Synthesis
International Scientific Conference of IT and Business-Related Research

COMPARATIVE ANALYSIS OF UNICAST ROUTING PROTOCOLS IN MANET NETWORKS

UPOREDNA ANALIZA UNIKAST PROTOKOLA ZA RUTIRANJE U MANET MREŽAMA

Dejan Tepšić, Mladen Veinović
Singidunum University, 32 Danijelova St., Belgrade, Serbia

Abstract:
Mobile ad hoc networks (MANETs) are self-configuring networks of mobile nodes connected by wireless links. Each node within MANET operates as an end system and a router for all other nodes in the network. Due to the dynamic nature of MANETs, traditional fixed network routing protocols cannot be used. Based on that, new routing protocols have been introduced in MANETs.
The purpose of this paper is to examine the current state-of- the- art of the existing unicast routing protocols for MANETs, and compare different approaches. For the purpose of this research, experiments are carried out in OPNET Modeler network simulator with the usage of reactive AODV and proactive OLSR unicast routing protocols. Data obtained in these experiments quantify and compare network performance, such as throughput, delay and network load.

Key words:
AODV, MANET, mobile ad hoc network, OLSR, unicast routing protocol.

Apstrakt:
Mobilne ad hoc mreže (MANET) su samokonfigurišuće mreže sastavljene od mobilnih čvorova povezanih bežičnim vezama. U okviru MANET mreže svaki čvor funkcioniše kao klijent i kao ruter ka drugim čvorovima unutar mreže. Zbog dinamične prirode MANET mreža tradicionalni ruting protokoli razvijeni za ožičene mreže ne mogu se koristiti. Stoga su razvijeni novi ruting protokoli za upotrebu u MANET mrežama.
Cilj ovog rada je ispitivanje trenutnog stanja postojećih unikast ruting protokola u MANET mrežama i poređenje različitih pristupa u njihovoj realizaciji. Za potrebe ovog istraživanja sprovedeni su eksperimenti u OPNET Modeler mrežnom simulatoru pri čemu su razmotreni AODV i OLSR unikast protokoli za rutiranje. Podaci dobijeni u tim eksperimentima kvantifikuju i porede odnos u mrežnim performansama, kao što su propusni opseg, kašnjenje i količina generisanog kontrolnog saobraćaja.

Ključne reči:
AODV, MANET, mobilne ad hoc mreže, OLSR, unikast ruting protokoli.

Acknowledgements:
This paper is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through the projects TR32054 and ON174008.

1. INTRODUCTION

Wireless ad hoc network is a collection of mobile nodes that dynamically form a temporary network without the use of any form of the existing network infrastructure. In mobile ad hoc network (MANET), nodes are not only the senders and receivers of messages that contain data, but at the same time each node works as a router being involved in forwarding the data packets to their final destination. Mobile ad hoc networks are highly dynamic, *i.e.* nodes can join or leave the network at any time, and have the flexibility of movement within the network. The fact that mobile ad hoc networks can be rapidly deployed with minimal advanced planning and without the need for existing infrastructure make this technology very attractive and suitable for numerous applications.

2. RELATED WORK

The motivation behind this research is exploration and comparison of performances within unicast routing protocols in mobile ad hoc networks. The existing papers in this field have partly elaborated on this.

The authors (Rahman *et al.*, 2009) explored different MANET routing protocols in QualNet network simulator. It is shown that AODV routing protocol achieves the best results in networks with low density of nodes, while in networks of high density nodes OLSR and DSR routing protocols are prevailing. Experimental results show that DSR routing protocol is optimal for packet data transmission in scenarios where delivery and throughput are critical factors. Also, it was stated that the best routing protocol for transmission of voice and video packets is OLSR, due to low rates of delay.

The authors (Shah & Shaheed, 2011) analyzed the performance of AODV, DSR and OLSR routing protocol using OPNET Modeler network simulator. When performing simulation they observed following metric values: packet delivery fraction, normalized routing load, throughput and end to end delay. Based on these results, the authors concluded that the value of the throughput for all three routing protocols decreases with increasing mobility of nodes. Among them DSR achieves the highest value of throughput. In contrast, the average value of the delay in DSR and OLSR routing protocol increases with the increase of mobility of nodes. Authors noted that AODV routing protocol has achieved the most consistent results. Also, it was shown that the OLSR routing protocol is not suitable for usage in highly mobile networks.

E-mail: tepsicd@gmail.com
DOI: 10.15308/Synthesis-2015-112-115

3. UNICAST ROUTING PROTOCOLS

Unicast routing protocol controls node decisions when routing packets are between devices in MANET. When a node joins or tries to join the mobile ad hoc network, it is not familiar with the network topology. By announcing its presence or by listening from the neighbor nodes, it discovers the topology. In MANETs route discovery process depends primarily on the routing protocol technique.

Unicast routing protocols within MANETs can be classified within three categories depending on the time when nodes acquire a route to a destination (Anjali & Singh, 2012). Those classes are proactive (table-driven), reactive (on-demand) and hybrid.

Proactive routing protocols are also known as table-driven protocols as they constantly keep updated network topology and routing tables on all of the nodes within MANET network. Whenever there is a change in the network topology proactive routing protocol updates this information on all of the nodes. One of the main advantages is that nodes can easily establish a session and get routing information.

Reactive routing protocols are also known as on-demand routing protocols because they calculate routes only when there is a need to transfer data packets within a MANET network. In that way, limited throughput of wireless links is more optimally used. Reactive routing protocols perform well in scenarios where route discovery is less frequent than the packet data transfer.

Hybrid routing protocols combine both proactive and reactive protocols in order to segregate MANET network within smaller zones, while trying to preserve best characteristics of both routing approaches. Proactive routing protocol is frequently used within small zones, while for inter-zone communication reactive routing protocol is used.

Summary comparison of the most important characteristics of proactive, reactive and hybrid unicast routing protocols (Gupta *et al.*, 2011) is presented in Table 1.

Routing Protocol Parameter	***Proactive***	***Reactive***	***Hybrid***
Storage Requirement	High	Low	Depends on size of each zone
Route Availability	Always available	Computed as per need	Depends on location of destination
Periodic Route Updates	Frequent	Sporadic	Used inside each zone
Delay	Low	High	Low for local destinations and high for inter-zone
Scalability	100 nodes	> 100 nodes	> 1000 nodes
Control Traffic	High	Low	Medium
Routing Information	Stored in table	Does not store	Depends on requirement
Routing Philosophy	Flat	Flat	Hierarchical

Table 1. Summary comparison of unicast routing protocols.

4. SIMULATION MODEL

Research of unicast routing protocols was carried out in the OPNET Modeler network simulator. OPNET Modeler is commercial software used by many researchers for network modeling and simulation (OPNET Modeler Network Simulator, 2012). Simulation is focused on the performance of MANET routing protocols, while observing values of throughput, delay and network load. In order to define a simulation model, 75 mobile nodes were randomly placed within a MANET network. Each node within a MANET network performs identical routing protocol. This research examined the behavior of reactive AODV (Perkins *et al.*, 2003) and proactive OLSR (Clausen & Jacquet, 2003) routing protocols with default settings within the OPNET Modeler network simulator for each protocol. Each simulation was run for 600 seconds while constant FTP data traffic was generated within the network.

Each node moves randomly within the defined wireless network range of 2000 m x 2000 m based on the Random Waypoint mobility model (RWP). All nodes are equipped with transponders that use the IEEE 802.11b standard in communication over wireless channel rate of 11 Mbps. Wireless transmission range was set to 250 meters.

These values were chosen on the basis of numerous examples from the literature in which measurements were done based on performance of MANET routing protocols (Kumar, 2012; Taft & Gandomi, 2011), and are presented in Table 2.

Simulation Parameter	***Value***
Simulator	OPNET Modeler version 14.5
Topology Size	2000 m x 2000 m
Network Size	75 nodes
Mobility Model	Random Waypoint (RWP)
Node Mobility Speed	Uniform (0, 10) m/s
Traffic Type	FTP
Simulation Time	600 seconds
Addressing	IPv4
Wireless Standard	IEEE 802.11b
Data Rate	11 Mbps
Transmission Range	250 m
Routing Protocol	AODV, OLSR

Table 2. Simulation parameters.

5. EXPERIMENTAL RESULTS

For the purposes of this research within the OPNET Modeler network simulator model, MANET network with 75 mobile nodes, 5 FTP clients and one FTP server is created (Fig. 1).

All mobile nodes run identical routing protocol and identical experiments are implemented for reactive AODV and proactive OLSR routing protocols, while following metrics were measured: throughput, delay and network load.

THROUGHPUT

Throughput represents the total number of bits forwarded from wireless LAN layers to higher layers in all nodes of the MANET network. High network throughput is desirable in *a* mobile Ad Hoc Network (MANET). According to simulation results in Figure 2, it is noticeable that proactive OLSR routing

DOI: 10.15308/Synthesis-2015-112-115

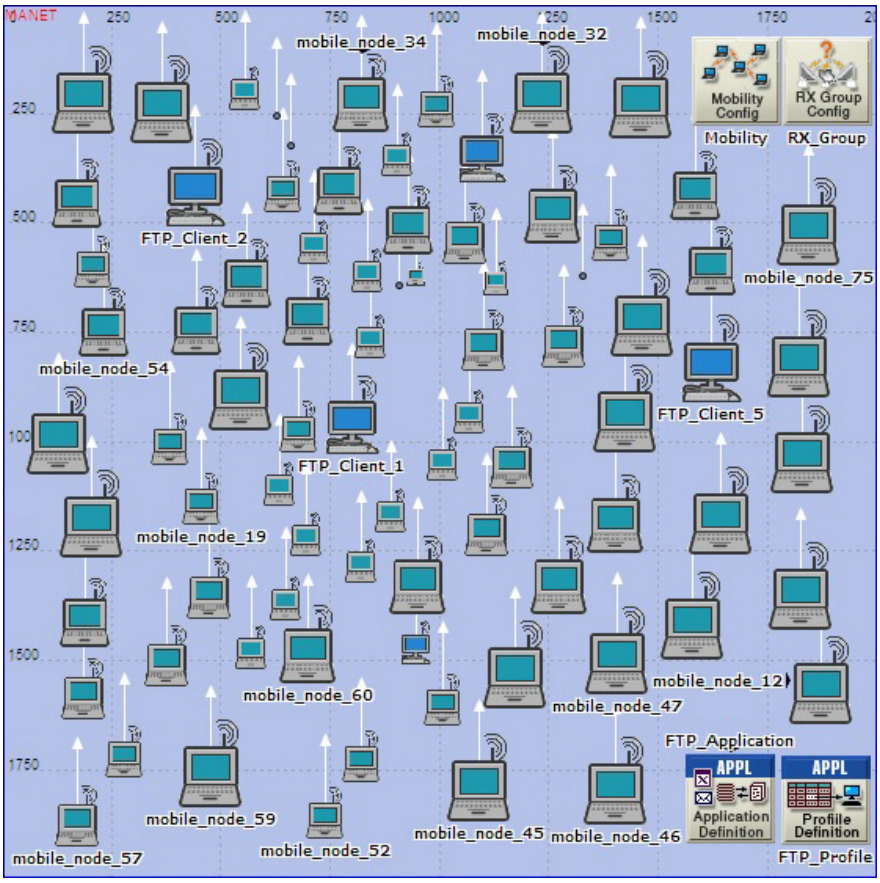

Figure 1. MANET network with 75 mobile nodes.

protocol achieves significantly higher value of throughput than reactive AODV routing protocol in MANET network with 75 mobile nodes. The reason could be that the OLSR maintains cluster of nodes in the topology by dividing them into different node sets. Division of the sets into one-hop and two-hop neighbors makes OLSR more efficient in link process without having all nodes taking part in this. Also, OLSR is a proactive routing protocol, which means that routes in the network are always available whenever there is data traffic to transmit.

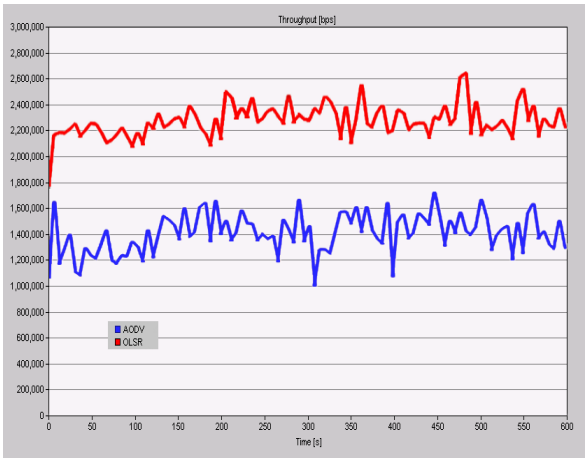

Figure 2. Throughput [bps].

DELAY

Delay is the average time that packets need to traverse the network. This is the time from the generation of the packets by the sender node up to their reception at the destination node. It also includes the route discovery wait time that may be experienced by a node when a route is not available. Different applications require different delay levels. Low average delay is required in the network of delay sensitive applications like voice.

According to Figure 3, it is evident that reactive AODV routing protocol achieves significantly higher value of delay compared to proactive routing protocol OLSR in mobile ad hoc network with 75 mobile nodes. OLSR routes are always available due to the characteristic of proactive routing protocols. Maintaining the neighbor table and keeping track of other nodes available via one and two-hop neighbors leads to usually less delay in OLSR.

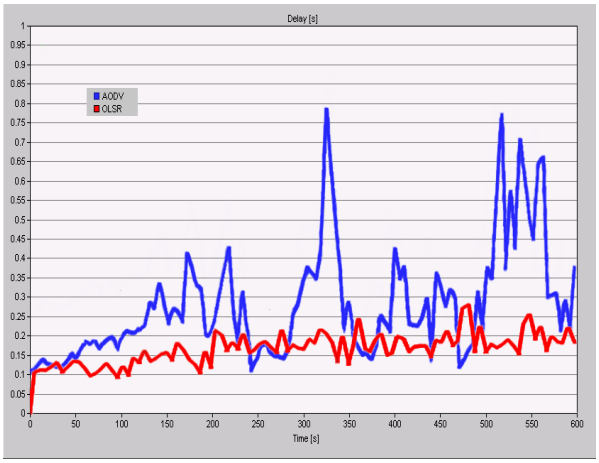

Figure 3. Delay [s].

NETWORK LOAD

Figure 4 shows the amount of routing traffic sent in MANET network with 75 mobile nodes for both routing protocols. There

DOI: 10.15308/Synthesis-2015-112-115

is an apparent significant difference between proactive and reactive routing approaches. The experimental results show that it is clear that proactive routing protocol OLSR builds up the full routing table at the start of the simulation. OLSR constantly floods the network with control and routing traffic to keep its routing tables up to date resulting in high network load. As opposed to that, reactive routing protocol AODV route to the destination is calculated only when there is a need to transfer data packets.

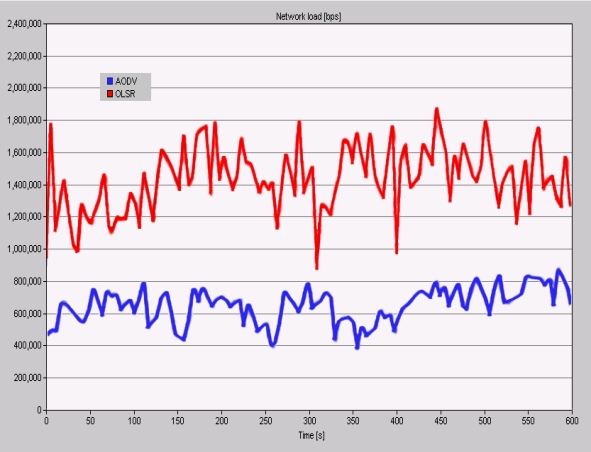

Figure 4. Network load [bps].

6. SUMMARY

This paper examines the performance of reactive AODV and proactive OLSR unicast routing protocols within the OPNET Modeler network simulator. The comparison of two protocols was conducted under the same conditions using the FTP data flows and random mobility model. Experimental results show that OLSR experienced higher throughput and lower delay compared to AODV because multipoint relays (MPR) reduce the delay and packet drop rate and increase throughput. AODV is the complete opposite of proactive OLSR routing protocol and generates significantly less network load, but it failed in all other aspects that favour the usage of proactive routing protocol OLSR.

Based on the research conducted in this paper, it can be concluded that there is no single unicast routing protocol that is superior in terms of all performance metrics. Different protocols have different qualities. One routing protocol can outperform the other one in terms of low rates of generated network load, whereas the other one may be more suitable for high throughput and low delay. Finally, taking into account the results obtained in this research, it can be concluded that the selection of MANET routing protocol should be done based on the network topology and the type of network traffic operated.

Further studies will involve new routing protocols that are planned for future implementation. Also, quantification of the existing routing protocols will be carried out in environment with IPv6 addressing.

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DOI: 10.15308/Synthesis-2015-112-115