Multimedia Traffic Over MANETs: Evaluation and Performance Analysis

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Abstract Providing required QoS guarantees in wireless mobile ad-hoc networks (MANETs) is much more challenging than in wired networks. This is mainly due to its characteristics such as frequently changing topology, un-centralized control, interference, multi-hop routing and collisions due to contention for channel access. Efficient and reliable routing in such an environment is very difficult task. In particular, it is essential for wireless routing protocols to provide some sort of QoS guarantees by incorporating metrics like achievable throughput, delay, jitter, packet delivery ratio, etc. In this paper, we compare and analyze the performance of various wireless routing protocols over MANETs. The source nodes are modeled using video trace files generated from real time video streams using H.264/SVC codec. Our basic goal of this paper is to analyze and exploit the in-built support for real time multimedia applications over MANETs. Performance evaluation and analysis of various wireless routing protocols over huge number of different scenarios is conducted. The results that evaluate the network performance are obtained using simulation in terms of packet delivery ratio, routing overhead and average end-to-end delay. The routing protocols are analyzed against the effects of change in network scalability (both in terms of size and number of nodes) and network load. Results obtained from simulations shows that it is possible to transmit multimedia applications traffic with limited support for video quality over MANETs.

Keywords Mobile ad-hoc routing · Performance analysis · Routing protocols · Simulation · AODV protocol · Video transmission

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1 Introduction

Presently, there is rapid movement in infrastructure-less wireless mobile ad-hoc networks (MANET) [6] due to their mobility and inexpensive nature. With this strong need, the major focus of researchers moves towards Quality-of-Service (QoS) [6] which is must in these networks. Multimedia and other delay or error sensitive applications require a good QoS. In MANET, we have collection of mobile nodes that can communicate with each other through wireless channels. The major benefit of using MANET is that here nodes are self dependent in terms of configuring and organizing themselves according to any change in network topology. In MANETs, communication takes place directly through radio channels if communicating nodes are in the range. Each node has its own range of transmission, in case nodes are out of the range then intermediate nodes play a major role in forwarding the message.

In this paper, we perform an analysis of different routing protocols under various MANET scenarios to evaluate their performance during the transmission of multimedia traffic. Multimedia data has characteristics such as variable frame size and small inter-packet time which makes its transmission difficult as compared to best-effort traffic. We use three MANET routing protocols for our performance analysis. The routing protocols selected are as follow: (a) Ad-hoc on-demand distance vector routing protocol (AODV) [8] (a reactive routing protocol), (b) Optimized link state routing protocol (OLSR) [3] (a proactive routing protocol) and (c) Zone based routing protocol (ZRP) [7] (a hybrid routing protocol). Furthermore, We discover and discuss the issues and challenges that are faced in wireless network's during the transmission of multimedia traffic.

The remainder of the paper is organized as follows. In Sect. 2, we present an overview of related work done on the performance analysis of MANETs routing protocols. Section 3, we identify the challenges imposed by wireless networks while realizing multimedia traffic over MANETs. In Sect. 4, result evaluation through simulations and analysis is discussed. Finally concluding remarks are given in Sect. 5.

2 Related Work

In this section, we discuss the previous work done on performance analysis of routing protocol in MANETs. In [4], simulation based experiments are performed to analyze the performance of Hybrid Routing Protocols ZRP, CBRP on the basis of Packet Delivery Ratio, End to End delay and Average Throughput. These results are compared with AODV, DSR and FSR routing protocols by varying number of nodes. Although, effects of network load and network mobility are not analyzed. Also, the traffic is generated using best effort traffic applications.

Authors in [2] analyze the reactive and proactive routing protocols with varying network conditions and speed to find an optimized route from a source to some possible destination. This paper presents how routing protocol will behave in less and more stressful condition, performance of mobile ad-hoc network routing protocol such as AODV, DSDV, DSR, to simulate the above said protocol on the base of normalize routing load, throughput, Average End-to-End to delay, packet loss and packet delivery fraction.

Authors in [10] presented a detailed survey to analyze the effect of random based mobility models on the performance of Proactive Routing Protocol (DSDV—Destination Sequence Distance Vector) and Reactive Routing Protocol (AODV—on Demand Distance Vector, DSR—Dynamic Source Routing). Performance analysis is done with respect to end-to-end delay, throughput and Packet delivery ratio for varying node densities. Some other papers that have done the performance analysis of various wireless routing protocols are [11, 5].

In this paper, we have done the performance analysis of various routing protocols to know their behaviour under multimedia traffic transmission. We use trace files generated from real time video file to model the network sources in network. This way we can stress the network with real-time traffic instead of relaying on applications such as constant bit rate or variable bit rate which generates traffic in some fixed patterns. The results presented in this paper helps the researchers working in the area towards provisioning the QoS support for real-time multimedia applications. This will help to select the routing approach that can be used to create new QoS-aware routing protocols.

3 Issues and Design Challenges for Multimedia Transmission in MANETs

There are several design issues that greatly affect the performance of multimedia traffic mainly video streaming. Earlier, routing protocols in MANET does not focus on QoS for any route from source to destination. But due to rapid attraction towards MANET and evolving a vast variety of multimedia applications and many QoS-aware applications there is a strong need to involve QoS in MANET for efficient transmission of such application's traffic.

3.1 Challenges in Implementing QoS for Multimedia Traffic over MANETs

Following are the challenges we face during the provisioning of QoS-aware solutions in MANETs:

- **Irregular physical behavior**: In ad-hoc networks, we have unpredictable atmospheric and operating conditions that includes interference, thermal noise, multipath fading and shadowing. So this leads to unpredictable physical characteristics.

- **Infrastructure less and distributed architecture**: In infrastructure-less networks, each node has to send its QoS state information to other nodes, this increases complexity.
- **Communication via multi-hop**: As the nodes on an intermediate route of a source-destination pair increases the probability of route failure also increases. In a multi-hop communication, each node is important as it plays an equivalent role in forwarding the message. So, failure of any node results in communication breakdown.
- **Contention in channels**: Sharing of channel results in collision and increase in collision results in increased delay, decreased packet delivery ratio, low utilization of channel bandwidth and drain in nodes battery power. Using TDMA technique, we can remove this problem but we cannot use TDMA or CDMA in MANETs due to its de-centralized nature.

3.2 Trade-Offs in Designing QoS-Aware Solutions

The general design trade-offs that may affect the design of QoS-aware routing protocols is as follows:

- **Reactive versus Proactive Routing algorithms**: Proactive(table-driven) routing protocols aim to maintain up to-date routing information between each pair of nodes in the network and keep them consistent by transmitting routing updates at fixed time intervals. Proactive protocols produce low delay during route discovery and route set-up but consume more channel capacity.
- **Channel Capacity versus Delay**: The delay between packets can be reduced by sending more data packets through different neighbors and thus increase network capacity. If repeated packets are sent via different paths, packets are received at destination with low delay. This scheme increases network capacity on the cost of delay.
- **Transmission power: Low versus High**: Reducing transmission power increases number of hops and save energy but at other side increasing power leads to less number of hops that decreases route failure, low routing and route maintenance overhead and increases path efficiency and end-to-end reliability.

4 Simulations and Performance Evaluation

All the simulations are performed using a well known network simulator called Qualnet v5.0. The source-destination pairs selected for data transmission and reception are random. To model the source nodes with real-time video traffic, we use the video trace files [12] generated using H.264/SVC [9] codec. Furthermore, the results are generated by taking average of ten trials performed using different seed values.

In all the network scenarios, we introduce background traffic using one Constant Bit Rate (CBR) data session. The traffic generated by CBR sessions has the following properties: (a) 20 packets per second are transmitted into the network, (b) The size of each packet is 512 Bytes. Other than this, the network is configured using the simulation parameters given in Table 1.

4.1 Effect of Increase in Network Load

In this section, we evaluate the performance of AODV, OLSR and ZRP against increase in number of video streaming sessions in network. The number of video streaming source-destination pairs are increased by one in each scenario. In Fig. 1, we present the results for routing overhead (RO) incurred by each routing protocol for different number of video sessions in network. As we can observe from Fig. 1,

Table 1 Simulation parameters

Parameters	Values
Simulator	Qualnet 5.0.1
Simulation time	500 s
Scenario dimension	600×600, 1000×1000, 1400×1400, 1800×1800 m^2
Number of nodes	Between 25 and 100
Application layer protocol	CBR, Traffic trace
Video	Big buck bunny CIF(352×288)
Video codification	H.264 SVC
Frame size	21–3930 Bytes
Inter-packet Time	33 ms
Routing protocols	AODV, OLSR, ZRP
Mobility model	Random way-point
Data rate	11 mbps

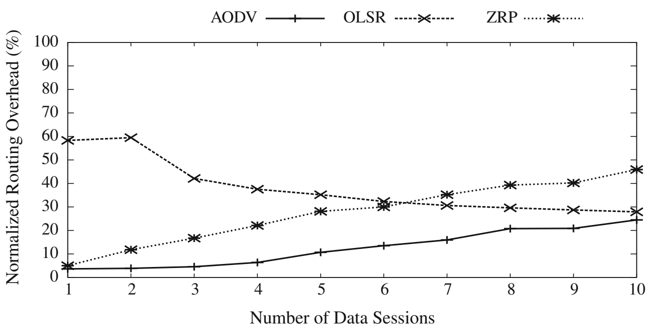

Fig. 1 Effect of increased number of data sessions on routing overhead

when number of video sessions are less in the network the RO of AODV protocol is low as compared to other routing protocols. This is because AODV maintains information about active routes only. As the number of video session increases in the network the routing overhead of OLSR decreases because it does not have to increase its RO with increase in number of video sessions. This is due to the fact that OLSR store routes for all destinations at the network start-up using its proactive routing approach, so it is not effected by any increase in source-destination pairs. On the other hand, ZRP gives intermediate RO values because it uses both, proactive and reactive route discovery processes for updating its routing tables.

Figures 2 and 3 show the effect on average end-to-end delay (EED) and packet delivery ratio (PDR) with increase in number of video sessions on AODV, OLSR and ZRP. As seen from Fig. 2 EED of AODV protocol is very low as compared to OLSR and ZRP. This is because the re-routing time of AODV is very low as compared to other routing protocols [1]. In addition to that, when we see the simulation log file for AODV, we observe that when the network traffic is increased due to increase in video sources AODV is able to find routes that are less congested as compare to other routes. Because of the above two reasons AODV protocol EED is low and PDR is high as compared to other routing protocols. On the other hand OLSR performs

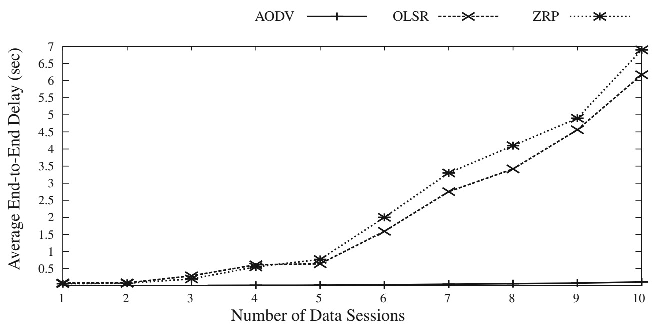

Fig. 2 Effect of increased number of data sessions on average delay

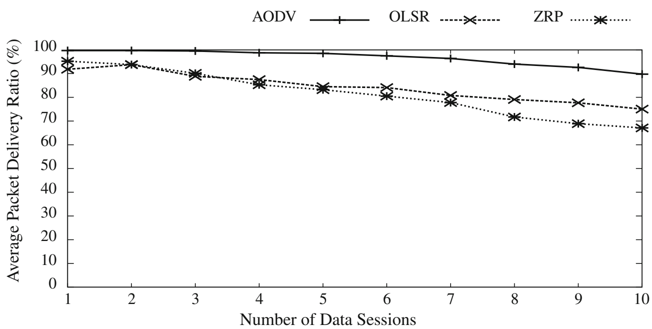

Fig. 3 Effect of increased number of data sessions on PDR

better than ZRP due to its fully proactive nature of making and updating routing table. This is because, in OLSR initial delay for route setup is very low due to the high probability of route availability for any destination is source routing table.

4.2 Effect of Increase in Network Size

In this section, we present simulation results obtained with increasing network scenario size in terms of number of nodes and scenario dimensions. The network is configured using the simulation parameters shown in Table 1. The number of source destination pairs in each scenario is kept constant (which is four). Figure 4 shows the RO caused by AODV, OLSR and ZRP on different sized network scenarios. As seen from Fig. 4, the RO of AODV is small as compared to OLSR and ZRP. This is because AODV only keep track of active routes so as long as the number of source-destination pairs are not changed there will be no significant change in AODV routing overhead. In addition to this, the small constant increase in AODV RO with network size is due to the increase in number of intermediate nodes in an active route. On the other hand, RO of OLSR increases greatly with increase in network size because of its proactive route discovery process due to which the number of control message broadcast increases greatly. ZRP performs slightly better than OLSR due to its semi-reactive route discovery process.

In Figs. 5 and 6, we present EED and PDR results with change in network size for AODV, OLSR and ZRP routing protocols. As we can observe from Fig. 5, the EED of AODV is less as compared to OLSR and ZRP. This is due to two reasons: (a) the size of routing table is low in AODV due to its reactive route discovery process. This helps to get a route for a destination from routing table very quickly as compared to routing tables that are build using proactive route discovery methods due to their large sizes. (b) As the size of network increases the intermediate routes between a source destination also increases which further increases the probability

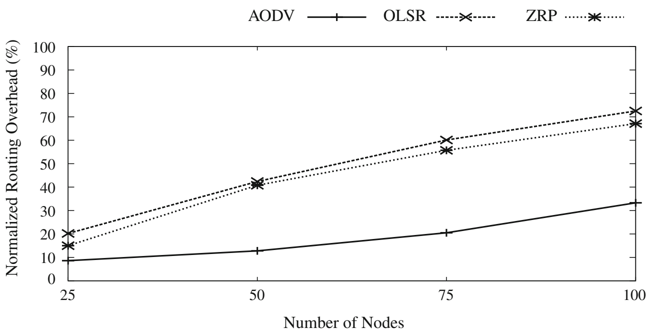

Fig. 4 Effect of increase in network scalability on routing overhead

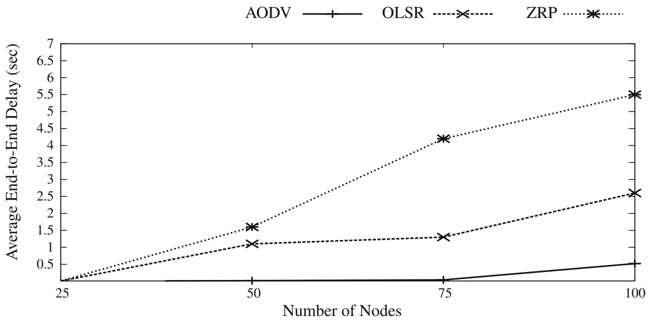

Fig. 5 Effect of increase in network scalability on average delay

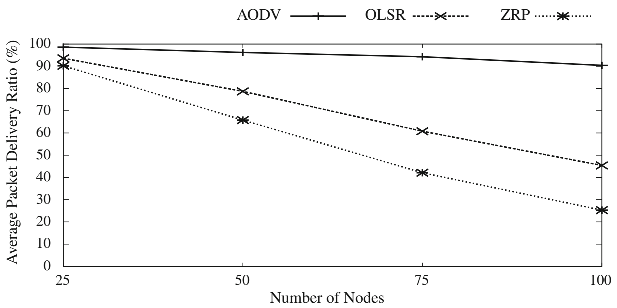

Fig. 6 Effect of increase in network scalability on PDR

of link failure. So, as mentioned above that the AODV has low re-routing time it will recover from these frequent route breaks quickly as compared to OLSR and ZRP. This will greatly minimizes AODV EED. In Fig. 6, we can observe that as the network size increases PDR starts decreasing due to increase in routing overhead and increase in route breaks caused by high number of intermediate nodes.

5 Conclusion and Future Work

In this paper, we have done performance analysis of various MANET routing protocols to evaluate their behaviour during transmission of multimedia applications. We have present and analyze results for different routing protocols in different scenarios with varying network load and network size. We observe from simulation results that reactive routing protocols (such as AODV) are well suited for MANET like environments due to their low routing overhead, low re-routing delay and adaptability towards dynamically changing network conditions due to node mobility.

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