash value in the receiving devices
7. If hash value found Drop message
   Else
   Accept message
8. If threshold device not found go to step9
   Else
   Go to step2
9. Stop

6. Analytical Evaluation

Performance is evaluated for Bluetooth broadcasting through multiple piconets. Implementation has been done as follows.

B is set of Randomly generated Bluetooth devices

$B = \{b1, b2, b3, b4, \ldots\ldots\ldots\ldots, bn\}$ ----------(1)

$B = \{b \mid b \varepsilon B\}$

B_1 is 1^{st} set of maximum eight devices

B_n is n^{th} set of maximum eight devices

$B = \{B_1\} + \{B_2\} + \ldots, + \{B_n\}$ ----------(2)

$B_n = \{b \mid b \text{ is } 0 \leq n^{th} \text{ set device} \leq 8\}$ ----------(3)

t_d is set of randomly generated device discovery time

$t_d = \{t1, t2, t3, \ldots\ldots\ldots\ldots\}$ ---------- (4)

t_p is Piconet formation time and t_n is message received time by n slaves.

T_b is the total broadcast time

$T_b = \sum t_d + t_p + t_n$ ---------- (5)

6.1 Performance evaluation on device discovery for Single piconet

Performance has been evaluated on single piconet, where seven bluetooth devices are taken as slaves and their discovery time is generated randomly. Master device discovered the slave devices are shown in figure4. Simulation results have shown that the total time taken by Master device to discover seven slave devices is approximately 54 units of time. Average device discovery time calculated as 7.7 units.

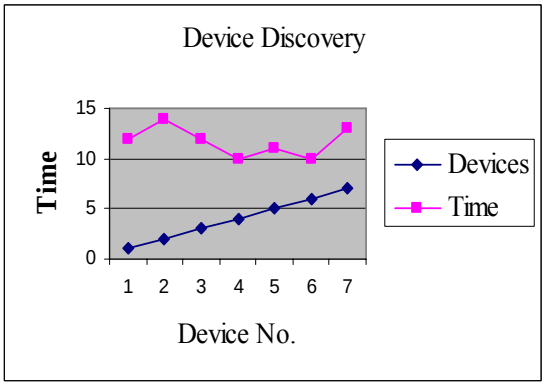

Figure4. Device Discovery

6.3 Performance evaluation for Message broadcast

Performance is evaluated for message broadcast up to 500 meters, using threshold devices in multiple piconets at different distances and shown in figure5. Total broadcast time is calculated for every 100 meter distance and increases with the distance. Total broadcast time increases with increase of number of devices and shown in figure 6. From simulation results, it is found that broadcast time for 500 meters is quite reasonable and acceptable.

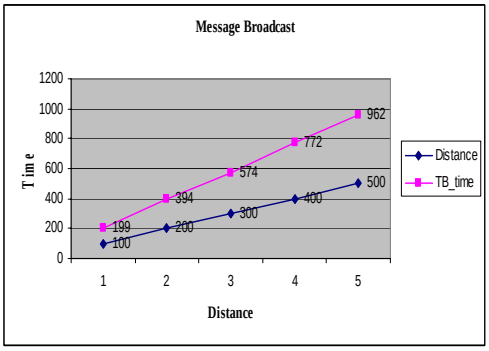

Figure5. Message Broadcast

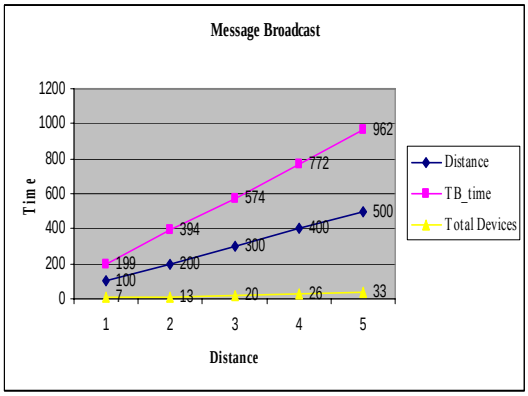

Figure6. Message Broadcast

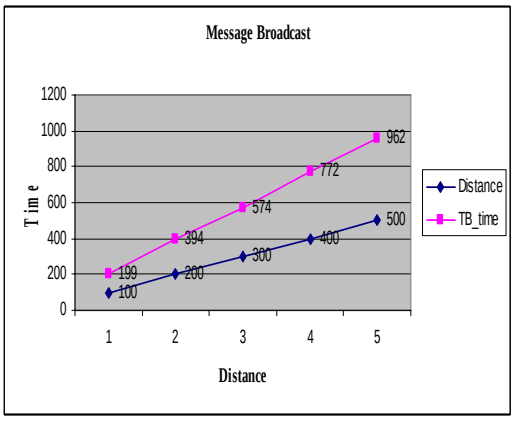

Figure7. Message Broadcast

7. Conclusions

In this paper we proposed the system model for long range bluetooth broadcasting based on information provided by GPS network. Maximum of 500 meters distance is used in simulation to broadcast the message. Our simulation results have shown that bluetooth technology could be used for long range broadcasting of messages within reasonable time. Hash function is used to avoid the flooding of multiple messages problem. This model could be used in educational institutions for announcement purpose and could also be used for commercial advertising propose with free of cost.

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