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Investigation and Performance Analysis of Network Congestion Reduction based on FLC Controller

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Abstract- Qos has became one of the most important factors that governs the quality of network traffic. In this study, routers are deployed with data controllers to tackle the traffic congestion. The core router queue will be tested and monitored to decide if any action need to be taken to regulate the source data sending rate. This study does not depend on measuring the main parameters such as bandwidth, delay and packet loss, but it is focused on the max-min fairness and low queuing delay and the comparison between them.

Index Terms- Quality of service, throughput rate, traffic management, FLC, buffer queue, BW.

I. Introduction

Network traffic management refers to the set of controls within he network that regulate traffic flow for the reason of maintain the availability of the network during high levels of congestion [1], [2]. Qos is the end to end performance and is used to quantify the performance needed by host applications. As we all know that TCP (Transmission Control Protocol) is a widely used protocol [3] that tackles the network traffic. However, TCP encounters different issues regarding performance. As an alternative, other congestion control protocols have been suggested to control traffic congestion levels more accurately such as XCP [4], RCP [5], and Max Net [6]. These protocols are implemented in the routers and they provide link price rates to the sources then the final sending rate is decided by the source. However, most of these protocols have to calculate the bottleneck bandwidth in order to compute the allowed source sending link data. This process can cause significant fairness and congestion issues [7], [8]. Some of these explicit protocols compute the sending rate based on the queue size but ignore the active flows in a router, this will lead to CPU consumption and high memory utilization [10]. Imagine a million of active flows that coming into a router per hour, with the miscomputation above, this could lead to a performance degrading [9]. There are many ways to improve QoS, such as service priority by providing different service priority to different clients, but in this study we will focus on the Fuzzy logic implementation. Fuzzy logic is an approach that was introduced by Dr. Lotfi Zadeh of the University of California in the 1960s. Dr. Zadeh provided that fuzzy is an approach based on the degree of truth rather than the traditional Boolean logic which is based on (0 or 1). Fuzzy logic introduces the various states of truth between the 0 and 1. Fuzzy logic provides an approach based on expert knowledge which is closer to human decision making [12] Fuzzy logic control (FLC) was implemented into the network environment since 1990s. First it was used with the ATM network [11], [12]. Later, FLC was used with TCP/IP networks [13], [14], to reduce packet loss and better performance levels. In this study analysis, we are going to investigate a traffic management scheme that overcome the excessive resource consumption and provide better buffer queue management. In this study the only parameter for congestion censoring is the queue size.

II. Network Design and Analysis

We implement a design topology of interconnected network, the topology will consist of an access router which is connected to the host and core routers which provides end to end connectivity. The design that we are going to assume is that we have our traffic controller inside each router which acts as a traffic or data rate regulator by measuring the buffer size. The process starts by the source requesting a sending rate which is represented inside the packet header. This field can be updated by the router. Each router in the network will calculate an allowed transmission rate for the source according to the buffer size and then compare it to the value field in the packet. If the former is smaller than the latter, then the value in the packet header will be updated; otherwise it does not change.

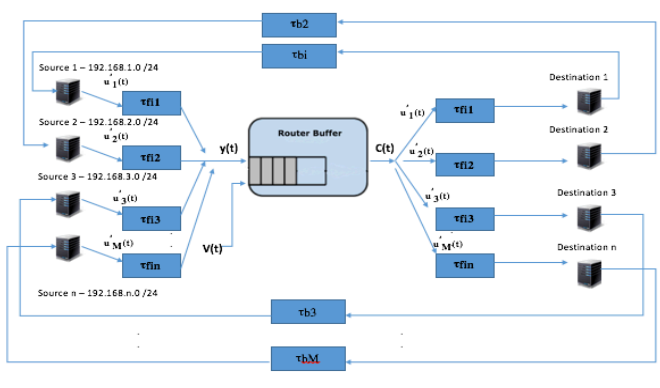

Fig. 1. Internal system model

In Fig. 1 we implement the model as M sources sending their network traffic to their respective destinations. For i = 1, 2, . . . , M, $u'_i(t)$ is the current sending rate of source i; $u_i(t)$ is the sending rate of source i determined by the routers along the end-to-end path; y(t) is the incoming controlled flow rate; v(t) is the incoming uncontrolled flow rate, and c(t) is the link bandwidth (measured in bps). For a particular source-destination pair i, τ_{fi1} is the time delay of a packet from source i to the router, and τ_{fi2} is the time delay of the packet of source i from the router to the destination i, and τ_{bi} is the feedback delay from destination i back to source i. As we can see, $\tau_{pi} = \tau_{fi1} + \tau_{fi2} + \tau_{bi}$ is the RTPD (Round Trip Propagation Delay). Let q(t) be the router buffer size. The variations in y(t) and/or c(t) can cause changes in the queue size of a router, as expressed in the following equation: We assume that the destination have enough space to receive any data from the source to eliminate any issues that may be caused by the destination on the source when requesting a sending rate. Also the sending process in this scheme will be based on the FIFO (First-In-First-Out). The following formulas is based on the block diagram below:

$$\dot{q}(t) = \begin{cases} y(t) + v(t) - c(t) & q(t) > 0 \\ [y(t) + v(t) - c(t)]^{+} & q(t) = 0 \end{cases}$$

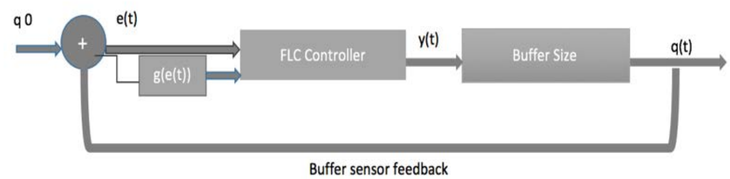

Fig. 2. FLC control system design

III. FLC Controller Scheme

A. Design Overview

In Fig. 2., The Target Buffer Occupancy $q_0 > 0$ is what we look for to achieve during congestion periods. The error can be represented in $e(t) = q_0 - q(t)$. In order to remove the steady state error, we choose the integration of e(t) as the other input of the controller, i.e. $g(e(t)) = u_i(t-\tau_i)$. In times of heavy traffic conditions, the controller will calculate the allowed sending rate $u_i(t)$ for flow i according to the current buffer size so that q(t) can be stabilized around q_0. The buffer size q(t) is the only parameter each router needs to measure in order to complete the control process.

B. FLC control process flow and Network implementation

The process works as the sources request the desired sending rate in the packet header [6]. The router then receives the packet and examine the header. The FLC in the router will compute the u(t) and compare it with the request rate in the packet header, if u(t) < request rate, it means that the link does not have enough bandwidth to fulfil the requested rate, then the FLC will update the request rate field with u(t).

In this study we have a simple network topology represented by two main core routers and 30 subnets (sources) and link is a Gig Ethernet. Each of the sources run different applications varies form http and ftp applications. Now, in order to make a congestion zone, each subnet need to send 20 flows at time. The packet size is different here, for http is ranging between [800 – 1300] bytes and for ftp is 1024 bytes. The https session has better performance than the ftp session. FTP session are knowing as slow and has lower throughput than the http. As we see in the Fig 3,4&5.

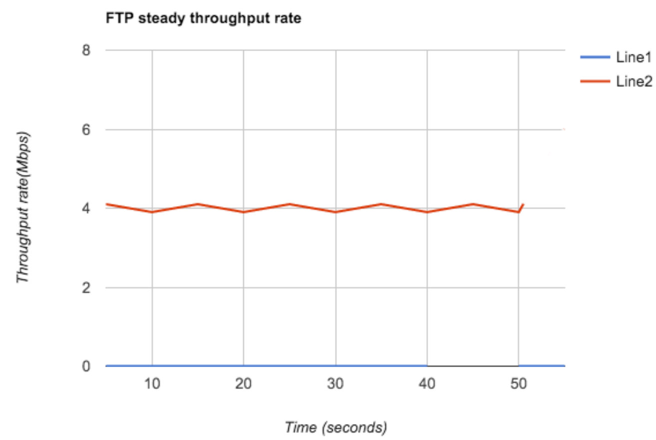

Fig. 3. FTP throughput rate at a high level bandwidth

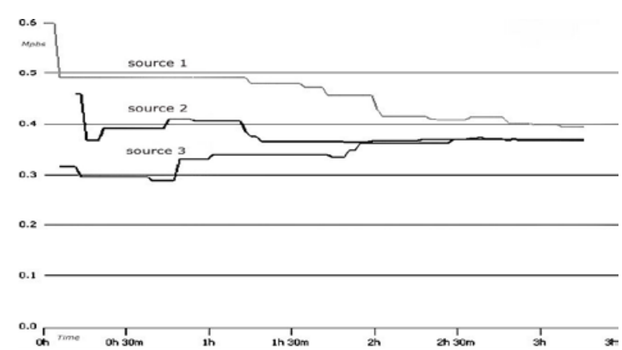

Fig. 4. FTP download response time at low level bandwidth

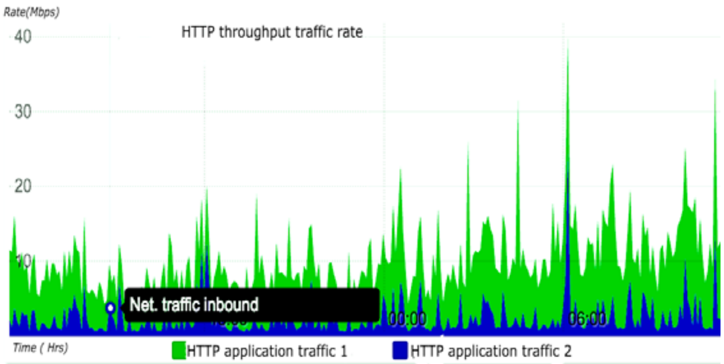

Fig. 5. HTTP throughput rate

The buffer capacity in this design will be assumed to be 60,000 packets, bandwidth c(t) is 5Gpbs, q0=6000 packets, and 5 of the subnets will be sending 5 ftp traffic as following (11.44, 22.95, 45.89, 91.80, 131) Mbps. In the Fig. 6., it shows the comparison between the actual bandwidth and the reference bandwidth in regards to the active flows, as we can see that not that much difference between the actual and the reference bandwidth but the big change that happens is when the the controller has to reduce the bandwidth c(t) in order to mange the queue buffer size in regards to the big active flows that comes in from the source.

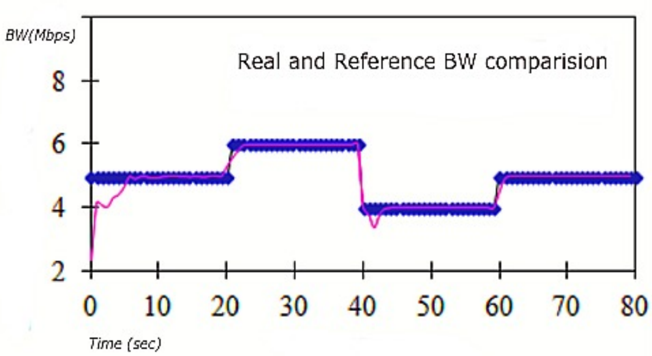

Fig. 6. (taken from reference [15] written by Liu and yang) Reference and actual BW comparison.

Now, the five FTP sources that we talked about previously will have different request rates. As we see in Fig. 8., source 1,2,3 &4 remain unchanged in regards to the throughput. However, source 5 rate is increases to 129.38 Mpbs from 90.21Mbps, also another change happens at t=40s to maintain regular throughput rate but it goes up again at t=60 due to high data flow request. In Fig. 7., the throughput rate fluctuates with the buffer size. As we see in t=20, the throughput is high, then the buffer size is low due to fast packet processing, but at t=40, buffer level increase and throughput goes down.

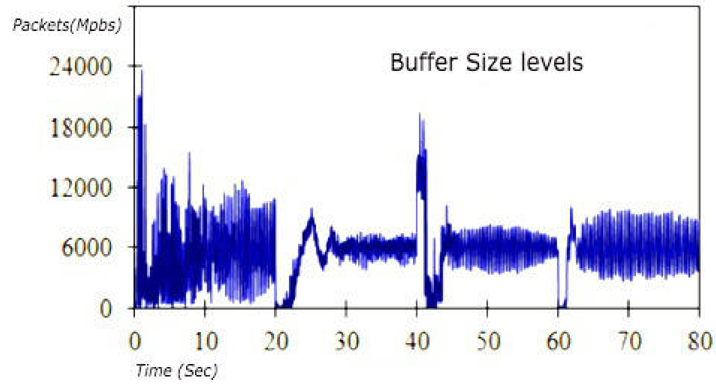

Fig. 7. Buffer size occupancy levels

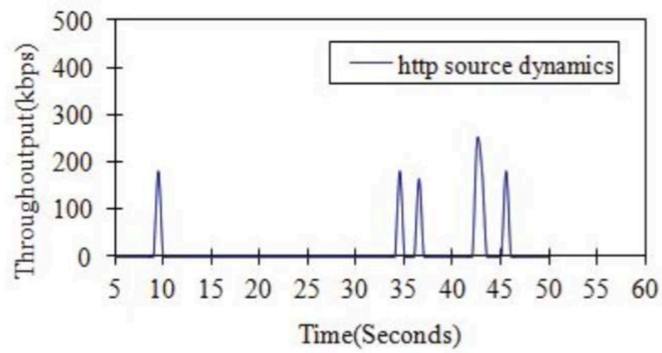

Fig. 8. (taken from reference [15] written by Liu and yang) represents source sending rates in regards to throughput.

IV. CONCLUSION

In this study analysis, a good performance has been shown by the FLC controller. The study focused on different BW levels and focused on showing the changes the occur to the throughput and in regards to the buffer size. Also the Max-Min fairness showed that the FLC can maintain the max output in a typical situation if we neglect the delay factors. The FLC showed also a buffer resource management by maintaining a reasonable buffer level in the situation of congestion. This study was focused only on one factor which is buffer size parameter that is managed by the FLC. There are lots of other factor that could be implemented as well in this study for future work keeping in mind that more parameters mean more CPU and memory utilization and more estimation. Packet flow and measurement was done using Wire Shark and Packet Sniffers. Topology was designed using Net Block Design application.

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