Performance Investigation of Routing Protocol with the velocity of 30 m/s for Random Mobility Model

Ajay Kumar Vyas
Adani Institute of Infrastructure Engg
Margam Suthar (ap1_mcwt@gtu.edu.in)
Gujarat Technological University, Ahmedabad, Gujrat, India

Research Article

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Abstract

A mobile ad-hoc network (MANET) is a network of mobile nodes short of Infrastructure, linked by wireless links. While mobility is the key feature of MANETs, the frequent movement of nodes may lead to link failure. A mobile multi-hop wireless ad hoc network carries a dynamic structure feature, and each node has mobility; due to this, the network has altered topology change dynamically. Developing the wireless ad hoc network protocol is the major challenge because, compared to the wired routing node, all node is mobile, energy limitation, the node's physical location, and multicast routing.

In this article, a comparative investigation of routing protocol performance for large wireless ad hoc networks (100 nodes) under the impact of the random mobile environment with the velocity of 30 m/sec for 1800 seconds with ten different results for each node-set.

The comparative analysis includes packet delivery ratio, throughput, packet dropping ratio, routing overhead, and end-to-end delay quality of service (QoS) metrics. It concludes that Ad-hoc On-demand Distance Vector protocol performance is more stable as the number of nodes & traffic increase in the random mobility environment.

1. Introduction

A wireless ad hoc network does not have any fixed infrastructure; the nodes are self-configuring and self-location changing in the network and communicate through the wireless link [1]. The last few years repaid growth in the usage of the ad hoc network. In particular, many developments in the research interest focus on developing efficient networking protocols for end-to-end wireless communication [2–3].

Infrastructure-based and infrastructure-less are the wireless ad hoc network [5]. In the ad hoc network, if the sender and receiver are within the range, then the sender directly transmits the data to the receiver. Otherwise, it transmits through the intermediate node using multiple-hop or intermediate nodes. Node works as a host and the router to route the data to the receiver. In the Ad hoc network, node movable and topology change dynamically because this traditional routing protocol does not work efficiently [4].

Infrastructure-based in which network centralized controlled each end-user network traffic but in case of the infrastructure-less network not regulated by the centralized controller (access point). Ad hoc network belongs in the infrastructure-less network category. This network node has random movement in the network, and it has the property to self-organizing, and they are self-configuring & self-healing. The collection of nodes themselves develops a network, and they start communicating [6].

Ad hoc network has restraints like dynamically changing network topology, link bandwidth limitation, no centralized network management, and physical layer limitation. It has challenges like scalability, quality of service, energy efficiency, and security [7]. Consequently, it is challenging to develop an ad hoc network protocol. So, it is required to develop the protocol to overcome the ad hoc network challenges and constraints. Ad hoc networks are heterogeneous [8] and homogeneous [9]. If the ad hoc network forms with a similar node characteristic, it is defined as a homogeneous network. If the node is not the same type & has a different operating system, then the network is called the heterogeneous type of the network. Ad hoc network protocol categorized into three categories: (i) Table-driven [10] (ii) Source-initiated [11] (iii) Balanced-hybrid protocol [12].

We have studied the comparative analysis of balanced-hybrid, table-driven, and source-initiated protocol for the small and large network scenario (i.e., 100 nodes) under the impact of random mobility for 30m/sec velocity, simulated for 1800 sec. It has maximum simulation time and high velocity compared to previously reported works (i.e.300 sec, speed of 24m/sec, and area of 900 x 900 m) [13–14]. Consequently, many studies have been so far, but most results are limited to fewer nodes and the simulation time [15–17].

The performance metrics used for measuring performance were packet dropping ratio, throughput, delivery ratio, routing overhead, and end-to-end delay for the ad hoc routing protocol by NS2.35 version. The article organized as the compressive study of proactive, source-initiated, and balanced-hybrid routing protocol in section 2 describes experimental simulation studies in section 3, section 4 provides results analysis, and the conclusion has presented in section 5.

The significant key findings of the study are the following:

1. QoS analysis of routing protocol for MANET.
2. Long simulation period (i.e., 1800 seconds).
3. Validated for small and large networks (i.e., 100 nodes).
4. The network is considered dense 900 X 900.
5. High random mobility of 30 m/s velocities.

2. Routing Protocol

In a mobile ad hoc network, the node has the transmission range. If the destination node is in transmission range, it will directly transmit the data. But if it is not the direct transmission range, then data is transmitted through the intermediate node [18]. The sender sends the data to the neighbor, and then the neighbor node forwards to another node to reach the destination. But for a large network, several routes must forward the data to the destination. So, it is required to employ an efficient routing mechanism to route data through the shortest path, and it overcomes the challenge & constraint of the ad hoc network [19–20].

2.1. Proactive Routing (Table- Driven) Protocol

Finding the route takes less time than the reactive routing protocol because all the node has information about the network. In this protocol, all node in the network contains information about the other node, and periodically routing update is propagated in the network [21–22]. But the disadvantage of this protocol is that all the node maintains a large amount of the data [23].

2.1.1. Destination Sequenced Distance Vector (DSDV): In this protocol, all node preserves a table that contains the possible destination and hops count information [23] with the sequence number. So, if any update in the network, then the routing changes are sanded instantly [24].
If any node moves away from the topology or adds in the topology, this information periodically updates the network. The receiver assigns entry in the table store with the sequence number and. Each node advertises its routing table in DSDV protocol by broadcasting [9] or multicasting. Through the node advertisement, the neighbor node knows about any node movement in the network. If any change in the network, then two types of routing tables update periodically forwarded in the network. Full dump and incremental update [25]. (i) Full dump: Routing table transmitted to the neighbor. (ii) Incremental update: send the only network update not contained in the last full dump update.

An incremental update reduces the network traffic when the network is stable, and the full dump is infrequent [26]. But in the fast-moving network, a full dump is more frequently used to update the network.

2.2. Reactive Routing (On-Demand) Protocol

When any source wants to transmit the data to another node, the Source-initiated protocol searches the shortest path in the network and sends the data to the receiver. Without any demand in the network, it does not initiate finding the path [27]. When any source node needs to send the data, it finds the path, called the source-initiated routing protocol. Source initiate to find the path by flooding the request packet to all connected neighbors and packet have the information about the destination node. It propagates in the network until it finds the route for the destination node [28]. The source to destination route discovered and maintenance phase after identification of route.

2.2.1. Dynamic Source Routing (DSR) is the on-demand source-initiated protocol. Compared to proactive routing, it provides more reliable routing and less overhead due to aperiodically broadcast. This protocol packet header contains the source to the destination address. So, as network size increases, overhead also increases in this network. Due to this, such protocol is more efficient to use in a small network. Compared to other protocols, it stored the different routing paths at the node's cache, and the source node checks the path in the cache before initiating the discovery phase [29].
Source initiated protocol work in route discovery and maintenance phase. Any node needs to transmit the packet it broadcast packet to nearby node and node check in its table to find the receiver path after its allocation, node replay route message. Otherwise, it rebroadcast the request packet to a nearby node until it finds the destination, and if any link breaks, it starts the route maintenance phase to recover it [30].

Before broadcasting, it first accesses the route cache and checks whether the destination routing path is available in the node cache or not. If a path is available in the node cache, then the source uses that path to transmit the data [31]. If the routing path is unavailable, it rebroadcast the route request packet to the neighbor node, as shown in figure 1.

Node rebroadcast until it reaches the destination node. Each node stores the path at the node header to reach the destination from the source. Route request process generates by the node if the destination addresses are not available in the node cache. Route reply is generated by the intermediate node or the destination node if they know about the destination path, as shown in figure 2.

2.2.2 Ad-hoc On-demand Distance Vector (AODV) is the enhanced reactive form of the DSDV and DSR protocol. It combines the feature of the DSDV and DSR routing algorithm. It broadcast route requests when the sender node wants to transmit the data, so it is called the on-demand protocol, but in the case of the DSDV, it stores the network information at the node [32].
Route request packet has the information about the sender and receiver node. The AODV protocol broadcasts the RREQ packet to all the neighbor nodes to find the path. When an intermediate node receives the packet, check its address in the routing table if the intermediate node does not have any information regarding the receiver node, then to find the path node rebroadcast the packet to the neighbor node [33]. This process continues until the packet reaches the receiver node. The receiver node prepares the reply packet. From the routing table, the destination node knows that it received from which the source node. So, it updates the table and sends a unicast response to the sender node [34].

In the case of the low mobility condition, DSR performance is better compared to the AODV. Routing table analysis before route discovery will help avoid the route discovery process in DSR. Still, in the case of AODV, it broadcast the request packet to a nearby node in the network [35].

2.3. Balanced-hybrid Protocol

The advantages of the proactive and source-initiated protocol are marge in the hybrid protocol. This protocol is generally designed for an extensive network. It divides the area into the zone, so it uses the best feature of proactive mechanism to find the destination path at the nearby node and reactive agent used to find the route for far away nodes [37]. So, it prevents the problem of both protocols [36].

2.3.1 The zone routing protocol (ZRP): The protocol's advantages and disadvantages make it suitable for the different types of networks. Proactive routing protocol network information is stored at the node and will update periodically to decrease delay to find the destination route in the network [35]. But in the reactive protocol, it is required to find the path when the sender wants to send the data, increasing delay initially [38]. It is easier to preserve the information for the small network, so ZRP divides the network into the zone and within the zone. It uses the proactive protocol, and outside the zone, it works as a reactive routing protocol. Inside the zone, it is easier to maintain routing information for the small and large networks. Some data only keep data for the zone node, propagating the update inside the routing zone. Inside the zone routing, the proactive protocol used is the Intra zone Routing Protocol (IARP). Outside the zone, the source-initiated used is the Inter-zone Routing Protocol (IERP) [38]. IERP uses the query reply mechanism to create the route.

3. Experiment Work

Comparative analysis of the proactive, source-initiated, and balanced-hybrid protocol is done on Network Simulator 2.35 (NS2.35) platform with the specifications of the parameters as given in Table1.

Table 1
Parameter Specifications

Parameter	Typical Value
Platform	NS-2.35
Routing Protocols	AODV, DSR, DSDV, ZRP
Area of Network	900 m x 900 m
No. of nodes	10, 20, 30, 40, 50, 60, 70, 80, 90,100
Mobility Model	Random Mobility
Velocity	Min 1m/s to Max 30m/s
Traffic Type	UDP
MAC Protocol	IEEE 802.11
Period of Simulation	1800s
Packet Size	512

In the comparative analysis, we increase the number of mobile nodes and the sender as receivers in the network with random mobility. In the first simulation setup, we developed an ad hoc network with ten nodes, and two nodes continuously communicate with each other, with all the nodes having random mobility.

4. Results Analysis

For the comparative analysis of mobile node network protocol, four performance parameters as discussed below:

Throughput

It characterizes the percentage of the number of packets that reach the reserve from the sender to the time is taken by the receiver to receive all the data as given in Eqn (1). Figure 3 and Table 2 show the throughput analysis of the AODV, DSDV, DSR, and ZRP protocols.

$$Thoughput = \frac{1}{n}\sum_{i=1}^{n}\frac{b_i}{t_i}$$

1

- Where b_i is the total number of bits transferred over the destination per unit time t_i, n channel capacity, and i is sequence number.

Figure 3 shows the throughput represented by the AODV protocol throughout better than the other routing protocol in a small and large network with a random mobility environment. The number of nodes increases from 10 to 100 nodes the AODV and DSR protocol throughput increase from 60.2835 to 514.3095 bits/sec and 58.953 to 443.991 bits/sec, respectively. It more stables compared to other routing protocols because It is an on-demand routing protocol. It finds the path in the network when required. So, it is not required to store any information in the table and cache as the DSDV and DSR protocol are stored. DSR protocol throughput 58.953 bits/sec (at 10 Node) to 443.991 bits/sec (at 100 Node) better compare to the DSDV protocol throughput 48.3825 bits/sec (at 10 Nodes) to 191.103 bits/sec (at 100 Nodes). DSDV protocol throughput increases gradually up to the 70 Node network. After that, it decreases because it is difficult to maintain the routing table at a large network.

Table 2
Routing Protocol Throughput

No of Nodes	Throughput (kbps)			
	AODV	DSDV	DSR	ZRP
10	60.2835	48.3825	58.953	58.449
20	126.9105	104.337	122.3085	122.6175
30	190.752	164.154	184.0995	183.687
40	254.352	216.2205	245.2965	231.003
50	317.337	279.528	306.012	215.583
60	378.813	338.478	364.7415	143.811
70	436.0755	371.478	410.04	89.559
80	478.3515	331.599	442.497	55.437
90	501.1335	271.2195	465.444	37.8495
100	514.3095	191.103	443.991	27.54

Throughput for ZRP protocol varies from 58.449 (at 10 Nodes) to 231.003 (at 40 Nodes), which is better at the small network as compared to the throughput of DSDV protocol which is 48.3825 (at 10 Nodes) to 216.2205 (at 40 Nodes) while the mobile and communicating nodes are increasing in the network. In this case, ZRP routing protocol performance drastically decreases because peripheral nodes are also part of the neighbor zone. Due to this, intermediate nodes flood the same route request many times in the network. It will increase the delay in the network and drastically reduce the throughput of ZRP compared to other routing protocols. At an extensive network with nodes 50 to 100, the throughput of ZRP reduces to 27.54 compared to AODV, DSDV, and DSR protocol throughout that is 514.3095 bits/sec, 191.103 bits/sec, and 443.991 bits/sec, respectively.

Packet Delivery Ratio is the packet delivered at the receiver to the packet transmitted by the sender as given in Eqn (2). For a better packet delivery ratio, the network's throughput and routing protocol are

$$\text{PacketDeliveryRatio} = \frac{1}{n}\sum_{i=1}^{n}\frac{PktR_i}{PktS_i}$$

2

Where $PktR_i$ is the number of Received Packets

$PktS_i$ is the number of Send Packets

Table 3
Packet Delivery Ratio of the routing protocol

No of Nodes	Packet Delivery Ratio (%)			
	AODV	**DSDV**	**DSR**	**ZRP**
10	132.2468	106.274	134.26	127.75
20	139.1768	114.478	139.44	134.12
30	139.5282	120.022	139.72	133.756
40	139.4862	118.552	139.72	126.196
50	139.1782	122.57	139.44	94.332
60	138.4684	123.76	138.46	52.444
70	136.6204	116.396	133.42	27.944
80	131.0862	90.916	125.86	15.134
90	122.0716	66.094	117.74	9.184
100	112.7938	41.902	101.08	6.013

Figure 4 and Table 3 show that the packet delivery ratio of Reactive protocol (AODV and DSR) between the node (10 to 20) increases from 132.2468 to 139.1768 and for AODV and 134.26 to 139.44 for DSR protocol because all the nodes randomly move in the network space 900m x 900m. The destination node is not within the transmission range to drop the packet. And hence between the nodes 20 to 50, it delivered 99% of the packet delivered at the destination. After that, protocol performance degraded due to the congestion in the network. An extensive network AODV (80.5%) performs better than DSR (72.2%).

ZRP protocol performance is better than DSDV protocol when the 40 nodes are present in the network. When the number of nodes increases, its performance is degraded due to the peripheral zone node overlapping and several nodes increasing. It is switching from reactive to proactive or vice-versa. In AODV and DSR protocol, the packet delivery ratio is more stable, and it will decrease as several nodes increase, but it is more stables than other routing protocols.

- Packet Dropping Ratio is the ratio of the total packet loss to the packet sent by the sender.

Table 4
Packet Dropping Ratio of Routing Protocol

No of Nodes	Packet Dropping Ratio (%)			
	AODV	DSDV	DSR	ZRP
10	8.03010	34.9305	5.9247	12.6875
20	0.85260	26.4277	0.609	6.0871
30	0.48865	20.6886	0.2842	6.46555
40	0.53215	22.214	0.34365	14.29845
50	0.85115	18.05395	0.57275	47.3048
60	1.58630	16.81855	1.5544	90.69025
70	3.50030	24.44265	6.77005	116.06525
80	9.23215	50.837	14.5754	129.3313
90	18.5687	76.5484	23.0115	135.488
100	28.17785	101.5957	40.29405	138.77225

Figure 5 and Table 4 show the packet dropping ratio, ZRP (138.77225) and DSDV (101.5957) drop a large number of the packet compared to AODV (28.17785) and DSR (40.29405) routing protocols at 100 node networks. DSDV drop packet because it periodically updates the routing table. AODV and DSR have similar behavior. Node increases from 10 to 60, DSR drops (5.9247–1.5544%) a smaller packet number than the AODV (5.5% to 1.094) because it maintains the routing cache. As the number of nodes increases from 70 to 100, DSR cache size increases, and it will drop a more number of packets (6.77005–40.29405%) than AODV (3.5003–28.17785%). The number of nodes increases every protocol packet dropping ratio also increases. DSDV and ZRP drop many packets 70% and 95%, respectively, at 100 nodes compared to AODV (28%) and DSR (40%) because DSDV performance degrades due to routing table and ZRP performance due to the zone overlapping.

Routing overhead: It is the total number of routing packets like RREQ, RREP, RERR, and Hello packet to the total number of delivered packets at the receiver [18].

Table 5
Routing Protocol Overhead

No of Nodes	Routing Overhead			
	AODV	DSDV	DSR	ZRP
10	0.05805	0.16065	0.0513	4.81815
20	0.09585	0.18495	0.04725	6.7662
30	0.135	0.23085	0.06615	8.81415
40	0.2052	0.2862	0.08505	10.9377
50	0.26595	0.34965	0.10125	15.498
60	0.3834	0.5211	0.13635	28.53495
70	0.5184	1.0827	0.22275	54.92205
80	0.7533	1.59975	0.32265	110.0358
90	1.0908	2.34765	0.42255	195.7716
100	1.34325	3.8286	0.79785	310.54995

Figure 6 and Table 5 show that ZRP has a significant routing overhead of 4.81815 to 310.54995 varies for 10 to 100 nodes, respectively. Compared to all other routing protocols, many control packets are required because it maintains the routing zone and change from proactive to reactive or vice-versa. As node density increases, the routing overhead also increases in the network. In DSR, routing overhead (0.05 to 0.7) is less because routing is maintained between the communicated nodes, whereas the DSDV routing overhead is less (0.1 to 3.8) due to the table maintenance. DSDV routing overhead goes smooth because it has small changes caused by the network load and the node mobility. AODV (0.05 to 1.3) preserves only one routing entry for each destination node, and it triggers a new routing discovery process when any link breaks in the network. Its routing overhead is higher compared to DSDV and DSR. In general, DSR performs the best result in the network in all routing protocols.

End-to-End Delay

It is given as the average time needed for data delivery at their receiver from the sender across the network.

The simulation-based analysis concludes that the network's number of nodes and traffic increase, and the end-to-end delay of the AODV, DSR, DSDV, and ZRP protocol increases, as shown in Figures 7 and 6. But AODV routing protocol performance is more stable than all other routing protocols for small and large network conditions with the number of the communicating node.

Table 6
End to End dealy for Routing Protocol

No of Nodes	End to End delay			
	AODV	DSDV	DSR	ZRP
10	0.09546	0.01419	0.129	0.15738
20	0.02064	0.02064	0.0516	0.03096
30	0.02451	0.02322	0.0516	0.03096
40	0.0258	0.02838	0.0645	0.21027
50	0.03741	0.02967	0.1161	1.49898
60	0.06321	0.10965	0.258	5.02068
70	0.15093	1.06425	0.9159	10.54575
80	0.37797	2.74254	1.806	14.8995
90	0.78948	5.31093	2.7477	18.3051
100	1.39062	9.81432	4.7859	21.5043

For the small network (i.e.10 to 50 Nodes), the DSDV protocol has a minor delay of 0.029sec as compared to AODV (0.029sec), DSR (0.11sec), and ZRP (1.49sec) protocol because it maintains the route for the destination in the route. When nodes increase from 60 to 100 and traffic increases, the delay also increases for the DSDV routing protocol from 0.10965 to 9.81432 sec. The AODV protocol increases from 0.09546 to 1.3 seconds because of the time consumed in the computation of the routes. Initially, AODV required more delay to find the route because it finds the path when any source node sends the data. After that, it has needed less delay of 1.39062 sec. (at 100 nodes) and more stable at large networks compared to DSDV (9.81432 sec.), DSR (4.7859), and ZRP (21.5043) protocol. Up to the 60 nodes, DSDV routing protocol delay varies from 0.01419 to 0.10965 sec. that is less than DSR protocol delay (0.1 to 0.258 sec.) but as the node increases in the network. Its performance degraded because it periodically updates the routing table in the network. For the extensive network of 100 nodes, DSDV and DSR delay 9.81 sec and 4.78 sec. respectively. Whereas 70 to 100 nodes DSR delay (0.9159 to 4.7859 sec.) better compared to DSDV delay (1.06425 to 9.81432 sec.), but it degraded as compared to AODV delay (0.15093 to 1.39062 sec.) because it stores the path at the node cache-memory. For the ZRP protocol, as the number of node increase from 10 to 100 nodes, the delay increase from 0.15738 to 21.5043 sec. because it has difficulty finding the route in mobility & traffic due to its zone-based algorithm.

5. Conclusion

This study analyzes AODV, DSDV, DSR, and ZRP routing protocols' performance metrics such as throughput, packet delivery ratio, packet dropping ratio, end-to-end delay, and routing overhead with the velocity of 30 m/s.

As traffic and nodes increase from 10 to 100 nodes, the AODV and DSR protocol throughput increase from 60.2835 to 514.3095 bits/sec and 58.953 to 443.991 bits/sec, respectively more stable as compared to other routing protocols. DSR protocol shows similar performance as AODV routing protocol in all the performance metrics; nevertheless, when the number of nodes increases, the protocol performance degrades compared to the AODV because it stored route in the node cache memory.

For small ad hoc networks, the ZRP protocol shows better performance than the DSDV protocol. Still, the large ad-hoc network's performance degraded because of maintaining the routing zone and switching between the protective and reactive routing mechanisms when the traffic increased. Amongst all routing protocols, the AODV protocol shows more stable performance than other protocols even when the network's number of nodes and traffic increased.

Declarations

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Figures

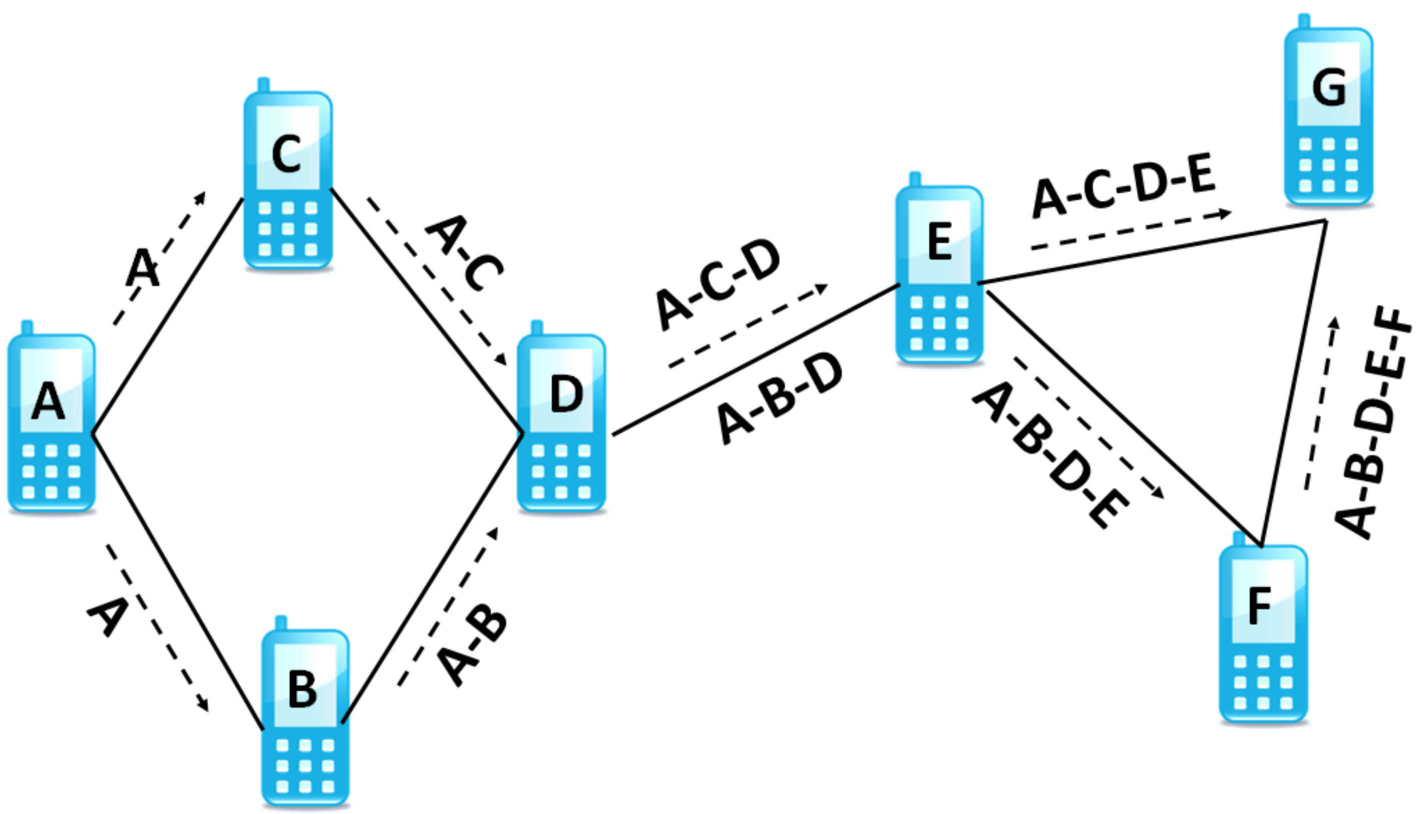

Figure 1

DSR Route Discovery

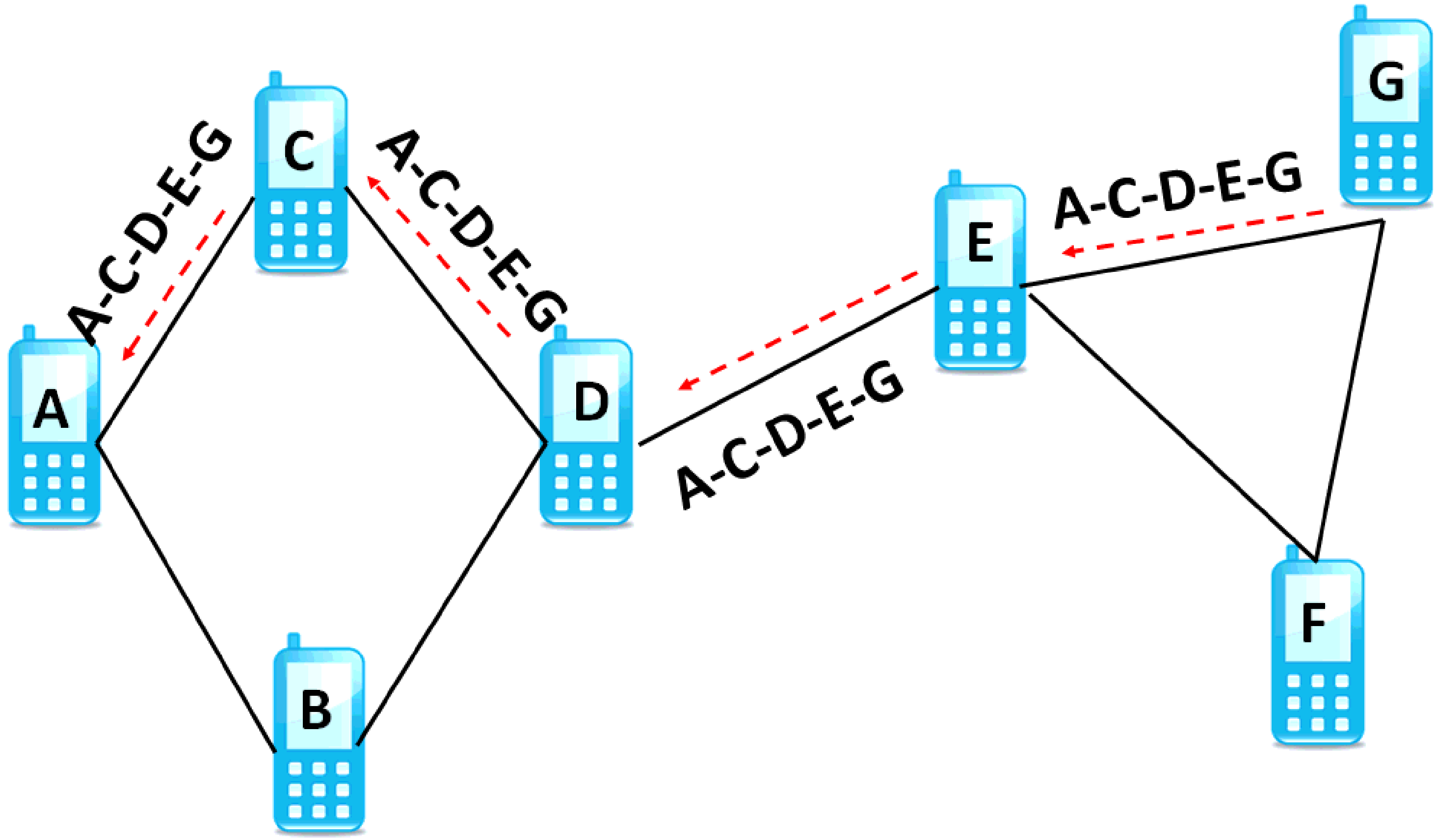

Figure 2

DSR Route Reply

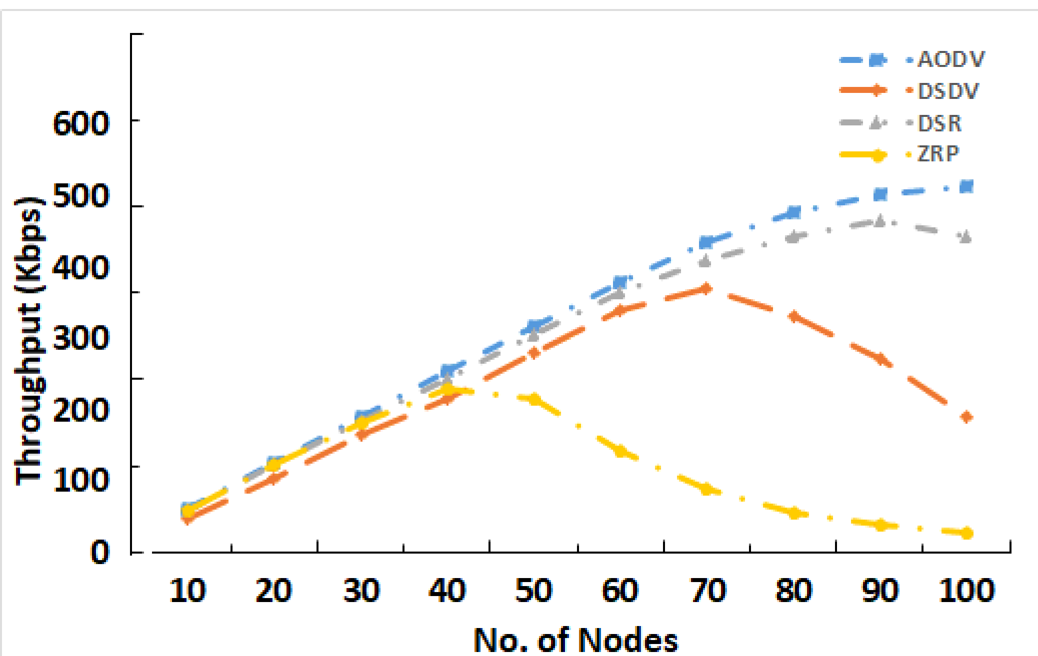

Figure 3

Throughput concerning the number of Node for AODV, DSDV, DSR, and ZRP protocol.

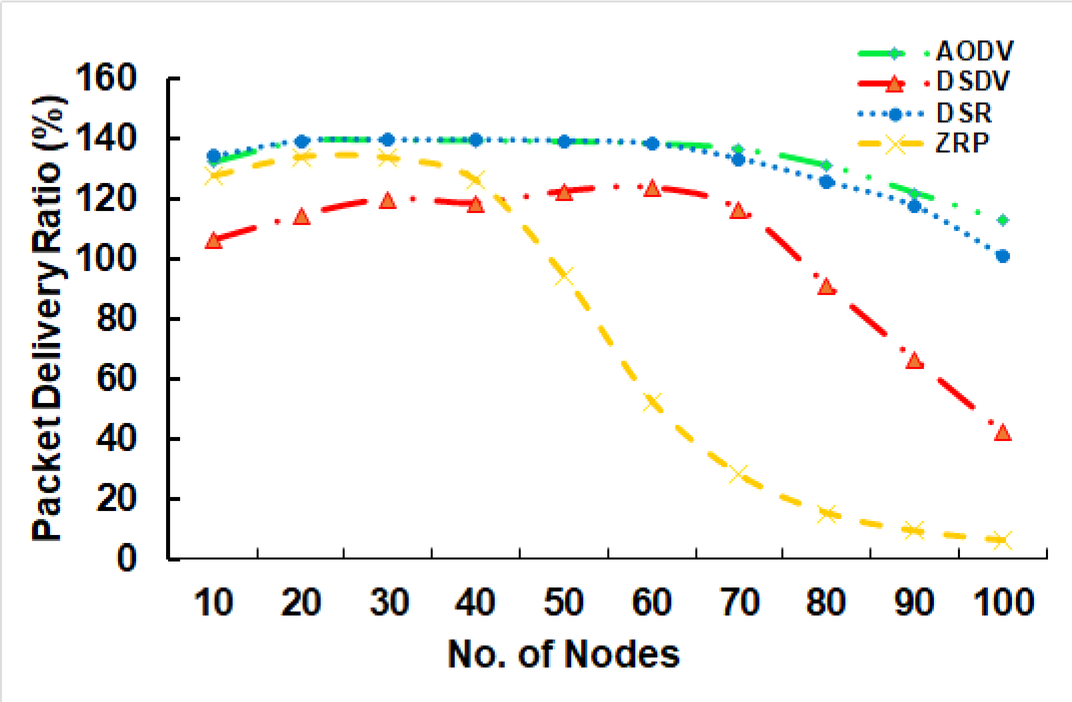

Figure 4

Packet delivery ratio

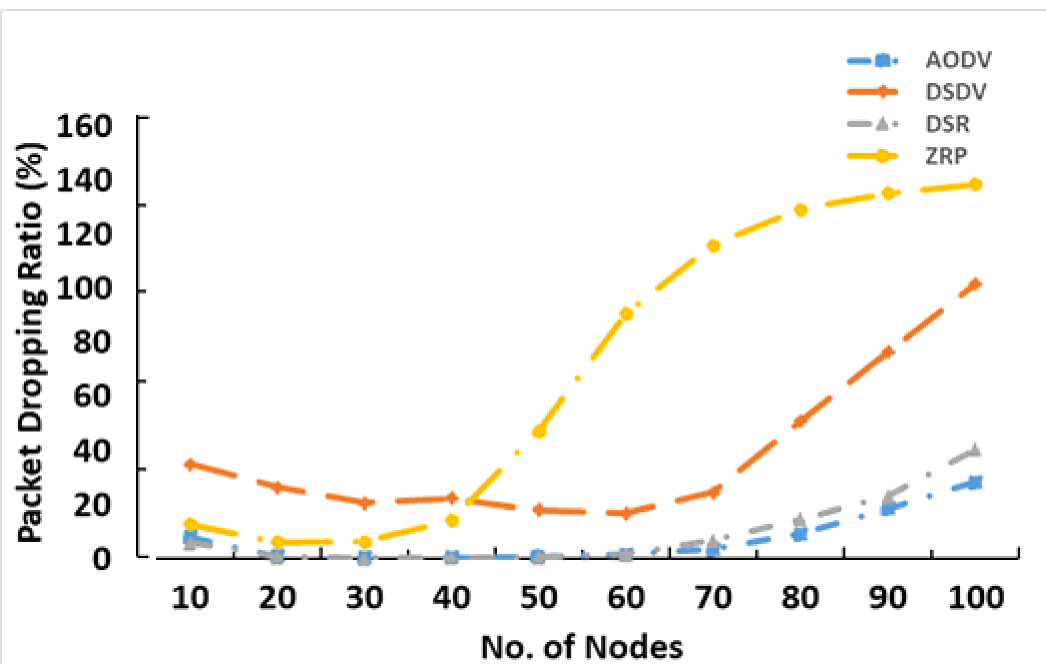

Figure 5

Packet Dropping Ratio

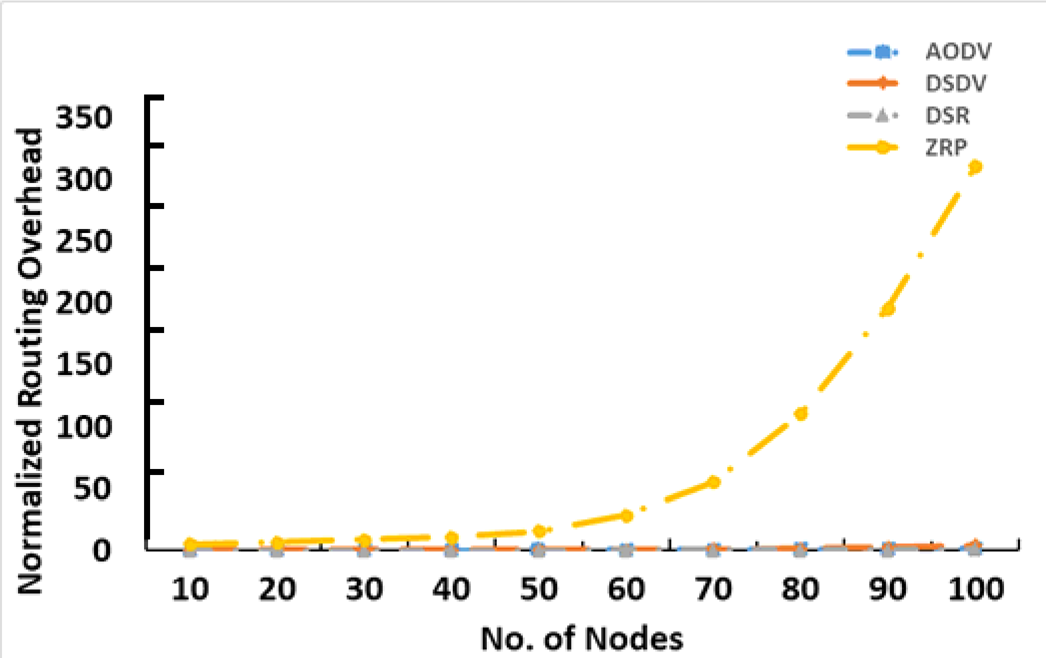

Figure 6

Routing Overhead

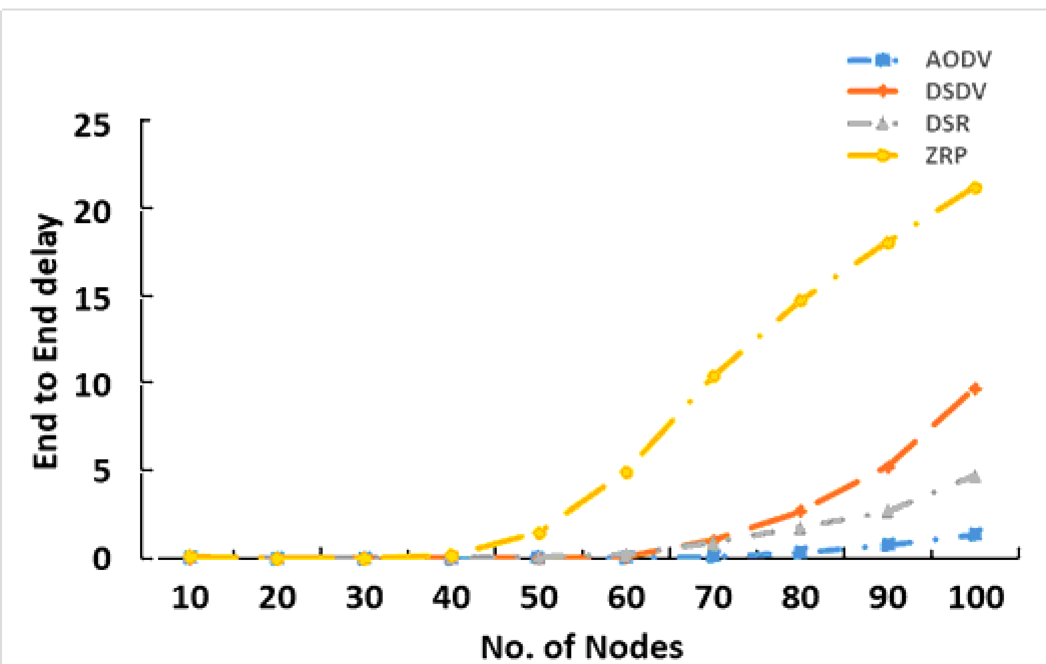

Figure 7

End to End Delay