ISSN 1512-1232

DESIGN AND ANALYSIS OF NETWORK MODELS FOR QOS ROUTERS ON UDP AND CBR

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Abstract

To address the issues of packet delay and unfairness among multimedia UDP flows, this paper presents the design and evaluation of network models to study different parameters for quality-of-service (QoS) provisioning in differentiated service (DiffServ) routers using user datagram protocol (UDP) as network traffic agent and constant bit rate (CBR) as traffic generator. Traffic marker algorithms are used to define the treatment an incoming traffic (packet streams) receives at the edge routers in a DiffServ domain. In order to implement the TSW2CM and TSW3CM marker algorithms, a network model was designed. The designed models were simulated, analysed and evaluated. For the purpose of evaluation, packet delay and fairness index were considered. The obtained evaluation results were analysed based on a ranking system approach to showcase the strengths and weaknesses of the TSW2CM and TSW3CM algorithms for multimedia UDP flows. The adopted approach showed that the TSW3CM algorithm was ranked first with a packet delay value of 0.237704 while TSW2CM algorithm was marked second (with 0.431778), and the TSW3CM algorithm was ranked first with a fairness rate value of 0.3823960 while TSW2CM algorithm was ranked second (with 0.2817353). The obtained results indicate that applications that requires low packet delay can be deployed on UDP protocol using TSW3CM algorithm while applications that requires high fairness rate values can be deployed on UDP protocol using TSW3CM algorithm.

Keywords: *Internet QoS, fairness rate, TSW2CM, TSW3CM, IETF, packet delay.*

1. Introduction

The influx of multimedia applications such as Video on Demand (VoD), Voice over Internet Protocol (VoIP), to mention a few, on the Internet in recent years has increased astronomically and this demands for Quality of Service (QoS) assurance due to the sensitive nature of these applications and their varying QoS requirements such as packet delay rate, packet loss rate, fairness, throughput [1]. These applications transits through a network as traffic and they are often confronted with congestive messages such as “try again or network busy” due to weaknesses of ancient TCP/IP protocol suite to provide QoS in a differentiated manner based on different traffic demands of incoming traffic stream. In order to meet the different QoS requirements of different multimedia applications, the Internet Engineering Task Force (IETF) came up with two Internet architectures, namely the integrated service (IntServ) architecture and the differentiated service (DiffServ) architecture [2]. The emergence of the IntServ can be described as an evolution of the

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best-effort service architecture. However, the IntServ architecture is confronted with a number of issues such as scalability which is mostly experienced in the core router. IEFT improved on this problem and came up with a new architecture called DiffServ. The DiffServ is able to provide a scalable edge-to-edge QoS within a single domain but it is also faced with unfairness problem that occur in DiffServ networks [3-5]. The DiffServ treats traffic (packet stream) through QoS service differentiation mechanisms namely the traffic classification and traffic conditioners. It uses a conditioner at the boundary of the DiffServ network to mark packets. Packets marking is done at the edge domains using traffic markers before traffic flows enters into the network core and packets are marked as either in-profile or out-profile. The traffic marker algorithm is used to define the treated to be accorded a traffic (packet streams) as it transverses through a DiffServ domain. Through IETF, time sliding window (TSW) based traffic marker algorithms have been proposed in recent years through Request For Comment (RFC), namely the Time Sliding Window Two Color Marker (TSW2CM) and Time Sliding Three Color Marker (TSW3CM). This study is aimed to analyse and evaluate the variants of TSW marker algorithms namely TSW2CM and TSW3CM on user datagram protocol (UDP) as network traffic agent for QoS assurance in the Internet.

Internet QoS

Quality of Service (QoS) is the capability of a network to provide resource assurance and service differentiation to meet the demands of time-sensitive applications that requires some guarantees to finish within a bounded time period such as VoIP, VoD and so on [6]. According to author in [7], QoS is defined as the collective effectiveness of service performance that determines the degree of satisfaction of an end user of a given service. The main essence of QoS in Internet is to provide priority such as dedicated bandwidth, controlled delay and jitter, as required by real-time traffic, and to improve packet loss rate. It is also important to make sure that providing priority to one or more flows does not make other flows fail. Moreover, QoS in Internet determine if the service offered by a network meets the users' quality demands. In this study packet delay and fairness rate were considered as QoS parameters for the experiments.

1. Traffic Classification and Conditioning

The traffic classification is done through classifiers, therefore, two types of classifiers are defined as the Behaviour Aggregate (BA) classifier and the Multi Field (MF) classifier. The task of a traffic classifier is to select a packet in a traffic stream based on some data carried in the packet's header and assign it to one of the service classes supported in the network. This implies that, the classification of traffics is done based on the information in the packet header. This is the first step taken at the ingress router to process packets. Also, the knowledge of the packet classifications is important in order to apply the appropriate metering, marking, shaping and dropping functions to each packet class according to the Service Level Agreement (SLA) [10]. The BA classifies packets based on the DSCP only and the MF classifier selects packets based on the value of a combination of one or more packet header fields. Also, the traffic conditioner contains essential components such as meter, marker, shaper, dropper, but it is not necessarily to contain all the four elements [7]. The traffic conditioning functions include metering, marking, shaping and dropping as illustrated in Figure 1. The traffic marker set the DS field of a packet to a particular code point based on the information from a classifier and meter. This implies that, a packet is assigned to a particular class of service (BA or MF) and may be marked as in-profile or out-profile. The in-profile packets are allowed to enter the network while the out-profile packets are further conditioned. Therefore, the marking of the packets determines the treatment a packet receives as it transverse (pass) through the network domain [10].

ISSN 1512-1232

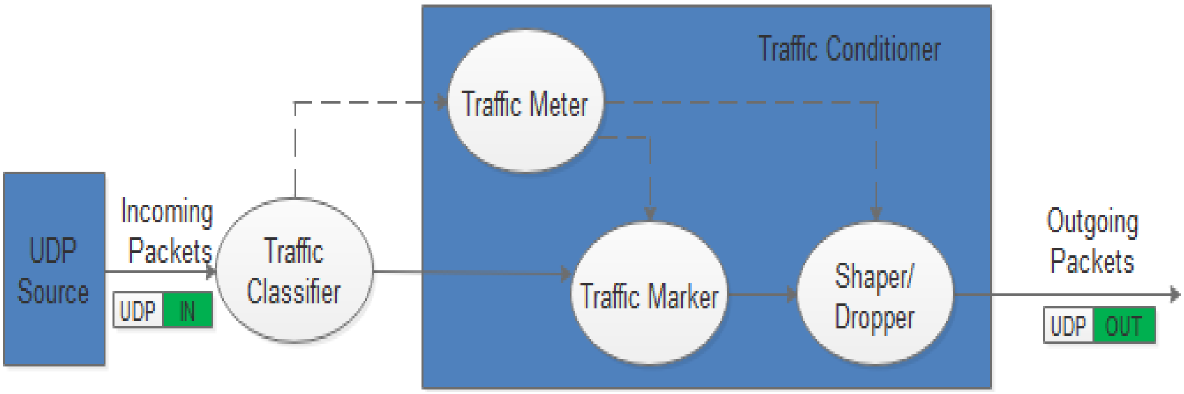

Figure 1: DiffServ traffic classifier and conditioner

2. Research Approach

In this study, a simulation approach was adopted to design and simulate the network model in Fig 4 to implement TSW2CM algorithm and TSW3CM algorithm so as to create a platform for comparison between the two variants of time sliding window marker algorithms on user datagram protocol (UDP) as network traffic agents while the constant bit rate (CBR) model was used for traffic generation. The designed network model was simulated using a software simulator called network simulator 2 (NS-2) which combines C++ and object tool command language (OTCL) together. OTCL was used as the front end to set up the simulation topology in order to accommodate varying of simulation parameters while the C++ programming language was used as the back end for algorithm simulation. In order to determine the strengths and weaknesses of TSW2CM algorithm and TSW3CM algorithm, throughput, fairness rate, packet loss rate and packet delay were used as performance metrics, and the data generated from the simulation experiments were traced into files, analysed and evaluated.

Network Design

The network topology in Figure 2 was used in this study to implement the algorithms of the variant of time sliding window of traffic maker algorithms (time sliding window 2 color marker (TSW2CM) and time sliding window 3 color marker (TSW3CM). In the network model, the same parameter settings were used to implement the two marker algorithms simulated (TSW2CM and TSW3CM) to create platform for comparison among the traffic marker algorithms. Moreover, since multimedia applications are expected to be routed through a core router, the user datagram protocol (UDP) was used in this study as the network traffic agents which requires no acknowledgement. The traffic sources (source nodes) were conditioned with different parameter settings and constant bit rate (CBR) was used to generate traffic from the four source nodes in Figure 2.

The network model designed consists of eight (8) nodes (four nodes are for sources, two nodes are for edge routers, one node core router and the remaining node is for destination). The node-to-node network links from sources to destinations were configured with bandwidths of 100Mbps and link delays of 5ms except from the core router C to the egress edge router E2 which was configured as 5Mbps of bandwidth and 5ms of link delay. The core router C to the egress edge router configuration was set to 5Mbps of bandwidth and 5ms of link delay to study the effect of congestions at the core router. The sources (P_1, P_2, P_3 and P_4) generated traffic streams (packets) with CBR for UDP traffic agents and send them to ingress edge router (E1). Each marker algorithm was implemented using the designed network in Figure 2. The core router C buffers the packets into respective queues using round robin scheduling discipline (a packet scheduler type) to forward them to respective destination node (**Dest**) through the egress edge router (E2). Network simulator-2 (ns-2) was used for the simulation which provides tools for visualization.

In terms of traffic agent, UDP was used to described the traffic type generated. The transmission mode used between sources and destinations are full duplex transmission modes while simplex transmission mode will be used between edge router and core router and also between core router and edge router. The model was implemented with UDP traffic agents using CBR. The simulation experiments were carried out for 80 seconds for each traffic marker algorithm implemented in the network model using sources with four different queues and the data generated in the course of the simulation were traced into files.

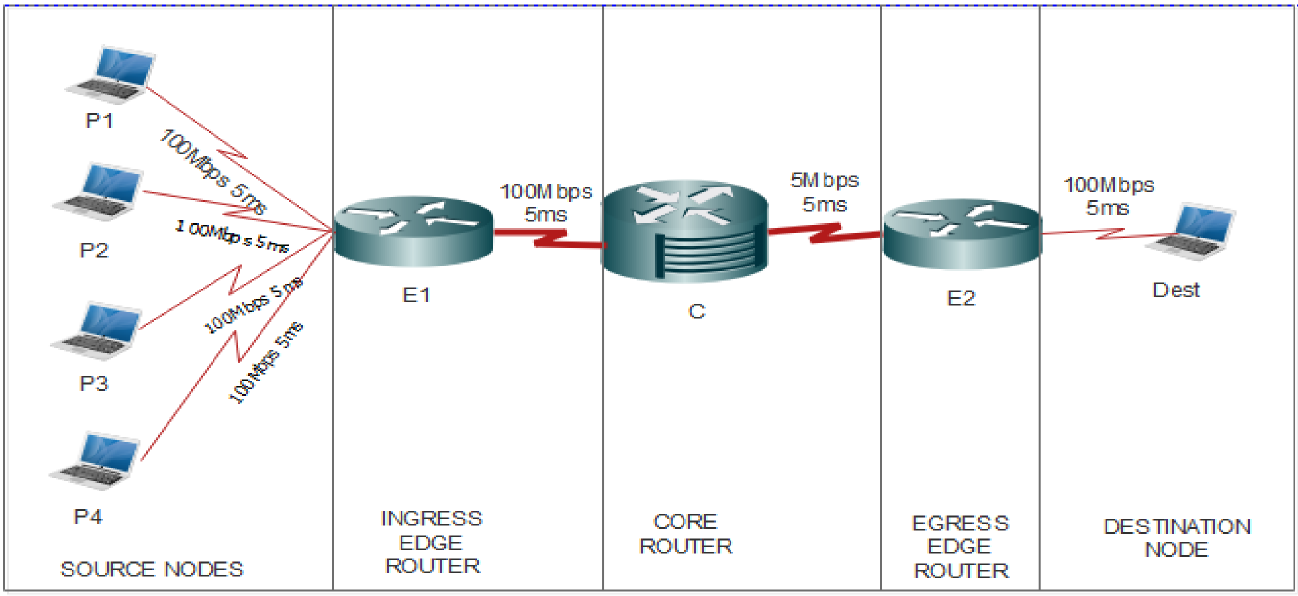

Figure 2: Network Topology

3. Results and Discussion

The evaluation of the simulation results obtained in this study were based on throughput, loss rate, fairness rate and jitter rate as performance metrics. The movement of the packets from core router (C) to edge router (E_2) in Figure 2 were traced into an output file for the purpose of analysis using the aforementioned metrics. The analysed results for the TSW2CM and TSW3CM algorithms using user datagram protocol (UDP) as the network traffic agents.

Analysis Based on Packet Delay

The packet delay was calculated by subtracting packets arrival time (a(n)) from the departure time (d(n)) as defined in Equation 1

$$\text{Packet delay } (\delta) \rightarrow d(n) - a(n) \quad (1)$$

The formula stated in Equation 1 was used to evaluate or calculate the packet delay for the two traffic marker algorithms using UDP as traffic agents. Table 1 and Figure 3 showed the packet delay evaluation for both traffic marker algorithms (TSW2CM and TSW3CM) using UDP as traffic agents. The lower the packet delay value using UDP traffic agents, the better the performance of the traffic marker. Using UDP as traffic agents, the delay of TSW3CM algorithm (with **0.237704**) was better than the delay of TSW2CM algorithm (with **0.431778**). Hence, applications that require low packet delay on UDP as traffic agents could use TSW3CM algorithm.

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Table 1: Packet delay evaluation using UDP as traffic agents

Traffic Markers	Packet Delay Values (Packets)	%	Rank
TSW2CM-UDP	**0.431778**	**43.1778%**	**1st**
TSW3CM-UDP	**0.237704**	**23.770%**	**2nd**

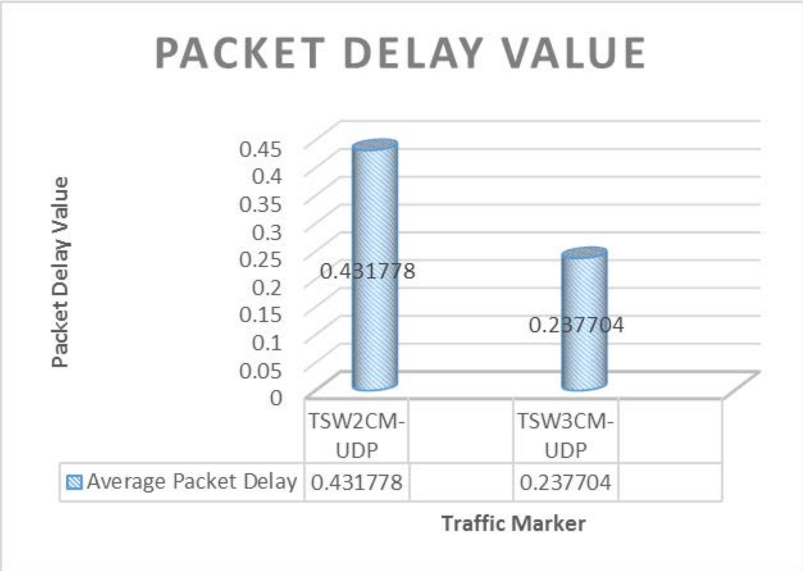

Figure 3: The packet delay for the traffic marker algorithms using UDP as traffic agent

Analyses Based on Fairness Rate

Among the different indices used to calculate fairness of the traffic marker algorithms, the Jain's fairness index (FI) formula in Equation 2 was used in this study to calculate the fairness rate among the queues (users)

$$FI = \frac{\Sigma(x_i + x_j)}{\Sigma\left((x_i)^2 + (x_j)^2\right) * N} \quad (2)$$

where:

FI defines the fairness index ($0 < F < 1$)

x_i defines the compliant packets,

x_j defines the non-compliant packets,

N is the total number of queues.

Moreover, the closer the fairness index is to1, the fairer the bandwidth distribution between sources.

The fairness rate of TSW3CM was ranked first (with **0.3823960**), while that of TSW2CM was ranked second (with **0.2817353**) using UDP as traffic agent. Table 2 illustrates the derived fairness values for TSW2CM and TSW3CM algorithms for a simulation experiment carried out in 80 seconds. Moreover, the simulation results in Table 2 were illustrated graphically in Figure 4 to describe the strength and weakness of the two time sliding variants algorithms. Therefore, using fairness rate analysis, TSW3CM marker algorithm emerged better between the two time sliding variants of traffic marker algorithms considered (TSW2CM and TSW3CM) with the higher fairness rate values using UDP as traffic agents. Hence, applications that require high fairness rate value on UDP traffic agent could use TSW3CM algorithm.

Table 2: Fairness rate evaluation using UDP as traffic agents

Traffic Markers	**Fairness Values (Packets)**	**%**	**Rank**
TSW2CM-UDP	0.2817353	28.17353%	**2nd**
TSW3CM-UDP	0.3823960	38.23960%	**1st**

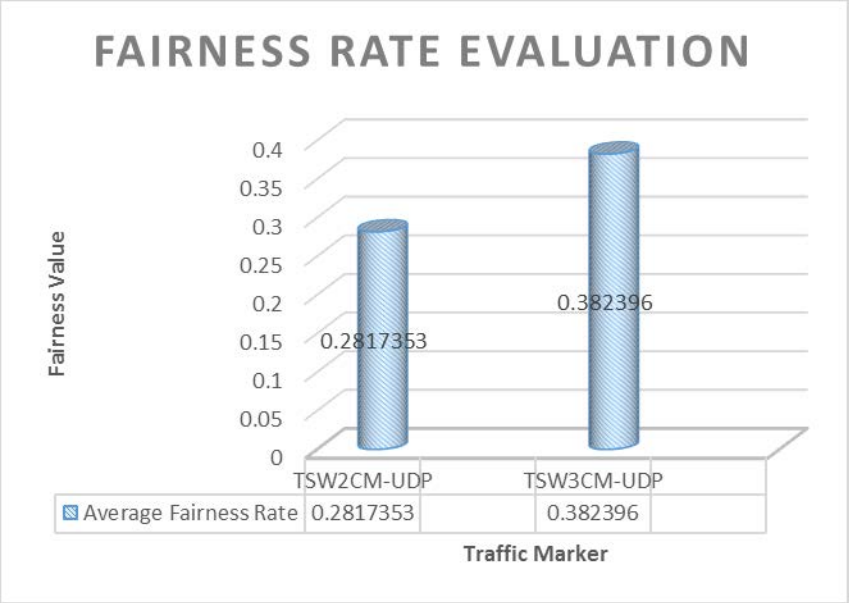

Figure 4: Fairness rate evaluation for traffic marker algorithms using UDP as traffic agents

4. Conclusion

This study has investigated the strengths and weaknesses of the existing traffic marker algorithms to determine their efficiencies for various applications (real-time and non-real time using packet delay and fairness rate as performance metrics, on user datagram protocol (UDP) and constant bit rate (CBR). Conclusively, applications that requires low packet delay can be deployed on UDP protocol using TSW3CM marker algorithm while applications that requires high fairness rate values can be deployed on UDP protocol using TSW3CM marker algorithm.

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Article received: 2017-03-22