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Performance analysis of AODV, DSR, OLSR and DSDV Routing Protocols using NS2 Simulator

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Abstract

Path routing and protocol selection are the primary strategies to design any wireless network. In Mobile Adhoc Network (MANET) the selected protocol should have best in terms of data delivery and data integrity. Hence the performance analysis of the protocols is the major step before selecting a particular protocol. In this paper, the performance analysis is carried out on Adhoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) protocols using NS2 simulator. The delay, throughput, control overhead and packet delivery ratio are the four common measures used for the comparison of the performance of above protocols.

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Keywords: Mobile Adhoc Network; Routing protocols; NS2 (Simulator); Throughput; Delay; Packet Delivery Ratio; Control Overhead.

1. Introduction

Ad hoc networks consist of hosts interconnected by routers without a fixed infrastructure and can be arranged dynamically. Considerable work has been done in the development of routing protocols in different types of ad hoc networks like MANETs, WMNs, WSNs, and VANETS etc [1]. In recent years, the interest in ad hoc networks has grown due to the availability of wireless communication devices that work in the ISM bands. While designing an ad hoc network in particular we are concerned with the capabilities and limitations that the physical layer imposes on the network performance. Since in wireless

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networks the radio communication links are unreliable so it is desirable to come up with an integrated design comprising of physical, MAC and network layers. The main vision of MANET is to support robust and efficient operation in wireless networks by incorporating routing functionalities at each mobile node. For such designing aspects of ad hoc networks Routing-based approach, Information-theoretic approach, Dynamic control approach or Game-theoretic approach has been implemented [2]. In MANET to support mobile computing a mobile host must be able to communicate with other mobile hosts which may not lie within it's radio transmission range. Hence routing protocols will need to perform four important functions as determination of network topology, maintaining network connectivity, transmission scheduling and channel assignment, and packet routing. Routing protocols in MANETs were developed based on the design goals of minimal control overhead, minimal processing overhead, multi hop routing capability, dynamic topology maintenance and loop prevention [3]. Classification on routing protocols in MANETs can be done on routing strategy wise or network structure wise. According to routing strategy the routing protocols can be categorized as table-driven or proactive and source-initiated or reactive or on-demand routing. Each of these types of protocols behaves differently on different wireless conditions. Hence the performance analysis of these protocols is a must task to know its behaviour and work in that environment. Several factors will affect the overall performance of any protocol operating in an ad hoc network. For example, node mobility may cause link failures, which negatively impact on routing and quality of service (QoS) support. Network size, control overhead, and traffic intensity will have a considerable impact on network scalability along with inherent characteristics of ad hoc networks may result in unpredictable variations in the overall network performance.

The primary objective of this paper is to evaluate and quantify the effects of various factors that may influence network performance. While there has been performance analysis of ad hoc networks [4-6], still some of the influential factor evaluation is also missing. Again none of these papers have compared with OLSR as a routing protocol and also they have not considered geographical network size into account. We emphasized on the performance metrics of end-to-end delay, throughput, control overhead, and packet delivery ratio. The above metrics are validated for variable network load, variable mobility and variable network size. The remainder of this paper is organized as follows. Section 2 gives a brief idea on the different routing protocols used for performance analysis. Section 3 describes the simulation methodology and performance metrics. The simulation results and design analysis is described in Section 4 followed by the conclusion and future work in Section 5.

2. MANET Routing Protocols

In this section, we briefly describe the key features of the AODV, DSDV, OLSR and DSR protocols studied in our simulations. We also describe the particular parameters that we choose when implementing each protocol. But before that the basic differences in these protocol implementation lies in the mechanisms they followed according to routing strategy based classification as reactive and proactive protocols. In Reactive or on-demand routing routes are only discovered when they are actually needed. Hence, a node that wants to send a packet to another node, the reactive protocols searches for the route in an on-demand basis and establishes a connection to transmit and receive a packet. The route discovery typically consists of network wide flooding of request message. In contrast, in proactive routing each node continuously maintain route between pair of nodes. Hence, route creation and maintenance is accomplished through some combination of periodic and event-triggered routing updates derived from distance-vector or link-state method. Both these approaches have some advantages as well as some disadvantages and can be analyzed from its performance metrics as discussed in next section. In this article, we focused on AODV and DSR as reactive protocol and DSDV and OLSR as link-state proactive protocol.

2.1. Ad-hoc On-demand Distance Vector (AODV)

AODV is a combination of on-demand and distance vector i.e. hop-to-hop routing methodology [7]. When a node needs to know a route to a specific destination it creates a ROUTE REQUEST. Next the route request is forwarded by intermediate nodes which also create a reverse route for itself for destination. When the request reaches a node with route to destination it creates again a REPLY which contains the number of hops that are require to reach the destination. All nodes that participate in forwarding this reply to the source node create a forward route to destination. This route created from each node from source to destination is a hop-by-hop state and not the entire route as in source routing.

2.2. Destination Sequenced Distance Vector (DSDV)

DSDV is a hop-by-hop distance vector routing protocol requiring each node to periodically broadcast routing updates based on the idea of classical Bellman-Ford Routing algorithm [8]. Each node maintains a routing table listing the “next hop” for each reachable destination, number of hops to reach destination and the sequence number assigned by destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid loop formation. The stations periodically transmit their routing tables to their immediate neighbors. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven. The routing table updates can be sent in two ways: a “full dump” or an “incremental” update.

2.3. Optimized Link State Routing (OLSR)

OLSR is an optimization of pure link state algorithm [9], uses the concept of Multi point Relays (MPR) for forwarding control traffic, intended for diffusion into the entire network. The MPR set is selected such that it covers all nodes that are two hops away. Due to proactive nature, OLSR works with a periodic exchange of messages like *Hello* messages and Topology Control (*TC)* message only through its MPR. The parameters used by OLSR to control the protocol overheads are Hello-interval parameter, TC-interval parameter, MPR coverage parameter and TC-redundancy parameter. So, contrary to classic link state algorithm, instead of all links, only small subsets of links are declared.

2.4. Dynamic Source Routing (DSR)

DSR is a simple and efficient routing protocol designed specifically for use in multihop wireless adhoc networks of mobile nodes [10]. It allows nodes to dynamically discover a source route across multiple network hops to any destination in the adhoc network. Each data packet sent then carries in its header the complete ordered list of nodes through which the packet must pass, allowing packet routing to be a trivially loop free and avoiding the need for up-to-date routing information in the intermediate nodes through which the packet is forwarded. With the inclusion of this source route in the header of each data packet, other nodes forwarding or overhearing any of the packets may easily cache this routing information for future use.

3. Simulation Methodology and Performance Metrics

3.1. Simulation Modeling

Simulation helps in analyzing the performance and behavior of complex networks before implementing it in today’s real application. Several network simulators are available, whose output depicts as close as possible to real time implementation. In this work, we used the discrete-event simulator NS2 (version 2.34) [11] and the performance analysis were conducted using AWK script [12]. There are several models available in NS2 simulator, from which, we considered the following models: (i) *Node Model* for energy source, memory capacity, processing capabilities etc, (ii) *Node deployment model* for placement of nodes and its position as uniform model, (iii)N*ode mobility model* for dynamic network topologies as Random Waypoint Mobility model, (iv) *Radio Model* for characteristics of radio used by node with a proper frequency, bandwidth, MAC layer functionality as IEEE 802.11 MAC model, (v) *Wireless Signal Propagation Model* for SNIR at receiver as Two Ray Ground propagation model, (vi) *Packet loss model* for packets collision or dropped in Markov error model, (vii) *Traffic Model* for nodes sending traffic to destinations mostly CBR, UDP Model.

3.2. Simulation Methods and parameters

The goal of our experiments is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks. Each run of the simulator accepts as input a *scenario file* that describes the exact motion of each node using Random Waypoint mobility model and the exact sequence of packets originated by each node together with exact time at which change in packet or motion origination occurs. Hence, to evaluate the performance at a particular factor, we consider 10 random simulation runs to generate 10 random scenario patterns and the performance of the considered factor is the average of these 10 outputs. In all our experiments we considered five sample points of a particular factor and verified for three different protocols i.e. AODV, OLSR and DSDV. Therefore 150 simulation runs were conducted to analyze each performance factor for these three protocols. Since our experiments is based on network layer characteristics so changes in routing strategy is only observed where as other characteristics like antenna gain, transmit power, ground propagation model and receiver sensitivity as physical layer characteristics, MAC 802.11 as wireless ethernet for data link layer characteristics, UDP as transport layer characteristics and CBR as application layer characteristics remain fixed. The parameters in our simulation are reported in Table 1.

3.3. Performance Metrics

The performance metrics helps to characterize the network that is substantially affected by the routing algorithm to achieve the required Quality of Service (QoS). In this work, the following metrics are considered.

End-to-End Delay(EED): It is the time taken for an entire message to completely arrive at the destination from the source. Evaluation of end-to-end delay mostly depends on the following components i.e. propagation time (PT), transmission time (TT), queuing time (QT) and processing delay (PD). Therefore, EED is evaluated as:

$$\boldsymbol{EED = PT + TT + QT + PD.} \tag{1}$$

Throughput: It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

Control Overhead: It is ratio of the control information sent to the actual data received at each node.

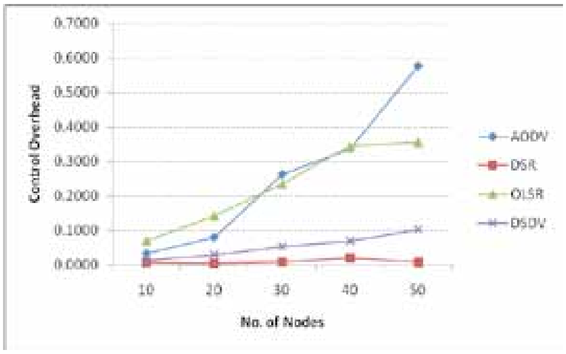
Packet Delivery Ratio (PDR): It is the ratio of the total data bits received to total data bits sent from source to destination.

4. Result Analysis

In this work the performance analysis is carried out in an adhoc network by varying three parameters i.e. number of nodes or pause time or network area while keeping other parameters constant. Four protocols i.e. AODV, DSR, OLSR and DSDV are considered for the comparison purpose on the above performance. The three above performance factors are known as Network Load analysis, Mobility analysis and Network Size analysis.

Table 1: Simulation parameters for MANETs

Simulation parameters	***Value***	***Simulation parameters***	***Value***
Network Type	Mobile	Connection type	CBR/UDP
Connection Pattern	Random	Simulation area(sq. m)	200, 400, 600, 800, 1000
Packet Size	500 bytes	Number of Nodes	10, 20, 30, 40, 50
Duration	150s	Pause time	0s, 30s, 90s, 120s, 150s



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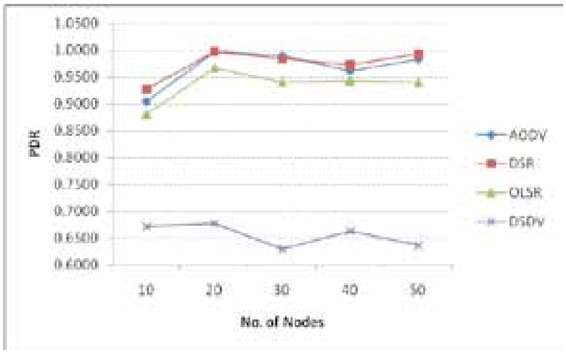

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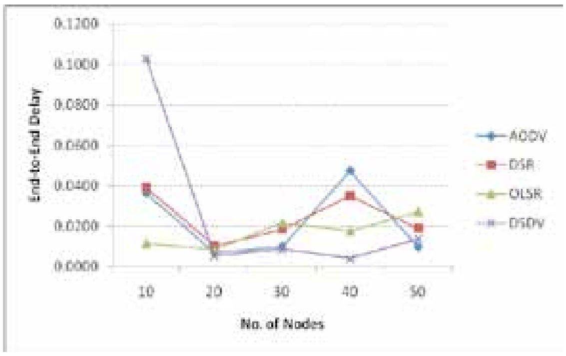

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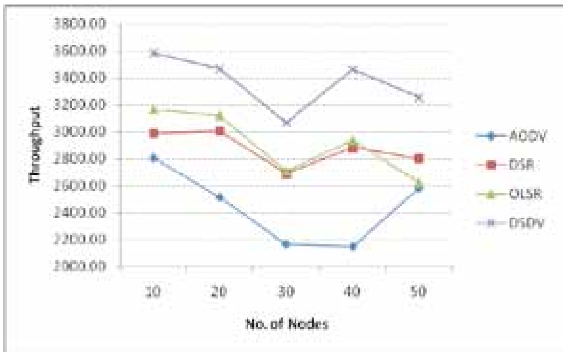

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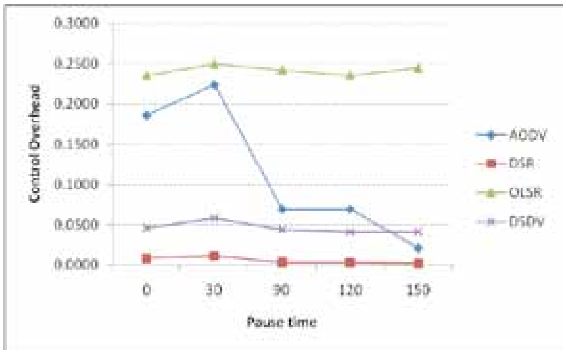
Fig 1 Performance analysis varying number of nodes.(a) Variation for control overhead (b) Variation of PDR (c) Variation of end-to-end delay (d) Variation of throughput.

Network Load Analysis: In this analysis the number of nodes varied from 10 to 50 with an increment of 10 nodes whereas the pause time , network size and simulation duration are fixed at 30s, 600X600 sqm. and 150s respectively. Other parameters of the network are same as described in the previous section. In simulation, 10 random scenarios are generated by 10 simulation runs for each sample point of a particular protocol and the average value is used to plot the performance of a network by varying the number of nodes. The performance plots i.e Number of nodes vs Control Overhead, Number of nodes vs PDR, Number of nodes vs End-to-end Delay and Number of nodes vs Throughput is shown in Fig 1 (a), (b), (c), and (d) respectively. In terms of control overhead the DSR protocol has less control overhead in comparision with AODV, OLSR and DSDV as shown in Fig 1(a). The OLSR has highest control overhead upto 25 nodes and after that it is almost similar to the AODV. If the number of nodes increases then the control overhead of all protocols increases whereas the control overhead of DSR has a very slow rate of change in comparision to other protocols considered in this work. From Fig 1(b) it is observed that the DSR outperforms the OLSR and DSDV whereas it is very closer with AODV in terms of PDR by increasing the nodes. Similarly the DSR gives an average result in terms of delay and the variation is very low as compared to DSDV and AODV for different nodes which are shown in Fig 1(c). The throughput of DSR is closer to OLSR but lower than the DSDV as shown in Fig 1(d). The AODV has lowest throughput in comparision with all the other three protocols considered.



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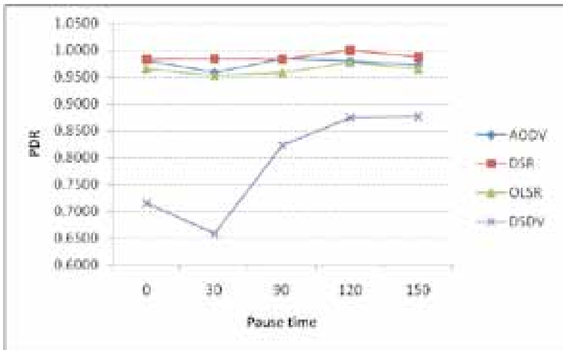

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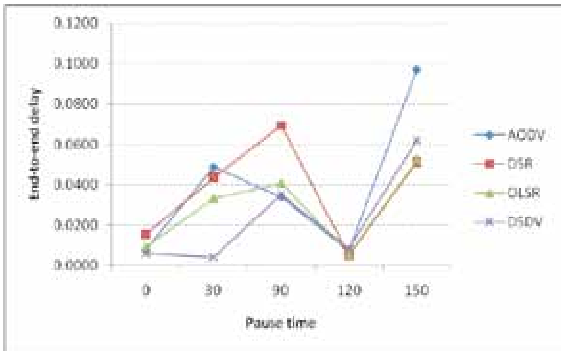

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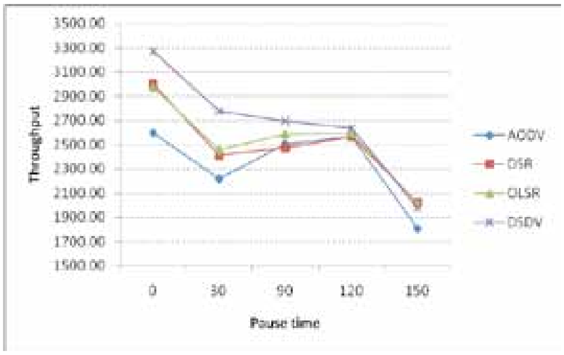
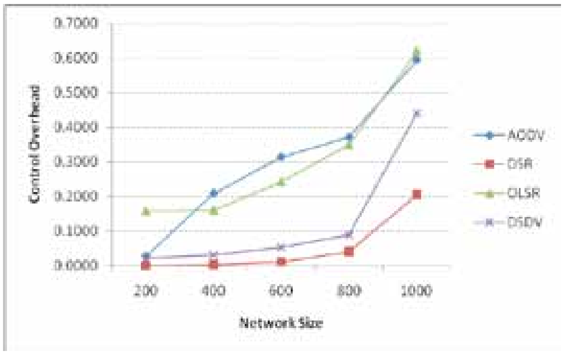


(d)

Fig 2 Performance analysis varying pause time.(a) Variation for control overhead (b) Variation of PDR (c) Variation of end-to-end delay (d) Variation of throughput.

Mobility Analysis: In this analysis we assumed that each node has different velocity and direction. We considered "Random Waypoint Mobility" model of NS2 simulator to generate different mobility scenario. In simulation we considered the following pause times: 0s,30s, 90s, 120s and 150s. i.e. the mobile condition (0s pause time) to static condition (150s pause time; same as total simulation duration). The maximum speed which is an important factor is fixed at around 10 m/s and the total number of nodes is fixed at 30 for each scenario of different pause time keeping all other parameters fixed. The performances like control overhead, PDR, End-to-End-Delay and Throughput are measured by varying the pause time which is reported in Fig 2(a), (b), (c) and (d) respectively. In terms of control overhead OLSR has the highest and DSR has the lowest overhead as shown in Fig 2(a). Hence DSR is the best in terms of control overhead with different pause time. Similarly the DSR has highest PDR in different pause time which is reported in Fig 2(b). From Fig 2(c) it is observed that the end-to-end delay is highest for the DSR up to 90 pause times and at 120 pause time all the protocols have almost same end-to-end delay; infact this is the lowest end-to-end delay and after 120 pause time, DSR protocol has the lowest end-to-end delay. As shown in Fig 2(d), DSR has the moderate throughput which is in between AODV and DSDV but closer to OLSR whereas after 120 pause time the throughput of all the protocols have almost equal throughput.



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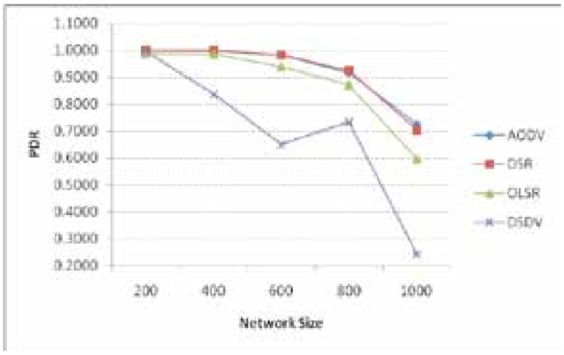

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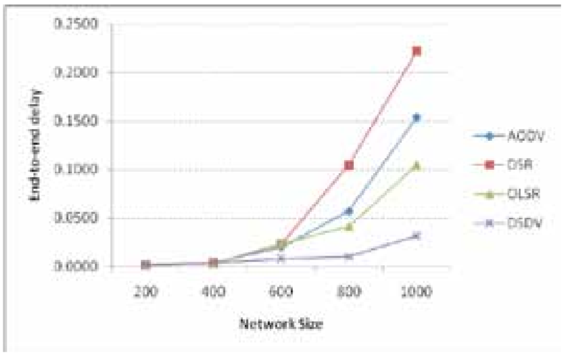

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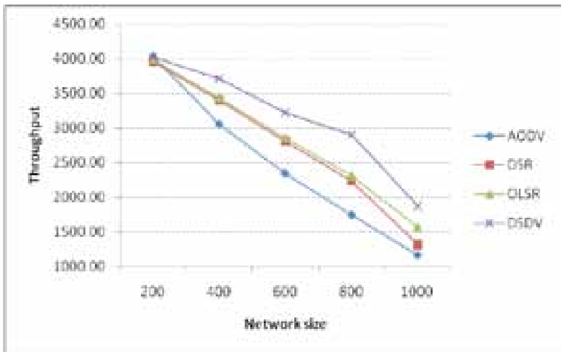

(d)

Fig 3 Performance analysis varying network size.(a) Variation for control overhead (b) Variation of PDR (c) Variation of end-to-end delay (d) Variation of throughput.

Network Size Analysis: In network size analysis the geographic network area is varied as 200x200 sqm, 400x400 sqm, 600x600 sqm, 800x800 sqm, and 1000x1000sqm keeping the number of nodes fixed at 30 under highly mobile condition. The performance plots varying control overhead, PDR, End-to-end delay and throughput with network size is shown in Fig 3(a), (b), (c) and (d) respectively. From Fig 3(a) it is observed that DSR performs better in terms of control overhead as it is very low in compared to other protocols i.e. AODV, DSDV and OLSR protocols. The PDR of AODV and DSR is almost same as shown in Fig 3(b). Again the PDR performance of OLSR is better than DSDV but poor than other two protocols after 400x400sqm. network size. From Fig 3(c) it is observed that the end-to-end delay gradually increases for all protocols as network size is increased. It is maximum for DSR and minimum for DSDV protocol after 400X400 sqm. network size. As delay is increased the throughput for all protocols are decreased gradually with increase in network size as shown in Fig 3(d). The DSDV protocol has the highest throughput, whereas DSR and OLSR have moderate throughput and are almost same for different network sizes upto 600X600sqm.

5. Conclusion

In this paper we evaluated the four performance measures i.e. control overhead, PDR, end-to-end delay and throughput with different number of nodes, different speed (pause time) of nodes and different size of network. From results reported in section 4 we concluded that DSR protocol is the best in terms of average PDR. For high mobility condition of nodes DSR gives better packet delivery ratio than other protocols making it suitable for highly mobile random networks. Similarly for network size analysis it is observed that the DSR protocols outperforms other protocols if the network size is less than 600x600sqm. From this analysis we consider 600X600 sqm size network to evaluate the network load anlaysis and mobility analysis. If the network size is more than 600x600sqm. and if PDR and throughput are the prime criteria, the OLSR protocol is the better solution for high mobility condition. In future, utilizing these performances we can design such a protocol that can be suitably provide data integrity as well as data delivery in highly random mobility network. Our focus is to analyze the energy metrics as the cost function for routing in these protocols for better QoS applications.

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