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VHTD Mechanism for Secure Data Transfer in Manets

S. Priya[*1], B. Gopinathan[2]
[*1] PG Scholar, [2] Associate Professor CSE, Adhiyamaan College of Engineering, Tamilnadu, India
gopinathanme@gmail.com

Abstract

In MANETs, nodes move freely and so the topology of the nodes is highly dynamic. The process of routing the data packets to the destination is a challenging task. Most existing ad hoc routing protocols are proposed but these protocols are susceptible to node mobility, especially for large-scale networks. In order to provide an efficient and reliable data delivery in a timely manner for these MANETs, Position-based Opportunistic Routing (POR) protocol is proposed. In POR, the data packets are sent out from the source node and some of the neighbor nodes will be elected as the forwarding candidates, if the best forwarder did not forward the packet in a particular period of time then the forwarding candidates will take turn to forward the packets. And by utilizing air backup, communication is maintained without being interrupted. The additional latency incurred by local route recovery is greatly reduced and the duplicate relaying caused by packet reroute is also decreased. In case of communication hole, that is if an intermediate node (Best forwarding candidate) fails or moves out of the coverage area of the node, then Void Handling mechanism based on Temporary Destination (VHTD) is further proposed to work together with POR to provide an efficient and reliable data delivery. This is achieved by adjusting the direction of data flow temporarily. By using Void Handling mechanism based on Temporary Destination (VHTD), the communication hole is avoided.Simulation results show that the proposed protocol achieves excellent performance even under high node mobility.

Keywords: Mobile Adhoc Networks, Secure data delivery, Air backup, POR, VHTD

Introduction

Mobile ad-hoc network (MANET) is a self-configuring infrastructure less network consisting of mobile devices connected by wireless. Equipping each device to continuously maintain the information required to properly route traffic is the primary challenge in building a MANET. Such networks may operate by them-selves or may be connected to the larger Internet. MANETs are a kind of networks thatusually has a routable networking environment on top of a Link Layer ad hoc network.Since there is high mobility of the independent mobile nodes the topology of the MANET may change uncertainly and rapidly, and because of the network decentralization, each node in the MANET will act as a router to discover the topology and maintain the network connectivity.

The network topology of MANET may change randomly and rapidly at unpredictable times. This makes routing difficult because the topology is constantly changing and nodes cannot be assumed to have persistent data storage. In the worst case, it is even not known whether the node will still remain next minute, because the node will leave the network at any minute. Thus the conventional protocols are susceptible to this node mobility leading to the failure of reliable transfer of data packets. To overcome this difficulty a Position-based Opportunistic Routing (POR) protocol is proposed in which several forwarding nodes cache the packet that has been received. And if the best forwarder node that has the highest priority does not forward the packet in certain time, then the next priority forwarding nodes will take turn to forward the packet according to alocally formed order. The effect of node mobility on packet delivery can be analyzed and explain the improvement brought about by the participation of forwarding candidates.In order to enhance the robustness of POR in the network where nodes are not uniformly distributed and large holes may exist; a complementary void handling mechanism based on temporary destination is proposed which deals with voids and guides the direction of packet delivery

Related Work

Geographic routing (GR) uses location information to forward data packets, in a hop-by-hop routing fashion. 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. 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. In the operation of greedy forwarding, the neighbor which is relatively far away from the sender is chosen as the next hop. If the node moves out of the sender's coverage area, the transmission will fail.

GPSR protocol [2] is the earliest geographical routing protocol for ad hoc networks. The GPSR adapts a greedy forwarding strategy and perimeter forwarding strategy to route messages. It makes use of a neighborhood beacon that sends a node's identity and its position. Every node in GPSR has a neighborhood table of its own. Whenever a message needs to be sent, the GPSR tries to find a node that is closer to the destination than itself and forwards the message tothat node. However, this method fails for topologies that do not have a uniform distribution of nodes or contain voids. Hence, the GPSR adapts to this situation by introducing the concept of perimeter routing utilizing the right-hand graph traversal rule. Every packet transmitted in GPSR has a fixed number of retransmits. Under mobility's frequent topology changes, GPSR can use local topology information to find correct new routes quickly. The GPSR does not elucidate more on the action taken in case a message is unable to be transmitted even in perimeter mode. Finally GPSR disallows the use of periodic broadcast of the neighborhood beacons and piggybacks these beacons on the messages sent by each node. As a strong geographical routing protocol GPSR is allowing nodes to send packets to a particular location and holding a promise in providing routing support in the network.

AOMDV shares several characteristics with AODV. It is based on the distance vector concept and uses hop-by-hop routing approach. 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. In AOMDV, RREQ propagation from the source towards the destination establishes multiple reverse paths both at intermediate nodes as well as the destination. Multiple RREPs traverse these reverse paths back to form multiple forward paths to the destination at the source and intermediate nodes. 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. AOMDV route update rules, applied locally at each node, play a key role in maintaining loop-freedom and disjointness properties [3].

Simple Opportunistic Adaptive Routing Protocol (SOAR) [4] is a proactive link state routing protocol. Every node periodically measures and disseminates link quality in terms of Expected Transmission Count (ETX). Based on this information, a sender selects the default path and a list of forwarding nodes. This protocol achieves high throughput and deals efficiently with fairness. However, periodic measurement and dissemination of link quality drains node energy. Each node maintains a routing table adding to memory overhead.

Applied opportunistic routing to a utility-based routing [5] where the successful delivery of a data packet generates a benefit. The optimal route depends on the benefit value. Accordingly, an optimal centralized algorithm and an approximation distributed algorithm are proposed to solve the routing problem. Failure of one path leads to retransmissions using alternate paths. Retransmission has a negative impact on routing and it has not been evaluated.

The Virtual Routing Protocol (VRP) [6] which is a hybrid source routing protocol. VRP defines a logical structure over the network which is unrelated to the physical network topology. Routes between units are built by translating virtual paths into physical routes. Although the protocol is found to achieve high packet delivery ratio, VRP performs poorly under heavy traffic conditions since units are not ableto maintain up-to date route information about their logical neighbors.

Extremely Opportunistic Routing Protocol (ExOR) [7], an integrated routing and MAC protocol that increases the throughput of large unicast transfers in multi-hop wireless networks. ExOR chooses each hop of a packet's route after the transmission for that hop. It chooses the forwarder with the lowest remaining cost to the ultimate destination. Though it transmits each packet fewer times than traditional routing causing less interference for other users of the network and of the same spectrum, the ExOR header grows with the batch size and many transfers may only have a few packets.

Proposed Work

Overview

In this paper, a novel Position-based Opportunistic Routing (POR) protocol is proposed, in which several forwarding candidates cache the packet that has been received using MAC interception. If the best forwarder does not forward the packet in certain time slots, suboptimal candidates will take turn to forward the packet according to a locally formed order. In this way, as long as one of the candidates succeeds in receiving and forwarding the packet, the data transmission will not be interrupted. Potential multi-paths are exploited on the fly on a per packet basis, leading to POR's excellent robustness. The main contributions are as follows:

- ✓ A position-based opportunistic routing mechanism is proposed and it can be deployed without complex modification to MAC protocol and achieve multiple reception without losing the benefit of collision avoidance provided by 802.11.
- ✓ The concept of in-the-air backup significantly enhances the robustness of the routing protocol and reduces the latency and duplicate forwarding caused by local route repair.
- ✓ In the case of communication hole, Void Handling mechanism based on Temporary Destination (VHTD) scheme is proposed along with POR in which the advantages of greedy forwarding (e.g., large progress per hop) and opportunistic routing can still be achieved while handling communication voids.
- ✓ The effect of node mobility on packet delivery is analyzed and also explains the improvement brought about by the participation of forwarding candidates.
- ✓ Through analysis, it is concluded that due to the selection of forwarding area and the properly designed duplication limitation scheme, POR achieves excellent performance in the face of high node mobility while the overhead is acceptable.

For a packet to be received by multiple candidates in conventional opportunistic forwarding either IP broadcast or a routing integration and MAC protocol is adopted. The former is vulnerable to MAC collision due to lack of collision avoidance support for broadcast packet in current.
802.11, while for the latter it needs complex coordination whichis not easy to implement. POR uses a scheme similar to the MAC multicast mode. The packet is transmitted asunicast (the best forwarder making the largest positive progress towards destination becomes the next hop) in IP layer and multiple reception is through MAC interception. Use of RTS/CTS/DATA/ACK greatly lowers the collision and nodes within the sender's transmission range could eavesdrop on a packet successfully with good probability due to medium reservation.

POR's routing scenario is illustrated in Fig. 1. In a normal situation, the packet is forwarded by the next hop node (nodes A, E) and forwarding candidates (nodes B, C; nodes F, G) are suppressed (the same packet in Packet List is dropped) by the next hop node's transmission. If node A fails to deliver the packet (node A has moved out and so cannot receive the packet), node B, the forwarding candidate with high priority relays packet and suppresses the lower priority candidate's forwarding (node C) and node S. By using MAC layer feedback, node S removes node A from neighbors list and selects a new next hop node for the subsequent packets. The interface queue packets taking node A as the next hop get a second chance to reroute. A packet pulled back from MAC layer will not be rerouted if node S overhears node B's forwarding.

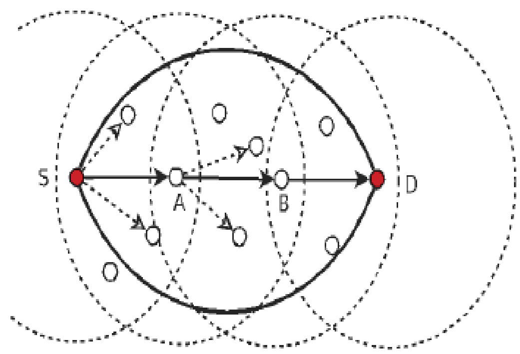

Figure 1: Position-Based Opportunistic Routing

3.2 Architecture of Position Based Opportunistic Routing

The following figure shows the Architecture of the Position Based Opportunistic routing (POR) system in which the source uses GPS to find the exact location of the destination. In order to find a route towards the destination, the source uses greedy algorithm which finds the farthest node in the positive progress towards the destination in the coverage area of the sending node and forwards the data packet by using the MAC unicast.

For the purpose of back-up in case of the packet drop and retransmission of data the greedy node elects 2 forwarding candidates which can overhear the data transmitted to the greedy node. In our Position Based Opportunistic routing (POR) system only the source and the greedy node maintains the forwarding table which reduces the network traffic.In case a communication hole occurs, (i.e.,) a node fails, then VDVH mechanism is used to route the data packet safely around the communication hole.

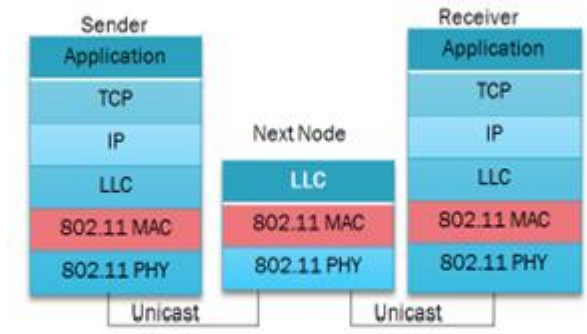

Figure 2: Architecture of POR

POR (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 through riding piggyback in the datapacket header. It is thought that location registration and lookup service that map node addresses to locations is available for the destination position. This can be realized through use of many types of location service. In this scenario, efficient and reliable ways are also available. Destination location can be transmitted by low bit rate and long range radios, which are implemented as periodic beacons, as well through replies when the source requests it.When a source node plans to transmit a packet, it gets destination location first after which it is attached to the packet header. Because of the destination node's movement, a multi-hop path may diverge from the final location's true location with a packet being dropped even if it has been delivered in the destination neighborhood. Additional destination node checks are introduced to handle such issues. The packet forwarding node checks the neighbor list at every hop to see whether destination is within transmission range. If yes, the packet is directly forwarded to the destination.

As data packets are transmitted multicast-like each is identified with a unique tuple (src_ip, seq_no) where src_ip becomes the IP address of source node and seq_no the corresponding sequence number. Each node has a monotonically increasing sequence number, and an ID Cacheto record packets ID which have been recently received. If a packet with the same ID is received again, it will be discarded.Otherwise, it will be forwarded at once if the receiver is the next hop, or cached in a Packet List if it is received by a forwarding candidate, or dropped if the receiver is not specified. The packet in the Packet List will be sent out after waiting for a certain number of time slots or discarded if the same packet is received again during the waiting period (this means a better forwarder has already carried out the task).

Selecting Best Forwarder

Only the nodes located in the forwarding area would get the chance to be backup nodes. The forwarding area is determined by the sender and the next hop node. A node located in the forwarding area satisfies the following two conditions:

a) It makes positive progress toward the destination.

b) Its distance to the next hop node should not exceed half of the transmission range of a wireless node. Some (maybe all) of them will be selected as forwarding candidates.

The priority of a forwarding candidate is decided by its distance to the destination. The nearer it is to the destination, the higher priority it will get. The candidate list will be attached to the packet header and updated hop by hop. Only the nodes specified in the candidate list will act as forwarding candidates. The lower the index of the node in the candidate list, the higher priority it has. Every node maintains a forwarding table for the packets of each flow (identified as source-destination pair) that it has sent or forwarded. Before calculating a new forwarder list, it looks up the forwarding table. The forwarding table is constructed during data packet transmissions and its maintenance is much easier than a routing table. It can be seen as a trade-off between efficiency and scalability. As the establishment of the forwarding table only depends on local information, it takes much less time to be constructed. The expire time can be set on the items maintained to keep the table records only the current active flows, while in conventional protocols, a decrease in the route expire time would require far more resources to rebuild.

VHTD (Void Handling mechanism based on Temporary Destination)

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 (e.g., with more hops compared to the possible optimal path). More importantly, the robustness of multicast-style routing cannot be exploited. In order to enable opportunistic forwarding in void handling, which means even in dealing with voids, one can still transmit the packet in an opportunistic routing like fashion. So the virtual destination is introduced, as the temporary target that the packets are forwarded to.

Virtual destinations are located at the circumference with the trigger node as center but

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radius of the circle is set as a value that is large enough (e.g., the network diameter). It is used to guide direction of packet delivery during void handling.

Creating Air-Backup

When the MAC layer fails to forward a packet the function implemented in POR mac callback will be executed. Theitem in the forwarding table corresponding to that destination will be deleted and the next hop node in the neighbor list will also be removed. If the transmission of the same packet by a forwarding candidate is overheard, then the packet will be dropped without re forwarding again; otherwise, it will be given a second chance to reroute. The packets with the same next hop in the interface queue which is located between the routing layer and MAC layer will also be pulled back for rerouting. As the location information of the neighbors is updated periodically, some items might become obsolete very quickly especially for nodes with high mobility. This scheme introduces a timely update which enables more packets to be delivered.

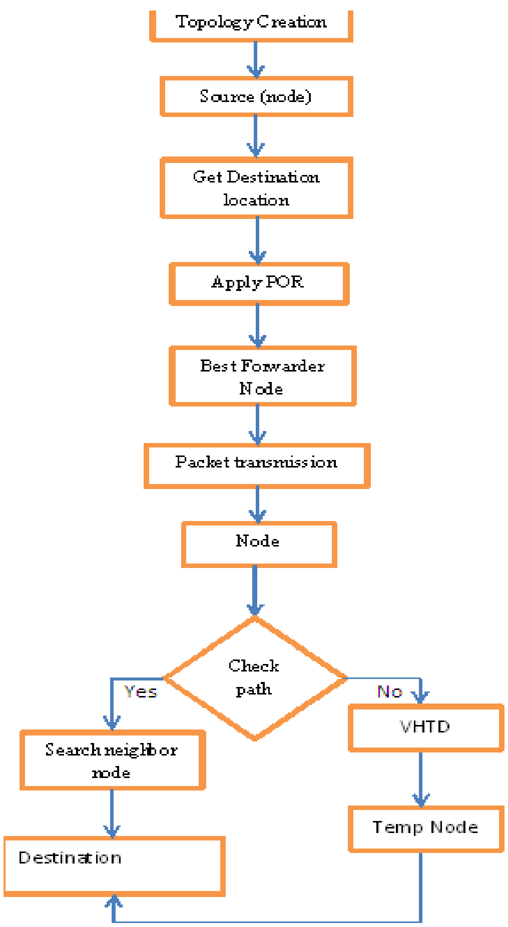

Figure 3: System architecture of POR

Results and Discussions

Performance Evaluation

The performance of POR is evaluated through a simulation study using NS-2.34. Table 3 summarizes the simulation parameters. For simulation the network is modeled with several mobile nodes placed randomly. The protocol,Position-based Opportunistic Routing (POR) is simulated independently and the performance metrics are evaluated.

Table -1: Simulation Parameters

Parameter	Value
Number of nodes	250
Transmission Range	300 m
Speed	15, 25, 150 m/s
Network topology	1500 ×1500 m^2
Antenna Model	Omni Antenna
Transmitter antenna gain	1 dBi
Receiver antenna gain	1 dBi
System loss factor	1.0
Propagation Model	Two- ray ground
Simulation Time	500 Sec

Performance Metrics

Packet Delivery Ratio: The ratio of the number of data packets received at the destination to the number of data packets sent by source.

End-to-end-delay: The time taken for a packet to be transmitted from the source to the destination.

Path Length: The average end-to-end number of hops for successful packet delivery.

The Network Simulator outputs POR routing.

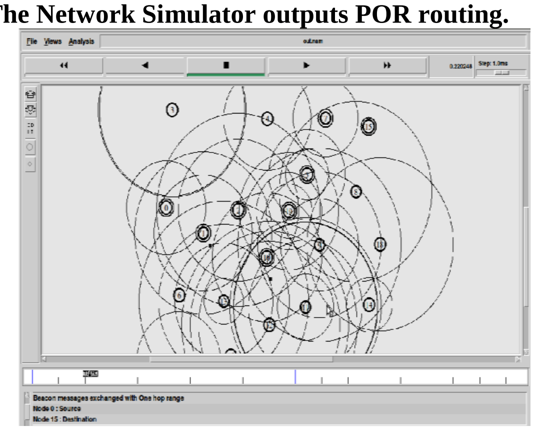

Figure 4: Beacons exchange

The Fig4 describe the exchanging of beacon messages in a dynamic time for position based routing.

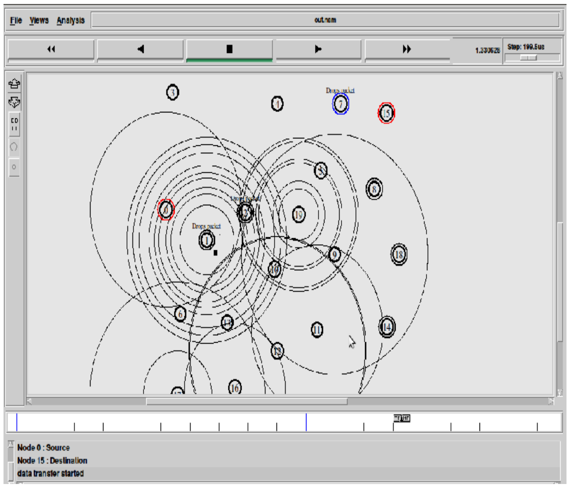

Figure 5: POR routing

The Fig5 describe dropping of packets in POR routing

Path form from node 0 to destination node 15
Backup nodes…………………
1>
2>
4>
6>
10>
19>
5>
7>
15>reaches End
Path form from node 0 to destination node 15
High Priority nodes selected…………………..
1>
2>
4>
6>
5>
7>
15>reaches End
Starting Simulation...
SORTING LISTS ...DONE!
ns2@ns2-pc$

Figure 6: Selecting Best Forwarder list in POR

The Fig6 describe Selecting Best Forwarder list in POR.In Forwarder list high priority node is selected for data transfer.Priority is given based on nearer (Short) distance to destination.The priority candidate list will be attached to the packet header and updated hop by hop.

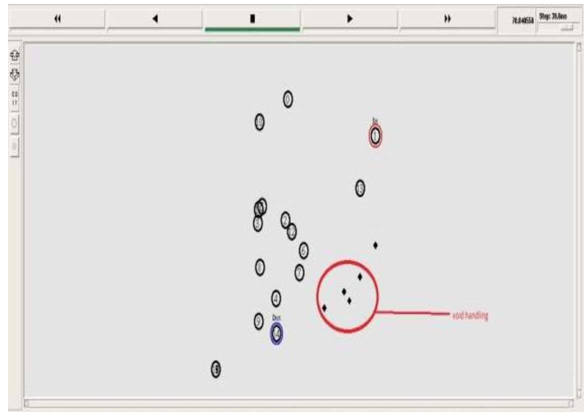

Figure 7: Void handling recovery

The fig 7 describes when the nodes are out of range or sleep state the communication hole will be appear so the nodes can't forward the packets. During this void handling process, the virtual destination is introduced as temporary target to guide packet delivery to the destination.

Conclusions

In this paper, the problem of reliable data delivery in highly dynamic mobile ad hoc networks is addressed. Dynamically changing network topology makes traditional 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, or experience long latency 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. Besides selecting the next hop, several forwarding candidates are also explicitly specified in case of link break. Leveraging on such natural backup in the air, broken route can be recovered in a timely manner. The efficacy of the involvement of forwarding candidates against node mobility, as well as the overhead due to opportunistic forwarding is analyzed. Through simulation, it is further confirmed that the POR is efficient. That is, high packet delivery ratio is achieved while the delay and duplication are the lowest. On the other hand, inherited from geographic routing, the problem of communication void is also investigated. To work with the multicast forwarding style, a virtual destination-based void handling scheme is proposed. By temporarily adjusting the direction of data flow, the advantage of greedy forwarding as well as the robustness brought about by opportunistic routing can still be achieved when handling communication voids. Traditional void handling method performs poorly in mobile environments while VDVH works quite well.

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