

Research Article

Mobility and Bandwidth Aware QoS Routing Protocol for MANET

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Abstract: Mobile Adhoc Networks (MANET) out of the many defies it is critical to guarantee quality-of-service, because of its complex distributed system. The problem of routing is based on a predefined set of customer preferences. In this study we have proposed to develop a Mobility and Bandwidth Aware QoS Routing Protocol for MANET. Initially as a clustering process in CFSR, the neighbour discovery procedure is used. It contains a pre-handshaking strategy to help each node be aware of activities of its neighborhood before the normal transmissions. Next to this QoS routing is provided. Finally we are using bandwidth estimation technique in order to provide QoS support. The overall frame work reduces the collision with a minimized level of redundancy.

Keywords: Clustered Fisheye State Routing (CFSR), Extended Fully Distributed Cluster-Based (EFDCB), FRIEND protocol, Mobile Adhoc Networks (MANET), Mobile Nodes (MN), QoS routing protocol

INTRODUCTION

Mobile Adhoc Networks (MANET): MANET is an autonomous system of mobile routers connected by wireless links. But in mobile ad hoc networks, there is no base stations (Premalatha and Balasubramanie, 2010). Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves (Deepalakshmi and Radhakrishnan, 2009). The Mobile Nodes (MN) in MANET are intercommunicate through single-hop and multi-hop paths in a peer-to-peer mode. Intermediate nodes between a pair of communicating MNs act as routers (Enneya *et al.*, 2009).

The following are the issues of MANET:

- Mobility management
- Security and power consumption
- Limited bandwidth
- Topology of network change rapidly and unpredictably (Enneya *et al.*, 2009)

Routing in MANET: Routing protocol is used to transmit a packet to a destination via number of nodes. Routing functionality in MANET is incorporated into each mobile host and, because of a limited transmission range the multiple hops may be required to allow one node to communicate with another across the ad hoc network (Premalatha and Balasubramanie, 2010).

Intermediate nodes will forward the data packets according to the unique flow identifier labelled in the data packets (Tai *et al.*, 2010). The routing protocols in MANET can be categorized as proactive, reactive and hierarchical. In proactive routing, route discovery is easy but route maintenance is hard. In reactive routing, route discovery is hard but route maintenance is easy. Hierarchical routing is the combination of both reactive and proactive routing (Senthilkumar and Somasundaram, 2011).

The nodes of Ad-hoc networks intercommunicate through single-hop and multi-hop paths in a peer-to-peer fashion. Intermediate nodes between two pairs of communication nodes act as routers. Single path routing protocols was no longer use for data transmission. Multipath routing allows the establishment of multiple paths between a source and a destination. These multiple paths can be used either alternatively for reliable data delivery, i.e., a node switches to an alternative path when the current path fails or simultaneously for load balancing by using several paths at the same time (Barolli *et al.*, 2001).

The main issues of routing are:

- Route failures due to node movement
- Power depletion hinder
- Bandwidth Utilization (Barolli *et al.*, 2001)

Mobility issues in MANET: In MANET, the complexity increases due to various characteristics like dynamic topology, absence of centralized authority, time varying QoS Requirements etc. The biggest

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challenge in this kind of networks is to find a path between the communication end points satisfying user's QoS requirement which is aggravated through the node mobility (Deepalakshmi and Radhakrishnan, 2009). High churn or node mobility can cause QoS requirements to become unachievable. Excessive node mobility can lead to topology changes before network updates can propagate (Llewellyn *et al.*, 2011).

QoS routing of MANET: Quality of Service (QoS) routing is a key network function for the transmission and distribution of digitized audio/video across next-generation high-speed networks (Gnanamurthy *et al.*, 2006). QoS is to define a level of performance in a communications network along with the type of network traffic. QoS requirements are present in many network situations, such as in critical infrastructure control and military communication. Effective mobile ad hoc networks require QoS capabilities that provide fault tolerance and fast recovery when links fail on an intermittent or permanent basis (Llewellyn *et al.*, 2011).

QoS guarantees to support real time and multimedia applications in MANET (Espes and Mammeri, 2009). The QoS constraints can be classified as time constraints, space constraints and frequency constraints (Senthilkumar and Somasundaram, 2011). Effective Mobile Ad hoc Networks (MANETs) require QoS capabilities that provide fault tolerance and fast recovery when links fail on an intermittent or permanent basis (Su *et al.*, 2014).

The major objectives of QoS routing are:

- To find a path from source to destination satisfying user's requirements
- To optimize network resource usage
- To degrade the network performance when unwanted things like congestion, path breaks appear in the network

The main problem to be solved by QoS routing algorithm is the Multi-Constraint Path problem (Deepalakshmi and Radhakrishnan, 2009). QoS Routing considers bandwidth constraint, delay constraints or both but don't meet these constraints while optimizing the overall network throughput (Espes and Mammeri, 2009). The notion of QoS is guarantee provided by network to satisfy a set of predetermined service performance constraints for the user in terms of the end-to-end delay statistics, available bandwidth and probability of packet loss and call admission delay (Gnanamurthy *et al.*, 2006).

However, these QoS routing algorithms cannot be applied directly to Ad-hoc networks, because of the bandwidth constraints and dynamic network topology of Ad-hoc networks (Barolli *et al.*, 2001).

Problem identification and solution: Paper Llewellyn *et al.* (2011) Presents the Extended Fully Distributed Cluster Based algorithm (EFDCB), in which clustering provides scalability by lowering the amount of information maintained at each node. In FDCB, for repairing the routing path failure, the QoS ratio metric is used which depends on the mobility ratio. EFDCB considers a fraction of total number of network links to find a new path through local recovery in the cluster.

The QoS routing scheme used by EFDCB is Clustered Fisheye State Routing (2014). In FSR, the frequency at which one node sends its link state information to another node depends upon the distance between the two nodes. In CFSR, cluster-heads and gateways execute the original FSR protocol to send link state updates about the cluster, while ordinary nodes only send link state about themselves.

But the drawback of CFSR is the link state discovery process does not avoid the collisions and idle slots and incurs additional latency.

LITERATURE REVIEW

Llewellyn *et al.* (2011), have proposed a cluster-based QoS routing algorithm for mobile ad hoc networks with the aim of providing fault tolerance, which is a critical feature in providing QoS in the link failure-prone environment of mobile networks. Performance of this new fault-tolerant cluster-based QoS wireless algorithm is evaluated according to failure recovery time, dropped packets, throughput and sustained flow bandwidth. However, the failure rate increases more than twice for the rate of increase for mean recovery time.

Espes and Mammeri (2009), have proposed a cross-layer TDMA-based routing protocol to meet delay and bandwidth requirements while optimizing network throughput. Since in TDMA-based ad hoc networks, slot reservation impacts two-hop neighbours, this routing protocol selects paths with the lowest number of neighbours. When a time slot is used by a node, the neighbours of such a node cannot use the same slot to send packets or to receive packets from other node. But the network throughput decreases because a few flows are admitted in the network.

Tai *et al.* (2010), have proposed an adaptive routing scheme that works with IPv6 that provides QoS for real time applications transmission in such an unpredictable ad hoc network by exploiting the Flow label resided in the IPv6 packet header. The protocol used to preserve the quality in transmission between two nodes in the ad hoc network. The proposed protocol uses flow id for flow transmission in order to reduce multiple routing metrics such as end-to-end delay and jitters to the minimum. However mobility in

ad hoc networks causes link failures and disrupts transmissions.

Hanzo and Tafazolli (2011), paper proposed and evaluated a new protocol for improving the performance (QoS guarantees) of QoS-aware routing and admission control protocols in the face of mobility, shadowing and varying link SINR. It is found that proactively maintaining backup routes for active sessions, adapting transmission rates and routing around temporarily low-SINR links can noticeably improve the reliability of assured throughput services. But with the severe shadowing fluctuations, the parameter does not have much effect because pretested backup routes often break before they come into use.

Barolli *et al.* (2001), have proposed to use Genetic Algorithms (GAs) and Multi-objective Optimization for QoS routing in Ad-hoc Networks. In order to reduce the search space of GA, we implemented a Search Space Reduction Algorithm (SSRA). After the reduction of search space the GAMAN search time improves. In swarm intelligence the scalability can be promoted by local and distributed agent interactions. Swarm intelligent processes do not rely on a centralized control mechanism.

Su *et al.* (2014), paper analyzed the designs methods for bandwidth estimation and allocation to provide QoS support without knowledge of slot status information and then, estimates and allocates non-assigned eligible bandwidth for Best Effort (BE) flows. With these bandwidth management methods, this study proposed a QoS routing protocol for a mixture of QoS and BE flows. Also this study considered the problem of joint Topology Transparent Scheduling (TTS) and Quality-of-Service (QoS) routing in ad hoc networks and presents a joint scheme for the problem.

Sun *et al.* (2013), have proposed a novel randomized protocol FRIEND, which is a pre-handshaking ND protocol, to initialize synchronous full-duplex wireless ad hoc networks. By introducing a pre-handshaking strategy to help each node be aware of activities of its neighbourhood, which significantly reduce the probabilities of generating idle slots and collisions. Moreover, with the development of single-channel full-duplex communication technology, third protocol further decrease the processing time needed in FRIEND and construct the first full-duplex ND protocol. However, the duty cycle of transmission is

Table 1: Neighbor list table

2 hop neighbors of i	
j's ID	j's neighbor list

Table 2: Priority table

3 hop neighbors of i	
j's P flag	Indicator

Table 3: Receive table

2 hop neighbors of i	
j's R flag	

very poor, when the packet send to subset will wait for transmission.

PROPOSED METHODOLOGY

Overview: In this study we have proposed to develop a Mobility and Bandwidth Aware QoS Routing Protocol for MANET. Initially as a clustering process in Clustered Fisheye State Routing (2014), the neighbour discovery procedure of FRIEND protocol (Sun *et al.*, 2013) can be applied. It contains a pre-handshaking strategy to help each node be aware of activities of its neighborhood before the normal transmissions. Next to this QoS routing is provided (Llewellyn *et al.*, 2011). In order to provide QoS support we are using a bandwidth estimation technique of Su *et al.* (2014). It uses three tables, Table 1 neighbour list table, Table 2 priority table and Table 3 receive table. D-slots are reserved for transmission, which is achieved by neighbour list table. The D-slots are fixed-length data slots in D-subframe which are used to transmit data packets for a mixture of QoS and Best Effort (BE) flows (Fig. 1).

EFDCB: The Extended Fully Distributed Cluster-Based (EFDCB) routing protocol (Llewellyn *et al.*, 2011), is a fault-tolerant protocol. EFDCB extends Fully Distributed Cluster-Based (FDCB) protocol to provide the scalability, efficiency and fault tolerance critical to maintain QoS connections in a mobile environment.

The objective is to determine if EFDCB provides efficient QoS route recovery by testing it against FDCB. EFDCB algorithm considers a fraction of the total number of network links when finding a new possible path through confined healing in the cluster. It reduces the impact of a connection failure since the cluster-head has complete cluster connectivity awareness.



Fig. 1: Block diagram

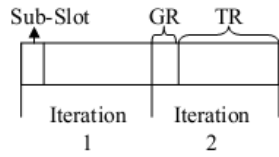


Fig. 2: Description of iteration GR (Greeting process) is used for pre-handshaking and TR (Transmission process) is used for transmitting discovery messages

FSR: Clustered Fisheye State Routing (2014) is an implicit hierarchical routing protocol. FSR is based upon a link-state foundation updating mechanism which maintains a topology map at each node. This reduces the control overhead by distributing topology information using the fisheye technique, where routing information is updated at different rates depending on the distance from the source. This is divided into the following steps:

- Node stores the Link State information for every destination in the network
- They periodically broadcast update messages to its neighbors
- The updates corresponding to closer nodes propagate more frequently

The QoS routing scheme used by EFDCB is Clustered Fisheye State Routing (2014). In FSR, the frequency at which one node sends its link state information to another node depends upon the distance between the two nodes. In CFSR, cluster-heads and gateways execute the original FSR protocol to send link state updates about the cluster, while ordinary nodes only send link state about themselves. It proposes a clustering framework to reduce redundant broadcast routing control messages.

FRIEND protocol: In order to build a link state table in CFSR we are using the neighbour discovery procedure of FRIEND-TR (Transmission process) process (Sun *et al.*, 2013). FRIEND is a distributed protocol and for each node, the target is to discover all its neighbors after finite iterations. It contains a pre-handshaking strategy to help each node be aware of activities of its neighborhood before the normal transmissions.

Algorithm: At the beginning of a subslot, each node determines its action in the following normal slot. The purpose is to find a subset of nodes in the network to send M_d without collisions:

- Initially node i sends discovery messages M_d and monitors the channel.
- If node A does not receive M_d during transmission time TR, it means the transmission is successful.
- If A receives the M_d from other TR nodes, the current transmission is failed.

- If A does not receive M_d during TR, it means that no nodes send M_d in TR. Therefore, the current iteration is invalid.
- If A receives a single M_d during TR then one node is successfully transmitting its M_d . So that node i records the ID in M_d and decrease the value of undiscovered neighbour i_n by 1.
- If there is collision at node i the current transmission is failed (Fig. 2).

Routing process using CFSR: CFSR (Llewellyn *et al.*, 2011) is QoS ready with the addition of bandwidth and channel quality information to the link state entry. CFSR is initiated once the clustering converges.

Algorithm:

- Initially each node starts with an empty neighbor list A_i and an empty topology table TT_i .
- Next node i initializes in the NodeInit () procedure and examines its neighbors from the sender ID of each received packet.
- Next to this node i call the Pkt_process procedure on the received packet which contains the link state information from its neighbors. This guarantees the most up-to-date link state information is used by comparing the local sequence number with the embedded sequence number $\text{pkt.SEQ}(j)$.
- If any entry in the incoming message has a newer sequence number for destination j , $TT_i.LS(j)$ is replaced with $\text{pkt.LS}(j)$ and $TT_i.SEQ(j)$ is replaced by $\text{pkt.SEQ}(j)$.
- Next FindSP (i) is used to generate the shortest path tree rooted at i . The shortest path algorithm needs to generate a next hop table for each path created. Using this shortest path tree, node i send route updates to the set of nodes in N .
- RoutingUpdate (i) scans the topology table and if the shortest path distance $D_i(x)$ is within range of the fish-eye scope level l , $TT_i.LS(x)$ is included in the update message. The UpdateInterval_l attribute is used to adjust the link state update frequency for the various fish-eye scopes (Fig. 3).

Information storage and exchange using tables: In case of estimating bandwidth for node $i \rightarrow j, j \in N_i^l$ node i maintain three tables a neighbor list table, a priority table and a receive table. And it also contains 2 one bit flags P_i (Priority flag of node i) and R_i (Priority flag of node i).

Neighbor list table: The neighbor list table of i contains an entry for each two hop neighbor of i . This entry consists of j 's ID and neighbor list.

Priority table: Node i activate P_i if it needs to have priority over other nodes to selectively use the common D-slots that are commonly assigned or else i inactivates P_i .

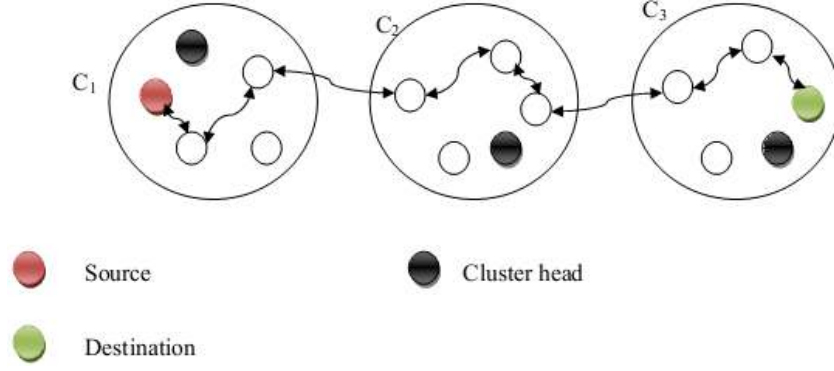


Fig. 3: Clustering and routing process

The priority table of node i contains an entry for each three hop neighbor of i , e.g., j . This entry consists of j 's P flag and an extra indicator (a simple one-bit tag). The extra indicator is used for specifying whether j has priority over i to exclusively use common D-slots between A_i^C and A_i^D (node activation time assigned for C-frame and D-frame).

Receive table: Node i activate R_i if it receives packets (i.e., acting as a relay or destination) for QoS flows; otherwise, i inactivates R_i .

The receive table of i contains an entry for each two-hop neighbor of i , e.g., j . This entry keeps track of j 's R flag.

Bandwidth estimation: In CFSR to provide the QoS with the addition of bandwidth and channel quality information to the link state entry bandwidth estimation is required in order to provide the status with complete slots reserved. For this the bandwidth estimation technique (Su *et al.*, 2014) is used, which provides QoS support without knowledge of slot status information.

When calculating $B_{i \rightarrow J}$, $J \subset N_i^I$ there are two conditions:

- $i \rightarrow J$ is received successfully by the nodes in J
- $i \rightarrow J$ does not interfere with packet reception at i 's interference nodes

To achieve condition 1: When a node have got to use a D-slot which is commonly assigned to its three-hop neighbors, it activates and disseminates its P flag to announce that it needs to have priority over other nodes to exclusively use common D-slots. Upon receiving information P, each node updates the indicator field in its priority.

To achieve condition 2: In addition to P, each node has to distribute another one-bit flag R to announce whether it has received packets for QoS flows. For this reason,

R only needs to be broadcast for a depth of two hops, as compared with P.

The bandwidth estimation from node i to j :

$$B_{i \rightarrow N_i^I} = (A_i^D - R_i) \cap \left(\bigcup_{k \in (\bigcup_{j \in J} N_j^I \cup \{j\} - \{i\}) \cap N_i^{3,P}} A_k^D \right) \cap \left(\bigcup_{k' \in \bigcup_{k'' \in N_i^{2,R}} (N_{k''}^I \cap N_i^{3,P})} A_{k'}^D \right) \quad (1)$$

where $(A_i^D - R_i)$ - set of available D-slot for $i \rightarrow J$:

$$\left(\bigcup_{k \in (\bigcup_{j \in J} N_j^I \cup \{j\} - \{i\}) \cap N_i^{3,P}} A_k^D \right)$$

Condition 1: set of D-slots over which no transmission from nodes in $(\bigcup_{j \in J} N_j^I \cup \{j\} - \{i\}) \cap N_i^{3,P}$ take place:

$$\left(\bigcup_{k' \in \bigcup_{k'' \in N_i^{2,R}} (N_{k''}^I \cap N_i^{3,P})} A_{k'}^D \right)$$

Condition 2: set of D-slots over which transmission from i can take place without interfering with packet reception at i ' interference nodes:

$$B_{i \rightarrow N_i^I} = (A_i^D - R_i) \cap \left(\bigcup_{k \in N_i^{3,P}} A_k^D \right) \quad (2)$$

where,

N_i^I = Neighbours of node i

A_i^D = NATs assigned to node i for channel access in the D-frame

R_i = One-bit flag for receive table

Overall algorithm:

- Initially as a neighbor discovery process node i send the discovery message M_d to monitor the channel.
- Next to this in order to provide QoS routing CFSR is used, in which each node starts with an empty neighbor list A_i and an empty topology table TT_i .
- Then node i examines its neighbors from the sender ID of each received packet.
- Next to this in order to guarantee link state information node i calls for the Pkt_process procedure on the received packet.
- After that using the shortest path tree, node i send route updates to the set of nodes in N .
- Finally bandwidth estimation is done.

SIMULATION RESULTS

Simulation model and parameters: The Network Simulator (NS2) NS-2 1995 (Network Simulator, 1995), is used to simulate the proposed architecture. In the simulation, the mobile nodes move in a 1250×1250 m region for 50 sec of simulation time. All nodes have the same transmission range of 250 m. The simulated traffic is Constant Bit Rate (CBR).

The simulation settings and parameters are summarized in Table 4.

Performance metrics: The proposed Mobility and Bandwidth Aware QoS Routing Protocol (MBAQRP) is compared with the EFDCB technique (Llewellyn *et al.*, 2011). The performance is evaluated mainly, according to the following metrics.

Packet delivery ratio: It is the ratio between the number of packets received and the number of packets sent.

Packet drop: It refers the average number of packets dropped during the transmission

Delay: It is the amount of time taken by the nodes to transmit the data packets.

Results:

Based on nodes: In our first experiment we vary the number of nodes as 50, 100, 150 and 200, respectively.

Figure 4 shows the delay of MBAQRP and EFDCB techniques for different number of nodes scenario. We can conclude that the delay of our proposed MBAQRP approach has 30% of less than EFDCB approach.

Figure 5 shows the delivery ratio of MBAQRP and EFDCB techniques for different number of nodes scenario. We can conclude that the delivery ratio of our

Table 4: Simulation settings

No. of nodes	50, 100, 150, 200 and 250
Area size	1250×1250
Mac	IEEE 802.11
Transmission range	250 m
Simulation time	15 sec
Traffic source	CBR
Packet size	512
Rate	50 kb
Speed	10, 20, 30, 40 and 50 m/sec

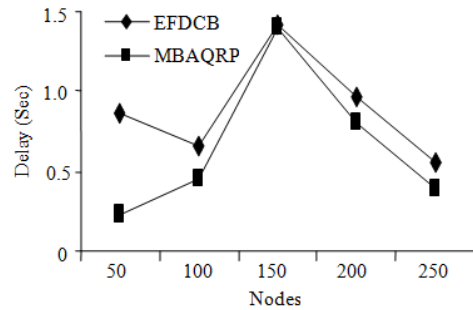


Fig. 4: Nodes vs. delay

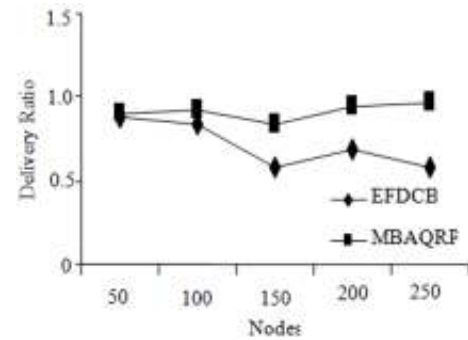


Fig. 5: Nodes vs. delivery ratio

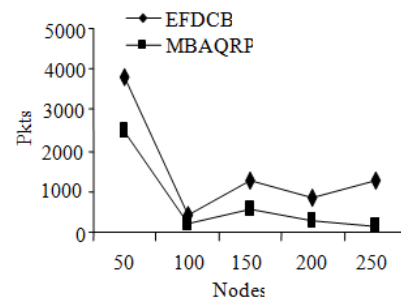


Fig. 6: Nodes vs. drop

proposed MBAQRP approach has 22% of higher than EFDCB approach.

Figure 6 shows the drop of MBAQRP and EFDCB techniques for different number of nodes scenario. We can conclude that the drop of our proposed MBAQRP approach has 61% of less than EFDCB approach.

Figure 7 shows the throughput of MBAQRP and EFDCB techniques for different number of nodes scenario. We can conclude that the throughput of our

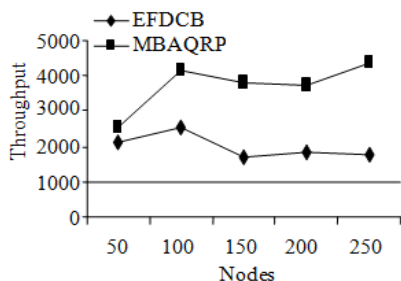


Fig. 7: Nodes vs. throughput

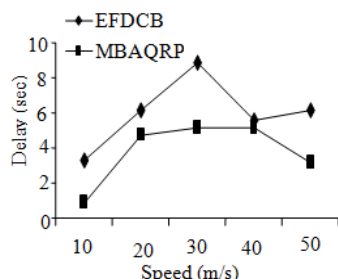


Fig. 8: Speed vs. delay

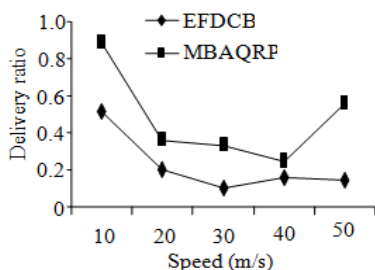


Fig. 9: Speed vs. delivery ratio

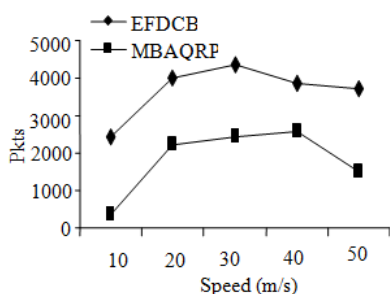


Fig. 10: Speed vs. drop

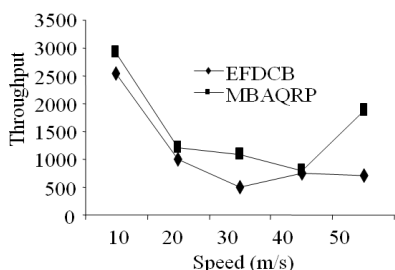


Fig. 11: Speed vs. throughput

proposed MBAQRP approach has 44% of higher than EFDCB approach.

Based on speed: In our second experiment we vary the mobile speed as 10, 20, 30, 40 and 50 m/sec, respectively.

Figure 8 shows the delay of MBAQRP and EFDCB techniques for different speed scenario. We can conclude that the delay of our proposed MBAQRP approach has 39% of less than EFDCB approach.

Figure 9 shows the delivery ratio of MBAQRP and EFDCB techniques for different speed scenario. We can conclude that the delivery ratio of our proposed MBAQRP approach has 53% of higher than EFDCB approach.

Figure 10 shows the drop of MBAQRP and EFDCB techniques for different speed scenario. We can conclude that the drop of our proposed MBAQRP approach has 52% of less than EFDCB approach.

Figure 11 shows the throughput of MBAQRP and EFDCB techniques for different speed scenario. We can conclude that the throughput of our proposed MBAQRP approach has 29% of higher than EFDCB approach.

CONCLUSION

In this study we have developed a framework for QoS routing information. Initially as a clustering process in CFSR, a neighbour discovery procedure is used. It contains a pre-handshaking strategy to help each node be aware of activities of its neighborhood before the normal transmissions. Next to this QoS routing is provided. Finally we are using bandwidth estimation technique in order to provide QoS support. The overall frame work reduces the collision with a minimized level of redundancy.

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