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Dynamic Routing Protocol for QoS Enhancement in Wireless Mobile Ad-Hoc Networks

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Abstract— One of the serious challenges of wireless mobile ad-hoc networks is the inability to guarantee link quality of service (QoS) due to the frequent changing topology nature. To remedy this effect, this paper proposes a dynamic multipath routing protocol that is capable of choosing a better path for fulfilling different data traffic requirements. A multiple-path metrics - using weighted cost function, available bandwidth estimation and data-driven expected transmission (DDET) count – are adopted in providing the needed QoS for different traffics. The obtained results from simulations demonstrate the new method's ability to achieve better round trip time and packet delivery ratio as perceived by the existing protocols. This work has demonstrated that an improved throughput and reduced end-to-end delay could be achieved using the multipath metrics selections to provide QoS for various traffics in mobile ad-hoc networks.

Keywords— Wireless mobile ad-hoc network; Multipath-metric routing protocol; Data-driven expected transmission; Quality of service; Round trip time; Packet delivery ratio.

1. INTRODUCTION

Most existing research works on routing protocols in wireless mobile ad-hoc networks focuses attention on how to cope with mobility of the nodes, fast changing topologies, scalability as well as choosing a minimum path for hop-count [1]. In such a network, it is highly desired to look for a reliable route that ensures high-quality multimedia streaming while considering lossy wireless or congested paths. This paper considers a mobile ad-hoc network (MANET) which streams multimedia traffic (audio and video) that requires exceptional quality of service (QoS). Multimedia streaming in MANET experiences setbacks such as increased variations in channel capacity and transmission error rate as a result of multipath fading and path loss propagation (shadowing) effect [2, 3]. Over the past many years, many MANET routing protocols have been proposed by researchers considering the inherent properties of the network. Ad-hoc on-demand distance vector (AODV) routing protocol and dynamic source routing protocol (DSR) are two well-known MANET routing protocols. In the DSR routing protocol, packets carry the whole route information in their header. Therefore, when the network size increases, the packet size also increases proportionally. This restricts the use of the DSR in larger networks. The AODV routing protocol overcomes this problem by storing the routing information in routing tables in each node's memory; therefore, even when the network size increases, the packet size will not increase.

Although some of the studies did not pay attention to QoS provisioning, single metric-based protocols treat all data traffic equally and focuses on providing the desired QoS with respect to throughput and delay [4, 5]. However, it is not necessary that single metric-based

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protocols might fulfill the demands of multimedia traffic. For such reasons, a few numbers of schemes did consider multi-metrics [6, 7] as well as multipath [8, 9]. In addition, the key metrics considered, by most of the protocols, for route selection are route expiration time and energy consumption which may not necessarily reflect the QoS requirements of multimedia traffic. In an on-demand basis, the reactive routing protocol tries discovering routes but doesn't frequently update the routing tables; e.g. AODV and DSR. However, each node maintains a table in the proactive routing protocol that comprises of the latest information about the routes to reach a node.

However, these works could not offer routes of better quality of services for variety of applications. To solve the problem of current routing protocols as well as making available service differentials to different applications, a multiple-metrics, multipath routing protocol (MMRP) that uses weighted cost function to choose the rightest route based on the needs of applications, is proposed. Data-driven expected transmission (DDET) and the incorporation of bandwidth aggregation methods with weighted cost function for quality of service provisioning, is also proposed in this work.

In MMRP, routing decision is made by considering traffic requirements because application requirements differ from those required by different service qualities such as generation of video streams that is more demanding than voice traffic. In order to achieve desired signal level, a minimum bandwidth for the video transmissions is necessary. However, for voice streaming more stringent steps are required and shortest reliable path to deliver while link reliability is key to the data. This implies that the new proposed protocol is at a mercy to choose the readily available bandwidth for the video traffic and the most reliable path for voice traffic. However, for the critical data, the path with low DDET is chosen for highly reliable link. Moreover, multipath based on aggregated requests is capable of providing the right path and each data traffic choses to individual data traffic. Results from simulations demonstrate some significant improvement as it concerns packet delivery ratio and mean packet delay on the overall performance of the existing ad-hoc protocols.

The rest of this paper is organized as follows: section 2 outlines the detailed design of the MMRP routing protocol. Section 3 presents the performance study of the proposed method while section 4 concludes the paper.

2. RELATED WORKS

Several research works have evaluated and addressed the behaviour of routing protocols over lossy links. The authors Sa'ad et al. [8] refer to links that delivers data routing protocol traffic as "gray zones". They proposed the use of link handshake and route count broadcasts to sort out the gray zone links. In a similar work, Lundgren et al. [9] equally proposed link handshake for filtering asymmetric links. A work - that describes how DSR route requests are preemptively issued- was provided by Fatna et al. [10] based on optimized scheme to secure IoT systems using Sharing Secret in a multipath protocol.

It has been observed in the work of Hu and Johnson [11] that for sensor networks, routing metric performs poorly in terms of hop-count. Therefore, they instead used loss-aware metric to present their results. However, the product of the per-link delivery ratios adopted path-metric routing to approximate. As earlier argued, the path/link with small quantity of high-loss may show better performance when compared to the metric where low-loss paths are likely to use multiple hops [12]. In a similar work, Awerbuch et al. [13] presented a high throughput complementary ETX path to a suggested metric path that does not account for losses on links at different bit-rates.

Redundancy was found to be one of the solutions to high link loss ratios in a measure of improving the apparent loss ratio. Other alternative approaches to solving this phenomenon; i.e., link loss ratios include forward error correction (FEC), re-transmission and MAC-level acknowledgment, as well as Snoop-TCP [13] and Tulip [14]. Low-loss-ratio technique is preferred over high-loss-ratio since it reduces link capacity and cause interference. In an effort to avoid high-loss-ratio links, thresholds of ad-hoc wireless routing algorithms are applied to bring together the signal strength of the links as discussed in [15-18]. This approach fails to accurately distinguish between links or avoids links that need to be connected.

The technique for route selection usually adopts a top-down approach to determine wireless QoS algorithms. To guarantee bandwidth availability, some of these metrics schedule either transmission slots in time or frequency division MAC layers as described in [19-21]. As long as the lower layers are capable of providing correct information on the links (average number of usable transmission slots or the achievable throughput), such approaches are assumed to succeed as none of the techniques consider lossy links conditions.

The authors in [22] adopted a technique and evaluated the performance of delay and DSR with multi-services traffic in mobile ad-hoc networks. In [23], a multi-services MANETs routing problem was formulated and a DSR protocol was implemented. The evaluation of constant bit rate (CBR) traffic was achieved in [24] after considering three mobility models of random waypoint (RWP), random direction (RD) and Mobgen-steady state (MSS). It was shown that optimal delay is achieved by RWP in weak densities of nodes and by MSS over high density of nodes. In another development, the work of [25] was able to achieve maximum packet delivery ratio (PDR) using strength pareto evolutionary algorithm (SPEA) protocol as well as calculate the fitness value. The fitness value was used to find out the optimal path for efficient data delivery to the target destination with substantial improvement in PDR, end-to-end delay and hop-count.

Furthermore, DSR protocol is one of the reactive routing protocols, which has distinguishing feature that uses source routing technique instead of independent hop-by-hop technique, where routing decisions are made. On the other hand, AODV protocol is a reactive or on-demand routing protocol since the routes are established and maintained only when required. It permits the users to find and maintain routes to other users in the network. However, the routing decisions are made based on distance vectors; i.e., distances measured in hops to all available routes created based on an on-demand request basis. In source routing, the packet that is to be routed through the network carries the complete ordered list of nodes in its header through which the packet will pass and therefore, the basic operation of DSR here is route discovery and route maintenance.

3. THE MULTIPATH-METRIC ROUTING PROTOCOL

The cost of a path according to the protocol architecture would be estimated by considering multipath-metrics. This is possible by using weighted cost function in determining the many routes starting from source node to destination node based on the requirements of data traffic.

3.1. Cost Function Design for Multipath-Metrics

A brief and precise explanation of the weighted cost function design is being described here with the objective of estimating the cost of each path with different path-metrics. Three important metrics were considered; bandwidth, DDET count and end-to-end path length with the costing of the metrics being estimated independently. Thereafter, the total cost of unit path is calculated individually from the costs of those metrics. Furthermore, the choice of the multitudes of metrics for the single route, makes it possible for multiple route quality. While different data traffic requires different services, multi-quality paths are likely to appropriately provide traffics for each data route. Therefore, the wholesome estimate (cost) of a route contains variety of cost functions as a weighted sum and is calculated as follows:

$$C_i = \alpha p(u_i) + \beta q(v_i) + \gamma s(x_i) \quad (1)$$

where C_i stands for the total cost of path i and $\alpha+\beta+\gamma=1,\ 0\le\alpha,\beta,\gamma\le 1$. The value N represents set of possible paths from the same source and those of destination pair and the functions $p(u)$, $q(v)$ and $s(x)$ are the individual cost functions for different metrics. With α , β and γ given as weights of those functions respectively, the cost functions are defined thus;

$$p(u) = \frac{u_{\max} - u}{u_{\max}}, 0 \le u \le u_{\max} \quad (2)$$

$$q(v) = \frac{v - v_{\min}}{v_{\max} - v_{\min}}, v_{\min} \le v \le v_{\max} \quad (3)$$

$$s(x) = \frac{x - x_{\min}}{x_{\max} - x_{\min}}, x_{\min} \le x \le x_{\max} \quad (4)$$

where x, u and v represent the DDET bandwidth and hop count of the route, respectively. Based on the data traffic requirements, the values of α , β and γ are chosen. Therefore, every data traffic, the same source and destination pair may have multiple paths.

The function $p(u)$ in Eq. (2) calculates the cost of the path in terms of bandwidth availability, whereas u_{max} is the channel bandwidth. It should be noted in Eq. (2) that, as the wider the available bandwidth p, the lower the bandwidth cost. Consequently, $q(v)$ in Eq. (3) estimates the cost of the path length v. The maximum route length (v_{max}) is calculated using analytical observation and discussed in section 3. Also to be noted in Eq. (3), is the fact that the shorter the path length is, the lower is the cost. Furthermore, function $s(x)$ uses DDET to compute the cost of the path which means that a lower DDET stands for lower cost of the route and all cost functions are having same scalar domain [0, 1].

A weight for each function is introduced to make chosen metrics a priority with the weighted values being changed based on the traffic requirements. In other words, the weighted value of α must be higher than β and γ while using Eq. (1) to calculate the route's cost. Additionally, for voice data, the weight of β should be higher than α and γ . This has become necessary due to the requirements of the voice traffic that require a shorter and reliable route. Similarly, important data, γ require even higher traffic than α and β . A bigger weight value of γ consequently shortens the cost of the route as it affects DDET and improves the chances of reliable path selection.

3.2. DDET Design

In observing the ratio of distributed link loss in ad-hoc networks, experiments were conducted for estimating the loss ratio of the link considering pair-wise packet delivery ratio. The physical layer of the wireless network 802.11b and CBR for the data traffic in the application layer were considered. Fig. 1 shows the diagram of pair-wise packet delivery ratio of the links involved in delivering the data. Two important things are observed in the link loss ratio distribution: i) a high loss ratio is experienced by large number of links (which are unlikely to deliver data packets) and ii) a much higher delivery ratio than the data and successfully acknowledged (ACK) packets are observed to be obtained. This phenomenon indicates that the data and ACK packets may not be the accurate reflection of the true link status.

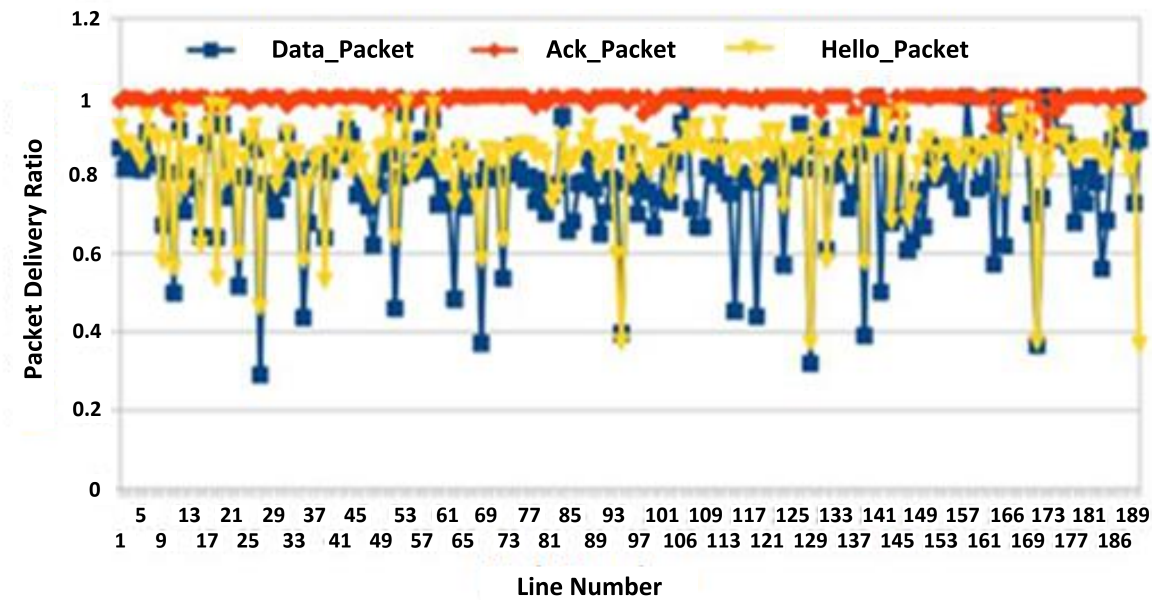

Fig. 1. Ratios of delivered data packets.

The expected transmission count (ETX) represents the number of packet transmissions inclusive of retransmissions. The source ETX adopted both forward and reverse delivery ratios computed for the links using dedicated broadcast probe packets with ETX of a routing path considered as the sum of all the ETX in the route.

Furthermore, the ratio of probe packets delivered may not necessarily account for the link transmissions or retransmissions because the size of probe packets broadcasted are small when compared to multimedia packets. Although the link is observed to be lossy, it is possible that ratio of probe packet delivered could be that high, while packet dropping probability is very low. Therefore, this paper proposed the calculation process to determine more accurate estimation of DDET protocol. Only probe packets are used when no data traffic is placed on the link to be considered for delivering the actual data packet ratio in estimating the DDET. Monitoring data traffic in the network is done periodically by each node to compute the links' packet delivery ratio (d_{data}) as given by [26]:

$$d_{data}(t) = \frac{N_{ack}(t-T,t)}{N_{data}(t-T,t)} \tag{5}$$

with $N_{data}(t- T, t)$ and $N_{ack}(t- T, t)$ are the number of packets transmitted and acknowledgements at time window T for the node, respectively.

The DDET could be measured from the probe packet only if at a particular time data traffic is not captured on the link. In this work, voice (Hello) message is being used as the probe packet where every host in the network sends series of packets "Hello" for a fixed time window T, during which the sent and received packets are counted. Assuming every mobile terminal sends a "Hello" packet of dedicated size every τ seconds, then, the delivery ratio (d_{voice}) at time t becomes:

$$d_{hello}(t) = \frac{N_{hello}(t-T,t)}{\frac{T}{\tau}} \tag{6}$$

where $N_{voice}(t - T, t)$ represents received "Hello" packets in the last T seconds and T/τ is the quantity of received probe packets.

Consequently, the estimate of data-driven transmission will be computed as:

$$\text{DDET} = (d)^{-1} \tag{7}$$

where d stands for route's forward delivery ratio of packets type. This is to say when data and "Hello" packets are being considered, d becomes $d_{data}(t)$ and $d_{voice}(t)$ of the route.

Forward and reverse delivery ratios are used to calculate the ETX of a link where the probability of successfully delivered forward packet ratio at the receiving end is denoted d_f. On the other hand, the probability of ACK packet delivery ratio is given as d_r. Therefore, the probability that a packet is successfully transmitted and acknowledged is measured as $d_f \times d_r$. For a packet that is not successfully acknowledged, retransmission is initiated and so Bernoulli trial is considered to calculate the expected number of transmissions using the formula in Eq. (8) as:

$$ETX = \frac{1}{d_f \times d_r} \tag{8}$$

3.3. Estimating Bandwidth Availability

It is required that routing protocol accurately estimates the bandwidth availability of a link in order to provide sufficient QoS for different traffics. However, estimating the bandwidth using the MAC layer of the IEEE 802.11 network is challenging since the individual nodes have no prior knowledge about the status of the neighbouring nodes with data traffic. However, since the bandwidth is shared among the neighbouring nodes of the IEEE 802.11 in the DCF mode, it has then become necessary to estimate the consumed bandwidth of all the nodes within the frequency range. Therefore, the consumed bandwidth within the frequency range is periodically estimated using voice messages.

The AODV voice message structure is modified to include the consumed bandwidth information and the nodes are used to check the amount of data going into the network within specified time window of 5 s. The nodes access information about the neighbouring consumed bandwidth through voice messages. However, the nodes also need to estimate the bandwidth range in its carrier sense and it should be noted that the transmission range is only half of that of the interference. Therefore, the paper considers the 2-hops bandwidth estimation process as proposed in [27], which has been enhanced by assuming the physical layer preamble and back-off time.

Assuming BW_{av}, BW_{ch} and BW_{cn} which are mean available, channel and consumed bandwidths, respectively; then:

$$BW_{av} = \frac{BW_{ch} - BW_{cn}}{w} \tag{9}$$

where w is the weight factor and $w = (T_{overhead} + p)/p$ with p representing packet size and $T_{overhead}$ representing overhead operations of routing and MAC protocols.

$$T_{overhead} = T_{PHY} + T_{MAC} + T_{UDP} + T_{IP} + DIFS + SIFS + T_{ACK} + T_{BCK} \tag{10}$$

where T_{PHY}, T_{MAC}, T_{UDP}, T_{IP} and T_{BCK} are physical layer pre-amble, MAC, UDP and IP headers as well as average back-off time, respectively.

For better and close estimations, the bandwidth, physical layer pre-amble and back-off time should also be added for the weight factor. In this work, T_{BCK} is approximated by:

$$T_{BCK} = \left(\frac{CW_{\min}}{2}\right) T_{slot} \tag{11}$$

when CW_{min} is standing for minimum window size and T_{slot} standing for the time slot.

3.4. Route Selection

The ad-hoc routing protocols usually consider minimum hop-count as the metric for delivering routing probe packets or routing updates. Consequently, scalability is critical to the successful deployment of these networks. The steps toward a large network consisting of nodes with limited resources are not straightforward and present many challenges that still need to be solved such as; addressing, routing, location management, configuration management, interoperability, security and high capacity wireless technologies. In MRP, a modified mechanism to discover route for AODV is chosen for multi-paths discovery nodes between source and destination. Moreover, the node at source usually initiates discovery of route when transmitting a packet to the destination using route request (R-Req) messaging. When intermediary nodes receive R-Req, it initially updates the bandwidth availability, DDET and the hop-count in the R-Req header. However, as soon as the destination node receives the R-Req, the first thing it does is to check the QoS of the streamed traffic (video, voice and data). When the required QoS for the traffic is achieved, the receiving node temporarily records the route and hold on for the route's request time-out period. On the other hand, if the required QoS for traffic is not achieved, a route reply (R-Rep) is immediately sent to the source node as in AODV. After the waiting period elapses, the receiving end node validates the cost of each path using Eq. (1) and selects the lowest traffic cost of the paths according to QoS type, thereby sending to the source node an R-Rep in the final run. The process of selecting the weighted metrics of cost is represented in Fig. 2 below.

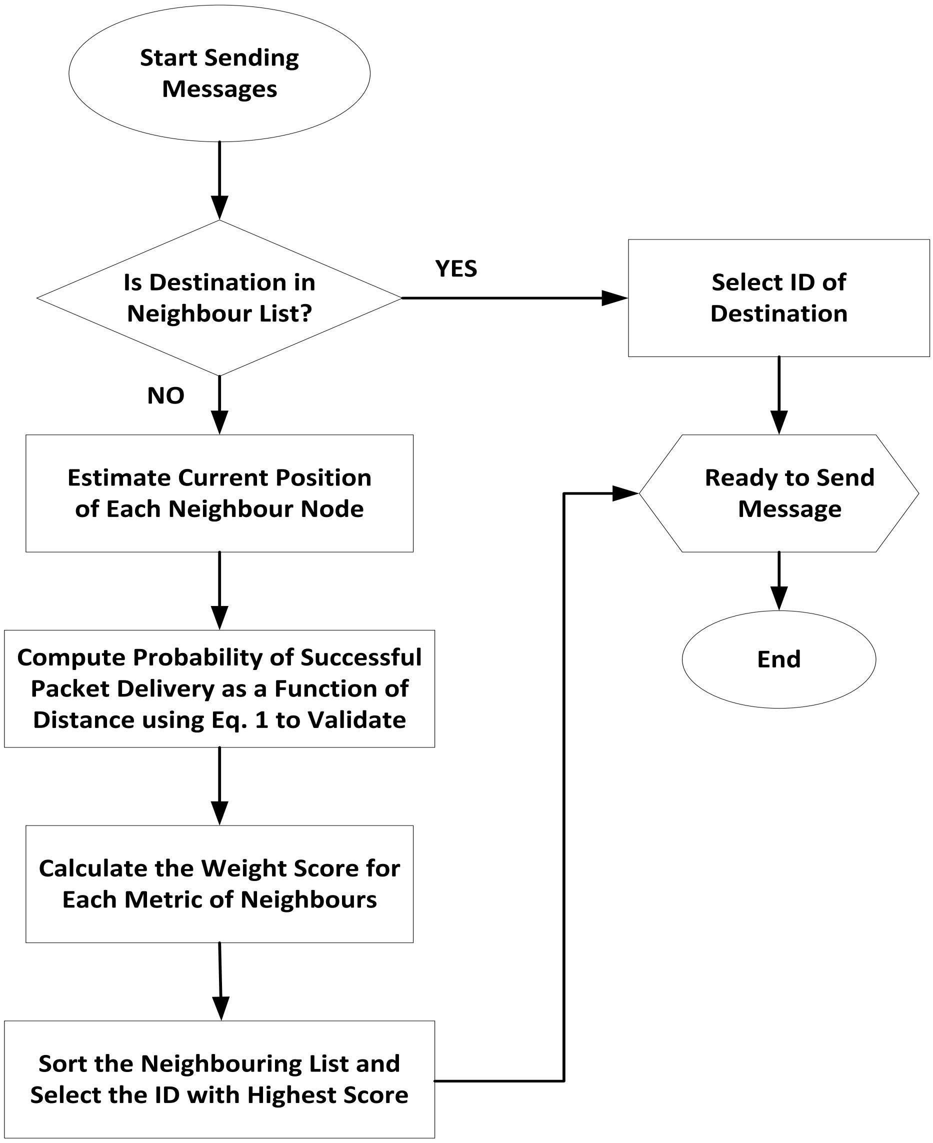

Fig. 2. Flow chart of node selection sequence.

4. PERFORMANCE EVALUATION

The evaluation of the proposed MMRP protocol is executed through simulation where the required QoS performances for data, video and voice traffics were analyzed. The Network Simulator-2 (NS-2) is used to perform the network simulation with Linux being chosen as the platform for the simulation, since it provides a number of programming tools. Therefore, random distribution of a 50 node wireless network of multiple hops within an area of 2 km^2 was assumed in which the disabled MAC protocol in IEEE 802.11 and Request-To-Send/Clear-To-Send (RTS/CTS) mechanism was considered to be used. It should be noticed here that RTS/CTS is adopted to avoid collisions from hidden terminal problem. However, for multimedia data to be transmitted, it is necessary to make RTS/CTS ineffective [26].

In this simulation, the physical layer of the 802.11b network was also considered because the physical layer is assumed to have the highest data rate (x_{max}). Furthermore, the

H.264/MPEG-4 is chosen for video encoding due to its supports for high video quality and compression ratio of relative low data rate. A 25 frames/second signal with frame size of 480 × 360 of average background motion is considered. The video traffic obtained at the node is about 0.6048 Mbps after the unprocessed data (video) is encoded. For encoding the voice traffic, the G.711 was used in order to get the best quality voice traffic that requires a data rate of 64 Kbps. When carefully observed, it could be noticed that for a network measuring 2 km^2 transmitting within a range of 250 m, the maximum hop distance (y_{max}) is nearly 5 on the average, while the maximum DDET of such route stand at about 2. Consequently, in this work, the least meaningful scenario was considered with the maximum DDET (z_{max}) of a path set to 10. For data traffic of voice and video to transmit, CBR of 460, 1500 and 160 bytes respectively was given priority than UDP.

Different scenarios and topologies were adopted and used in determining the performance of the protocol. Simulation results of only two sets of network scenarios (static and mobile) are presented in this paper where various numbers of traffic qualities linked to fixed networks with different mobility speeds over the mobile network were used. A comparison of MMRP, AODV, DSR, AODV with ETX, and bandwidth estimation-based QoS routing protocol (BEQRP) [28] are obtained and analyzed. Data, video and voice traffics were chosen to simulate source node with data rates of 32 Kbps, 6.048 Kbps and 64 Kbps, respectively. Weighted values of various traffics were considered and presented as shown in Table 1. Here, the weighted average method is used to get the fitness value and these values are selected based on the data traffic requirements. Therefore, the same source and destination pair may have multiple paths for every data traffic (multiple paths can be used to carry data from the source to the destination nodes).

Table 1. Weighted values of data traffics.

Traffic type	α	β	γ
Data	0.2	0.3	0.5
Video	0.5	0.3	0.2
Voice	0.2	0.5	0.3

4.1. Analysis of Networks with Fixed Nodes

As noticed, the effects of video traffic on PDR in MMRP and AODV are depicted in Fig. 3 because at the initial stage, the network is not fully loaded which indicates that all protocols will show some level of acceptable performance. When there is an increase in node connectivity, the network load consequently rises, making the PDR show how protocols decrease with the MMRP and showing a significantly better PDR for all scenarios other than AODV, DSR, ETX-AODV and BEQRP. This could be as a result of the MMRP protocol trying to select the highest bandwidth path that is reliable and trying to avoid the lossy links as well as the congested paths. This will reduce the packet dropping probability and enhance the quality of the bandwidth availability. However, in Figs. 4 and 5, while comparing voice to data with other protocols, the MMRP shows greater improvement of the PDR for the various traffic mix. Due to the fact that delay sensitivity is one of the characteristics of real-time voice traffic, it is therefore paramount that it meets the required timeout deadline. Since DDET metric makes it possible for the MMRP to avoid lossy and congested routes in the case of data traffic, a few link breakages occur when measured with other protocols and therefore the MMRP selects the shortest reliable path.

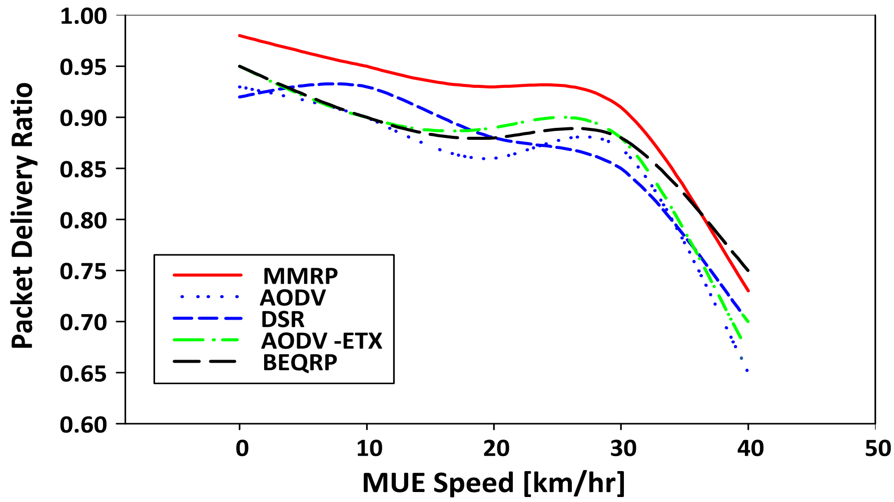

Fig. 3. Effects of video traffic on packet delivery.

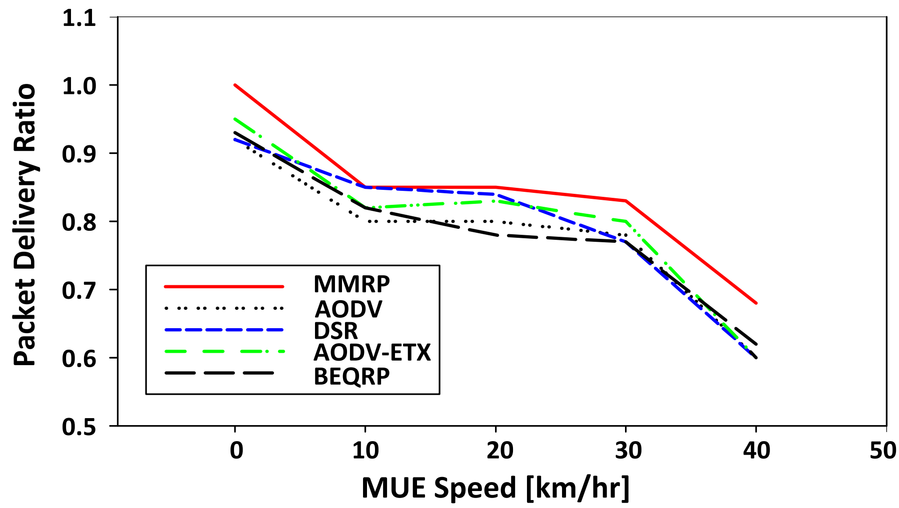

Fig. 4. Effects of voice traffic on packet delivery.

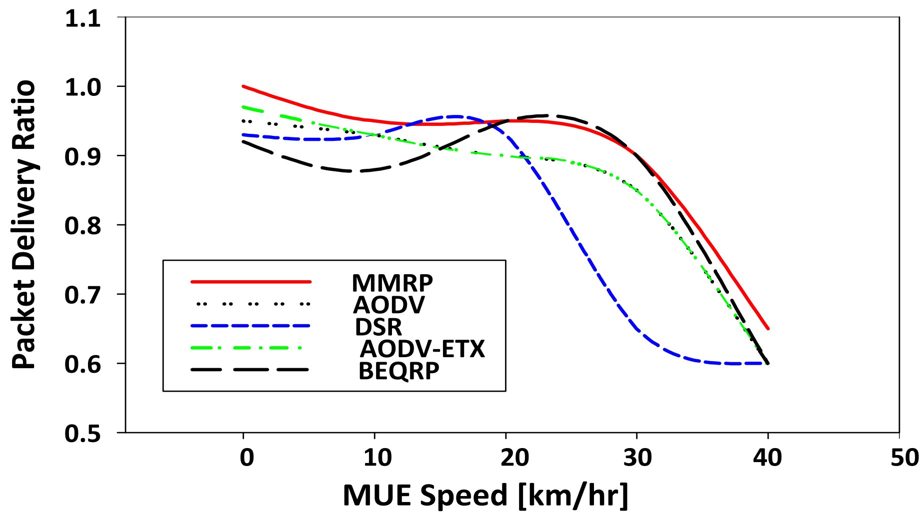

Fig. 5. Effects of data traffic on packet delivery.

It is important to note that overall performance of MMRP in terms of delay plays a great role in real-time video traffic. This is demonstrated in Fig. 6 where the performance stood out to be better than what is obtainable in AODV, ETX-AODV and BEQRP. The analysis indicates how these routing mechanisms of AODV, DSR, and ETX-AODV chose routes that are not minding the problems caused by network congestion and bandwidth limitation. Packets take longer time in queue for AODV and ETX-AODV once there is congestion of the route. As demonstrated in Figs. 6 and 7, DSR records significant delay for both video and voice traffics, while it makes impractical the cost at low throughput as earlier shown in Figs. 3 and 4. On the other hand, Fig. 8 shows the lowest latency for data traffic in MMRP, not minding the reliability of the protocol. It happens due to the fact that reliable route does have delays as a result of re-discovering paths and retransmitting packets.

4.2. Analysis of Networks with Mobile Nodes

The simulation model considered the use of RWP for the nodes' movements. However, the speed of the node is chosen randomly (0, v_{max}), with v_{max} for highest nodal speed. This indicates that the performance of protocols is preferable over speed variation of the node while maintaining same data connections.

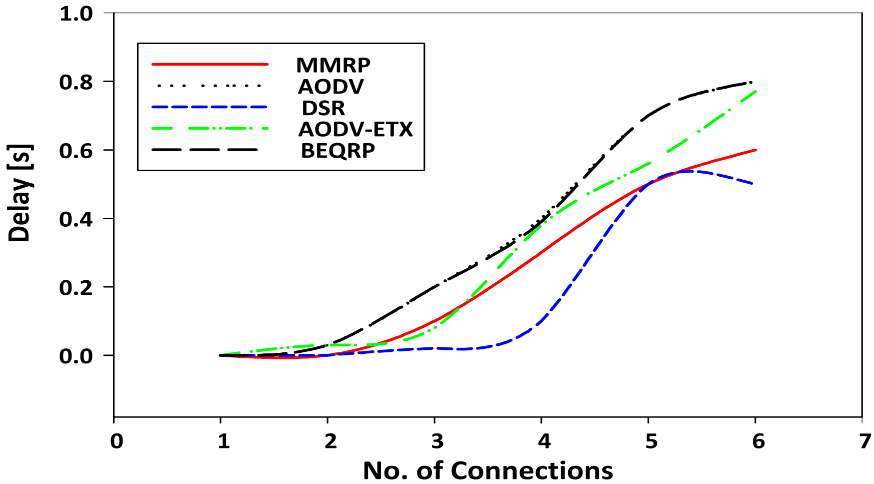

Fig. 6. Effects of video traffic on end-to-end delay.

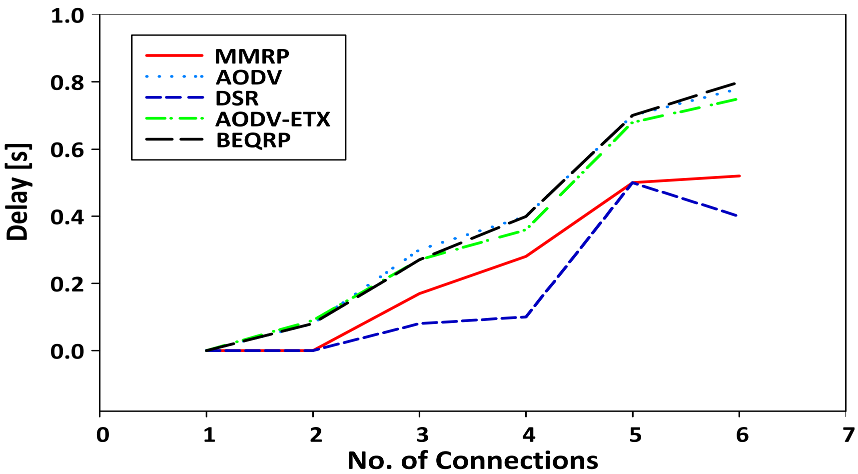

Fig. 7. Effects of voice traffic on end-to-end delay.

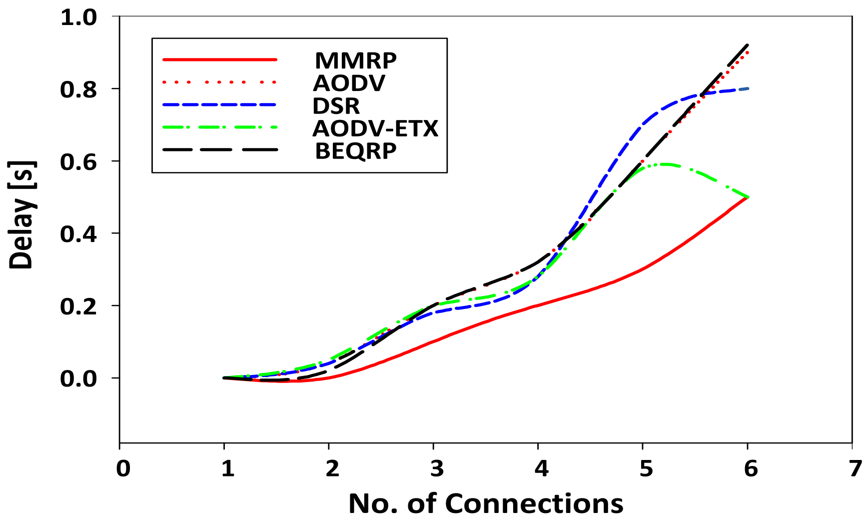

Fig. 8. Effects of data traffic on end-to-end delay.

As shown in Fig. 5, MMRP gains high PDR compared to other protocols. Fig. 5 shows the PDR of voice traffic. In this case, MMRP obtains the highest performance in all cases. It is evident that MMRP choses the shortest and reliable path length. Furthermore, a replica schemes are shown in AODV, ETX-AODV and BEQRP. The results show the values of PDR data in Fig. 5 where packet data rates decrease as the speed of the nodes increases. However, MMRP protocol indicates an improved performance due to lower number of route break that occurred in MMRP.

As a result of mobility of the nodes, delay is imminent due to link breakage caused by protocol as seen in Fig. 6. However, MMRP regains lower delay as compared to AODV, ETX-AODV and BEQRP. Furthermore, MMRP records low latency when compared to other protocols, making AODV and BEQRP to produce higher delay. Concerning data traffic, the figure shows the latency in AODV, ETX-AODV and BEQRP as high when compared with MMRP. This is due to link breakage in AODV, BEQRP as well as in ETX-AODV that occur most often.

5. CONCLUSIONS

In this paper, MMRP capable of choosing a reliable path that suites the application's quality of service requirements was proposed. In determining the cost of the link, a cost function model was designed by estimating the bandwidth, DDET as well as the route length from source-to-destination. The results of the simulation demonstrate that the new method has significantly improved packet delivery ratio and latency compared to the existing routing protocols.

While varying speed and pause time for smaller networks, DSR maintained high packet delivery fraction. Being on-demand protocol, there is always a chance of fresh and active route to be selected, so fewer packets are dropped. Nevertheless, this on-demand route discovery causes more routing packets in the network and slightly more end-to-end delay due to more link breaks. Increasing speed not only leads to more packets drops but also increases NRL and delay.

DSR performs better in small networks and as density increases it fails and due to formation of temporary loops it shows high delay. The degradation in performance of DSR as compared to AODV is due to its inability to expire stale routes, so for denser networks AODV is more effective. AODV and DSR perform better than DSDV in high mobility scenarios because high mobility leads to frequent link failures and the larger overhead is involved in updating routing tables of all the nodes with this new routing information. In future, work will consider packet loss, delay and throughput as performance metrics for measuring this proposed routing protocol in order to provide better insight of ad-hoc network routing protocols.

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