Analytical Learning of a Delay Aware Routing Protocol for Multi-hop Mobile Ad-hoc Networks

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***Abstract*— In today's scenario, wireless network is mainly used in those areas where infrastructure based networks are unavailable. The mobile ad-hoc network (MANET) is the mobile network where infrastructure is not required and nodes can be connected in random manner[1]. In MANET, sensor networks are incarnated in which mobile nodes have sensing capability. Ad hoc On demand Distance Vector (AODV), Dynamic Destination Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR) are well know communication protocol of wireless sensor network. These conventional protocols use shortest path or minimum hop count for path selection to transfer a packet from source to destination but those sensor networks which requires high quality of service(QoS),works over several criteria's and possibilities which could affect the quality of path selection service. The QoS is affected by a certain number of parameters like delay, bandwidth, jitter, throughput, latency and packet loss etc. In this paper we analysis currently exist delay aware routing protocols focusing at route selection mechanism & their solution. This analytical learning could be very fruitful for future enhancement in AODV.**

Keywords— **MANET, QoS, Delay Aware Routing, AODV**

I. Introduction

2.1 Ad hoc networks

An ad hoc network is a collection of wireless mobile nodes creating a highly dynamic and temporary network without the help of any established fixed infrastructure or centralized administration [2]. In such an environment, each node can act as a router to forward packets for intermediate nodes or destination node and a MANET routing protocol should be able to adapt fast and effectively to sudden changes in network layout. Mobile ad hoc networks (MANETs) do not rely on any fixed infrastructure but communicate in a self-organized way. Quality of Service guarantees in a MANET is very challenging due to the dynamic and uncertain nature of these networks.

A. Challenges in MANETs

Regardless of the attractive applications, A MANET environment has to overcome certain issues of inefficiency and limitation. They are as following [3, 4]:

1. **Exploits Allowed by Existing Routing Protocols**

Current ad hoc routing protocols are having two different type of attack: *passive* attack and *active* attack. An attack is said to be active if the misbehaving node has to loss some energy costs in order to perform the threat, whereas passive attacks are those which occur due to incorporation in order to save energy selfishly.

2. ***Lack of Cooperation***

Battery life is most important feature for any node. This thing makes nodes selfish to save battery for their own communication. For this they have not participated in network operation by not involving in routing protocol or by not executing the packet forwarding.

3. ***Routing***

As we know topology of the network changes constantly so routing between any pair of nodes is very difficult and challenging Multicasting is more difficult to unicasting as multicasting is more dynamic due to random movement of nodes in network

4. ***Quality of Service (QoS)***

It is very challenging to provide high quality of service in this constantly changing environment of MANET. The uncertain feature of communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. To support the multimedia services, an adaptive QoS must be implemented over the traditional resource reservation.

5. ***Limited range of wireless transmission***

The fixed radio band results in reduced data transmission rates compared to the wired networks. Hence proper usage of bandwidth is necessary by keeping less overhead as possible.

6. ***Power Consumption***

Mostly all mobile devices are based on their limited battery life, so it is very important, the communication-related process should be less power consumption. Conservation of power-aware routing must be taken into consideration.

II. QoS in MANETs

Quality of Service (QoS) is a set of mechanisms which allow to share reasonably various resources offered by the network to every application as needed, to present, if possible, to every application the desired standards (or the network's ability to provide a service). The QoS can be measure network throughput, jitter, latency and packet loss, etc. and it can be defined as the degree of user satisfaction. In MANETs, the arrangement of quality of service (QoS) guarantees is very tough compared to wired networks, mainly due to multihop communications, contention for channel access, node mobility, and a lack of central coordination.

QoS model defines architecture that will provide the best possible service. This model should considered all the challenges enforced by Ad-hoc networks like, constraints of reliability, changed network topology due to the mobility of its nodes and energy consumption, so it provides a set of services that allow service users to select a number of safe-modes that govern such properties as power, time, reliability, etc.. [5][6].

Multimedia and real-time applications require less delay and high data rates which require the facility of new routing protocols supporting QoS [7] [8]. QoS can be implemented into different layers of network like MAC Layer at channel access functions, Network layer at routing protocols [9].

QoS parameters

QoS parameters are changed from application to application. For example, for multimedia applications, the delay and data rate are the key factors, whereas, in military application, security and reliability are big concern. For emergency cases such as earthquake, flood etc. the key factor should be the availability of network. Battery life and energy conservation becomes prime factor in sensor networks.

In real time applications, QoS requests can be expressed in term of many metrics in routing protocols. The most important metrics are delay and data rate. To provide QoS requirements, we have to calculate available data rate and delay for each route and check which route could be used with satisfying QoS.

III. QoS FOR AODV

In 2000, QOS for AODV was introduced by Charles E_ Perkins and Elizabeth M Royer[10,11]. *QoS.*In this paper they provide operational overview of AODV in order to achieve delay and bandwidth constraints. Nodes are allowed to request the delay and bandwidth required from a route. They added *Delay* and *Bandwidth* field to the RREQ and RREP messages. When a source 'S' request a RREQ message, it contain the maximum permit able transmission time and minimum required bandwidth between the next node and the destination node 'D'.Similarly when destination node 'D' reply through a RREP message, it holds the current estimate for the cumulative delay and the available bandwidth between the next node and the source. When a node at any moment detects that route can't provide the guaranteed QoS, all sources which are using this specified route, should be informed by sending ICMP QOS_LOST message.

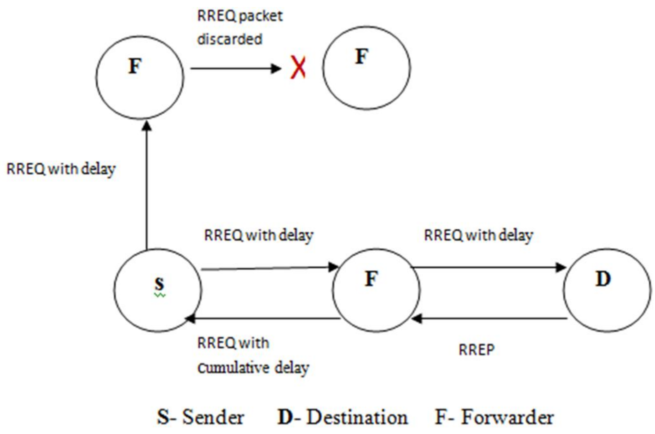

Fig.1 Route Discovery for QoS AODV

Following four entries are added in every route table respectively to every destination.

a) Maximum Delay
b) Minimum Available Bandwidth
c) List of Sources Requesting Delay Guarantees
d) List of Sources Requesting Bandwidth Guarantees

Major drawbacks of this version are:

(a)It doesn't generate correct value of route delay every time. The reasons behind this are the NODE_TRAVERSAL_TIME, are only a constant approximation of the average one hop traversal time and queuing delay, may change dangerously depending on network congestion.

(b)The *ICMP QOS_LOST* message does not provide specific information as it only informs nodes that delay has increased or bandwidth has decreased [2].

IV. LITERATURE REVIEW

A. Ad-hoc on-demand distance vector multipath (AODVM) routing

In 2004, Z. Ye, S. V. Krishnamurthy and S. K. Tripathi [12] introduced a new protocol, a modified version of the AODV routing protocol to facilitate the discovery of multiple node-disjoint paths from a source to a destination. They propose a deployment strategy that determines the positions and the trajectories of these reliable nodes to achieve a framework for reliably routing information. This protocol defines characteristics of reliable path which is collection of multiple pieces, each of which either entirely consists of reliable nodes, or has a preset number of multiple paths between the end points of the piece.

In this mechanism, to enabling the discovery of multiple node disjoint paths [3], protocol allows intermediate node to accept multiple RREQ message, but saves the information in RREQ table (Fig 2(a) and forward them. Later, only a destination is allowed to a reply message.

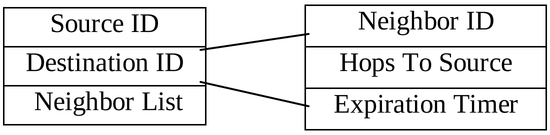

Fig 2 (a) Route request table entry

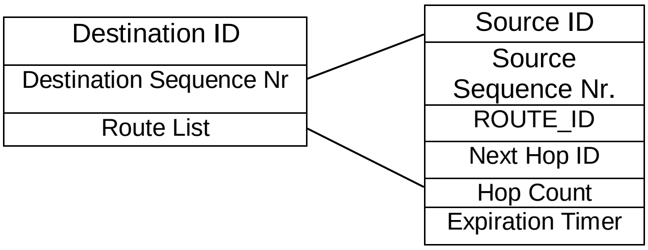

Fig 2 (b) Route table entry

For each RREQ message of a single route discovery instance received by a destination node, a RREP message is created containing a unique route ID number in an appended ROUTE_ID field. The RREP packet is then sent back to the source via the node from which the destination received the RREQ packet. In case, if an intermediate node receives a RREP message, it updates its route table (Fig. 2(b)), finds for the smallest route to the originator, and deletes the related entry from its RREQ table and then forwards the RREP message. Route Discovery Error (RDER) message generates in case of empty RREQ table. and sends it to the previous hop. The previous hop then attempts to use an alternative route to forward the RREP message. They presented some results which show that the probability of establishing a reliable path between a random source and destination pair increases exponentially even with a small number of reliable nodes are inserted. AODVM shows better results compare to AODV in terms of end-to-end delay and packet delivery ratio.

B. Delay Aware AODV-Multi-path (DAAM)

In 2008, Boshoff and Helberg[13] proposed multi-path protocol which is extending version the AODV routing protocol. It uses end-to-end delay as a metric for route selection, instead of hop count. They maintain the Routing table, which store multiple paths for each route with end to end delay. Whenever route failure occurs due to any reason, an alternative route to the destination node is searched in the route before a new route discovery process is started. By this they reduce both end-to-end packet delay and routing overhead. It had been done with the help of changing in route metric and Multi-path routing.

(i) Changing the metric

They modified the Delay field, which contain cumulative delay, of RREQ and RREP. Whenever a one or more packets are waited for the specific destination, the delay offered by the route is compared by delay requested by each packet and if requested route delay is equal or less than the route delay, then route is used Later if new route to destination is discovered, If a new route to a destination is discovered, then we apply a modified AODV rule to compare exiting and current route. This rule state as "If a new route's sequence number is the same as the existing ones, but the new route provides lower delay, or the new route has a higher sequence number and thus is fresher, and its delay is anything lower than the requested delay, the new route is selected over the existing". DAAM uses following rule of update :

if $(((seq\_nr^d_j == seq\_nr^d_i)$ and $(route\_delay^d_j < route\_delay^d_i))$ or $((seq\_nr^d_j > seq\_nr^d_i)$
and $(route\_delay^d_j < route\_request)))$
then
$seq\_nr^d_i := seq\_nr^d_j$;
$hop\_count^d_i := hop\_count^d_j + 1$;
$next\_hop^d_i := j$;
$route\_delay^d_i < route\_delay^d_j$
endif

The notation applies for

node i : receives routing information to destination d from neighbor j.
seq_nr di : The destination sequence number,
hop_count di : hop count
next_hop di : next hop for a destination d at node i is represented
route_delay di: Representing the route delay to destination d at node i
delay_request: Representing the delay request of an application packet.

(ii). Multi-path routing

In DAAM, intermediate nodes forward all RREQ messages instead of discarding, except for the case where a same RREQ message with the same request ID has already received from the same previous hop. The RREQ table is managed as in AODVM [3].When any node receives a RREP message, an intermediate node searches smallest reverse path in route table and as we reaches next hop, all the details for this specific destination – source pair is deleted from route table.
If RREP message returns to source node, the new discovered route stores in route tale with route ID and route delay. Now whenever route discovery process started in AODV, DAAM searches the route table for alternative routes, and if it find alternative route then it compares with delay requested by applicant packet and if alternative route satisfy the application packet's delay request, then it discard the route discovery process.
For DAAM protocol, network simulation has been done with the help of OPNET where two different scenarios are configured. One scenario is configured for static nodes and other for mobile nodes and they used VoIP and video conferencing as traffic. Through this setup, performance of DAAM compared with DSR, DYMO, OLSR and AODV and simulation result shows that end-to-end delay, routing overhead, Delay variation and Packet Delivery Fraction are significantly improved by using the problem with DAAM is

that route delay information might not always be up to date as mentioned in this study. The functionality and efficiency of DAAM did not compare to other QoS protocols and the authors recommended this as a future work.

C. Energy and Delay-Constrained AODV (EDC-AODV)

In 2005, Laura, Natalia Vesselinova-Vassileva, Francisco Barceló,And Patricia Carbajo-Flores [15] proposed a new mechanics EDC-AODV for Energy conservation in wireless mobile ad hoc networks, since the nodes are battery operated so lifetime of network depend on their battery power. In this mechanism, energy saving and timely delivery of data packets is incorporated into the route discovery phase to select shortest paths. This algorithm uses two metrics: residual energy and queue length at each node. Buffer packets are consider as a traffic load and its use is dual as end to end delay and limitation of battery power consumption. A simulation-based performance comparison between a routing ad hoc protocol and its modified energy and delay-constrained version demonstrates that the latter one improves system performance for certain network scenarios. They compared EDC-AODV with AODV and showed using simulation results that EDC-AODV minimizes the end-to-end delay compare to AODV and life time of the network increases tremendously.

D. Energy and Delay AODV (EDAODV)

In 2008, Asokan and Natarajan [16] are added two fields with AODV routing table for each entry; the minimum energy and maximum delay. When a source generates a RREQ message to transmit packets, it must announce QoS energy and delay extension. The extension of delay gives the maximum delay permitted between the source and destination.
The mechanism for this technique execute in two steps as:
Step 1: Before forwarding the RREQ packet an intermediate node compares its available energy to the energy field indicated in the QoS extension. If node energy is less than QoS energy then the packet will discarded, otherwise it will be pass to next assessment.
Step 2: In this assessment they checks the delay estimation of the node, if it exceeds the QoS delay, it will discard the packet; otherwise the node subtracts its node traverse time (NTT) from the delay bound provided in the extension.
In mechanism of EDAODV, each RREQ packets in the network keeps a record for the delay and energy consumed by them so far and routing table also maintains energy and delay for every route as well. With the help of this new cost metrics, AODV works on all duplicate RREQ packets received by other route if they carry lower cost metrics. If node, which receives a RREQ packet with lower cost ,is not destination nor having route to destination, then node forward it else reply it.
Author use ns2 to create simulation environment and work over packet delivery ratio (PDR), end-to-end delay and remaining energy .The result shows that EDAODV has better performance in terms of end-to-end delay, PDR and other measured metrics over AODV. In this protocol, they majorly working on routing layer and explore only route specific information. Author suggested working over MAC layer and other layers information for future work.

CONCLUSIONS AND FUTURE SCOPE

In this analytical study, we have been reviewed various delay aware routing protocols of ad-hoc mobile network and found that delay is the major metric for path selection to transfer a packet from source to destination node. Few protocols also use some other metric such as bandwidth, energy etc. Compare to *Ad-hoc on-demand distance vector* (AODV), *Delay Aware AODV-Multi-path* (DAAM), *Energy and Delay-Constrained AODV* (EDC-AODV), *Energy and Delay AODV* (EDAODV) are generate great results and showed better performance when tested using simulation. There is lot of scope in energy efficient and power efficient protocols in future.

Table 1: Analytical Study of Various AODV Based Protocols compare to AODV

Protocol Name	Multiple Routes	Routing Type	Major Metrics	Energy Efficiency
AODV	NO	Reactive (Hop Count)	Hop Count	Low
Q-AODV	NO	Reactive (Hop Count)	Delay & Bandwidth	Low
AODVM	Yes	Reactive (Multiple Path)	Delay & Multiple Path	MOD
DAAM	Yes	Reactive (Multiple Path)	Delay & Multiple Path	MOD
EDC-AODV	Yes	Reactive	Energy and Delay	High
EA-AODV	Yes	Reactive (Multiple Path)	Energy and Delay	High

Table 2: Analytical Study of Various AODV Based Protocols compare to AODV

Protocol Name	Packet Delivery Ratio	Through Put	end-to-end delay	Network Life
AODV	MOD	MOD	MOD	MOD
Q-AODV	MOD	MOD	MOD	MOD
AODVM	High	High	Low	MOD
DAAM	High	High	Low	MOD
EDC-AODV	High	High	MOD	High
EA-AODV	High	High	MOD	High

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