Traffic Load based Performance Analysis of DSR, STAR & AODV Adhoc Routing Protocol

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***Abstract*- The wireless adhoc network is comprised of nodes (it can be static or mobile) with wireless radio interface. These nodes are connected among themselves without central infrastructure and are free to move. It is a multihop process because of the limited transmission range of energy constrained wireless nodes. Thus, in such a multihop network system each node (also known as router) is independent, self-reliant and capable of routing the packets over the dynamic network topology and therefore routing becomes very important and basic operation of adhoc network. Many protocols are reported in this field but it is difficult to decide which one is best. In this paper table driven protocol STAR and on demand routing protocols AODV, DSR based on IEEE 802.11 are surveyed and characteristic summary of these routing protocols is presented. Their performance is analyzed on throughput, jitter, packet delivery ratio and end-to-end delay performance measuring metrics by varying CBR data traffic load and then their performance is also compared using QualNet 5.0.2 network simulator.**

Keywords-Adhoc networks; wireless networks; CBR, routing protocols; route discovery; simulation; performance evaluation; MAC; IEEE 802.11; STAR; DSR; AODV.

I. INTRODUCTION

The wireless adhoc network is collection of nodes with wireless radio interface, which can move freely and are connected among themselves without any infrastructure. The adhoc networks are very flexible and suitable for several types of applications, as they allow the establishment of temporary communication without any pre installed infrastructure (fig.1). Due to the limited transmission range of wireless radio interfaces, in most cases, the communication has to be relayed over intermediate nodes. Thus, in mobile multi-hop ad-hoc networks each node also acts as a router [6]. Beside the disaster and military application domain the deployment of mobile ad-hoc networks for multimedia applications is another interesting domain. With newly emerging radio technologies, e.g. IEEE 802.11[10] and bluetooth, the realization of multimedia applications over mobile ad-hoc networks becomes more realistic.

To find a route between the end-points is a major problem in mobile multi hop ad-hoc networks. The problem is further aggravated because of the nodes mobility. Many different approaches are reported to handle this problem in recent years, but it is very difficult to decide which one is best routing algorithm. It is also reported in the performance analysis of different routing protocols [11,12,13] in literature. Other aspects of ad-hoc networks are also subject to current research, especially the dynamic changing network topology of nodes.

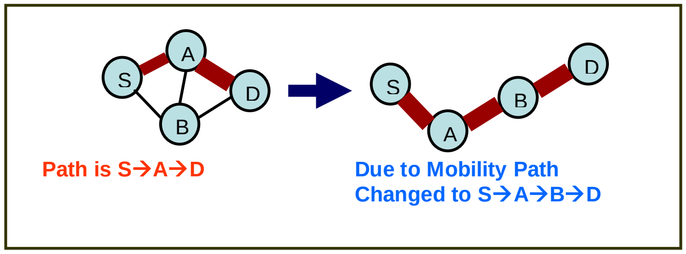

Fig. 1 The dynamic scenario of network topology with mobility

In this paper the comparison of STAR a table driven and AODV, DSR on-demand routing protocol based on IEEE 802.11 [10] is analyzed, compared and presented. This paper explores the impact of MAC overhead on achievable data throughput, jitter, end-to-end delay and packet delivery ratio in environments with varying data traffic CBR (Constant Bit Ratio) load over UDP using Qualnet 5.0.2 simulator [2].

II. ROUTING PROTOCOLS: CLASSIFICATION IN BRIEF

Routing is the process of finding a path from a source to some arbitrary destination on the network. The broadcasting [14,15,16] is inevitable and a common operation in ad-hoc network. It consists of diffusing a message from a source node to all the nodes in the network. Broadcast can be used to diffuse information to the whole network. It is also used for route discovery protocols in ad-hoc networks. The routing protocols are classified as follows on the basis of the way the network information is obtained in these routing protocols.

A. *Proactive or Table-driven) routing protocol*

For example
1. Destination sequenced Distance vector routing (DSDV)[5]
2. Source Tree Adaptive Routing (STAR) [8]

B. *Reactive or On-demand routing protocol*

For example
1. Ad-Hoc On-demand Distance Vector (AODV) [1]
2. Dynamic Source Routing (DSR) [3,4]

C. Hybrid Protocols

For example

1. Temporally ordered routing algorithm (TORA)[7]
2. Zone Routing Protocol (ZRP)[9]

These classes of routing protocols are reported but choosing best out of among them is very difficult as one may be performing well in one type of scenario the other may work in other type of scenario. In this paper it is observed with the simulation of AODV, DSR and STAR routing protocols. These three protocols are briefly described below. The characteristic summary of these routing protocols is also presented in this paper in table 2.

III. DYNAMIC SOURCE ROUTING PROTOCOL

The key feature of DSR [3,4] is the use of source routing. The source (sender) knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. It is an on-demand routing protocol and composed of two parts:

A. Route Discovery
B. Route Maintenance.

A. Route Discovery

When a node in the ad hoc network attempts to send a data packet to a destination for which route is not known, it uses a route discovery process to find a route. Route discovery uses simple flooding technique in the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it further, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed so far. The RREP routes itself back to the source by traversing this path backward, the route carried back by the RREP packet is cached at the source for future use.

B. Route Maintenance

The periodic routing updates are sent to all the nodes. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. Some of the techniques that are evolved to improve it are:

i) Salvaging: an intermediate node can use an alternate route from its own cache, when a data packet meets failed link on its source route.

ii) Gratuitous route repair: a source node receiving a RERR packet piggybacks the RERR in the following RREQ.

This helps cleaning up the caches of other nodes in the network that may have the failed link in one of the cached source routes.

IV. SOURCE TREE ADAPTIVE ROUTING (STAR)

Source Tree Adaptive Routing (STAR) Protocol for adhoc network, is a proactive table driven routing protocol. The network topology is presented in the form of a graph G. The G = (V, E) is a directed graph, where E is the set of edges connecting the vertices and V is the set of nodes. These vertices are called nodes (or Routers) and edges are called links between them. The adjacent nodes are called neighbors and all of them have unique address for identity. In a wireless network, a node can have connectivity with multiple nodes over a single physical radio link.

A. Route Discovery & Maintenance

Each node builds a shortest path tree (source tree) and stores preferred path to destination and so each node discovers and maintains information related to network topology. STAR protocol uses two different techniques to neighbor discovery using hello or update messages. It is energy saving protocol in the sense that every node of it updates about only the changes to its source routing tree when they found changes or breakage in the links. If over a given period of time a node doesn't receive any such message, it assumes that either node is out of its range (node may be dead) or link is broken. Within the finite time frame all the changes like link failures, new neighbor notifications etc. are processed and send to neighbors in their order of occurrences and one at time.

B. Different Operating Modes

The STAR routing protocol operates in two different mechanisms but chooses one at a time. It may work either in the Least Overhead Routing Approach (LORA) mode or Optimum Routing Approach (ORA) mode. With ORA, the routing protocol attempts to update routing tables as quickly as possible to provide paths that are optimum with respect to a defined metric whereas in LORA mode it tries to provide shortest route as per performance and delay metrics.

V. AD-HOC ON-DEMAND DISTANCE VECTOR (AODV)

The brief discussion of the AODV protocol is given here as it analyzed further for the impact of MAC overhead and multiple hops on achievable data throughput and packet delivery ratio using ns2 simulator

A. Ad Hoc On-Demand Distance-Vector Protocol (AODV)

The Adhoc On-Demand Distance-Vector Protocol (AODV)[1] is a distance vector routing for mobile ad-hoc networks. AODV is an on-demand routing approach, i.e. there are no periodical exchanges of routing information.

The protocol consists of two phases:

i) Route Discovery, and
ii) Route Maintenance.

A node wishing to communicate with another node first seeks for a route in its routing table. If it finds one the communication starts immediately, otherwise the node initiates a *route discovery* phase. The route discovery process consists of a route-request message (RREQ) which is broadcasted. If a node has a valid route to the destination, it replies to the route-request with a route-reply (RREP) message. Additionally, the replying node creates a so called *reverse route* entry in its routing table which contains the address of the source node, the number of hops to the source, and the next hop's address, i.e. the address of the node from which the message was received. A lifetime is associated with each reverse route entry, i.e. if the route entry is not used within the lifetime it will be removed. The second phase of the protocol is called *route maintenance*. It is performed by the source node and can be subdivided into: i) source node moves: source node initiates a new route discovery process, ii) destination or an intermediate node moves: a route error message (RERR) is sent to the source node. Intermediate nodes receiving a RERR update their routing table by setting the distance of the destination to infinity. If the source node receives a RERR it will initiate a new route discovery. To prevent global broadcast messages AODV introduces a local connectivity management. This is done by periodical exchanges of so called HELLO messages which are small RREP packets containing a node's address and additional information

B. The Basic Protocol

Each AODV router is essentially a state machine that processes incoming requests from the SWANS network entity. When the network entity needs to send a message to another node, it calls upon AODV to determine the next-hop.
Whenever an AODV router receives a request to send a message, it checks its *routing table* to see if a route exists. Each routing table entry consists of the following fields:

- Destination address
- Next hop address
- Destination sequence number
- Hop count

If a route exists, the router simply forwards the message to the next hop. Otherwise, it saves the message in a *message queue*, and then it initiates a route request to determine a route. Upon receipt of the routing information, it updates its routing table and sends the queued message(s). AODV nodes use four types of messages to communicate among each other. *Route* Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance.

VI. SIMULATION SETUP

The Qualnet 5.0.2 simulator is used for the analysis. The animated simulation is shown in fig. 2. The IEEE 802.11[10] for wireless LANs is used as the MAC layer protocol. In the scenario UDP (User Datagram Protocol) connection is used and over it data traffic of Constant bit rate (CBR) is applied between source and destination. The 100 nodes are placed uniformly over the region of 1500mx1500m. The mobility model uses the random waypoint model in a rectangular field. The multiple CBR application are applied over 13 different source nodes – 4,53,57,98,100,7, 5,49,10,93,1,92,9) and destinations nodes - 51,91,94,59,60,96,58,97,100,54,45, 44,38 respectively. The data traffic load is varied as 1, 2, 4, 5, 10 packets per sec to analyze the performance of AODV, DSR and STAR-LORA (STAR with LORA method) routing protocols. The simulations parameters are shown in table 1.

Performance Metrics

Throughput: Throughput is the average rate of successful data packets received at destination. It is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second.

TABLE 1. Simulation Parameters

Parameter	Value
Area	1500mX1500m
Simulation Time	90,120, 200 sec
Channel Frequency	2.4 Ghz
Data rate	2.Mbps
Path Loss Model	Two Ray Model
Mobility Model	Random-Way Point
Packet size	512 bytes
Physical Layer Radio type	IEEE 802.11b
MAC Protocol	IEEE 802.11
Antenna Model	Omni-directional

End-to-End Delay: A specific packet is transmitting from source to destination and calculates the difference between send times and received times. Delays due to route discovery, queuing, propagation and transfer time are included in the delay metric.

Jitter: Jitter is the variation of the packet arrival time. In jitter calculation the variation in the packet arrival time is expected to be low. The delays between the different packets need to be low for better performance in ad-hoc networks. It becomes a matter of concern if it is more that the threshold value which is different for data, voice or video transmission services.

Packet Deliver Ratio (PDR): The (PDR) is defined as the ratio between the amount of packets sent by the source and received by the destination.

VII. RESULTS & DISCUSSION

The Qualnet 5.0.2 network simulator is used to analyze the parametric performance of Dynamic Source Routing (DSR) [3,4], Ad Hoc On-Demand Distance-Vector Protocol (AODV) [1] and STAR [8] routing protocols. The LORA method of STAR is used in this paper for analysis. The animation of broadcasting, nodes mobility and transmission of data is shown in figure 2. The performance is analyzed with varying traffic load. In this analysis thirteen different CBR traffic as described in simulation setup is applied on separate source to destination nodes. The results are shown in figures from 3 to 6.

Packet Deliver Ratio: Performance is analyzed on this parameter and it is observed that AODV routing protocol performs better than both DSR and STAR-LORA but DSR performs better than STAR-LORA initially but as the traffic load is increased more than 2 packets per sec the STSR-LORA protocol outperforms the DSR protocol as shown in figure 3.

Throughput: With the varying CBR data traffic the throughput is analyzed. The successful packet delivery in an adhoc network is observed with increasing MAC based CBR traffic load. It is found that AODV performs better than both DSR and STAR-LORA generally but for traffic of 10 packets per sec STAR-LORA performs better. It is also observed that at low traffic load of 1 packet per sec the DSR protocol perform better than STAR-LORA but as the traffic is loaded heavily the STAR-LORA performs much better than DSR as shown in figure 4.

End-to-End Delay: When a packet is transmitted from source to destination it takes time to reach. This time includes different delay as described in its definition above. In this analysis it is found as expected the delays are increasing as the traffic load is increasing. The average end-to-end delay is very high in DSR than STAR-LORA and AODV protocols. The AODV also has more end-to-end delay for heavy load than STAR-LORA as shown in figure 5.

Jitter: Jitter, the variation of the packet arrival time, is an important metrics for any routing protocol. In this analysis it is found to vary with the traffic load in case of DSR and is largest when traffic load is 4 packets per sec. But in SATR-LORA case it is uniformly increasing. It is also noted that the jitter of DSR is always more than both AODV and STAR-LORA and the STAR-LORA has least jitter as shown in figure 6.

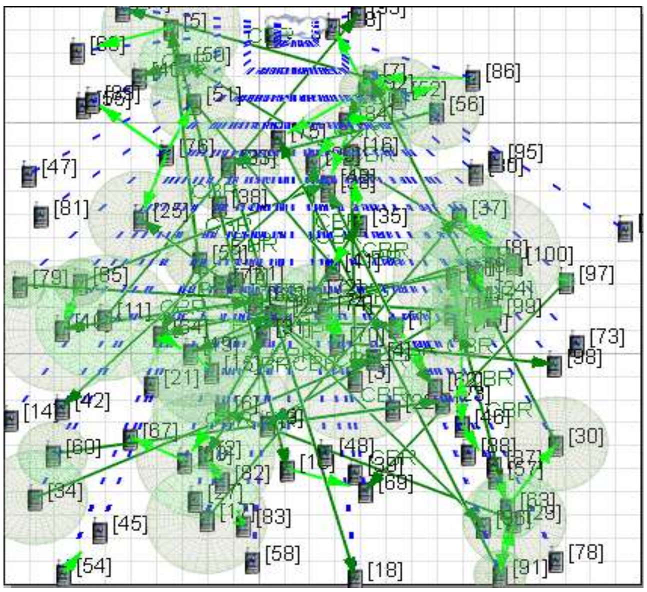

Fig 2 Animation view of simulation

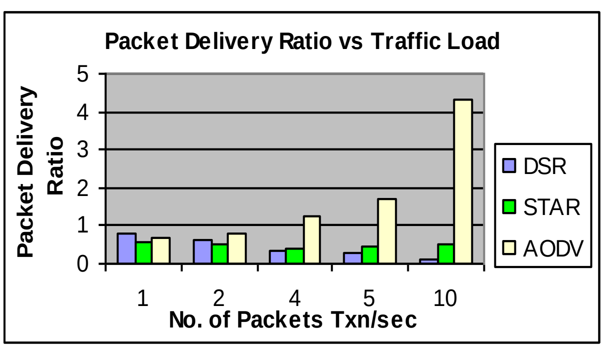

Fig 3: Packet Delivery Ratio vs Traffic Load

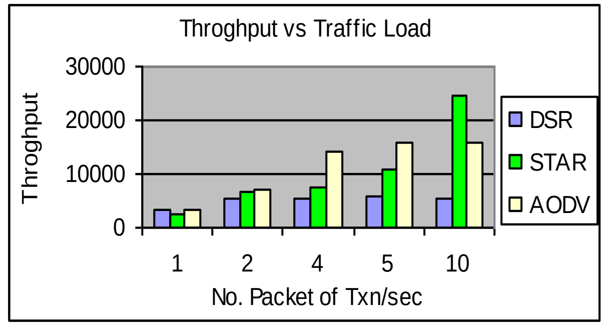

Fig 4: Throughput Vs Traffic Load

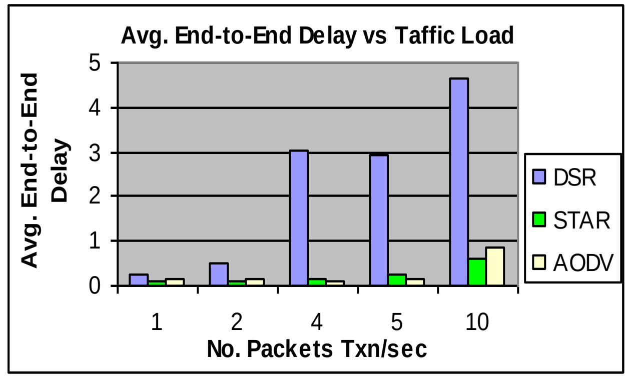

Fig 5: Average End-to-End Delay vs Traffic Load

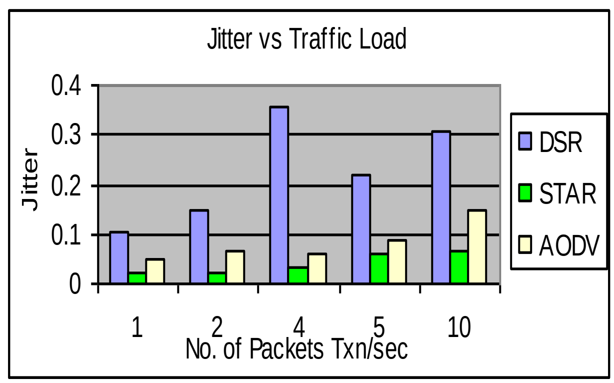

Fig. 6. Average Jitter vs Traffic Load

VIII. CONCLUSION

It is observed that AODV outperforms both of the DSR and STAR-LORA routing protocols in terms of the packet delivery ratio as it uses the fresh routes and STAR-LORA performs poorer as it takes more time to find the routes with LORA method. The throughput is generally good with the AODV but STAR performs better than both when heavy load is applied. The DSR performs poorer than both because of aggressive use of cache. The poor performance of DSR is also because it doesn't have proper mechanism to expire the stale routes and therefore the jitter and the average end-to-end delay is also very high in comparison to AODV and STAR. It is observed that the throughput and Packet deliver is good with the AODV but with increased traffic load the throughput is good in case of STAR routing protocol.

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TABLE 2 Characteristic summaries of DSR, AODV, STAR routing protocols

Protocol	Dynamic Source Routing **(DSR) [3,4]**	Ad hoc On-Demand Distance Vector **(AODV)[1]**	SOURCE TREE ADAPTIVE ROUTING (STAR) **[8]**
Category	Reactive	Reactive	Proactive
Metrics	Shortest path, next available	Newest route, shortest path	Shortest path works in two mode • Least Overhead Routing Approach (LORA) mode or • Optimum Routing Approach (ORA) mode
Route Recovery	New route, notify source	Same as DSR, local repair	Reverse link
Route repository	Route cache	Routing table	Routing table
Broadcasting	Simple	Simple	Simple
Multiple paths	Yes	No	No
Loop freedom maintenance	Source route	Sequence number	Updated messages
Communication Overhead	High	High	High
Feature	Completely on demand	Only keeps track of next hop in route	Control packets localized to area of topology change