PERFORMANCE ANALYSIS OF SLA: QoS UPE Metro Ethernet

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Abstract— **A Service Level Agreement (SLA) between a service provider and its customers will assure customers that they can get the service they pay for and will obligate the service provider to achieve its service promises. Failing to meet SLAs could result in serious financial consequences for a provider. Hence, service providers are interested in gaining a good understanding of the relationship between what they can promise in an SLA and what their IT infrastructure is capable of delivering. Similarly, consumers are interested in understanding the impact of the SLAs they sign on their own productivity. In this paper, we presented several measurement techniques to verify the guaranteed QoS for customer satisfaction based on the acceptable standard values.**

Index Terms— **SLA (Service Level Agreement), User Provider Edge (UPE), RFC2544, Quality of Service (QoS), throughput, packet loss.**

I. INTRODUCTION

For the past few years, high quality and high bandwidth traffic has become a necessary and the demand has been increased tremendously. Equipment for UPE Metro-E is medium example the aggressive internet market nowadays, service providers and IT companies need to increase their data *speed, a better way to enhance the network performance.* Furthermore, high speed network is able to adapt various type of traffic with a minimum congestion.

One of the common value added services users seek from the service provider is the Quality of Service (QoS). Quality of Service (QoS) is not only a value added services but is a must to any corporate or enterprise customers which require high reliability network to connect to their branches. In another hand, Quality of Service (QoS) also is very crucial to the Financial Institution such as Banking or Insurance companies which requires high reliability, prioritization and security of their traffic across the internet network.

In particular, end to end Quality of Service is very demanding which concern the bandwidth throughput, delay, jitter and packet loss rate. In recent years, the multimedia traffic application such as IPTV, video conferencing are very popular. The service mechanism in IP network is on best-effort basis and will no longer able to meet the emerging business needs. Plus, with the current demand for High Definition (HD) IPTV which require a lot of bandwidth consumption. A details and excellent network planning is necessary for a service provider to ensure minimum packet drop, delay for multimedia traffic such as video, voice and data .Currently, this new technology is the most preferable choice among the Telecommunication and Internet Service Provider.

Table below is the standards of throughput based on percentage of speed use and this is one of the guides to all service providers to ensure QoS are achieved.

Frame Size (bytes)	Expected result (% of test speed)
64	76.2
128	86.5
256	92.3
512	96.2
1024	98.1
1280	98.5
1518	98.7
9000	99.7

Table 1 - International standard of throughput based on percentage of speed use.

In Metro Ethernet networks, devices can be categorized into three kind network focus area. One is in the core network, second in edge network and third in access network. The focus areas basically specify the kinds of aggregation, network trunking capabilities and services offered to support Service Level Agreements (SLA)s in Metro Ethernet Network. Fig.1 depicts the typical Metro Ethernet network architecture

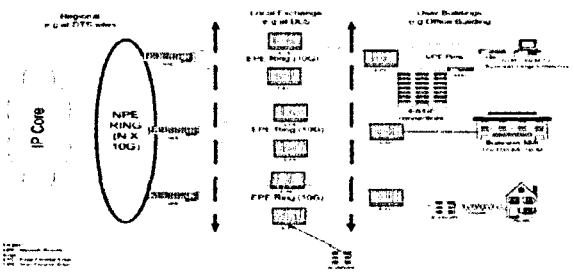


Figure 1 – The Metro Ethernet Network Architecture

There are three main components that constitute the network: Network Provider Edge (NPE), Edge Provider Edge (EPE), and User-Provider-Edge (UPE).

In this paper, the network performance will be evaluated based on the throughput, latency, jitter and frame loss rate. The results will be compared with the acceptable range from ITU-T. RFC2544 recommendations have become well accepted in the test and measurement industry for network performance testing [1]. The RFC2544 test suite performs a set of four automated tests (throughput, latency, frame loss, and burst or back-to-back) to qualify the performance of a network link under test. The tests are especially popular for the verification of network links with certain service level agreements (SLA) by using RFC2544 test, Actual testing with the four selected customer area Penang was done over a real network by using test gear VeEX Vepal MX-120

II SCOPE OF THE RESEARCH

A service level agreement is an agreement regarding the guarantees of services from service provider to the customers. It defines mutual understandings and expectations of a service between the service provider and service consumers. The service guarantees are about what transactions need to be executed and how well they should be executed. An SLA may have the following components:

Purpose - describing the reasons behind the creation of the SLA

Parties - describes the parties involved in the SLA and their respective roles (provider and consumer).

Validity period - defines the period of time that the SLA will cover. This is delimited by start time and end time of the term.

Scope - defines the services covered in the agreement.

Restrictions - defines the necessary steps to be taken in order for the requested service levels to be provided.

Service-level objectives - the levels of service that both the users and the service providers agree on, and usually include a set of service level indicators, link availability, performance and reliability. Each aspect of the service level, such as availability, will have a target level to achieve.

Penalties - spells out what happens in case the service provider under-performs and are unable to meet the objectives in the SLA. If the agreement is with an external service provider, the option of terminating the contract in light of unacceptable service levels should be built in.

Optional services - provides for any services that are not normally required by the user, but might be required as an exception.

Exclusions - specifies what is not covered in the SLA.

Administration - describes the processes created in the SLA to meet and measure its objectives and defines organizational responsibility for overseeing each of those processes.

A service level agreement (SLA) is a commercial agreement binding both parties to a defined service level specification (SLS). The SLA may require redundant network equipment, protocols that support redundancy and the appropriate network topology. SLA needs to be supported by the appropriate QoS mechanisms and protocol capabilities

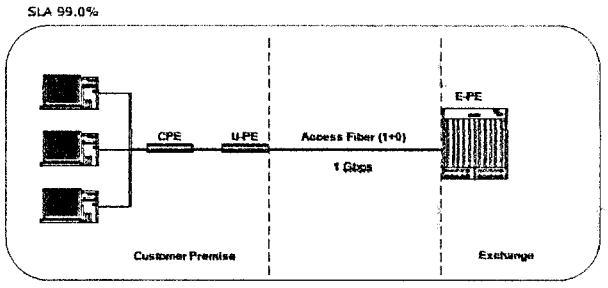


Figure 2 - The service shall be provided with no redundancy (1+0) connection to customer premises.

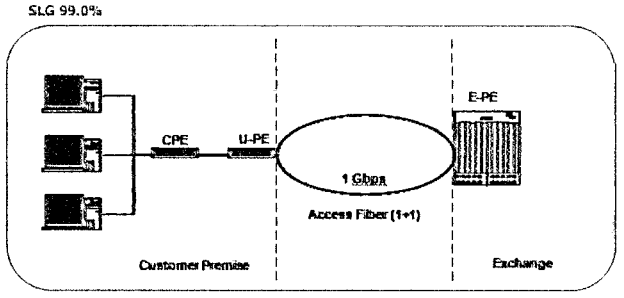


Figure 3 - The service shall be provided with 1+1 redundancy right up to customer premises. Service Provider provides one U-PE connecting to two different fiber paths served from one E-PE exchange nodes.

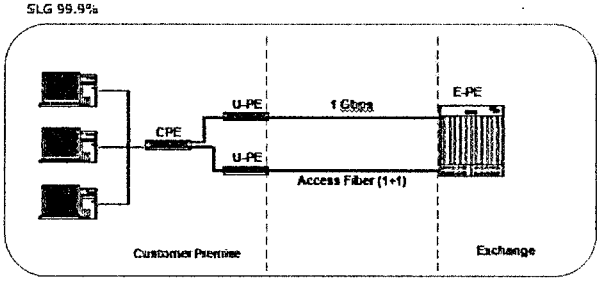


Figure 4 - The service shall be provided with 1+1 redundancy right up to customer premises. Service provider shall provide two U-PE on two different fiber paths served from one E-PE exchange nodes. All HSBB area will adopt this type SLG 99.99%

III METHODOLOGY

Higher Bandwidth usage has more demand especially for Triple Play. With a scarce Telco's provider make control limits to maintain and give a best quality network , happen when network is congested .Voice ,Video and Data packet require good quality and reliability network data to avoid all parameters which packet loss, jitter and latency for video and voice quality distorted. This issues need to be resolved as year by year, internet users demand increases for multimedia traffic across the global network. More related analysis of network performance in network traffic platform need continuously to be focus. In this research more focus to Metro Ethernet network. With using the appropriate QoS mechanism can overcome or at least minimize the packet jitter, latency and loss during data transmission as well as increasing the network overall performance

RFC2544 meaning of Request For Comments and this is recommendations have become well accepted in the test and measurement industry for network performance testing. The RFC2544 test suite performs a set of four automated tests (throughput, latency, frame loss, and burst or back-to-back) to qualify the performance of a network link under test. The tests are especially popular for the verification of network links with certain service level agreements (SLA).

In order to ensure that an Ethernet network is capable of supporting a variety of services (such as VoIP, video, etc.), the RFC2544 test suite supports seven pre-defined frame sizes (64, 128, 256, 512, 1024, 1280 and 1518 bytes) to simulate various traffic conditions. Small frame sizes increase the number of frames transmitted, thereby stressing the network device as it must switch a large number of frames. It also depends with the customers needed with add up with the Jumbo frames with 9000 bytes.

Portable RFC2544 test equipment enables field technicians, Engineers, installers and contractors to immediately capture test results and demonstrate that the Ethernet service meets the customer SLA. These tests can also serve as a performance baseline for future reference.

Phase 1: Literature Review

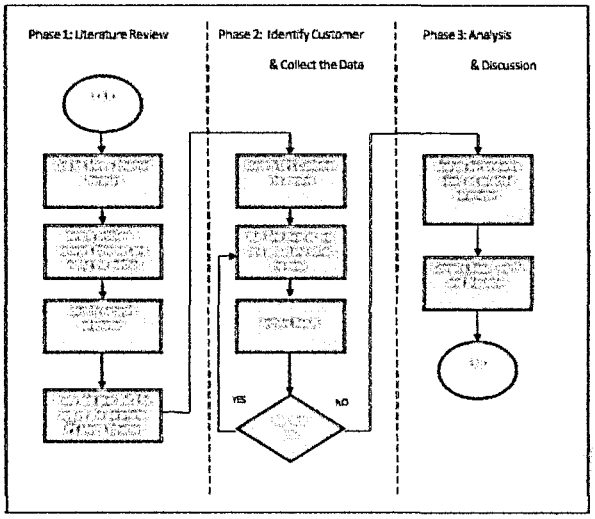
In the first part, more to understand needs and study more on Metro Ethernet technology, Identify the problem, analyse network Ethernet and finding appropriate method will be made to test and finding the issue of the QoS on the Metro Ethernet. This is crucial to get in-depth information on the technology, Study the parameter involve it to the QoS, and also familiarization with test gear VeEX for use at the customer last end for the UPE (User Provider Edge) and understand all the technique for testing.

Phase 2: Identify the customer and collect the data

The second phase of this project will identify the UPE at the customer's site test using Test gear VeEX. This project more to analyze selected customers for achieve Quality of Service network which measure the real-live network. After testing have completed all the results which the parameters selected at beginning have to collect and ensure Test Gear running the set of time. All simulation's results will be archive for analysis.

Phase 3: Analysis and Discussion

The third phase is when all data collected will be analyzed and discussed based on network parameter chosen. From there different performance for different type of traffic scenario can be analyzed and the optimum or the best QoS implementation can be decided and also can be analyzed using software Minitab statistical. All parameter can more get detail using this Minitab.



The objectives of this thesis are to testing, collect the actual data and analyze the results of the testing RFC 2544 is the selected testing in SLA's focus the Penang area,

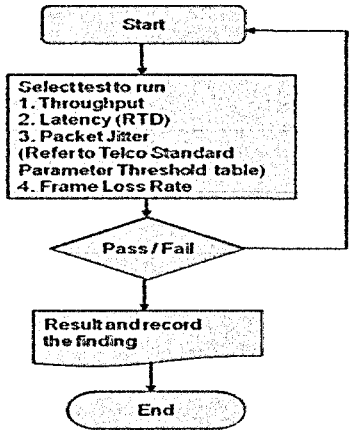
A. Selected Customer

The testing RFC2544 have focus in the selected customer was done at Bayan Lepas area in Penang. Two test gears were use it with one runs the test and another one setting with the looping.

B. Network

Currently, there are focus only at the UPE (User provider Edge) at the customer side with follow the setting and with one port in the UPE customers to ensure the real network have to measure and actual data have to get.

C. Data Analysis



A. Benchmarking tests

RFC2544 provides a lot of parameters applied in different network equipments test, it have four most important ones of them.

1) Throughput

Definition: the throughput is the fastest rate at which the count of test frames transmitted by the DUT (device under test) is equal to the number of test frames sent to it by the test

equipment. It reflects maximum data traffic which the DUT can handle.

Data Throughput = Frame Rate** x Frame Size x 8
**Frame Rate = Network Speed / ((Frame Size + 20) x 8)

2) Loss Rate

Definition: under constant load, some data packets should be forwarded by the DUT but lost due to lack of resources. The loss rate refers to the percentage of lost packets in the whole packets which should be forwarded. It reflects the ability of the DUT to withstand a specific load.

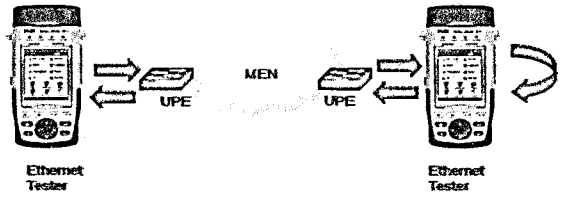
Frame Loss = Less than 0.1%
** Frame loss = {(Tx frames – Rx frames) / Tx frames} x 100%

3) Latency

Definition: latency is the time the DUT need to forward data packets with load. Tester sends a certain amount of packets, records both time the packet being sent and received after being forwarded by the DUT. For storing and forwarding devices, latency is the time interval between the time spot when the last bit of input frame reaches the input port and the time spot when the first bit of output frame reaches the output port. For pass-through device, latency is the time interval between the time when the first bit of input frame reaches input port and the time when the first bit of the output frame reaches the output port. Latency reflects the speed of DUT to handle packets.

4) Back-to-back

Definition: the back-to-back value is the number of frames in the longest burst that the DUT can handle without the loss of any frames. Back-to-back reflects the ability to handle burst data. Stand-alone mode: It is the ideal test mode advocated by RFC2544. DUT receives test data stream from the transmitting port of a tester, then forwards it to the receiving port of the same tester, which will summarize and analyze the test data to provide test results according to RFC2544. Dual mode: There are two testers in a test system, and the transmitting port and receiving port are respectively on tester A and B. Tester A sends test data stream, which is forwarded by the DUT and received by tester B; Tester B then analyzes the data stream according to RFC2544. Stand-alone mode and dual mode both have advantages and disadvantages. For stand-alone mode, because all the testing process is in a single tester, it is easy to control test accuracy and process, but difficult to generate sufficient test pressure. On the contrary, for dual mode, testing processes are respectively on two machines, resulting in process synchronization and time synchronization problems. Yet it is easy to generate sufficient test pressure.



Standard RFC 2544 Test Setup

Figure 5 – Standard RFC 2544 Test Setup

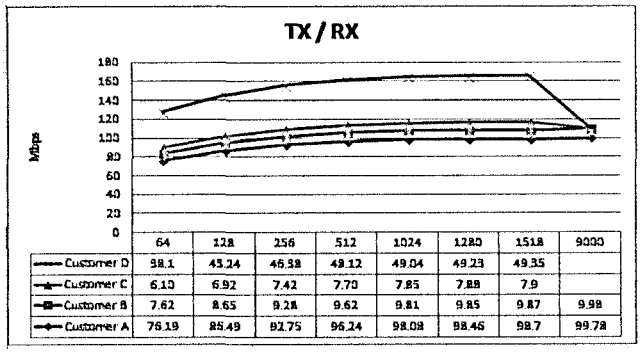
IV RESULTS AND ANALYSIS

Besides product pricing, a good quality and high reliability network are also the main factor to be considered before choosing a service provider. With a competitive market today, service provider needs to maintain the engineering cost as well as sustain the network performance. During network congestion, Quality of Service (QoS) is beneficial to help traffic being prioritized based on the class of service and ensure there will be no packet drop, jitter or latency especially to the highly sensitive traffic such as video and voice.
All testing for RFC2544 have collected and recorded focus the four customers selected, table below shows the all results for testing RFC2544.

RFC2544 testing focused on throughput test, latency, jitter and Frame loss test with jumbo frames and without jumbo frames. These differences involve high capacity for frame size with the 9000 bytes for jumbo frames.

		WITH JUMBO FRAMES				WITHOUT JUMBO FRAMES			
		CUSTOMER A		CUSTOMER B		CUSTOMER C		CUSTOMER D	
	Frame	TX	RX	TX	RX	TX	RX	TX	RX
THROUGHPUT	64 bytes	76.19 Mbps	76.19 Mbps	7.62 Mbps	7.62 Mbps	6.10 Mbps	6.10 Mbps	38.10 Mbps	38.10 Mbps
	128 bytes	86.48 Mbps	86.48 Mbps	8.65 Mbps	8.65 Mbps	6.92 Mbps	6.92 Mbps	43.24 Mbps	43.24 Mbps
	256 bytes	92.75 Mbps	92.75 Mbps	9.28 Mbps	9.28 Mbps	7.42 Mbps	7.42 Mbps	46.38 Mbps	46.38 Mbps
	512 bytes	96.24 Mbps	96.24 Mbps	9.62 Mbps	9.62 Mbps	7.70 Mbps	7.70 Mbps	48.12 Mbps	48.12 Mbps
	1024 bytes	98.08 Mbps	98.08 Mbps	9.81 Mbps	9.81 Mbps	7.85 Mbps	7.85 Mbps	49.04 Mbps	49.04 Mbps
	1280 bytes	98.46 Mbps	98.46 Mbps	9.85 Mbps	9.85 Mbps	7.88 Mbps	7.88 Mbps	49.23 Mbps	49.23 Mbps
	1518 bytes	98.72 Mbps	98.72 Mbps	9.87 Mbps	9.87 Mbps	7.90 Mbps	7.90 Mbps	49.35 Mbps	49.35 Mbps
	9000 bytes	99.78 Mbps	99.78 Mbps	9.98 Mbps	9.98 Mbps	N/A	N/A	N/A	N/A
LATENCY	64 bytes	448.84 us		9375.90 us		571.20 us		2231.20 us	
	128 bytes	469.46 us		9383.24 us		595.14 us		2257.68 us	
	256 bytes	500.72 us		9396.84 us		640.62 us		2106.78 us	
	512 bytes	571.74 us		9425.80 us		733.26 us		2207.02 us	
	1024 bytes	726.56 us		9487.42 us		919.20 us		2409.18 us	
	1280 bytes	805.90 us		9518.60 us		1012.8 us		2509.30 us	
	1518 bytes	1012.72 us		9547.04 us		1256.84		2604.12 us	
	9000 bytes	4218.12 us		12456.54 us		N/A		N/A	
JITTER	64 bytes	2.94 us		2.99 us		7.52 us		4.56 us	
	128 bytes	1.06 us		10.27 us		5.92 us		1.92 us	
	256 bytes	0.42 us		8.36 us		8.32 us		3.68 us	
	512 bytes	0.19 us		3.77 us		0.48 us		6.72 us	
	1024 bytes	0.44 us		9.61 us		2.08 us		2.64 us	
	1280 bytes	0.58 us		15.68 us		0.80 us		1.52 us	
	1518 bytes	2.10 us		3.65 us		0.32 us		3.76 us	
	9000 bytes	0.30 us		2.64 us		N/A		N/A	
FRAME LOSS	64 bytes	0.00%		0.00%		0.00%		0.00%	
	128 bytes	0.00%		0.00%		0.00%		0.00%	
	256 bytes	0.00%		0.00%		0.00%		0.00%	
	512 bytes	0.00%		0.00%		0.00%		0.00%	
	1024 bytes	0.00%		0.00%		0.00%		0.00%	
	1280 bytes	0.00%		0.00%		0.00%		0.00%	
	1518 bytes	0.00%		0.00%		0.00%		0.00%	
	9000 bytes	0.00%		0.00%		N/A		N/A	

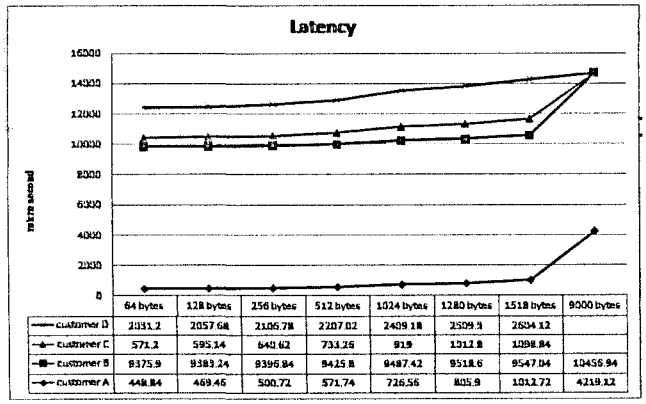
Table 2 – All results RFC2544 testing for four customers selected



	64	128	256	512	1024	1280	1518	9000
Customer D	38.1	45.24	46.58	48.12	49.04	49.23	49.35	
Customer C	6.19	6.92	7.42	7.79	7.85	7.88	7.9	
Customer B	7.62	8.65	9.28	9.62	9.81	9.85	9.87	9.98
Customer A	76.19	86.49	92.75	96.24	98.08	98.46	98.7	99.78

Figure 6 – Throughput RFC 2544 Tx and Rx same results.

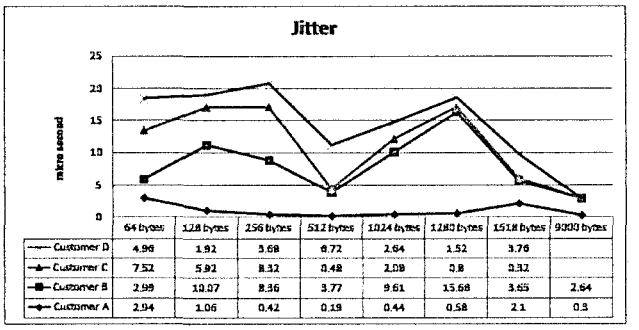
From Figure 6, testing results of four customers have to analyze and we learn that throughput increases with growth of frame length, because in the same bandwidth, the smaller the data frames are, the greater the data frames amount becomes. As a result, network devices will spend more time handling these data frames. Because when the data frame length increases, the number of data packets the device handles in unit time decreases; at the same time, the time network equipment spends handling a single data packet doesn't increase, so the forwarding rate increases and so does the throughput. On the contrary, when the frame size is larger, the frame will have smaller impact on the throughput.



	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1280 bytes	1518 bytes	9000 bytes
Customer D	2031.2	2057.68	2106.78	2207.02	2409.18	2509.9	2634.12	
Customer C	571.3	595.14	640.62	731.26	919	1312.8	1098.84	
Customer B	8375.9	9383.24	9396.84	9425.8	9487.42	9518.6	9547.04	10456.84
Customer A	448.84	469.46	500.72	571.74	726.56	805.9	1013.72	4219.32

Figure 7 – Results Latency for testing RFC2544

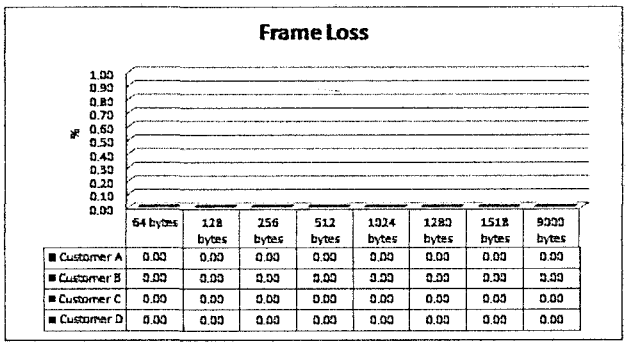
From figure 7 we can learn that latency is increasing with the growth of frame length. Because with larger single data packet length, it will take longer time for the device to process data packets, and the corresponding latency will also increase.



	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1280 bytes	1518 bytes	9000 bytes
Customer D	4.96	1.92	3.68	8.72	2.64	1.52	3.76	
Customer C	7.52	5.92	8.32	8.48	2.08	0.8	0.32	
Customer B	2.99	10.07	8.36	3.77	9.61	15.68	3.65	2.84
Customer A	2.94	1.06	0.42	0.19	0.44	0.58	2.1	0.3

Figure 8 – Results Jitter in RFC2544

In order to investigate the jitter parameter in QoS evaluation of suggested scenario, the average of the delay of passing packets in RFC2544 test with then deviation rate and are calculated. Jitter is defined as the criteria deviation of packets *delay or the amount of packets 'delay fluctuation around the* average amount which is the balance or imbalance of packets 'delay in packets' arrival. One of the factors of QoS is jitter. With less jitter, the system will have a better operation



	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1280 bytes	1518 bytes	9000 bytes
Customer A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 9 – Results for Frame Loss

For this testing, results for Frame Loss shows that all frames have no errors and good quality network. It's follow the QoS and absolutely this results is better for the customer needed.

Analysis Results Using Minitab 16 Statistical Software.

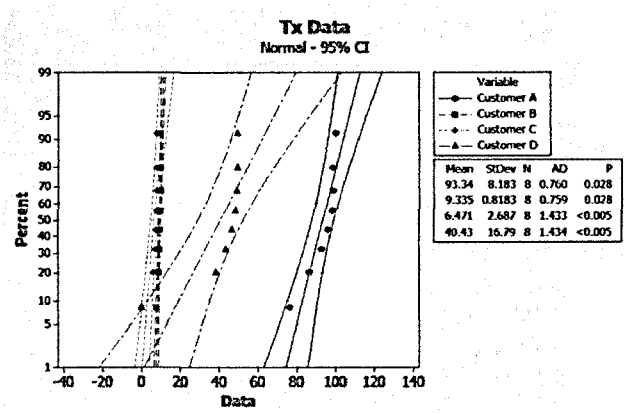


Figure 10 – Results Throughput for TX using Minitab 16

All results using Minitab 16 Statistical Software with using variable all customers involve have shows important value like Mean, Standard Deviation, Sample size, Anderson-Darling and Probability.

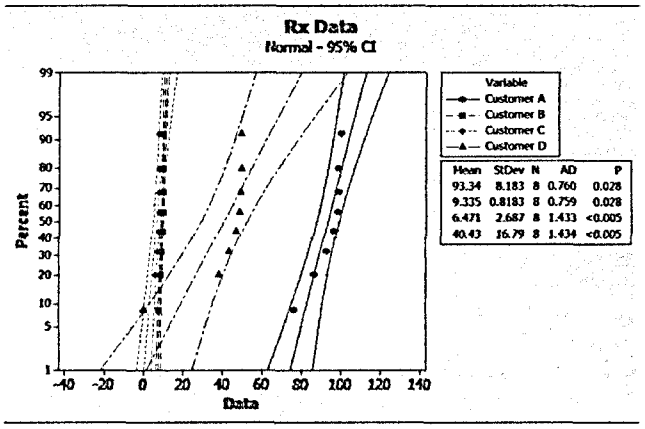


Figure 11 – Results Throughput for RX using Minitab16

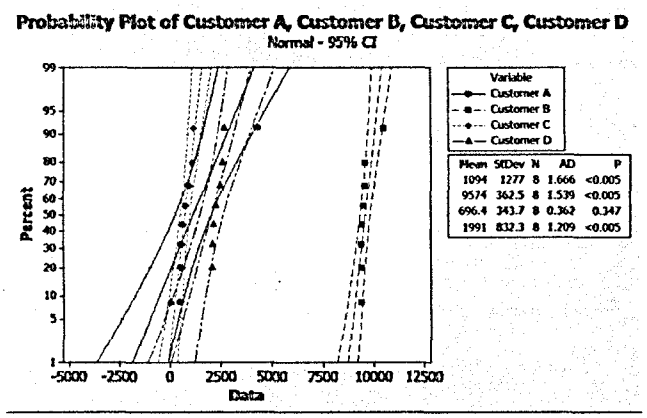


Figure 12 – Results Latency in Probability using Minitab16

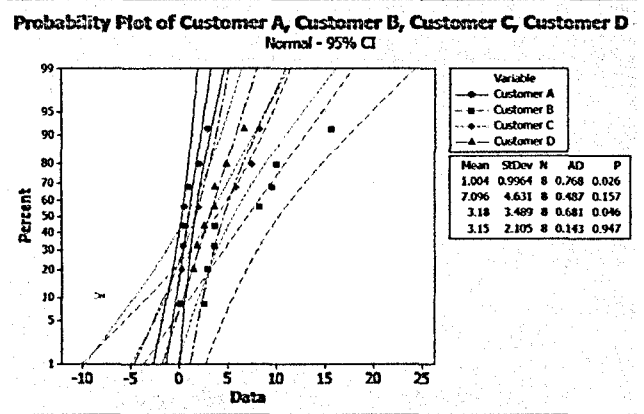


Figure 13 - Results Jitter in Probability using Minitab16

V CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

This research more related the Service Level Agreement with the customers network performance measurement technique based on RFC2544, results from a study of four of the affected customers were all found to meet Service Level Agreement (SLA) specifications and it can conclude the testing RFC2544 is the appropriate testing and proposed for service provider can use this testing for ensure the QoS meet the customers needs and follow the specifications. From the analysis it can be concluded that SLA can be verified with the RFC2544 testing. Service providers can utilize the proposed parameters and testing method to guarantee customer's satisfaction.

B. Future Recommendations

Due to the time constraint, the project only focus on four QoS parameters: throughput, jitter, latency and frame loss and more related also focus to the User Provider Edge (UPE). Therefore, for future enhancement, other elements such as bandwidth, packet loss, bit rate, and burst should be included. Furthermore, other relevant testing can be implemented to ensure better QoS.

ACKNOWLEDGEMENTS

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