Predictive Preemptive Ad Hoc on-Demand Multipath Distance Vector Routing Protocol

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Abstract: Routing in Ad-Hoc network is a challenging problem because nodes are mobile and links are continuously created and broken. Routing protocol for Ad-Hoc networks uses the route discovery and route maintenance mechanisms, the performance of these routing protocol depends on these mechanisms. In the existing on-demand protocols the route discovery algorithm initiates the route discovery after the path breaks, so it creates the frequent route discovery and route failure problem. To avoid this problem, in this paper we propose a Predictive Preemptive approach to route discovery. Route discovery is initiated when a "route failure" is about to occur rather than waiting for the break to happen. Proposed predictive preemptive routing protocol predicts the route failure by the received power of the packet. To evaluate this approach added it to the AOMDV routing protocol, and evaluated its performance with AOMDV. The Predictive Preemptive AOMDV was implemented using NS-2.The simulation results show the Proposed approach improve the performance. It reduces the routing overhead, decreases the route discovery, delay and improves PDF.

Keywords: Ad-Hoc networks, AODV, AOMDV, Multipath Routing, PPAOMDV.

1. Introduction

A mobile Ad-Hoc Network (MANET) [1] is a collection of mobile nodes that form a wireless network without the use of any fixed base station. Each node acting as both a host and a router arbitrarily and communicates with others via multiple wireless links, therefore the network topology changes greatly. The routing protocols proposed so far can be divided in to 2 categories: proactive routing protocol and reactive routing protocol. Reactive routing protocol, which initiates route computation only on demand, performs better than proactive routing protocol, which always maintains route to destination by periodically updating, due to its control overhead.

In such dynamic network, it is an essential to get route in time, perform the routing with maximal throughput and minimal control overhead. Several on-Demand routing protocol have been proposed. In such protocols, nodes build and maintain the routes as they are needed. Examples of these protocols include the Dynamic Source Routing (DSR) [8] and Ad hoc On-Demand Distance Vector AODV Routing protocol [2]. These protocols initiate a route discovery process whenever a node a route to a particular destination. In AODV the source broadcasts a route Request (RREQ) packet in the network to search for route to the destination. When a RREQ reaches either the destination or an intermediate node that knows a route to the destination, a Route Reply (RREP) packet is unicast back to the source. This establishes a path between the source and destination. Data is transferred along this path until one of the links in the path breaks due to node mobility. The source is informed of this link failure by means of a Route Error (RERR) packet from the node upstream of the failed link. The source node then re-initiates a route discovery process to find a new route to the destination. It is a single path routing, which needs new route discovery whenever path breaks. To overcome such inefficiency, several studies have been presented to compute multiple paths. If primary path breaks, they provide alternative paths to send data packets without executing a new discovery.

The current multipath routing protocols multiple route obtained during Route Discovery process [12]. The best path that is the path with the shortest hop count is chosen as the primary path for data transfer while other paths are used only when primary path fails. These protocols do not perform any prediction of route failure before the path breaks or route fails. As a result it leads the problem of frequent route discovery for data transmission.

In this paper, we propose an approach that uses the "Route Failure Prediction Technique" for estimating whether an active link is about to fail or will fail. To evaluate this approach to route failure prediction, we have added it to Ad Hoc on- Demand Multipath Distance Vector Routing Protocol (AOMDV) using the Network simulator. This simulator includes implementations for many ad hoc routing protocols, and it has been validated by the frequent use by researchers.

In the existing On-Demand Routing Protocol the Route Discovery is initiated when all the path breaks, waiting to break the path leads to problem of frequent route discovery and increases the delay. To solve this problem it computes "the received power of each receiver node" using route failure prediction technique to discover the route from source and destination. A source node sends the RREQ packet, if the receiver node is less than threshold value then drops the packet and sends the warning packet to the sender than a source node discards the route containing, therefore, the selected routing path exclude the nodes that are going out of threshold. Similarly, to send the DATA packet it again calculates the received power of the receiver node if it is less than threshold sends RERR packet. A Route Maintenance mechanism is implemented to repair a broken route or finds the new route when all route failed. A Route Maintenance mechanism is implemented to repair a broken route or finds the new route when all route failed.

The rest of the paper is organized as follows. Section 2 describes related work. Section 3 describes the AOMDV route discovery and route maintenance. The proposed protocol is presented in section 4, and its performance is evaluated and compared with that of AOMDV in section 5. Some conclusions are given in section 6.

2. Related Work

This section summarizes various examples of on-demand multipath routing protocols especially from the viewpoint of route discovery strategy

AODV Backup Routing (AODV-BR) [3] enhances the AODV by letting each neighboring node of a primary route maintain its own backup route. When the node over a primary route detects a link failure, it transmits a route update message and a neighboring node receiving this message activates the backup route. A problem of this approach is limitation of the route selection that is at most within one hop distance.

Preemptive Ad Hoc routing Protocol [12] propose a preemptive route maintenance extension to on-demand routing protocols. Its aim is to find an alternative path before the cost of a link failure is incurred. The received transmission power is used to estimate when a link is expected to break. A link is considered likely to break when the power of the signal received over it is close to the minimum detectable power. Route repair is the responsibility of a source node after receiving a warning about the imminence of a link break on an active route to a destination. This mechanism has been applied to DSR; AODV is also considered, but only superficially.

Predictive Preemptive Ad-Hoc On Demand Routing Protocol [13] propose a predictive preemptive approach to route maintenance. Route maintenance is initiated when a link break is expected rather than waiting for the break to happen. To evaluate the approach, we have added it to the AODV routing protocol, and evaluated its impact on performance using detailed simulations. The simulation results show that the proposed approach can be expected to improve performance significantly.

AOMDV (Ad hoc On-demand Multipath Distance 'Vector routing) [5] is a sophisticated protocol which produces multiple routes with loop-free and link-disjoint properties. When an intermediate node receives copies of a RREQ packet, it compares a hop count field in a packet with the minimum hop count, called *advertised-hopcount*, stored in a routing table for previous RREQ packets. Only a packet with the minimum hop count is accepted to avoid routing loops. Furthermore, a *firsthop* field in a RREQ packet is then compared with the firsthop-list in a routing table. When a route with node-disjoint property (new *firsthop)* is found, a new reverse route is recorded. Destination returns RREP packets accordingly, and multiple routes with link-disjoint' property are established at a source node. A problem of AOMDV is that several efficient routes may be missed due to strong restriction by the firsthop field. Another problem is lack of backup route maintenance that causes timeout expiration of backup routes.

3. AOMDV Overview

Ad Hoc On-Demand Multipath Distance Vector Routing Protocol (AOMDV) [5] is one of the most used Ad-Hoc routing protocol. It is a reactive routing protocol based on DSDV. AOMDV is designed for networks with tens to thousands of mobile nodes.

The main idea in AOMDV is to compute multiple paths during route discovery. It is designed primarily for highly dynamic ad hoc networks where link failures and route breaks occur frequently. When single path on-demand routing protocol such as AODV is used in such networks, a new route discovery is needed in response to every route break. Each route discovery is associated with high overhead and latency. This inefficiency can be avoided by having multiple redundant paths available.

The AOMDV protocol has two main components:

1. A route update rule to establish and maintain *multiple loop-free* paths at each node.
2. A distributed protocol to find *node-disjoint* paths that is route discovery.
3. The Route Maintenance Strategy.

In AOMDV a new route discovery is needed only when all paths to the destination break. A main feature of the AOMDV protocol is the use of routing information already available in the underlying AODV protocol as much as possible. Thus little additional overhead is required for the computation of multiple paths.

3.1 Route Discovery

The route discovery process has two major phases: route request phase and route reply phase. The route discovery process will be initiated when a route is requested by a source node and there is no information about the route in its routing table. First, the source node generates an RREQ and then floods the packet to networks. The RREQ’s are propagated to neighbors within the source’s transmission range. They also broadcast the packets to their neighbors. The process is repeated until the destination receives the RREQ. When an intermediate node receives the RREQ, it performs the following process:

1. When an intermediate node receives the information of RREQ, either it sends the route reply if the node is destination, or it rebroadcasts the RREQ to its neighbors.
2. The node reads the information from the RREQ.

In order to transmit route reply packets to the source, the node builds a reverse path to the source. The node will insert the path to its multiple path lists. Otherwise, the node will ignore the path and discard the RREQ.

3.2 Route Maintenance

Link failures in ad hoc networks are caused by mobility, less received power, congestion, packet collisions, node failures, and so on. In the AOMDV protocol, the link layer feedback from IEEE 802.11 is utilized to detect link failures. If a node sends packets along the broken link the node receives a link layer feedback. When a node detects a link break, it broadcasts route error (RERR) packets to its neighbors. If a source node receives the RRER, remove every entry from its routing table that uses the broken link. Differing from single path routing protocols, the route error packets should contain the information not only about the broken primary path but also the broken backup paths. When the source node receives the RERR's, it removes all broken routing entries and uses the shortest backup paths as primary paths. The source node initiates a route discovery process where all backup paths are broken.

4. Predictive Preemptive AOMDV

4.1 Protocol Assumptions

In this section we present the operation of predictive Preemptive Ad-Hoc On Demand Multipath Distance Vector routing protocol (PPAOMDV). The Predictive Preemptive AOMDV is ad-hoc Reactive routing protocol based on DSDV. Predictive preemptive AOMDV is an extension of AOMDV, The goal behind the proposed protocol is to provide efficient recovery from "route failure" in dynamic network. To achieve this goal in this approach the "route failure prediction technique at the time of route discovery, computes the "received power of the receiver node" to predict pre-emptively before the route fails.

In Ad Hoc networks route failure may occurs due to less received power, mobility, congestion and node failures. Predictive Preemptive AOMDV predicts pre-emptively the route failure that occurs with the less received power.

4.2 Route Discovery

Predictive Preemptive AOMDV uses the Route Discovery method to discover the multiple node-disjoint paths. The route discovery uses the 2 different phases. Route Discovery phase and Route Reply phase. The Route Request phase is used to discover the path it broadcasts the RREQ packets. When an intermediate node receives the RREQ it performs following operation.

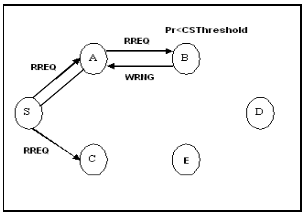

Figure 1. Route Request in EAOMDV

The above figure 1 shows the Route Request in EAOMDV; here the source node S wants to send the data to the destination D. Source S floods the RREQ packet to its neighbour nodes , Node A broadcasts the RREQ to the others nodes. After Broadcasting the Route Request Node B calculates the Receiver Power if it has less than Threshold it Drops the packet and sends the WRNG packet.

When an intermediate node receives the RREQ it performs following operations.

Step 1: The node measures its Received Power (Pr) by comparing the "Carrier Sense Threshold".

Step 2: If Received power Pr of receiver node is less than threshold then the host drop the packet and send the warning packet.

Step 3: The routes with the less received power can be avoided, and then selects another path for transmission. The received power is goes on checking at every node.

The following algorithm 1 shows the Route update Rule for Route Request:

Route Reply Phase, when the destination receives the route request packet, it sends route reply (RREP) packet to the source along the reverse paths created previously. The destination sends RREP to next nodes of reverse paths. They also forward the packet to next nodes until the source receives the RREP.

The pseudo code of our RREQ method is presented below; each time when a Route Request (RREQ) is received we execute the following code

Definations:
RREQ: A route request packet.
CSThreshold: carrier sense threshold.
Pr: Received power.
WRNG: Warning Packet.

Procedure Route Request (RREQ)

```
Begin
When an intermediate node receives RREQ
 if (Pr < CSThreshold) then
Drop the packet and send the WRNG packet to
source node.
else if (Pr == CSThreshold)
else ((Pr > CSThreshold)  then
boardcast the RREQ to its neighbor nodes;
endif
 else
 Drop the packet RREQ and choose the another
path;
 endif
```

Algorithm1. Route update rule for Route Request.

4.2 Data Transmission Phase

Predictive preemptive AOMDV sends the Route reply using the reverse path. When source node receives the RREP it starts the transferring the DATA packet from Source to Destination using the same path (forward path). Again after transferring the DATA packet it checks the Received power (Pr) of receiver node with the threshold value. If the pr is greater than the CSThreshold it transfers the DATA packet else drops the packet along with this path and sends the RERR packet. The received power is goes on checking at every node.

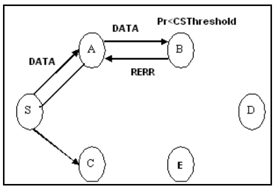

Figure 2. DATA Transmission in EAOMDV

The above figure 2 shows the DATA Transmission phase in Predictive preemptive AOMDV; here the source node S wants to send the DATA packet to the destination D. When an intermediate node receives the DATA packet, it performs following Steps.

Step 1: The node measures its Received Power (Pr) by comparing the "Carrier Sense Threshold".

Step 2: If Received power Pr of receiver node is less than threshold then the host drop the packet and send the REER packet through the MAC Layer.

Step 3: The routes with the less received power can be avoided, and then selects another path for transmission. The received power is goes on checking at every node.

The following algorithm 2 shows the Route update Rule for DATA Transmission:

Definitions:

RERR: route Error.
CSThreshold: carrier sense threshold.
Pr: Received power.
DATA: DATA Packet.

Procedure Route Request (RREQ) update

Begin
When an intermediate node receives DATA
if (Pr < CSThreshold) then
Drops the packet and send the RERR packet to source node.
else if (Pr == CSThreshold)
if ((Pr > CSThreshold) then
boardcast the DATA to its neighbor nodes;
endif
else
Drop the DATA packet and sends the REER packet and choose the another path;
endif
End

Algorithm2. Route update rule for DATA transmission.

Link failure is detected by the link layer and sends the REER packet through the MAC Layer. It receives the RRER the Route Maintenance phase is called to maintain the REER.

5. Simulation and Performance Results

5.1 Simulation Environment

The Predictive Premptive AOMDV was evaluated using the Ns-2 [9] simulator version 2.32 with CMU's multihop wireless extensions. In the simulation, the IEEE 802.11 distributed coordination function was used as the medium access control protocol. The physical radio characteristics of each wireless host were based on Lucent's WaveLan. WaveLan was direct spread spectrum radio and the channel had radio propagation range of 250 meters and capacity of 2Mb/sec. The AOMDV and Predictive Preemptive AOMDV (PPAOMDV) are to be compared in the simulation. Our results are based on the simulation of 50 wireless nodes forming an ad hoc network moving about in an area of 1500 meters by 300 meters for 100 seconds of simulated time. Nodes move according to the random waypoint model in a free space model.

The traffic patterns consists of 30 constant bit rate(CBR) sources sending 512 byte packets at a constant rate 4 packets per second. The random waypoint model was used to perform node movement. The movement scenario files used for each simulation are characterized by a pause time. Each node begins the simulation by selecting a random destination in the simulation area and moving to that destination at a speed distributed uniformly between 0 and 20 meters per second. It then remains stationary for pause time seconds. This scenario is repeated for the duration of the simulation. We carry out simulations with movement patterns generated for 5 different pause times: like 0, 10, 20, 30, 40 and 100 seconds. A pause time of 0 seconds corresponds to continuous motion, and a pause time of 100 (the length of the simulation) corresponds to limited motion.

5.2 Simulation Results and Analysis

The following performance metrics used to evaluate the two routing protocols:

Packet delivery ratio: The ratio of the data packets delivered to the destination to those generated by the CBR sources.

End to End delay: Average time between data packets received by the destinations and data packet sent by CBR source. The data were collected only successfully delivered packets. The delay is determined by any factors such as buffering during route discovery, queuing at the interface queue and routing paths between two nodes.

Overhead: The number of routing packets transmitted per data packet delivered to the destination.

Throughput: the total size of data packets that are received in CBR destinations per second. It represents in whether the protocols make good use of network resources or not.

We report the results of the simulation experiments for the original AOMDV protocol with the PPAOMDV. In this we analyze the performance metrics by the pause time.

Figure 3 compares the Average end-to-end delay by the different pause time. The routing protocols in varying in pause time. The graph demonstrates the node-disjoint PPAOMDV performs better then AOMDV; End-to-End delay is less Because of less route discovery.

Figure 4 plots the routing overhead of two routing protocols against pause time. Observe that node-disjoint PPAOMDV has a less overhead than AOMDV. The reasons for less overhead is less route discoveries are initiated in PPAOMDV, which lead to the flooding of RREQ.

Figure 5 compares the packet delivery ratio of routing protocols in varying pause time. In the simulation all the nodes move the same specified speed. The graph demonstrates the node-disjoint PPAOMDV performs better then AOMDV; the paths in the Nod-Disjoint PPAOMDV fail independently due to their node-disjoint property.

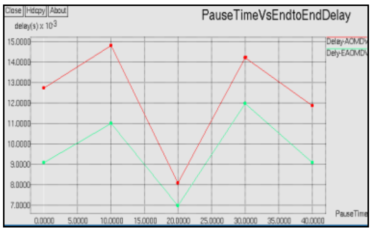

Figure 3.End-to-End Delay of AOMDV and PPAOMDV

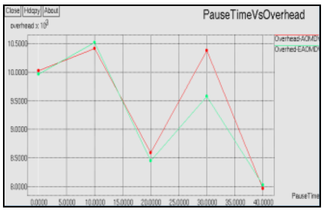

Figure 4: Overhead of AOMDV and PPAOMDV

Figure 6 compares the throughput for both the protocols. Throughput of PPAOMDV is better compared to AOMDV because of less Route Discovery; it saves the bandwidth and the network resources

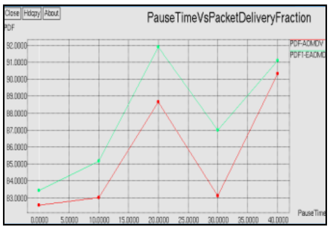

Figure 5: Packet Delivery Fraction of AOMDV and PPAOMDV

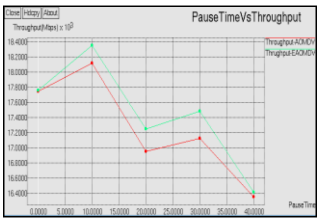

Figure 6: Throughput of AOMDV and PPAOMDV

6. Conclusion and Future Work

Multipath routing can be used in on-demand protocols to achieve faster and efficient recovery from route failures in highly dynamic Ad-hoc networks. In this project we have proposed an Enhanced Ad-Hoc on-Demand Multipath Distance Vector routing protocol that extends the AOMDV protocol to compute the stable path. There are three main contributions in this work. One is computing multiple loop-free paths at each node, another calculating received power of each node while transferring packets and node-disjoint route discovery mechanism.

Simulation results show that the throughputs, packet delivery fraction PPAOMDV are more than that of AOMDV. Also overhead of PPAOMDV is less than that of AOMDV. This is because PPAOMDV selects the node disjoint path pre-emptively before the path fails. If one path breaks then it selects an alternative and reliable node-Disjoint path. The advantage is less Route Discovery and Reduces the Route Error Packets.

In PPAOMDV it uses multiple paths only one path is used at a time. It is possible to use multiple paths simultaneously for increasing data rate, which is not considered in this project. This aspect can be one area for future work.

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