PERFORMANCE EVALUATION OF IMPROVED AODV WITH CROSS-LAYER FUNCTIONALITY

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Abstract

The purpose of this paper is to work on the cross-layer design and study the impact of transport layer protocol; Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) on the quality of service parameters of ad hoc network using Improved Ad hoc On-Demand Distance Vector Routing (IAODV) protocol. IAO DV has a cross-layer approach with improvements on the physical layer, data link layer and transport layer. It combines the effect of modifications in expanded ring search, wait time and time to live; and allows node participation only above a set energy level while establishing a route. At transport layer, selection of TCP or UDP protocol will help in optimizing the performance of overall ad hoc network. The simulation result indicates that UDP performs better for the specified optimized values of IAO DV. Our results show that the improved protocol IAO DV offers lower Energy consumption in the range of 12% to 23%, End to End Delay is reduced in the range of 12% to 27%. The performance on account of PDR remains same for both AODV and IAO DV. By deploying UDP protocol for transport layer using Constant Bit Rate (CBR) traffic further improves the performance of the end to end delay, retransmissions and overhead over 30%. The performance of energy and packet delivery ratio remains unaffected.

Keywords : AODV, UDP, TCP, Improved AODV, Cross-layer, Delay, Energy, PDR, Retransmission

1. Introduction

Unlike traditional networks mobile ad hoc networks (MANETs) are infrastructure less networks. The main focus of a protocol deployed in MANETS is to achieve reliability by finding the most reliable and robust route from source to destination and maintain the same for a longer duration. [1]

In the case of wireless Ad hoc networks like MANETS, the nodes have limited energy levels, and they are mobile. To offer a comprehensive solution in line with traditional networks for finding a reliable route, it is necessary to consider more than one attribute like energy consumption and end to end delay. It is increasingly important today that the protocol deployed shall ensure minimum "end to end delay" and higher network lifetime, thus guarantee QoS [2]. Developing a protocol considering all above aspects is done at the network layer. Also, the conventional one layered protocol improvement does not provide optimal performance for ad hoc networks. If optimization is done considering all layers of the protocol stack, then optimal network performance may be achieved. While developing a protocol at network layer, if physical, data link, the transport layer is also considered, then that becomes a cross-layer problem. Dealing with the cross-layer problem, considering more than one layer for optimization and improving two attributes simultaneously is still an

open issue for research in MANETs, and our attempt is to take a positive step in that direction.

The research community is still trying to figure out which of the transport layer protocol to be used in MANET. In most of the cases, TCP is used without much thought. This work shall contribute in finalizing the transport layer protocol by discussing the effect on various performance parameters.

Section 2 of the work presented in this paper first establishes the cross-layer approach of IAO DV and summarizes the improvements attained. Section 3 discusses the simulation environment for the work to compare the performance of MANET with TCP and UDP. Section 4 evaluates the impact of transport layer on the performance of MANET by deploying TCP and UDP on IAO DV[5]. Finally, Section 5 draws a conclusion and Section 6 mentions the future scope.

2. Description of Protocol

IAODV protocol is elaborately discussed with the results obtained that will lay the foundation for further discussion. The TCP and UDP major features are listed. The detailed discussions may be found in relevant reference.

2.1. Improved AODV Routing Protocol

While dealing with the performance improvement of a

routing protocol, it has been observed that improvements on one layer of communication stack offer a marginal improvement as the other layers also have a critical role. Therefore, IAODV combines a novel approach to improvement in a physical layer with a new algorithm that sets rules for the participation of nodes in route formation, another algorithm that works on data link layer offering expanded ring search [6], and the choice of transport layer protocol between TCP and UDP. Thus, working on all three layers makes IAODV[7] a cross-layer protocol.

In mobile communication, if the destination is not within the range of source then intermediate nodes play an important role in setting up the route between source and destination. To form the shortest path between source and destination, some nodes act as routers. After a short period of time, the energy resources of those nodes get depleted, which leads to node failure and thus consecutively leads to link failure. Due to this, either local repair is initiated, or the fresh route rediscovery is initiated. Thus, a better choice of route is one where packet gets routed through a path which contains a node that has enough energy.

The following section explains what makes the IAODV different over regular AODV[9].

2.1.1. Verification of remaining energy of the node:

QoS improved AODV protocol considers energy as one of the metrics for finding the route [3][4]. Route requests are sent to the neighboring nodes. If the energy of the node is above the threshold, then the node accepts the route request. Otherwise, it will drop the RREQ. Thus, all the nodes participating in the route for data transmission will have enough energy for transmission. It is assumed that if the energy of the node goes below the threshold while transmission, the node will generate RRER and follow the normal AODV procedure for route repairing.

The remaining energy of the nodes is checked by comparing it with threshold Energy (TE). The node then decides whether to take part in communication or not. The threshold energy of a node is defined as the ratio of its remaining energy to initial energy. Hence, the value of threshold energy will have a range between 0 and 1.

The decision about acting as a router is taken by every node depending on its threshold energy. So there is no need to pass its value of TE to neighbors through any of the control messages. In existing AODV protocol,

whenever a node receives an RREQ message it is processed without considering its energy. In IAODV, when a source node initiates an RREQ message, the neighboring nodes first check their TE. If its TE is greater than some threshold then only it processes the RREQ message. Due to this node saves its energy in processing RREQ too. This modification puts a limit on who should participate in forming a route from source to destination. If a node participates in the formation of the route then it is assumed that it has sufficient energy to work for that data session as a router. Due to consideration of TE at the local level, network lifetime increases and also a number of broken links decreases. This is explained below, Threshold Energy (TE) is calculated by using equation (1) for every node when it receives route request packet. Threshold Energy of node n is given by,

$$TE = RE/IE \quad (1)$$

Remaining energy of node is calculated as given in equation 2

$$RE = \text{Initial Energy} - \text{Consumed Energy} \quad (2)$$

2.1.2 Reducing End to End Delay:

To reduce end to end delay and improve other quality of service parameters, the IAODV protocol uses following mechanisms:-

- A faster ad hoc routing mechanism for finding the path between source and destination.
- Decrease in the wait time during the route reply back-off
- Modifying the predefined time to live (TTL) threshold.

2.1.3. Algorithm for IAODV Route Discovery

- a) Modify the Time to live (TTL=1) threshold , ERS (increment by 3) & the Wait Time.
- b) Source node initiates the RREQ on demand.
- c) if Neighboring nodes in radius (TTL value) of ring search of source receives the RREQ message
- d) then update route to the source of RREQ
- e) check
- f) if the node is the intended destination
- g) then send RREP to the source.
- h) Else
- i) Calculate TE of the node.
- j) Check

- k) if $TE > \text{threshold}$.
- l) then act as a router and broadcasts the RREQ message to nodes in its range.
- m) Else simply discard the RREQ packet.
- n) RREP is received by source S then normal operation like AODV is done.

2.2. Transmission Control Protocol (TCP)

TCP is connection oriented protocol. It is suited for applications which require high reliability and no critical time constraint. The header size is 20 bytes. The data transmission speed is low. TCP requires 3 packets to set up a connection before sending any user data. The biggest problem with TCP where multiple sources are used is its congestion control algorithm. It treats packet loss as a sign of bandwidth limitation and automatically controls the rate of data transfer. This increases the latency on 3G or Wi-Fi networks.

2.3. User Datagram Protocol (UDP)

UDP is a connectionless protocol. It is suitable for applications that need a fast and efficient transmission. It is faster than TCP. The header size is 8 bytes.

2.4. Comparison of AODV and IAODV with TCP

The evaluation of the performance of IAODV shows improvement in performance as shown in Table 1.

Table 1 : Improvement in Performance of IAODV

Parameter	Improvement Range in %
Energy	12% to 23 %
Delay	12% to 27%
PDR	No Change

The Plots in Fig.1 is a representation of improvement obtained in the performance of IAODV over AODV. The Transport layer protocol used during simulation is TCP[8]. As the performance of PDR remains same for both AODV and IAODV, the plots are not presented in the paper to save space.

Fig. 1 : Comparison of AODV and IAODV

3. Simulation Environment

Table 2 : Simulation Parameters

Parameter	Value
Channel type	Channel/Wireless channel
MAC Layer Protocol	802.11
Area (m*m)	500*500
Simulation duration	100s
Pause Time	1 s
Maximum speed	5m/s
Mobility model	Random waypoint
Number of nodes	30
Traffic type	Constant bit rate CBR
Payload Data	512 bytes/packet
Packet Rate	50 packet/s
Protocol	IAODV

The simulations are conducted in NS-2.34. UDP is compared with TCP for IAODV. We have observed the effect of variation in speed on energy consumption, PDR, overhead, Throughput, Delay, link breaks, and Retransmissions. The simulation parameters considered are mentioned above in Table 2.

4. Simulation Results and Discussions

In this section, we present the results comparing TCP and UDP.

4.1 Energy Consumption

The remaining energy of overall network is measured. As shown in Fig. 2, the performance of MANET for energy consumption with TCP and UDP is plotted. The procedure for TCP is fixed. The increase in speed has no effect on functioning of the protocol. Hence,

energy consumption is also stable. Even for UDP, the performance on energy parameters is stable. We do not observe the impact of the change in transport layer protocol on energy consumption. The benefits obtained with IAODV remains unaltered.

Fig. 2 : Energy Consumption as Function of Speed.

4.2 Packet Delivery Ratio

PDR shows how packets are delivered successfully from source to destination.

Fig. 3 : Packet Delivery Ratio as Function of Speed.

As it may be observed in Fig.3, change in transport layer protocol has shown the negligible impact on PDR. The data transmission in UDP is faster compared to TCP. The header size is small, 8 bytes. Thus, even if packets are dropped, the information loss is less.

4.3 Overhead

TCP requires three packets to set up a connection before sending any user data. Also, three-way handshaking is done to establish a connection. Hence, the overhead required is more in TCP. It may be observed in Fig. 4.

Fig. 4 : Overhead as a function of speed.

4.4. Throughput

The data transmission in TCP is reliable. It takes care of congestion control. Hence, the throughput in TCP is more. TCP is used where high reliability is required. However, the reduction of throughput performance for UDP does not affect the network performance of Adhoc network. UDP is used for applications where speed required is high and delay low. If data rate chosen do not cause congestion then throughput in IAODV_UDP can be improved. It may be seen in Fig.5

Fig. 5 : Throughput as Function of Speed

4.5. Linkbreak

The number of linkbreaks are constant irrespective of speed in UDP. In TCP, as the speed increases the number of linkbreaks also increase due to frequent change in topology. The same may be observed in Fig.6. It may be seen that at lower speed and higher speed, the improvement is 80%

Fig. 6 : Linkbreak as Function of Speed.

4.6. Retransmission

Since the number of link break is more in TCP, the retransmissions are also more. With the increase in the speed, the retransmission is fairly constant. The increase in TCP is due to its way of implementation of the protocol. The improvement is in the range of 39% to 51%

Fig. 7 : Retransmission as a function of speed.

4.7. End-To-End Delay

The time required to establish a link in TCP is more due to its handshaking mechanism. As the speed increases, the rate of collision also increase. UDP does not take care of flow control in case of congestion. The packets dropped are lost. Hence, delay is observed in receiving data packets at higher speeds. From the data available after simulation in Fig.8, it may be observed that the improvement in delay is in the range of 31% to 91%

Fig. 8 : End to End Delay as function of speed

5. Conclusion

From the data available after simulation, it may be observed that the performance of IAODV with UDP shows improvement in QoS parameters namely, End to End delay in the range of 31% to 91%, retransmissions have reduced and is in the range of 39% to 57%. The link breaks and overhead over complete speed range are consistently lower for UDP as compared to IAODV with TCP. This may be attributed to UDP's connectionless communication set up. UDP does not need to establish a connection before sending data. Communication consists of only data segments. It does not consist of acknowledgment, flow control, and sequence.

Based on the results it may be concluded that IAODV with UDP can be used for video or audio streaming where loss of data is acceptable and time is not a constraint.

6. Future Scope

Instead of running the IAODV protocol on simulation platform, the trail may be taken on real time scenario to see the actual effect of cross-layer designing.

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