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Performance Evaluation of Cross Layer Based AODV Protocol using Multipath Gateway Route Discovery for MANETs

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Abstract: The quality of service is a fundamental attribute of MANETs that makes an impression on the performance of the network when connected to the internet. Several researchers have proposed some solutions to improve the performance of the integration of mobile ad hoc network and internet to achieve effective data services at high data rates. A gateway node is needed in this case to establish connection between mobile ad hoc networks and internet. The usage of AODV routing protocol faces problems like establishing a long route, time delay and breakage of routes which leads to perform degradation in the quality of service parameters. This study focus on the development of a multipath gateway route discovery scheme using a cross layer based AODV protocol. The performance analysis of this protocol brings out a better quality of service for data transfer between MANETs and internet environment.

Key words: MANET, multipath gateway route discovery, CBAODV protocol, QoS parameters, routing discovery time, retransmission attempts and throughput

INTRODUCTION

Many researchers have tried and established connection between mobile ad hoc network and internet for data transfer in a bidirectional way and to have a better performance. A mobile ad hoc network does not rely on a fixed infrastructure for its operation. The network is an autonomous transitory association of mobile nodes that communicate with each other over wireless links. These nodes that lie within each other's send range can communicate directly and are responsible for dynamically discovering each other. The interconnection of MANET and the internet into a hybrid network to increases the network capacity, extend the coverage of wireless network and expand the communication base as well as the application range of ad hoc networks. In the internet connectivity is a provided to potential service that could increase the benefit of MANETs and also make the application scenarios more relevant. A hybrid MANETs consists of nodes that required connectivity to the infrastructure network for the purpose of transfer the data and multimedia services like VoIP and video over IP. Their arises a need to extended services of MANETs for long distance activities which may provide a data transfer between different nodes situated at different places.

Researchers provided the solution for such types of need by way of the provision of connectivity between MANET and internet. One of the solution providers is the selection of gateway node between MANET and internet. The research has been extended to better services using multiple gateways. It is important to choose an appropriate gateway in order to provide on improved data transmission. The gateway access has an intermediate device between the MANETs and the internet. Even enough various architecture is available for interconnection of MANETs to the internet, they faces the connectivity problem and extension of the connectivity, breakage of link and long time delay for data transmission. So, in order to achieve better route establishment and for efficient data transmission an adaptive gateway route discovery has been used.

In this study, a modified AODV protocol has been proposed namely cross layer based AODV protocol to establish an improved QoS for data transmission between MANET and internet. This cross layer approach is based on the data transfer between physical layer and network layer. The performance of the proposed protocol provide better QoS based data transmission to improve parameters like reduction in the delay for route discovery, improved traffic and throughput.

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Literature review: Commonly there are three approaches for gateway discovery process namely proactive, reactive and hybrid. In proactive approach by Kumar and Chaudhary (2012), the gateway periodically sends the gateway advertisement messages which are broadcasted in the whole network. Whereas in reactive approach by Sandhu and Garg (2012), the node requiring connectivity to internet sends a gateway solicitation message to the gateway that consequently responds with the advertisement message. The hybrid approach uses the feature of both proactive and reactive approach. In hybrid network, the advertisement messages are sent by the gateway to a predetermined range which is defined by TTL value of the advertisement message. One more approach popular now a day is the adaptive gateway discovery approach. This method mainly improves network throughput and reduces congestion.

Gateway Selection Method by Shen *et al*. (2005), proposed to choose a gateway node on the basis of hop count. A gateway discovery message is broadcasted by gateway and on the basis of that message each node estimates its distance metric to gateway with short distance path in term of hop count which is preferred for data transmission from MANET to the internet. Bouk *et al*. (2012), proposed mainly three gateway selection parameters which are path availability period, a residual load capacity and the path latency. The path availability period between two nodes that are not immediate neighbors of each other is equal to the minimum link availability period between intermediate nodes in that path. On the basis of these parameters, an overall QoS performance for all paths between a MANET node and gateway nodes are achieved. Brannstrom *et al*. (2005) have proposed to measure the variance in the delay between successive gateway advertisements and use this as a metric for gateway selection. Both a higher number of hops between mobile node and gateway as well as a higher amount of traffic along the path will lead to increase the variance of the arrival rate of advertisements. Hemalatha *et al*. (2013), focus on gateway selection scheme for improving the QoS performance in the gateway nodes. Many gateway selection schemes have been proposed to select gateway node based on single QoS and multiple non QoS path parameters. This scheme considers that has all QoS and multiple non-QOS parameters present in single gateway node connecting two networks.

Chaba *et al*. (2012), focused for hybrid MANET that considers mobility metric as one of the criteria for the gateway selection for gateway selection the combined load value is computed based on some metrics mobility, inter and intra MANET load and residual energy using Simple Additive Weight (SAW) technique. Ratanchandani and Kravets (2003), focus hybrid gateway discovery approach to discover gateways that restrict the effects of broadcast overhead. This method using AODV and two mobile IP foreign agents are used to be linked between MANET and the internet. Palani and Ramamoorthy (2012), focus on the proxied adaptive algorithm creates a proactive zone and a reactive zone when the node is connecting to the Internet. The Gateway Control message Requests (GC REQs) is do not sent flooded to the whole network and intermediate nodes in the border of a proactive zone reply in unicast to the originator with a Gateway Control message Reply (GC REP) therefore the overhead is reduced. Domingo (2007), discuss an adaptive gateway discovery method that has been mostly considered to decrease congestion problems in an ad hoc network and that helps real-time applications to maintain their QoS parameters. Shen *et al*. (2005) focused an adaptive gateway discovery scheme with the purpose of dynamically change the TTL value of GWADV messages. This protocol provides internet access to MANET nodes using mobile IP.

Related research: Once mobile nodes want to discover route, it is first register the gateway and connects to the internet. Mainly there are three different gateway discovery route mechanisms. First is proactive gateway discovery route approach in which the gateway from time to time transmits gateway advertisement messages (GW_ADV) containing significant information using which a mobile node can enter by the gateway. Second is reactive gateway discovery route approach in which the gateway does not send GW_ADV messages. Whenever a mobile node desires Internet connectivity, it broadcasts a gateway solicitation message (GW_SOL). When the GW_SOL message reaches a gateway, it sends a GW_ADV message to the mobile node which then registers with the gateway.

Third is hybrid approach, Fig. 1 refer in which the mobile nodes in a part of the mobile ad hoc network, defined by the TTL value use the proactive approach for gateway discovery and the rest of the nodes outside the TTL range use the reactive approach, the primary challenge in the design of hybrid gateway discovery is to determine an optimal proactive area. If the proactive area is large (i.e., a large TTL value) more overhead is incurred in maintaining routes in a wider area. On the other hand, if proactive area is small then less maintenance overhead is incurred but more delay in gateway discovery is experienced. A modified hybrid gateway discovery mechanism which dynamically adjusts value of TTL and periodicity of GW_ADV messages depending on the

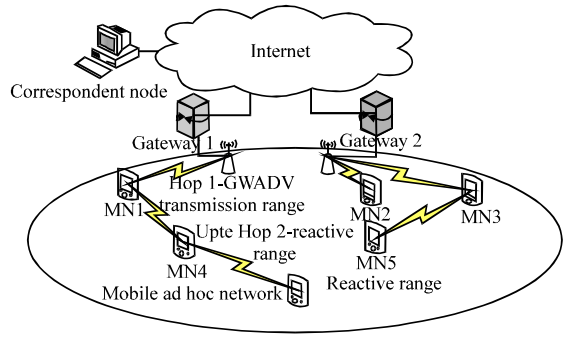

Fig. 1: Hybrid gateway route discovery mechanisms in MANETs

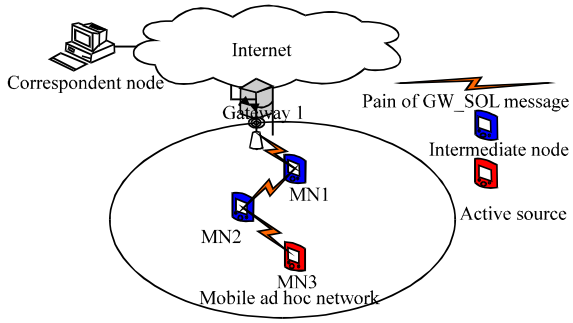

Fig. 2: Adaptive gateway route discovery scheme

MANET characteristics in order to achieve a good trade-off between performance and network overhead is called an adaptive gateway discovery mechanism (Fig. 2).

The first adaptive gateway discovery mechanisms proposed on dynamic adjustment of TTL value using Maximal Source Coverage algorithm does not address the issue of periodicity of the GW_ADV messages. Ruiz and Gomez-Skarmeta (2004a) proposes a research which is based on the dynamic adjustment of the TTL value of GW_ADV messages using Maximal Benefit Coverage algorithm wherein gateways set the TTL value of their GW_ADV messages which gives maximal benefit. Ruiz and Gomez-Skarmeta (2004a, b) proposes a research, gateway discovery scheme is suitable for real-time applications. It adjusts the frequency of GW_ADV messages dynamically. The GW_ADV time interval is associated with the quality of service of the traffic whenever a source node chooses to send real-time traffic if the real-time traffic is not delivered within a stipulated time period, the destination sends a QoS_LOST message back to the source. A load-adaptive Access Gateway (AG) discovery scheme is proposed by Park *et al.* (2007) which dynamically resizes the range of proactive AG advertisements and reduces AG acquisition latency. Maximum source coverage scheme may not be applicable to all scenarios since one part of the network may be highly loaded and other part may be lightly loaded. A new scheme called Adaptive Distributed Gateway Discovery (ADD) is proposed by Javaid *et al.* (2008) which is based on the hypothesis that gateway advertisements should be targeted at active sources and not at other nodes. Instead of adjusting TTL at the gateway, a distributed approach is used. Xie *et al.* (2008) propose the optimal TTL value depends on the particular scenario and network conditions. A futuristic architecture combining cellular and WLAN networks is proposed in which each base station or gateway decides its TTL value independently according to the link quality as well as density of active source nodes in the network.

There is a need for gateway discovery mechanisms that support several Heterogeneous Wireless and Mobile Networks (HWMN) applications. Boukerche *et al.* (2009) proposes a research which is based on HWMN architecture. Vehicular Ad Hoc Network (VANET) is considered as a multi-hop network as an alternative to Mobile Ad Hoc Network (MANET). In this architecture, the proposed protocol is a layer on top of the network layer. Palani and Ramamoorthy (2013) focus on contention aware QoS based adaptive routing protocol by manipulating the information gained at the link layer as well as to the information obtainable at the network layer to achieve higher PDR compared to existing protocols. In this study, a modified version of AODV routing protocol has been proposed which is based multipath gateway discovery scheme.

MATERIALS AND METHODS

The main advantage of proactive routing protocols is an existing route always ready to the target. But it comes with cost of an intense a huge part of the bandwidth; most of resources may not be used. Therefore, a suitable routing protocol for MANETs should imply a sensible over-head in order to conserve the partial bandwidth. Message complexity must be kept very low. The other option is the reactive routing protocol reduces the overhead traffic by creating a route only when it is necessary. While a route is no longer used in reactive protocols, it is just expunged from the routing table. For these reasons reactive protocols are of more attention for the MANET community as reactive protocols. This research selected Ad Hoc On-Demand Distance Vector (AODV) protocol for improving performance. As an outcome, a route is conventional only when it is essential by a source node for transmitting data packets. It employs destination sequence numbers to identify the most recent path. The source node and the intermediate nodes store the next hop information corresponding to each flow for data packet transmission.

This research focus on the design of cross layer concept in the lower to upper layers move to where information from physical layer is used in the network layer. The physical layer is responsible for convey of bits and to acquire minimum bit error rate. The most common parameters are used in the physical layer for bit error rate, signal to noise ratio and signal to noise-interference ratio captures the barrier outcome from the environment. Other main issue is the transmitting power and battery level, the design of physical layer and information very useful from physical layer setting to be capable of work the upper layer solutions. This research is carried out for the duration of gateway discovery process and each node has associate with the channel side information offered in terms of likely SNR/RP in to packet transmission. When a node receives the route request, it also has the information of the SNR/RP. If the node takes part in the route reply process then it stores the SNR/RP value in the buffer. In the reverse path setup of routes the SNR/RP values beside. The same concept is proposed on Alnajjar and Chen (2009) used for DSR protocol but this methodology adopting the multipath gateway discovery approach for Cross layer Based AODV protocol with respect to a suitability of application. It is consider that in the MANET when a node receives the packet and it has the channel side information existing in terms of likely SNR/RP, CBAODV route reply packet format is refer in Fig. 3.

The above format has nine reserved bits in the packet which is set to zero in AODV operation. In order to insert the SNR/RP information in the route reply process, modify the use of reserve bits as exposed in Fig. 4.

C = 1 bit: Catch bit 1 or 0; if 1 then the proposed Cross layer Based AODV will be activated and if 0 then traditional default AODV will be activated. SNR/PR = 8 bits: puts the received SNR/RP at node W from a transmission of route request from (S, W) as described.

Figure 5 describes the values on links represent the values of signal to noise ratio of the link or values of received power of the link. When node S needs to send a packet to node G. Node S sends 2 route request packets along path 1 and 2. Node G generates 2 route reply packets to node S along the reverse routes of paths 1 and 2. Now, at node S there 2 available routes to gateway G, path1 with 5 hops but the lowest value of SNR or RP found in the end to end path is 3 and path 2 with 4 hops but the lowest value of SNR or RP found in the end to end path is 2. Source node S will sort the two routes and select path 1 based on the new mechanism since the best worse value of path 1 is 3 is greater than the worse value of the other path which is 2. Default AODV and CBAODV protocols will select path 2 that has minimum number of hops even though the path has low-quality of service.

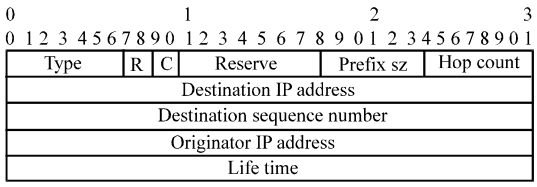

Fig. 3: Cross layer Based AODV route reply packet format

Fig. 4: Cross layer based AODV route reply packet reserve bits allocation

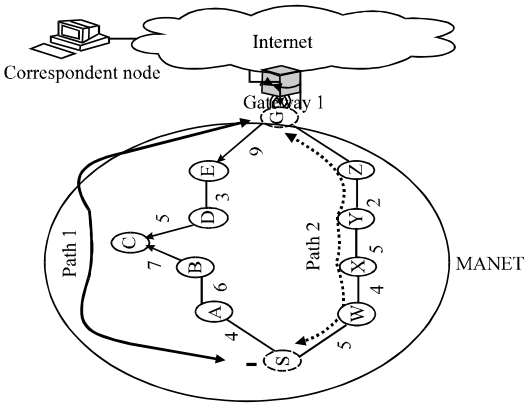

Fig. 5: Multipath gateway route discovery scheme

Algorithm for multipath gateway route discovery process for cross layer based AODV:

Step 1: A route is established from source to corresponding node via gateway. The nodes in the network will identify to put C = 1 to activate Cross layer Based AODV protocol in the route reply packet.

Step 2: The neighbor nodes of source and so on get delivery of route request packet and received SNR/RP of the packet for the time of delivery.

Step 3: The every node can performs the following options:

- Step 3.1: If the node itself is gateway, it provides the normal SNR /RP value in the route reply packet.
- Step 3.2: If the node is to rebroadcast the route request to its neighbors', it supplies the SNR/RP value in its buffer for helpful use.
- Step 3.3: If the node is neither the gateway nor is to rebroadcast the route request, it junks the Predictable SNR/PR value.

Step 4: With the communicate method; the route request reaches the gateway. Step 3.1 above is executed.

Step 5: In the reverse path transmission of route reply, every pair of nodes compares the SNR/RP values 'stored in the buffer' and 'received via route reply'. Only the lesser value of the two is stored in the next route reply reverse path. The process continues till getting back to source node.

Step 6: The source node receives one or several routing paths. For multiple routing paths, each route reply packet for all paths have the lowest existing SNR/PR value available through that path. In its place of lowest hop count, the source selects the path with privileged value of SNR/RP and which is among the lesser of each path.

Step 7: The data starts transmitting in the recently defined privileged SNR /RP path.

The proposed research namely as cross layer based AODV protocol applied to multipath gateway route discovery processes to achieve QoS performance objectives such as reduction in average delay, low response time and less number of retransmission attempts. This scheme provides the advantage of increase in traffic and improve throughput for data transmission application.

RESULTS AND DISCUSSION

Performance of this scheme has been verified used NS-2 simulation for two controlled scenarios namely Manet's traffic and FTP applications (Table 1 and 2).

Figure 6 shows that the routing traffic sent is little greater than for cross layer based AODV protocols on average. But the Cross layer Based AODV received more MANET traffic at the gateway which leads to more throughputs.

Table 1: Scenario-2 (FTP application)

Parameters	Values
Area	2000×2000 m
Nodes	20 (5 m sec^{-1})
Access points	1
Application	FTP
Protocol	AODV default and CBAODV
Traffic rate	11 Mbp
Packet size	1024 bits
Freq	2.4 GHz

Table 2: Scenario-1 (MANET traffic)

Parameters	Values
Area	2000×2000 m
Nodes	25 (10 m sec^{-1})
Gateway	1
Traffic	Raw MANET traffic
Protocol	AODV default and CBAODV
MAC	802.11b CSMA/CA
Pause time	100, 200, 300, 400, 500, 600
Packet Size	512 bits
Node range	300 m

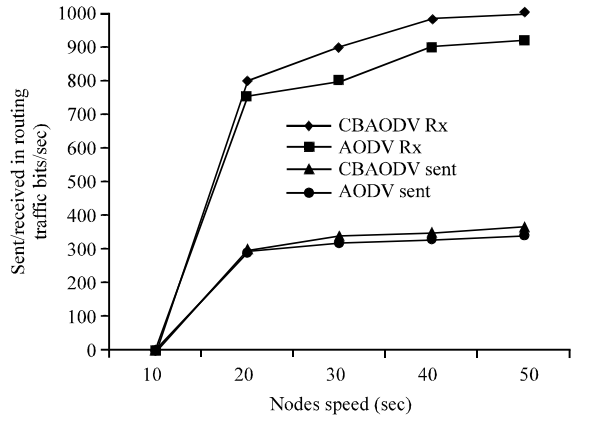

Fig. 6: Routing traffic-sent and received by destination

Figure 7 shows that even to achieve this more throughputs, the MANET delay was little more in the default AODV over than the cross layer based AODV protocol and the default AODV has less route discovery time which is also expected since the cross layer based AODV takes more hops. Figure 8 describes the result of MANET traffic scenario with respective QoS parameters.

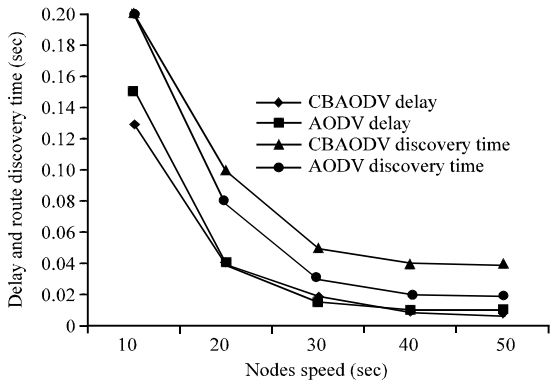

Fig. 7: Delay and routing discovery time

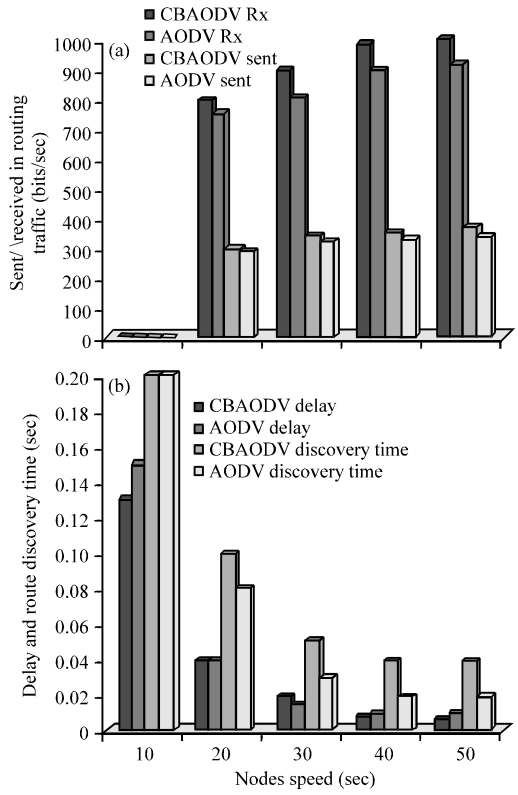

Fig. 8: Result of manet traffic scenario-sent, received packets by the destination, delay and routing discovery time

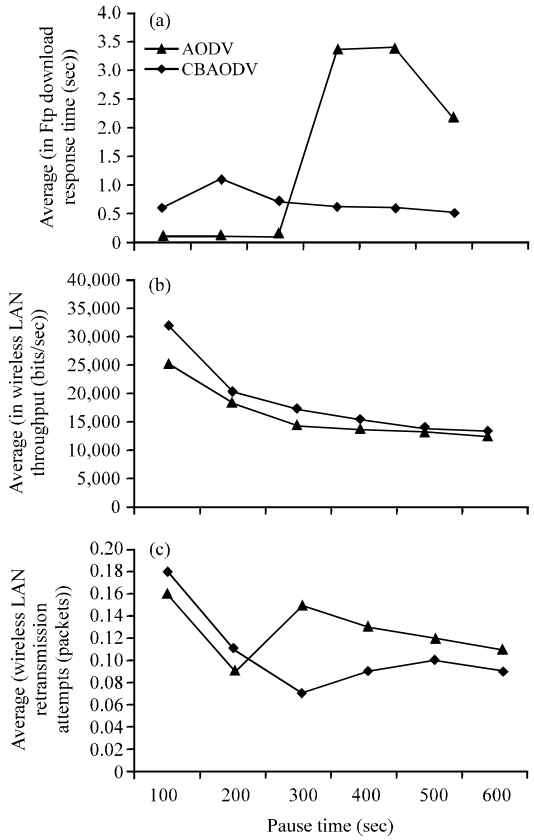

Fig. 9: a) Response time of FTP download; b) throughput of wireless LAN and c) retransmission attempts of wireless LAN

Figure 9a shows greatly lesser download response time for cross layer based AODV which is a popular parameter for FTP application. Figure 9b shows that the cross layer based AODV has enhanced throughput than the default AODV protocol. Figure 9c shows that due to link permanence in the cross layer based AODV, the retransmission attempts are greatly lesser than that of default AODV. This in return helps the network to have less routing overhead and sending the same data again and thereby consuming the bandwidth. Hence, it is observed that the cross layer based AODV protocol outperforms the default AODV routing protocol in some of the major performance metrics as shown. It is also observed that some of the data applications, the stability of the link helps to achieve higher throughput in the cross layer based AODV protocol.

CONCLUSION

MANETs are infrastructure-less networks when all the nodes are activate as host as well as routes to deliver data. By the nature and the architecture, the performance is affected by channel conditions, network connectivity, mobility and resource limitations. Various cross-layering approaches are utilized to improve the QoS performance of MANETs and their associated routing protocols. This research is investigated a modified version of AODV routing protocol utilizing physical layer information received SNR/RP to find its gateway route instead of the default hop count mechanism of AODV protocol. The simulation results and analysis of proposed Cross layer Based AODV shows better performance improvement over the default AODV protocol.

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