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ANALYSIS OF QUALITY OF SERVICE OF MOBILE AD-HOC NETWORKS USING DIFFERENT QUEUING POLICIES

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ABSTRACT
A wireless Ad-hoc network consists of wireless nodes communicating without the need for a centralized administration; all nodes potentially contribute to the routing process. The fragile and temporary nature of mobile ad-hoc connectivity makes quality of service a crucial issue. In this paper, mobile ad-hoc wireless network of 25 nodes were modelled using Riverbed Modeller for the purpose of evaluating quality of service performance of different queuing policies. The simulation results of four different scenarios of wireless ad hoc networks were reported. The quality of service of the different queuing policies were evaluated in terms of traffic received, network delay and throughput. In this simulation environment, priority queue and Weighted Fair Queuing (WFQ) scheduling performs better than First In First Out (FIFO) and custom queuing scheduling in terms of traffic received. On the other hand, Wireless Local Area Network (WLAN) delay in FIFO and Custom queuing scheduling is less than that of Priority queuing scheduling. The research concludes that the type of application in focus should be part of determinant factor for the choice of queuing mechanism. According to the result, FIFO is faster for applications that have fairly close time priority while time sensitive applications have to consider Priority queue or weighted queue scheduling.

Keywords: *Quality of Service; Queuing Policies; Throughput; Delay, Mobile Ad-hoc Network*

INTRODUCTION

A wireless Mobile Ad-hoc Network (MANET) consists of wireless nodes communicating without the need of centralized administration. A collection of autonomous nodes or terminals that communicate with each other by forming a multihop radio network and maintaining connectivity in a decentralized manner is called an ad-hoc network (Manoj, Parmanand, & Singh, 2009). There is no static infrastructure for the network, such as a server or a base station. The idea of such networking is to support robust, scalable and efficient operations in mobile wireless networks by incorporating routing functionality into mobile nodes. In an ad-hoc network, there are numerous combinations of transmission areas for different nodes. From the source node to the destination node, there can be different paths of connection at a given point in time.

The mobile nature of wireless networks makes topology of such networks change dynamically as mobile nodes join or depart the network. Wireless mobile ad-hoc networks, consisting of a collection of wireless nodes, all of which may be mobile, dynamically create a wireless network amongst themselves without using any infrastructure or administrative support. Very often, ad-hoc network refers to a mode of operation of IEEE 802.11 wireless networks (Leonidas, 2001). Figure 1 is a typical structure of Mobile Ad hoc network.

Ad-hoc wireless networks are self-creating, self-organizing, and self-administering. They come into being solely by interactions among their constituent wireless mobile nodes, and it is only such interactions that are used to provide the necessary control and administration functions supporting such networks. Mobile ad-hoc networks offer unique benefits and versatility for certain environments and certain applications. Since there is no fixed infrastructure, all nodes are allowed to be mobile. According to Basagni and Lee, (2002), the lack of infrastructure in ad-hoc networks, which differentiates ad-hoc networks from cellular networks, raises several research challenges. Each network node must act as a router and packet forwarder. If a node wishes to communicate with another node that is not within its transmission range, it must build a multihop route and rely on intermediate neighbouring nodes to forward the packet (Jasmeet & Singh, 2009).

Recently, one of the areas of interest in mobile ad-hoc networks is the provision of Quality of Service (QoS) guarantees. The first aspect of QoS is related to routing for which much research has been done and many different routing protocols have been proposed in the current literature. Secondly, QoS is affected by the queuing policy/algorithm implemented. In this research four different queuing algorithms are applied to a model of MANET as a means of evaluating the performance of these algorithms in providing QoS guarantees.

Fig. 1: Sample Architecture of MANET (Kebande, 2013)

The availability of modelling and simulation tools to aid research these days, make network building and evaluation a virtual type that incur very little infrastructure expenses. One of these research tools is Riverbed Modeller, previously known as OPNET modeller which was used for this research. Riverbed's Modeller provides a Virtual Network Environment that models the behaviour of different type of networks, including its routers, switches, protocols, servers and individual applications from different technologies. By working in the Virtual Network Environment, IT managers, network and system planners, and operations personnel are empowered to diagnose difficult problems more effectively, validate changes before they are implemented, and plan for future scenarios including growth and failure. For the purpose of this research, a mobile ad-hoc network was modelled and simulated using the following queuing policies: Priority Queue, Weighted Fair Queuing (WFQ), First In First Out (FIFO) and Custom Queuing.

The rest of the paper is structured as follows: section two consist of review of quality of services and queuing policies, Section three contains the research methods and materials, Section four has Result and discussions, while Section five concluded the research.

QUALITY OF SERVICE IN MOBILE AD-HOC NETWORK

Quality of Service defines a set of criteria used to classify the level of service allotted to an application. These criteria include data rate, and round trip delay and packet loss. Quality of Service is the ability to provide different priorities to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. The term quality of service also refers to the physical parameters and settings which ensure the good quality of service to user applications as the case demands (Jasmeet & Singh, 2009).

QoS guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over IP (VOIP). In the case of ad-hoc networks, where the topology is decentralized, the QoS requirements are even more difficult to ascertain; the node transmitter should first of all obtain access to the common wireless medium, overcome hidden/exposed station effects and then assure bandwidth and/or bounded delay.

Queuing Policies

A queuing model or discipline can be described as the technique used in determining the waiting period of a packet after its arrival (if it is not immediate), and its departure from the system after being served. It is the principle behind the prioritization of voice packets over data packets. This principle is what the channel performs as the traffic arrives from both voice and data to the channel to be served (Bhalla, Monga, & Malhotra, 2012).

The queuing discipline determines which packet is selected from the queue for processing when a server becomes available. It plays an important role in providing Quality of Service guarantees. Some of the most common queuing disciplines considered in this researh are FIFO, Priority Queuing and WFQ.

First in First Out (FIFO)

FIFO queuing is a basic queue scheduling policy where all packets are treated equally by placing them into a single queue, and then servicing them in the same order that they were placed into the queue. FIFO queuing is referred to as First come, first served (FCFS) queuing. FIFO embodies no concept of priority or classes of traffic and consequently makes no decision about packet priority. There is only one queue, and all packets are treated equally. Packets are sent out to an interface in the order in which they arrive. Higher priority packets are not transmitted faster than lower priority packets. When FIFO is used, ill-behaved sources can consume all the bandwidth, busty sources can cause delays in time-sensitive or important traffic, and important traffic can be dropped because less important traffic fills the queue (Sobrinho & Krishnakumar, 1999).

Priority Queue (PQ)

Priority queuing supports some number of queues, usually from high to low. Queues are serviced in strict order of queue priority, so that high queue always is serviced first, than the next-lower priority and so on. If a lower-priority queue is being serviced and a packet enters a higher queue, that queue is serviced immediately. This mechanism is good for important traffic, but can lead to queue starvation. PQ guarantees strict priority in that it ensures that one type of traffic will be transmitted, possibly at the expense of all others. For PQ, a low priority queue can be detrimentally affected, and, in the worst case, never allowed to transmit its packets if there is a limited amount of available bandwidth or if the transmission frequency of critical traffic is high (Jasmeet & Singh, 2009).

Custom Queuing

Custom Queuing (CQ) assigns a certain percentage of the bandwidth to each queue to assure predictable throughput for other queues. It is designed for environments that need to guarantee a minimal level of service to all traffic. CQ allows you to specify a number of bytes to forward from a queue each time the queue is to be serviced, thereby allowing you to share the network resources among applications with specific minimum bandwidth or latency requirements. You can also specify a maximum number of packets in each queue.

CQ handles traffic by specifying the number of packets or bytes to be serviced for each class of traffic. It services the queues by cycling through them in round-robin fashion, sending the portion of allocated bandwidth for each queue before moving to the next queue. If one queue is empty, the routing protocol will send packets from the next queue that has packets ready to send (Cisco IOS Release, 2009).

Weighted Fair Queue (WFQ)

Weighted Fair Queuing (WFQ) allocates a percentage of the output bandwidth equal to the relative weight of each traffic class during periods of congestion. WFQ offers dynamic, fair queuing that divides bandwidth across queues of traffic based on weights. WFQ ensures that all traffic is treated fairly, given its weight. WFQ ensures satisfactory response time to critical applications, such as interactive, transaction-based applications, that are intolerant of performance degradation (Bhalla, Monga, & Malhotra, 2012) .

WFQ is an automated scheduling method that provides fair bandwidth allocation to all network traffic. WFQ applies priority or weights to identified traffic to classify traffic into conversations and determine how much bandwidth each conversation is allowed relative to other conversations. WFQ is a flow-based algorithm that simultaneously schedules interactive traffic to the front of a queue to reduce response time and fairly shares the remaining bandwidth among high-bandwidth flows. In other words, WFQ allows you to give low-volume traffic, such as Telnet sessions, priority over high-volume traffic, such as FTP session (Cisco IOS Release, 2009).

MATERIALS AND METHODS

This section highlights the tool and the procedures used for the network design, simulations and traffic analysis. The tool is Riverbed's Modeller and the procedures comprises of modelling with the wireless Ethernet Technologies, Application configuration, Profile configurations and settings, QoS policies implementation and scenarios setups. This is depicted in Figure 2.

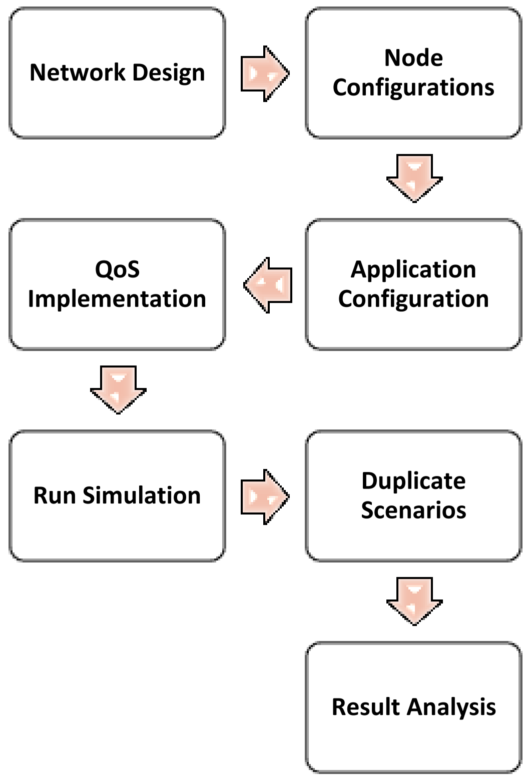

Fig. 2: Procedural Flow

Modelling of wireless Network using Riverbed Modeller

Riverbed's Modeller provides a Virtual Network Environment that can be used to model a wide range of networks and their behaviours with availability of several network devices from different technologies such as Ethernet and CISCO. By using this modeller, a wireless network of 25 nodes was modelled in the Virtual Network Environment. The network set up configured in four scenarios varying network parameters to evaluate the performance of queuing policies.

Wireless Network Model

Figure 3 is a model of ad-hoc wireless network of mobile nodes. The communication between the nodes does not have rigid specific paths. Each node is configured to participate in routing services. The model comprises of 25 wireless mobile nodes icons, QoS icon, Profile Configuration symbol and Application Configuration icon.

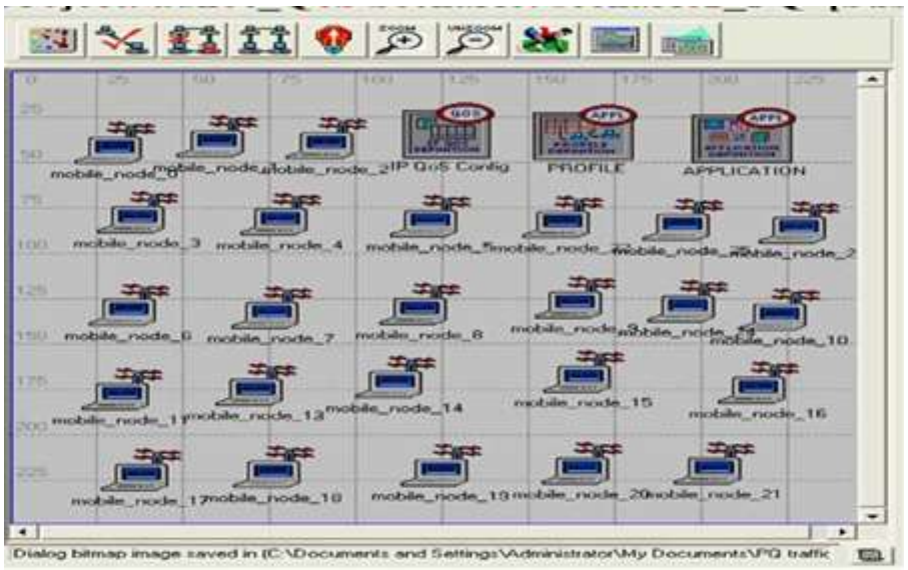

Fig. 3: A Model of Ad-Hoc network, using OPNET.

Quality of Service Configuration

The QoS attribute Configuration object defines profiles for the following technologies: FIFO, WFQ, (CQ) and (PQ). Each queuing-based profile (e.g., FIFO, WFQ, PQ, CQ) contains a table in which each row represents one queue. Each queue has many parameters such as queue size, classification scheme etc. Some examples of setting queue priorities are:

a) Weight for WFQ profile. Higher priority is assigned to the queue with a higher weight.

b) Byte count for Custom Queuing profile. More traffic is served from the queue with a higher byte count.

c) Priority label for Priority Queuing. Higher priority is assigned to the queue with a higher priority label.

Application Configurations

Application Configuration is used to specify applications that will be used to configure user profiles. Even though there are different possible applications which can be configured, like database access, email, file transfer, file print, telnet session, video conferencing, ftp low and high priority applications were chosen for individual clients. **Table 1** shows Simulation Environment common to all Scenarios

Table 1. Application configuration settings from Riverbed (OPNET) model.

Area	250M by 250m
Packet Reception	7.33E-14
Buffer size	256k
Fragmentation threshold	512
Data rate	2Mbps
Number of nodes	25

QoS Configurations

A scenario is created for each queue algorithm implementation, Tables 2 to 5 indicate the configuration for different queue policies.

Table 2. Scenario 1 Peculiar Configuration for Priority Queue Implementation

Number of nodes	25 wireless mobile nodes
Queue Scheduling	Priority Queue policy at QoS interface
Area	250M by 250m
Packet Reception	7.33E-14
Buffer size	256k
Fragmentation threshold	512
Data rate	2Mbps
Number of nodes	25 wireless mobile nodes

Table 3. Scenario 2 Peculiar configuration for WFQ Implementation

Queue Scheduling	Weighted fair Queue policy at QoS interface
Area	250M by 250m
Packet Reception	7.33E-14
Buffer size	256k
Fragmentation threshold	512
Data rate	2Mbps

Table 4. Scenario 3 Peculiar Configuration for FIFO Implementation.

Queue Scheduling	FIFO Queue policy at QoS interface
Area	250M by 250m
Packet Reception	7.33E-14
Buffer size	256k
Fragmentation threshold	512
Data rate	2Mbps
Number of nodes	25 wireless mobile nodes

Table 5. Scenario 4 Peculiar Configurations for Custom Queue

Queue Scheduling	Custom Queue policy at QoS interface
Area	250M by 250m
Packet Reception	7.33E-14
Buffer size	256k
Fragmentation threshold	512
Data rate	2Mbps
Number of nodes	25

Evaluation Parameters

Many things can happen to packets as they travel from origin to destination or sender to receiver resulting in the either acceptable or poor QoS. The following parameters can therefore be used to measure a network's quality of service:

a) Traffic Received is used to measure the total number of packets received by a node in relation to the total packets sent.

b) Delay is measured in multiple fractions of seconds and determines the total time it takes for a packet to move across the network.

c) Throughput which is usually measured in bits per second (bps) or data packets per second indicates the level of successful transmission of packets from one network node to the other.

RESULTS AND DISCUSSIONS

The evaluation was reported based on average performance of the queuing mechanism across various application scenarios. Figure 4 is the snapshot of network delay (sec) for the different queuing mechanisms. Figure 5 is the network throughput showing a higher value for FIFO and CQ. The traffic received from all the queuing mechanisms are displayed in Figure 6. This indicates that the number of packet received in FIFO and CQ correspond with the higher throughput obtained.

Network Delay of the Four Queuing Scenarios

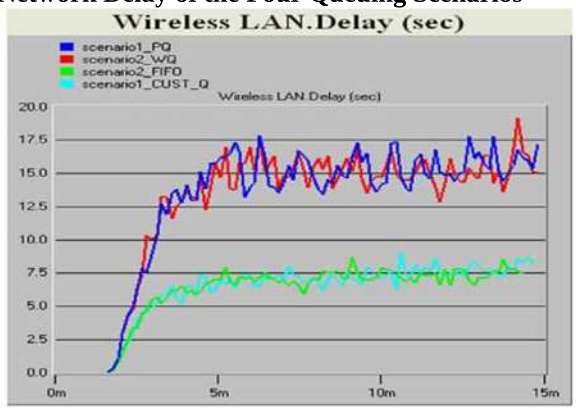

Fig. 4: The network delay of the four scenarios.

Network Throughput

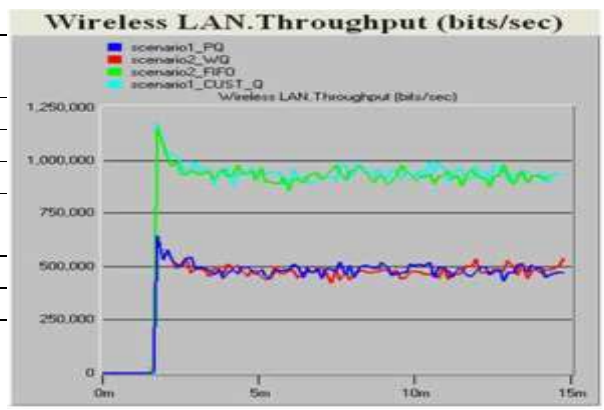

Fig. 5: The network throughput of the four scenarios.

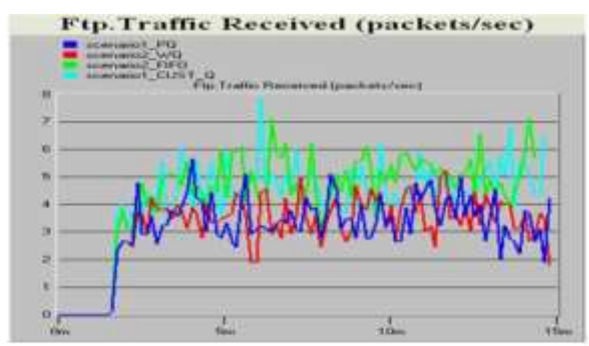

Fig. 6: The traffic received of the four scenarios.

From the result displayed, the network transmission is stable for all the queuing mechanisms. Considering the average traffic received, FIFO and custom queuing scheduling recorded a higher throughput and at a very close range. This reveals that the applications deployed have timing demand that are not far in sensitivity to each other. The average WLAN delay in FIFO and custom queuing scheduling is also less than that of Priority and Custom queuing scheduling. Priority queue gave the highest priority to time sensitive applications and this subsequently make low priority applications to suffer starvation.

CONCLUSION

The type of queue policy to be implemented in quality of service interface should actually depend on the type of application in focus. If all the data to be transmitted actually need equal attention, the FIFO queue policy might be appropriate. Time sensitive applications will definitely have to implement alternative policy like PQ to enable real time applications have the required Quality of service.

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