

## Dynamic Source Routeing in Bluetooth Personal Area Networks

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**Abstract** - This paper presents on-going work on a simulator that is being designed for investigating Policy versus Cost trade-offs for a wide range of topologies of Bluetooth Personal Area Networks (PAN). This work reports on a mobility model of mobile units that randomly move around a grid. These units have a particular wireless range of reception. The user may specify the number and the initial position of the mobile units, the source and sink nodes for messages and the time and distance moved for each time step. The Dynamic Source Routeing protocol is used to calculate an appropriate multi-hop route through the PAN.

**Keywords** - Bluetooth, Dynamic Source Routing, Route Discovery, Simulation

### I. INTRODUCTION

Bluetooth Personal Area Networks (PANs) are becoming increasingly important in connecting users, their personal devices and surrounding networks of Bluetooth-enabled sensors. The PAN may contain Network Access Points (NAPs) that connect to a Local Area Network such as Ethernet, Router Nodes (RNs) and PAN User devices (PANUs).

The methodology of routeing within PANs remains to be standardised: PANs are a heterogeneous mixture of both fixed and mobile nodes with many different physical capacities, capabilities and modes of operation. Some Bluetooth nodes may have external host controllers with a power supply and adequate memory. Other nodes may be stand-alone with a Bluetooth device attached to an external sensor and a battery. Some devices may be operated continuously whereas others spend nearly all their time in the deep sleep or the park mode of operation.

There is a need for a simulator to investigate optimum PAN initiation, build, maintenance and operation (Policy) procedures under the (Cost) constraints of power utilisation, latency, data and voice throughput, congestion and error control.

A general-purpose PAN simulator is being constructed using software components [Pollard, 2000]. This simulator will be accessible over the World-Wide Web [Pollard, 2000]. Physical layer and Base-band layer components of the simulation have been described elsewhere [Kontakos and Pollard, 2003].

The present paper describes progress that has been made on the mobility model of a PAN and the simulation of Dynamic Source Routeing (DSR) as an on-demand Network layer protocol that may be suitable for power-limited, multi-hop, ad hoc mobile devices. Programming was in Java.

### II. DYNAMIC SOURCE ROUTEING

The DSR protocol is the encapsulation of a message with the route that it is to follow from source to sink (destination). Figure 1 illustrates an example network:

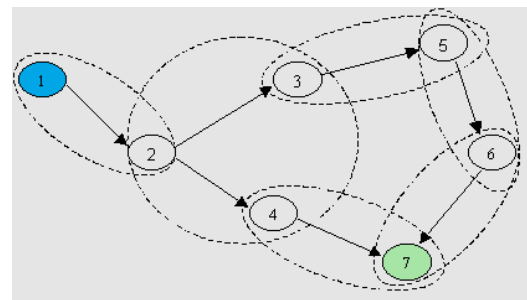


Figure 1. An example network

Two possible routes are stored in memory at node '1' that allows packets to be sent to node '7'. The intermediate stages of the multi-hop sequence (1, 2, 3, 5, 6, 7 or 1, 2, 4, 7).

Two mechanisms work together in order to discover or maintain a route within an ad hoc network:

*Route Discovery:* If there is no route present within the memory of the source node (node '1'), a route must first be found.

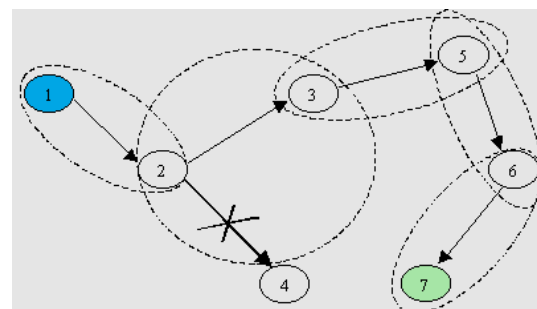


Figure 2. Route Maintenance

*Route Maintenance:* In Figure 2, node '4' no longer is in transmission range of node '2'. The route '1, 2, 4, 7' can no longer be taken so the other route stored in node 1: '1, 2, 3, 5, 6, 7' must be used.

Both Route Discovery and Route Maintenance have no extra overhead packets if there is no movement of nodes within a network. Overhead packets are required only if there is node movement and alternative routes are not cached in the source node. This speeds the routing process and limits the amount of route discovery actions.

A source route may be composed of hops over a combination of any network types available [Maltz, Broch, Jetcheva and Johnson]. As an example: The NAPs in PANs will give access to the Internet via gateways.

### III. MOBILITY MODEL

A general mobility model has been implemented in this simulator component.

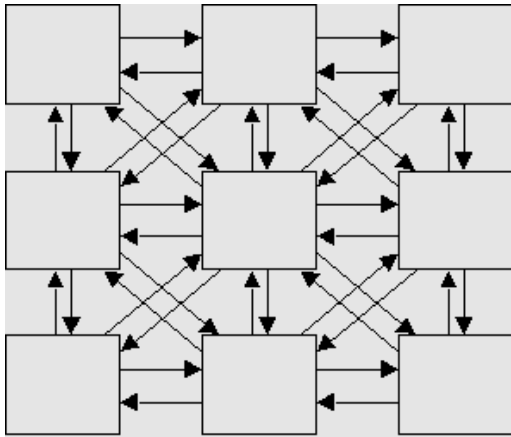


Figure 3. Positions where devices may be located

The squares in the above figure 3 represent positions where devices may be located and the arrows indicate the direction in which movement is allowed for every discrete time step. Movement speeds are constant in this model.

When the simulation is started, the mobile units begin to move one grid square around the grid in a random direction. The location of the units may be tracked in a data structure array.

### IV. ROUTE DISCOVERY

#### A. Data Structure of Adjacent Nodes

Knowledge is required of units that are within receivable range of one another. Consider the following figure 4 that illustrates seven nodes and their ranges are shown as ellipses:

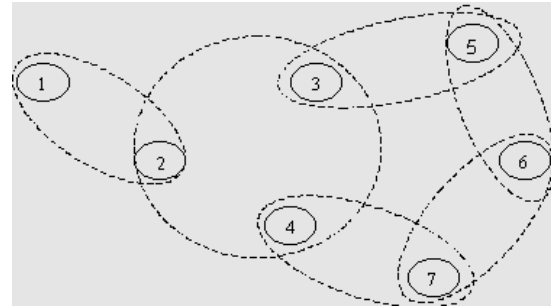


Figure 4. Seven nodes and their ranges shown as ellipses

In the future, it is planned that the range of each device will be calculated from position calculations and information derived from the Physical channel and Base-band layer simulator [3]. This present work assumes all units have a constant range.

The data structure contains an array of source nodes each of which has a linked list of adjacent nodes, see figure 5.

1	→ 2		
2	→ 1 → 3 → 4		
3	→ 2 → 4 → 5		
4	→ 2 → 3 → 7		
5	→ 3 → 6		
6	→ 3 → 5 → 7		
7	→ 4 → 6		

Figure 5. Each source node has a linked list of adjacent nodes

#### B. Route Discovery Algorithm

A source node and a sink node are chosen. A route record for the path is required.

The source node broadcasts the pair: {source label, sink label} to all the adjacent nodes that it can reach.

If the receiving node has not received the {source, sink} request before, or

If the receiving node's label is not present on the route record, or

If the receiving node's label is not the sink label

THEN:

It appends its own label to the route record from whence it received the discovery request.

It rebroadcasts the updated route record to all nodes that it can reach

ELSE

If it is the sink node

THEN

The message is successively sent back to previous nodes in the route record until it reaches the source node. The source node then records it as its route to the required sink.

## V. RESULTS

### User Input:

The simulator requests the user to specify:

- Number of mobile units,
- The initial position of each unit,
- Source label,
- Sink label,
- Number of time-step loops for movement of the mobile unit.

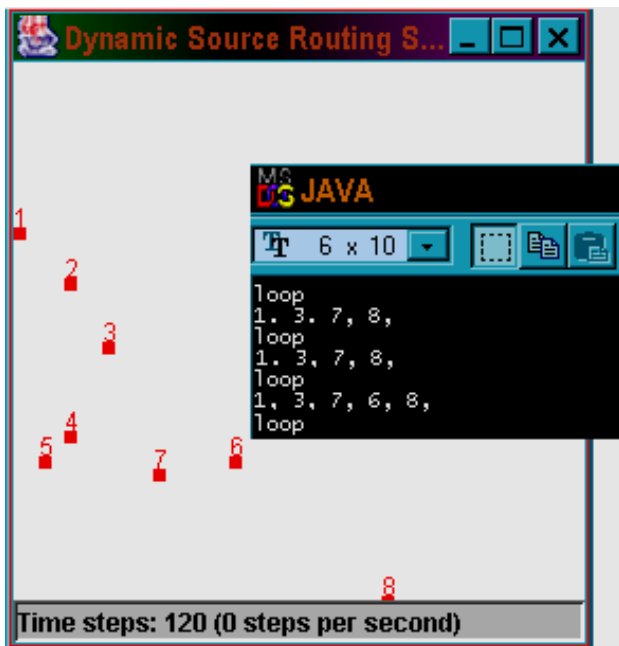


Figure 6. Simulation image with eight Bluetooth units

*Example Image:* Figure 6 shows an image of the simulation with eight Bluetooth units where node '1' is the

initiator and '8' is the sink. Nodes move from an initial position by three time-step loops. Each time-step loop is delimited by the word "loop". At the final stage as seen in the graphical interface, the possible route is '1, 3, 7, 6, 8'.

## VI. SUMMARY AND CONCLUSION

The simulator is able to take in a user specified number of Bluetooth units; these are labelled and positioned. They are able to move around a grid in a random fashion. This is the mobility model.

The Route Discovery algorithm was developed to run independently of the mobility model. When supplied with information on wireless reception ranges, it can find a set of routes from a given source to a specified sink node

Mobility model and route discovery algorithms were integrated within the simulator so that the user can specify the source and sink mobile units. It is then able to carry out route discovery after a specified number of movement time steps.

*Future Work:* In this present work we assumed all units have a constant range. In our future work, it is planned that the range of each device will be calculated from position calculations and information derived from the Physical channel and Base-band layer simulator [3].

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