

QuAADD: A Quick Access Routing Algorithm using Distance and Direction of Nodes in MANET

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Abstract

Critical applications to be deployed over MANET need Performance as a key factor. Performance can be measured by certain Quality of service (QoS) attributes such as energy efficiency, bandwidth, security, and resource. In order to achieve higher throughput, certain parameters in MANET are optimized in terms of path/direction investigation, angle alignment, distance, and packet load. Packet Delivery Ratio (PDR) and Average End-to-end throughput (AET) decreases at certain threshold and may lead to decrease in performance of MANET. To overcome this scenario, a new algorithm is proposed namely Quick Access Algorithm (QAA). QAA algorithm considers the calculation of the distance and direction using Average Time-of Arrival (ATOA) and Direction Estimation algorithm (DES). The performance in terms of throughput is evaluated through other conventional routing algorithms like AODV, DSR, and DSDV.

Keywords QAA, ATOA, DES, PDR, AET, Performance Evaluation.

INTRODUCTION

Among various networking technology, wireless ad hoc network is low cost yet efficient compared to infrastructure-full wired network. Mobile Adhoc Network

(MANET) is back-boneless network that can configure itself dynamically. In MANET, any node can roam inside the network, and join or leave the network at any point of time. The benefit in MANETs are as follows (i) Resource requirement is minimum, (ii) Self-configurable, (iii) Robustness and decentralized, and (iv) Cost-efficient. MANETs are mainly used in critical application, emergency, and rescue operations, etc. [2]. MANET with high performance is required to operate and cope with above specified applications. The primary factors that influence performance of MANETs are security, bandwidth, resources, and energy.

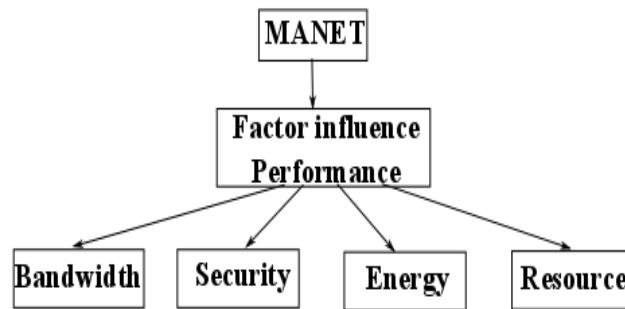


Figure 1: Promising Factors for MANET Performance

The main objective of this work is to increase the performance of MANET. This shall be accomplished by using Quick Access Algorithm (QAA) to improve the routing performance and also focused on increasing the Quality of Service (QoS) in MANET. QAA algorithm optimizes certain QoS attributes such as bandwidth, energy, and throughput. The way of organizing the MANET communication is managed by routing algorithm. The proposed routing algorithm consists of collective measures for improving performance. The factors involved in routing algorithm differ in each scenario, but the ultimate aim is to achieve high performance and throughput. The factors that are considered in routing algorithm to increase performance are as follows. In [4], the QoS factor scrutinized for increasing performance are neighbor node behavior, mobility segment, traffic, and data redundancy. This QoS measure yields high performance in terms of overhead, delay, and mobility.

In [3], the distance and direction are used for forwarding data in Wireless Sensor Network. The angular communication range is fixed. In [5], the distance and hop count is evaluated for refining performance. The path consisting of minimum distance and minimum hop count were constructed. The statistics show that by employing this path, the energy consumption is less for communication purpose. In [7], the positions of nodes are assessed using the distance and direction factor for performance optimization. In [6], the author explains the importance of bandwidth. A node with low bandwidth leads to low throughput, low path optimization, and traverses fewer hops. Performance is diminished in low bandwidth nodes. Energy is one of the factors to optimize performance. The nodes in MANET have energy deficiency (limited energy resource), and energy level is maintained for survival of a

node. Energy should be effectively organized throughout the transaction for better performance [8].

The factors that influence the performance are evaluated in the proposed work. The commonly used factors are distance, direction, and mobility factor. The Packet Delivery Ratio (PDR) and Average End-to-End Throughput (AET) decreases at a certain threshold. This may lead to decrease in performance of MANET. To address this issue, a new routing algorithm QAA is proposed which comes out with collective factor to improve the performance. The collective factors are distance, delay, direction, and mobility factor. In the proposed work, the source node send route signal to all nodes that take part in communication. The intermediate nodes and destination sends the route reply signal to source node. The mobility metric is calculated for the destination node. The distance and direction of the destination are estimated using the Average Time-of-Arrival (ATO) and Direction Estimation Algorithm (DES). An angular communication range (i.e. angle) is calculated based on distance and direction of the destination. A table is maintained for every node that takes part in communication. The table consists of mobility metric, distance and direction of destination nodes. This table is frequently updated every time the destination node moves. The source node estimates the distance of other nodes that is present in its transmission range. The data packet is sent to the next intermediate node from the source that has a maximum distance and present within the angular communication range and following the similar pattern which is based on the distance, direction, and angle to reach ultimate destination.

The main contribution of this work is to

- Estimate the direction and angle of the destination node. Due to this direction estimation, the energy consumption is reduced
- Estimate the distance between two nodes along the path. The distance is persuaded using the signal rate of nodes and time taken to that signal to travel.
- Transmit the data packet to next maximum distance node in the range. Due to this hop count can be reduced, and throughput can be increased.

The remaining section of this work is organized as follows

The next section presents a review of related work in the area of QOS metric and methods of establishing it. The third section describes proposed work and steps for the proposed routing algorithm. The fourth section analyzes the performance of MANET using the metric considered for it. The last section ends up with the conclusion of the proposed work.

RELATED WORKS

Recently many studies have tried to introduce various measures that can achieve high performance in MANET. In each study, they have used these factors individually to achieve their desired outcomes. Zhonghai Wang, et.al [9] introduces a localization evolution technique. Usually, Global Position System (GPS) is used for positioning a

node in MANET but here Time-of-arrival (TOA) and Direction-of-Arrival (DOA) is used. By using the position of each node, an appropriate shortest path is established to reach the target node. Marc Ciurana, et.al [10] compares the performance of IEEE 802.11v with WLAN based on TOA. In this TOA is calculated using the Round Trip Time (RTT). RTT is the time taken for a signal to travel to a node and return to the initial node. Biswanath Mukherjee, et.al [11] explained about various routing algorithm. They have come out with various issues faced in routing algorithm; the issues are power consumption, load balancing, and neighbor selection. To overcome these issues they have used the certain factors individually to improve the performance. The certain factors are distance, direction, hop count and mobility metric.

Fazli Subhan, et.al [12] present location estimation technique based on trilateration approach. The position of nodes is established using the Received Signal Strength (RSS). Comparing to TOA the RSS shows less performance. Hoa Le Minh, et.al [13] employs a new factor named Mobility Factor (MF) based on detecting the change of neighbor sets in a period to examine the link stability before sending a packet. It introduces the Path Encounter Rate (PER) factor which is based on the concept of encounter (i.e.) how many nodes are encountered between the time limit. The proposed factor reflects the environment's changes and therefore boosting the performance of routing protocols in MANETs. PER defined as the sum of square Average Encounter Rate (AER) values of all nodes along to that path. AER of node is defined as the average number of new encounters per time unit.

Summary of above routing algorithm says about the factors such as distance, direction, and mobility factor. Each factor is responsible in optimizing the performance of MANET. These above algorithms have some drawbacks and/or challenges: 1) certain factor like distance, direction, hop count, and node behavior is concentrated individually. 2) The characteristics of Multi-hop are not utilized well because the nodes broadcast the signal to only nearby node, it doesn't broadcast a signal to a maximum distance node but present within the coverage area of that node. 3) Complex algorithms are used in the estimation of the direction. 4) Mobility factor is complex because of its randomness.

PROPOSED QAA ROUTING ALGORITHM

The basic idea of Quick Access Algorithm (QAA) is to establish the collective measure that can achieve high performance in MANET. The System is designed for effective communication path to improve the end-to-end performance. The proposed Quick Access Routing framework is shown in Figure 2.

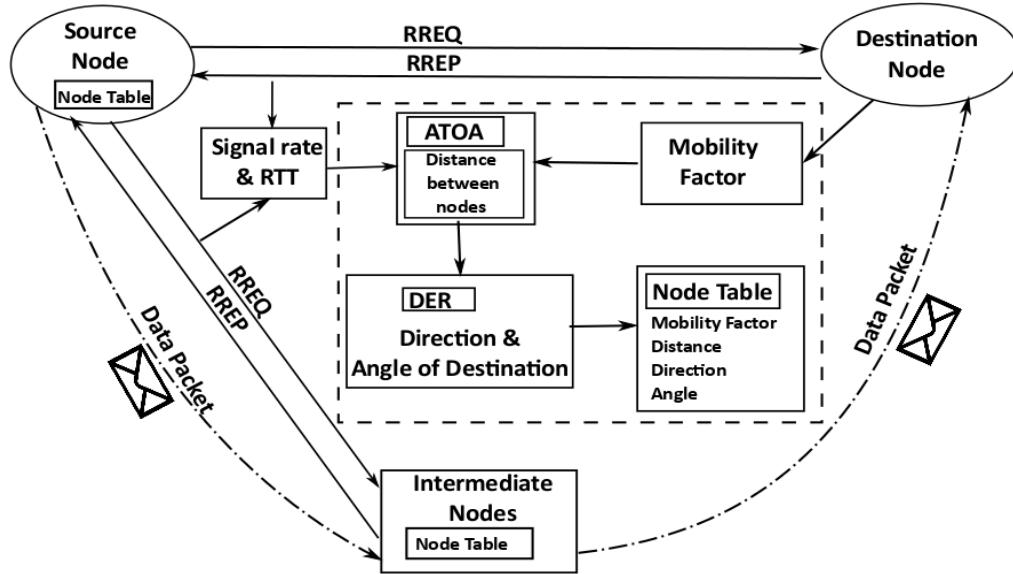


Figure 2: Quick Access Routing Framework

TABLE 1: Preliminaries

NOTATION	DESCRIPTION
S and D	Source node and Destination node
$\{n_1, n_2, \dots, n_i, \dots, n_k\}$	Intermediate nodes
D_N	Distance between nodes
DI_D	Direction of Destination node
MF	Mobility factor
S_R	Signal Rate
Θ	Angle between source and destination node

The source node send Route Request signal (RREQ) to all nodes that take part in communication. The intermediate nodes and destination sends the Route Reply signal (RREP) to source node. The mobility Factor (MF) is calculated for the destination node. The distance (D_N) and are estimated using the Average Time-of-Arrival (ATOA) and signal rate S_R . The ATOA is determined by the Round Trip Time (RTT). The direction of the destination (DI_D) is calculated using Direction Estimation Algorithm (DES). The DES is defined using reference nodes and trigonometric formulas. An angular communication range (i.e. angle) is calculated based on distance and direction of the destination. A table is maintained for every node that consists of mobility metric, distance, direction of destination nodes, and angle. This table is frequently updated every time the destination node moves. Before

the data forwarding this table is access for the distance and direction of the next node. The source sends the data packet to next intermediate node which has maximum distance. The intermediate node follows the same pattern to forward data packet to destination node.

Implementation of Proposed QAA algorithm

QAA algorithm is proposed to show better performance in MANET compared to other routing algorithms. Let $R \{n_1, n_2, \dots, n_i, \dots, n_k\}$ be a multihop route from the source node S to the destination node D .

Multicasting

The source node S multicast RREQ (Route Request signal) to all nodes $\{n_1, n_2, \dots, n_i, \dots, n_k\}$. The nodes $\{n_1, n_2, \dots, n_i, \dots, n_k\}$ and the destination node D send the RREP (Route Reply Signal) to source node S . A Time limit is maintained as Time-to-Live (TTL). TTL is a time till the source node receives the RREP. The node that sends RREP after the time limit will not be taken into account and RREP message is discarded.

Mobility factor (MF)

The mobility factor (MF) is estimated by calculating the distance it travels within the time limit. The mobility factor is defined as

$$MF = \frac{\text{Distance } (D_N)}{\text{Time } (T_N)}$$

For the destination node D , the MF is calculated. The movement range at which destination node D is present can be determined using mobility factor.

Estimating Direction

Direction and Angle Formation

The proposed Direction Estimation Algorithm (DES) is employed to find direction of the destination node D and angular communication range (i.e. angle). The working principle of DES is described as follows

In DES, many reference points are fixed at a position. The location and coordinate of this reference point is known. A signal is sent to the destination node from this reference points. The distance between the destination node and reference points is identified using the ATOA algorithm. After establishing the distance, the direction of the destination node is determined using the x and y quadrant. The direction of the destination node is obtained. An angular communication range is formed between source and destination node by using the trigonometry formula. The formula is defined as

$$\theta = \sin^{-1} \frac{a}{h}$$

- $h \rightarrow$ distance between source S & destination D
- $a \rightarrow$ distance between source S & Reference R

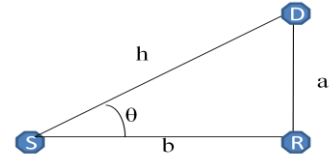


Figure 3: Angle Estimation

Distance between Any Two Nodes

The distance between any two nodes is obtained using Average Time-of-Arrival algorithm (ATOA). The working strategy ATOA are described below

For each node, the time taken to send RREQ signal and received the RREP signal from the source node S is said to be Round Trip Time (RTT). Like this for all the nodes the RTT is determined. The RTT for $\{n_1, n_2, \dots, n_i, \dots, n_k\}$ is established. Using this RTT, the Time-of-Arrival is calculated by the formula

$$TOA = \frac{(RTT-t)}{2} - D$$

- $t \rightarrow$ Processing time
- $D \rightarrow$ Delay Factor

To maintain more accuracy, Average of TOA is defined. The TOA is calculated for five different values and average is taken from it.

$$ATOA = \frac{\text{Sum of TOA}}{5}$$

The five times differs based on network size. Now distance between S to all intermediate node $\{n_1, n_2, \dots, n_i, \dots, n_k\}$ is defined by using the ATOA and signal rate S_R . This is represented as

$$\text{Distance } (D_N) = S_R * ATOA$$

Data Packet Forwarding

In every node, a table consisting of the mobility factor, distance between nodes, direction of the destination node and angular communication range is maintained. The table is frequently updated. The source nodes forward the data packet to the next node which has a maximum distance and present within the angular communication range. The intermediate nodes forward the packet to the next node that has a maximum distance and present within the angular communication range. This procedure repeated until it reaches the destination node.

PERFORMANCE EVALUATION

In this section, the simulation is used to study the performance of the proposed Quick Access Algorithm (QAA). The simulation is implemented using Java simulator.

Simulation Setup

The experiment was performed on a system running on Windows OS with an Intel i3 processor and 2 GB RAM. The experimental setup is established to show the performance of MANET. The Performance evolution is considered to show high performance while using this QAA algorithm. An extensive simulation is performed on QAA algorithm to show performance in MANET. The Java simulator package (JSIM) is used for implementation purpose. For implementation purpose, the Netbeans is used in the system. JSIM package is an open source package in which implementation done easy and effectively.

Simulation Setup Parameters:

TABLE 2: Setup Parameter

PARAMETERS	VALUES
Simulation Area	20 x 20 (CMS)
No of Nodes deployed	100
Transmission Range	Fixed
Node Placement Strategy	Random
Mobility Speed	0-5 m/s
Data Packet Size	2 Mb
Signal Rate	2 Kbps
Time-to-Live	10 minutes
Routing protocol used	Our proposed QAA routing protocol

Performance Evaluation Metrics

In this work, the proposed Quick Access Algorithm (QAA) is compared with Ad Hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), and Destination Sequence Distance Vector Routing (DSDV). The performance is evaluated according to following metrics:

Packet Delivery Ratio (PDR): The ratio between the number of the data packet transmitted by the source and number of the data packet received by the destination node.

$$PDR = \frac{\sum \text{Number of data packet received}}{\sum \text{Number of data packet sent}}$$

Average End-to-End Throughput (AET): The ratio of the total amount of data packet that reaches destination from the source to the total time taken for destination to receive the last data packet.

$$AET = \frac{\sum \text{Amount of data packet received}}{\text{Total time taken for receiving the data packet}}$$

Simulation Result

Packet Delivery Ratio in case of Number of Nodes

Figure 4 & 5 shows the ratio between the PDR values with number of nodes. The PDR shows reliability the network and the greatest value of PDR means better performance between communications. The PDR is estimated with number of nodes for speed 2 & 20. The PDR value of QAA routing is greater than the AODV, DSR, and DSDV algorithm. It shows that QAA can perform well in critical application.

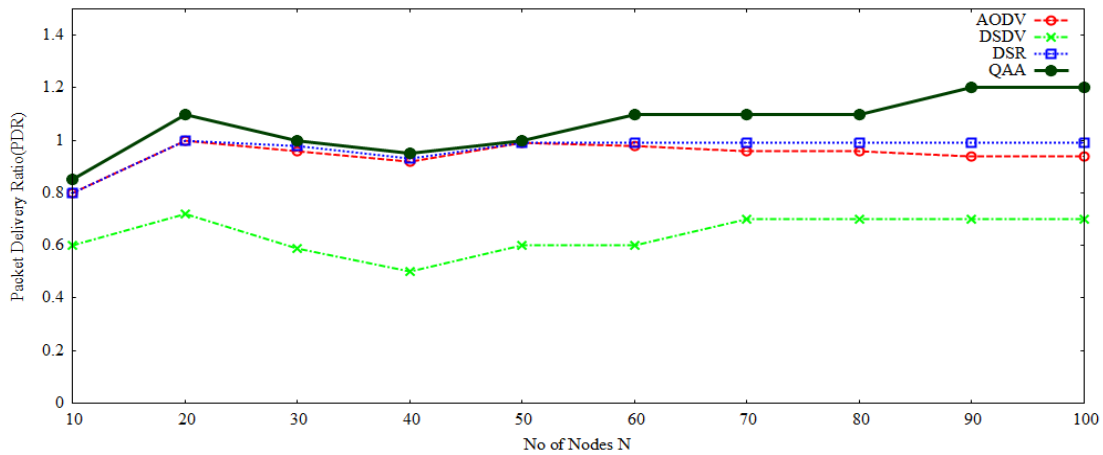


Figure 4: Comparison of PDR for speed 2

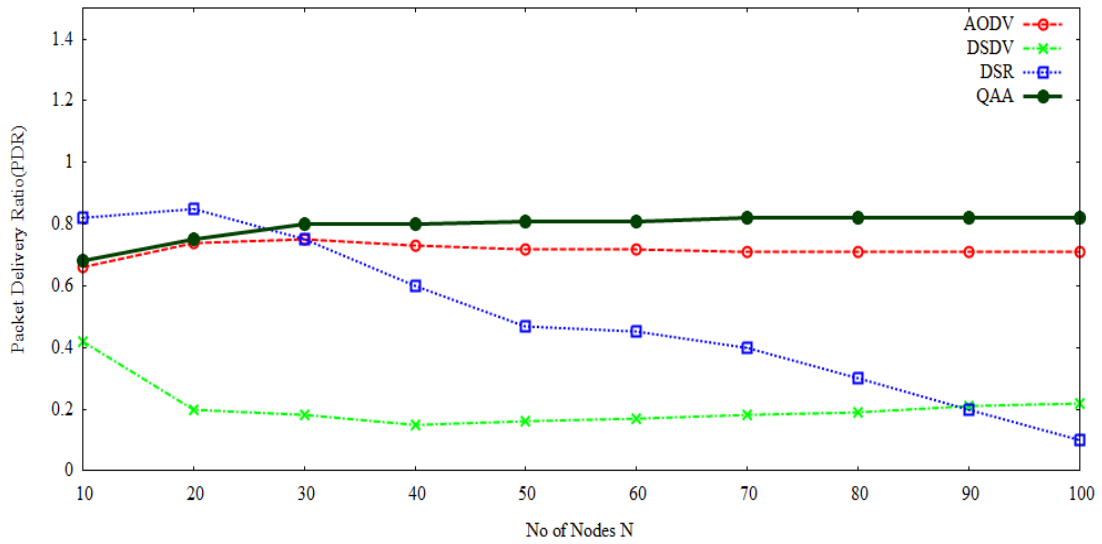


Figure 5: Comparison of PDR for speed 20

Average End-to-end Throughput (AET) in case Number of Nodes

The AET is estimated with varying number of nodes. The throughput is directly related to performance. When throughput is increase, then performance also increases. The AET rate of QAA is greater compared with AODV, DSR, and DSDV algorithm. It shows that QAA can exit in more number of nodes with more performance level. As shown in Figure 6, the throughput of QAA is greater compared with AODV, DSR, and DSDV.

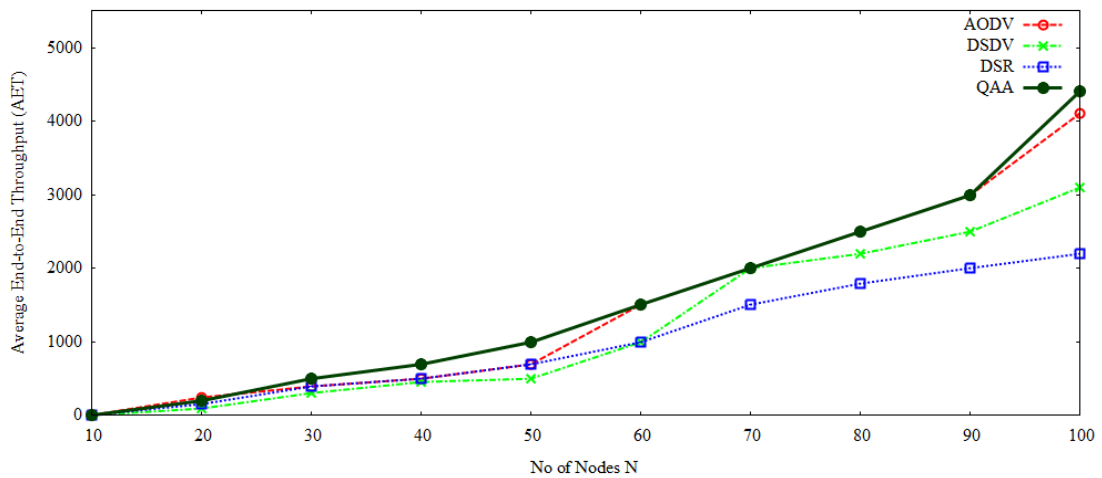


Figure 6: AET with varying Number of Nodes

CONCLUSION

Thus, the performance of new routing algorithm, Quick Access Algorithm (QAA) is compared with the conventional algorithm like Ad Hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Destination-Sequence Distance Vector Routing (DSDV). The result shows that QAA routing algorithm shows better performance by using its collective factor. The distance factor can improve the bandwidth between nodes, the direction factor reduces energy consumption in nodes, and hop count is reduced by combining both distance and direction which can indirectly increase the throughput. Thus, the combination of this collective measure can enhance the Quality of Service (QoS) attribute. It leads to high performance in mobile nodes which can have better communication among other nodes.

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