PERFORMANCE ANALYSIS OF FIFO PRIORITY AND WEIGHTED-FAIR PACKET QUEUING MECHANISMS IN MANETS

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ABSTRACT

- Prudent resource allocation in Mobile Ad Hoc Networks (MANETs) requires scheduling mechanisms that manage buffering of packets during waiting time.
- Various scheduling algorithms may be implemented to govern packet transmission and control packet loss.
- Such mechanisms include first-in-first-out (FIFO), priority queuing (PQ), and weighted-fair queuing (WFQ).
- In this presentation, a comparison is made between use of FIFO, WFQ and PQ mechanisms in a mixed traffic scenario (file transfer and VoIP applications).
- OPNET simulator is utilized in this study

INTRODUCTION

- Ad Hoc architecture has many benefits, such as self configuration, ease of deployment, and so on.
- However, this flexibility and convenience come at a price such as bandwidth optimization, power control, and transmission quality enhancement.
- These leads to design challenges which include but mot limited to:
  - ✓ Dynamically changing topologies,
  - ✓ Radio interface at nodes
  - ✓ Limited range leading to issues such as hidden terminal problems,
  - ✓ Limited link bandwidth issues,
  - ✓ Poor quality of links, unreliability, poor security
  - ✓ Variation of link and node capabilities,
  - ✓ Energy issues, robustness, scalability issues
  - ✓ Quality of service issues

INTRODUCTION CONT...

- A quality of service (QoS) guarantee is essential for successful delivery of multimedia network traffic.
- QoS requirements typically refer to mobile ad hoc specific network characteristics and a wide set of metrics which include;
  - ✓ Throughput,
  - ✓ Packet loss,
  - ✓ Delay,
  - ✓ Jitter
  - ✓ Error rate Wireless
- Constraints described above, pose extra difficulty in achieving the required QoS guarantee in a mobile ad hoc network.

FIRST IN FIRST OUT (FIFO)

- FIFO is an acronym for First In First Out.
- This expression describes the principle of a queue or first-come first serve behavior: what comes in first is handled first, what comes in next waits until the first is finished etc.
- Thus it is analogous to the behavior of persons "standing in a line" or "queue" where the persons leave the queue in the order they arrive.
- FIFO is the most basic queuing discipline.
- In FIFO queuing, all packets are treated equally by placing them into a single queue, then servicing them in the same order they were placed in the queue. FIFO queuing is also referred to as First Come First Serve (FCFS) queuing

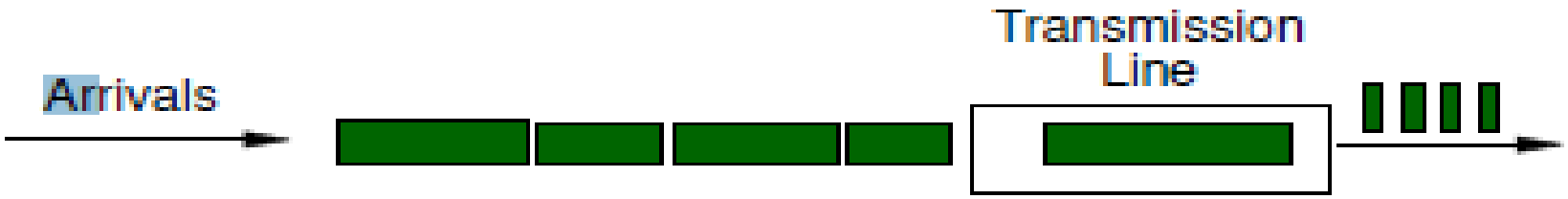


Figure 1: FIFO queuing

FIFO offers the following **benefits;**

- Low computational load on the system when compared with more elaborate queue scheduling algorithms.
- Behavior of the queue is predictable. Packets are not re-ordered and maximum delay is determined by maximum depth of the queue.
- As long as the queue remains short, it provides a simple contention resolution for network resources without adding significantly to queuing delay experienced at each hop.

FIFO CONT…

However, it has **limitations** which include;

- Does not allow routers to organize buffered packets and serve them in classes of urgency and priority.
- A single FIFO queue impacts all flows equally because the mean queuing delay for all flows increases as congestion increases Mean queuing delay of all queues increases as the queue increases hence an impact to all flows.
- During congestion, there is increased delay, jitter and reduction in throughput.
- A burst flow can consume the entire buffer space of a FIFO queue. That denies all other flows to be denied service till that burst is served.

PRIORITY QUEUING

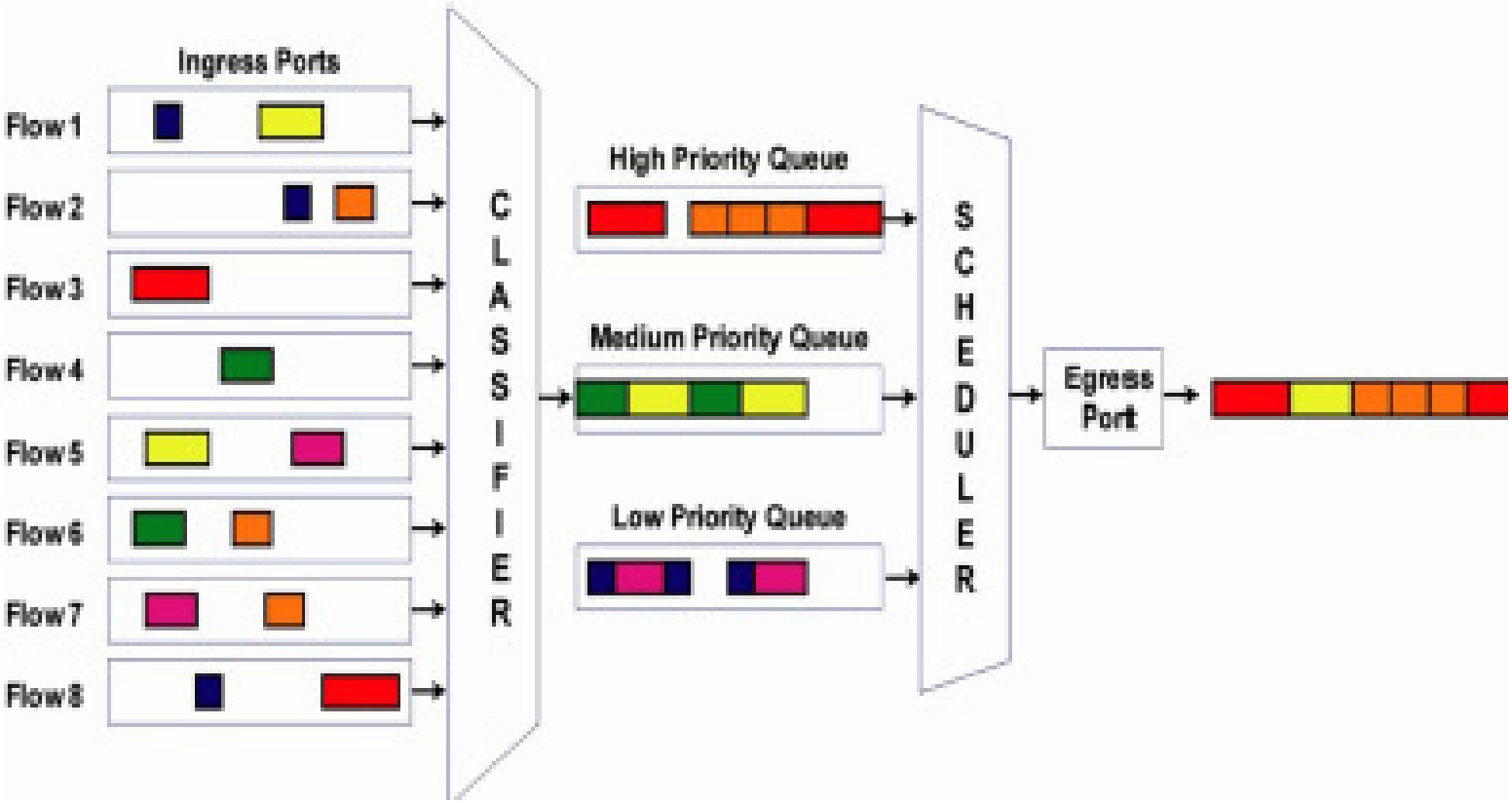


Figure 2: Priority Queuing system

PRIORITY QUEUING CONT…

- Priority queuing assigns multiple queues to a network interface with each queue being given a priority level.
- A queue with higher priority is processed earlier than a queue with lower priority.
- Priority Queuing can have four preconfigured queues: **high, medium, normal and low** priority queue.
- When a packet is sent out on an interface, the priority queues on that interface are scanned for packets in descending order for priority.
- The high priority queue is scanned first, then the medium priority queue and then so on.
- The packet at the head of the highest priority queue is chosen for transmission.

WEIGHTED FAIR QUEUING (WFQ)

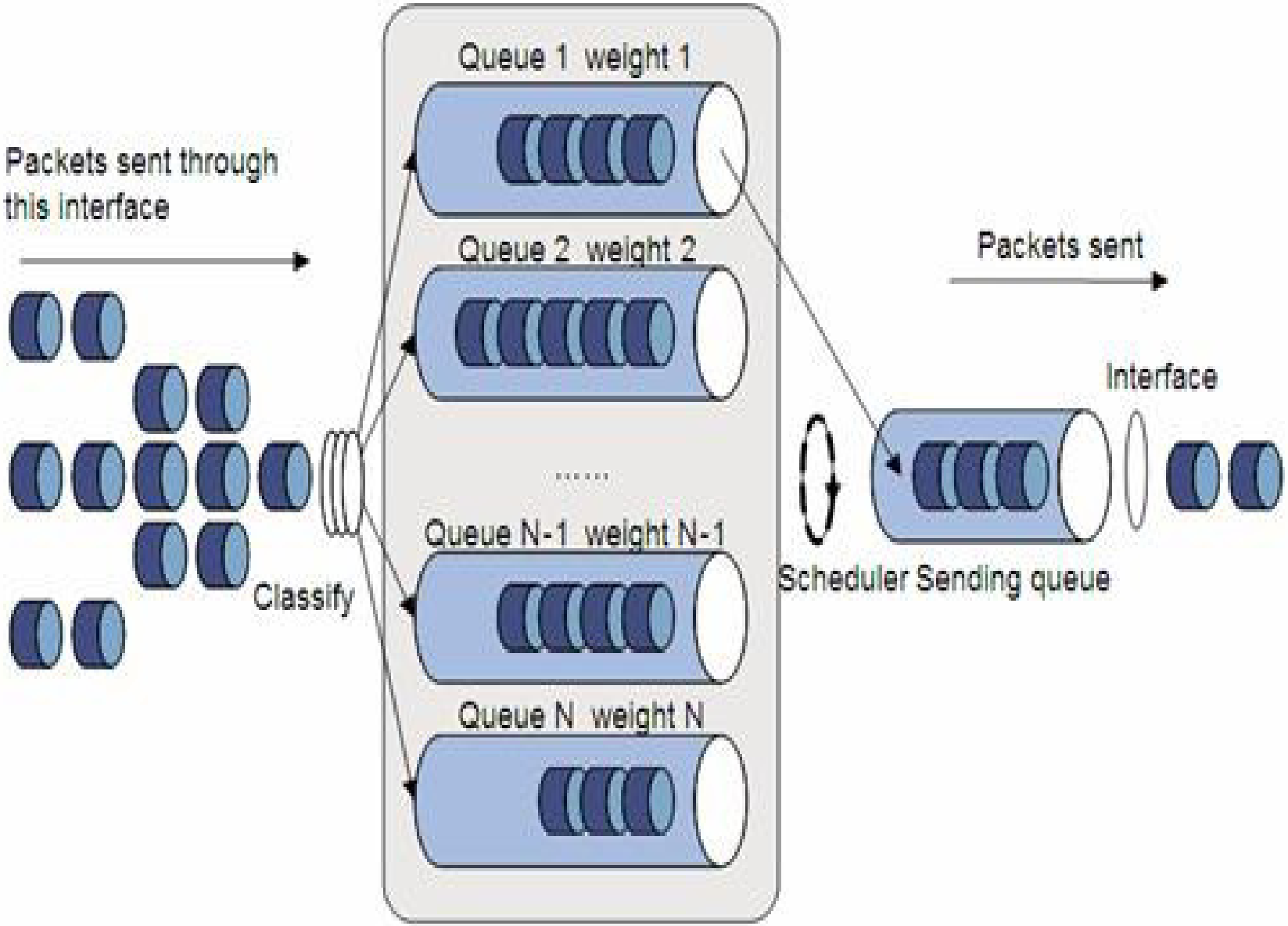
- Is a data packet scheduling technique allowing different scheduling priorities to statistically multiplexed data flows.
- WFQ is a generalization of fair queuing (FQ)
- As opposed to FQ, WFQ allows different sessions to have different service shares.
- If data flows currently are active, with weights data flow number will achieve an average data rate of;

$$\frac{Rw_i}{(w_1 + w_2 + ... + w_N)}$$

where average data rate= R/N.

- In WFQ, the priority given to network traffic is inversely proportional to the signal bandwidth.
- Thus, narrowband signals are passed along first, and broadband signals are buffered.

WFQ Cont…


Queue 1 weight 1
Packets sent through this interface
Queue 2 weight 2
Packets sent
Interface
Queue N-1 weight N-1
Classify
Scheduler Sending queue
Queue N weight N

OPNET

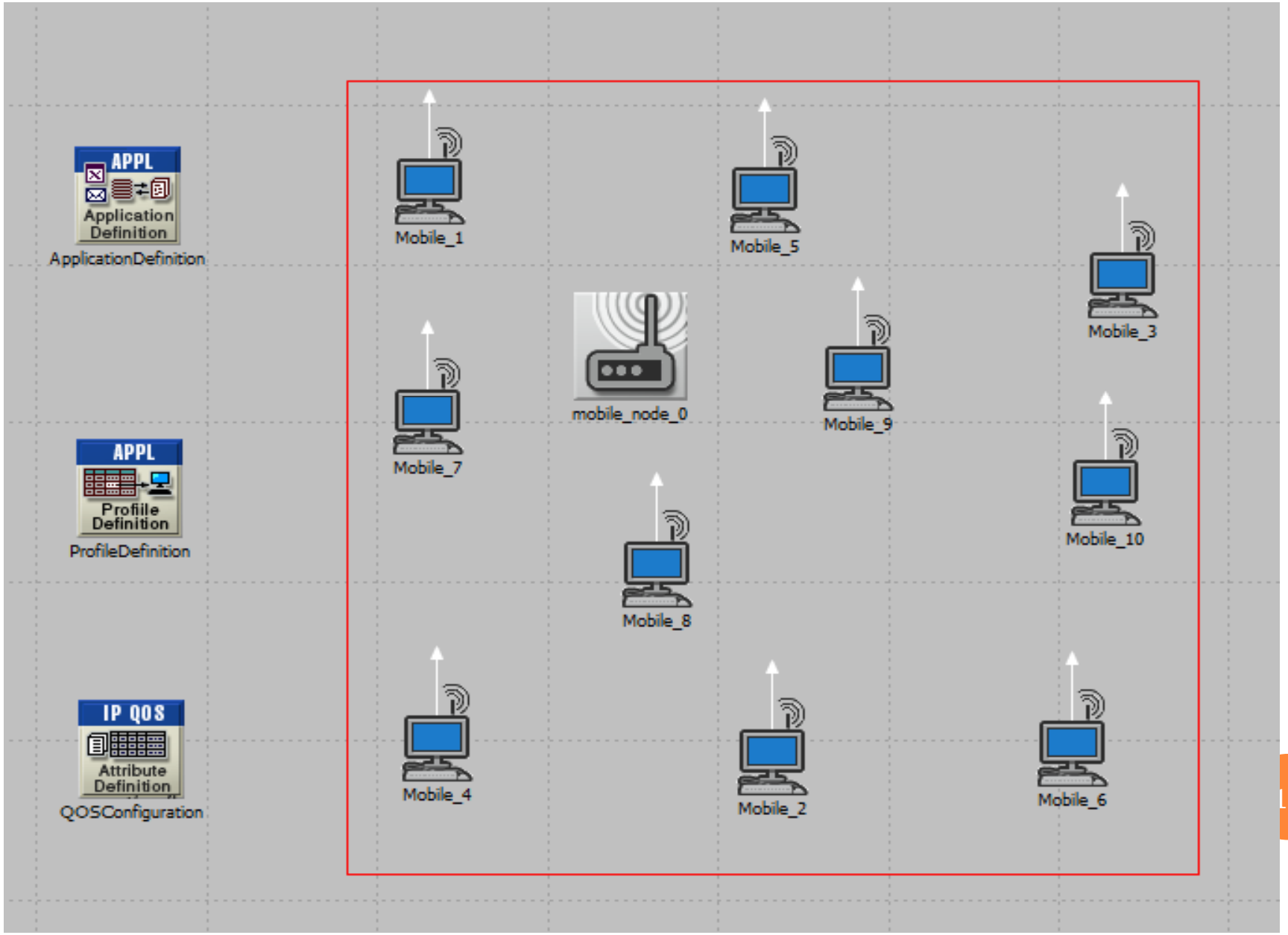
- Optimized Network Engineering Tool (OPNET) is a top discrete event network simulator used both by research and commercial communities
- It provides a wide-ranging framework for modeling wired and wireless network scenarios.
- Simulation models are organized in a hierarchy consisting of three main levels: the simulation network, node models and process models.
- The top level refers to the simulation scenario or simulation network. It defines the network layout, the nodes and the configuration of attributes of the scenario nodes.
- the second level consists of set of modules describing the various functions of the node.
- The modules in the nodes are implemented using process models, the lowest level in the hierarchy.

NETWORK DESIGN AND CONFIGURATIONS

- A MANET network comprising of 10 mobile nodes was set up. Each node is configured to move randomly at a speed of 5m/s within an area of 1000 square meters

PARAMETER	VALUE
Data Rate	2 Mbps
Transmit Power	0.005 Watts
Packet reception power threshold	-95 dB
Buffer size	64 000
Mobility	Random at 5m/s

NETWORK DESIGN AND CONFIGURATIONS



NETWORK DESIGN AND CONFIGURATIONS

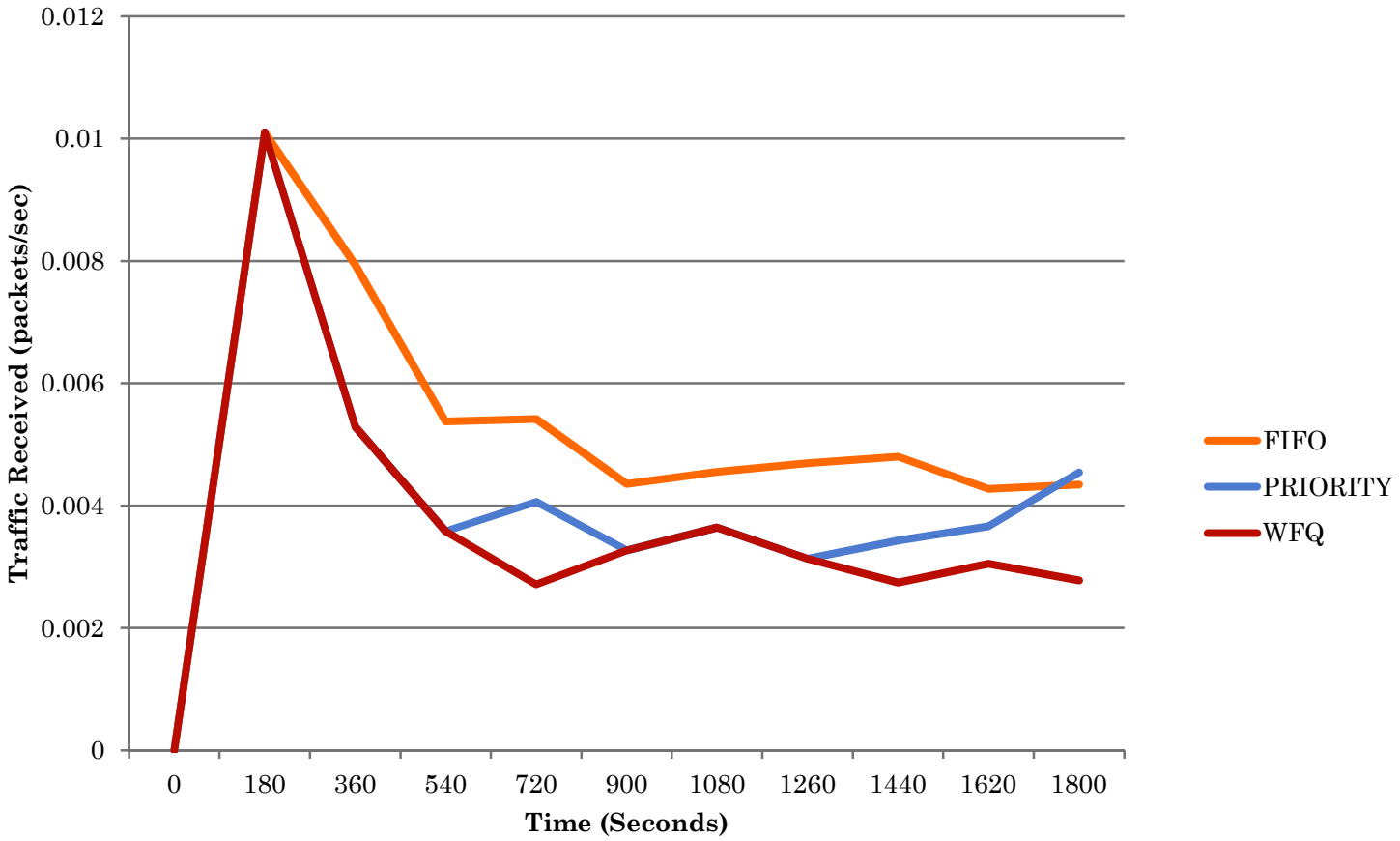
- A VoIP application is configured to run between two mobile nodes 1 and 2.
- A file transfer application is configured to run between nodes 3 and 4.
- A HTTP application is configured to run between two mobile nodes 5 and 6

PARAMETER	VALUE
Encoder Scheme	G.711
Voice Frames Per Packet	2
Compression Delay	0.02 Seconds
Decompression Delay	0.02 Seconds

SIMULATION RESULTS : FILE TRANSFER APPLICATION

	FIFO	PRIORITY	WFQ
time (sec)	Traffic Received (packets/sec)	Traffic Received (packets/sec)	Traffic Received (packets/sec)
0	0	0	0
180	0.01010101	0.01010101	0.01010101
360	0.007936508	0.005291005	0.005291005
540	0.005376344	0.003584229	0.003584229
720	0.005420054	0.004065041	0.002710027
900	0.004357298	0.003267974	0.003267974
1080	0.004553734	0.003642987	0.003642987
1260	0.004694836	0.00312989	0.00312989
1440	0.004801097	0.003429355	0.002743484
1620	0.004273504	0.003663004	0.003052503
1800	0.004346234	0.004544445	0.002778938
AVERAGE	0.005078238	0.004065358	0.003663823

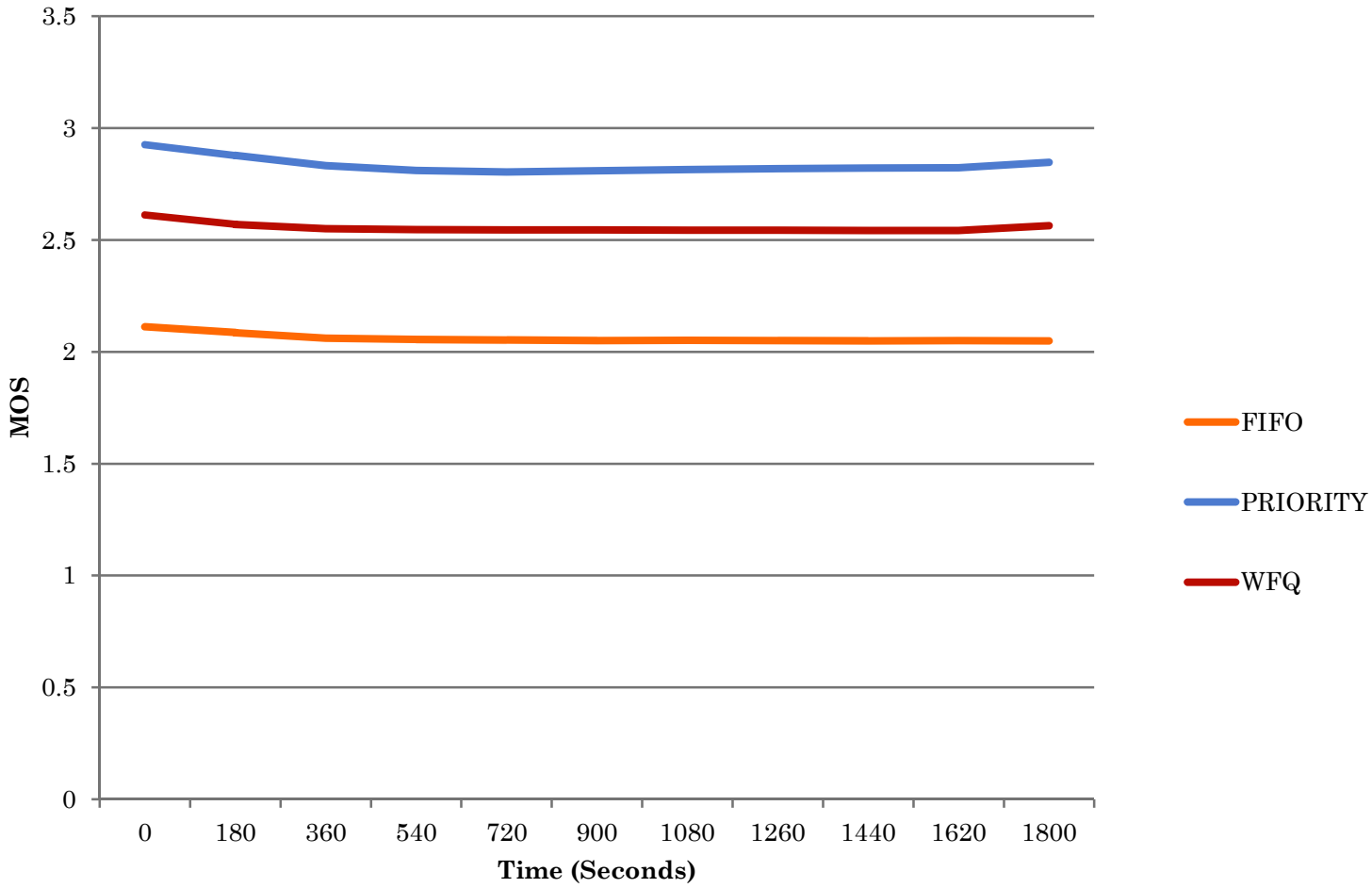
SIMULATION RESULTS : FILE TRANSFER APPLICATION



SIMULATION RESULTS : VOIP APPLICATION

time (sec)	MOS (FIFO)	MOS (PQ)	MOS (WFQ)
0	2.111223529	2.926062977	2.611526346
180	2.0856879	2.877679164	2.569556072
360	2.061340048	2.831882409	2.550853814
540	2.054901668	2.810507024	2.546094767
720	2.053242482	2.803890282	2.54506305
900	2.050786474	2.809749892	2.545509597
1080	2.051241515	2.815230855	2.543741835
1260	2.050209366	2.818934291	2.543070526
1440	2.049230941	2.820899463	2.542304635
1620	2.049717767	2.822209042	2.542003867
1800	2.048940628	2.846757467	2.563431539
AVERAGE	2.060592938	2.834891169	2.554832368

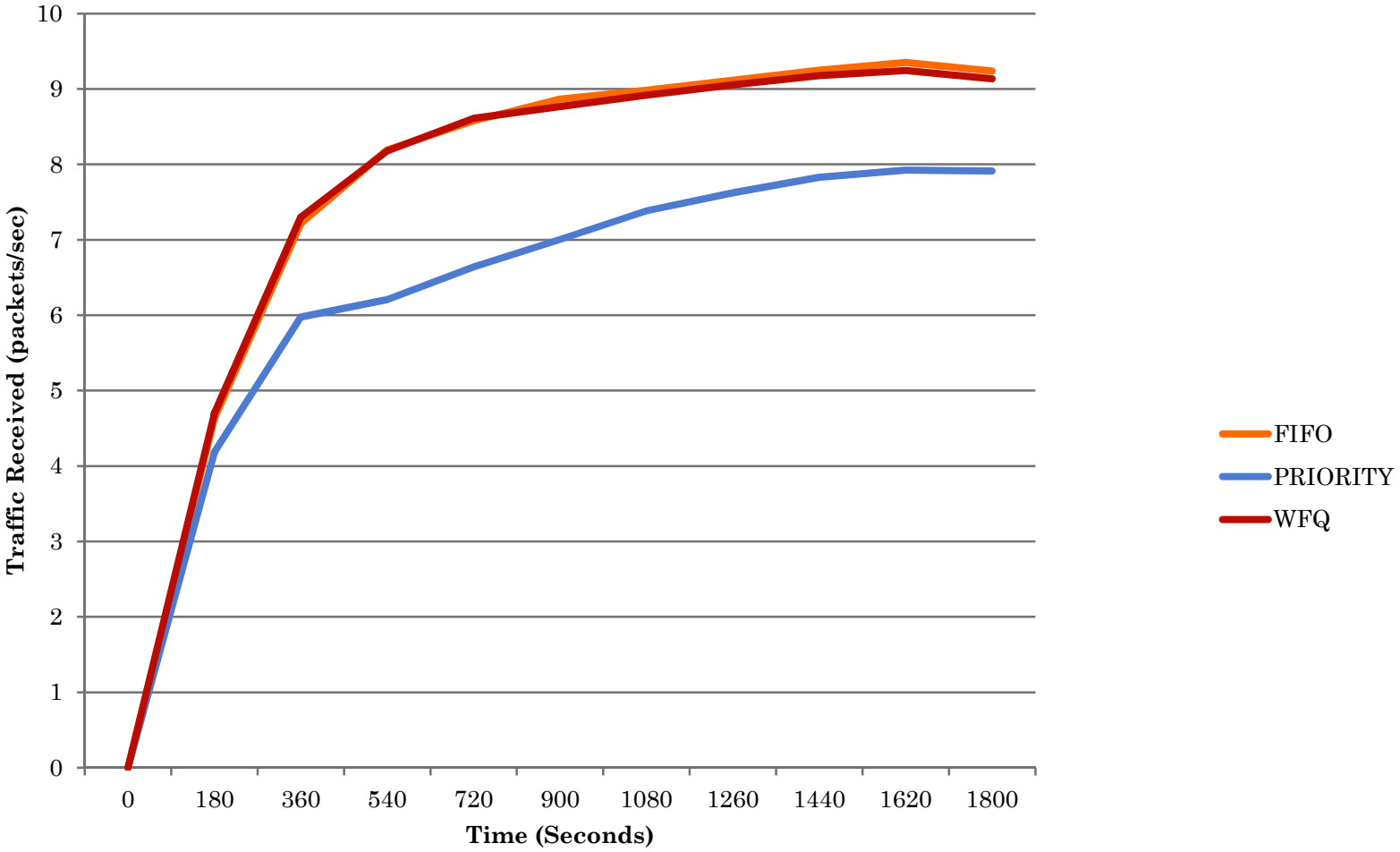
SIMULATION RESULTS : VOIP APPLICATION



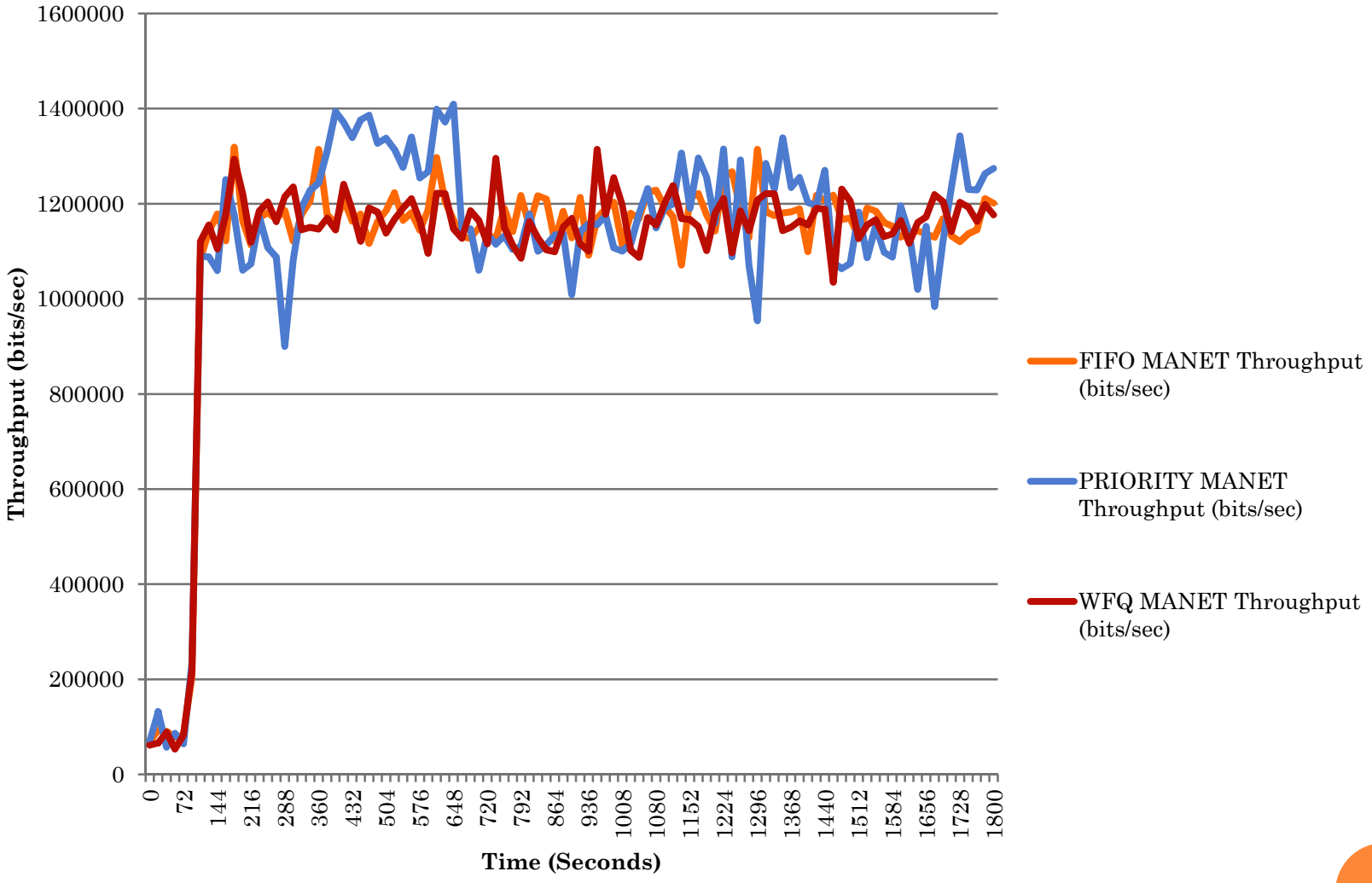
SIMULATION RESULTS : HTTP APPLICATION

	FIFO	PRIORITY	WFQ
Time (sec)	Traffic Rcvd (pkts/s)	Traffic Rcvd (pkts/s)	Traffic Rcvd (pkts/s)
0	0	0	0
180	4.631313131	4.181818182	4.696969697
360	7.216931217	5.976190476	7.298941799
540	8.193548387	6.207885305	8.177419355
720	8.577235772	6.640921409	8.612466125
900	8.867102397	7.004357298	8.767973856
1080	8.982695811	7.386156648	8.918943534
1260	9.116588419	7.624413146	9.05399061
1440	9.247599451	7.827846365	9.17558299
1620	9.34981685	7.923076923	9.246031746
1800	9.23681685	7.912765653	9.136236032
AVERAGE	7.58360439	6.244130128	7.553141431

SIMULATION RESULTS : HTTP APPLICATION



SIMULATION RESULTS :OVERALL NETWORK THROUGHPUT



RESULTS ANALYSIS : FILE TRANSFER

- Each application set up is simulated for 30 minutes.
- For the file transfer application, FIFO seems to deliver a higher number of packets followed by PQ.
- However, towards the end of the simulation period, PQ overtakes the FIFO and delivers a higher number of packets per second.
- In the voice application, PQ gives the highest MOS value of 3, followed by WFQ at around 2,5 and finally FIFO with MOS values of 2.0.
- In HTTP application, FIFO and WFQ deliver almost the same number of packets per second throughout the simulation period. The results are above those of PQ.
- In general, best throughput is from the PQ as seen in figure of average throughput. The throughput is compiled from the average deliveries in each of the three applications for each of the queuing mechanisms

CONCLUSION

- After the comparison of the results of the simulations, its clear that Priority queuing is found to yield better performance in the simulated MANET when compared to FIFO.
- Since MANETS require special attention when it comes to QoS, it is therefore important to note that the traditional FIFO mechanisms cannot guarantee this.
- PQ allows routers to organize buffered packets and then service one class of traffic differently from other classes of traffic.
- For example, one can set priorities such that real time applications such as, interactive voice and video, get priority over applications that don't operate in real time.

THE END