Bluetooth Enhancement using AODV

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Abstract: ***Bluetooth is extensively used technology in today's cell phone. It enables a device to communicate wirelessly without being in line of site of other device, but Bluetooth has its own shortcomings such as it is applicable between only two Bluetooth enabled mobile phones at a time and it is restricted by range. To prevail over these disadvantages we propose a new system BlueBooster system. This BlueBooster system will extend physical range of Bluetooth without using any external hardware. Also by using this BlueBooster system more than two devices can communicate with each other which form a network of devices. It is based on AODV (Ad-hoc on demand distance vector routing) algorithm used to create Ad-hoc networks, and providing some enhancements to it.***

Keywords: Blue Booster, Bluetooth range expander, Bluetooth Network Expansion, Bluetooth Optimizer, Bluetooth Community**.**

1. Introduction

Mobile devices have evolved immensely from their humble beginnings of being a gadget that provided only voice transmission to that which is capable of handling multiple technologies and even controlling other equipment around it. Some of the other technologies that today's mobile phone can handle are Infrared (IR), Bluetooth and Wireless Local Area Network (WLAN).

Bluetooth is an industrial specification for wireless personal area networks (PANs). It is available in a wider range of mobile phones than WLAN. Some of the main benefits it provides its users are, Enable users to create Ad-hoc networks. Enable users to interact within a peer to peer network configuration. Enable users to transfer files and data among each other.

Bluetooth has its own shortcoming such as

1. Physical range limitation of 10 m.
2. Applicable between only two Bluetooth enabled mobile phones at a time.

There are two existing systems to overcome these problems which are Piconet and Scatternet.

1) Piconet:-
A Piconet is a network of devices connected in an Ad-hoc fashion using Bluetooth technology.One device is acting as master and other as slave. Maximum devices that can be in Piconet are 8 devices 1 as master and other 7 as slave.
2) Scatternet
A Scatternet is No of interconnected piconets. It is formed when member of one piconet acts as slave in another separate piconet. Using this approach a large scatternet can be formed which expands physical range of Bluetooth.

Problems of existing systems:
a. Master slave restrictions.
b. Interoperability breakdown.
c. Multicasting is not allowed.

To overcome those problems, we propose new system The BlueBooster system: Mobile Network Bluetooth Expansion. The BlueBooster is a proposed software solution to the range limitation that implements a routing methodology using the principles of Ad-hoc On-demand Distance Vector routing (AODV) and some modifications to the AODV protocol itself. Because of Ad-hoc network there is no master slave restrictions. The main concept behind the BlueBooster solution will be to allow the creation of a virtual community, and use the nodes of the community as relay points between two nodes, which are not in the direct range of each other which will help to expand physical range of 10 m of Bluetooth. Multicasting is a feature in BlueBooster system where the user can select multiple destinations from within the virtual community, and send the same file to all of them in just one operation because of no master slave restrictions. If any in- between node fails then another path will be chosen by AODV Algorithm dynamically hence no interoperability breakdown. BlueBooster system features:

1) To extend existing Bluetooth range of 10 m.
2) To provide Bluetooth network of wide range.
3) For expanding range middle Bluetooth device as router.
4) Multicasting (sending one file to many destinations).
5) No master slave restrictions.
6) No interoperability breakdown

2. Requirements Review

2.1 Bluetooth Structural Design

Bluetooth provides communications based on Radio Frequency. There are different kinds of Bluetooth devices from different manufactures built already. The aim of the Bluetooth specification is to ensure the communications between these devices in an efficient and effective manner. To achieve the above, the Bluetooth specification specifies a protocol stack to ensure that Bluetooth devices can discover each other, explore each other's services, and make use of these services [1].

2.2 Object Exchange (OBEX) Protocol

OBEX layer is used to transfer data such as files, as objects. The OBEX protocol uses Client-server model to send/receive files between Bluetooth devices. The server

should open up an OBEX connection with the client to perform put and get operations. To pass additional information can use OBEX headers.

2.3 File Transfer Profile

Bluetooth profiles define vendor-neutral device capabilities, to ensure interoperability and consistency between devices. They provide a well defined set of higher layer procedures and uniform ways of using the lower layers of Bluetooth. Bluetooth applications which provide file transferring should understand the requirements of the protocols (OBEX) and procedures which will be used.

2.4 Radio Frequency Communication (RFCOMM) Protocol

RFCOMM is a Transport protocol. RFCOMM is better used to send stream data and it provides emulation of serial ports, which are normally necessary to transfer stream data [2]. It is better to use RFCOMM instead of OBEX to send/receive simple text string between Bluetooth devices.

3. Existing Solutions

3.1 Piconet

Piconet is a network of devices connected in an Ad-hoc fashion using Bluetooth technology. One device is acting as master and other as slave. Maximum devices that can be in Piconet are 8 devices out of which 1acts as master and other 7 as Slave. Piconet is one technique which can be used to overcome the distance limitation to some extent. Piconet operates in range of about 10m and transfer rate is from 400 to 700kbit/s, depending on synchronous or asynchronous connection used. All devices in a Piconet are peer units and have identical implementations. However, when a Piconet is formed between two or more devices, one device is dynamically elected to take the role of 'master', and all other devices assume a 'slave' role for synchronization reasons.

3.2 Scatternet

A Scatternetis a number of interconnected Piconets that supports communication between more than 8 devices. Scatternets can be formed when a member of one Piconet elects to participate as a slave in a second, separate Piconet. The device articipating in both Piconets can relay data between members of both Ad-hoc networks. Using this approach, it is possible to join together numerous Piconets into a large Scatternet, and to expand the physical size of the network beyond Bluetooth's limited range. Some of the main disadvantages of Scatternet are the Master-Slave restrictions, interoperability breakdown [3].

3.3 Ad-Hoc Networking

The vision of mobile Ad-hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes.

Such networks are envisioned to have dynamic, sometimes rapidly- changing, random, multi hop topologies which are likely composed of relatively bandwidth-constrained wireless links [4]. When considering the networks that exist today, they can be classified to two main categories as infrastructure and infrastructureless. Infrastructured networks consist of fixed and wired gateways. Local area networks (LANs) and wireless LANs are good examples of infrastructured networks. In both there is at least one fixed and wired base station to which other nodes connect to, with either a wired or wireless connection. Infrastructureless networks on the other hand do not have any fixed or wired gateways. All nodes are mobile and can have dynamic and arbitrary connections. Infrastructureless networks can be called as 'Ad-hoc' networks. Ad-hoc mobile wireless networks have a constantly changing network topology. Each node in an Ad-hoc network acts as a router. The main advantage of Ad-hoc networks is that they can be established very quickly and they do not require a fixed infrastructure and it's a temporary connection made between two or more devices when connection released, network disappears again [5].

3.4 Routing Algorithm

Ad-hoc on demand distance vector routing (AODV)

Ad-hoc on demand distance vector routing was implemented based on the protocol DSDV and is a much improved version. When a source node needs to send a message to a destination which is not directly reachable it initiates a path discovery process to find and establish a route [6]. Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs) are the message types defined by AODV. These message types are received via Universal Datagram Protocol (UDP), and normal IP header processing applies. In the process of forwarding the RREQ, intermediate nodes record the address of the source to them, the sender of the first copy of a particular RREQ. Once the destination is found a REP is sent back using the reverse path. While the RREP is forwarded, the nodes keep the RREP source node addresses to them, creating the forward path. The source will use this path to send the message to the destination. In AODV, if the source node is moved, it will reinitiate the RREQ.

4. Design of Bluebooster

The BlueBooster application will extend the communication facilities via Bluetooth between mobile phones. There are several core areas in the BlueBooster system, BlueBooster service, creation of community list, the blue community concept, Blue line concept, message transfer, file transfer, multicasting & security module. The two new terms 'blue community' and 'blue line' were introduced for the BlueBooster application. The "blue community" as shown in Fig. 1, is created when a Bluetooth enabled device running BlueBooster application, is connected with all Bluetooth enabled nodes around it, that are running BlueBooster application.

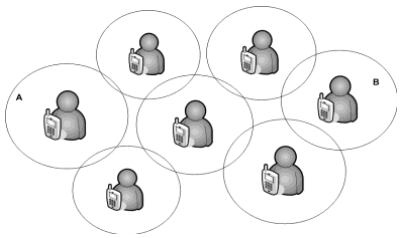

Figure 1: BlueCommunity

4.1 Bluetooth Range Expansion

The BlueBooster application first allows the user to start the

BlueBooster Service. This service is used to identify Bluetooth enabled mobile devices which are willing to participate in a virtual community as shown in Fig 2, and ensures consent of the users eliminating any privacy violations. When a user is sending a file or a message through the blue line, intermediate users (between source and destination) do not need to worry about 'send file/message' or 'receive ACK' operations this will be handled automatically through the BlueBooster application. Intermediate users only need to have the BlueBooster application running with the BlueBooster service started. If the intermediate users are not using the application they can run it in the background. A log will be maintained by the system, keeping track of all the connection details, data transferring and other activities done. This log can be used by the user to track all the activities done through the device. In a scenario where a Blue Community member sends a file to another member who has the application in the sleep state, then the destination user's application will be brought to the active state to notify the file/message receipt.

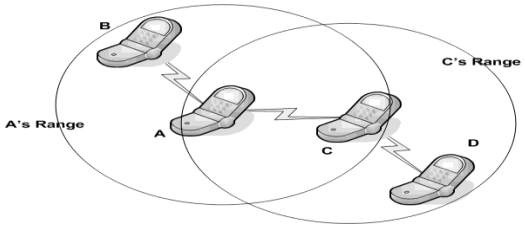

Figure 2: Connection Initiation

4.2 Blue Community and Connection Initiation

The First step to start communicating using the Blue Community is to join the community. Once the user joins, the BlueBooster service will be started in his/her device (if not already started) and a list of the other reachable members will be shown. Initially the directly reachable nodes are listed in the community list. To see all nodes in the virtual community the user can choose the option ―show more devices‖ then the application will search for nodes that the successive devices can reach, this will result in the successive nodes sending the list of nodes that they can reach and all lists will be collected and appended to list all nodes that are in the community. When creating the list the duplicates will be avoided. The community list will be sorted according to the distance based on the number of hops to a specific node (all destination nodes will be assigned the least number of hopes to it from the source).[7]

4.3 Routing Methodology and the Blue Line Concept

The following set of diagrams would describe the routing model clearly. Please consider that all nodes are Blue Community members. In Fig 3, node A needs to communicate with node E. E **can be reached via two paths but a single route will be established for communication. The length of both paths is the same. Length is determined by the number of hops to reach the destination. First a route request message (RREQ) will be broadcasted by A then by all other subsequent nodes that receive the RREQ. Once the RREQ reaches E, since it is the destination then a route reply (RREP) will be sent back through its source to A and the Blue Line will be established, if A receives.

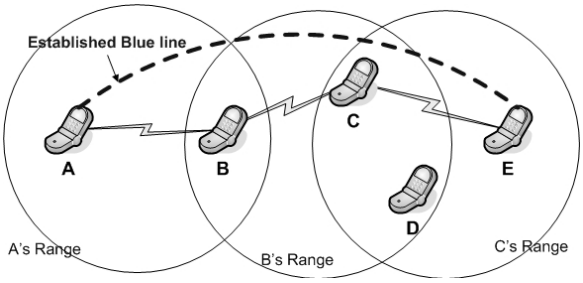

Figure 3: Blue Line

4.4 Multicasting

This functionality of the BlueBooster system allows the user to send a single file or a message to multiple users by just one action from the user. This feature is more effective and efficient when selected multiple nodes are in a single Blue Line. The community list will be sorted and listed according to the distance to each node from the current node.[8] In this case the distance is measured according to number of hops to remote device from the current node. As mentioned earlier when creating the list, the system will retrieve community lists from other nodes. Each list will consist of friendly name, Bluetooth address and number of hops to every node.

4.5 Security in Ad-hoc Networks

Providing security in Ad-hoc networks is a great challenge due to the reason that the nodes can move freely and there is no fixed infrastructure. Most Ad-hoc routing protocols are cooperative by nature, and rely on implicit trust-your-neighbour relationships to route packets among anticipating nodes [9]. Most popular method of providing security is encryption with a secret key. Almost all the existing algorithms use a third party certificate authority for the key distribution. This is possible in wireless networks where there is a central server or node. For example we can consider the master node in a Piconet.

The master can act as a certificate authority. But the certificate authority concept for key distribution cannot be implemented practically in a scenario like a Blue Community. Some other solutions are, defining security levels using Security-Aware Routing (SAR) protocol within the community, using Zone routing protocol (ZRP), Using ―WatchDog‖ technique that identifies misbehaving nodes and patthrater that helps routing protocols avoid these nodes or maintain several key servers. But none of them are ideal for the BlueBooster system. The most basic and practical solution for key distribution in Ad-hoc networks is to maintain a shared secret. After the research was done and discussions held, it was decided to use the shared secret as the key distribution mechanism in the BlueBooster application. Accordingly the community will maintain a predefined secret key. This key can be changed with the consent of the members.

5. Simulation Model

The emulator provided by the Java Wireless Tool Kit was used to simulate and test the BlueBooster application. In order to simulate real mobile phones that are in the Blue Community the java location API was used to specify the location of each emulator so that the distance between the

source and destination exceeded the standard range of Bluetooth in mobile phones which is usually of 10m. Emulators become clients and servers depending on the role they play in the data transferring process [10]. An emulator that requests connection is a client and the emulator that responds to it is a server. If the emulator is a server then the longitude value will be stored in the server's services as an attribute. The Movement Tracker class will update this service attribute if location was changed. When a client connects to a server the system will check the longitude of client and server. If the difference in the longitudes is less than simulated distance limitation (10), then system allows client to connect and communicate with server via Bluetooth.

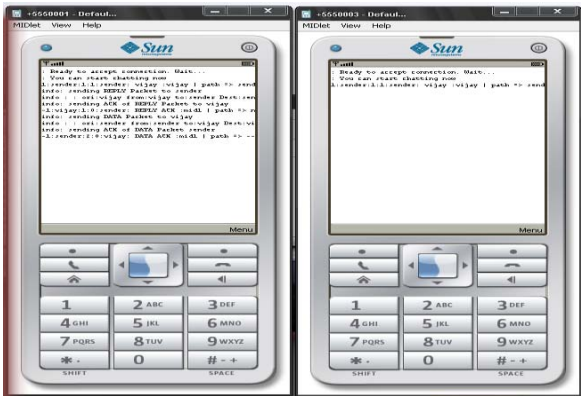

Figure 4: Wireless Toolkit 2.5.2

6. Advantages and Uses

The usages of the BlueBooster application are endless. It can be used by any application which requires an Ad- hoc networking platform. Since BlueBooster system has improved the success rate of message being delivered to the destination it can be considered to be very reliable. Looking at a real life application, in a campus environment or in an office environment once the Blue Community is created it provides a very cost effective way of communication. In an exhibition or a conference like environment, the Blue Community can provide the administrators a way of broadcasting advertisements and important messages among the visitors, this will result in a huge reduction in cost. The BlueBooster system can also be used as a device finding mechanism. A user in a Blue Community can create a Blue Line to the desired destination then looking at the message received from the application the user can determine the relative location of the destination in relation to the other nodes in the community.

7. Future Enhancements

In this research the BlueBooster system is limited to the Bluetooth technology, if it is further expanded to integrate other technologies it will increase the capabilities and allow the mobile users to interact with other wireless networks around them. By introducing techniques like file streaming the system can be further enhanced so that if a mobile phone in the Blue Line cannot handle the file sent due to its size, then the file can be broken down into small pieces and sent to the destination through the same Blue Line. If a method was found to securely distribute the encryption key in Ad-hoc networks and make them much secure it will allow this system to be implemented in military and other high risk applications.

8. Conclusion

In this way we are extending the current Bluetooth range from 10 m range to more by using other idle Bluetooth devices running this BlueBooster application. The BlueBooster system has also enhanced the data transferring capabilities. With a single operation the system allows data to be sent to multiple destinations. This allows system to be used in a wide variety of community applications such as multi destination chat programs and multi player games can run on top of it. In this research the BlueBooster system is limited to the Bluetooth technology, if it is further expanded to integrate other technologies it will increase the capabilities and allow the mobile users to interact with other wireless networks around them.

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