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ENHANCED AD HOC ON DEMAND MULTIPATH DISTANCE VECTOR FOR MANETS

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ABSTRACT

Mobile Adhoc Networks (MANETs) include wireless devices communicating over bandwidth-constrained links with nodes being free to move, join or leave network. Limited range wireless communication and node mobility ensure that nodes cooperate with each other to network and with underlying network, dynamically changing to meet needs continually. This research investigates performance of a highly dynamic mobile network using Ad hoc On-demand Multipath Distance Vector (AOMDV) routing protocol under various active route timeout and proposes a Link Quality based improved AOMDV (LQ-AOMDV) routing protocol modeled on how quickly link changes occur and optimizes protocol overheads. Quality of Service (QoS) parameters are measured and compared to AOMDV routing protocol.

Keywords: *Mobile adhoc networks (MANETs), Adhoc On-demand Multipath Distance Vector (AOMDV), Link Quality (LQ) and Quality of Service (QoS).*

1. INTRODUCTION

MANET, a type of wireless adhoc network, is a self-configuring network of mobile routers which is connected by wireless links without access point. Each mobile device in a network is autonomous and are free to move haphazardly and organize themselves arbitrarily i.e. adhoc network do not rely on any fixed infrastructure. Communication in MANET is done by using multi-hop paths. In MANET, communication link break is very frequent, as nodes freely move everywhere. The density of nodes and node numbers are dependent on the applications in which MANET is used [1].

MANET are wireless devices communicating over bandwidth-constrained links with nodes being free to move, join or leave network – factors that with the time-varying wireless channel behaviour result in a highly-dynamic network system [2]. MANETs differ from conventional cellular networks as links are wireless and mobile users communicate without a base station. Autonomous mobile users collection is a MANET, where communication is over bandwidth constrained wireless links. MANETs use peer-to-peer wireless connections, where packets from source node are transmitted through intermediate nodes called relay nodes to a destination node. A MANET topology dynamically changes when users join, leave or re-join network. Sometimes, MANET radio links may be unusable due to node mobility [3].

Routing determines source to destination path to enable nodes to communicate. Adhoc networks routing protocols are reactive, proactive and hybrid. Reactive protocols are called demand driven protocols as they locate paths only when needed. Such protocols discover new routes by sending route request and receiving route replies. Nodes maintain active routes. Delay is the major drawback of these protocols. Network topology is maintained by proactive protocols such protocols. In a network every node has information about neighbors in advance. Different tables enable keeping of routing information and are constantly updated according to network topology changes. Topology information is exchange by nodes to ensure they have route information. Combining proactive and reactive protocols produces hybrid protocols which use distance-vector for precise metrics to establish best paths to destination networks. Here, every node has own routing zones and zone size is defined by zone radius. Every node has a routing information record for own zone. Routers maintain information of adjacent routers in hybrid protocols. Source initiates route establishment to a destination on demand during reactive operation [4].

An on-demand, single path, loop-free distance vector protocol is Adhoc On-demand Distance

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Vector (AODV) which combines DSR's on-demand route discovery mechanism with destination sequence numbers concept from DSDV. But, unlike DSR which uses source routing, AODV takes a hop-by-hop routing approach. AOMDV has many characteristics similar to AODV. It is distance vector concept based using hop-by-hop routing approach. Moreover, AOMDV finds routes on demand using a route discovery procedure. The difference is in number of routes in every route discovery. RREQ propagation from source to destination sets up multiple reverse paths at intermediate nodes and the destination in AOMDV. Multiple RREPs traverse reverse paths to form multiple forward paths to destination at the source and intermediate nodes. Note that AOMDV provides intermediate nodes alternate paths as they are useful to reduce route discovery frequency [5].

AOMDV calculates multiple paths during route discovery in highly dynamic adhoc networks where link breakage is frequent due to vehicles high velocity. AODV routing protocol needs a route discovery procedure after every link failure. Performing this leads to high overhead and latency which is overcome by making multiple paths available. In AOMDV, performing route discovery procedure is only after all paths to source or destination fails. AOMDV routing protocol uses routing information available in underlying AODV protocol. Nonetheless, little additional modification is required to calculate multiple paths. AOMDV protocol includes two main sup-procedures:

- Calculating multiple loop-free paths at each node: Route discovery procedure define alternate paths to source or destination in AODV routing protocol. Each RREQ packet copy received by nodes, introduce alternate paths to source.
- Finding link-disjoint paths through use of distributed protocols: Loop-free mechanism enables nodes to establish multiple paths to destinations which conveys it to next stage that is dis-jointness process [6]

Power consumption is also an issue in an adhoc network with battery-powered nodes. Quality of service is required in an adhoc network supporting delay sensitive applications like video conferencing. A routing protocol has to balance traffic based on links traffic load [7]. Link quality is a promised parameter, as it defines link and devices ability to support traffic density for the connected period. Link state amid two neighbors is affected by many parameters like distance, battery power and mobility. The second parameter in route selection is the connections number over same path to choose those with fewer connections (traffic) as route to save intermediate nodes resources over this path by distributing network traffic on other nodes. This consequently increases system life and end to end delay [8].

The traditional AOMDV finds shortest paths based on hop count which is not feasible as the quality of the links in the path maybe below par. This leads to degradation of QoS provided. To overcome this, the proposed routing considers link quality during path selection. This study models a new protocol based on how fast a link change occurs and optimizes protocol overheads to a minimum. QoS parameters are measured and compared to AOMDV routing protocol. This study is as follows: section 2 deals with reviews of some of approaches for BCI in literature. Section 3 discusses methodology used in the study and section 4 reports results of experiments with section 5 conclude the paper.

2. LITERATURE REVIEW

Network Coding-based AOMDV (NC-AOMDV) routing in MANET proposed by Yang, et al., [9] suggested a routing algorithm to increase data transmission reliability or provide load balancing. In simulation, NC-AOMDV routing protocol is compared to AODVM routing protocol, regarding packet delivery ratio, packet overhead and average end-to-end delay during packet transmission. Simulation results reveal that NC-AOMDV routing protocol provides accurate and efficient estimates and evaluates route stability in dynamic MANETs.

An improved AOMDV to increase path stability by using node mobility information in MANET was proposed by Park, et al., [10] where authors suggest an algorithm that excludes high mobility nodes from constructing a path by collecting and managing mobility information. Hence, the proposed algorithm ensures more stable paths. In this algorithm, MRecord Field and Relieve Field are appended in the routing table to collect and manage mobility information by extending current AOMDV. Additionally, Mbl Field is added to RREP message to adapt collected information for path configuration. The proposed protocol's performance is analysed, and compared to existing AOMDV using ns-2 simulator.

A revised AODV protocol with QoS for MANETs was proposed by Ping and Ying [11], in which AODV routing protocol was revised by calculating corresponding QoS provision values to

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find best routes and to apply the carrier sense mechanism in IEEE 802.11b to get available bandwidth. Simulation showed that use of QoS parameters in route discovery process significantly reduces end-to-end delay and increases packet delivery ratio under high load and moderate to high mobility conditions, though AODV routing load was slightly less than that of the new protocol.

AOMDV protocol based on Autoregressive Moving Average (ARMA) model forecasts resources to meet adhoc networks QoS requirements was proposed by Tekaya, et al., [12]. The authors applied this model to AOMDV protocol. The results show that combining AOMDV protocol with time QoS forecasting based on ARMA processes performs better than that based on AR processes and conventional AOMDV.

Associativity-based dynamic source routing in MANETs was suggested by Heo and Song [13] where authors provided stable path(s) between communicating pair of end nodes. A new notion for gauging nodes temporal and spatial stability of nodes is used and also on paths interconnecting them. Paths thus discovered are easier to maintain and suit QoS provisioning. This protocol reduced end-to-end delays leading to better QoS provisioning and data communication performance. The new mechanism was compared to DSDV, AODV and AOMDV.

A assessment of QoS routing protocols in MANETs was presented by Gulati and Kumar [14] with its strengths and weaknesses. A comparative study of QoS routing protocols was undertaken and also current issues and future challenges involved in this exciting research were included.

A mechanism-based QoS and security requirement for MANETs was proposed by Sedaghat, et al., [15]. The study aimed to present a new mechanism for AOMDV to handle the issues of QoS reliability and security with minimum data redundancy. Coding techniques were used and original data dispersed over many paths. As a security tool, hop-by-hop authentication mechanism was used to prevent important and known attacks. Simulation revealed that the mechanism ensured high packet delivery ratio and low overhead.

A new approach to improve AOMDV protocol robustness was proposed by Yelemou [16] where the author defined a method to record reasonable number of paths at intermediate nodes for route request processes. These will solve route breakage problems locally. Thus, source node is rarely asked to reinitiate route request process. As a second improvement, links reliability in the route choice was considered. The author modified route request process so that reliable paths regarding Bit Error Rate (BER) were preferred. The new protocol's effectiveness considered these improvements and were tested under realistic conditions and compared to standard AOMDV and AODV protocols. The results reveal that author improved standard AOMDV performance in difficult conditions like mobility or Multi-communication.

Bongartz, et al., [17] evaluated proactive link quality based uni- and multicast routing protocol for MANETs. They evaluated a new approach to use link layer parameters to determine link quality value for route calculation, especially for multicast data dissemination. Simulation suggests that a shortest path metric is not the best choice. Instead, signal strength based metric provided better results compared to common protocols.

Using long routing messages to screen out low-quality link information in MANET was introduced by Kang and Bahk [18]. For this, routing messages structure of two proactive routing protocols, DSDV and OLSR were modified to enable routing nodes transmit longer Hello messages. Simulation shows that use of longer Hello message improved packet delivery ratio, and had acceptable routing message overhead.

A QoS-Aware Routing Protocol based on Entropy (QARPE) for MANETs was proposed by Lian, et al., [19]. QARPE provides stable multi-path routing which inhibited entropy metric to guarantee stability and QoS conditions of selected routing. It adopted QoS conditions like delay, bandwidth and jitter to reduce route reconstructions as much as possible, QARPE ensures a standby route. Simulation showed that QARPE was an accurate and efficient method with stable multi-path satisfying MANETs QoS constrains.

3. METHODOLOGY

This study models a new protocol based on how fast link change occurs and optimizes protocol overheads to minimum. QoS parameters are measured and compared to AOMDV routing protocol.

3.1 AOMDV routing:

The idea behind multi-path routing is to find multiple paths between source and destination. MANET on-demand routing protocols discover routes when sources need to communicate with destinations. The multi-path routing protocol locates many paths during single route discovery.

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These paths are used for load spreading or as backup routes when primary routes fail [20].

AOMDV is a multi-path extension of AODV. When a source, in AODV, wants to communicate with a destination it initiates route discovery by flooding route Request (RREQ) packets to destinations through networks. Duplicate RREQs are recognized, and rejected through use of unique sequence numbers. When an intermediate node receives a non-duplicate RREQ packet, it first sets up a reverse path to source using earlier RREQ hop as next hop on reverse path. If a valid destination route is available in the routing table, then intermediate nodes generate route reply (RREP) packet, or else RREQ is rebroadcast. When destinations receive a non-duplicate RREQ, it in turn generates a RREP which is reverted to source through reverse path. Nodes update routing information and propagate RREP on receipt of further RREPs only when it has either a larger destination sequence number (fresh) or when a shorter route is located.

AOMDV, like AODV is based on distance vector using a hop by hop routing approach. AOMDV finds routes on demand using route discovery. Unlike AODV, AOMDV locates multiple routes on a single route discovery. AODV discards all duplicate RREQs whereas AOMDV seeks a chance to get an alternate route with every duplicate RREQ. RREQ propagation from source, in AOMDV, to the destination establishes multiple reverse paths at intermediate nodes and destinations. Multiple RREPs traverse these reverse paths to form multiple forward paths to destination at source and intermediate nodes. AOMDV provides alternate paths to intermediate nodes as they are useful to reduce route discovery frequency. AOMDV protocol's core is in ensuring that located multiple paths are loop free and disjoint; and in finding paths efficiently using flood-based route discovery. AOMDV route update rules, applied at each node locally, has a key role in maintaining loop-freedom and disjoint-ness properties. [21-24].

Evaluating link quality according to received signal strength is descriptive for other network factors like battery power, intra node distance and mobility. Battery power is important as a node with less energy in its battery has small transmission range affecting link quality in its neighborhood. Reception power is relative to distance between nodes as whenever distance increases, link quality decreases. Link between two nodes is affected directly by nodes' mobility in the way link quality decreases whenever neighbors go away and increases whenever they come closer [27].

This study proposes Link Quality (LQ) parameter based on Packet Reception Rate (PRR) and Received Signal Strength (RSS) as

$$LQ = PRR*RSS \quad (1)$$

PRR and RSS are computed as follows:

PRR is a percentage of nodes that receive a packet from tagged node when all receivers are within transmission range of sender when packet is sent out [3]. From the above explanation, PRR can be taken as percentage of mobile nodes in tagged node's transmission range which receive broadcast messages successfully in a virtual slot. PRR is for single packet transmission [25].

$$PRR = PRR_1 . PRR_2 . PRR_3 \quad (2)$$

$$= \frac{e^{\beta R \tau}}{2\beta R^2 c\tau}\left(1 - e^{-RC}\right)\left(1 - e^{-\beta R\tau}\right) \quad (3)$$

PRR is divided into three 1) nodes receive transmitting packet from tagged node when there are no nodes within transmission range of tagged node transmit at time instant when tagged node transmit; 2) only some nodes receive transmitting packet as there is at least a node in transmission range of tagged node transmitting in virtual slots; 3) some nodes in [-R, R] may not receive broadcast packet if nodes in two potential hidden terminal areas transmit during the vulnerable period T_(vuln.).

RSS is a readily available and cost-effective method to locate, estimates, or localize in wireless networks. [26].

$$RSS = P_t - PL(d_0) - 10\alpha \log_{10}\frac{d}{d_0} + X_{\sigma RSS} \quad (4)$$

where RSS is received signal strength in decibels with respect to milliwatts (dBm). In the equation d is true distance from sender to receiver, α is path-loss exponent, Pt is transmit power of sender in dBm, $PL(d_0)$ is power loss in dBm at reference distance d_0. Quantity $X_{\sigma RSS}$ in dBm is a random variable representing noise in measured RSS and assumed to be a zero-mean Gaussian random variable with variance σRSS. Source of noise $X_{\sigma RSS}$ in measured RSS comes from time varying and time-invariant sources. Time varying errors, like interference is averaged out by taking multiple measurements corresponding to same distance. Time-invariant errors like shadowing due to

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heterogeneity in medium due to objects like walls or buildings, causes signal to degrade contrary to path-loss model. These errors are not averaged out by taking multiple measurements, as path loss model cannot be specifically designed for every wireless channel in every deployed network. Many researchers observed that random effects of shadowing are modeled by assuming error $X_{\sigma RSS}$ to be Gaussian.

4. RESULTS AND DISCUSSION

In this study, a new protocol is modeled based on how fast the link change occurs and optimizes the protocol overheads to a minimum. The QoS parameters are measured and compared with AOMDV routing protocol. The results obtained are shown from figure 1- 4.

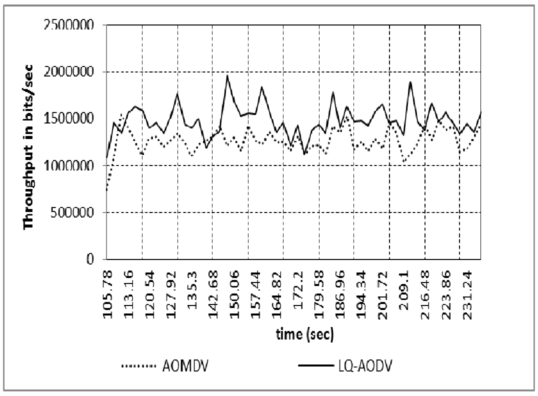

Figure 1: Throughput in bits/sec

Figure 1 depicts the proposed LQ-AOMDV having high throughput than normal AOMDV protocol.

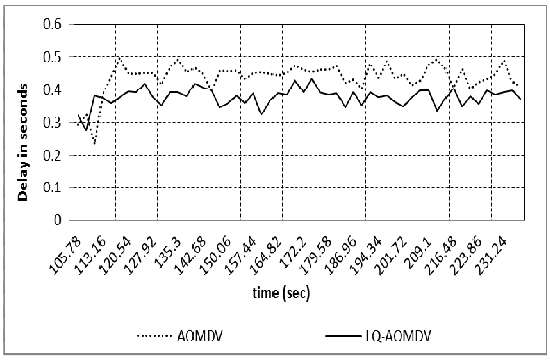

Figure 2: Delay in seconds

Figure 2 depicts the proposed LQ-AOMDV having low Delay in seconds than normal AOMDV protocol.

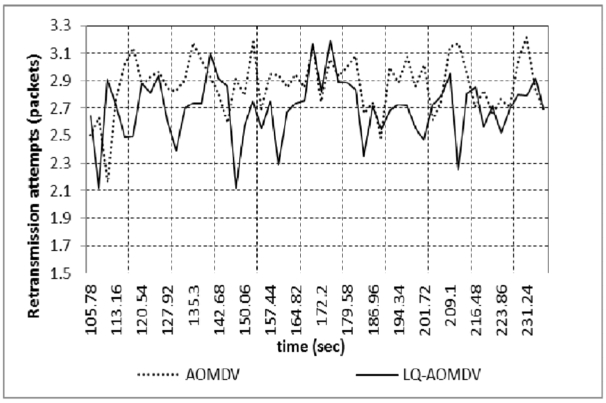

Figure 3: Retransmission attempts (packets)

Figure 3 depicts the proposed LQ-AOMDV having low Retransmission attempts (packets) than normal AOMDV protocol.

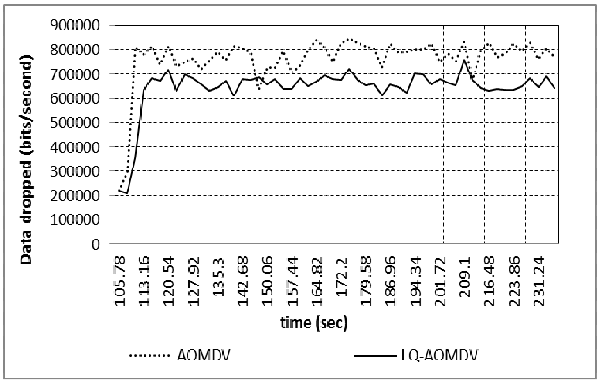

Figure 4: Data dropped (Bits/sec)

Figure 4 depicts the proposed LQ-AOMDV having low Data dropped (Bits/sec) than normal AOMDV protocol.

5. CONCLUSION

MANETs are mobile adhoc network systems which are dynamic and self-organized in temporary topologies. This research investigates performance of a highly dynamic mobile network using AOMDV routing protocol under various active route timeout and proposes an Link Quality based improved AOMDV routing protocol. The new protocol is modeled on how fast link change occurs and optimizes protocol overheads. QoS parameters are measured and compared to AOMDV routing protocol. The new LQ-AOMDV has 17.13%, high throughput, 13.79% lower delay, 5.86% low Retransmission and 15.66% low Data dropped (Bits/sec) than normal AOMDV protocol. Further

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investigations are required to optimize the parameter selection in AOMDV.

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