Performance Study of Proactive, Reactive and Hybrid Routing Protocols for MANET in Multiple CBR Scenario

[1]Jyothi V, [2]Suhas K R, [3]Mohankumar N M, [4]Devaraju J T
[1]Vijaya College, R. V. Road, Basavanagudi, Bangalore, India
[2,3,4]Dept. of Electronic Science, Bangalore University, Bangalore, India

Abstract

Mobile Ad-Hoc Network (MANET) comprises of numerous ubiquitous mobile computing devices called nodes which form distributed network and support dynamic topology without any centralized infrastructure like base station. In such distributed network, the communication between the nodes relies on multi-hop technique. Since, the nodes in a MANET do not have a priori knowledge of the network topology, it discovers the route through broadcasting and listening to announcement from the neighbours. As the process continues, each node finds one or more routes to all other nodes. Hence, the end-to-end communication in a MANET does not rely on any underlying static network infrastructure but implicates routing via several intermediate nodes. The routing of data in the network depends on the protocol which determines the most appropriate path to forward packets to the intended destination. The routing protocols are classified into proactive, reactive and hybrid. In this paper, an attempt has been made to evaluate performance of proactive, reactive and hybrid routing protocols in scenarios with multiple CBR connections by varying node density and node mobility. The simulation studies are carried out using Qualnet 6.1 network simulator by considering total packets received, throughput, average end-to-end delay and average jitter as performance metrics.

Keywords

MANET, AODV, OLSR, ZRP, Qualnet 6.1, IEEE 802.11.

I. Introduction

Mobile Adhoc Networks (MANETs) are collections of self-organizing nodes with dynamic topologies and no fixed infrastructure [1, 2]. Some of the applications of MANET include crisis management, where the entire communication infrastructure is destroyed and quick re-establishment of communication is crucial. MANETs also meet the requirements for military applications, such as rapid network formation, extended operating range and survivability. MANETs are expected to play an important role in the future since it supports flexible and adaptive applications with no fixed infrastructure.

In MANET, communication is achieved by forwarding packets through intermediate nodes on routes that link source and the destination. Nodes in a MANET do not have a priori knowledge of the network topology as they have to discover it. A node will find its local topology by broadcasting its presence and also listening to the broadcast announcements from its neighbours. As the process continues, each node gets to know about all other nodes and finds one or more ways to reach them. Hence, the end-to-end communication in a MANET does not rely on any underlying static network infrastructure but requires routing via several intermediate nodes.

All networking functions of a MANET, such as routing and packet forwarding, are realized through node cooperation. The nodes in MANETs are usually battery-powered mobile devices with constrained resources such as memory, life time, bandwidth etc. Also, design of robust routing protocol adaptable to frequent change in network topology is a challenging issue in MANET. In order to cope up with these challenges, many researchers have proposed routing protocols. In this paper, different routing protocols have been evaluated using Qualnet 6.1 network simulator by considering total packets received, throughput, average end-to-end delay and average jitter as performance metrics. The rest of the paper is organized with routing protocol in Section II followed by related works in Section III, simulation results and discussion in Section IV and conclusion.

II. Routing Protocols

Routing is a process of selecting an optimal path for transmission of data from source to destination node. In MANET, nodes communicate with each other using multi-hop wireless links. Since, there is no predefined infrastructure, each node in the network acts as a router, thereby forwarding data packets for other nodes. A crucial challenge in designing of Adhoc networks is finding routing protocols that can efficiently discover routes between two communicating nodes. The routing protocol must be able to keep up with the high degree of node mobility that often changes the network topology drastically and unpredictably. Basically, the routing protocols are classified into three categories namely proactive, reactive and hybrid routing protocols. Proactive routing protocols are table-driven protocols that always use link-state routing algorithms to frequently flood the link information about its neighbours [1]. Reactive or on-demand routing protocols use distance-vector routing algorithms to create routes when demanded by the source [3]. However, the hybrid routing protocols incorporates the advantages of both proactive and reactive protocols.

A. Proactive Routing Protocol

In proactive routing protocol, each node has one or more routing tables that contain the latest information of the routes to all other nodes in the network. Various table-driven protocols differ in the way how the information propagates through all nodes in the network when topology changes. The proactive routing protocols are not suitable for larger networks as they need to maintain each and every node entries in the routing table. This results in more overhead in the routing table leading to consumption of more bandwidth. Examples of such schemes are the conventional routing schemes: Optimised Link State Routing protocol (OLSR), Destination Sequenced Distance Vector (DSDV), Bellman ford protocol, etc. In this work, the performance of OLSR protocol is evaluated for the considered scenarios.

1. Optimised Link State Routing (OLSR)

Optimised Link State Routing (OLSR) is a proactive routing protocol, where the routes are always available when needed. OLSR is an optimised version of a pure link state protocol. The topological changes cause the flooding of the topological information to all available nodes in the network. To reduce the possible overhead in the network, Multi-Point-Relays protocol (MPR) is used. Reducing the time interval for the control messages,

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transmission conveys more reactivity to the topological changes [4]. OLSR uses two kinds of the control messages namely hello and topology control. Hello messages are used for finding the information about the link status and neighbours of the nodes. Topology control messages are used for broadcasting information about its own advertised neighbours, which includes at least the MPR selector list [4].

B. Reactive Routing Protocols (On-demand)

Reactive routing protocol is also known as on-demand routing protocol since they do not maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then the protocol searches for the route in an on-demand manner and establishes the connection to transmit and receive packets. The route discovery occurs by flooding the route request packets throughout the network. Examples of such reactive routing protocols are the Adhoc On-demand Distance Vector routing protocol (AODV), Location Aided Routing protocol (LAR) and Dynamic Source Routing protocol (DSR) [5]. In this work, the performance of AODV protocol is evaluated for the considered scenarios.

1. Ad-hoc On demand Distance Vector routing (AODV)

Ad-hoc On Demand Distance Vector (AODV) protocol is suitable for Unicast and Multicast routing. It is a reactive routing protocol [4] and is basically a combination of DSDV and DSR. It incorporates the basic on-demand mechanism of route discovery and route maintenance from DSR, the use of hop-by-hop routing, sequence numbers and periodic beacons from DSDV. This protocol performs route discovery using control messages such as route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. The forward path sets up an intermediate node in its route table with a lifetime association RREP. The neighborhood information is obtained from broadcast Hello packet. When the source node receives the route error (RERR) message, it can reinitiate route if it is still needed. AODV is a flat routing protocol which does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The RREQ and RREP messages which are responsible for the route discovery do not increase significantly the overhead from these control messages. AODV reacts relatively quickly to the topological changes in the network. It updates the hosts that may be affected by the change, using RERR message. The Hello messages are responsible for the route maintenance and are limited so that they do not create unnecessary overhead in the network. The AODV protocol is a loop free and uses sequence numbers to avoid the infinity counting problem which are typical to the classical distance vector routing protocols.

C. Hybrid Routing Protocol

Hybrid Routing Protocols combines the merits of both proactive and reactive routing protocols. Some of the hybrid routing protocols include Zone Routing Protocol (ZRP), Fisheye Routing Protocol (FSR), etc. In this work, the performance of ZRP protocol is evaluated for the considered scenarios.

1. Zone Routing Protocol

ZRP limits the scope of the proactive procedures only to the node's local neighborhood, while the search being global throughout the network can be performed efficiently by querying selected nodes in the network, as opposed to querying all the network nodes[6]. Hence, ZRP is said to be a neighbor selection based protocol. A node employing ZRP proactively maintains routes to destinations within a local neighborhood, referred to as a routing zone. Routing zone is defined as a collection of nodes whose minimum distance in hops from the node in question is no greater than a parameter referred to as zone radius. Each node maintains its zone radius and there is an overlap between neighboring zones. A node learns its zone through a proactive scheme Intra zone Routing Protocol (IARP). For nodes outside the routing zone, Inter-zone Routing Protocol (IERP) is responsible for reactively discovering routes to destinations located beyond a node's routing zone. The IERP is renowned from standard flooding-based response protocols by exploiting the constitution of the routing zone. The routing zones increase the probability that a node can respond positively to a route query. This is beneficial for traffic that is intended for geographically close nodes.

III. Related Work

In [7], authors have compared the performance of two reactive MANET routing protocol AODV and DSR by using Group mobility model and have analyzed the performance of protocols by varying network load, mobility and type of traffic (CBR and TCP). A detailed simulation has been carried out in NS2. It has been observed that AODV gives better performance in CBR traffic and real time delivery of packet, whereas DSR gives better results in TCP traffic and under restricted bandwidth condition.

In [8], the performance of AODV, OLSR, DSR and GRP protocols is evaluated in various network conditions and with different packet size patterns. Also, different MAC layers like 802.11b, 802.11g in ordinary and large-scale networks are considered. All simulations have been done using OPNET. It is observed that DSR and AODV outperform OLSR and GRP for packet delivery ratio with the variation of number of source nodes. GRP outperforms OLSR for packet delivery ratio and OLSR outperforms GRP for End-to-End delay.

In [9], the author described the design and implementation of various gateway discovery approaches and carried out a detailed ns2 based simulation to study and analyse the performance of AODV under different scenarios. From the simulation results, it is observed that the proactive approach shows better packet delivery ratio than the reactive approach which is mainly due to the instant availability of fresher and newer routes to the gateway all the time. In terms of throughput the reactive approach out performs the proactive and hybrid approach. Reactive is also superior in packet loss ratio.

In [10], authors evaluated the performance of on demand routing protocols AODV, DSR and DYMO based on IEEE 802.11CSMA/CA MAC protocol and characteristic summary of these routing protocols is presented. The performance is analyzed using QualNet 5.0.2 network simulator. It is observed that AODV outperforms both of the DSR and DYMO routing protocols in terms of the packet delivery ratio as it uses fresh routes and DSR performs poorer because of aggressive use of cache.

IV. Simulation Results and Discussions

The performance comparison of routing protocols AODV, OLSR and ZRP is studied using Qualnet 6.1 simulator [11] for MANET. In this simulation studies, the performance of the routing protocols are analysed and compared for various node densities and mobility by considering total packets received throughput, average end-to-end delay and average jitter as performance metrics.

A. Simulation scenario – 1

In this scenario, the performance of AODV, OLSR and ZRP protocols are studied for various node densities. The simulation parameters configured for the performance evaluation are shown in the Table 1.

The simulation is carried out for node density of 50 with 5 CBR connections and random way point mobility for AODV. The performance metrics considered are evaluated. The simulation studies are repeated by increasing node densities from 50 to 200 nodes in steps of 50 nodes. The similar simulation studies are repeated for OLSR and ZRP routing protocols.

The variation of total packets received, throughput with different node density are shown in the figure 1 and 2 respectively. It is clear from the figure 1 and figure 2 that the total packets received, throughput corresponding to AODV is better compared to OLSR and ZRP routing protocols. This is due to the on demand reactive nature of AODV routing protocol where the utilization of bandwidth in discovering the route and communication is minimum [3].

Table 1: Simulation Parameters

Parameter	Value
Radio type	802.11
Simulation time	300 sec
Routing Protocols	AODV, OLSR& ZRP
No. of Channels	One
Channel frequency	2.4 GHz
Path loss model	Two Ray
Energy model	Mica Motes
Shadowing model	Constant
Battery model	Linear model
Number of nodes	50, 100, 150 and 200
Traffic types	5 CBR connections
Mobility of nodes	Random Way Point
Node Placement	Grid
Packet size	50 bytes

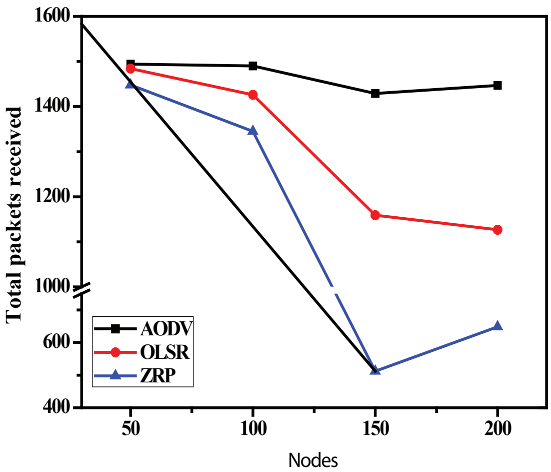

Fig. 1: Variation of Total Packets Received With Varying Node Density

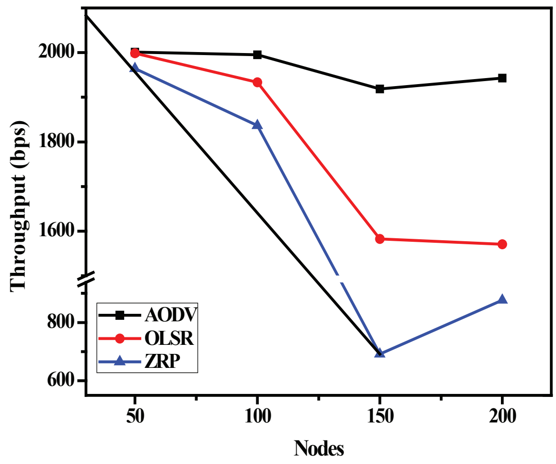

Fig. 2: Variation of Throughput With Varying Node Density

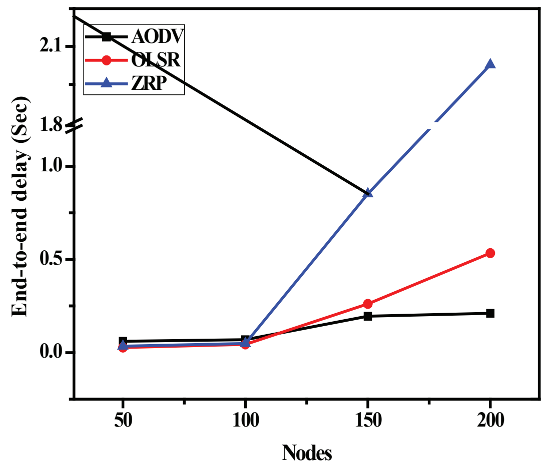

Fig. 3: Variation of end-to-end Delay With Varying Node Density

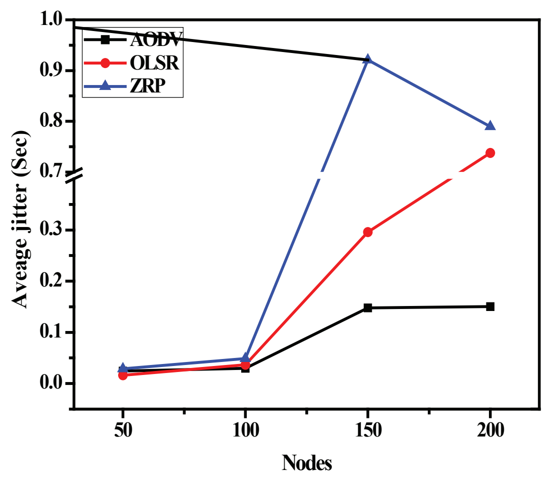

Fig. 4: Variation of Average Jitter With Varying Node Density

Fig. 3 and 4 illustrate average end-to-end delay and average jitter respectively. It is evident from fig. 3 and 4 that end-to-end delay and the average jitter corresponding to AODV are less compared to OLSR and ZRP at all node densities. This is because, OLSR

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and ZRP routing protocols discover the route to destination continuously irrespective of demand initiated by the source node [4, 6].

B. Simulation scenario – 2

In this scenario, the performance of AODV, OLSR and ZRP protocols are studied for various node mobility. The simulation parameters configured for the performance evaluation are shown in the Table 2.

The simulation is carried out for AODV by considering 100 nodes enabled with random way point mobility of 10 mps and the performance metrics are evaluated. The simulation studies are repeated by increasing node mobility from 10 mps to 50 mps in steps of 10 mps. The similar simulation studies are carried out for OLSR and ZRP routing protocols.

The variation of total packets received and throughput for varying node mobility are shown in the fig. 5 and 6 respectively. It is clear from the fig. 5 and 6 that the total packets received and throughput achieved with AODV is better compared to OLSR and ZRP routing protocols at each varied node mobility. This is due to the reactive nature of AODV routing protocol where route discovery is faster compared to OLSR and ZRP with change in topology [3].

Table 2: Simulation Parameters

Parameter	Value
Radio type	802.11
Simulation time	300 sec
Routing Protocols	AODV, OLSR& ZRP
No. of Channels	One
Channel frequency	2.4 GHz
Path loss model	Two Ray
Energy model	Mica Motes
Shadowing model	Constant
Battery model	Linear model
Number of nodes	100 nodes
Traffic types	5 CBR connections
Mobility of nodes	10,20,30,40 and 50mps
Node Placement	Grid
Packet size	50 bytes

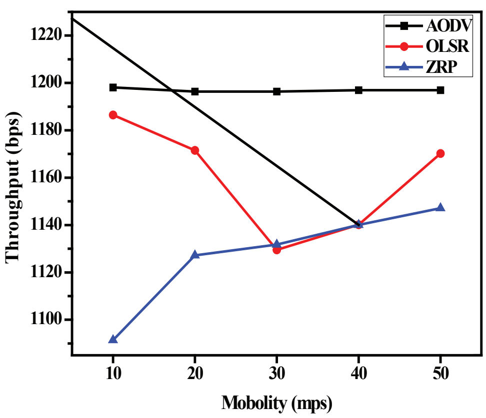

Fig. 5: Variation of Throughput With Varying Node Mobility

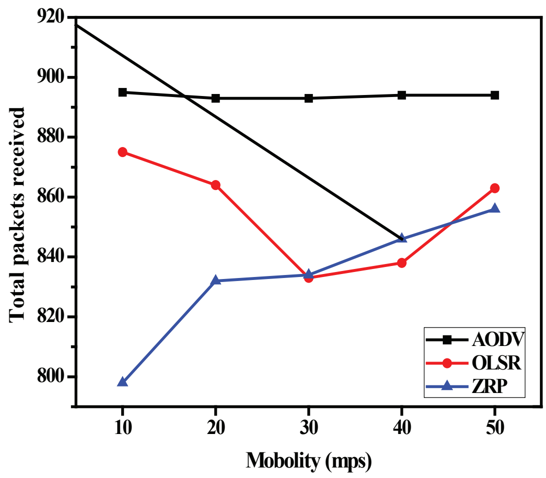

Fig. 6: Variation of Total Packets Received With Varying Node Mobility

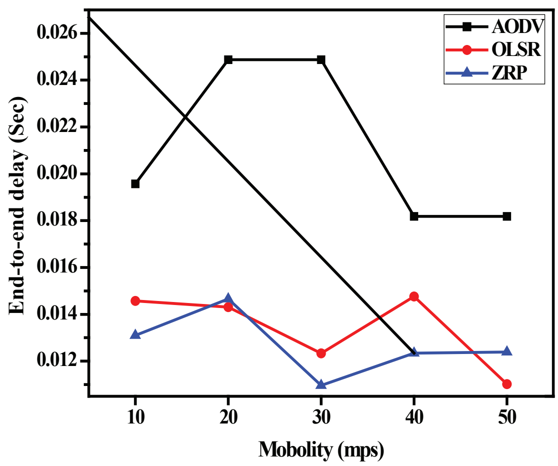

Fig. 7: Variation of end-to-end Delay With Varying Node Mobility

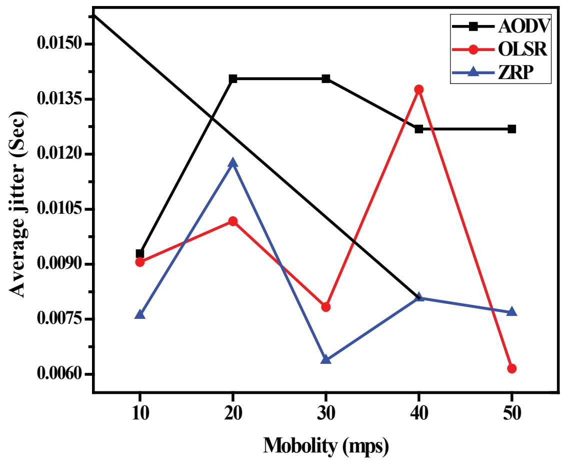

Fig. 8: Variation of Average Jitter With Varying Node Mobility

Fig. 7 and 8 illustrates average end-to-end delay and average jitter for different node mobility respectively. It is evident from fig. 7 and 8 that end-to-end delay and the average jitter corresponding to AODV are more compared to OLSR and ZRP at all node mobility values. This is because of the occurrence of frequent link failures in AODV and also stores only one route entry in the routing table [3].

V. Conclusion

In this paper, the performance of routing protocols AODV, OLSR and ZRP with multiple CBR connections are analyzed and compared for different node densities and node mobility. From the simulation results, it is clear that the reactive routing protocol exhibit better performance compared to proactive routing protocol OLSR and hybrid routing protocol ZRP.

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Jyothi V. is an Assistant Professor at Vijaya College, Bangalore. She is currentlypursuing Ph.D program in the department of Electronic Science, BangaloreUniversity, Bangalore. Her field of interest is WirelessSensor Networks.

SuhasK. R.received M.Sc degree from Bangalore University. Currently, he is pursuing his Ph.D in the Department of Electronic science, Bangalore University. His interests include Distributed Wireless Networks and Multimedia in WSN.

Mohan Kumar N. M. received M.Sc degree from Bangalore University. Now he is pursuing his Ph.D in the Department of Electronic science, Bangalore University. His interests include Long Term Evolution networks and Wireless Sensor Networks.

Devaraju J. T. is working as an Professor and chairman at Department of Electronic Science, Bangalore University. He has 19 years of teaching and research experiance in Electronics. He received his Ph.D degree from Bangalore University. His research interests include Embedded Systems, Wireless Networks and Chalcogenide glasses. He has worked as a member for several committees. He and his research team are working on Broadband Wireless Access networks and Wireless Sensor Networks.