Optimized Remote Network Using Specified Factors As Key Performance Indices

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***Abstract*-This paper discuss the implementation of an optimized remote network, using latency, bandwidth and packet drop rate as key performance indicator (KPI) to measure network performance and quality of service (QoS). We compared the network performance characteristics derived on the Wide Area Network (WAN) when using Fiber, VSAT and Point-to-Point VPN across the internet respectively as the network infrastructure. Network performance variables are measured across various links (VAST, Fiber and VPN across the internet) and the corresponding statistical data is analyzed and used as base-line for the optimization of a corporate network performance. The qualities of service offered on the network before and after optimization are analyzed and use to determine the level of improvement on the network performance achieved.**

Keywords-Key performance indicator, optimized remote network, latency, bandwidth, WAN, VSAT.

I. INTRODUCTION

Most network users often attribute the problem of slow network and poor quality of service to lack of sufficient bandwidth, which is not generally correct. Sometimes, poor network performance can be traced to network congestion, high packet drop rate, chatty protocols and high latency [1] among others. This paper uses the technique of network base lining to obtain the best combination of network metrics that can enhance the performance of network resources up to maximum data flow energy (MDFE) which allows maximum amount of data to be sent in the fastest amount of time using the optimum bandwidth capacity [2]. We assume that the Server and client processing time are minimal relative to the total time it takes to complete a transaction. Hence, it attributes the cause of service transaction delays to WAN delay. It try to find out the causes of poor quality of service across the WAN and makes recommendation or how to implement efficient remote network with better quality of service (QoS) [3]. In the methodology, three sets of parallel links (Fiber, VSAT and Point-to-Point VPN across the internet) of equal bandwidth are set up between two geographically separate locations. Files of different size were sent between the locations across each link respectively. The key performance indicators (latency, bandwidth and packet drop rate) [4, 5, 6] were recorded using standard monitoring tools to monitor each of the experiment performed. Graphical analysis of the data obtain from the link performance were used as the bases for the conclusion made in this paper using latency, bandwidth and packet drop rate as key performance indicator for network performance.

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II. NETWORK PERFORMANCE CRITERIA

A network can be rated as performing when end-users are able to access applications and carry out given task without undue perceived delay, error or irritation. The primary measure of user perceived performances are availability and completion time. It is important to identify whether utilization factors, collision rate or bandwidth congestion are responsible for network problems [7]. In general, the performance of a computer network can be divided into three sections for easy analysis and trouble-shooting:

- The performance of the application,
- The performance of the servers,
- The performance of the Network infrastructures.

Based on end-user perception of the network, we can also view the network performance in terms of service oriented and efficiency oriented as shown in the Fig. 1.

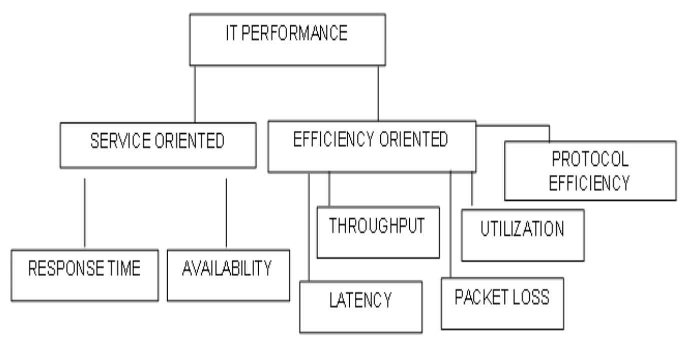

Fig:1. Block diagram of IT performance

It is noted that, service oriented performance measures how well an application provides service to the customer, whereas efficiency oriented performance measure how much of available channel resource are actually used to provide end-user request. This tend to measure how much of available channel resources are being wasted due to inefficiencies inherent in the communication channel.

III. METHODOLOGY

The performance of a wide area network can be verified by studying the effect of network contribution to transaction time (NCTT) on the network [3].

In a high performance network, TCP packets are transferred across the WAN with minimal delay (low latency) within the optimum load limit. When the network becomes overloaded, congestion sets in and TCP packets are drop and consequently re-transmitted which adds to the total time required to complete a transaction in a busy network [8]. Network contribution to transaction time is the sum of the round-trip times necessary to complete a given transaction type, plus the time for recovery from any lost packets during the transaction [3]. The network contribution to transaction time can be calculated as:

$$NCTT = E * RTT + L * RTO$$

where, E – number of round-trip exchange necessary to complete the transaction,

RTT – round-trip time for packet transfer,

L – number of round-trips exchanges that experience packet loss,

RTO – retransmission time-out

The number of losses experienced in the course of a transaction depends on round-trip packet loss probability, *p*.

For a two-ways traffic path, loss probability is given by:

$$P = P_{RTT} = 1 - \{(1 - P_{oneway}) * (1 - P_{otherway})\}$$

If each round-trip exchange, takes A_i attempt to complete successfully, and the total attempts to complete a transaction given as:

$$A = \sum_{i=1}^{E} A_i$$, then

$$\Pr ob(A_i = a) = p^{a-1}(1-p)$$

Expected value of *A* is given by:

$$E = \{A\} = E_x \sum_{a=1}^{\infty} axp^{a-1}(1-p) = \frac{E(1-p)}{p} \sum_{a=1}^{\infty} axp^{a}$$

this converge as:

$$E\{A\} = \frac{E}{1-p} \text{ for } 0 < p < 1$$

A is equal to the constant *E* plus a random number of losses *L*, so $E\{A\} = E + E\{L\}$

$$E\{L\} = \frac{E}{1-p} - E = E(\frac{p}{1-p})$$, and the average

$$NCTT = E * RTT + [E\{L\} * RTO]$$

Note that the probability distribution of NCTT is a set of discrete values [11] at

(E x RTT),

{(E x RTT) + (1 x RTO)},

{E x RTT) + (2 x RTO)},

The performance of the WAN and remote network can also be viewed in terms of its effective throughput.

Throughput is the quality of error-free data that can be transmitted over a specified unit of time [9].

$$Throughput = \frac{Bandwidth}{TotalLatensy}, bps$$

Also, $$Thoughput = \frac{MSS}{RTT} * \frac{1}{\sqrt{p}}$$, bps

where,

MSS – Maximum segment size (fixed for each internet path, typically 60 bytes)

RTT – Round trip time (as measured by TCP)

P – Packet loss rate (%)

The efficiency of the WAN link can be calculated from statistical data on the link utilization, where Utilization (U) [7] is the percentage of total channel capacity currently being consumed by aggregate traffic.

$$Utilization = \frac{Traffic}{Channel\ capaciy} * 100$$

Also,

$$Utilization = \frac{[(Data\ sent + data\ received) \times 8}{Link\ speed \times sample\ time} * 100$$

Further more, in this research, three point-to-point WAN link were setup between two separate locations A and B using three different WAN technologies, namely:

(i) 128/256Kbps leased fiber line

(ii) 128/256Kbps point-to-point VPN across the public internet.

(iii) 128/256Kbps VSAT link

The key performance indicators (KPI) metrics for the research were Latency, Bandwidth and Packet Drop Rate. The following approach methods were used to obtain the required performance characteristics of the various WAN technologies adopted:

(a)Files of various sizes were sent from Host A to Host B across the different WAN links.

(b)These KPI values were measured and recorded for different remote network infrastructure in use (Fiber, VSAT, Point-to-Point VPN across the internet with bandwidth of 128/256 kbps respectively)

(c) The performance statistic values obtained in both cases were plotted in graphical form and analyzed.

(d) Recommendation for error correction and performance improvement were made

(e) Conclusion was drawn based on the result obtained from the key performance indices.

The alternative WAN links between two remote locations shown in Fig. 1, were routed to Host A and Host B using different connection links (Fiber, VSAT, P2P VPN) to measure the KPI of the network.

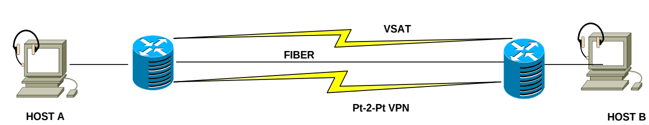

Fig. 1. Schematic diagram of alternative WAN links between two remote locations

The Table 1, shows the result of the throughput obtained from the remote link of the WAN with different Packet Drop Rate of the links.

Table 1. Throughput result of a network as affected by both the latency and the packet drop rate

LATENCY (ms)	THROUGHPUT						
	TP1(KBPS) 0.01% PDR	TP2(KBPS) 0.05% PDR	TP3(KBPS) 0.10% PDR	TP4(KBPS) 0.50% PDR	TP5(KBPS) 1.00% PDR	TP6(KBPS) 2.00% PDR	TP7(KBPS) 3.00% PDR
9	1822.22	814.95	576.29	257.70	182.22	128.85	105.20
30	546.67	244.48	172.89	77.31	54.67	38.66	31.56
60	273.33	122.24	86.44	38.66	27.33	19.33	15.78
90	182.22	81.50	57.63	25.77	18.22	12.86	10.52
120	136.67	61.12	43.22	19.33	13.67	9.66	7.87
150	109.33	48.90	34.58	15.46	10.93	7.73	6.32
300	54.67	24.45	17.29	7.73	5.47	3.87	3.16
500	32.80	14.70	10.37	4.64	3.28	2.32	1.90
800	20.50	9.17	6.48	2.90	2.05	1.45	1.18
1000	16.40	7.34	5.19	2.32	1.64	1.16	0.95

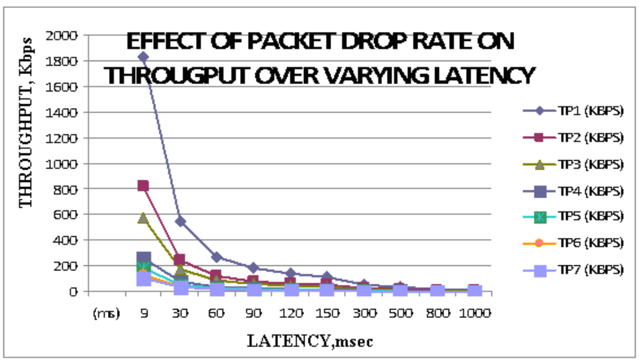

Fig. 3. Graph of throughput against latency for different packet drop rates

The Fig. 3, shows the effect of packet drop rate on the network throughput over different latency. The throughput of a network is affected by both the latency and the packet drop rate of the link where an increase in latency decreases the network throughput performance. Similarly, the throughput also decreases as the packet drop rate increases which might put the network quality of service to network degradation. Analysis of the achieved result indicates that, the best quality of service will be obtained by using a link whose latency is between 1 – 30 milliseconds and packet drop rate of 0.01% or less. Such latency can only be achieved using Fiber or radio link where packets are propagated at the speed of light with very low bit-error-rate.

The worst quality of service occurred when latency is between 800 – 1000 milliseconds and the packet drop rate stands at 3% or more.

The link latency of 800 milliseconds and above is usually associated, with VSAT link because of its technological limitation caused by distance along the propagation path between two locations via the orbital satellite.

However, VSAT links could still be used for none delay-sensitive application if there are no packet loss. The situation becomes worse when increasing packet drop rate is associated with VSAT links. For a Point-to-Point virtual private network (VPN) across the public internet with average latency of 250 milliseconds, most real-time and data-based applications performance is considered favorable. However, Point-to-Point VPN is always associated with higher packet drop rate than VSAT or Fiber links because of the large number of hop and routing protocols across the part from source to destination. This is even worse when considering a two-way traffic situation usually experienced in real life scenario.

IV. Improvement in Quality of Service

The improvement in quality of service (QoS) can be seen by comparing the network throughput of the Fiber, VPN, and VSAT link of a network. If we assume a minimal packet loss for all the three infrastructures: latency of 850ms for VSAT, Point-to-Point VPN across the internet at 260ms and Fiber link of 25ms.

Throughput for VSAT gives 0.6168Mbps that of the VPN across the internet gives 2.016Mbps and the throughout for fiber gives 20.97 Mbps. By replacing the VSAT infrastructure with Fiber Optic link, the following improvement in QoS would be achieved.

Hence the improvement in QoS gives

$$\frac{20.97 - 0.6168}{0.6168} * 100 \Rightarrow 3300\%$$

Similarly, replacing the VPN with Fiber optic link would be achieved with an improvement in quality of service QoS as follows:

$$\frac{2.016 - 0.6168}{0.6168} * 100 \Rightarrow 530\%$$

V. Conclusion

The Key Performance Indices of network services (packet drop rate, latency and throughput) affects the network performance as one the factors goes out of the optimized range value obtained in the research work.

Under perfect conditions (assuming minimal percent of packet loss), the use of WAN link with low latency, and use of optimized bandwidth would significantly enhance the quality of service (QoS) experienced by a remote network user over a WAN link.

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