POR: Position based Opportunistic Routing for Reliable and Efficient Data Transmission in MANETs

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Abstract: In mobile ad hoc networks (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. In order to provide an efficient and reliable data delivery for these MANETs, a position-based opportunistic routing (POR) protocol is used. This protocol uses the best features of the exiting protocols and algorithms to achieve good performance. It uses GPS to find the exact location of the destination and greedy to route the data packets in an efficient manner to the destination. For the purpose of back up, POR uses the forwarding candidates, which are selected by the greedy node. In case of communication hole, that is if an intermediate node fails or moves out of the coverage area of the node, then Virtual Destination-based Void Handling (VDVH) scheme 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. The features such as greedy forwarding and robustness through opportunistic routing can still be achieved when handling communication voids. It is proved through simulation that the conventional void handling method exhibits poor results in mobile environments where as VDVH outperforms quite well.

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1. Introduction

In an wireless environment the nodes which are self-configuring, infrastructure less network of mobile devices are called as Mobile ad-hoc networks (MANETs). The node in the MANET will traverse independently and hence it changes it's link state information to other devices very often. While traverse it also forwards the information which are not related to that particular node to other node and hence it performs the operation of a router. In addition to the information that are to be equipped with individual devices for routing, it should also maintain the information required to properly route traffic. This functionality makes the device in MANET to act as sender, receiver and an intermediate node.

The remarkable advantages of MANETs such as multi-hop, infrastructure-less transmission etc., makes it as a best medium to networks. However, the constraints that are to be addressed in MANETs such as error prone wireless channel, the dynamic network topology, reliable data delivery (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006), especially in challenged environments with high mobility remains an issue. Traditional topology-based MANET routing protocols (e.g., DSDV, AODV, DSR) (J. Broch et al., 1998) (S. Biswas and R. Morris 2005) are quite susceptible to node mobility. The reason is due to the predetermination of an end-to-end route before data transmission. It is very difficult to maintain a deterministic route owing to the constantly and even fast changing network topology. The discovery and recovery procedures are also time and energy consuming. Once the path breaks, data packets will get lost or be delayed for a long time until the reconstruction of the route, causing interruption in transmission.

So, to provide an efficient and reliable data delivery (Visu. P and Kannan. E., 2013) in MANETs, a Position-based opportunistic routing protocol (POR) (M. Mauve et al., 2001) (D. Chen et al., 2007) (Stamatiou, K. et al., 2012) is used which when compared with the MANET protocols provides excellent data delivery. This takes advantage of the stateless property of geographic routing (N. Arad and Y. Shavitt 2009) (Xiang, Xiaojing et al., 2012) (Guoliang Xing et al., 2006) (Quanjun Chen et al., 2013) and the broadcast nature of wireless medium. When a data packet is forwarded, the nodes which overheard the transmission will serve as forwarding candidates, and take turn to forward the packet if it is not relayed by the specific best forwarder within a specific period of time. By utilizing such in-the-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 the case of communication hole, a Virtual

Destination-based Void Handling (VDVH) scheme is further proposed to work together with POR.

This paper is to focus on certain objectives. First, the deployment of position-based opportunistic routing mechanism (S. Biswas and R. Morris 2005),(S. Chachulski et al., 2007),(E. Rozner et al., 2007),(Z. Yang et al., 2009) without applying complex modification to MAC protocol and achieve multiple reception without losing the benefit of collision avoidance provided by 802.11. Secondly, the robustness of the routing protocol and reduces the latency and duplicate forwarding significantly enhances due to the concept of in-the-air backup the caused by local route repair. Third attention is to suggest a Virtual Destination-based Void Handling (VDVH) scheme in which the advantages of greedy (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006) forwarding like a large progress per hop and opportunistic routing (D. Chen et al., 2007)(Stamatiou, K. et al., 2012) can still be achieved while handling communication voids. Fourth objective is to analyse the effect of node mobility on packet delivery and explain the improvement brought about by the participation of forwarding candidates. Fifth is to consider the overhead of POR with focus on buffer usage and bandwidth consumption due to forwarding candidates' duplicate relaying is also discussed. Through analysis, it is concluded that due to the selection of forwarding area and the properly designed duplication limitation scheme, POR's performance gain can be achieved at little overhead cost. Finally, the performances of POR evaluated through extensive simulations and verify that POR achieves excellent performance in the face of high node mobility while the overhead is acceptable.The routing mechanism concepts described in detail by Carmel Mary Belinda. M. J and Kannan. E., (2013). The details presented in the remaining part of this paper are as follows: section 2 describes the conventional MANET routing protocols (J. Broch et al., 1998) (D. Ganesan et al., 2001) and the proposed Position based Routing Mechanism. Section 3 presents the architecture of the proposed work, Section 4 dealt with the results and discussions and the section 5 conclude with future scope.

2. System Analysis

2.1. Conventional MANET Routing Protocols

BrochJ et al (1998) compared the performances of the various available MANET protocols. And they addressed the issues of various topology-based MANET protocols DSDV, DSR, AODV and provide comparison between them. However, the link breakages are not detected quickly and so most of the data packets are dropped. Further, irrespective of the availability of current data for exchange, DSDV maintain routes between all nodes. This causes unnecessary traffic and prevents nodes from saving battery power. Even though only some user data has to be transmitted, it keeps the track of topology through the nodes by exchanging routing information.

Similarly the drawbacks of DSR such as the route maintenance mechanism that does not locally repair a broken link, so rerouting must be carried out. Stale route cache information could also result in inconsistencies during the route reconstruction phase. Also, the connection setup delay is higher than in table-driven protocols. The performance degrades rapidly with increasing mobility even though the protocol performs well in static and low-mobility environments,

With regard to the constraints of AODV, the intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Similarly, the Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. Hence, there is unnecessary bandwidth consumption due to periodic beaconing.

2.2. Position-Based Routing Mechanism

Widmer A and Hartenstein H (2001) presented a survey on the various methods used in position-Based Routing. They presented the pros and cons of the different location services and forwarding strategies used in position-Based Routing. The following are the basic Location services:

1. DREAM(Distance Routing Effect Algorithm For Mobility)
2. Quorum-Based Location service
3. GLS(Grid Location service)

DREAM (Distance Routing Effect Algorithm For Mobility):

As per this algorithm, each node maintains a position database that stores position information about each other node that is part of the network. It's an all-for-all approach.

Quorum Based Location Service:

By this service, Information updates are sent to a quorum of available nodes, and information requests are referred to a potentially different subset. A virtual backbone is constructed between the nodes of the subset, using a non-position-based ad hoc routing mechanism. A mobile node sends position update messages to the nearest backbone node, which in turn chooses a quorum of backbone nodes to host the position information.

GLS (Grid Location Service):

The area that contains the ad hoc network is divided into a hierarchy of squares. Each node maintains a table of all other nodes within the local first order squares. Similar to the location service, there are two main Forwarding Strategies adopted. One is Greedy Packet Forwarding (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006) where, the packet is forwarded to the node that makes the most progress towards the destination. And the second is restricted directional flooding, where, the sender of a packet will forward the packet to all one-hop neighbors that lie in the direction of the destination by calculating the expected region.

There are few constraints faced in location services such as the least scalable position service and thus inappropriate for large scale and general purpose ad hoc networks (D. Ganesan et al., 2001) (W. Seah, and S. Rao 2001) in DREAM service. The quorum system requires operations for position updates and position lookups thereby increasing the communication complexity. Similarly, it is more difficult to control the location service which is based on GLS in a dynamic environment (Quanjun Chen et al., 2013) (D. Chen and P. Varshney 2007) and in the presence of node failures.

Equal amount of drawbacks are also encountered in forwarding strategies they are the only drawback of greedy approach (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006) is that the position of the destination needs to be known with an accuracy of a one-hop transmission range. Restricted directional flooding as a communication complexity and therefore does not scale to large networks with high volume of data.

2.3. Void- Handling Techniques

D. Chen and P. Varshney (2007) presented an overview of various void-handling techniques that are available for geographic routing (N. Arad and Y. Shavitt 2009) (Xiang, Xiaojing et al., 2012) (Guoliang Xing et al., 2006) (Quanjun Chen et al., 2013). Their work on A planar graph is graph that can be embedded in the plane so that no adjust intersect. In a wireless network the nodes are considered as vertices and the links as edges. The graph formed by a wireless network is usually not planar. Thus, additional techniques are required to obtain a planar sub graph.

The concept of Flooding Based Void Handling is assumed that every node in the network is supposed to receive a copy of stuck packets. When a packet gets stuck at a void node for a specific destination, its starts route discovery. The route discovery phase finds a path from the void node to the destination on demand and updates the routing table at all the nodes on the path.

The second method of Void handling is Heuristic Void Handling. This technique is based on some intuitive ideas that can't be named to a strict theoretical analysis of their effectives and efficiency. It utilizes some extra resources are directly exploit some inherent properties of network topology and some geographic properties of void areas. Some of the heuristic voids handling techniques are alternate network, active exploration, and passive participation**.**

Another method is Hybrid Void handling, this method combines at least two void handling techniques together to handle void more effectively and efficiently. Some of the hybrid void handling techniques is partial source routing plus passive participation, bound hole plus restricted flooding and active exploration plus passive participation.

2.4 Conventional Mobile Ad-Hoc network routing Protocol

The traditional topology based mobile ad hoc network routing protocols (J. Broch et al., 1998) (S. Biswas and R. Morris 2005) like DSDV, AODV, DSR lack the reliable and timely delivery of the data to the mobile nodes due to the predetermination of an end-to-end route before data transmission. The main challenging task comes if the location of the intermediate nodes changes. Because the process of routing the packets will be difficult due to change in position of the nodes. This method suffers due to the following. That is Due to the predetermination of an end-to-end route before data transmission the data is not delivered. Second, the discovery and recovery procedures are time and energy consuming. Finally, during path breaks or transmission interruptions the data packets will get lost or be delayed for a long time until the route is reconstructed.

2.5 Position Based Opportunistic Routing

In the Position Based Opportunistic routing (POR) system, the geographic routing (N. Arad and Y. Shavitt 2009) (Xiang, Xiaojing et al., 2012) (Guoliang Xing et al., 2006) (Quanjun Chen et al., 2013) for finding the location and the opportunistic routing using the greedy algorithm (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006) for the reliable and timely delivery of the data packet is used.This mechanism can be deployed without complex modification to MAC protocol. 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. Virtual Destination-based Void Handling (VDVH) is used to overcome communication voids.

3. Architecture of Ad-Hoc routing Protocols

3.1 Architecture of Mobile Based Ad-hoc routing Protocols

The following figure shows the Architecture of the Mobile Ad-hoc routing Protocols system. In the Mobile Ad-hoc routing Protocols system (D. Ganesan et al., 2001) (W. Seah, and S. Rao 2001), the forwarding table is maintained by each and every node to know the location of the neighbouring nodes. This is done by exchanging beacon messages between each and every node which leads to un-necessary traffic in the network.

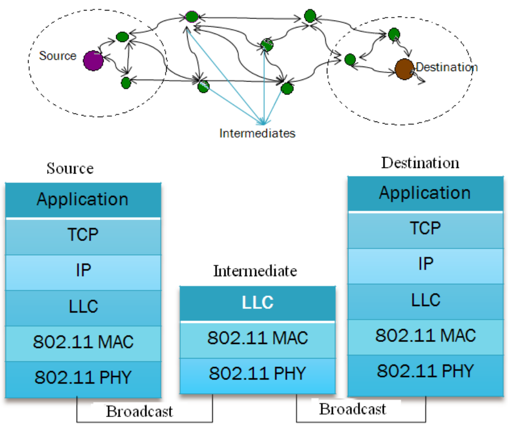

Figure.3.1.Architecture of Mobile Based Ad Hoc routing Protocols

In addition, to find the route towards the destination, the broadcast nature of the MAC protocol is used. But, broadcasting is not reliable as it may lead to packet drop or the sending of the data packet to un-necessary node. Therefore, it leads to the traffic in the network. Even though the packet reaches the destination, the network overhead in the Mobile Ad-hoc routing Protocols system is really high.

3.2. Architecture of Position Based Opportunistic Routing

The following figure shows the Architecture of the Position Based Opportunistic routing (POR) system. In the Position Based Opportunistic routing (POR) system, 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 (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006) 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 (B. Karp and H.T. Kung 2000) (Guoliang Xing et al., 2006). 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 that has occurred.

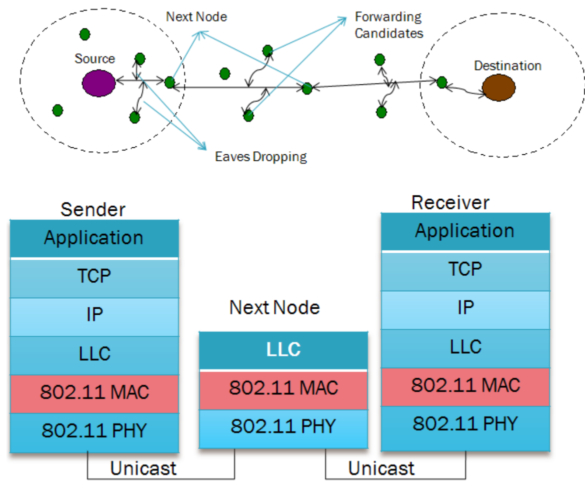

Figure.3.2. Architecture of Position based Opportunistic Routing

4. Results And Discussion

This work used the ns2 simulator to run the experiments. The network covers a 1000 m by 1000 m area, in which 25 nodes are deployed randomly. For our evaluations, we use the average of 20 runs for each set of parameters tested. The resulting 95% confidence intervals are within ±2% of the values shown.

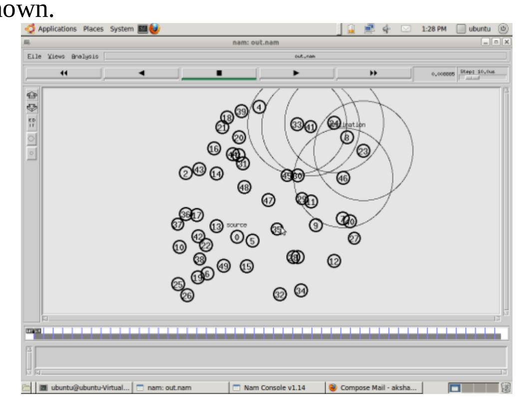

Figure 4.1Position update by the destination (node 8) to the neighbouring nodes

Initially, all the nodes present in the network update their position to all of its neighbouring nodes. These updates are updated in the routing table that is maintained by each and every node. The update of the destination node is made and that can be seen in Figure 4.1. Once the positions of the neighbouring nodes are updated, the route to the destination is found and the data transmission takes place.

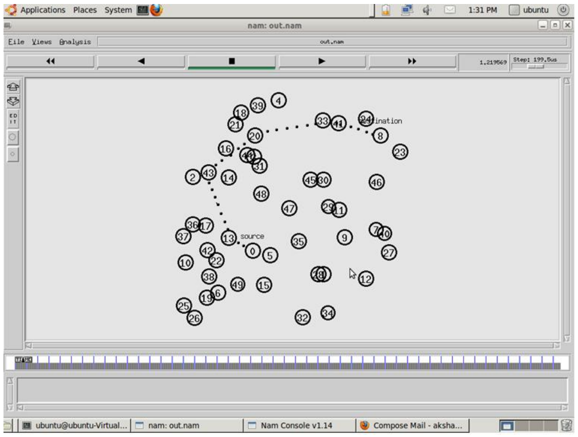

Figure 4.2 Data transmission from source(node 0) to destination(node 8) through node 13, node 43, node 20, node 33.

In the above Figure 4.2, the data transmission of the data packet from the source node to the destination can be seen. The dotted lines represent the path of the data transmission. If a new node is present in the coverage area of the source, then that node updates its location to the source so that the data can be transmitted in the efficient manner.

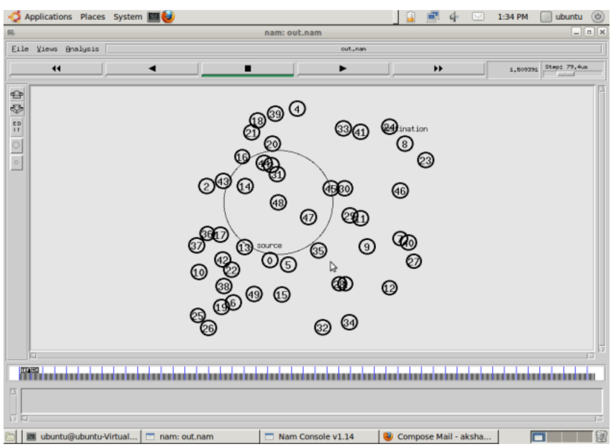

Figure4.3 Position update by node 48

In the above Figure 4.3, it is presented that the position update of node 48 to the source as the route towards the destination is changed via 48, which is the shortest and efficient method of transmitting data. After the updation of the node 48, the data transmission takes place in an alternate path, which traverses less number of nodes to reach the data to the destination.

The new path to the destination is through 0->48->30->8, where node 0 is the source and node 8 is the destination.

As the node 48 moves out of the coverage area of the source node, the source sends the data to the destination through a new path.

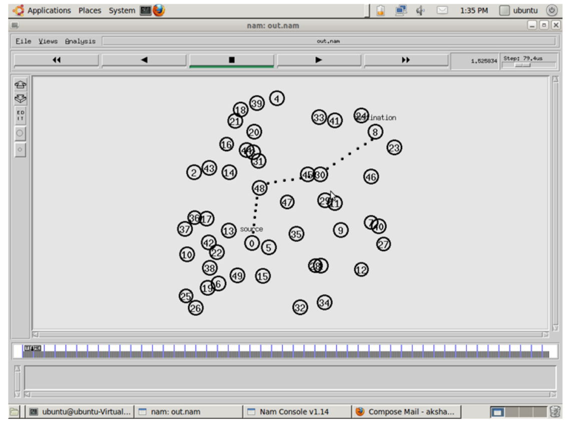

Figure 4.4 Data transmission from source (node 0) to destination (node 8) through node 48, node 30 after node 48 updates its position

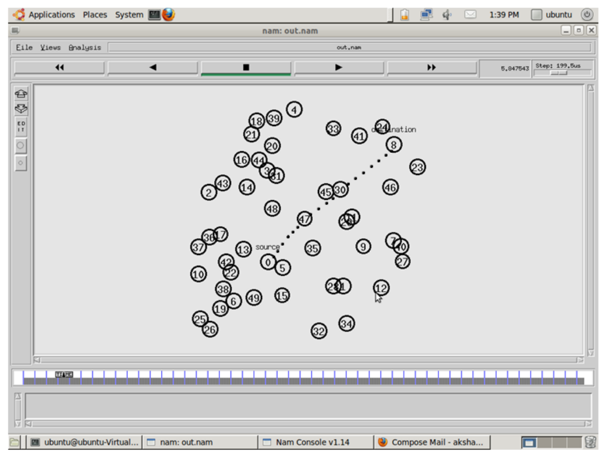

Figure 4.5. Data transmission from source (node 0) to destination (node 8) through node 47 and node 30

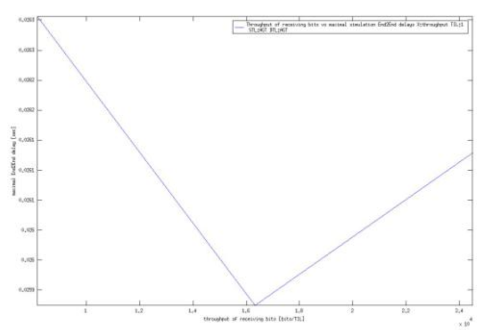

Figure 4.6.Throughput of sending bits vs. end-to-end delay (DSDV)

The data transmission takes place through the node 47 instead of node 48 as node 47 is the farthest node towards the destination from the source. This re-routing is done faster when compared to other protocols. In the existing protocol (DSDV), the throughput of sending bits initially increases with the increase in the end to end delay, but at a certain point (i.e.,) when a particular node moves out of the coverage area of the other node, the throughput of sending bits starts getting decreased due to the packet drop that occurs. This shows that the process of finding an alternate route to the destination takes more duration and hence leads to the dropping of the packets.

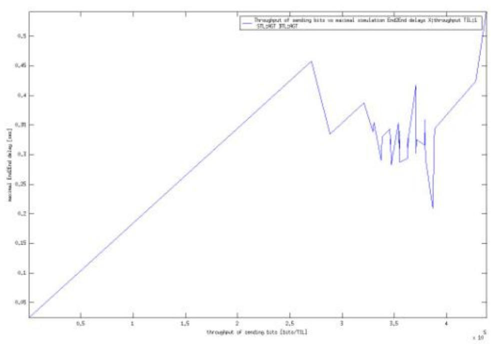

Figure 4.7.Throughput of sending bits vs. end-to-end delay(POR)

In the Position Based Opportunistic routing (POR) protocol (POR), the throughput of sending bits increases linearly with the increase in the end-to-end delay. This shows that the end-to-end delay is not a problem in case of POR and so, if a node moves out of the coverage area then an efficient VDVH mechanism is followed by POR, to route the packets safely to the destination.

When the POR is compared with the DSDV, it performs well in case of a communication void and the process of rerouting. This can be clearly inferred from the graphs in Figure.4.6 and Figure 4.7.

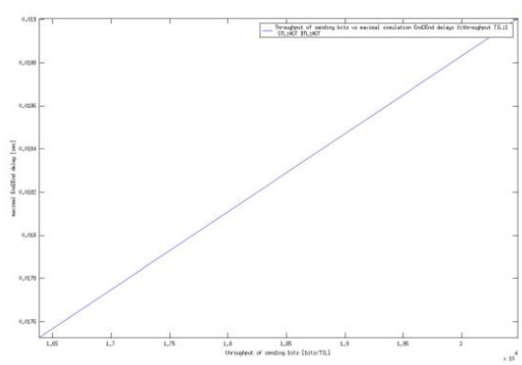

Figure 4.8.Throughput of receiving bits vs. end-to-end delay (DSDV)

In the existing protocol (DSDV), the throughput of receiving bits initially increases with the increase in the end to end delay, but at a certain point (i.e.,) when a particular node moves out of the coverage area of the other node, the throughput of receiving bits starts getting decreased due to the packet drop that occurs. This shows that the process of finding an alternate route to the destination takes more duration and hence leads to the dropping of the packets.

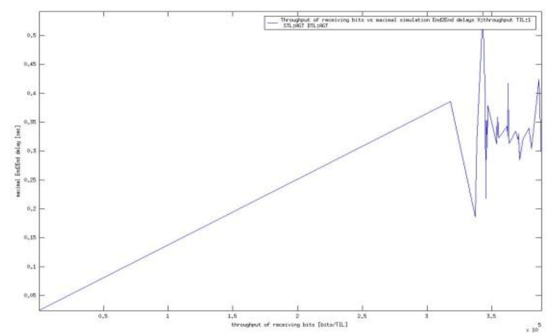

Figure 4.9.Throughput of receiving bits vs. end-to-end delay (POR)

In the Position Based Opportunistic routing (POR) protocol (POR), the throughput of receiving bits decreases linearly with the decrease in the end-to-end delay. Once the end-to-end delay increases due to communication hole, the throughput of receiving bits also increases. This shows that the end-to-end delay is not a problem in case of POR and so, if a node moves out of the coverage area then an efficient VDVH mechanism is followed by POR, to route the packets safely to the destination.

When the POR is compared with the DSDV, it performs well in case of a communication void and the process of rerouting. This can be clearly inferred from the graphs in Figure4.8 and Figure 4.9.

5. Conclusion & Future Scope

This work addressed the problem of reliable data delivery in highly dynamic mobile ad hoc networks. It is observed that the constantly changing network topology makes 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.

This work presented a novel MANET routing protocol POR 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 effectiveness and efficiency of POR: 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.

This work may further continued with the enhancement of POR by including the security in the data transmission. The current MANETs lack security as the concept of security in MANETs is challenging and still under research. Also one can improve the void-handling technique by improving the strategies that are presently used.

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