A Study on Reliable Data Delivery for Highly Dynamic MANETs

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Abstract---This paper addresses the problem of delivering data packets in highly dynamic Mobile Ad Hoc network. Existing routing protocols are susceptible to node mobility. To overcome this issue, an efficient Position based Routing Protocol (POR) and Virtual Destination based Void Handling scheme (VDVH) is proposed. POR protocol takes advantage of stateless property of Geographic Routing and Broadcast nature of wireless medium. When a node wants to send data to another node, it first broadcast the data to nodes within its range. The best node in turns forwards to another node which is close to the destination and if the best node fails to forward the data packet then the sub-optimal node will forward the data packet. To handle the communication void, VDVH scheme is proposed.

Keywords: Mobile ad-hoc Network; VDVH; Greedy forwarding; POR;

I. INTRODUCTION

A mobile ad-hoc network is a network composed of mobile nodes that does not rely on an existing infrastructure. MANETs have gained a great deal of attention because of its significant advantages brought about by multi-hop, infrastructure-less transmission [1]. Traditional routing protocols in mobile Ad Hoc networks (MANETs) introduce probe packets to store the cost of the path that they traverse and enable route discovery. Based on the cost information an appropriate path is chosen. The selected paths are stored in a routing table. These protocols may fail due to network disconnectivity caused by node mobility.

Due to node mobility in traditional MANET routing protocols, an opportunistic protocol called Position-based Opportunistic Routing Protocol (POR) [2,3] is proposed, since the network is highly dynamic. To enhance a system's robustness, the most straight forward method is to provide some degree of redundancy. According to the degree of redundancy, existing robust routing protocols for MANETs can be classified into two categories. One uses the end-to-end redundancy, e.g., multipath routing, while the other leverages on the hop-by-hop redundancy which takes advantage of the broadcast nature of wireless medium and transmits the packets in an opportunistic way. POR falls into the second category.

Opportunistic routing [4] utilizes the broadcast nature of the wireless medium to choose at least one relay node as a forwarder at each hop in a highly dynamic environment. The neighbouring nodes are prioritized according to some metrics such as distance to the destination, link stability etc. The node with the highest priority is chosen as the best forwarder and is specified in the next hop field of the packet. When the packets are broadcast the nodes other than the best forwarder receive the packet by eavesdropping. Among the receivers, the node specified as the best forwarder in the packet header becomes the next forwarder. Other nodes get suppressed when they hear the transmission by the best forwarder.

Communications void is a major challenging problem for geographic routing. Although the use of wireless nodes can reduce the likelihood of the occurrence of a void in the network [5], it is still achievable for some packets to encounter voids that are induced by obstacles, untrustworthy nodes, the boundaries of a wireless network. Thus, it is imperative to design a void-handling technique for geographic routing in an effective and efficient manner. Here, Communication hole is handled by Virtual Destination-based Void Handling (VDVH) scheme. This scheme uses the advantage of greedy forwarding and opportunistic routing. Greedy forwarding is used to select next hop forwarder with the largest positive progress toward the destination while void handling mechanism is triggered to route around communication voids.

II. LITERATURE REVIEW

M.K. Marina and S.R. Das [6] proposed a modified version of the AODV protocol called AOMDV which shares several characteristics with AODV. It is based on the distance vector concept and uses hop-by-hop routing approach. But, AODV is a reactive routing protocol [7] where as the DSDV is a proactive routing protocol [7]. Moreover, AOMDV also finds routes on demand using a route discovery procedure. The main difference lies in the number of routes found in each route discovery. The core of the AOMDV protocol lies in ensuring that multiple paths discovered are loop-free and disjoint, and in efficiently finding such paths using a flood-based route discovery.

M. Mauve, A. Widmer, and H. Hartenstein [2] proposed a geographic routing scheme which uses location information to forward data packets, in a hop-by-hop routing fashion. No energy is spent on route discovery [8]. No routing table is constructed. As a result, establishment and maintenance of routes are not required, reducing the overhead considerably. No end-to-end routes need to be maintained, leading to GR’s high efficiency and scalability. However, GR is very sensitive to the inaccuracy of location information [9]. If the node moves out of the sender’s coverage area, the transmission will fail. The update message size in GR is relatively large compared to those in some other scheme. Large message size and propagation delay wastes a considerable amount of network bandwidth. That makes it difficult to predict GR performance on different size of the network.

Brad Karp and H.T. Kung [10] proposed Greedy Perimeter Stateless Routing (GPSR), a novel routing protocol for wireless datagram networks that uses the positions of routers and a packet's destination to make packet forwarding decisions. GPSR adapts a greedy forwarding strategy and perimeter forwarding strategy to route messages. When a packet reaches a region where greedy forwarding is not possible, then the algorithm recovers by routing around the perimeter of the region. Due to frequent topology changes, GPSR use local topology information to correct new routes quickly.

III. POSITION BASED OPPORTUNISTIC ROUTING

POR design is based on geographic routing and opportunistic forwarding. The nodes are thought to be aware of their location and their direct neighbor’s positions. Neighborhood location information is exchanged through a one-hop beacon or piggyback in the data packet header. Then the location registration and lookup service that maps node addresses to the locations is available for the destination position [11], which can be realized through use of many types of location service.

A. Routing Mechanism

The source node obtains the address of the destination from a location registration and lookup service. It then attaches destination’s address to the packet header. If the destination is within the source’s transmission range, then the next hop is the destination. The packets are forwarded directly and the routing process ends. Otherwise, neighbours are prioritized based on the node which makes positive progress towards the destination and that node gets the highest priority to become the best forwarder.

B. Selection of Best Forwarder and Candidate Node

Forwarding area is selected as the intersection area of the transmission range of the source and half of the transmission range of the best forwarder. Among the nodes within this intersection area, only those nodes which are closer to the destination than the source and which are farther from the destination than the best forwarder, become the candidate nodes. The candidate list is attached to the packet header and the packet is broadcast. The best forwarder and the candidate nodes cache the packets. If the best forwarder fails to transmit the packets, then the candidate node with the next highest priority transmits the packet. All other candidate nodes get suppressed on hearing the transmission and drop the cached packets. Duplicate packets can be identified using a sequence number and are not propagated further.

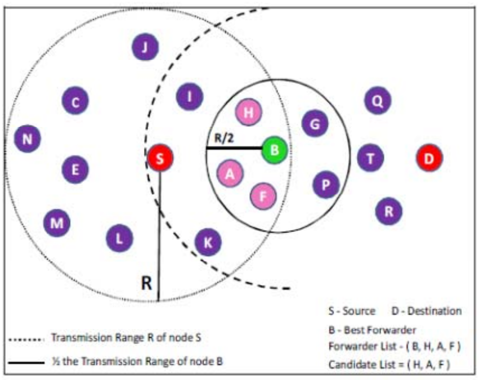

Figure 1 : Best forwarder and candidate nodes selection

In Figure 1 node S is the source and D is the destination node. R is the radius of the transmission range of node S. The transmission range of S is denoted by the dotted circle. The nodes in the area enclosed within the dashed arc make positive progress towards the destination. From these nodes, the one which makes the positive progress towards the destination is chosen as the best forwarder, namely node B. R/2 denotes the radius of half the transmission range of node B. The intersection area of the transmission range of S and half of the transmission range of B is taken as the forwarding area. Nodes within the forwarding area, other than node B, become candidate nodes, namely nodes H, A and F.

Algorithm 1: Best Forwarder and Candidate Nodes Selection

1. Find if Destination node is in the Neighbor List.
2. If found, set the next hop as Destination node and exit.
   Else continue.
3. For each node in the Neighbor List, do the following:
   //Checking for positive progress towards destination

3.a Check if its distance from the Destination node is greater than or equal to the distance between the current node and Destination node.
If yes, break. Else,
add node to an array.
// Selecting candidate nodes

4. For each node in the array, other than the Best forwarder, do the following:

4.a. Check if it is within half the radius of the Best Forwarder's transmission range.

4.b If yes, check if its distance to the destination is lesser than the distance of the source node to the destination and the node's distance to destination is greater than distance of the Best Forwarder to the destination.

4.c If yes, add the node to Candidate list.

5. Exit

IV. VIRTUAL DESTINATION BASED VOID HANDLING

A. Routing Hole Handling

Communication holes may exist since nodes are not uniformly distributed. When the best forwarder seeks the next hop node and finds none, a communication void is said to be encountered. The protocol then switches to a routing hole handling mechanism. When the best forwarder encounters a communication hole, it sends a void signal to the previous forwarder. The previous forwarder becomes the trigger node and the best forwarder becomes the void node.

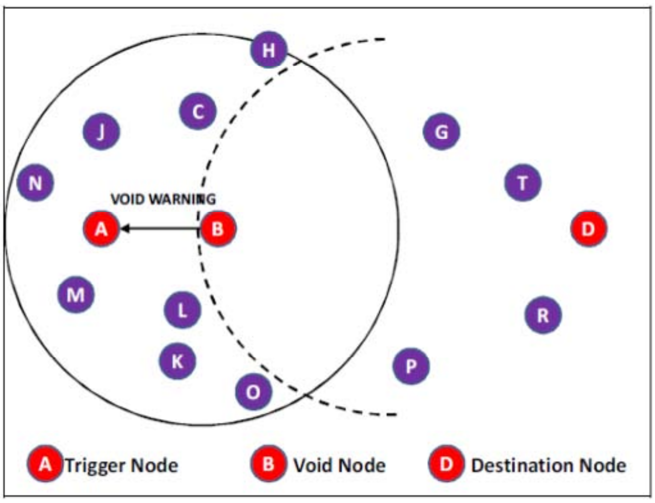

Figure 2 : Sending a void warning signal

In Figure 2 node A has chosen node B as the next forwarder. Node B finds no forwarders to forward the packets. In such a situation node B is said to encounter a routing hole. It sends a void warning signal to node A. Now, node B becomes the void node and node A becomes the trigger node. Node A switches to a hole handling algorithm. Node A chooses another forwarder based on Algorithm-2 excluding the void node. It may route around the void through C-H-G-T or L-O-P- R. If destination is reached, then an acknowledgement is sent to the trigger node, else a disrupt signal is sent. The trigger node triggers Algorithm-2 excluding the void node in order to avoid looping.

Algorithm 2: Routing Hole Handling

1. If the current node receives void warning from the Best
   Forwarder, then do the following:

1.a Set the Best Forwarder as Void node.

1.b Set the current node as Trigger node.

2 Ignoring the void node, find the Best Forwarder based
   on Algorithm-1 for the Trigger node.

3. If the next hop node is the Destination node, send
   acknowledgement to the Trigger node.
   Exit.

4. If no forwarders are found, send Disrupt message to
   the Trigger node.
   Exit.

5. If a forwarder is found, switch to Algorithm-1.

6. Exit.

B. Virtual Destination

Virtual Destination based Void Handling Technique first selects the Trigger node in which it is responsible for transmitting data in Void situations. To handle communication voids, almost all existing Mechanisms try to find a route around. During the void handling process, the advantage of greedy forwarding cannot be achieved as the path that is used to go around the hole is usually not optimal. In order to enable opportunistic forwarding in void handling, which means even in dealing with voids, virtual destination is introduced, as the temporary target that the packets are forwarded to. Virtual destinations are located with the trigger node as center and the radius of the circle is set as a value that is large enough(e.g. the network diameter). A virtual destination has a certain degree of offset, compare to real destination. Compared to the real destination D, a virtual destination (e.g. D_ Left and D_ right) has a certain degree of offset, e.g. ψ (π/4 in our simulation) in Figure 3. The potential forwarding area is significantly extended, with the help of virtual destination.

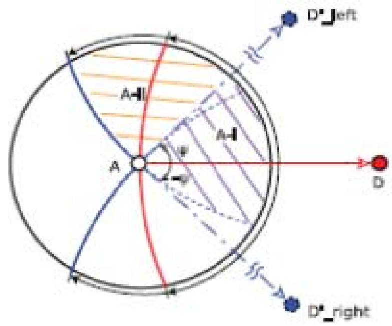

Figure 3 : Potential forwarding area is extended with virtual destination

V. RESULTS AND DISCUSSIONS

The POR and VDVH schemes can be implemented as shown in the above snapshot with various modules like Client, Server and Proxy. Data requested by the client is transmitted from the Server to the client through the proxy (provider). Provider shows various information such as to which server and client it is connected to. Server shows the number of users connected to the Provider. On the other hand void situation is overcome by temporarily introducing the destination to which the data is transmitted.

VI. CONCLUSIONS

Constantly changing network topology makes conventional ad hoc routing protocols incapable of providing satisfactory performance. In the face of frequent link break due to node mobility, substantial data packets would either get lost before restoration of connectivity. Inspired by opportunistic routing, a novel MANET routing protocol POR is proposed which takes advantage of the stateless property of geographic routing and broadcast nature of wireless medium. To achieve more robustness, a virtual destination-based void handling scheme is proposed. By temporarily introducing the destination, the advantage of greedy forwarding as well as the robustness brought about by opportunistic routing is achieved when handling communication voids.

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