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Performance Evaluation of ACO Algorithm Based Multirouting Protocol to Improve QoS

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Abstract: ***Mobile ad hoc network (MANET) is an autonomous and self-configuring system connected by wireless links. It is a collection of mobile nodes and is widely used where network establishment is challenging. Wireless ad hoc network makes available multiple paths for data transmission, but it is necessary to choose most efficient path and provide better Quality of Service (QoS). Due to frequent movement and formation of dynamic connections in MANET, it is challenging to maintain quality of service. This QoS is inspected using performance matrices such as end to end delay, bandwidth, throughput, probability of packet loss, delay variance (jitter) etc. A new protocol QoS enabled ant colony optimization based multipath routing protocol (QAMR) is proposed based on an ant colony optimization algorithm which provides plausible path out of multiple paths for data transmission. This algorithm is scalable, adaptive and efficient. The performance is evaluated by comparing QAMR protocol and AODV protocol using network simulator.***

Keywords: MANET, Quality of services, Ant colony optimization, QAMR

1. Introduction

A network is a link launched among nodes i.e. electronic devices which can be wired or wireless. This connection establishes communication between nodes. In today's life wireless networks has gained popularity over traditional wired connection because it can be deploy anywhere and convenient to use. In wireless networks, it is necessary to set up routes from one host to another to exchange information. Routing is the process of finding an efficient path to forward data from source to destination maintaining Quality of Service. Quality of service is set of pre defined services to fulfill the needs of end users. Now a day's wireless ad hoc network is in demand. Meaning of Ad hoc is "for this purpose only" which implies that this can be implement where construction of network is a challenge.

Mobile Ad Hoc Networks (MANETs) are an emerging class of network with self configuring and dynamic topology properties. It does not hold specific infrastructure to establish connections due to mobile nodes. These nodes can move randomly and simultaneously establish links between source and destination as per requirement. As MANET is an autonomous system, it is only suitable for temporary communication links because it has dynamic topology and has no centralized control. So the base stations do not exist in the network topology and each node acts as a host. Due to such properties it is applicable in military operations, disaster relief situations, video conferencing and emergency rescue operations. To perform such operations MANETs have protocols which are classified into three categories: 1) table driven or proactive protocol (DSDV)which maintains up to date information of nodes for fixed interval of time. 2) On demand or reactive routing protocols (ad hoc on demand vector routing protocol) establish routes as per requirement. 3) Hybrid protocols (ZRP) are the combination of reactive and proactive routing protocol.

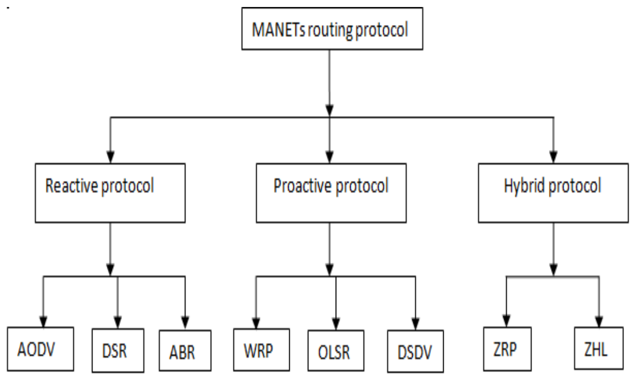

Figure 1: Basic routing protocols of MANET

These protocols are designed using different algorithms such as Bellman ford, Djkestra algorithm, shortest path algorithm etc. All of these protocols are better for specific applications but are not adaptive for all circumstances. Many protocols have been designed as per applications. It is necessary to design an efficient, scalable and adaptive protocol which can make decisions in critical situations. The main objectives of designing new protocol is to find a path from source to destination satisfying user's requirement by enhancing QoS and repairing the path quickly in case of link failure without degrading the level of QoS.

2. Literature survey

Ant Colony Based QoS Routing Algorithm for Mobile Ad Hoc Networks is an on-demand QoS routing algorithm [2] proposed by P. Deepalakshmi. This algorithm is adaptive in nature and reduces the end to end delay in high mobility cases. But the other QoS constraints i.e. other network layer or link layer metrics like energy, jitter, link stability etc. are not considered here. Furthermore, here link failure is not handled properly.

Metrics in Mobile Ad Hoc Networks proposed by R. Asokan [3] and it performs well in route discovery phase with dynamically changing topology and produces better throughput and low delay variance. Again flooding of route request may potentially reach all nodes in the network, so bandwidth wastage increases and efficiency degrades. This protocol is contention prone and also there are chances of collision. Due to these disadvantages throughput and packet delivery ratio decreases along with increase in congestion. The routing overhead is also increased.

An on-demand routing protocol Ant-E [4] is introduced by Srinivas Sethi which is based on Blocking Expanding Ring Search (Blocking-ERS) to control the overhead and local retransmission to improve the reliability. It resumes its route discovery process to discover a route to the destination node from the place where it ended in the last round but the routing process leads to energy consumption.

S.Kannan has projected a multi agent ant based routing algorithm for MANET [5]. It is a hybrid algorithm which combines the concepts of multi agents and ant algorithm. This technique increases node connectivity and decreases average end to end delay and increase packet delivery ratio. But complex optimization problems are not considered in algorithm.

B. R. Sujatha has proposed a PBANT algorithm [6] which optimizes the route discovery process by considering the position of the nodes which can be obtained by GPS receiver. But here energy parameter is not taken into account.

Shahab Kamali has proposed POSANT which uses the information about the position of nodes to increase the efficiency of ant routing and does not fail when the network contains nodes with different transmission ranges. POSANT is a multi-path routing algorithm and converges to routes which are close in length to the shortest path. But it doesn't consider energy parameter in routing.

3. AODV routing protocol

AODV is a reactive, on demand, distance vector routing protocol [7]. Using Bellman-Ford distance vector algorithm routing table of AODV is put into service. It discovers routes to a destination only when a node wants to send a data packet to that destination. As there is no need of periodic routing updates control overhead is less and only some necessary information is propagated. AODV obtains route quickly for new destination of mobile nodes [7]. AODV is also responsible for quickly responding the source node if any link will breaking and change in its network topology in a timely manner. When any link of its routes is break AODV immediately inform the affected set of nodes to invalidate its routes that consist of this lost link [7].

Destination sequence numbers is the most significant feature of AODV is, which plays important role in deciding the routes to a destination. Sometimes if there are more than one route from a node to destination then requesting node select those routes that having the greatest sequence number. Destination sequence number is associated with each route entry of nodes that maintain in its routing table and maintain record of its routing information obtained from routing packets. All the operations of AODV eliminate the routing loops. In AODV routing protocol there are two phases route discovery and route maintenance. In route discovery process there are three types of message defined by AODV which are used to locate route.

RREQ- Broadcasts Route Request message to all nodes
RREP- This message is send to source by destination and source nodes.
RERRs- This message is broadcasted if any error has been occurred in the route.
While in route maintenance phase transmission of data is maintained.

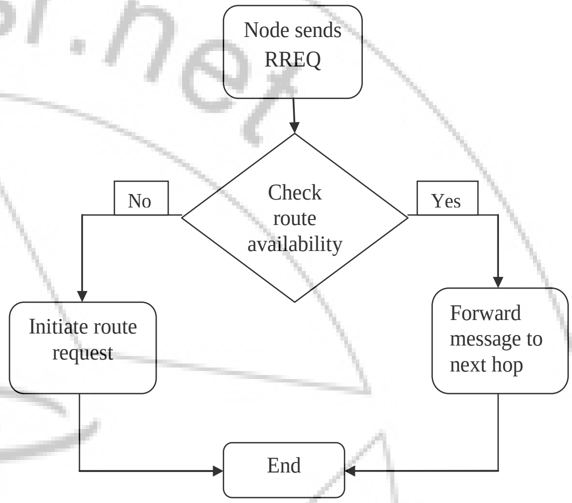

Figure 2: AODV routing mechanism

4. Ant colony optimization algorithm

Ant Colony Optimization (ACO) is subset of swarm intelligence uses the Ant's behavior to find an optimal path successfully in real time. It is inspired by the foraging behavior of real ants, where they are able to find shortest path to food source [8]. When multiple paths are available from nest to food, ants do random walk initially to find out most probable path. While roaming in search of food, ants deposit chemical substances named pheromone to mark the path which is traced by new ants. During return journey ants follow the laid pheromone marks. The ants follow the highest pheromone concentration and fortify it to communicate with each other. Such kind of indirect communication is known as Stigmergy.

To illustrate this behavior, let us consider fig. 3. A set of ants moves along a straight line from their nest A to a food source B (a). In (b) obstacle is put across this way so that side C is longer than side D. The ants will thus have to decide which direction they will take: either C or D.

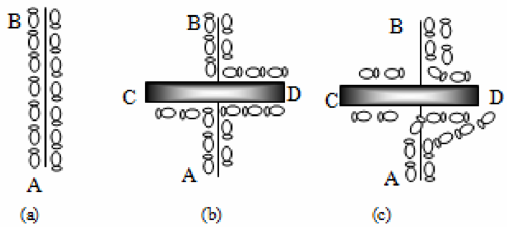

Figure 3: Behaviour of the ants for searching the food [8]

The first ones will choose a random direction and will deposit pheromone along their way. Those taking the way ADB will arrive at the end of the obstacle before those that take the way ACB. The following ants' choice is then influenced by the pheromone intensity which stimulates them to choose the path ADB rather than the way ACB (c). The ants will then find the shortest way between their nest and the food source.

Since in mobile ad hoc networks the existence of links are momentary ACO mainly suits for ad hoc networks due to link quality, local work and support for multipath [2]. To select a reliable path from multiple paths algorithm makes use of intelligence of ants. Ant colony optimization algorithm withstands for dynamic topology of network and also supports multipath routing which makes algorithm adaptive.

5. Proposed methodology

MANET has dynamic topology and supports both single hop and multiple hops. Many algorithms have proposed. On the other hand many of them are application dependent so there is a need to design an adaptive protocol. The proposed algorithm QoS enabled ant colony based multipath routing [1] provides this feature in which a path is chosen out of multiple paths by path preference probability. Route establishment and communication between mobile nodes is carried by ant like agents such as forward ants (FANT) and backward ants (BANT). The packet structure of ant agent consists of source address, destination address, hop count, pheromone concentration. These agents help protocol to take intelligent decisions during messy situations such as congestions, link failures etc.

Different parameters such as delay, bandwidth, and next hop availability (NHA) [1] [7] are calculated to find path preference probability. These parameters are required to maintain QOS by checking different performance matrices such as throughput, delay, packet delivery ratio etc. The NHA is taken into consideration for finding out trusted neighboring nodes. For all trusted neighboring nodes NHA should be greater than threshold of NHA to control routing overhead. To find path preference probability the paths should ensure that calculated values of delay and hop count must be less than threshold values of respective parameter. In case of bandwidth the calculated values must be greater than threshold values. For each node routing table is maintained which collects information different parameters.
Path preference probability can be calculated as,

$$P_i = \frac{(d_g b_g h_g)_i}{\sum_{j \in p_i} (d_g b_g h_g)_j} \quad [1][2]$$

Where, d_g, b_g, h_g - Goodness values

5.1 Route exploration phase

In route exploration phase most probable path is chosen among multiple paths. While sending information from source to destination number of paths is available. It is necessary to select a unique path which performs efficient transmission which is done by sending some routing messages to the nodes Let the source node *A* has data to send to a destination *D* without any data loss and delay. First node A broadcasts Hello message to all the nodes by sending FANTs [1]. FANT collects network information, and BANT updates the pheromone in the path. When FANT is broadcast by the sender, the intermediate nodes dispose the FANT as shown in fig. 4. There are three restrictions for receiving a FANT:

(a) Satisfying the bandwidth requirement.
(b) The maximum hop number is limited by 6.
(c) Receiving the broadcast packet for the first time.

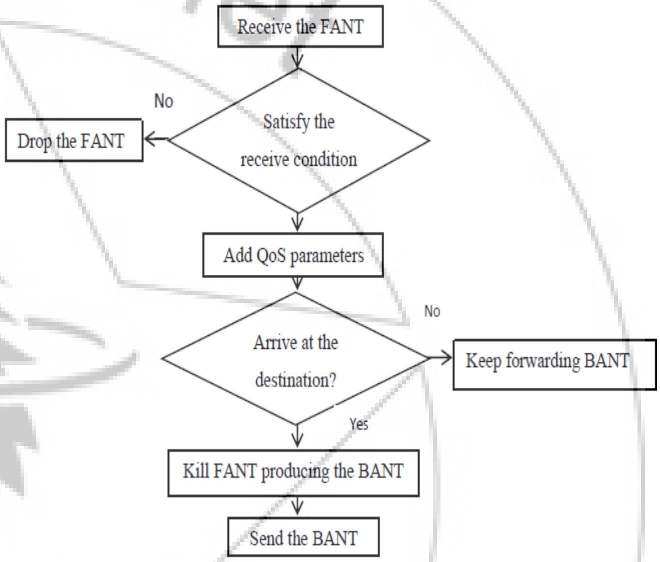

Figure 4: The process of FANT positioning

The node should satisfy the above three restrictions at the same time when it response to the FANT. In the process of routing discovery, the grade of path should be known, which depend on the cost of path. Generally, the more the time delay and the packet loss rate, the more the cost of the path would be. For the bandwidth, the more the bandwidth of the path, the less the cost of the path would be. Then the intermediate node will dispose the BANT, as shown in fig. 5. When the source node receives a BANT, data packets will be sent by the path which has the highest priority.

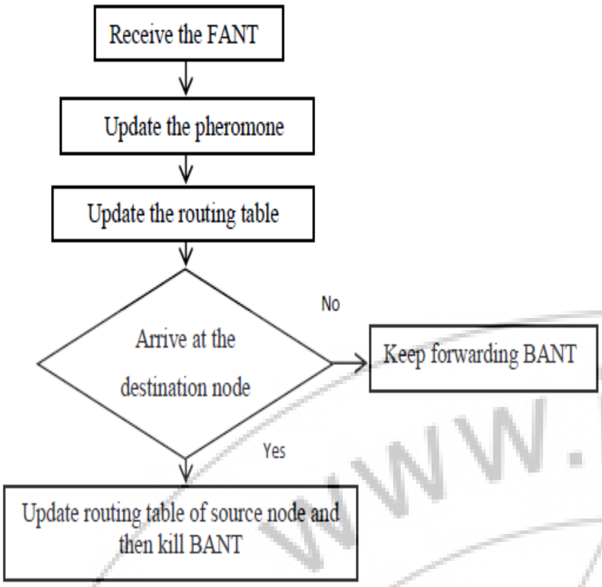

Figure 5: The process of the BANT positioning

5.2 Route Safeguarding Phase

Route exploration phase establishes most probable route for data transmission by choosing a path reinforced with highest pheromone concentration [2]. The route maintenance phase is responsible for maintaining QoS of network [8]. It is a must thing to maintain the selected path from link failures causing due to random movement of nodes. Sometimes when transmission is going on, overcrowding occurs due to the load on the selected path which may increase causing more delay and less available bandwidth leads to decrease in path preference probability [1]. At this stage an intelligent decision is taken by finding alternate route during route exploration phase and a notification ant will be sent to the source to notify the source node about route alteration. Due to random movement of nodes link breakage occurs.

6. Performance evaluation

Network simulator (NS2) is used simulate all types of network. It is a discrete event driven simulator and start packet sending for specified time. Results are generated in the form of graph. Performance metrics are evaluated to check QoS of a presented protocol.

1) *Packet delivery ratio*- It is the percentage of ratio between the number of packets sent by sources and the number of received packets at the sink or destination.
2) *Throughput*- It is the average rate of successful message delivery over a communication channel which is measured in bits per second i.e. bps.
3) *End to end delay*- It is a time required for packets to reach to destination node from source node

In the scenario, nodes are placed randomly in a 1000 m × 1000 m region. The maximum transmit range of each mobile node is 250 m. Each simulation is run for 150s each time. The data traffic was generated by a number of CBR sources with repeated sources and repeated destinations. DropTail queue type is used for data transmission with queue length 50 packets. Same scenario is implemented for both the AODV and QAMR protocol number of nodes is varied to examine the performance of protocols.

Table 1: Simulation parameters

Parameter	*Value*
Simulator	NS-2.35
Radio Propagation Model	Two Ray Ground
MAC Type	802.11b
Interface Queue Type	Drop tail
Link Layer Type	LL
Antenna	Omni Direction Antenna
Area	1000m x1000 m
Queue length	50
Packet size	512
Data rate	50
No. of nodes	25,50,75,100,150
Simulation time	150 sec
Routing protocol	AODV, QAMR

While Fig.6 shows the NAM file of QAMR protocol for 100 nodes. In this simulation scenario data transmission is shown between source and destination nodes which are marked with black circles.

Figure 6: NAM of QAMR protocol (100 nodes)

The comparison between the conventional technique and proposed technique can be drawn by using three basic parameters of mobile ad hoc networks i.e. throughput, energy and end to end delay.

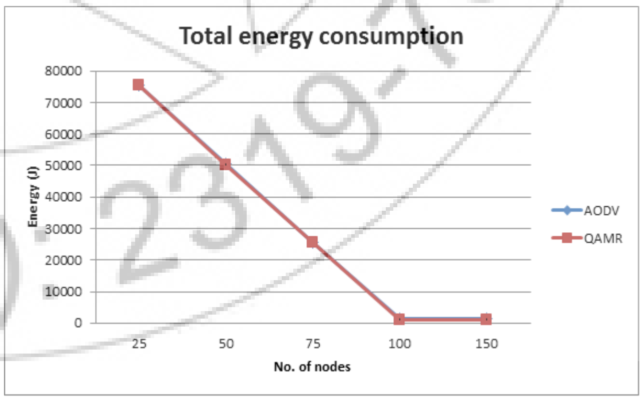

Figure 7: Plot for total energy consumption vs no. of nodes

Fig. 7 shows the evaluation graph of total energy consumption vs no. of nodes between AODV and QAMR. The graph evaluates that as the number of nodes increases the total energy consumption decreases for both the protocols. But the energy consumed by QAMR protocol is slightly less than AODV.

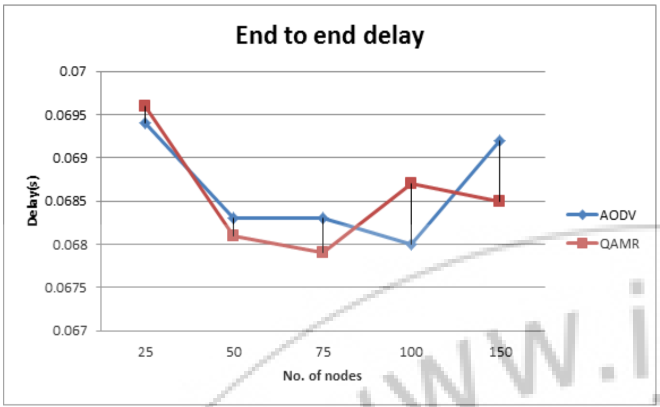

Figure 8: Plot for average delay vs varying no. of nodes

In case of AODV, there are possibilities that some links might be shared by more than one shortest path. This will increase traffic on selected links which may lead to congestion and hence data packets transmitted through these links may face additional delay. Fig. 8 shows the comparison graph of average delay vs no. of nodes between AODV and QAMR. For varying number of nodes the average delay varies for both the protocols. The average delay of QAMR decreases continuously but then shows some additional delay compared to AODV, for AODV it increases suddenly. But average delay of QAMR is less than AODV.

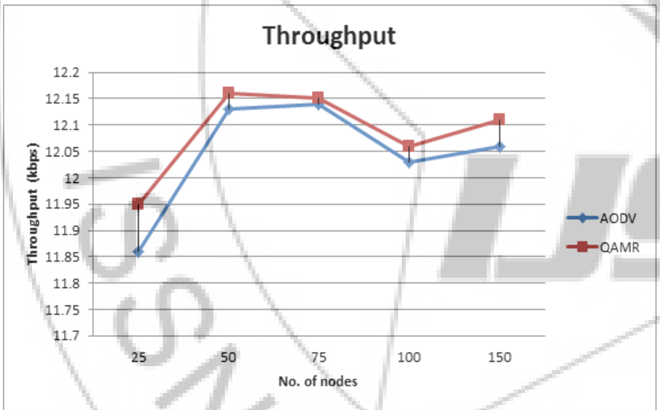

Figure 9: Plot for throughput vs varying no. of nodes

Fig. 9 shows the comparison graph of throughput vs no. of nodes between AODV and QAMR. As the number of nodes increases throughput increases gradually in both cases but QAMR protocol performs better than AODV. From the above performance analysis, being an ant-based multipath scheme, the throughput, packet delivery ratio, energy consumption, average delay and the QoS success rate of QAMR is higher when compared to AODV.

7. Conclusion

A new QAMR protocol based on ACO algorithm is introduced having properties like multipath routing, path preference probability which make the protocol intelligent and adaptive. The path with higher path preference probability offers an optimized consideration of multiple QoS metrics delay, bandwidth, and shortest hop count. ACO algorithm increases reliability of protocol along with adaptive nature and makes the protocol smart to build verdict during link failures.

Performance of QAMR is checked and compared with AODV protocol for the energy, throughput and delay parameters for varying number of nodes. In both cases QAMR protocol maintain QoS and gives better results for throughput compared to AODV protocol. In case of energy, both protocols present almost same energy consumption but QAMR performs slightly better than AODV. In case of delay, it is varying for AODV but decreases gradually for QAMR protocol.

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