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Reliable Data Delivery in MANET Using POR

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Abstract: In Mobile Ad hoc Networks, since nodes move arbitrarily the network topology changes frequently and unpredictably. This paper address the problem of reliable data delivery in MANET, especially in a challenged environment with high mobility remains an issue. To deal with such issue, a novel position based opportunistic routing protocol (POR) is proposed to efficiently maintain uninterrupted communication. When a node sends or forwards a packet, the neighbor nodes that have overheard the transmission will serve as forwarding candidates, and forwards the packet if it is not relayed by the specific best forwarder. In this way, as long as one of the candidates succeeds in receiving and forwarding the packet, the data transmission will not be interrupted. To handle the communication voids, a virtual destination based void handling scheme is further proposed to enhance the robustness of POR. Simulations are done in NS2 to confirm the effectiveness and efficiency of POR in high mobility networks.

Keywords: Geographic Routing, Opportunistic Forwarding, Reliable Data Delivery, Void Handling, Mobile Ad hoc Network.

INTRODUCTION

Ad-hoc network is a collection of wireless hosts that are free to move randomly. These networks operate without any support of the fixed infrastructure or centralized administration and are completely self-organizing and self-configuring. Nodes are connected dynamically to form a network, depending on their transmission ranges and positions. Nodes can communicate directly with all nodes within its transmission range. With the limited transmission range, two nodes may not be able to communicate directly and they must rely on the intermediate nodes to forward their packets. A source node sends a packet to one of its neighbors, which will then forward the packet to their neighbors, and so on until the destination is reached. Thus, nodes must cooperate to provide connection and paths are normally multi-hop. Routing helps to find the appropriate paths between source and destination nodes, possibly over many intermediate nodes.

Traditional routing protocols for ad-hoc networks perform poorly because of these network's distinct characteristics such as the dynamically changing topology, the broadcast propagation medium, and the existence of unidirectional links. The topology-based routing protocols uses routing tables and information about available path to forward packets based on the destination address. On the other hand, these routing protocols will not easily get adapt to frequently changing topology. These changes results in inconsistent routing tables. Furthermore, these protocols scale poorly with large number of nodes.

Geographic routing [1] operates via local interactions among the neighboring nodes. This requires the limited amount of state information that does not grow with the number of communicating node's, therefore, it is called stateless. The location information of the nodes can be exchanged with their neighbors. In position-based routing [2], the node's geographic positions are used to make routing decisions. A node forwards a packet to the neighbor that is closest to the destination node in a greedy manner. If this greedy routing fails, the packet is forwarded further in a recovery mode. Therefore, a node must be able to find its own position and the position of the destination node. This information is generally provided by a global navigation satellite system and a location service, respectively. The location service is responsible for maintaining node's positions and provides the destination node's location as it receives request from the source node. Further, nodes must be aware of their neighbors through beacons, short hello messages broadcasted periodically from each node.

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Position-based routing algorithms do not need to establish the end-to-end route prior to data transmission, and also nodes does not store routing tables, as packets are simply sent to neighbors in the direction of the destination. These characteristics make position-based routing protocols suitable for ad hoc networks with highly dynamic topologies and for a large number of nodes, where topology-based protocols have their limitations.

Geographic routing protocols suffer from the problem of voids. A void is an area where the nodes are unable to route the packet to the destination node. The intermediate node's which does not have the better forwarder to the destination node can cause the greedy forwarding to fail. The void handling schemes are used to route around these communication voids by finding the better forwarder to forward the packet to the destination.

In this paper, a novel Position based opportunistic routing (POR) protocol and effective virtual destination based void handling scheme is proposed to prove that the performance of the proposed system is better than the traditional routing protocols.

POSITION BASED OPPORTUNISTIC FORWARDING

The design of POR is based on geographic routing and opportunistic forwarding. Each and every node must be aware of its own location and its direct neighbor's position. The location information of the neighbor's are exchanged using one-hop beacon or piggyback in the data packet's header. When the source node wants to transmit the packet, first the position of the destination is obtained using location service or by periodical beacons and attached to the packet's header. The neighbor list is calculated according to the distance between the nodes and the destination. The node with the minimum distance to destination is chosen as the better forwarder.

A. Opportunistic Forwarding

Opportunistic forwarding does not commit to any node before the transmission starts and it chooses the node which is closer to the destination to forward the packet. Among the neighbors the node which is nearer to the destination will get higher priority and it is chosen to forward the packet.

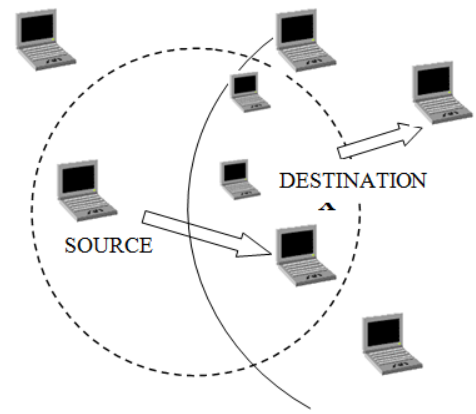

Fig. 1: Operation of POR in normal situation

From Fig. 1, in the normal situation without the link break, node 'X' is chosen as the next hop node among the neighbors. Node 'X' can forward the packet until it moves out of the transmission range and before the neighbor time expires.

B. Candidate Selection

Algorithm 1:
ListN: Neighbor List
N_D : Destination Node
base : Distance between current node and N_D

iffind(ListN, N_D) **then**
    next hop ← N_D
return
end if
for i ← 0 to length(ListN) **do**
    ListN[i].dist ← dist(ListN[i], N_D)

```
end for
ListN.sort()
next hop ← ListN[0]
for i ← 1 to length(ListN) do
   if dist(ListN[i],ND) ≥ base
   then
            break
   else if dist(listN[i], listN[0]) < R/2 then
            next ← ListN[i]
    end if
end for
```

In case next hop node from the neighbors fails to forward the packet, the forwarding candidate with the highest priority will take its turn to forward the packet. Only the nodes in the forwarding area will get a chance to act as the forwarding candidate. The forwarding area is decided by the sender and the next hop node. The node should satisfy the following two conditions to act as the forwarding candidate: i) it makes positive progress towards the destination; ii) its distance to the next hop node should not exceed half of the transmission range of a wireless node.

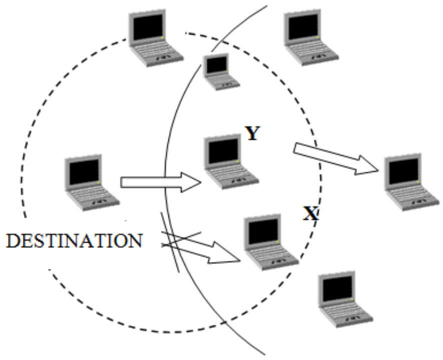

Fig. 2: Operation of POR when next hop node fails

The intersection of the nodes transmission range is the forwarding area. Among the neighbors in the forwarding area, the node with the highest priority is selected as forwarding candidate. The priority is decided by node's distance to the destination. It gets the higher priority, if it is nearer to the destination. Fig. 2 illustrates the selection of forwarding candidate. In case node X fails to deliver the packet (i.e. node X has moved out of the transmission range and cannot receive the packet), node Y, the forwarding candidate with highest priority is chosen to forward the packet.

VOID HANDLING

A. Virtual Destination

In this paper, virtual destination based void handling scheme is proposed as the complementary scheme to opportunistic forwarding that is invoked when communication voids are encountered. A communication void is a state where all the neighbor nodes are far away from the destination than the current node. A node where the packet cannot be forwarded further is called a void node. If the sender cannot find the next hop node that has the positive progress towards the destination, it switches to void handling mode and attempts to route the packet around the void to the destination node.

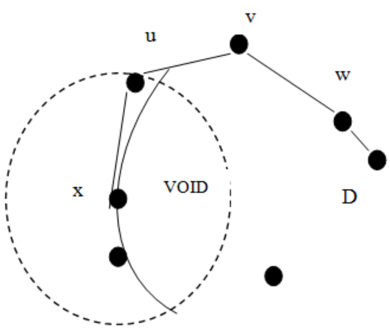

Fig. 3: Void handling

Virtual destination is located at the circumference with the void node as the center. The forwarding area is extended to certain degree offset. This extended area is used to guide the direction of packet delivery during the void handling state. The better forwarder is found to route the packet around the communication void. When the source node finds that the forwarder is nearer to the destination node, it will switch back to the opportunistic forwarding mode.

PERFORMANCE EVALUATION

To evaluate the performance of POR, the algorithm is simulated in ns-2 [9] and compared with the geographic routing protocol GPSR which is an accepted stateless location- based routing protocol.

A. Simulation Setup

In the present work, the event driven simulator ns-2 [9] is used for the simulations. The network consists of 50 nodes which are randomly distributed initially in an area of size 500m by 500m. Transmission range of each node is 250m. The simulation runs for 100 seconds. The traffic sources were CBR flows with 512 bytes per packet. The key performance measures are packet delivery ratio, average end-to-end delay, path length. The other simulation parameters are given in Table 1.

Table 1: Simulation parameters

Simulator	NS-2 version 2.29
Simulation area	500m by 500m
Number of nodes	50
Transmission radio range	250m
Connection type	UDP
Simulation time	100
MAC	802.11
Traffic model	CBR over UDP

B. Simulation Results

Fig. 4(a) shows the packet delivery ratio of POR and GPSR. And the results are averaged over nine simulation runs. Even when the node speed increases to 50m/s, POR still delivers nearly 99% of the packets to reach the destination while the delivery ratio of GPSR decreases significantly.

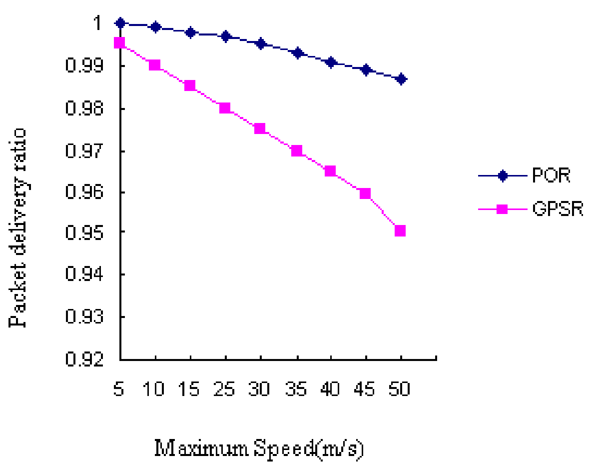

Fig. 4(a): Packet delivery ratio

In case of 50 nodes, the density is too low and GPSR is not able to achieve a high packet delivery ratio because face routing is often used to forward packets, which then may loop. Large number of packets are dropped due to the cycles formed when face routing is applied in recovery mode. Generally, GPSR guarantees only the delivery of packets for static networks.

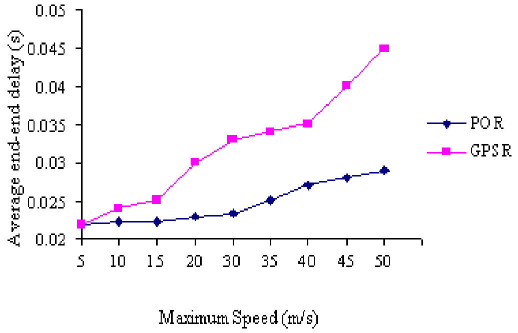

Fig. 4(b): Average end-end delay

Fig. 4(b) shows that POR is not only effective but also efficient. It delivers as many as possible packets at extremely low delay. GPSR faces large delay because packets are routed over longer path, when face routing is applied.

RELATED WORK

There have been some prior research efforts for reliable data delivery in MANETs. Eric Rozner et al. [3], proposed the Simple Opportunistic Adaptive Routing protocol (SOAR), a new addition to the opportunistic routing protocol design space. Opportunistic routing exploits the broadcast nature of the wireless medium and does not commit to a particular route before data transmission. Instead, the sender broadcasts its data; among the nodes that hear the transmission, the one closest to the destination is selected to forward the data. In this way, opportunistic routing can effectively combine multiple weak links into a strong link and take advantage of transmissions that reach unexpectedly near or unexpectedly far. Different from the existing opportunistic routing protocols, SOAR explicitly supports multiple simultaneous flows by strategically selecting forwarding nodes and employing adaptive rate control.

Mei-Hsuan Lu et al. [4] proposed an efficient opportunistic retransmission protocol (PRO, Protocol for Retransmitting Opportunistically) that improves network performance in dynamic infrastructure WLANs. The idea is to exploit over hearing nodes to retransmit (or relay) on behalf of the source after they learn about a failed transmission. Opportunistic retransmission leverages the fact that wireless networks inherently use broadcast transmission and that errors are mostly location dependent. Thus, if the intended recipient does not receive the packet, other nodes may receive the packet and then become candidate senders for that packet.

A location aided opportunistic routing [5], which directly uses location information to guide packet forwarding. However, just like the other opportunistic routing protocols, it is still designed for static mesh networks and focuses on network throughput while the robustness brought upon by opportunistic forwarding has not been well exploited. Geographic opportunistic routing (GOR) was proposed to cope with the unreliable transmissions by exploiting the broadcast nature of the wireless medium and the spatial diversity of the network topology.

Greedy Perimeter Stateless Routing (GPSR) [1], that uses the positions of routers and the packet's destination to make packet forwarding decisions. The greedy forwarding decisions are made using the information about a router's immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. GPSR makes use of local topology information to find the correct new routes quickly and scales better in per-router state than shortest-path.

CONCLUSION AND FUTURE WORK

Designing an efficient routing protocol for MANET is a very difficult task. Various routing protocols have been proposed by different researchers which differ from each other in one or more way. Existing Routing protocols faces frequent link break due to node mobility. Substantial data packets would either get lost, or experience long latency before restoration of connectivity. In this paper, the position based opportunistic routing protocol is proposed for dynamic mobile ad hoc networks which takes the advantage of the stateless property of geographic routing and broadcast nature of the wireless medium. Besides selecting the next hop node, the involvement of several forwarding candidates leads to recover the broken route in timely manner. Therefore the uninterrupted communication will help to achieve high packet delivery ratio while the delay and duplication are lowest.

As a future work, Multi-path routing can be done to increase the reliability of data transmission in wireless ad hoc networks, allows the establishment of multiple paths between the source and the destination.

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