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Mechanical Converged Transparent Satellite for LTE: An Evaluation State-of-the-Art Layer 2 Method

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Abstract. As 4G LTE is based on a full IP architecture, all the network interfaces between the LTE NEs are over IP – even when they are further encapsulated or transported over other technologies. This means that from an LTE point of view we are always dealing with IP links and all issues on LTE interfaces can be analyzed and understood by their effects on the IP layer. This effectively means that we can simplify any scenario (whatever the mix of issues, technologies, layers) to (a combination of) IP Impairments. In this paper, we present basic considerations regarding the support of Bridge Satellite SCPC transmission for the 4G-LTE communication network that will continue the satellite transmission. We design, implement, and evaluate the performance of transport protocol solutions based on the IEEE 802.1Q switching architecture in 4G LTE satellite systems. The resulting parameter values are indexed Σ throughput (bit / s) Σ the amount of data sent (outbound) at the time of delivery. The parameters of the index throughput obtained reach the amount of allocated bandwidth from 3072Kbps. Bandwidth Utilization Index = Σ Bandwidth The use of inbound and outbound reaches 100% and the value of packet loss results is 0-2%. The delay parameter value is 0-2 (ms) on the transmission connectivity.

1. Introduction

Along with the deployment of 3G and 4G technologies, increasing data traffic challenges the capabilities of existing backhaul networks, and this trend is expected to increase [1]. What does this mean for customers or prospective customers who do not live in the main metropolitan or rural area? What does this mean for customers or prospective customers who do not live in the main metropolitan or rural area? Will the connectivity gap? The answer is no. LTE and its ability to cost effectively provide fast, highly responsive mobile data services, a scalable bandwidth and a reduced latency will become ever more important [2]. The use of satellite technology, especially the very small aperture terminal system, has increased rapidly, enabling cellular traffic from operators to backhaul voice and data remote and rural areas [3].This research paper presents a transmission scheme using the SCPC [4] combination as a transparent satellite with a standardized encapsulation protocol (IEEE 802.1Q) and Bridge Setup (IEEE 802.1D), on transmissions that will continue satellite communication to be able to carry a 4G- LTE TCP connection, namely User Plane (S1-U) data traffic, Mobility Management Entity (MME) and Operations and Management (OAM), ABIS from eNodeB to packet data network gateway (P-GW) and serve Gateway (S-GW) [5]. The application of a simple scheme, using the optimization of the use of bandwidth allocation to be allocated 3072 kbps on the VSAT transmission channel from the satellite SCPC system. Furthermore, it will function as a traffic transparent data satellite originating from eNodeB. Testing throughput, bandwidth, packet loss and delay values will be optimized and analyzed in the transmission process to satellite backhaul. Furthermore, from the backhaul satellite will be forwarded with transmissions using terrestrial media. Scheme about converged satellite- delay tolerant capabilities LTE: A evaluation state-of-the-art layer 2 method will be explained in Figure 1.

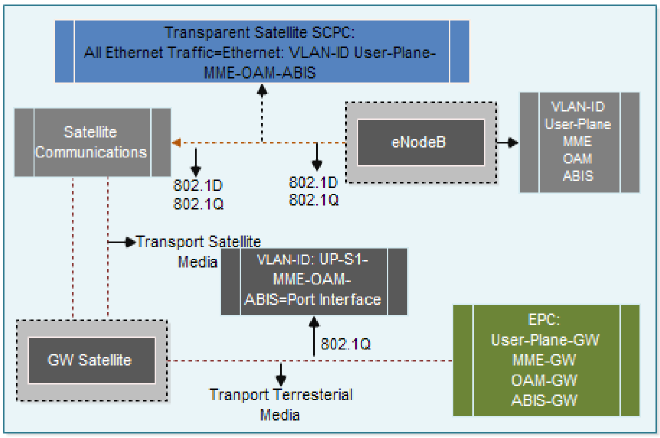

Figure 1. Scheme on Transport transparent through Satellite For 4G LTE

2. Literature Review

2.1. Tagged Ethernet (802.1Q)

The IEEE 802.1Q is the standard defining VLANs. The VLAN tag consists of 12-bits length in the Ethernet frame, creating up to 4,096 VLANs on a LAN. The concept of private VLAN is used to secure and restrict traffic inside a specific broadcast sub-domain. VLAN (Virtual LAN) is a technology which can configure logical networks independent of the physical network structure [6]. Additionally, 802.1Q has only 12 bits for VLAN identifiers, which allows for 212^2 = 4094 VLANs to exist inside a single domain (VLANs 0 and 4095 are reserved). Transport service providers can have thousands of corporate customers, each having multiple VLANs [7]. Proposed Scheme will be explained in representation in Figure 2 and Figure 3, respectively.

for i **from** S1U-ID **do**={
:int vlan add name=("User-Plane".$i) vlan-id=$i interface=Port
}
{
:int vlan add name=("User-Plane".$i) vlan-id=$i interface=Bridge Port
}
 	
:**for** i **from** MME-ID **do**={
:int vlan add name=("MME" . $i) vlan-id=$i interface=Port
}
{
:int vlan add name=("MME" . $i) vlan-id=$i interface=Bridge Port
}
	:**for** i **from** OAM-ID **do**={
	:int vlan add name=("OAM" . $i) vlan-id=$i interface=Port
	}
	{
	:int vlan add name=("OAM" . $i) vlan-id=$i interface=Bridge Port
	}
	
	:**for** i **from** ABIS-ID **do**={
	:int vlan add name=("OAM" . $i) vlan-id=$i interface=Port
	}
	{
	:int vlan add name=("OAM" . $i) vlan-id=$i interface=Bridge Port
	}

Figure 2. Represent Allocation Tagged Ethernet (802.1Q)

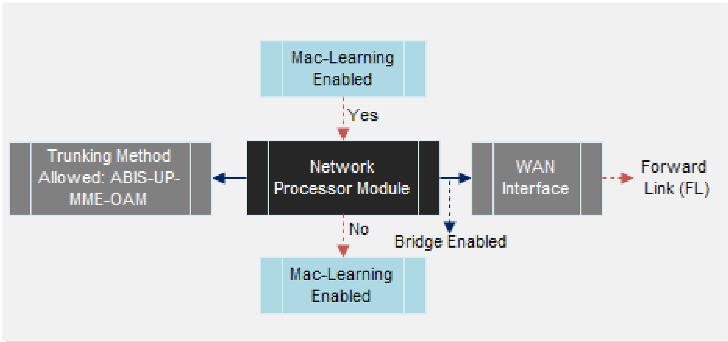

Figure 3. Bridge Interface and Tagged Mode (Modem Satellite)

2.2. Bridge Interface and Trunking Mode

P2P capability on SCPC technology enables layer 2 operation so that the Advanced VSAT network can operate as an Ethernet switch with MAC learning, VLAN tagged and VLAN access mode while benefiting from one of them is Multi-level QoS [8]. The design and implementation that will be carried out in this paper, the transparent satellite to be used is bridge and tagged on the satellite Comtech EF (CDM-840) SCPC modem [9]. Protocol will be used as a transmission through the SCPC VSAT network to carry packages and traffic from LTE eNodeB. The proposed scheme will be explained in the flowchart representation in Figure 4.

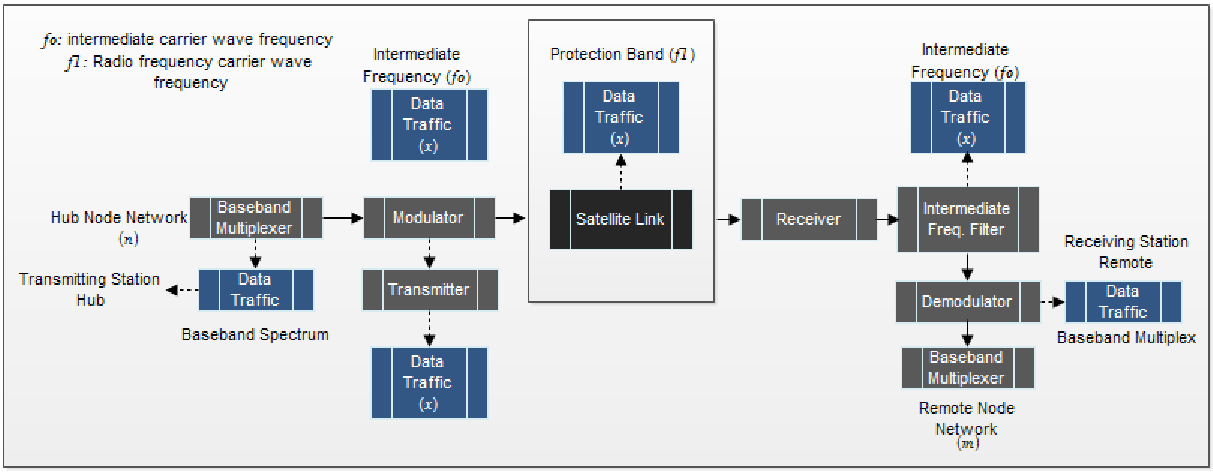

Figure 4. Communication between two earth stations: Hub Station and Remote Station

3. Research Method

Methodology that will be applied is in terms of integrating and analyzing the performance of the LTE network that will pass through satellite transmission. Then evaluated the quality of service value produced by the concept that will be applied. The following is explained the methodology that will be applied is as follows:

3.1. Topology Network Configuration Schema and Method

3.1.1. SCPC Satellite Communication

SCPC mode means two earth stations in each wave and the carrier frequency only transmits one route signal in the SCPC system [10]. In the papers carried out Earth station transmitters Hub stations only modulate, change and amplify the signal of one route, and then will be transmitted. The receiving earth station (Remote Node) changes the central frequency of the intermediate frequency filter to the transmitter station's earth frequency (Hub Station) [11]. So, only the signal transmitted by the earth station (Hub Station) can be sent to the demodulator. After the frequency is converted, filleted and demodulated in receiving the earth station (Remote Node), we can get a signal emitted from the earth station (Hub Station).

3.1.2. Interface VLAN and Bridge Setup Schema

Each VLAN is treated as a separate subnet. This means that by default, hosts in certain VLANs cannot communicate with hosts that are members of other VLANs, even though they are connected in the same switch [12]. The interface on the port will be set to tagged and bridge circuit so that it can brought 4 VLAN IDs: namely User Plane (S1-U), Mobility Management Entity (MME) and Operations, Management (OAM) and LTE-ABIS.

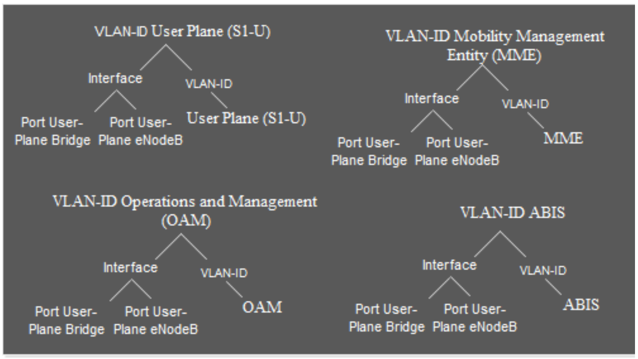

Figure 5. Schema Interface VLAN Setup

According to the scheme in Figure 5, it will be explained in the pseudocode representation as follows:

1. Step.1 Set VLAN-IDs, namely VLAN-ID = UP- S1U, VLAN-ID = MME, VLAN-ID = ABIS and VLAN-ID = OAM.
2. Step.2 VLAN-IDs will be forwarded to the interface leading to the eNodeB node interface.
3. Step.3 These three VLAN-IDs will be forwarded to the Interface which leads to bridge which leads to the modem satellite to modem satellite gateway interface.
4. Step.4 Port: one of the ports on the switch will be set as tagged interface (trunk-port that passes all VLAN- IDs).
5. Step.5 Then port becomes a member for all VLAN- IDs.
6. End

3.2. Proposed Integration and Optimization

System design integration and optimization as well as research design specifications are modeled as Figure 8. Design of the network configuration modeled resembles a metro-ethernet transmission. Where LTE transmission connectivity from eNodeB to the aggregator gate is modeled, it will carry traffic packets from eNodeB to the Gateway. This research discussion did not focus on the hub and remote satellite configuration. Existing satellite configuration is running and is focused on how to brought layer 2 eNodeB LTE transport to the EPC 4G. The topology and scheme in Figure 8. is the overall proposed integration and configuration optimization that will be applied [9].

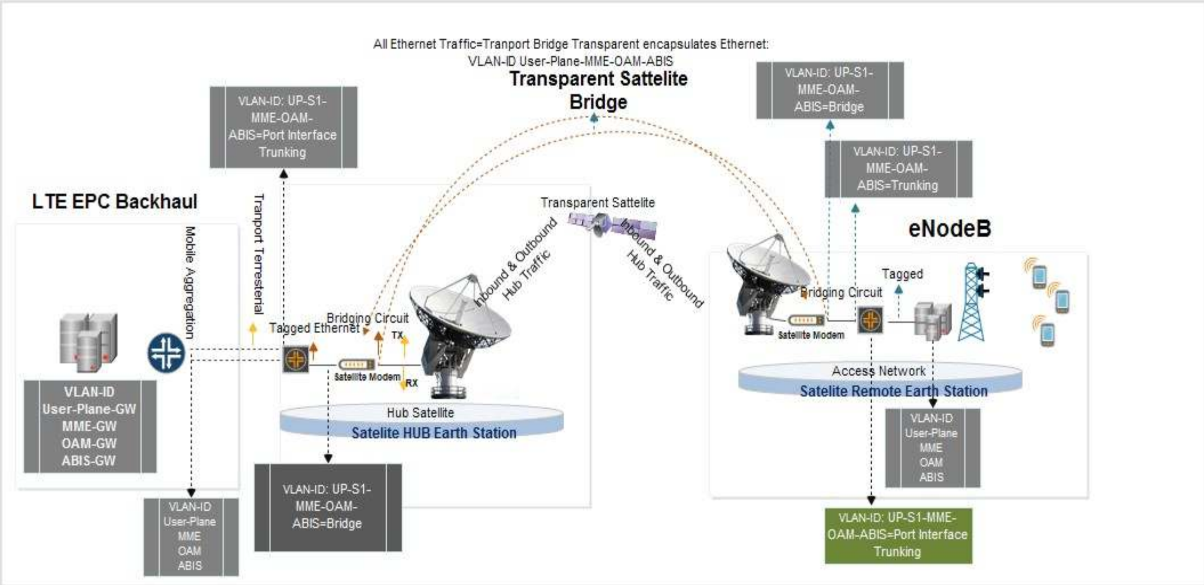

Figure 6. Designing a Long Term Evolution (LTE) Topology Model for Transport through Satellite and Bridging for Long Distance Mobile Connectivity

Table 1 and Table 2 have the following design specifications and instrumentation hardware and software requirements,

Table 1. Hardware and Software Instrumentation Design and Specifications

Hardware and Software Instrumentation		
Hardware	Device Function	Software Monitoring
Comtech EF (CDM-840)	Bridge Tagged	MRTG Cacti
WS-C2960-24TT-L	Management VLAN Tagged and Member	PRTG
Juniper EX4200	Metro Tagged	

Table 2. Features Data Interface

Features Data Interfaces	Hub ad Node Remote Satellite Parameter
Symbol rate	1.365 Mbaud
Data Rate	3072
Double Talk Carrier-in-Carrier bandwidth compression	Yes
ACM and CCM	No
GSE – low overhead <1% encapsulation	No
Super Jumbo Frame 10,240 Byte Support	No
Modulation: QPSK, 8PSK, 16APSK, 32APSK	QPSK
Dual IF: 70/140 MHz, L-Band and L-Band monitor	Yes
Freq. TX-RX Hub	1117.2944
Freq. TX-RX Remote	1357.7056
Symbol Rate Range	1.365
Modulation Type	QPSK
FEC Frame	0.75 / 3/4
Modulator or Demodulator	Phase Modulate
Output Power	-10 until -30

3.3. Data Collection and Data Analysis Quality of Service

QoS monitoring can be classified into two categories: end to end QoS monitoring (QM EE) and monitoring QoS distribution per node (distribution monitoring (DM)). in this paper DM is conducted where the QoS monitoring process is carried out in the shipping line segment or between the desired nodes along the data packet transmission path [13]. Measurement of the QoS value in this study will be measured based on the segment of the eNodeB package to satellite backhaul. Process of measuring Quality of Service parameters consists of:

a) Index Throughput (bit/s)
Transmission speed of the data transfer rate is effective, which is measured in bps. Throughput is the total number of packets that reach the destination, which is observed at the destination for a certain time interval divided by the duration of the time interval [14]. Throughput calculation equation with the following equation:

$$Throughput \sum bit/s \frac{number\ of\ data\ sent}{data\ delivery\ time}$$
$$Category\ Throughput \sum (\%) \frac{Bandwidth\ (kbps)}{avg\ number\ data\ sent} \quad (1)$$

b) Bandwidth Utilization (%)
- Inbound Traffic (i) is the maximum number of bits per second a network element can transfer (Upload). The capacity of an end-to-end path is determined by the slowest network element along the path [15].
- Outbound Traffic (o) is the maximum number of bits per second a network element can transfer (Download). The capacity of an end-to-end path is determined by the slowest network element along the path.
- Utilization (U) is the percentage of the capacity on a link or path currently being consumed by aggregated traffic.
- Bandwidth utilization is,

$$BW = \sum bps \frac{total\ traffic\ inbound+outbound}{bandwidth\ capacity}$$
$$BW\ util = \sum kbps \frac{total\ traffic\ inbound+outbound}{bandwidth\ capacity} \quad (2)$$

c) Index Packet Loss (%) and Delay (ms)

$$Loss = \% \frac{packet\ data\ sent+data\ packet\ received}{packet\ data\ sent}$$
$$Delay = bit/s \frac{Number\ of\ packet\ transmission\ data}{packet\ number} \quad (3)$$

4. Result and Discussion

4.1. Index Throughput (bit/s) Performance

Throughput parameters in this implement is done by MRTG monitoring, it can be seen throughput values generated in the transmission connectivity from the eNodeB source to the Backhaul Satellite Hub. There is Figure 7 can be seen from 1 month.

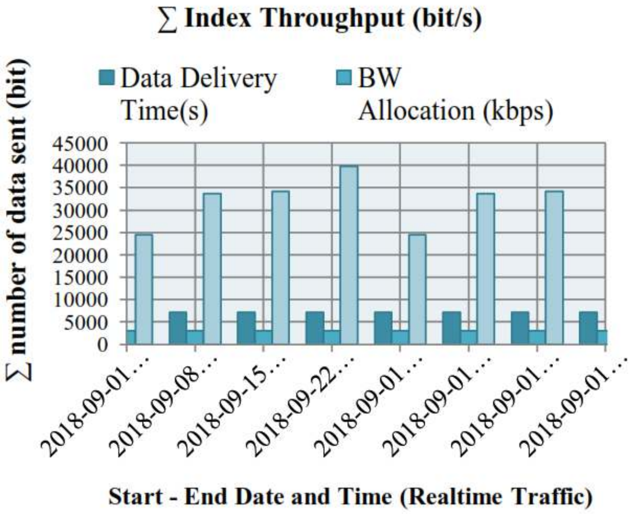

Figure 7. Throughput Performance in one month

Table 3. Index ∑ Throughput (kbit/s) Performance

Date and Time	Data Delivery Time (s)	∑ BW Allocation (kbps)	Index ∑ Throughput (kbit/s)
2018-09-01 23:00:00 2018-09-07 23:00:00	7200	3072	2442.53498
2018-09-08 01:00:00 2018-09-14 23:00:00	7200	3072	3372.65440
2018-09-15 01:00:00 2018-09-21 23:00:00	7200	3072	3417.93172
2018-09-22 01:00:00 2018-09-31 23:00:00	7200	3072	3983.64850

Table 3 shows the relationship between throughput and the actual bandwidth capacity utilization provided. First to fourth week implementation of results obtained can be seen from the distribution of throughput values (outbound (kbps) + data sent (∑) in the amount of inbound (kbps) sent data (kbps)) on 4G / LTE cellular networks that have an average total capacity of pipe width provided. The total throughput of the arrival of successful packets observed at the destination during a certain time interval is divided based on the duration of the interval.

4.2. Index Bandwidth Performance

Figure 8 shows the available network bandwidth measured at intervals of 1 month and indicates that the measurement of available bandwidth varies greatly depending on what time interval is used. ∑ bandwidth utilization outbound (kbps) + ∑ number of data sent (bit) inbound (kbps) divided bandwidth capacity (kbps).

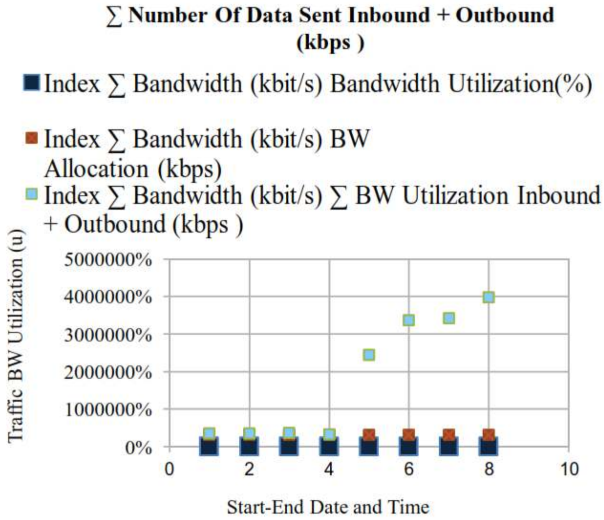

Figure 8. Bandwidth Performance in one month

Table 4. Index ∑ Bandwidth (kbit/s) Performance

Date and Time Evaluation	Bandwidth Utilization (%)	BW Allocation (kbps)	∑ BW Utilization Inbound + Outbound (kbps)
2018-09-01 23:00:00 2018-09-07 23:00:00	100%	3072	3572.283872
2018-09-08 01:00:00 2018-09-14 23:00:00	100%	3072	3519.421278
2018-09-15 01:00:00 2018-09-21 23:00:00	100%	3072	3677.421823
2018-09-22 01:00:00 2018-09-31 23:00:00	100%	3072	3308.442654

4.3. Index Packet Loss (%) Performance

Packet loss analysis in this implementation is used to find out how big the package is lost when sending with designing LTE network transmission configuration with SCPC Satellite Bridge. Maximum packet loss recommended by TIPHON and ITU is 0-15%. Figure 18 implementation of LTE Transport through Satellite it included a very good category in the transmission media because the value was 0-2%.

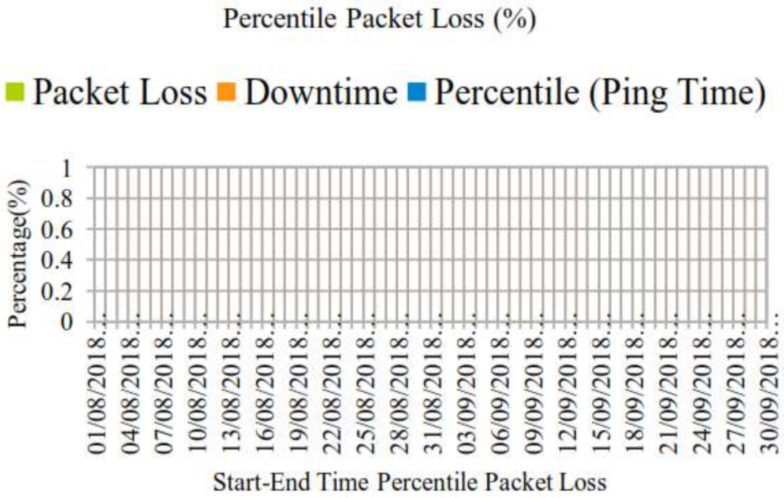

Figure 9. Index Packet Loss (%) Performance

4.4. Index Delay (ms) Performance

In this paper delay (ms) is used to find out how much the packet is lost when sending by designing the satellite transmission network configuration for LTE technology with the SCPC transparent bridge. We can conclude that delay is very dependent on network configuration. Can vary depending on the implementation scheme, and how the delay budget is consumed by the 4G LTE network element in its implementation. Any impact on the performance of network components can have an impact on overall network performance. In this paper the delay is generated it is an excellent category in transmission media because the value is 0-2 (ms).

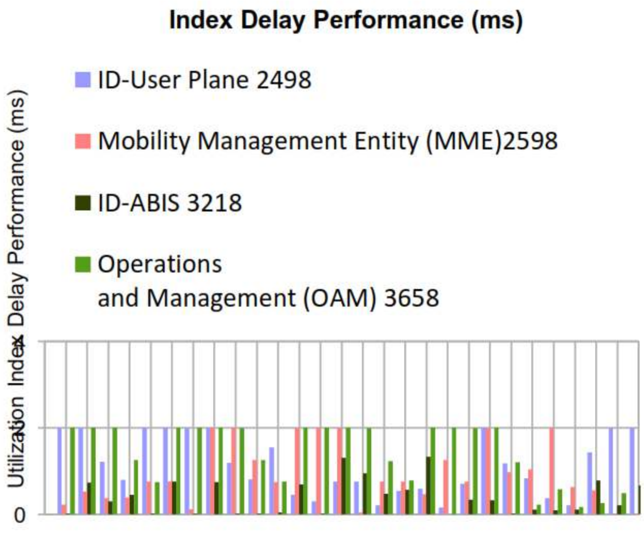

Figure 10. Delay Performance in one month

5. Conclusion

This paper presents SCPC packaged satellite bridges, combined with Tagged Ethernet (802.1Q), 802.1D (Bridging). This 4G LTE application is done by sending via satellite transportation. Analysis of measurements of TCP performance on 4G LTE, Quality of Service focus parameters are throughput, bandwidth utilization, delay and packet loss and all data compared with ITU-T and TIPHON. Based on the analysis that has been done, it can be concluded that, in the evaluation process, it can be seen that the value of Through Throughput (kbit / s) reaches the width of the pipe allocation used, which is 3072 Kbps. The total throughput of successful packets observed at the destination during a certain time interval is divided based on the duration of the interval. That is 3983 kbps. This means that the scheme is implemented, to pass data and voice on 4G LTE communication, using a SCPC satellite bridge that is packaged successfully with value parameters that are in accordance with the throughput value obtained. The greater the value of throughput generated on a network, the better the data packet transmission on the network. Index of Bandwidth Utilization = Bandwidth Width The use of inbound and outbound reaches 100% and the value of packet loss is 0%. The parameter delay value is 0-2 (ms) for transmission connectivity.

Concept of implementing SCPC satellite bridging tagged is a solution that enables mobile operators to expand their network coverage in underserved areas while maintaining quality experience for end users and managing the cost of satellite bandwidth used for 4G LTE backhaul.

Our future research will focus on how the solution alternates to the current 4G architecture, and we will expand our performance comparison approach to run a series of analyzes on different architectural options for example in 4G management based on Satellite TDMA Technology. Results of Quality of Service obtained are Throughput, Bandwidth Utilization, and need to be re-examined to assess each parameter using the ACM DVB- S2 technique. Use modulation and a high-efficiency COD scheme (MODCODs) resulting in optimal statistical multiplexing, allowing the delivery of very high throughput services to individual terminals.

6. References

[1] Ahmed, N. J. Performance Analysis on Throughput in 4G Network in Digital Environment with SISO Technique, June 2013, 71–79.
[2] Tabany, M. R., & Guy, C. G. An End-to-End QoS Performance Evaluation of VoLTE in 4G E-UTRAN-based Wireless Networks, (DL), 2014 90–97.
[3] Jha, A. Techno-economic assessment of the potential for LTE based 4G mobile services in rural India, 2015, 1–6.
[4] Satellite Backhaul vs Terrestrial Backhaul: A Cost Comparison. Gilat Satellite Network, 201
[5] Solutions, M. B., Multiservice, T., & Chest, T. BENEFITS OF 4G OVER, September 20
[6] Lehocine, M. B., VLAN, P., & Acl, V. Flexibility of Managing VLAN Filtering and Segmentation in SDN Networks, 2017.
[7] Haiyan, Y. Application of VLAN and HSRP Technology in the Dual Core Campus Network. 2018 International Conference on Smart Grid and Electrical Automation (ICSGEA), 2018.
[8] Zhou, J., & Ma, Y. Topology discovery algorithm for ethernet networks with incomplete information based on VLAN. 2016 IEEE International Conference on Network Infrastructure and Digital Content (IC-NIDC), 2016.
[9] Shin, M.-S., Ryu, J.-G., & Oh, D.-G. On the mixed support of TDMA and SCPC for satellite disaster communications network. 2017 International Conference on Information and Communication Technology Convergence (ICTC), 2017.
[10] Fan, S., Guo, Z., Zhang, J., Yang, X., & Geng, L. An auxiliary switched-capacitor power converter (SCPC) applied in stacked digital architecture for energy utilization enhancement. 2017 IEEE International Symposium on Circuits and Systems (ISCAS).
[11] Qian, X. (2010). SCPC & Principle of FDMA Which Used in Satellite Communication. 2010 2nd International Workshop on Database Technology and Applications, 2010.
[12] Tsai, P.-W., Cheng, P., Yang, C.-S., Luo, M.-Y., & Chen, J. (2013). Supporting Extensions of VLAN-tagged Traffic across OpenFlow Networks. 2013 Second GENI Research and Educational Experiment Workshop.
[13] Bhandary, V., Malik, A., & Kumar, S. (2016). Routing in Wireless Multimedia Sensor Networks: A Survey of Existing Protocols and Open Research Issues, 2016.
[14] Abolfazli, S., Sanaei, Z., Wong, S. Y., Tabassi, A., & Rosen, S. (2015). Throughput Measurement in 4G Wireless Data Networks: Performance Evaluation and Validation, March 2015.
[15] Rusan, A., & Vasiu, R. Emulation of Backhaul Packet Loss on the LTE S1-U Interface and Impact on End User Throughput, 529–536, 2015.