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SERVICE LEVEL AGREEMENT PERFORMANCE ANALYSIS ON QUALITY OF SERVICE UPE-METRO ETHERNET

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ABSTRACT

A Service Level Agreement (SLA) between a service provider and its customers is an assurance to customers in fulfills the best services. Customers can get the service they pay for which obligates the service provider to achieve its service promises. Failing to meet SLAs could result in serious financial consequences for a provider and lost customers trust. This paper presents an analysis on performance of Quality of Service (QoS) SLA on a User Provider Edge –Metro Ethernet (UPE-ME) network. A QoS SLA tested method called RFC 2544 is performed on four customers in one industrial area. Actual data on four of QoS parameters which are throughput, jitter, latency and frame loss are tested by using test gear VeEX Vepal MX-120. The customers are focus to the User Provider Edge (UPE) customer. A few measurement and techniques are presented on the tested method. Analysis result on the tested throughput, jitter, latency and frame loss performance are presented based on growth of bytes. Network performance tested is identified that it is qualify as a perform network link. Performance presented results on growth of throughput with growth of frame length and latency increased with growth of frame length. Analyzed on frames loss presented that there are no errors thus this proved good quality network. Some jitters presented that they are in a low value which means that less jitter presents system with a better operation. Identifications on parameter value are presented based on an analyzed QoS using Minitab16. The produce result shows the implemented of SLA QOS UPE-ME follow the QoS and this result is a better proved for customer satisfaction and good services from the service provider.

Keywords: service level agreement, user provider edge, metro Ethernet, RFC2544, quality of service, throughput, packet loss.

INTRODUCTION

Today's network really needs a high quality of reliable network performance. Thus, high bandwidth service for high traffic load has become a necessary and the demand is increased tremendously. User Provider Edge (UPE) Metro-Ethernet (ME) medium services is an example of an aggressive internet market services today. UPE-ME is a network services which is chosen based on the increases of data speed. ME networks emerged as the next area of growth for the networking industry and its represents a major shift in how data services are offered to businesses and residential customers. The metro has always been a challenging environment for delivering data services because it has been built to handle the stringent reliability and availability needs for voice. Carrier's servicer has to go through fundamental shifts to equip the metro for next-generation data services demanded by enterprise customers and consumers. (Halabi and Halabi, 2003). Thus high bandwidth link is provided in order to serve better network performance. Furthermore, high speed network like UPE-ME is able to adapt with various type of traffic on minimum congestion.

In providing high speed network with reliable network performance, Quality of Service (QoS) is one common value added services to users seek especially in Service Level Agreement (SLA) from the service provider (Rabie, Aboul-Magd, Abdullah, and Barka, 2013). 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. Regular QoS aware is a must driven task in maintaining high performance service especially in UPE-ME network (Kern, 2007). QoS not only important in network management but it affect more with used network applications or communication. Many network applications and system requires high reliability, prioritization and secured traffic transferred or communications across the internet network. Thus, QoS in network not only rely to speed or performance but also, secured and reliable system. Performance in QoS network is identified as one of the most demanding factors in network management. Many new method, scheme or algorithm has continuously develop in enhancing the speed performance in a network (Kassim, Ismail, Jumari, & Yusof, 2012). Four network traffic characteristic and parameter are evaluated which are bandwidth throughput, delay, jitter, and packet loss rate are evaluated. In recent years, the multimedia and video traffic applications are very popular. These applications 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.

This paper presents an analysis on performance of QoS service level guarantee on a UPE-ME network. The objectives of this research are to collect the actual data, tests and analyze the results using RFC 2544 SLA tested method focus in one industrial area. RFC 2544 is a performance test which is performed on four set automated tests which is throughput, latency, frame loss, and burst or back-to-back. Network performance is evaluated to qualify the performance of a network link. An

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actual testing also is done where four selected customer are taken as a benchmark area. Actual testing is based on real network by using test gear VeEX Vepal MX-120. Results are presented and compared with the acceptable range from ITU-T network standard.

NETWORK BACKGROUND

Literature review on network QoS standard test, metro Ethernet architecture and service level guarantee method are discussed.

Network QoS standard test

The important of a standard test is always questioned. This is to make sure the testing is able to prove with correct parameter and characteristic. Testing in network communications is applied to verify an implementation, in terms of functionality, conformance, interoperability, performance, robustness, and stability (Y.-D. Lin and Johnson, 2014). An aspect of a method and system for QoS management in most standard networks should be identified and provided. One research presented in a one communication device which enabled to communicate utilizing a variety of communication networks, QoS information, such as latency, available bandwidth, and throughput. A QoS management entity may be enabled to poll other QoS management entities to discover QoS information (Walley et al., 2014). Table-1 derived the standards of throughput test based on percentage of speed use. This standard is taken as guideline to all service providers to ensure QoS are achieved.

Table-1. International standard test on throughput speed.

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

Metro Ethernet

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) in Metro Ethernet Network. SLA is failure avoidance. A system and method for communicating may fail in a metro Ethernet network. Research presents that Packets are communicated through multiple maintenance entities. A determination is made that there is a failure between or at one of the multiple maintenance entities. Thus, a method to adapt failures in ME is developed called alarm which is routed at least two a communications service provider determined to be associated with the failure (Bugenhagen, 2014). Figure-1 depicts the typical Metro Ethernet network architecture which implements with Cisco products (A. Lin, 2004). There are three main components that constitute the network: Network Provider Edge (NPE), Edge Provider Edge (EPE), and User-Provider-Edge (UPE).

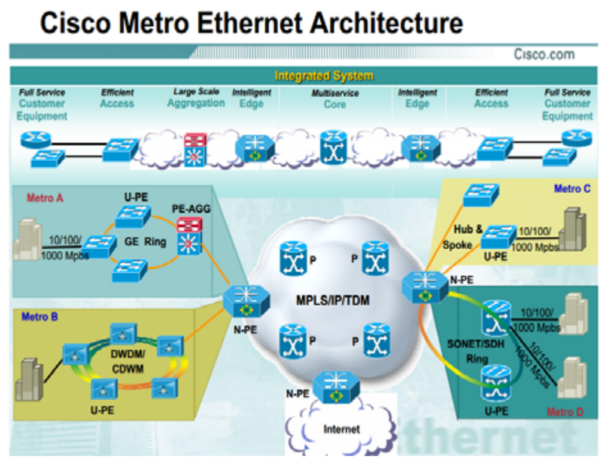

Figure-1. The Cisco Metro Ethernet network architecture.

Service level agreement

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. Thus, a method and apparatus for measurement-based conformance testing of service level agreements in networks is important. Research presented that the test proved the transmitted test traffic is received at the destination, and quality of service information is identified by comparing characteristics of the test traffic transmitted by the source to characteristics of the test traffic received by the destination (Schuster, Borella, Grabiec, and Sidhu, 2002). RFC 2544 is identified as one well accepted recommendations tester and measurement industry for network performance. (Lifu, Dongming, Bihua, Yuanan, and Hefei, 2012). It is also popular for the verification of network links with certain service level agreements (SLA). 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).

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- 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, like 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-perform and is 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 present SLA which provided with no redundancy (1+0) connection to customer premises.

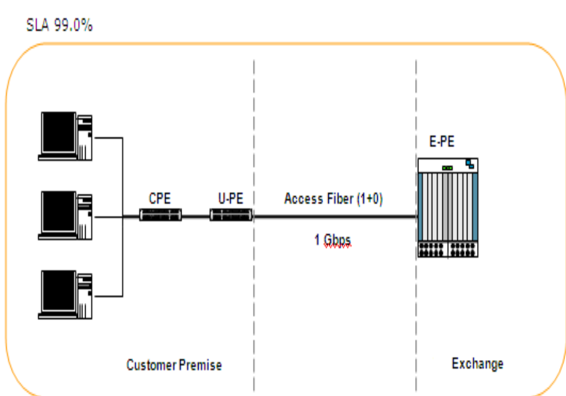

Figure-2. SLA with No Redundancy (1+0).

Figure-3 present SLAwith 1+1 redundancy which is right up to customer premises. This Service Provider provides one U-PE connecting to two different fiber paths served from one E-PE exchange nodes. Figure-4 shows SLA 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 is adopted with a type of SLG 99.99%.

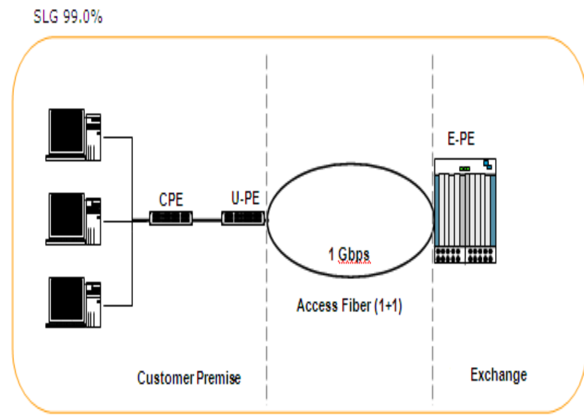

Figure-3. SLA with 1+1 redundancy one fiber.

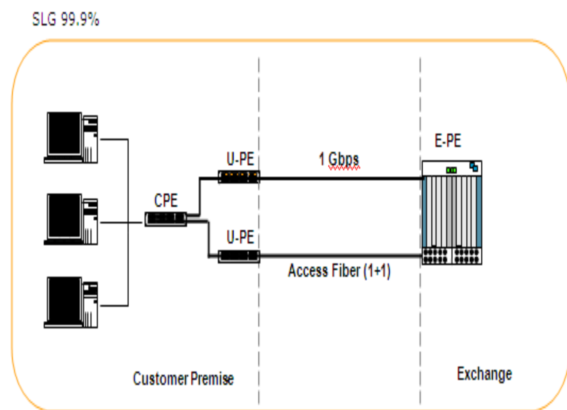

Figure-4. SLA with 1+1 redundancy 2-Fiber.

METHODOLGY

Figure-5 presents three phases of research methodology in analyzing the performance of SLA QoS UPE-ME. The three phases are derived as below:

Phase 1: Study case

A study case is done to understand needs and identified Metro Ethernet technology. Problem in ME is recognized, network Ethernet is identified and appropriated method is made to test on QoS. Depth information on the technology, parameter evaluation involve with QoS is derived. Familiarization with test gear VeEX for use at the customer last end for the UPE (User Provider Edge) is done. All techniques for testing are learnt and demo. In this phase RFC2544 which is Request for Comments is tested and measured. The RFC2544 test suite performs a set of four automated tests which are throughput, latency, frame loss, and burst or back-to-back.

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Qualified performance of the network link is tested. In order to ensure that an Ethernet network is capable of supporting a variety of services such as VoIP or video, the RFC2544 test is suited supports with seven pre-defined frame sizes. The frames size are 64, 128, 256, 512, 1024, 1280 and 1518 bytes which simulated with 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. This testes size is depended on customers request test. The frames size also can add up with the Jumbo frames with 9000 bytes. A portable RFC2544 test equipment is used which immediately captured results and demonstrated that the Ethernet service meets the customer SLA. Two test gears were use it with one runs the test and another one setting with the looping. This tested result is also taken as a performance baseline for future reference.

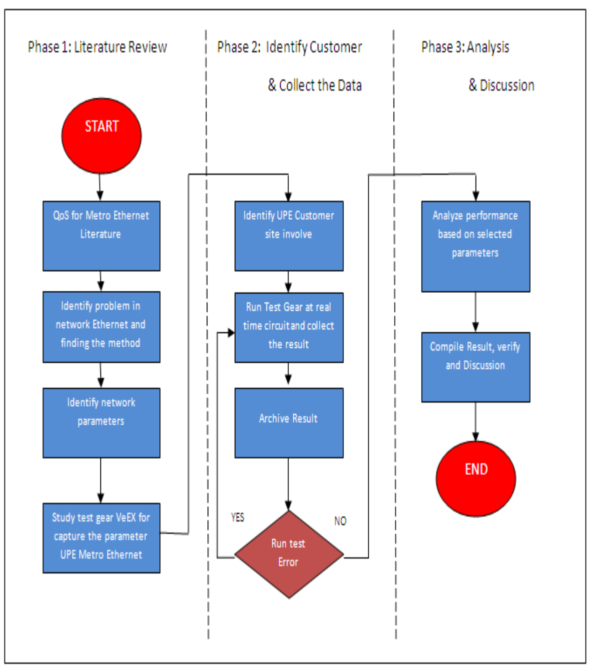

Figure-5. Three phases on sla analysis methodology.

Phase 2: Identify the customer and collect the data

The second phase of this research has identified the UPE at the customer's site test using Test gear VeEX. Selected customers for achieve Quality of Service network which measured the real-live network are analyzed. After testes are completed, the indentified result on parameters which the parameters evaluation is collected. The Test Gear is assured running the set of time. All simulation's results are archived for analysis. 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. Figure-6 shows the stand RFC test setup.

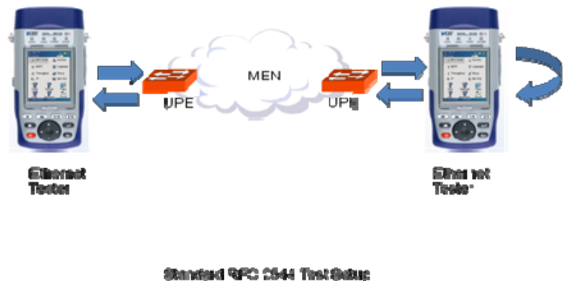

Figure-6. Standard RFC 2544 test setup.

Phase 3: Analysis and discussion

Data collected and analysis

Data collected and analysis is done in the third phase. Analyzed results are discussed based on network parameter chosen. Performance result is presented with the comparison on different type of traffic scenario. Optimum result on best QoS implementation is decided. Analysis on data collected also is analyzed using Minitab statistical method. All detail parameter are presented. Figure-7 presents the algorithm flow of data analysis on the identified traffic.

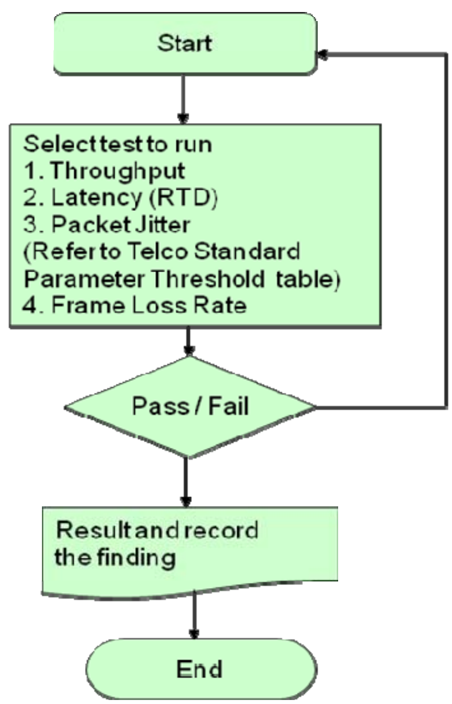

Figure-7. Algorithm flow on QoS SLA test.

Benchmarking tests

Benchmarking tests are done with RFC2544 on four identified parameters as listed.

Throughput

Throughput is the fastest rate at which the count of test frames transmitted by the DUT is equal to the

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number of test frames sent to it by the test equipment. It reflects maximum data traffic which the DUT can handle. Throughput culcalation as in Eq. 1 and frame rate as in Eq. 2.

$$\text{Data Throughput} = \text{Frame Rate} \times \text{Frame Size} \times 8 \quad (1)$$

$$\text{Frame Rate} = \text{Network Speed} \frac{1}{(\text{Frame Size}+20) \times 8} \quad (2)$$

Loss rate

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. Eq. 3 presents the percentage of lost packets where Frame Loss (FL) is less than 0.1%.

$$\text{FL} = (\text{Tx frames} - \text{Rx frames}) / \text{Tx frames}) \times 100\% \quad (3)$$

Latency

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.

Back-to-back

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's easy to generate sufficient test pressure.

RESULTS AND ANALYSIS

Table-2 presents all testing for RFC2544 results. The collected and recorded results are focused to four selected customers. This 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.

Table-2. Results on RFC2544 testing for four selected customers.

		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	86.49 Mbps	86.49 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	98.70 Mbps	98.70 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		2031.20 us	
	128 bytes	469.46 us		9383.24 us		595.14 us		2057.68 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		919.00 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		1098.84		2604.12 us	
	9000 bytes	4219.12 us		10456.94 us		N/A		N/A	
JITTER	64 bytes	2.94 us		2.99 us		7.52 us		4.96 us	
	128 bytes	1.06 us		10.07 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	

Figure-8 presents testing results of four customers. It is identified that throughput increases with growth of frame length. All four customers show a growth result if greater the data frames amount becomes. Thus, result identified that network devices actually spends more time handling these data frames due to when data frame length increases. The number of data packets increased when the device handles in unit time decreases. At the same time, when network equipment spends handling a single data packet doesn't increase, the forwarding rate increases and so does the throughput. On the contrary, when the frame size is larger, it presented smaller impact on the throughput. Figure-9 presents latency result on four tested customers. Result presents that latency increased with growth of frame length. This is due to larger single data packet length took longer time for the device to process data packets and the corresponding latency also has increased.

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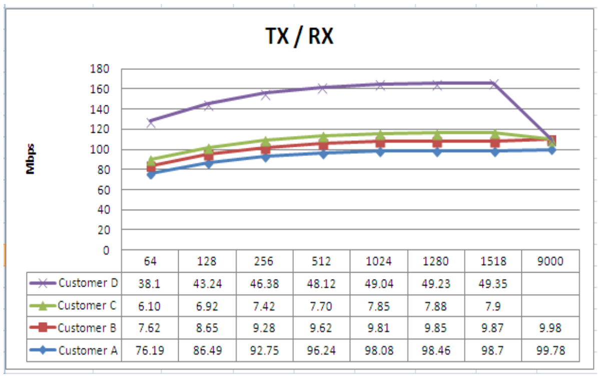
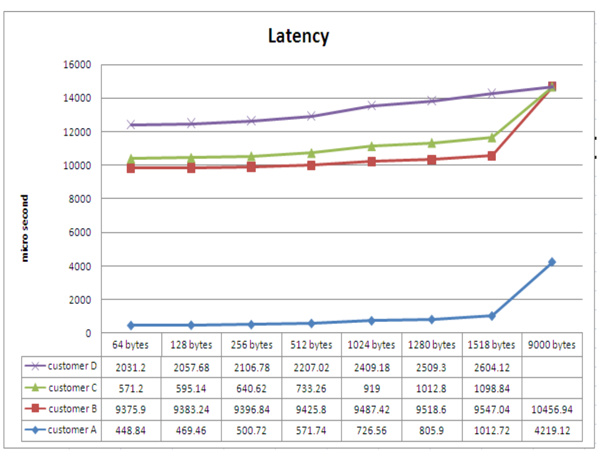
Figure-10 presents Jitter result on four tested customers. In order to investigate the jitter parameter in QoS evaluation of suggested scenario, the average of the delay of passing packets in RFC2544 is tested. The deviation rates are calculated. Jitter happened when deviation of packets delay or the amount of packets 'delay fluctuation around the average amount which is the balance or imbalance of packets 'delay in packets' arrival. Results present not a stable jitter with low and high value when greater bytes are tested. Some jitters are in a low value even when at the 64 bytes tested. Predicted on jitter effect is unexplained but theories mentioned that one factors of QoS is jitter. With less jitter, the system will have a better operation. Figure-11 presents comparisons of four tested customers are on Frame Loss. It 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.



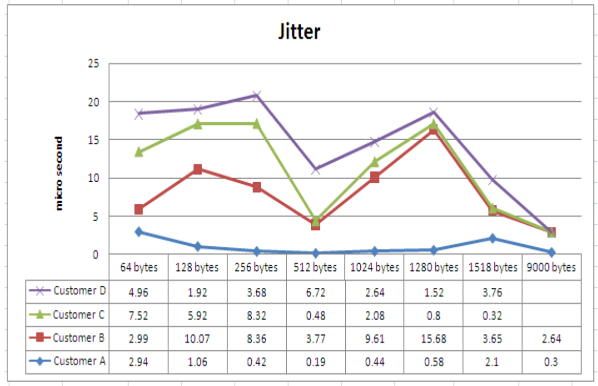
	64	128	256	512	1024	1280	1518	9000
Customer D	38.1	43.24	46.38	48.12	49.04	49.23	49.35	
Customer C	6.10	6.92	7.42	7.70	7.85	7.88	7.9	
Customer B	7.62	8.65	9.28	9.62	9.81	9.85	9.87	9.98
Customer A	76.19	86.49	92.75	96.24	98.08	98.46	98.7	99.78

Figure-8. Comparison throughput for four customers RFC 2544 Tx and Rx test.



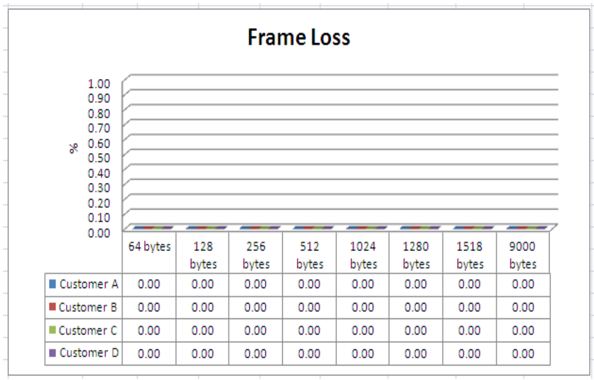
	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1280 bytes	1518 bytes	9000 bytes
customer D	2031.2	2057.68	2106.78	2207.02	2409.18	2509.3	2604.12	
customer C	571.2	595.14	640.62	733.26	919	1012.8	1098.84	
customer B	9375.9	9383.24	9396.84	9425.8	9487.42	9518.6	9547.04	10456.94
customer A	448.84	469.46	500.72	571.74	726.56	805.9	1012.72	4219.12

Figure-9. Comparison latency for four customers on RFC2544 Test.



	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1280 bytes	1518 bytes	9000 bytes
Customer D	4.96	1.92	3.68	6.72	2.64	1.52	3.76	
Customer C	7.52	5.92	8.32	0.48	2.08	0.8	0.32	
Customer B	2.99	10.07	8.36	3.77	9.61	15.68	3.65	2.64
Customer A	2.94	1.06	0.42	0.19	0.44	0.58	2.1	0.3

Figure-10. Comparison jitter for four customers on RFC2544 test.



	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-11. Comparison frame loss for four customers on RFC2544 test.

Figure-12 to Figure-14 present all parameter characteristic on tested throughput probability. Important parameter like mean and standard deviation is important in recognizing the samples tested traffic. Figure-12 presents the identified parameters based on tested QoS for probability throughput. Figure-13 presents Latency for Probability and Figure-14 presents Jitter for Probability. The fits probability on throughput tested QoS are done using Minitab 16.

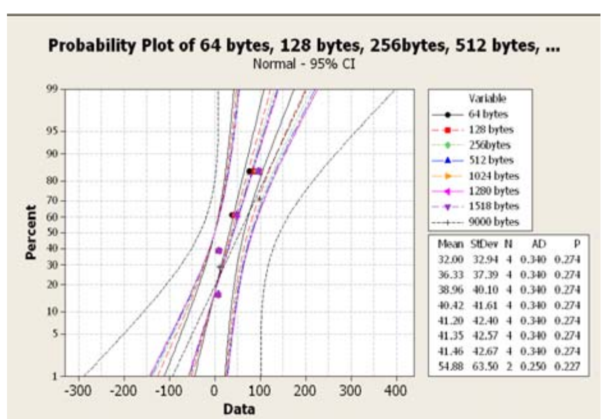


Figure-12. Throughput for probability.

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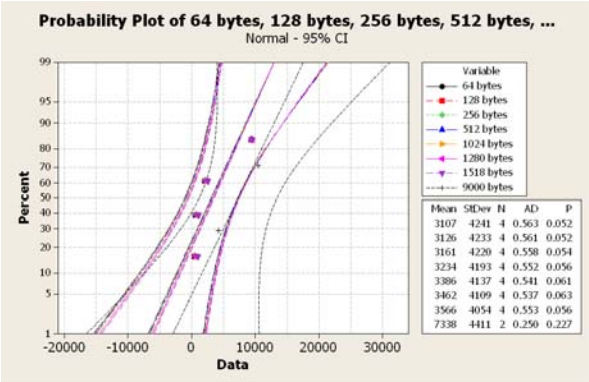

Figure-13. Latency for probability.

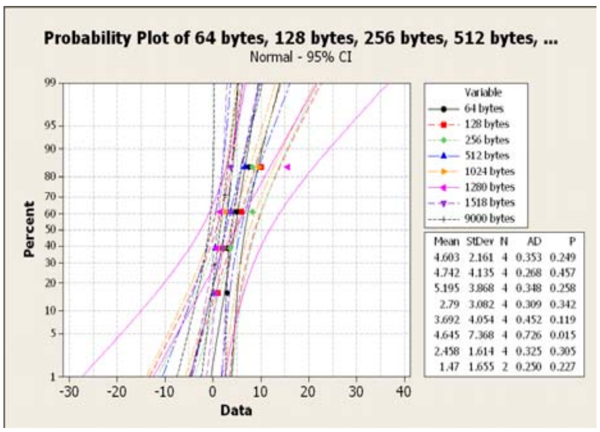

Figure-14. Jitter for probability.

CONCLUSIONS

This paper presents Service Level Agreement with the customers' network performance measurement technique based on RFC2544. Results from the study of four affected customers are all found to meet Service Level Agreement (SLA) specifications. The testing with RFC2544 is successfully done. The result can be used to propose for service provider in ensuring the QoS meet the customers' needs and follow the specifications. The analyzed result is concluded that SLA is verified with the RFC2544 testing. The analyzed on parameter evaluation is taken as proved to guarantee customer's satisfaction.

Due to the time constraint, these researches only analyzed four of QoS parameters, throughput, jitter, latency and Frame loss and more related and 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 in future researches and suggest to focus with the another testing for ensure QoS will be achieve.

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