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Investigation of self-similar nature of video streaming traffic in corporate network

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In this work, a model of the corporate network had been developed, simulated and implemented using an optimized network engineering tool in a simulation area of 1.5 × 1.5 km enterprise topology network to stream video between each other. Total of 14,670 video traffic (traffic load) is streamed from different sources and destinations at random. The video streaming traffic is monitored, analyzed in view of identifying traffic self-similarity in the network. The results of the analysis show that video traffic is highly self-similar in the network using Abry-Veitch and smoothing algorithms method. The effect of self-similarity in the network is reduced with the help of 1D wavelet technique.

Key words: Smoothing algorithms, video, traffic, optimized network engineering tools (OPNET), self-similar.

INTRODUCTION

Today, the increasing demand in telecommunication service make the structure of network traffic very complex more especially with the introduction of multimedia service such as audio and video streaming over IP network in addition to the traditional web browsing, file transfer protocol, email and so on. Due these massive demands it is then predicted that traffic in most telecommunication network becomes inherently self-similar in nature. Traffic monitoring is a very difficult task because one would not know exactly when input characteristics will change (Karagiannis et al., 2002). Unfortunately they are limited mathematical model to capture the traffic behavior while traffic volume continuous to grow in its exponential form.

When we want to study traffic of all kinds in telecommunication network usually question of constructing a model of input characteristics (volume of the traffic) arises. However, to design a suitable model for any network and to develop fast algorithms of free flow of information across a network from source to destination, understanding network traffic become a critical issue because the fundamental aim of network monitoring is to deliver an outstanding quality of service to the end user with little or no interference.

Many researches in this field show that in general, telecommunication traffic are self-similar or fractal in nature (Adas, 1997; Chaoming, 2005; John, 1981; Oleg et al., 2007; Nikolai, 1995; Nagurney, 2008; Walter, 1997) been global system for mobile communication [GSM], GPRS or Ethernet. The presence of self-similarity in a network may be associated with amplified queing delay, packet loss rate, bottle neck or affect buffer capability (Beryes, 2007; Hamibindu et al., 2007).

In order to investigate the presence of self-similarity in our developed simulated network model, we imposed high-resolution video traffic statistics and we monitored video streaming traffic for several minutes. The behavior of internet traffic is usually time dependent and they are

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Table 1. Simulation metrice parameter.

Simulation size	1.5 × 1.5 km
Traffic monitored	Video
Simulation time	30 min
Application configuration setting	High-resolution Video
2 LANs	3 host users each

Table 2. Sample statistics of all the observations for video streaming.

		Sample mean(s)	Min value(s)	Max value(s)	Range
All Observations	1 4,670	145.25	0	121	121

usually considered being long range dependence (LRD) while self-similar behavior of network traffic is best described in terms of long range dependence and autocorrelation function of the time series (Guaghui et al., 2004; Karagiannis et al., 2002).

There are various popular methods in which self-similar nature of internet traffic can be identified for example using time-variable plot, periodogram, ratio variance residuals, wavelet, absolute moment, whittle, and R/S method. While in this work we used two techniques to check the presence of self-similarity in our simulated network model. That is log plot of Abry-Veitch and smoothing algorithms while in second method we closely observed the autocorrelation function (ACF) and fast Fourier transform energy spectrum behavior to validate our results.

This work considers two separate corporate networks located at a remote locations to each other with at least three host users in each corporate network streaming video to one another.

IMPLEMENTATION OF THE SIMULATION MODEL

An optimized network engineering tools (OPNET) is used to realize the entire structure of the network in a simulation area of 1.5 km × 1.5 km enterprise topology network. The simulation model is first created using a startup wizard. The topology of each corporate network is then created. The required number of the nodes is dragged into the empty space base on number of nodes required per corporate network, then the nodes fields are adjusted as follows to enable them stream video to each other. The application configuration attribute is set to video to enable us stream video across the network, profile configuration attribute is also set to match with application configuration attribute while the personal computer attributes at each corporate network are set to support the profile as given in the simulation matrices parameter of Table 1.

Collection of statistics

In OPNET, there are two major statistics available that is global statistics and nodes statistics; global statistics tell us about the statistics of the entire network while node statistics tell us about the statistics of an individual node. Appropriate statistics are then imposed on the model. Simulation is run, and the result is taking.

Mathematical relationship between LRD and self-similarity

If we assume X (t) is a second order stochastic stationary process. Let's consider β(x), ρ(x) be the ACF and spectrum of the second order stochastic stationary process. There is a close relationship that exist between LRD and self-similarity given by:

$\beta = 2H - 1$ when $\frac{1}{2}$<H<1 is valid

$$\beta x(p) \sim k_{\beta} |p|^{-\infty} \quad as \quad |p| \quad where \; \infty \in (0,1)$$

$$\rho x(q) \sim k_{\rho} |q|^{-|1-\infty|} \quad as \quad |q| \quad where \; \infty \in (0,1)$$

$\beta x(p)$ Usually goes to zero slowly called LRD;

If Z(t) is said to be self-similar If and only if $k^{-H} Z(kt) = Z(t)$, $when \; k$ >0

RESULTS AND DISCUSSION

The result given in Table 2, is video streaming for the length of simulation assumed to be the same with video streaming data traffic in real life network as shown in Figure 1 shows the video streamed data traffic for the length of the simulation, on the vertical axis is the video traffic sent in packet per second against time in second on the horizontal axis. It seems that slightly close to 60 s no packet is transmitted thereafter the video packets were transmitted continuously with an increase in packets, slightly above 60 s, the packets exhibit stochastic stationary behavior. Stochastic stationary process is one of condition of suspecting self-similarity in a network (Higuchin, 1988). Figure 2 present log plot of the video data traffic; for the process to be LRD the logscale plot will exhibit a region where by the log scale plot will be approximately linear with time axis while remain constant with the video traffic axis then the H

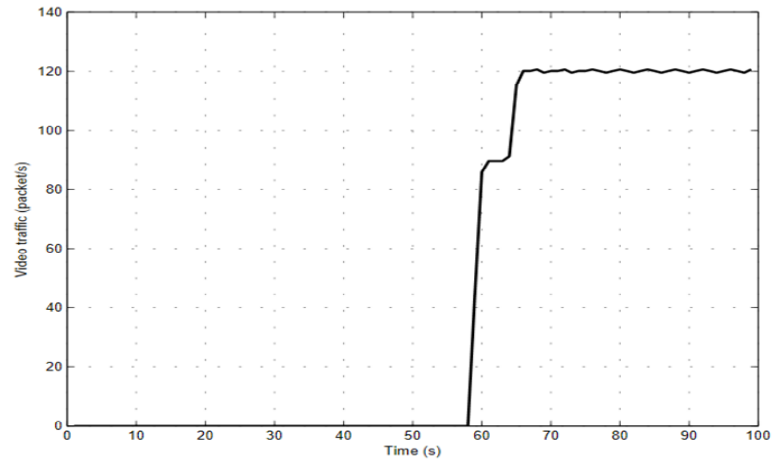

Figure 1. Video streamed data traffic.

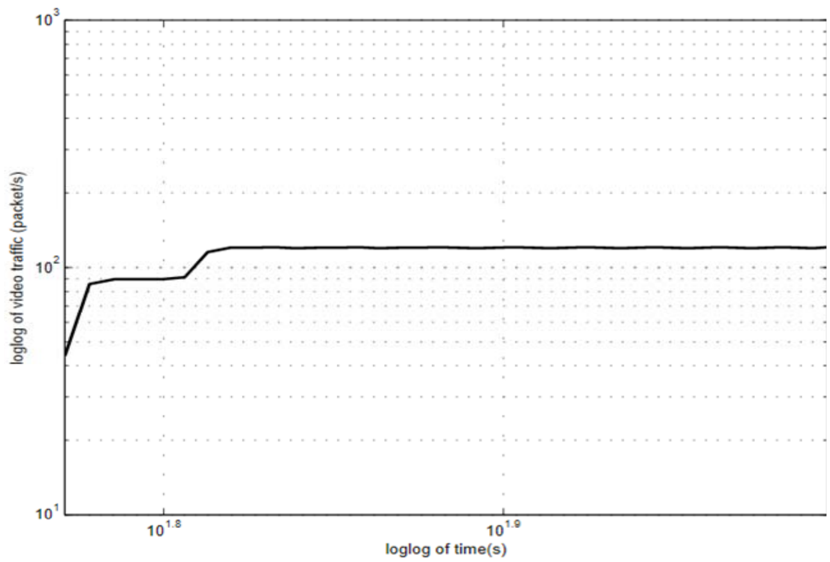

Figure 2. Loglog plot of video data traffic streamed.

exponent can be estimated from logscale plot by {H=(slope+1)/2} (Abry et al., 1998). The slope is calculated as 14.32 while the Hurst exponent is evaluated as 7.66; this evident that in this work video data traffic is highly self-similar considering the fact that for traffic in the network to become self-similar Hurst exponent must falls within $0.5<H<1$; the degree of the self-similarity increases as H get close to 1 (Oleg et al., 2007).

In the second method, we used smoothing algorithms. Smoothing algorithms has shown sufficient performance over different sets of data (Umer et al., 2008). Having known that the process is stochastic stationary, we then apply the smoothing algorithms technique; this technique involve different decomposition and reconstruction levels of a signal (video data traffic) using 1D wavelet (Rami, 2011) also taking into consideration ACF which is believed, that its coefficient decay slowly to zero with LRD which describe the intensity of self-similarity in network (Karim, 2007). Next we decomposed, de-noised and reconstructed the stochastic stationary video data traffic step by step up to 5 levels using db 10 wavelet type to validate the ACF and FFT energy spectrum property as given in Figure 3 to 5. When a process is decomposed and reconstructed up to 5 levels it means the process is highly LRD because the maximum decomposition and reconstruction level of db wavelet type is 7; the higher the level of the decomposition and reconstruction stronger the LRD as well as self-similarity (Xiaomo et al., 2004).

In Figure 3 the ACF coefficient is almost zero, FFT has less energy indicating strong relationship with LRD, Figure 4, ACF coefficient move slightly from zero. FFT energy increases showing a decrease in relationship with LRD while Figure 5, ACF coefficient increase significantly,

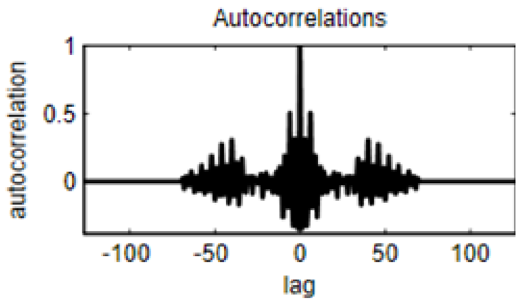

Figure 3a. ACF after level 1 reconstruction.

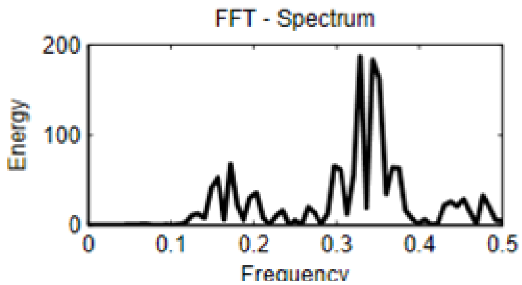

Figure 3b. FFT after level 1 reconstruction.

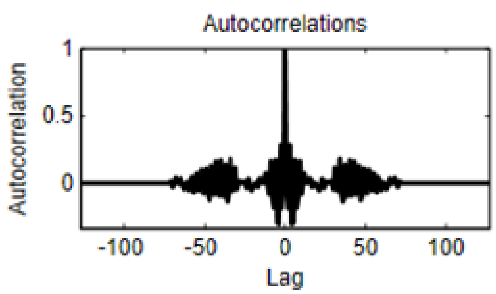

Figure 4a. ACF after level 3 reconstruction.

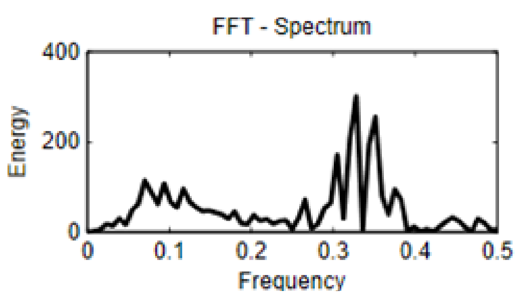

Figure 4b. FFT after level 3 reconstruction.

FFT energy increase tremendously showing poor relationship with LRD as well as self-similarity. Figure 6 present the original data traffic and de-noised data traffic assuming the LRD and self-similarity are not applicable

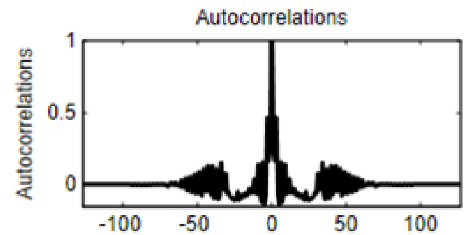

Figure 5a. ACF after level 5 reconstruction.

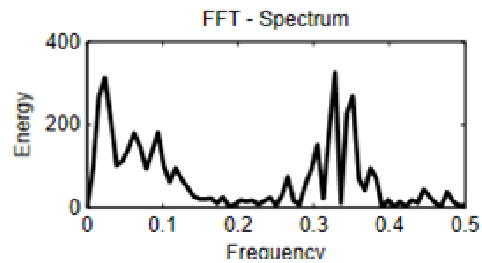

Figure 5b. FFT after level 5 reconstruction.

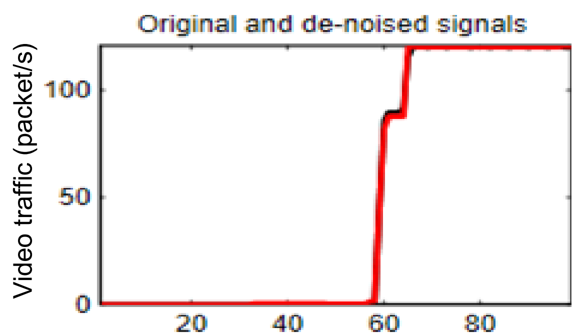

Figure 6. Original and de-noised video traffic data.

to the network. Therefore, it is expected that minimal delay, packet loss, packet retransmission and high buffer capacity will be the feature of the simulated network.

Conclusion

A video traffic had been monitored, analyzed in a model of simulated network developed with a view of checking presence of self-similarity in the network using Abry-Veitch and smoothing algorithms method. Both methods revealed that video traffic is highly LRD and self-similar. The presences of self-similarity in any telecommunication network change the characteristics or behavior of the network by affecting the overall network quality of service (QoS). This work is centered on checking and reducing self-similar properties of network, but does not take into consideration the causes of self-similarity in the network. Hope this work has provided some basic information on how to investigate self-similarity of video traffic in telecommunication network and reduce its effects. Further recommends that another research work should be conducted to identify the causes of the self-similar process in telecommunication network.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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