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Optimized Resource Allocation and Queue Management for Traffic Control in MANET

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Abstract: A set of mobile devices that employs wireless transmission for communication is termed Mobile Ad hoc Networks (MANETs). Offering better communication services among the users in a centralized organization is the primary objective of the MANET. Due to the features of MANET, this can directly End-to-End Delay (EED) the Quality of Service (QoS). Hence, the implementation of resource management becomes an essential issue in MANETs. This paper focuses on the efficient Resource Allocation (RA) for many types of Traffic Flows (TF) in MANET. In Mobile Ad hoc Networks environments, the main objective of Resource Allocation (RA) is to process consistently available resources among terminals required to address the service requirements of the users. These three categories improve performance metrics by varying transmission rates and simulation time. For solving that problem, the proposed work is divided into Queue Management (QM), Admission Control (AC) and RA. For effective QM, this paper develops a QM model for elastic (EL) and inelastic (IEL) Traffic Flows. This research paper presents an AC mechanism for multiple TF for effective AC. This work presents a Resource Allocation Using Tokens (RAUT) for various priority TF for effective RA. Here, nodes have three cycles which are: Non-Critical Section (NCS), Entry Section (ES) and Critical Section (CS). When a node requires any resources, it sends Resource Request Message (RRM) to the ES. Elastic and inelastic TF priority is determined using Fuzzy Logic (FL). The token holder selects the node from the inelastic queue with high priority for allocating the resources. Using Network Simulator-2 (NS-2), simulations demonstrate that the proposed design increases Packet Delivery Ratio (PDR), decrease Packet Loss Ratio (PLR), minimise the Fairness and reduce the EED.

Keywords: MANET; resource allocation; end-to-end delay; fuzzy logic; QoS

1 Introduction

A MANET comprises a mobile access point with multiple hosts and nodes. Nodes have complete freedom of movement. There may be multiple hosts per router and nodes in aeroplanes, ships, trucks, cars, people, and small devices. The system may operate autonomously/through gateways connected to the base station [1]. MANET does not require any infrastructure and allows each user to communicate directly. Wireless links connect the mobile access points in a self-organizing network without using an Access Point (AP). In MANET, communication among the nodes can be performed using multi-hop paths, the wireless medium can be shared, and the network topology changes irregularly and dynamically. Since the nodes are freely moving anywhere, communication links are easily broken [2].

More efficient allocation performance can be achieved if the time slot allocation is done with precise traffic volume information rather than assuming standardised traffic. Consequently, it is essential to measure the TF that each node controls accurately. There are two types of TF in MANET. They are described as follows. (a) *EL Traffic:* It adjusts its expected EED and throughput between end hosts based on the changes in network condition. (b) *IEL Traffic:* It is slow to adapt to changing circumstances in latency and bandwidth. Multimedia applications like video and VoIP belong to IEL traffic [3]. The main aim of RA is to increase QoS and the utilization of resources for the application. The QoS satisfaction level for the respective applications is based on the availability of resources and application criticality. In MANET, the resource manager executes the RA and deviates the applications to get familiarized with resource availability. Queuing can be mainly applied in packet scheduling, in which packets are arranged in a specific order to minimise the resequencing of EED. PLR can be reduced through proper scheduling and improved throughput. Active Queue Management (AQM) is dropping congested packets in routers before the queue is fully occupied. Internet routers typically contain a set of queues per interface. AC is an essential mechanism for providing QoS guarantees. It controls the utilization and allocation of network resources in real-time applications, where additional bandwidth is required. It allows the bandwidth to be utilized by data flows only when free [4].

Since the link quality rapidly varies due to frequent mobility in MANET, RA meeting the QoS requirements are challenging. The network's topology varies constantly, and hence the TF in and out of the network keeps varying. Hence, controlling the admissions into the network would optimize the TF in the network when performed by considering the bandwidth required for data transmission as the deciding criteria. Thus, avoiding traffic EED and collisions in the network and making the network more efficient. The problem of routing packets among any pair of nodes turns out to be a difficult task as the network topology varies persistently. Compared to single-hop communication, multiple hops existing in the routes among the nodes result in complexity. As MANET is an infrastructure-less network with random moving nodes, implementing resource management becomes complex [5]. The link quality changes in availability, bandwidth and EED due to *hop-by-hop* message forwarding, node mobility and signal quality. Hence the RA becomes a challenging task in order to assure QoS limitations.

The main objectives of this work are to

- *To develop a Design of Effective Queuing Management (DEQM)*
- *To create a Method for Optimized Admission Control (MOAC)*
- *To propose a Resource Allocation Using Tokens (RAUT)*

2 Related Works

The author has proposed an optimization framework for Congestion Control (CC) in MANET. It is impossible to have the same EED for all frames in this framework. Hence it should discuss with regards to the difference in frame EED. The author has proposed an MA-based congestion aware routing method.

This scheme uses Mobile Agent (MA) and static agent for route discovery and CC. The static MA utilizes the information collected by MA to significantly minimize the congestion over the network. In the MA-based routing protocol, the static MA searches the routing table to find the valid routes brought by the MAs to the destination [6]. The route discovery is not required when a ready route is in the routing table. This route establishment system minimizes the EED experienced by packets in the network and the control overhead on the network.

The researcher investigated the Fibonacci Multipath Load Balancing (FMLB) protocol for MANETs. The Fibonacci sequence distributes packets across multiple paths. The FMLB protocol uses the hops count to determine the order in which packets are sent during transmission. The shortest path is preferred over others. The work proposes a MANET routing algorithm based on IEEE 802.11e EDCA MAC protocol with distributed Call Admission Control (CAC) algorithms [7]. Data flow measures a node's load, and flow detections are based on the Bloom filter. The network will only accept a new flow if it can find an appropriate path, which is proven by the distributed CAC method in conjunction with the node's load. Meanwhile, the QoS of the original flows in the network can't be influenced.

Furthermore, the load balance control mechanism on the admission flows has been discussed. Using the proposed CAC algorithm, new flows can create excellent use of bandwidth resources without impacting neighbouring flows, according to the simulation study. Bloom filter's bandwidth characteristics make it suitable for use in MANET, where nodes' storage and computational resources are limited.

The author has proposed a Time Division Multiple Access (TDMA) MAC protocol for MANET, which performs distributed time slots assignments. Their RA scheme is suitable only for TDMA based Medium Access Control (MAC) protocol [8]. It is required for each node to exchange access control and RA information at pre-determined intervals to guarantee that the time available slots are not congested. Priority is assigned to each node/TF so that the node or the TF with higher priority can keep time slots before those with lower priority to provide QoS. For vehicular ad-hoc networks, the paper developed the Adaptive Time Division Multiple Access Slot Assignment (ATSA) protocol. It divides time slots into different groups based on the direction of the vehicles. A node selects a frame length based on its communication path and position with other nodes. The frame length is dynamically adjusted using a binary tree algorithm [9].

Using multi-state cooperation, the authors addressed a multiple access method. To ensure fairness, each node is given an equal level of energy. They introduced a distributed energy optimisation framework to allocate energy and transform the transmission sets concurrently. They have allocated equal energy and lifetime to all nodes to provide fairness. Also, they do not consider and differentiate any M-SF [10].

3 Proposed Work

3.1 Design of Effective Queuing Management

This section proposes DEQM for EL and IEL TF. QM is when a router decides when to PLR and which packets to drop at its output port when congestion occurs [11]. The main advantages of queuing include packet scheduling and congestion avoidance. The architecture consists of three phases, as illustrated in Fig. 1.

In Phase-I, a Virtual Queue (VQ) algorithm using a utility function is designed, which reduces the experienced EED. In Phase-II, a fair scheduling algorithm is used for CC [12]. In Phase-III, Proportional-Integral-Design (PID) provides differentiated services according to their priority. IEL traffic does not quickly adapt to changes in EED and throughput, and hence it has strict priority order. It results in poor utilization for Variable-Bit Rate (VBR) applications. The IEL flows are not unaware of the EL flows in the queues. In some cases, the link might be heavily loaded by the IEL traffic, resulting in high EEDs.

By applying VQ, this EED can be reduced. It uses a utility function based on the VQ length. The packets in this VQ are served as a fraction of the actual service rate [13].

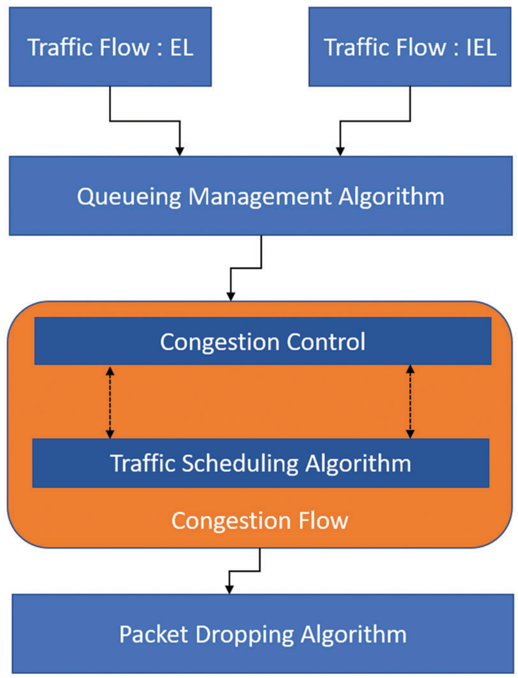

Figure 1: Proposed design of DEQM

3.1.1 Algorithm for Load Balancing and Congestion Control

STEP 1: VQ design for a link l can be derived as follows Eq. (1)

$$\theta_l(t) = (z_l(t) + y_l(t) + \alpha_1 C_l)_{\theta_l(t)} \quad (1)$$

where *(t)* is a continuous-time indicator, 'y_l' and 'z_l' denote the aggregated EL and IEL rates, 'α_1' is the virtual queue which controls the total load and 'c_l' is the total available bandwidth of link l ∈ L.

STEP 2: The VQ design for link l for IEL flow by Eq. (2)

$$\gamma_l(t) = (z_l(t) - \alpha_2 . C_l)_{\gamma_l(t)} \quad (2)$$

where α_2 is the VQ which controls the IEL flow load

STEP 3: CC ler for EL flow by Eq. (3)

$$xe(t) = \cup_e^{t-1}(SRc(t)) \quad (3)$$

where SR_c is the summation of the VQ length of the EL flow and U is the utility function

STEP 4: Load balancing is applied for IEL flow

The packets of flow '*i*' at route '*r*' are given by, Eq. (4)

$$x_i^{(r)}(t) = (\mu_i^{'}(t) - \mu_{R\,i}^{(r)}(t))\, x_i^r(t) \quad (4)$$

where $\mu_i'(t)$ satisfies $\sum_{r=1}^{|Rl|}((\mu_i'(t) - \mu_{R_i^{(r)}}(t))x_i^r(t)) = 0$ and $\sum_{r=1}^{|Rl|} x_l^{(r)}(0) = a_i$, a_i denotes the arrival rate of IEL flows.

Let S_{il} and S_{el} denote the number of IEL and EL data packets that begin at $t = 1, 2, \ldots, T$, respectively. Let $S(a_i, c)$ symbolise a feasible routine, and '*c*' recognise the broadcast status.

The VQ lengths of EL and IEL flows at link l are given by $q_l\ (k)$ and $d_l\ (k)$, respectively, where '*k*' is the current frame.

STEP 5: CC is performed using Eq. (5)

$$x^{*}_{el}(k) \in \frac{\arg\max}{0 \leq xelX\ \max \in \in} \frac{1}{} Ul(xel) - ql(k)xel \tag{5}$$

The EL arrival rate indicates the number of EL packets admitted in '*k*'.

Let the EL arrival at link l $a_{el}(k)$ is a random variable, and P_r is the Probability. This satisfies $Pr(a_{el}(k) = 0) > 0$ and $Pr(a_{el}(k) = 1) > 0$ for all l∈L and all '*k*'. Let $a_i(k)$ be the number of IEL arrivals and $c(k)$ be the channel state.

STEP 6: Scheduling si performed using Eq. (6)

$$\vec{s}\, ai(k),\ c(k),\ d(k),\ q(k) \in \arg\max \sum \{[\frac{1}{\in} wt + dl(k)] \sum_{t=1}^{T} Sil,\ t + ql(k) \sum_{t=1}^{T} Sel,\ t\} \tag{6}$$

Here, the number of IEL arrivals at $l(a'_{il}(k))$ has the parameters $\{a_{il}(k), 1 - p_l\}$. The scheduler is a function of $\{a_i(k), c(k), d(k), q(k)\}$. $d_l(k)$ is the VQ that counts the shortage in service for a link.

3.1.2 Packet Dropping Algorithm Using PID Control

An input condition evaluates a control action and feedbacks the gain multipliers that control stability, error, and response. Proportion, integral, and derivative controllers are used in PID. Following Fig. 2 illustrates the PID-based network feedback control.

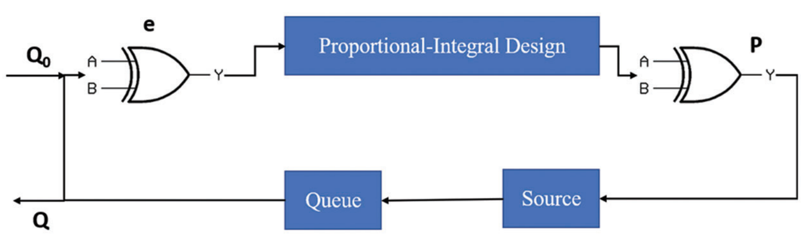

Figure 2: Flow process of PID

Here q_0 signifies the expected queue length, '*q*' is rapid queue length. $e = q - q_0$ is the error signal that is the PID controller's input, and the packet loss rate '*p*' is the output returned from the PID controller. The PID controller determines the dropping probability *(p)* of each incoming packet based on the difference in queue lengths of the router. It then estimates the congestion level based on '*p*' and alters its sending rate to control the router length. *The source detects' p'* after a link EED time.

p can be assessed by Eq. (7)

$$P = \begin{cases} 0 & p < 0 \\ p & 0 \leq p \leq 1 \\ 1 & p > 1 \end{cases} \tag{7}$$

p ranges from 0 and 1.

Algorithm For Priority Dropping

Step 1. Receive (pkt)

Step 2. P = Esimate_p(pkt)

Step 3. IF pkt = dropped **THEN**

Step 4. IF prior(pkt) = 0, **THEN**

Step 5. PLR (pkt)

Step 6. ELSE

Step 7. L_pkt = **LOOK FOR** _Low_Priority (queues)

Step 8. IF pkt = L_pkt **THEN**

Step 9. PLR (L_pkt)

Step 10. Enque(pkt)

Step 11. ELSE

Step 12. PLR (pkt)

Step 13. END IF

Step 14. END IF

Step 15. END IF

The packet priority is assigned whenever data is received and stored in the packet's priority field. The priority for the background flows is assigned to '*0*'. The packet drop probability of the incoming packet is computed using Eq. (7). If a packet is to be dropped, then the packet with lower priority than the current packet is dropped, and the current packet is admitted. If no such lower priority packet exists, the current packet will be dropped [14–20].

3.2 Method for Optimized Admission Control (MOAC)

AC is necessary for providing QoS guarantees. It controls the utilization and allocation of network resources in real-time applications, where additional bandwidth is required. It allows the bandwidth to be utilized by data flows only when free. In every MANET, QoS is offered through AC by verification before forming a link to ensure that the available resources are enough to maintain the link. This section presents a MOAC for M-SF in MANET [21–23]. Fig. 3 shows the proposed MOAC. The bandwidth requirement of each type of TF can be represented in terms of the session's capacity requirement on a link. AC succeeds by estimating the state of network resources and thereby deciding which applications data flow can be admitted. In order to avoid route failures during AC, a mobility aware node selection algorithm was proposed [24–30].

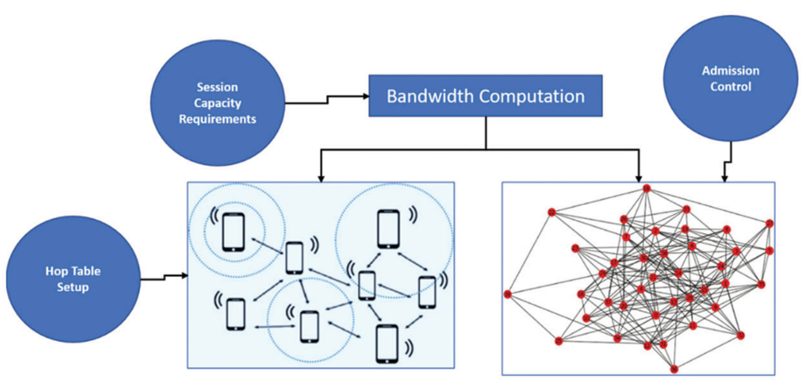

Figure 3: Block diagram of MOAC

3.2.1 Estimation of Bandwidth Requirement

The bandwidth needs for every TF can be expressed in the session's capacity needs on a link estimated using the contention count formula.

Step 1: Estimation of the channel time engaged by the MAC layer overhead is determined using the conventional standards. Let N_{CS} be every Carrier Sensing neighbour set of the present node on the route, R is the set of forwarding nodes on the current routing session. Hence, the contention count for these components is estimated according to Eq. (8).

$$c_{cont} = \left| \sum_{j=0}^{|N_{cs} \cap R|} \frac{\alpha_0}{\alpha_j} \right|, \ \forall j \in N_{cs} \cap R \tag{8}$$

All links originating at transmitters which belong to both N_{CS} and R are included.

Step 2: Session's capacity requirement on a link j is given by Eq. (9)

$$B_{req} = b_{req} \frac{T_{IPhdr} + T_{SRhdr} + T_{Data}}{T_{Data}} \left(\sum_{j=0}^{|N_{cs} \cap R|} \frac{\alpha_0}{\alpha_j} \right) + b_{req} \frac{T_{MAChdr} + T_{DIFS} + T_{RTS} + T_{Ack} + 3T_{SIFS} + T_{bkoff}}{T_{Data}} |N_{cs} \cap R| \tag{9}$$

Here α_0 indicates the introductory rate and α_j indicates the rate of link '*j*', which is under consideration. '*Tx*' represents the transmission times of the respective headers.

Step 3: The current link rate for that hop approximates the channel occupation time at the BS of a session's traffic.

Step 4: Hence the bandwidth requirement BW_{req} is given by, Eq. (10)

$$BW_{req} = B_{req} \tag{10}$$

3.2.2 Algorithm for Admission Control

Step 1. Admission_Control (BW_{req}, Dest_IP, HC)

Step 2. {

Step 3. HC = 0

Step 4. IF (Dest_IP is FNT)

Step 5. {

Step 6. IF ($BW_{avai\_inter} > BW_{req}$)

Step 7. Broadcast RREQ with HC + 1

Step 8. ELSE IF ($BW_{avai\_inter} > 2\ BW_{req}$ && HC == 1)

Step 9. Broadcast RREQ with HC + 1

Step 10. ELSE IF ($BW_{avai\_inter} > 3\ BW_{req}$ && HC > 1)

Step 11. Broadcast RREQ with HC + 1

Step 12. Else

Step 13. Discard RREQ

Step 14. }

Step 15. ELSE IF (Dest_IP is SNT)

Step 16. {

Step 17. IF ($BW_{avai\_inter} > 2\ BW_{req}$)

Step 18. Broadcast RREQ with HC + 1

Step 19. ELSE IF ($BW_{avai\_inter} > 3\ BW_{req}$ && HC == 1)

Step 20. Broadcast RREQ = HC + 1

Step 21. ELSE

Step 22. Discard RREQ

Step 23. }

Step 24. ELSE IF (($BW_{avai\_inter} > 3\ BW_{req}$) || ($BW_{avai\_inter} > 4\ BW_{req}$))

Step 25. Broadcast RREQ with HC+1

Step 26. Else If (($BW_{avai\_inter} > 2\ BW_{req}$) && (HC == 1))

Step 27. Discard RREQ

Step 28. ELSE

Step 29. Discard RREQ

Step 30. }

Step 31. End

3.2.3 Algorithm for Bandwidth Reservation

Step 1. BW_Reservation(BW_{TRAN}, Total_HC, Reverse_HC)

Step 2. {

Step 3. Reverse_HC = 0

Step 4. IF (total_HC == 1)

Step 5. {

Step 6. $BW_{avai\_dest} = BW_{req} + 1$

Step 7. Reverse_HC = Reverse_HC + 1

Step 8. Unicast RREP with BW_{req}, Reverse_HC, Total_HC

Step 9. $BW_{avai\_src} = BW_{req} + 1$

Step 10. }

Step 11. ELSE IF (Total_HC = 1)

Step 12. {

Step 13. $BW_{avai\_dest} = 2\ BW_{req} + 1$

Step 14. Reverse_HC = Reverse_HC + 1

Step 15. Unicast RREP with BW_{req}, Reverse_HC and total_HC

Step 16. }

Step 17. ELSE IF (Total_HC == 2)

Step 18. $BW_{avai\_src} = 2\ BW_{req} + 1$

Step 19. ELSE IF (total_HC 2)

Step 20. $BW_{avai\_src} = 3\ BW_{req} + 1$

Step 21. ELSE IF ((total_HC == 2)&& (Reverse_HC == 1))

Step 22. {

Step 23. $BW_{avai\_inter} = 2\ BW_{req} + 1$

Step 24. Reverse_HC = Reverse_HC + 1

Step 25. Unicast RREP with BW_{req}, Reverse_HC, Total_HC

Step 26. }

Step 27. ELSE IF ((total_HC $\neq$ 2)&& (Reverse_HC == 1))

Step 28. {

Step 29. $BW_{avai\_inter} = 3\ BW_{req} + 1$

Step 30. Reverse_HC = Reverse_HC + 1

Step 31. Unicast RREP with BW_{req}, Reverse_HC, Total_HC

Step 32. }

Step 33. ELSE IF ((Reverse_HC == 1) && (Total_HC == 3))

Step 34. {

Step 35. $BW_{avai\_inter} = 3\ BW_{req} + 1$

Step 36. Reverse_HC = Reverse_HC + 1

Step 37. Unicast RREP with BW_{req}, Reverse_HC, Total_HC

Step 38. }

Step 39. ELSE IF ((Reverse_HC == 1) && (Total_HC == 3))

Step 40. {

Step 41. $BW_{avai\_inter} = 4\ BW_{req} + 1$

Step 42. Reverse_HC = Reverse_HC + 1

Step 43. Unicast RREP with BW_{req}, Reverse_HC, Total_HC

Step 44. }

Step 45. }

Step 46. END IF

Step 47. END

3.3 Resource Allocation Using Tokens

The main aim of RA is to improve QoS and better the utilization of resources required for the application. The goal of RA in a MANET is to smartly allocate the limited available resources among terminals required to address the service requirements of end-users. The QoS satisfaction level for the respective applications is based on the availability of resources. It proposes a RAUT for M-SF in MANET. The priorities of EL and IEL TF are determined using the Fuzzy Logic Decision (FLD) model [31–35]. The token holder selects the node from the IEL queue with high priority for allocating the resources. Finally, the token is submitted to the EL traffic queue. The results show that the proposed RA achieves better performance in the allocated bandwidth. FL is a logical system used in computer science that mimics the human way of problem-solving. FL is a technique for simulating human decision-making using natural language terms rather than mathematical terms. Many scientific and industrial applications have made use of FL automation. FL contains a fuzzy set containing elements with only a partial degree of membership. For each point in the input vector, a Membership Function (MF) maps a membership value between '0' and '1'. The input vector is also known as the universe of discourse. Straight lines are used to create the most basic MFs. The triangular MF is the most basic of these. Some of the other MFs used in FL are the trapezoidal MF and the sine MF. FL is primarily comprised of fuzzy sets and fuzzy operators. Conditional statements are written using *if-then* rule statements. A mapping from a given set of inputs to output is known as fuzzy inference. MFs, FL operators, and *if-then* rules are used in the fuzzy inference process.

3.3.1 Algorithm-1

Step 1. IF N_i To Transmit $DATA_{inel}$ **Then**

Step 2. REREQ: [ID_i| D_{exp}| SNR| Re_{req}]

Step 3. ELSE IF N_i To Transmit $DATA_{el}$

Step 4. REREQ: [ID_i |R_{Tx}| SNR| Re_{req}]

Step 5. END IF

Step 6. N_i Forwards REREQ to ES State

Step 7. ScH Checks the type of REREQ

Step 8. IF REREQ is $DATA_{inel}$ **Then**

Step 9. $QUEUE_{inel}$

Step 10. ELSE

Step 11. $Queue_{el}$

Step 12. END IF

3.3.2 Algorithm-2

Step 1. IF TH in CS state leaves the current resource

Step 2. IF the type of TH is $QUEUE_{ine}$

Step 3. TH chooses node with priority High, Very High

Step 4. DO

Step 5. {

Step 6. IF AvB > Re_{req} **THEN**

Step 7. ScH allocates the IEL service matching the remaining AvB

Step 8. END IF

Step 9. } **WHILE** (IEL queue = empty)

Step 10. ELSE

Step 11. A token to $QUEUE_{el}$

Step 12. END IF

Step 13. END

3.3.3 Fuzzy Based Flow Prioritization

Fig. 4 shows the fuzzy controller architecture, a non-linear MF system with four main components. The admitted IEL flows are prioritized over EL M-SF by utilizing the Fuzzy Logic System (FLS). FLS encompass two sub FLS as FLS1 and FLS2 for IEL and EL M-SF.

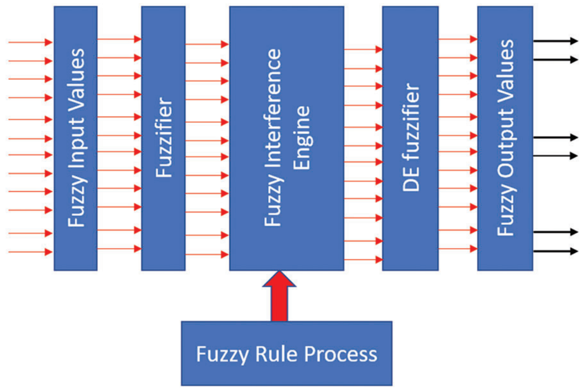

Figure 4: Fuzzy controller

3.3.4 Fuzzification

In FLS1, for IEL M-SF, the two-input metrics are fuzzified, such as EEE and Signal to Noise Ratio (SNR) [36–38]. The MF such as "*LOW", "MEDIUM"*, "*HIGH"* are utilized to describe SNR. The "*LOW"* value means a high lossy channel among the nodes. The "*HIGH"* value demonstrates a low error-prone channel. The "*MEDIUM"* value is obtained during the motion of nodes. The "*HIGH"* SNR is given higher priority. Similarly, the MF such as "*LOW", "MEDIUM"*, "*HIGH"* are utilized to describe EED. The channel with minimum EED is given higher priority. The MF such as "*VERY HIGH", "HIGH", "MEDIUM", "LOW", "VERY LOW"* are used to describe the outputs. Using these outputs, ScH sets the priority. In FLS2, for EL M-SF, the two-input metrics are fuzzified, such as transmission rate and SNR. Transmission rates are presented using MFs such as "*LOW", "MEDIUM"*, "*HIGH"*. Long transmission intervals result in low throughput and energy requirements when the "Low" value is used. RTx is prioritised according to its "*HIGH"* value. SNR's MF is comparable to FLS1's MF. ScH assigns EL M-SF priority depending on the outcomes of FLS2. Figs. 5–7 showed the MF of SNR, EED and transmission rate, respectively.

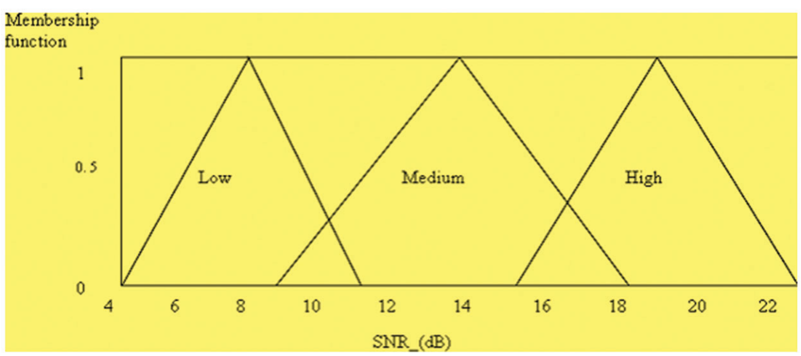

Figure 5: MF for SNR

4 Result and Discussion

NS2 is used to simulate the proposed model. Tab. 1 summarises the simulation setup and specifications [39–41]. The performance of DEQM has been compared with the Optimal Scheduling Algorithm (OSA). Since DEQM uses the VQ model for elastic and IEL flows for reducing the EED, it attains a minor delay than the OSA. Moreover, DEQM posses a load balancing algorithm to provide maximum network utilization, the allocated bandwidth and fairness are higher. Experimental tests demonstrate that our proposed method provides a more reliable OSA. The performance measures used for work performance: are PDR, PLR, EED and Fairness.

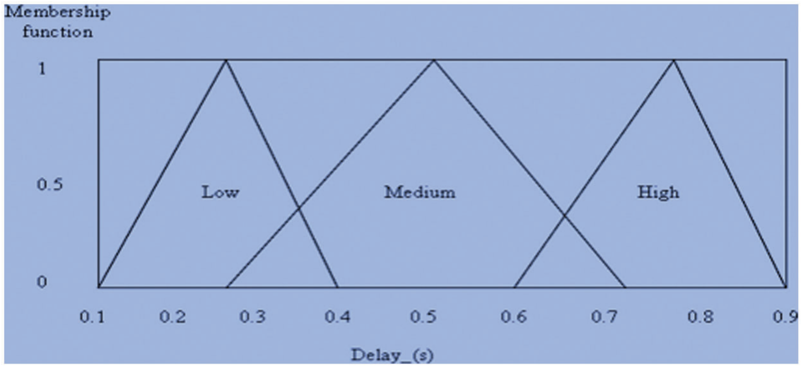

Figure 6: MF of EED

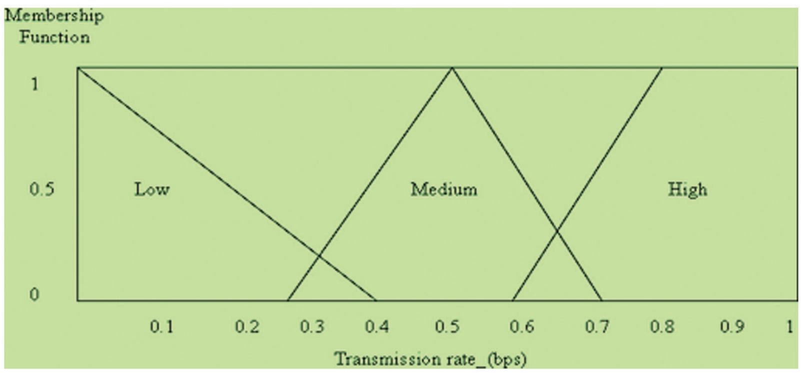

Figure 7: MF of data transmission rate

Table 1: Simulation settings

Parameters	Value
Nodes count	100
Simulation area	1500 m × 300 m
Radio frequency	250 m
Execution time	50 s
Traffic flow	CBR and Video
No. of links	6
Packet	512 bytes
Mobility	RWP, CSM
Node speed	5 ms
Interval	5 s
Transmission proportion	50 to 500 Kbps

4.1 Performance Metrics of DEQM

The proposed DEQM is compared with the OSA. The performance is evaluated in PDR, PLR, fairness, EED. The proposed DEQM is compared with the OSA. Simulation results have shown that DEQM achieves improved fairness with less EED and PLR.

Tab. 2 and Fig. 8 explain PDR performance, fairness, EED and PLR. It is observed that the performance of the presented method obtained better values.

Table 2: Summary of DEQM

Algorithms	PDR %	Fairness	EED (s)	PLR %
DEQM	64.45	0.722	12.640	35.55
OPTIMAL	60.78	0.651	16.820	39.22

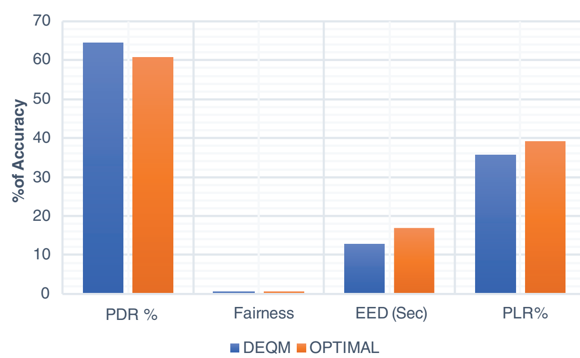

Figure 8: Performance analysis of DEQM

4.2 Performance Metrics MOAC

The proposed MOAC is simulated in NS2 and compared with Distributed Admission Control Protocol (DACP) and FAACMM. The performance is evaluated in PDR, PLR, fairness, and EED parameters. In the simulation experiment, the number of data flows is varied from 1 to 10—the results of DACP, FAACMM, and MOAC vary the number of flows. Using the mobility aware forward node OSA, MOAC avoids overloaded nodes in the routes, thus increasing the fairness and PDR.

Tab. 3 and Fig. 9 shows the overall performance analysis. When the proposed algorithm MOAC is compared with existing algorithms DACP and FACC-MM, the MOAC has a better performance for each metric. In this chapter, MOAC for M-SF is developed for MANET. In *Phase-I*, all link's session capacity requirements are calculated to determine the bandwidth requirement for each type of TF. In *Phase-II*, the AC algorithm is performed. In *Phase-III*, bandwidth reservation is made. Thus, data admission is controlled efficiently, and bandwidth utilisation is also kept under control. An aware mobility node OSA performs implicit AC by the previous-hop nodes. This algorithm selects forwarder-node based on the connectivity, current load and distance, which performs explicit AC. We prove through simulation results that the recommended EACM reaches higher bandwidth, less fairness, and high PDR with a lower EED.

Table 3: Summary of MOAC

Algorithms	PDR %	Fairness	EED (s)	PLR %
MOAC	83.62	0.957	5.041	16.38
DACP	82.54	0.924	8.489	17.46
FACC-MM	81.53	0.913	9.527	18.47

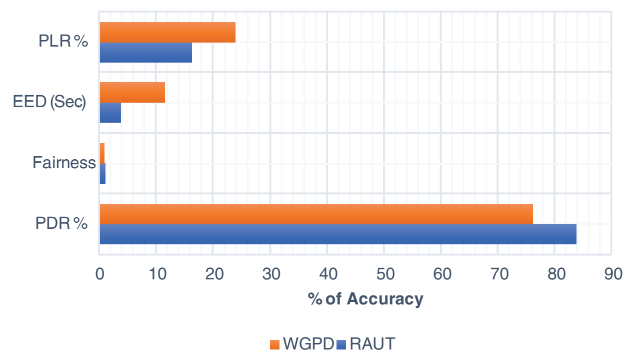

Figure 9: Performance analysis of MOA

4.3 Performance Metrics of RAUT

The proposed RAUT is compared with the Wireless Greedy Primal-Dual (WGPD) Algorithm. The performance metrics used for evaluation are Average EED, Average PDR, PLR, and Fairness. Since WGPD does not consider the specific requirements of EL and IEL TF, such as EED and transmission rate, RAUT attains better results for all the metrics, as depicted in the following section.

Tab. 4 and Fig. 10 shows the overall performance analysis. When the proposed algorithm RAUT is compared with existing algorithms WGPD, the RAUT has a better performance for each metric. This section proposes a RAUT for M-SF in MANET. When a node requires resources, it constructs the RRM based on EL and IEL flows and forwards it to the ES state. The OSA then assigns the RRM in different queues using the fuzzy-based flow resource allocation method. The token holder chooses the node that has a higher priority. While allocating resources, if the available resource is more excellent than the required resource, then the scheduler allocates the IEL service that suits that remaining available resource. We have demonstrated that the proposed method allocates resources efficiently by results.

Table 4: Summary of RAUT

Algorithms	PDR %	Fairness	EED (s)	PLR %
RAUT	83.73	0.979	3.733	16.27
WGPD	76.07	0.842	11.455	23.93

4.4 Comparison of Proposed Works

It compares the proposed RAUT, DEQM, EACM, and the performance is analysed. The performance of the proposed solutions is compared by varying the data sending rate from 100 to 500 *Kb*. Tab. 5 shows the results of RAUT, DEQM, EACM for varying the rate.

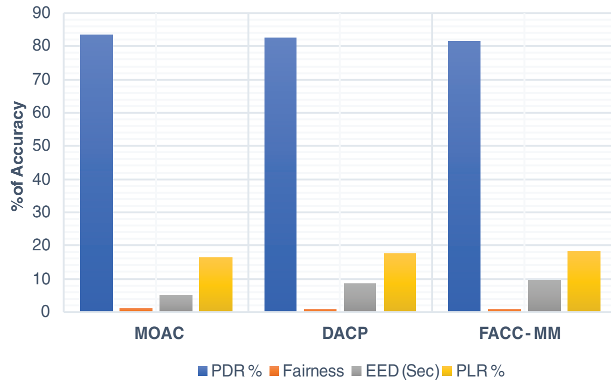

Figure 10: Performance analysis of RAUT

Table 5: Summary of RAUT, DEQM, EACM

Rate (Kb)	PDR			Fairness (Mb)			EED (s)			PLR		
	TB RA	DEQM	EACM	TBRA	DEQM	EACM	TB RA	DEQM	EACM	TBRA	DEQM	EACM
100	7.58	12.56	11.69	0.98	0.69	0.98	1.926	8.99	0.47	92.42	89.44	89.51
200	7.99	27.77	13.32	0.98	0.71	0.979	1.065	11.86	1.28	92.01	72.23	86.68
300	16.6	42.23	14.06	0.98	0.66	0.969	3.913	13.93	3.33	83.4	57.77	85.94
400	27.21	52.84	14.71	0.98	0.69	0.964	5.022	16.50	3.86	72.79	48.78	85.29
500	31.96	59.86	15.6	0.97	0.70	0.957	5.99	15.07	5.63	68.04	40.14	84.4

Fig. 11 shows the PLR of RAUT, DEQM, EACM when the transmission rate varies from 100 to 500 *Kb*. It shows that PLR of RAUT increases from 7.58 to 31.96, PLR of DEQM increases from 12.56 to 59.86, and PLR of EACM increases from 11.69 to 15.6. Based on the result, the PLR of EACM is 53% is higher than DEQM and 54% higher than RAUT.

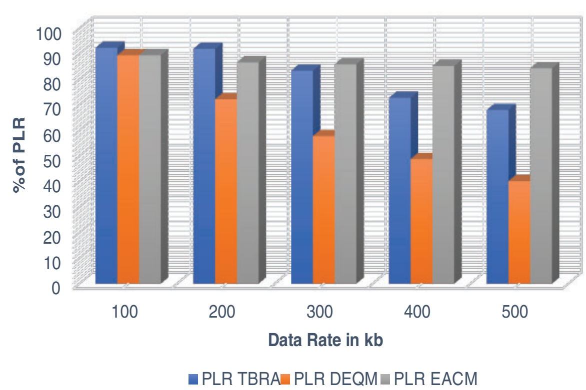

Figure 11: Performance analysis of PLR

Fig. 12 shows the fairness of RAUT, DEQM and EACM when the transmission rate is varied from 100 to 500 *Kb*, and it shows that the fairness of RAUT increases from 0.987 to 0.976 and the fairness of DEQM increases from 0.69 to 0.709 and the fairness of EACM increases from 0.98 to 0.957. Based on the result, the fairness of RAUT is 29% is higher than DEQM and 28% higher than EACM.

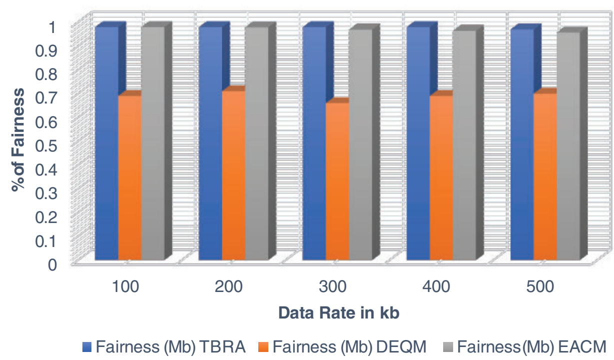

Figure 12: Performance analysis of fairness

Fig. 13 shows the EED of RAUT, DEQM and EACM when the transmission rate varies from 100 to 500 *Kb*. It shows that EED of RAUT increases from 1.926 to 5.99, DEQM increases from 8.99 to 15.074, and EED of EACM increases from 0.478 to 5.63. Based on the result, the EED of RAUT is 74% less than DEQM and 80% lesser than EACM.

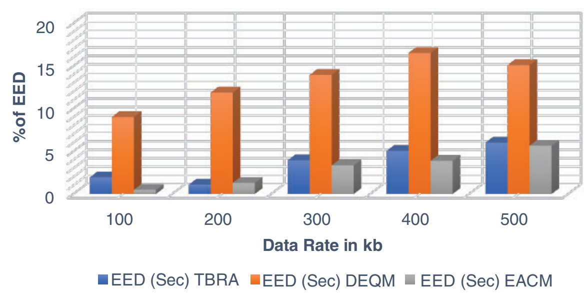

Figure 13: Performance analysis of EED

Fig. 14 shows the PDR of RAUT, DEQM and EACM when the transmission rate varies from 100 to 500 *Kb*. It shows that PDR of RAUT increases from 92.42 to 68.04, PDR of DEQM increases from 89.44 to 40.14, and PDR of EACM increases from 89.51 to 84.4. Based on the result, the PDR of RAUT is 26% is higher than DEQM and 29% higher than EACM.

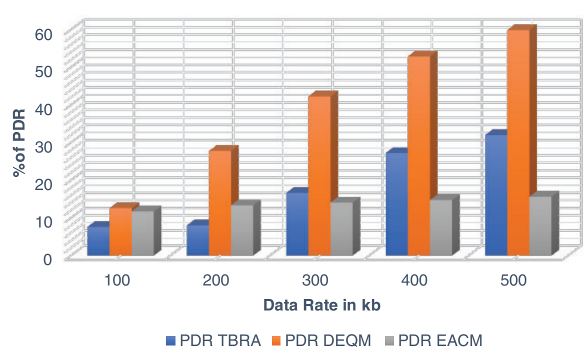

Figure 14: Performance analysis of PDR

Tabs. 6 and 7 show the percentage-wise improvement of RAUT over DEQM and EACM over EQMD, respectively (Figs. 15 and 16).

Table 6: Summary of RAUT *vs.* DEQM

Rate (Kb)	PLR (%)	Fairness (%)	EED (%)	PDR (%)
100	39.6	30.1	78.5	3.2
200	71.2	27.5	91.0	21.4
300	60.6	32.4	71.9	30.7
400	48.5	28.7	69.5	32.9
500	46.6	27.3	60.2	41.0

Table 7: Summary of EACM *vs.* DEQM

Rate (Kb)	PLR (%)	Fairness (%)	EED (%)	PDR (%)
100	6.9	29.5	94.6	0.07
200	52.0	26.9	89.1	16.6
300	66.7	31.3	76.1	32.7
400	72.1	27.4	76.6	42.8
500	73.9	25.9	62.6	52.4

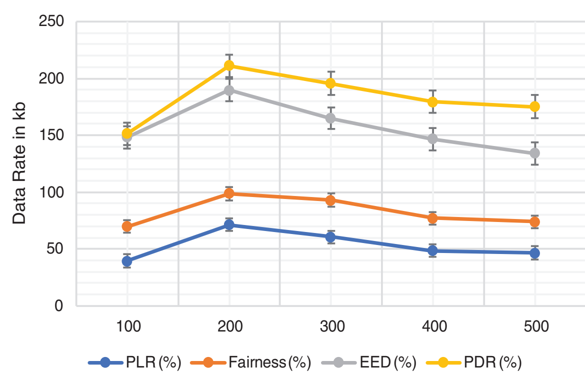

Figure 15: Performance of RAUT *vs.* DEQM

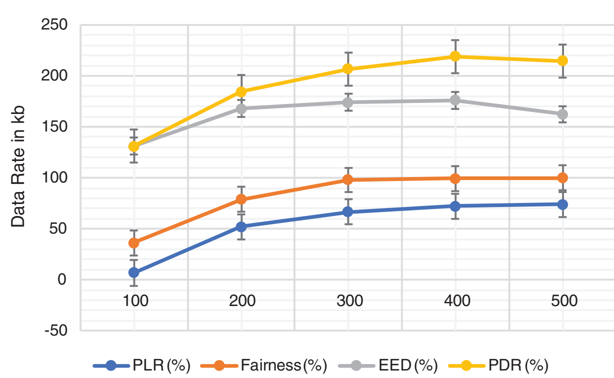

Figure 16: Performance of EACM *vs.* DEQM

5 Conclusion and Future Work

The main aim of the proposed work is to develop the efficient RA method for M-SF in MANET. This article has focused on EL and IEL M-SF. The IEL flow is used for EED-sensitive services such as VoIP services which are offered with a particular data rate. It holds the maximum per EED requirements. In the analysis of DEQM performance, it can be seen that the PDR of DEQM is obtained 64%, the fairness of DEQM is attained 0.7, the EED of DEQM is obtained 13 s and the PLR of DEQM is achieved 36%, but the existing method OSA produces 61% for PDR, 39% for PLR, 17 s for EED and 0.7 for fairness. The performance of EACM is connected with DACP and FAAC-MM. By using the mobility aware forward node OSA, EACM avoids overloaded nodes in the routes, thus increasing the fairness and PDR. While analysing the performance, it can be seen that PDR of EACM is gained 84%, the fairness of EACM is achieved 0.9, the EED of EACM is reached 5 s, and PLR of EACM is attained 16%, but the existing methods FAACMM and DACP produces 82% and 83% for PDR, 18% and 17% for PDR, 10 and 8 s for EED and 0.92 and 0.91 for fairness. While analyzing overall performance, it can be seen that the PDR of RAUT is obtained 84%, the fairness of RAUT is obtained 0.9, the EED of RAUT is obtained 4 s, and PLR of RAUT is obtained 16%, but the existing method WGPD produce 76% for PDR, 24% for PLR, 11 s for EED and 0.8 for fairness.

Future work concentrates on energy consumption constraints and interference with the proposed RA and AC mechanisms.

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