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MANET performance for source and destination moving scenarios considering OLSR and AODV protocols

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Abstract. Recently, a great interest is shown in MANETs potential usage and applications in several fields such as military activities, rescue operations and time-critical applications. In this work, we implement and analyse a MANET testbed considering AODV and OLSR protocols for wireless multi-hop networking. We investigate the effect of mobility and topology changing in MANET and evaluate the performance of the network through experiments in a real environment. The performance assessment of our testbed is done considering throughput, number of dropped packets and delay. We designed four scenarios: Static, Source Moving, Destination Moving and Source-Destination Moving. From our experimental results, we concluded that when the communicating nodes are moving and the routes change quickly, OLSR (as a proactive protocol) performs better than AODV, which is a reactive protocol.

1. Introduction

During recent years, we have witnessed a lot of research on wireless networks [5,16,17,21,1,8,24,25]. There are two network architectures for wireless networks: infrastructure and ad-hoc architecture.

Wireless networks often extend, rather than replace, wired networks, which are referred to as infrastructure networks. The wide area and local area wired networks are used as the backbone network. The wired backbone connects to special switching nodes called Base Stations (BSs). The BSs are often conventional PCs and workstations equipped with custom wireless adapter cards. They are responsible for coordinating access to one or more transmission channel(s) for mobiles located within the coverage cell.

Ad-hoc networks, on the other hand, are multi-hop wireless networks in which a set of mobile nodes cooperatively maintain network connectivity. Ad-hoc networks are characterized by dynamic,

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unpredictable, random, multi-hop topologies with typically no infrastructure support. The mobile nodes must periodically exchange topology information which is used for routing updates.

A Mobile Ad hoc Network (MANET) is a collection of wireless mobile terminals that are able to dynamically form a temporary network without any aid from fixed infrastructure or centralized administration. In recent years, MANET are continuing to attract the attention for their potential use in several fields. Mobility and the absence of any fixed infrastructure make MANET very attractive for mobility and rescue operations and time-critical applications.

Most of the work for MANETs has been done in simulation, as in general, a simulator can give a quick and inexpensive understanding of protocols and algorithms [9,10,20,26]. However, experimentation in the real world are very important to verify the simulation results and to revise the models implemented in the simulator. A typical example of this approach has revealed many aspects of IEEE 802.11, like the gray-zones effect [14], which usually are not taken into account in standard simulators, as the well-known *ns-2* simulator [22].

So far, we can count a lot of computer simulation results on the performance of MANET, e.g. in terms of end-to-end throughput, delay and packet loss. However, in order to assess the computer simulation results, real-world experiments are needed and a lot of testbeds have been built to date [12,23,13]. The baseline criteria usually used in real-world experiments is guaranteeing the repeatability of tests, i.e. if the system does not change along the experiments. How to define a change in the system is not a trivial problem in MANET, especially if the nodes are mobile.

In this paper, we focus on comparing the performance of two types of routing protocols Ad-hoc On demand Distance Vector (AODV), which is a reactive routing protocol, and Optimized Link State Routing (OLSR), which is a proactive routing protocol. Both protocols have been gaining great attention within the scientific community. Furthermore, the *aodv-uu* [4] and the *olsrd* [18] software we have used in our experiments are the most updated software we have encountered.

In our previous work, we found the following results. We proved that while some of the OLSR's problems can be solved, for instance the routing loop, this protocol still have the self-interference problem. There is an intricate inter-dependence between MAC layer and routing layer, which can lead the experimenter to misunderstand the results of the experiments. We carried out the experiments considering stationary nodes of ad-hoc network. We considered the node mobility and carry out experiments for AODV, OLSR and BATMAN protocols [2]. We found that throughput of TCP were improved by reducing Link Quality Window Size (LQWS), but there were packet loss because of experimental environment and traffic interference. For TCP data flow, we got better results when the LQWS value was 10.

In this work, we implemented four MANET scenarios and carried out real world experiments in an indoor environment. We assess the performance of two routing protocols AODV and OLSR for different source and destination moving scenarios.

The structure of the paper is as follows. In Section 2, we give a short description of AODV and OLSR. In Section 3, we describe the testbed and its implementation. The moving scenarios are described in Section 4. In Section 5, we present experimental evaluation. Finally, conclusions are given in Section 6.

2. Routing protocols

2.1. AODV overview

AODV is one of the most popular reactive routing protocol for MANETs [19]. As a reactive (on demand) protocol, when a node wants to transmit data, it first starts a route discovery process, by flooding a RREQ (Route Request) packet. The RREQ packets are forwarded by all nodes by which they are received. This procedure continues until the destination is found. On the way to destination, the RREQ informs all the intermediate nodes about a route to the source. When the RREQ reaches the destination, destination sends a Route Reply (RREP) packet which follows the reverse path discovered by RREQ. This informs all intermediate nodes about a route to the destination node. After RREQ and RREP are delivered to their destination, each intermediate node on the route knows what node to forward data packets in order to reach source or destination. Thus data packets do not need to carry addresses of all intermediate nodes in the route. It just carries the address of the destination node, decreasing noticeably routing overheads.

A third kind of routing message, called Route Error (RERR), allows nodes to notify errors, for example, because a previous neighbor has moved and is no longer reachable. If the route is not active (i.e., there is no data traffic flowing through it), all routing information expire after a timeout and is removed from the routing table.

In AODV, the route discovery process may last for a long time, or it can be repeated several times, due to potential failures during the process. This introduces extra delays, and consumes more bandwidth as the size of the network increases.

2.2. OLSR overview

The link state routing protocol that is most popular today in the open source world is OLSR from olsr.org. OLSR with Link Quality (LQ) extension and fisheye-algorithm works quite well. The OLSR protocol is a pro-active routing protocol, which builds up a route for data transmission by maintaining a routing table inside every node of the network.

The routing table is computed upon the knowledge of topology information,which is exchanged by means of Topology Control (TC) packets. The TC packets in turn are built after every node has filled its neighbors list. This list contains the identity of neighbor nodes. A node is considered a neighbor if and only if it can be reached via a bi-directional link. OLSR checks the symmetry of neighbors by means of a 4-way handshake based on the so called HELLO messages. This handshake is inherently used to compute the packet loss probability over a certain link. This can sound odd, because packet loss is generally computed at higher layer than routing one. However, an estimate of the packet loss is needed by OLSR in order to assign a weight or a state to every link.

In OLSR, control packets are flooded within the network by electing special nodes, called Multi Point Relays (MPRs), to the role of forwarding nodes. By this way, the amount of control traffic can be reduced. These nodes are chosen in such a way that every node can reach its neighbors 2-hops far away. In our OLSR code, a simple RFC-compliant heuristic is used [3] to compute the MPR nodes. Every node computes the path towards a destination by means of a simple shortest-path algorithm, with hop-count as target metric. In this way, a shortest path can result to be also not good, from the point of view of the packet error rate. Accordingly, recently OLSRd has been equipped with the Link Quality (LQ) extension, which is a shortest-path algorithm with the average of the packet error rate as metric. This metric is commonly called as the Expected Transmission Rate (ETX), which is defined as ETX$(i) = 1/(NI(i) \times LQI(i))$. Given a sampling window W, NI(i) is the packet loss probability seen by a node on the i-th link during W. Similarly, LQI(i) is the estimation of the packet loss seen by the neighbor node which uses the i-th link. When the link has a low packet error rate, the ETX metric is higher. The LQ extension greatly enhances the packet delivery ratio with respect to the hysteresis-based technique [6].

Table 1
Node addressing table

Node ID	IP Address	Operating System
Node 1	192.168.0.1	Fedora Core 4
Node 2	192.168.0.2	Ubuntu 9.04
Node 3	192.168.0.5	Ubuntu 9.04
Node 4	192.168.0.6	eeeUbuntu 9.04
Node 5	192.168.0.7	Ubuntu 9.04
Node 6	192.168.0.10	Ubuntu 9.04
Node 7	192.168.0.11	Ubuntu 9.04

(a) Node 1 (b) Node 2

Fig. 1. Hardware of the testbed.

3. Testbed description

3.1. Testbed environment

We implemented a MANET testbed and carried out experiments in the fifth floor of Building D, at Fukuoka Institute of Technology. This testbed provides the environment to make different measurements for indoor and outdoor communications. However, in this paper we deal only with indoor environment.

3.2. Operating system and routing software

The operating system installed on machines is Ubuntu 9.04 Linux (x5), eeeUbuntu 9.04 Linux (x1) all with kernel 2.6.28-18-generic and Fedora Core 4 Linux (x1) as shown in Table 1. Each of them can support all installed routing softwares.

In each machine, the AODV and OLSR routing softwares are installed from their source code in their respective web pages. Both of them are open source. See [4,18] for more information.

3.2.1. Network configuration

All machines used their own wireless adapter, except for the Fedora machine which uses a Linksys wireless card, whose drivers can be found at [15]. Each machine wireless card transmits at frequency 2.412 GHz (channel 1), and is put to ad-hoc infrastructure. In Fig. 1, we show a screen-shot of every node we used in experiments. Node IDs and IP addresses are shown in Table 1.

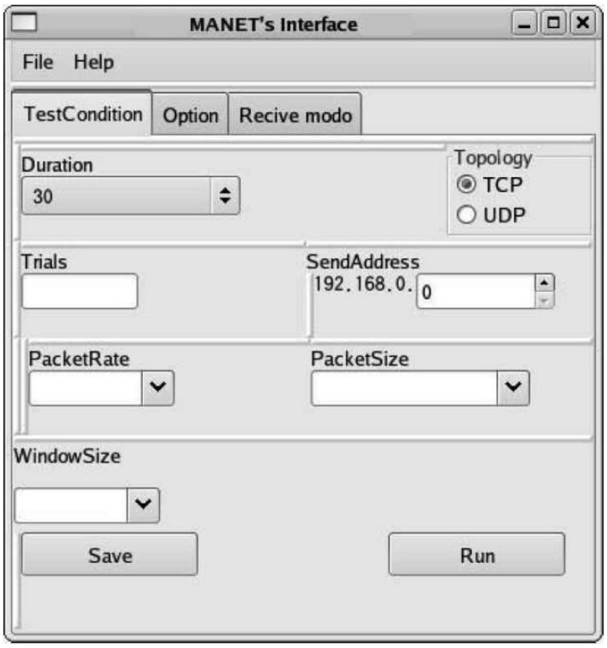


Fig. 2. GUI interface for parameter settings.

3.2.2. Traffic generation and getting the data

After configuring the network all nodes are put to their respective position, in accordance to the experimental scenario. To generate some traffic between nodes, we used D-ITG (Distributed Internet Traffic Generator) software, which is a Traffic Generator [7]. With D-ITG, one could send different type of traffics from one node to another. The amount of information to be sent and the duration of the transmission is set as an option. After finishing the transmission, D-ITG offers decoding tools to get information about network metrics along the whole transmission duration.

3.2.3. Testbed interface

All settings, editing and calculations can be done with the aid of a Graphical User Interface (GUI) as shown in [11]. This is helpful in saving time in the case of repeated experiments, and avoiding misprints during set-up. The GUI uses wxWidgets tool and each operation is implemented by Perl language. wxWidgets is a cross-platform GUI and tools library for GTK, MS Windows and Mac OS X. Many parameters are implemented in the interface such as transmission duration, number of trials, source address, destination address, packet rate, packet size, LQWS, and topology setting function. These parameters can be saved in a text file and can manage the experimental conditions in a better approach. The GUI interface of the implemented testbed is shown in Fig. 2.

4. Topology description

The implemented testbed provides a real-time system for analysing various aspects of MANETs. The purpose of this paper is to evaluate the performance of two routing protocols: AODV and OLSR. Performance evaluation is done for four different scenarios. The MAC filtering is not used in these experiments, so the nodes form e Mesh Topology. We describe the four scenarios in the following. The

Table 2
Experimental parameters

Parameters	SS	SMS	DMS	SDMS
Nr. of experiments	20	10	10	10
Duration of experiment(s)	60	120	120	120
Packet rate (pkt/s)	200	200	200	200
Packet size (bytes)	512	512	512	512

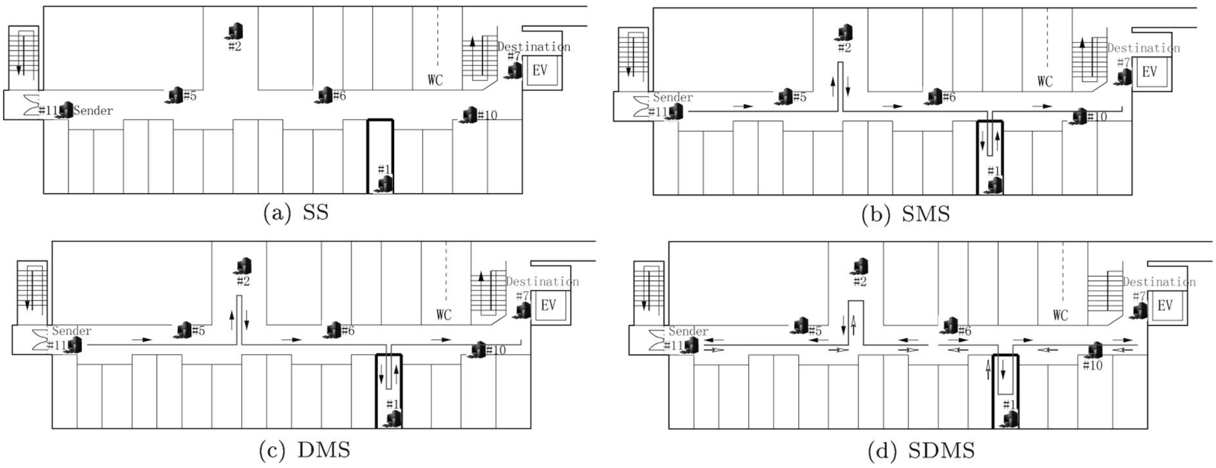


Fig. 3. Different topologies for experiments.

topologies for different experiments are shown in Fig. 3. All experimental parameters are shown in Table 2.

For the static scenario, 20 experiments were performed for each protocol, and every experiment lasted 60 seconds. The source node sent 512-byte packets, with a frequency of 200 packets per second. For the moving scenarios, we performed 10 experiments with a duration of 120 seconds each.

4.1. Static scenario

In the Static Scenario (SS), first all nodes are put in the positions shown in Fig. 3(a). Then, in each machine, the routing protocol deamons are started. In this paper, we consider AODV and OLSR and their deamons $aodvd$ and $olsrd$, respectively. To let the routing protocol initialize routes, no data was transmitted for the first five minutes.

4.2. Source moving scenario

The Source Moving Scenario (SMS) is shown in Fig. 3(b). The nodes are in the same position as in SS (Fig. 3(a)), except that source node moved towards the destination node, as shown in Fig. 3(b). This movement is realized using a simple wheeled office chair.

4.3. Destination moving scenario

In Fig. 3(c), we show the Destination Moving Scenario (DMS). The destination node moves away from the source, starting its movement in the same position as the source node. At the end of 120 seconds, destination node and source node have the maximum distance between them.

Table 3
Average values for different experiments

Nr.	Scenario	Protocol	Bitrate	Delay	Packetloss
1	SS	AODV	819.1863	0.0032	0.000076
2		OLSR	819.1727	0.0036	0.000056
3	SMS	AODV	613.9733	1.5855	0.2942
4		OLSR	618.8715	1.6504	0.2532
5	DMS	AODV	720.2372	0.7445	0.1654
6		OLSR	719.2644	0.8486	0.1597
7	SDMS	AODV	727.7739	0.8986	0.2265
8		OLSR	775.7824	0.8352	0.1656

4.4. Source-destination moving scenario

As shown in Fig. 3(d), in Source-Destination Moving Scenario (SDMS), both source node and destination nodes are moving. Starting near the position of node 6, they both move away from each other for the first 60 seconds. Then they go back by the same route, to the starting position for the last 60 seconds.

5. Performance evaluation

5.1. Experimental settings

We performed the experiments in indoor environment (our departmental floor), as shown in Fig. 3, with the size nearly 70 m $\times$ 25 m. We used UDP traffic for experimental environment (see Table 2). The D-ITG is used to create the traffic and to collect the data. Data in the network were collected in a Mesh Topology for different scenarios of node movement and for two routing protocols. We were interested in Bitrate (kbps), Delay (ms) and Packetloss (No.of packets).

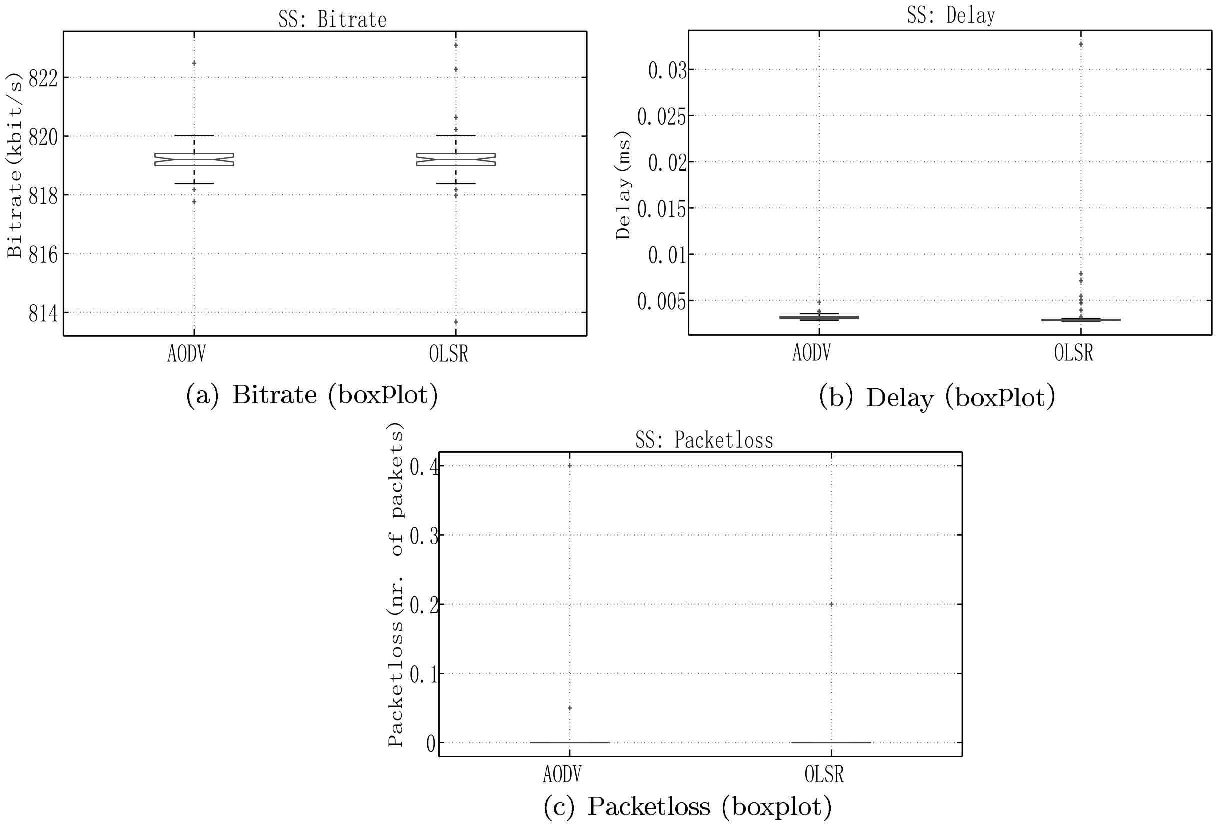
We used CBR (Constant Bit Rate) over UDP to create the traffic. The transmission rate of the data flow is 200 pkts/s, and the packet size is fixed to 512 kB, meaning a maximum bitrate of 819.2 kbps. Nodes (laptops) could access each other within the 70 meter region where the experiments were performed. We checked this by the $ping$ command of Ubuntu 9.04. In total, we performed 8 experiments, as shown in Table 3.

As MAC protocol we used the IEEE 802.11 b protocol and configured the wireless cards to operate at central frequency 2.412 GHz (channel 1) and with enough power to have connectivity with every node in the network. The main interest on these experiments was in the routing protocols and their behaviour in different scenarios, so all MAC parameters were kept unchanged. We should mention that during experiments all the IEEE 802.11 spectrum had been used by other access points operating within the campus, causing a considerable interference.

We took samples of 500 ms for every experiment, and computed the averages of each sample, using linux bash scripting and Matlab.

5.2. Experimental measurements

In Table 3, we show all the calculated average values for every experiment. We investigated all mean values of Bitrate, Delay and Packetloss, which are measured in “kilobits per second (kbps)”, “milliseconds (ms)” and “percentage (%)”, respectively.



(a) Bitrate (boxPlot)

(b) Delay (boxPlot)

(c) Packetloss (boxplot)

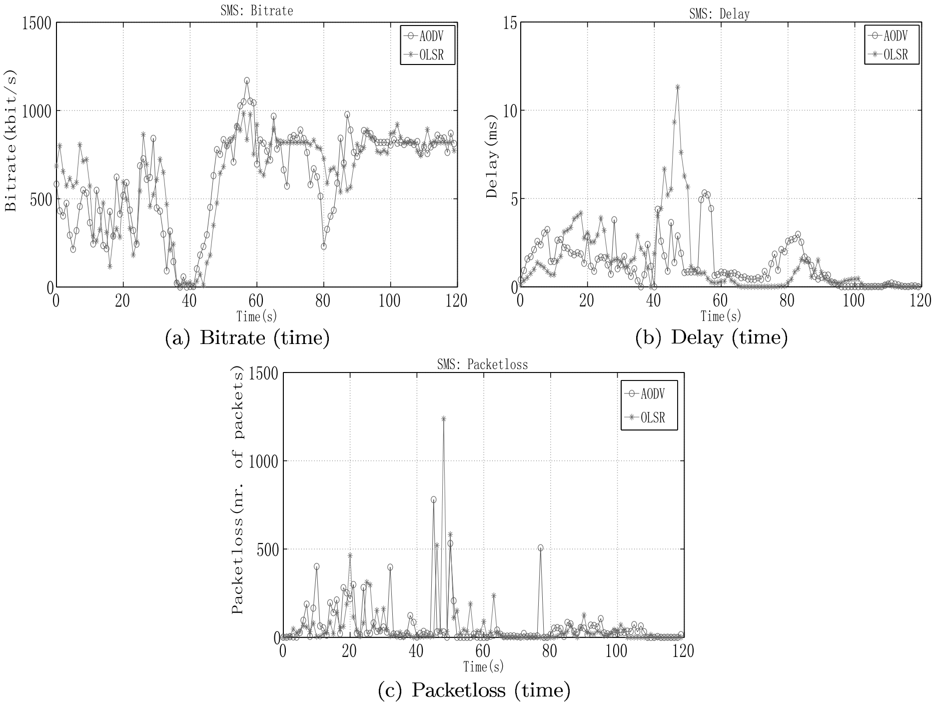
Fig. 4. Different metrics vs different protocols for SS (boxplot).

For SS, in Fig. 4, we can see that for both AODV and OLSR, bitrate is almost the maximum (max = 819.2). This means that the routes have been established and the communication is performed at almost maximum performance. This is also shown in Table 3.

In SMS, the source node is approaching the destination node and at two time periods 30 s–50 s and 70 s–90 s they loose LOS (Line of Sight). In Figs 5 and 6, we show three metrics in time-domain and boxplot, respectively. In Fig. 5(a), the bitrate in the period of time 30 s–50 s reaches the value 0. This means that the source node could not find a route to the destination node. At this period of time the nodes loose LOS and a complete route (2 or more hops) is difficult to be established. At the time period 70 s–90 s, we also observe a decrease on the value of bitrate, which is more considerable in the case of AODV. In this case, even though there is no LOS between the communicating nodes, they are closer to each other and 1-hop or 2-hops routes can be quickly re-established.

In Fig. 6(a), we can observe that both protocols show the same performance regarding bitrate metric. At the period of time 30 s–50 s, when the bitrate reaches very low values, we notice a proportional increase in packetloss as shown in Fig. 5(c). At time period 70 s–90 s, we encountered a considerable amount of packet loss for AODV.

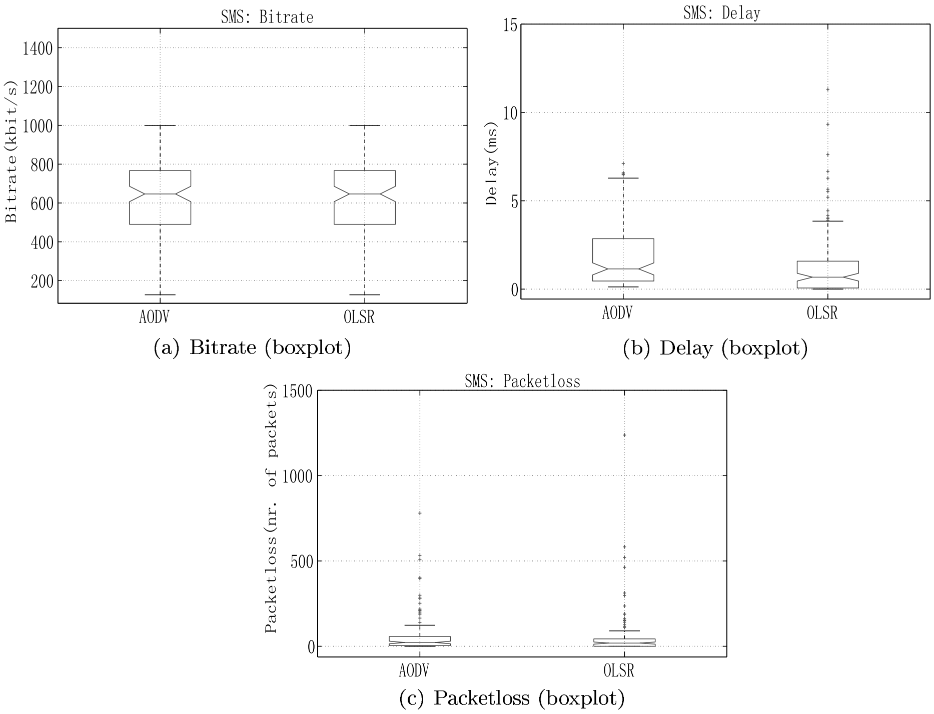
In Fig.6(c), it is shown that both protocols show almost the same performance considering packetloss metric. At time periods 30 s–50 s, in the case of OLSR, we notice that the delay is increased as shown in Fig. 5(b). At this time period, the communicating nodes are in NLOS (Non Line of Sight) conditions and the communication needs 2 or more hops to occur. Thus, as described in [2], OLSR performance



(a) Bitrate (time) (b) Delay (time)

(c) Packetloss (time)

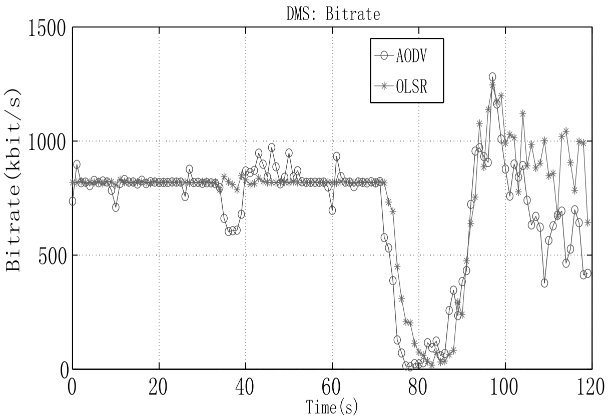
Fig. 5. Different metrics vs different protocols for SMS (time).



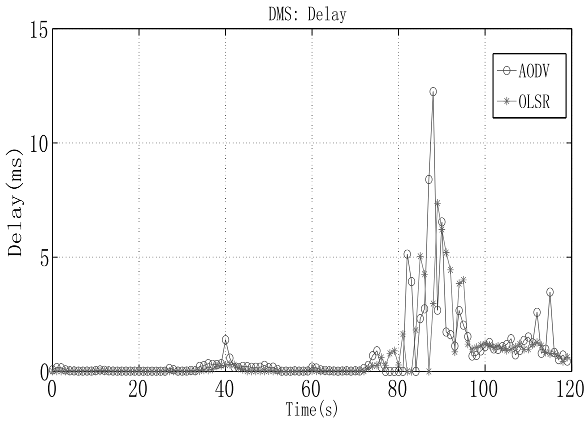
(a) Bitrate (boxplot) (b) Delay (boxplot)

(c) Packetloss (boxplot)

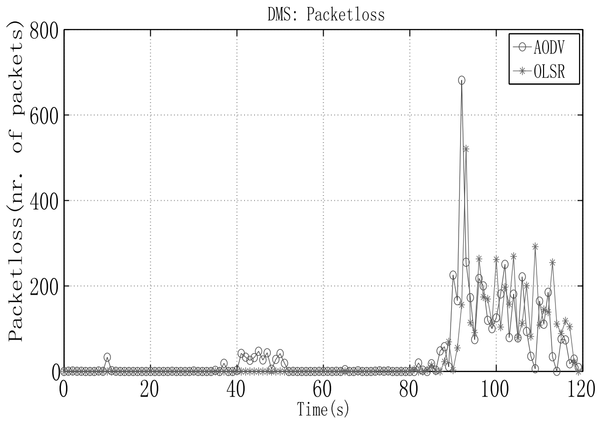
Fig. 6. Different metrics vs different protocols for SMS (boxplot).



(a) Bitrate (time)



(b) Delay (time)

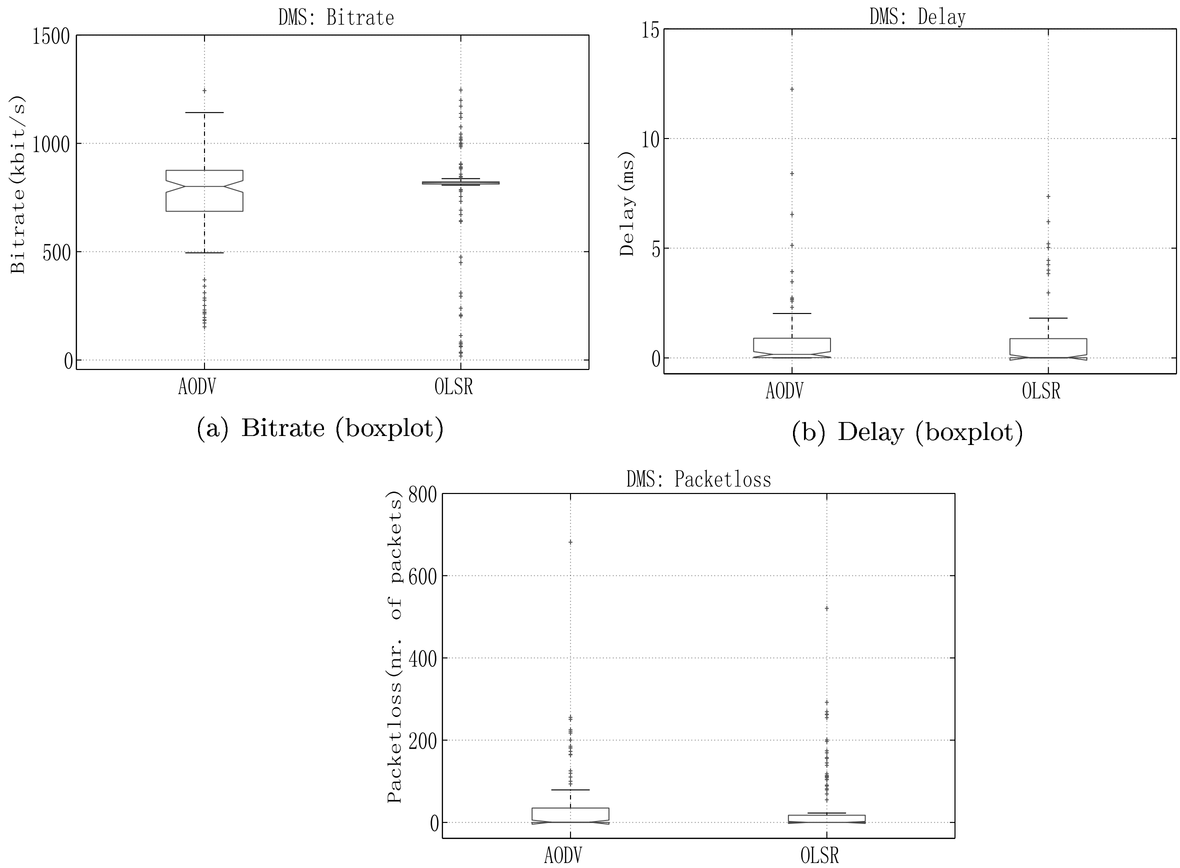


(c) Packetloss (time)

Fig. 7. Different metrics vs different protocols for DMS (time).

at 2-hops or 3-hops communication undergoes a degradation. As shown in Fig. 6(b), both OLSR and AODV protocols show the same performance considering the delay parameter.

In DMS, the destination node is moving away from the source node. In Figs 7 and 8, we show three metrics in time-domain and boxplot, respectively. In Fig. 7(a), the bitrate in the time period 75 s–90 s reaches the value 0, which means the source node could not find a route to the destination node. At this period of time the two nodes loose LOS and a complete route of 2 or more hops is difficult to be established. As is shown in Fig. 8(a), the OLSR has a better throughput than AODV. After time 90 s the bitrate in case of AODV is lower than the case when OLSR is used. This happens because at that time, routes need to be re-established, and for AODV the route discovery process is not always successful, thus it needs more time. This fact is reflected in delay and packetloss graphs, respectively in Figs 7(b) and 7(c) after time 90 s. At the period of time 75 s–90 s, when the bitrate reaches very low values, we notice a proportional increase in packetloss as shown in Fig. 7(c). After time 90 s the communications still has a considered amount of packetloss. In Fig. 8(c) is shown that AODV has a slightly worse performance than OLSR. At time period 75 s–90 s, we notice an increased delay in Fig.7(b), which is due to the low bitrate experienced at these time periods. As shown in Fig. 8(b), both AODV and OLSR protocols have almost the same performance.



(a) Bitrate (boxplot)

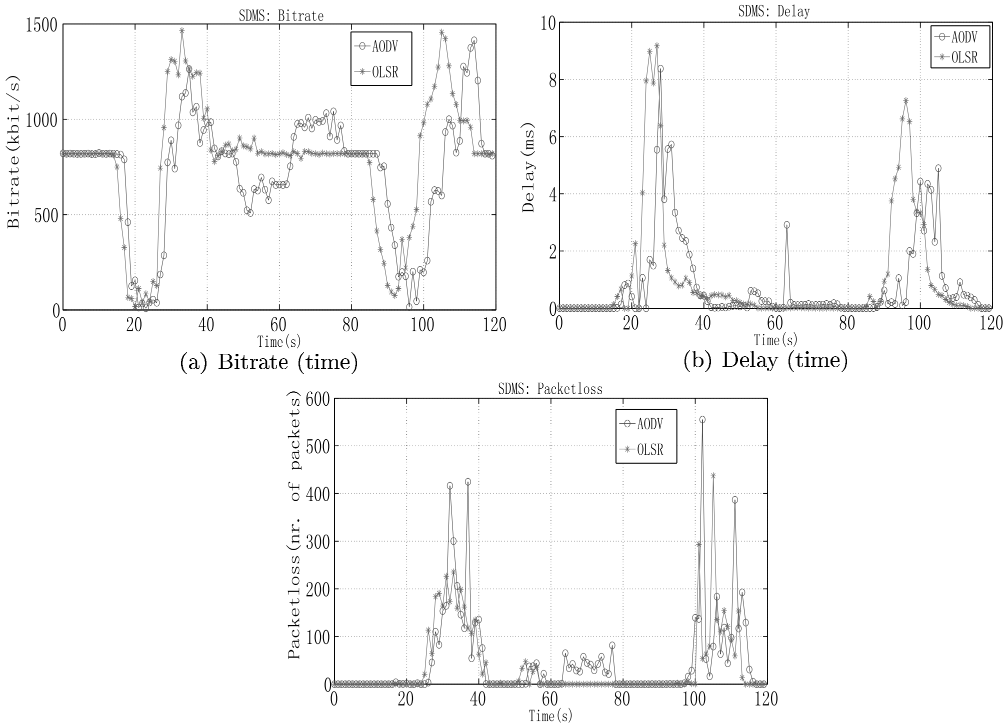
(b) Delay (boxplot)

(c) Packetloss (boxplot)

Fig. 8. Different metrics vs different protocols for DMS (boxplot).

In SDMS during the first 60 seconds both nodes are moving away from each other and then during the last 60 seconds they are approaching each other via the same route of movement. In Figs 9 and 10, we show three metrics in time-domain and boxplot, respectively. In Fig. 9(a), the bitrate in the time periods 15 s–35 s and 90 s–105 s reaches the value 0, which means the source node could not find a route to the destination node. At this periods of time the nodes loose LOS and a complete route of 2 or more hops is difficult to be established. As it is shown in Fig. 10(a), OLSR has a better performance than AODV regarding bitrate metric. At time periods 15 s–35 s and 90 s–105 s when bitrate reaches very low values, we notice a proportional increase in packetloss as shown in Fig. 9(c). In Fig. 10(c) for packetloss metric, AODV has a slightly worse performance than OLSR. At time periods 15 s–35 s and 90 s–105 s, we notice an increased delay in Fig. 9(b), which is due to the low bitrate experienced at these time periods. As shown in Fig. 10(b), OLSR shows a better performance than AODV considering delay. This delay is caused by the continuous change of routes in SDMS.

AODV is more sensible to route changing, because it has to redefine the whole route before starting to send data. AODV protocol acts worse than OLSR in the cases when routes are lost. Being a reactive protocol, AODV has to redefine the communicating route, so it takes more time to re-establish the communication. In contrary OLSR chooses one of the old available routes, until the new routes are defined.

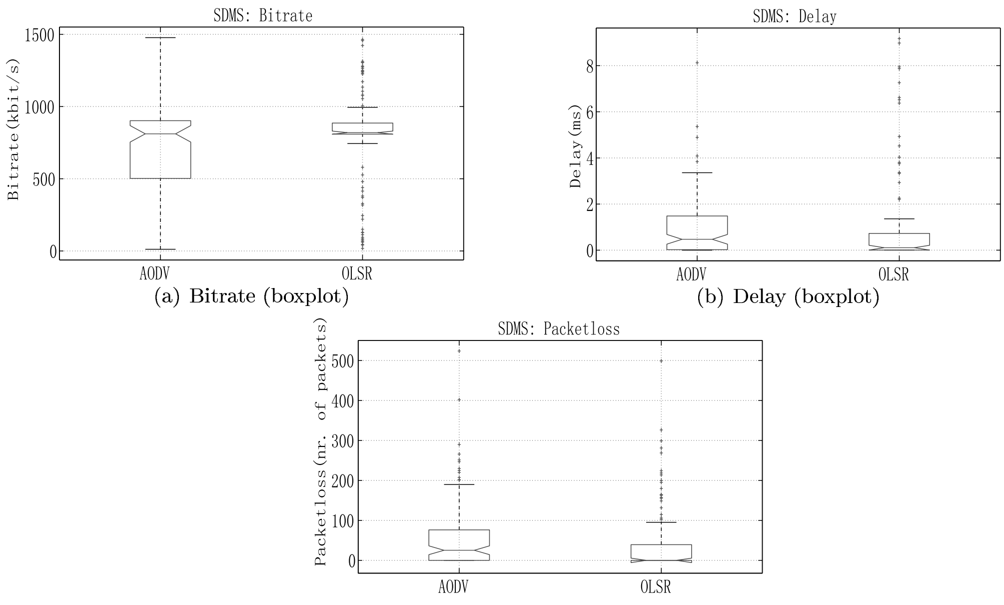


(a) Bitrate (time)

(b) Delay (time)

(c) Packetloss (time)

Fig. 9. Different metrics vs different protocols for SDMS (time).



(a) Bitrate (boxplot)

(b) Delay (boxplot)

(c) Packetloss (boxplot)

Fig. 10. Different metrics vs different protocols for SDMS (boxplot).

6. Conclusions

In this paper, we used AODV and OLSR protocols for experimental evaluation and comparison and we implemented four scenarios (SS, SMS, DMS and SDMS) in a small MANET testbed of 7 nodes. We considered 3 metrics for performance evaluation: bitrate, delay and packetloss. We investigated the performance of MANET when two communicating nodes loose LOS during a period of time.

From our experimental results we found that, when the communicating nodes are moving and the routes change quickly, OLSR as a proactive protocol performs better than AODV, which is a reactive protocol.

In our future work, we would like to increase the number of nodes in our testbed and implement more realistic moving scenarios. We will run multiple flows between the communicating nodes and we will use the linear topology, in order to minimize the interference caused by multiple links in mesh topology.

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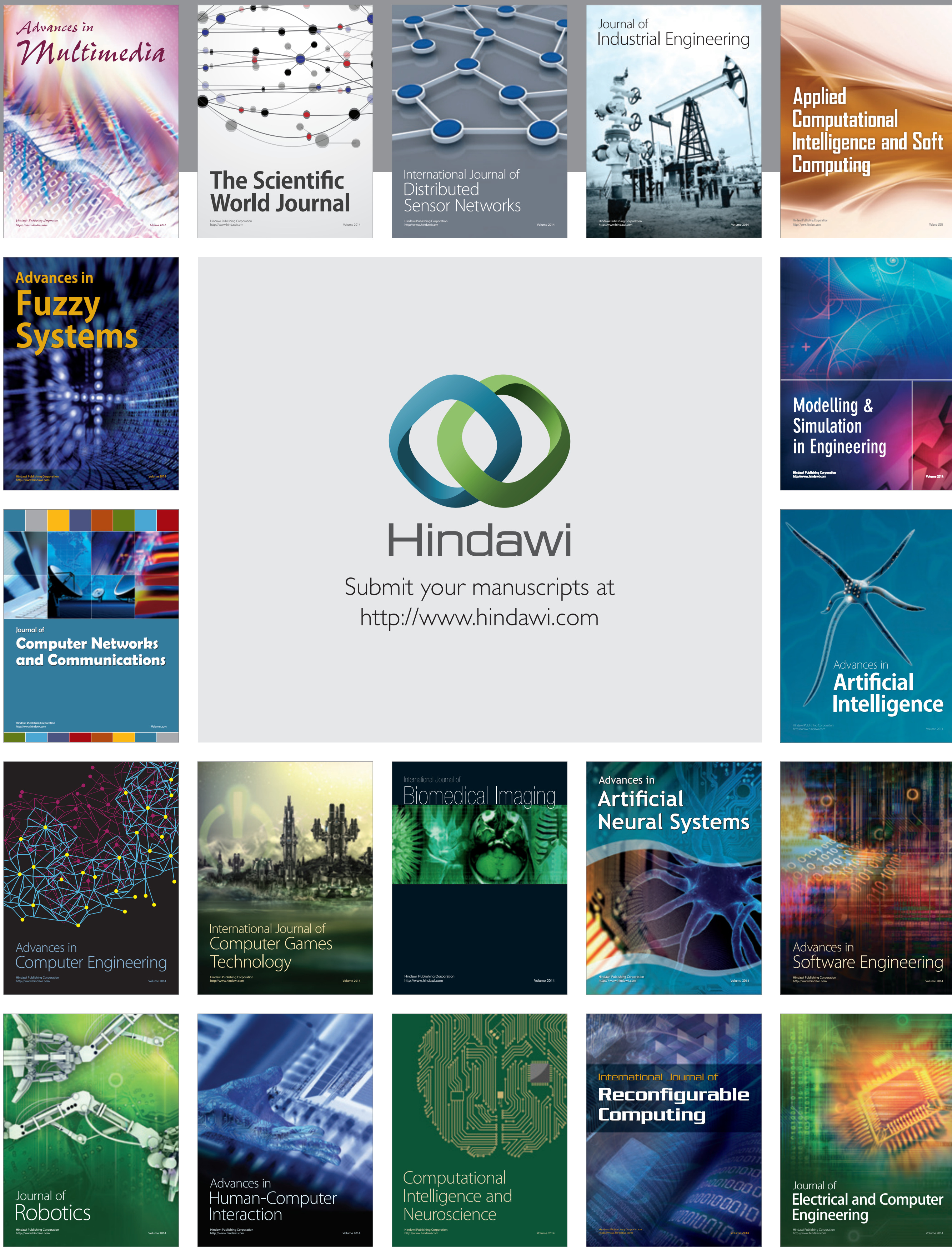

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