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**Scheduling algorithm for real time applications in mobile ad hoc
network with opnet modeler**

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Abstract

Providing Quality of Service (QoS) for Mobile Ad-Hoc Networks (MANETs) is a taxing task owing to the dynamic topology and limited resources in MANETs. But the need for sustaining real time applications for users of MANET has become very important. This paper makes primary contribution on scheduling algorithms that categorizes and prioritizes the real-time traffic with the intention of improving the performance of the real-time applications. Five types of scheduling algorithms have been analyzed using OPNET simulator. Simulation results shows that Low Latency queuing algorithm improves the overall performance of the real time applications than all other algorithms.

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1. Introduction

With the extension in personal computing devices and the development in wireless communication technologies, wireless networks have obtained worldwide attention in recent years. The great popularity of Internet services makes more people enjoy and depend on the networking applications. Nevertheless, the Internet is not always accessible and trustworthy, and hence it cannot gratify people's demand for networking communication at anytime and anywhere.

Mobile ad hoc network (MANET) [1], without any fixed infrastructures, allow mobile terminals to set up a temporary network for instant communication. The MANETs sustain vast applications in these scenarios, including disaster recovery, emergency relief, mobile conferencing, battle field communication, electronic payments anytime and anywhere, dynamic database access, mobile offices, vehicular services and so on. So, the emergence and the foreseeing future of real-time and multimedia applications have stirred the need of high Quality of Service support in wireless and mobile networking environment/. [2] But providing Quality of Service (QoS) for Mobile Ad-Hoc Networks (MANETs) is a taxing task owing to the dynamic topology and limited resources in MANET's

Quality of Service (QoS) [3] is the performance level of a service offered by the network to the user. The level of the service is based on some parameters or constraints often known as available bandwidth, end-to-end delay, delay variations or jitter, probability of packet loss etc.

QoS factors vary from application to application. For example, for real time applications, the data rate and delay are the vital factors, whereas, in military use, security and reliability become more important. In case of emergency situations, the key factor should be the availability [4].

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For transmission of non-real time data, timing is not a critical issue, the data is elastic. But it always has high requirement for packet loss. Retransmissions are used if there are some lost packets. For real time transmissions like telephone, video conference, streaming video and audio, the prime requirement is to transmit packets to the destination on time. People cannot tolerate large delay. As a result, some QoS mechanisms are needed to ensure the required quality of the connection for real time transmissions.

Because of the inadequate availability of transmission bandwidth in MANET's[5], QoS techniques need to optimize the sparse resource by giving more priority to the real-time flows over best-effort flows in order to comply with the QoS requirement such as delay bounds and throughput. To support the fair distribution of bandwidth to each of the different service classes contending for bandwidth on the output port, need to develop a resource allocation method. In this paper, we present Low Latency Queuing algorithm for real time applications.

2. Related Work

Roja Kiran Basukala et al. [6] assured QoS for multimedia traffic using Custom Queuing (CQ) and Low Latency queuing (LLQ) algorithm in residential network with Hybrid Coordination Function (HCF). It is shown that CQ with HCF performs better than LLQ in terms of delay and jitter.

Sotirios et al. [7] proposed Queue management architecture for delay tolerant networks. The scheduling algorithm assigns priority for the packets based on application requirements, data requirements and time to live which reduces waiting time and increases application satisfaction.

Tetsuji hirayama et al. [8] analyzed multi class feedback queues with priority selection orders. Multiple classes of customers in each group served in the basis of limited FCFS, gated FCFS, exhaustive FCFS and exhaustive Priority algorithms. They extended their algorithms for mission critical traffic by mixing Priority with DRR algorithms.

Jui-Chi Chen et al. [9] developed optimized packet scheduling management for multimedia communications. They proposed batch arrival model to analyze multimedia packet scheduling next generation mobile networks. The model provides favorable scheduling and maximum bandwidth utilization according to specific QoS constraints.

Jun Zoo et al. [10] devised a binary linear programming for the scheduling problem of real time constant bit rate traffic and proposed bottleneck first scheduling scheme. The proposed algorithm preferentially treats the traffic with higher load to avoid bursty traffic delay.

Brunonas Dekeris et al. [11] combined Weighted Fair Queuing (WFQ) algorithm with Low Latency Queuing (LLQ) algorithm for ensuring Quality of Service for real time applications. When the network load is high, the WFQ algorithm can not achieve expected QoS for real time applications.

Shaimaa Badr et al. [12] proposed a model to support real time service in e-learning system and developed a QoS model in multi tiered real time systems. They evaluated the performance voice and video traffic in the e-learning system by combining Weighted Fair Queuing (WFQ) and Low Latency Queuing (LLQ) algorithms. It is shown that the combined algorithms gave better performance for voice and video traffic.

Youssef Dehbi et al. [13] developed a new packet scheduling scheme for multimedia packets in Mobile Ad hoc Network. A modified Earliest Deadline First (EDF) scheduling was used to assign priority for multi class packets. Results were proven that it performs better than the original EDF.

Saber Ghasempour et al. [14] proposed a fuzzy based scheduling algorithm for wireless networks. They calculated the priority index for each packet by considering the data rate and channel capacity of the nodes. The fuzzy scheduler improves the packet delivery and reduces the end-to-end delay.

Hyunchul Joo et al. [15] developed an urgency based packet scheduling to effectively deliver delay sensitive data in Mobile Ad hoc Networks. Packet urgency, Route urgency and Node urgency are defined based on the end-to-end delay requirements and number of hops over a route. The urgency metrics determine the order of packet scheduling and dropping the packets.

3. Scheduling Algorithms

Queue scheduling algorithms are important components in the provision of guaranteed quality of service parameters. It will manage the changes in queuing dynamics in different situation also improves the performance of the network. The emergence of new multimedia and Internet applications has insisted to study the scheduling algorithms for providing QoS guarantees. These guarantees are usually in the form of bounded delay and jitter, guaranteed rate and fairness among sessions.

3.1. First-In-First-Out (FIFO) Scheduling Algorithm

FIFO queuing is the most basic queue scheduling algorithm. In FIFO queuing, all packets are placed into a single queue and processed in the same order as they were received.

Benefits

- This queuing policy requires very low computational load.
- The behavior of a FIFO queue is predictable – the maximum delay is calculated by the maximum depth of the queue

Limitations

- Since all packets are placed into the single queue, it is not possible to offer different services for different packet traffic classes.
- If a bursty flow comes, it will occupy the entire buffer space and other flows will not be serviced until the buffer is emptied.

3.2. Priority Queuing Algorithm

Priority Queue offers a method for supporting differentiated service classes. It classifies the incoming packets and placing them into different priority queues. The packets that have the highest priority will be processed first before the packets with lower priority [16].

Benefits

- When compared to more elaborate queue scheduling algorithms, priority queue requires low computational load.
- Priority Queuing supports differentiated service classes.

Limitations

- Due to the excessive volume of higher-priority traffic, lower priority traffic can be dropped as the buffer space allocated to lower priority queues starts to overflow.
- Complete resource malnourishment for lower-priority traffic when the amount of higher-priority traffic is excessive.

3.3. Weighted Fair Queuing (WFQ) Algorithm

Weighted Fair Queuing supports flows with different bandwidth requirements by approximating a Processor Sharing (PS) system. It assigns each queue with different weights that relates to the proportion of the allocated output port bandwidth.

All the incoming packets are time stamped with a finish time in addition to being placed into its respective flow queues. The WFQ scheduler selects the packets with smallest finish time as the next packet for the transmission on the output port [16].

Benefits

WFQ guards each service class by guaranteeing a minimum level of output port bandwidth independent of the activities of other service classes.

Limitations

- Traffic cannot be queued based on user-defined classes.
- WFQ cannot provide specific bandwidth guarantees to a traffic flow.

3.4. Class Based Weighted Fair Queuing (CBWFQ) Algorithm

CBWFQ expands the original Weighted Fair Queuing (WFQ) functionality to afford support for user-defined traffic classes. It describes traffic classes based on match criteria including protocols, access control lists and input interfaces. Packets fulfilling the match criteria for a class comprise the traffic for that class.

For each class a queue is created, and traffic belongs to that class is directed to the corresponding queue. CBWFQ uses the weights assigned to the queued packets to ensure that the class queue is serviced fairly [16].

Benefits

- The exact amount of bandwidth to be allocated for each traffic class is mentioned.
- Provides coarser granularity by allowing to use access control lists and protocols to define traffic classification.

Limitations

No mechanism exists to provide a strict-priority queue for real-time traffic, such as VoIP, to alleviate latency

3.5. Low Latency Queuing (LLQ) Algorithm

The LLQ facilitates the use of a single priority queue within which individual classes of traffic can be placed as shown in Fig.1. The strict priority queuing scheme possible with LLQ permits delay-sensitive traffic such as voice to be processed first before packets in other queues are processed [16].

In other words, delay-sensitive traffic is given special handling over other traffic. Priority status can be given to one or more classes. When a single policy map is configured with many priority classes, all traffic from these classes is queued to the same, single, strict priority queue.

The key difference between LLQ and PQ (which also has a strict priority queue), is that the LLQ strict-priority queue will not starve all other queues. The LLQ strict-priority queue is policed, either by bandwidth or a percentage of the bandwidth [17].

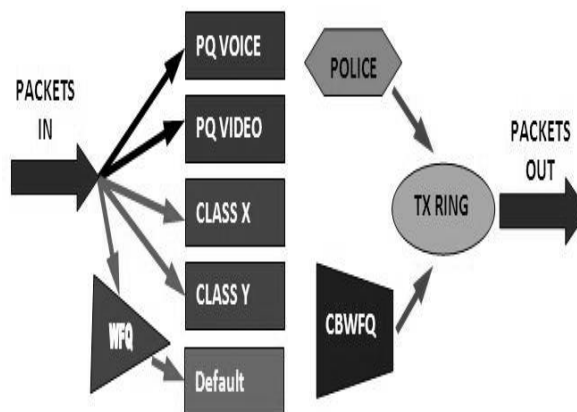


Fig.1. LLQ Algorithm

```

policy-map policy1
  class voice
    priority 540
  class interactive-video
    priority 460
  class data
    bandwidth 20
  class class-default
    fair-queue

```

The above mentioned configuration specifies that there is only a single Priority Queue of size of 1 Mbps which is time shared between the two applications by the implicit policer. Voice and interactive-video classes of traffic are placed into the high priority queue and get strict priority queuing over data traffic. The classes will be separately rate-limited even if they go into the same queue, for voice traffic 540 kbps and for video traffic 460 Kbps will be rate limited.

4. Network Scenario in Opnet Modeler

The simulation has done by Optimized Network Engineering Tools (OPNET V17.1) [18] with MANET module. The initial step is to design and create the MANET network. A snap shot of the system simulation model is shown in Fig.2.

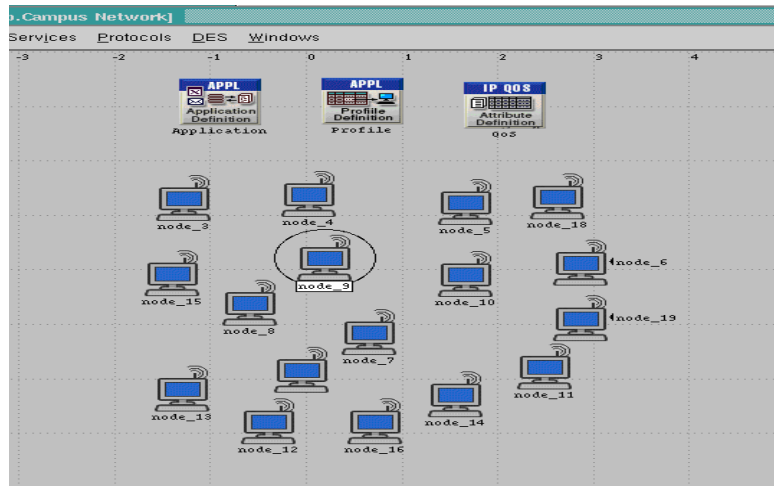


Fig.2. MANET network scenario

4.1. Application and Profile Configuration

To support VoIP and Video applications, the application attributes have to be configured as shown in Fig.3. Once the application attributes is set, Voice Profile and Video Profile have been created by profile configuration as shown in Fig.4.

Created profiles assigned to work stations through attributes of the mobile nodes. Queue attributes show the different parameter of FIFO, PQ, WFQ and LLQ algorithm. We run this scenario for all types of queuing algorithms. All the attributes remained the same except for the type of queuing algorithm.

All the four scenarios were used AODV routing protocol and analyzed the performance for delay, throughput and jitter for voice and video traffic

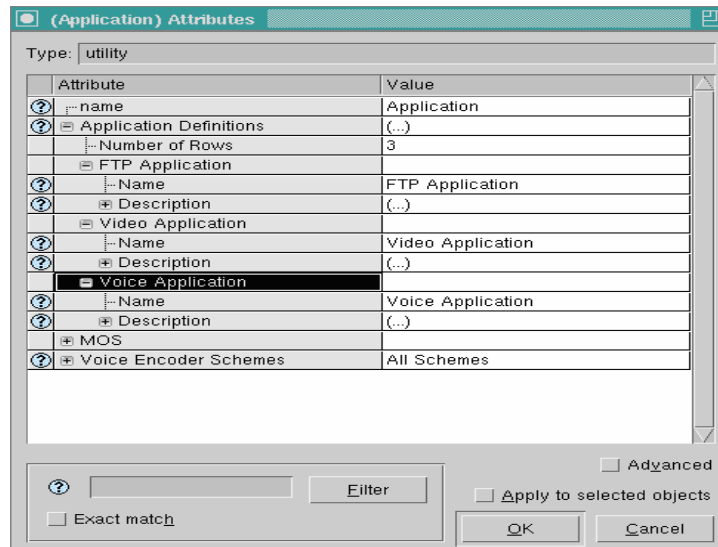


Fig.3. Application Configuration

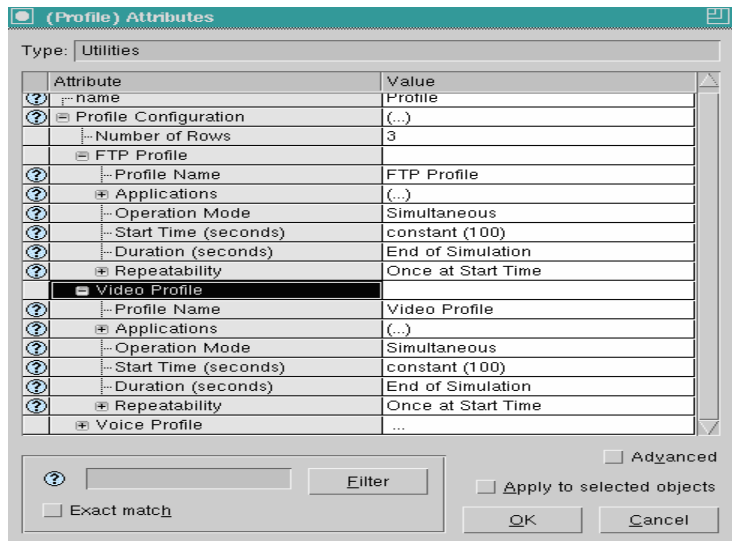


Fig.4. Profile Configuration

4.2. Steps of the work

- A first step is to create the network topology consists of 50 mobile nodes and assigning the routing protocol as AODV to all the mobile nodes.
- A second step is configuring Application and Profile configuration for enabling mobile nodes to support Voice and Video applications. Once the configuration is created, it could be applied to the mobile nodes. Now the nodes are enabled to support voice and video application.

- Four separate scenarios have been created for each type of queuing algorithms like FIFO, PQ, WFQ and LLQ respectively in the same topology. The incoming traffic is processed based on the queuing algorithm.
- The last step is to analyze the performance of Voice and Video applications in all the four scenarios based on Throughput, Delay and Delay variations.

5. Simulation Result Analysis

This section presents the performance of the queuing algorithms for real time applications. The duration of the simulation for all the four scenarios is 200 seconds.

5.1. Voice Traffic Received

In this scenario, in the case of LLQ, at the time 1m 80s, number of received byte is 32,000 bytes/sec and in the case of WFQ, at the time 2m 0s, number of received byte is 30000 bytes/sec, and in the case of PQ, at the time 2m, number of received byte is 30,000 bytes/sec and for the FIFO, at the time 1m 80s, number of received byte is 24000 bytes/sec as shown in Fig.5.

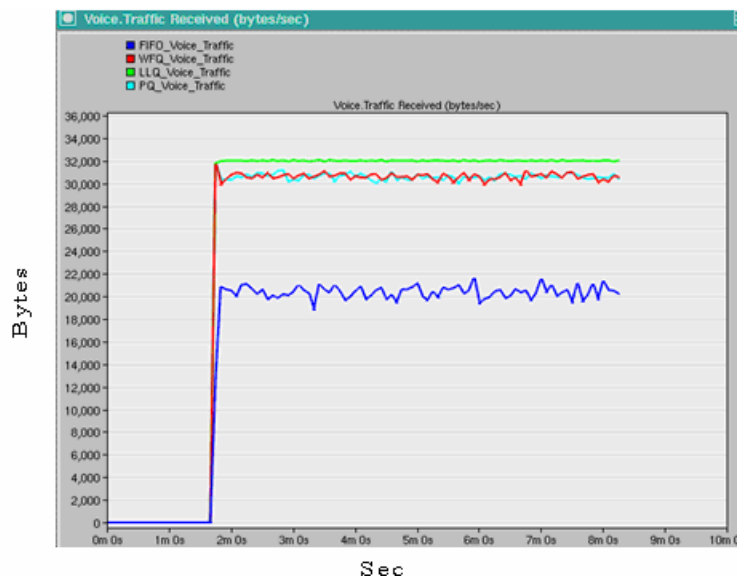


Fig.5.Voice Traffic Received

Thus traffic is varied at every instant of time at all. Due to the strict priority queue, voice traffic received using LLQ is higher than all the other queuing algorithms.

5.2. Video Traffic Received

In case of FIFO the number of received byte is 2,60,000 bytes/sec, in case of PQ the number of received byte is 52,000 bytes/sec, in case of WFQ the number of received byte is 2,40,000 bytes/sec, and in case of LLQ the number of received byte is 3,60,000 bytes/sec.

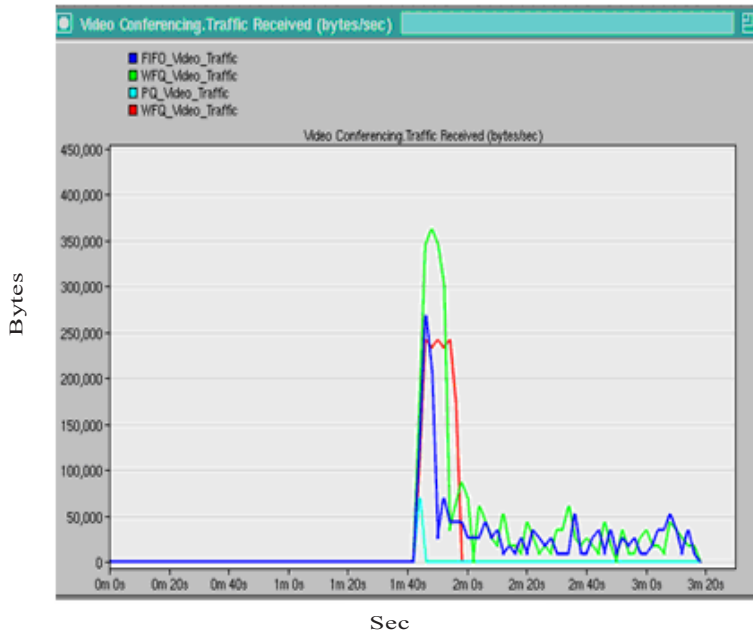


Fig.6. Video Traffic Received

Thus for the video conference traffic PQ traffic is less as compared to all other traffic due to the bandwidth starvation by voice traffic. Because of the strict priority queue for voice and video traffic, video traffic received using LLQ is higher than all other algorithms as shown in Fig.6.

5.3. Voice Packet End-to-End Delay

The end-to-end delay for voice packet is very small for PQ, WFQ and LLQ algorithms compared to FIFO as shown in Fig.7.

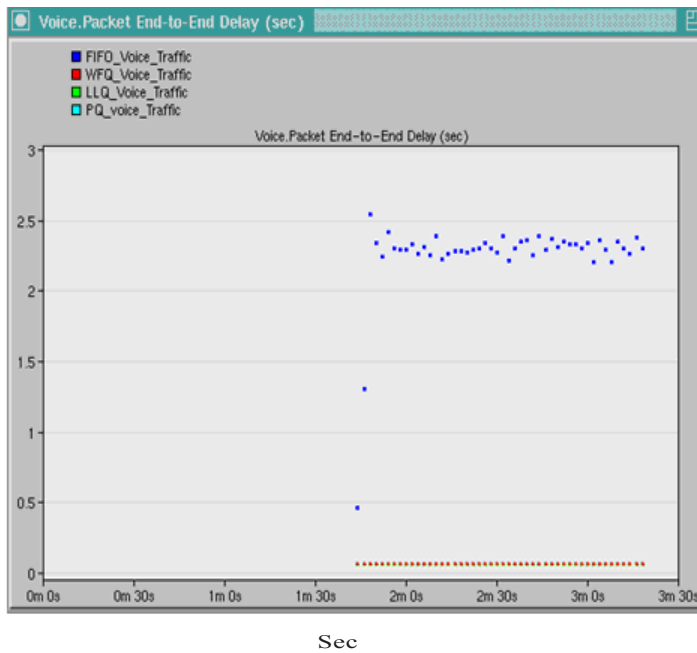


Fig.7. Voice Packet End-to-End Delay

5.4. Voice Packet Delay Variation

The delay variation for voice packet is very small for PQ, WFQ and LLQ algorithms compared to FIFO as shown in Fig.8.

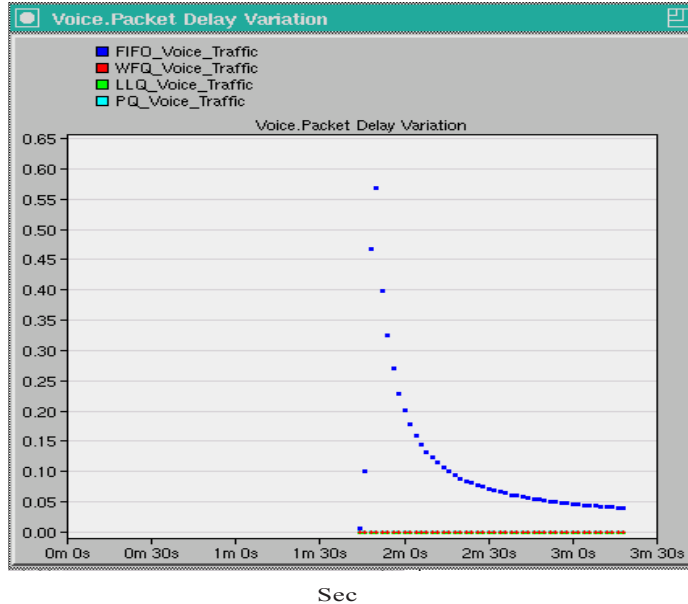


Fig.8. Voice Packet Delay Variation

6. Conclusion and Future work

This work explores the use of LLQ scheduling algorithm for MANET by analysing the various scheduling algorithms for real time applications. The algorithm has also been tested under different parameters to evaluate the performance using OPNET Modeler. The simulation results show that the voice traffic is transmitted with minimum delay and maximum throughput in the LLQ algorithm when compared to the other scheduling algorithms.

The existing LLQ algorithm uses only a single strict priority queue that will be predominantly used for voice traffic. In the future work, based on the importance of the applications the video traffic can also be treated preferentially with other traffic. The existing LLQ algorithm can be modified by introducing two strict priority queues dedicated for voice and video traffic separately. For each voice and video traffic, weights will be assigned based on the importance of the application.

In the two strict priority queues, the queue which is having maximum weight will be processed first. Consequently, the traffic which is more significant will be processed first rather than giving preference always to the voice traffic. The queue sizes and threshold values could be fixed based on the application requirements. The proposed work can also be implemented using the OPNET modeler.

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