Controlling Link Congestion on Complex Network

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Abstract - *We studied the impact of bandwidth utilization factor on converged network of Zain Contact Centre which is a complex network environment in Nigeria. Some congestion control techniques were reviewed. Experiments were carried out on the real network, a legacy network and an integrated converged network considering the same number of users. The corresponding packets were compared. As a result, higher throughput and minimal packet loss were achieved at lower bandwidth utilization and better than what was obtained at higher utilization using the same parameters.*

Keywords: Network convergence, Packet Switching, Bandwidth Utilization, Congestion control.

1 Introduction

Enterprises across the globe are continuously investigating ways to implement voice, video and data over a single network for various reasons and usage. Today's communication networks need robust and compatible platforms to meet our global society's needs. Businesses and telecommunication companies have used diverse equipments, wiring and personnel to operate and maintain separate voice, video and data networks. Traditionally, data signals are transported over dedicated Local Area Network (LAN) or (Wide Area Network (WAN) networks. Voice signals are also carried over the dedicated voice devices like Private Branch Exchange and voice gateways via circuit switched techniques. Live video contents are also sent via terrestrial broadcasting to televisions in various homes; via wireless radio and microwave technologies [1]. Network convergence is enabling enterprises and service providers to deploy a wide range of services such as Voice over Internet Protocol (VoIP), Internet Protocol Television (IPTV). A lot of benefits are accruable from the implementation of converged networks some of which are: lower cost and increased access, enhanced capacity for innovation, positive impact on the society. The drawback associated with converged networks is the contention for the limited bandwidth which brings about network congestion [2, 3]. Due to the packetization of the signals in a converged network, the random access and the contention techniques accessing a shared medium often results in collision of packets on the common link [4]. Over the years, several efforts have been invested in the study of assessing the impact of congestion on such a converge network [5-7]. This research was channeled into alleviating the challenges posed by contributing factors that leads to congestion, thus, to obtain low latency and higher throughput in the converged network environment. This paper investigates the impact of link congestion on the converged network of Zain Contact Centre.

2 Materials and Methods

In order to achieve accurate results, the converged environment was first isolated, where the conventional legacy data network was first examined and also behavioral characteristics of the network was observed. The network monitoring tool used for parameter measurement was the Orion Solarwind Software®. The software was modified to measure the latency, throughput, retransmission time (RTT), and packet loss first for a single user and then up to 30 users. Results from the link between Lagos Contact Centre and Abuja Contact Centre were obtained from the Cisco® 7201 border router at the Lagos contact centre. All convergent-possible devices on the network (like IP Phones, IP Video conferencing devices, wireless networks, streaming of video on the network and internet) were first disabled, so that the measurement for the legacy network could be taken before upgrading to the converged network, which was the objective of this work. Then, for the converged network, sources and destination of nodes were identified; the idea was to identify the origin and destination of probe packets for analyzing the network performance. The Tanderberg® video conferencing devices for both Lagos and Abuja were connected to the network via the Ethernet ports on a Cisco® Catalyst 2950 switch.

3 Analysis of Results and discussions

There are several types of delays in a complex network which differ from each other as to where they are created. The delay components are classified based on the place of their creation, mechanism or some other attributes. The causes of delay in the network could be traced to delay induced by multiple of devices and protocols responsible for the transmission of packet on the network collectively called device latency. Delay occurred (Network or Server side delay) at a particular device when the device cannot process requests arriving at its node as soon as they arrived resulting in a backlog of request or queues, thus resulting to network congestion.
The bandwidth for the LAN network was 100Mbps. The test was first carried out for a single user, and was later

extended to 30 users each with average file size of 4Mbps. A legacy network was first put in place and converged packets were eliminated from the network. Measurements and results were taken and evaluated. Later, the converged packets were introduced and comparisons of the generated results were considered. Table 1 shows the file size against throughput in a legacy network, while Figure 1 depicts the graph of the table.

Table 1: File size and throughput results for a single user in the legacy network

File size (Mb)	Throughput (Mbps)
2	1.96
2.5	2.36
3	2.96
3.5	3.44
4	3.88

Figure 1 showed that as the file sizes were increased the throughput of the network increased exponentially toward its threshold.

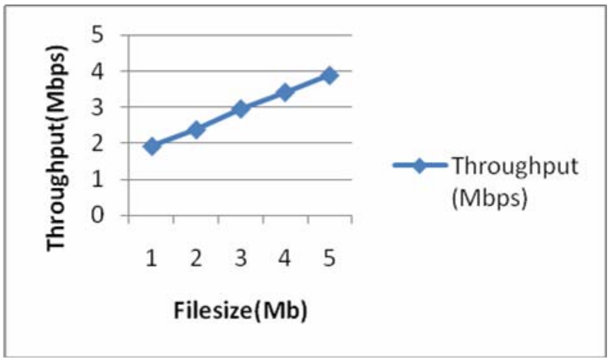

Figure 1: Throughput against file size for a single user in the legacy network.

Table 2 shows file size against throughput in a converged network with a single user. In Table 3 and 4, the number of users on the link was increased to 10, and gradually to 30 for the legacy network, and then for the converged network.

Table 2: File size and throughput results for a single user in the converged network.

File Size (Mb)	Throughput(Mbps)
2	1.92
2.5	2.38
3	2.96
3.5	3.42
4	3.89

The situation was the same as when for a single user in the converged network, Figure 2

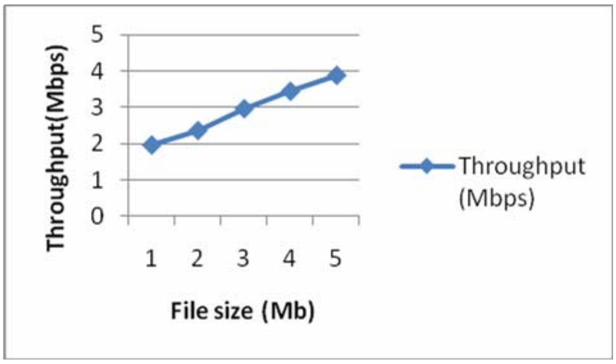

Figure 2: Throughput against file size for a single user in the converged network.

There was a gradual increase in the throughput, though the throughput appeared to respond sharply to the increase in the number of users, most noticeable between 10 and 25 users, as depicted in Figure 3 and Figure 4.

Table 3: Result of network throughput for 10-30 users in the Legacy Network.

File Size (Mb)	10 Users	15 Users	20 Users	25 Users	30 Users
	Throughput (Mbps)				
2	19.4	28.8	38.8	46.4	57.4
2.5	24.3	37.1	48.6	61	72.4
3	28.3	43.4	58.7	73.4	81.2
3.5	34.4	51.1	68.4	86.2	94.6
4	38.9	58.6	77.6	93.2	94.7

Table 4: Result of network throughput for 10-30 users in the Converged Network.

File Size (Mb)	10 Users	15 Users	20 Users	25 Users	30 Users
	Throughput (Mbps)				
2	18.8	27.6	36.2	42.6	62.1
2.5	23.8	33.8	47.6	46.3	68.4
3	26.6	41.3	53.4	71.9	82.7
3.5	32.3	49.3	64.8	82.6	82.8
4	37.6	56.2	73.4	82.8	82.6

In Figure 3 and Figure 4, the throughput increased for both networks, until when the number of users got to 30. As the file size began to increase for the 30 users, a trend began to emerge, where the throughput linear increment reduced, and then, remain constant. This suggests that a limit of saturation on the network was fast approaching, with the converged network most noticeable.

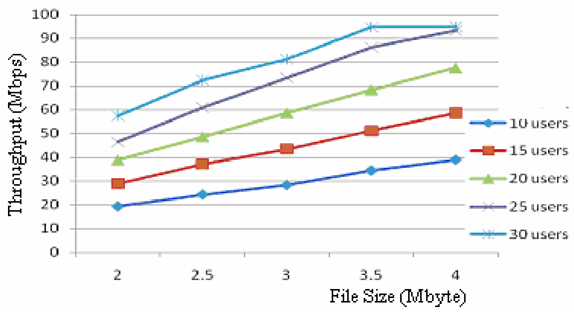

Figure 3: Graph of file size against throughput for 10-30 users in the Legacy Network.

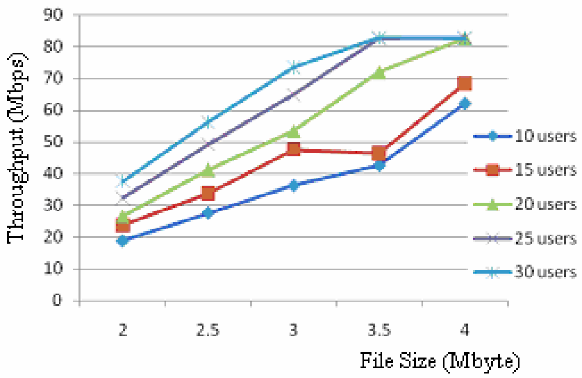

Figure 4: Graph of file size against throughput for 10-30 users in the converged Network

The graphical analysis has shown that the linear relationship between packet size, latency and round trip time (RTT) affects throughput and packet loss. Additional increase in the packet size for a given network decreases the throughput for respective users. This explains the degradation in bandwidth performance as evidenced in the loss in throughput value (around 40%).

It is also shown that the burst nature of the converged packets tend to contribute to the high latency and congestion encountered on the network as against when it was just a legacy network.

The upward linear nature of throughput in a 10-user environment was complemented when the number of users increased; this however became altered when the number of users got to 30. As more packets traversed the network, and the certainty of high packet retransmission caused by the high-bandwidth usage by the converged network, congestion occurred on the network as depicted in Figure 3 and 4.

Comparing the throughput for the legacy and converged network shows that both networks behave very much alike, that is, their response to increased packet size is similar, until where the number of users increased to a mid-point. At this stage, when throughput on the legacy network was still ascending in the linear direction, on the contrary, the throughput of the converged network was already nose-diving, and packet drops were becoming imminent, this is seen in Figure 3 and 4.

The quality of the bandwidth improves at low bandwidth utilization factor as compared to when the utilization was high. At the initial stage, the high utilization tends to improve the network performance, but this later proved to be the contrary when the amount of traffic on the network became high. Whereas when the low utilization factor was still sustaining the traffic flow and maintaining network balance, the high utilization had already saturated the traffic via a high round trip time (RTT). This translates to high latency on the network. The throughput at higher utilization factor *($\rho \geq 1$)* was found to be lower than the corresponding throughput at lower utilization factor *($\rho < 1$)*. It was observed that the results from the real experimental network had packet loss, jitter in delays and that the network bandwidth was not sufficient for all requirements. There was delay on the network due to network overloads or congestions. Thus, the network bandwidth was limited and was not enough for all applications and users at the same time and there were packet loss which affects the network performance. This further substantiates the discovery as earlier pointed out, that the bursts nature of converged network traffic defies simple analytical estimation. It also indicates that a very precise latency cannot be evaluated from the simple combination of serialization, propagation and queue delay [8]. Increasing the efficiency of data exchange in computer networks based on the TCP/IP protocol requires solving complex problems which are related to the following: choice and optimization of network topology, optimizing the bandwidth capacity of the channel, choice of routes, choice of methods of data flow streams and verifying the parameters in control, analyzing the buffer sizes of switches and routers, and choosing strategy for congestion control.

4 Conclusions

The real experimental network showed that analytical model was not very good at describing packet loss rate and its relation to throughput and latency when the number of simultaneous converged packet - flow increases across the network. It should be noted that the model for evaluating the latency on the network is not exhaustive; other inherent sources of delay on the network which were not considered in this paper can be very useful in further work on the subject. In addition, the methodology used in the real experimental network, using simplex communication may also be reviewed to accommodate for duplex communication and multi stream of convergent packet data in further study.

5 References

[1] ITU-T *Recommendation Y.2001 (12/2004) - General overview of NGN*

[2] L. Mamatas and V. Tsaoussidis," *Approaches to Congestion Control in packet networks*" 2nd edition, Academic Press, Amsterdam, 2003.

[3] L. G. Roberts and B. D. Wessler, "*Computer network development to achieve resource sharing,*" Proc. SJCC 1970. pp. 543-549.

[4] E. Souza and D. A. Agarwal. "*A High Speed TCP study: Characteristics and deployment issues*". Technical Report LBNL-53215, 2003.

[5] John S.N.: "*Increasing the Efficiency of Data Exchange in a Computer Networks based on the Protocol of TCP/IP Suite*", Donetsk (DonNTU), Ukraine, Vol. 93, pp. 256-264, 2005.

[6] Eric He, Rajkumar Kettimuthu, Sanjay Hegde, Michael Welzl, Jason Leigh, Chaoyue Xiong and Pascale Vicat- Blanc Primet, "*Survey of Protocols and Mechanisms for Enhanced Transport over Long Fat Pipes*", Data Transport Research Group,2003/2004. http://www.globus.org/alliance/publications/papers/Survey.pdf.

[7] Gerd Keiser, "Local Area Networks" ; PhotonicsComm Solutions, Inc. Second Edition, Mc GrawHill 2002.

[8] S. N. John, R. E. Okonigene, A. Adelakun: Impact of Latency on Throughput of a Corporate Computer Network, Proceedings: The 2010 World Congress in Computer Science, Computer Engineering, and Applied Computing (WORLDCOMP'10), Annual Summer Conference on Modeling Simulation & Visualization Methods (MSV'10), Las Vegas, Nevada, USA, July 12-15, 2010, pp.282-287.