International Digital Organization for Scientific Research
IDOSR JOURNAL OF COMPUTER AND APPLIED SCIENCES 1(1):1- 22, 2016. ISSN: 2579-0803

LS-RSVP: An Improved Congestion Management Scheme in Hotspot Environments

[1]Godspower I.A, [2]Obi Okonkwo, [3]Okafor, K.C

[1,2]Department of Computer Science, UNIZIK, Awka, Nigeria.

[3]National Agency for Science and Engineering Infrastructure, NASENI-ELDI, Awka, Nigeria.

ABSTRACT

This paper is a part of an ongoing research on congestion managements in hotspots networks considering realistic loads in such environments. Cooperative packet recovery has been widely investigated in wireless networks, where corrupt copies of a packet are combined to recover the original packet. While previous work such as Grid WLAN, FA-WLAN, delay tolerant networks (DTN), and other IEEE 802.11 WLAN works have avoided explicit discussion on how resource reservation can be combined in TCP flows thereby avoiding packet losses. The reason is rooted in the prohibitive overhead of sharing raw symbol information between different APs of an enterprise WLAN. This paper observed that the generic TCP cannot handle traffic congestion in a Flow Aware-WLAN for scalable Internet traffic as its continual packet drops at the event of congestion is unacceptable for realistic loads. This work, then presents an enhanced link state resource reservation protocol (LS-RSVP) as a feedback congestion control mechanism in an given hotspots environment resulting from its ability to fit into the network condition dynamically following its algorithm for link state resource reservation setup mechanism introduced in this work. In our results, under realistic loads, the steady-state throughput response achieved by TCP LS-RSVP algorithm was observed to about 3500 packet/bits compared with TCP plots in our earlier empirical study. The latency Plot of LS-RSVP under realistic load maintained a steady rate of about 0.004s relative to generic TCP. Considering network service availability, this was observed to be dependent on fault-tolerance of the hotspot network. In the simulation experiment, a TCP connection between servers at the remote core layer and the access layer was setup. We observed a peak threshold occurs at 0.009. ie 90% which is widely acceptable for service availability compared with the existing TCP WLAN model. For packet drop effects, an analysis on the network behavior with respect to the LS-RSVP algorithm yielded a packet drop response of about 0.000106 bits/sec which is much lower compared with the case with generic TCP with over 0.38 bits/sec. The latency profile of average FTP download response was found to be 0.030secs, but with that of FTP upload response, this yielded about 0.028 sec. From the context of FA-WLAN, these values demonstrate efficiency and optimality for realistic loads. The methodology is enshrined in the body of the work.

Keywords: Hotspots, TCP flows, Traffic, Congestion, Throughput, latency, Service Availability, Fault tolerance and Algorithms.

INTRODUCTION

In networks generally, congestion occurs when the demand is greater than the available resources, such as bandwidths of links, buffer space and processing capacity at the intermediate nodes such as routers. Congestion control is concerned with allocating the resources in a network such that network can operate at an acceptable performance level when the demand exceeds the capacity of the network resources. Careful design is required to provide good service under heavy realistic load. Otherwise, there can be a congestion collapse that is highly resource wasteful and causes undesirable state of operation. Essentially, Transmission control Protocol, TCP, [1], is usually used to provide reliable communications on top of IP and Ethernet, as it employs loss-based congestion control algorithm, which continues to increase sending rate until it gets packet losses, while its queuing delay can grow to maximum rate, [2].

Despite congestion challenges with respect to hotspot devoices and topologies, the use of wireless local area networks (WLANs) in homes, offices, and public areas is growing by leaps and bounds [3 and 4]. The Media Access Control (MAC) and Physical (PHY) layers in the WLAN are defined by the IEEE 802.11 standard [4]. In FA WLANs, most WLAN equipment uses the Distributed Coordination Function (DCF) defined in the standard to coordinate channel access. DCF belongs to the class of algorithms that employ Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In DCF, the basic access is a two-way handshake procedure. A successful data frame transmission is acknowledged by the receiver [5].

The current use of WLAN hotspot for Internet access from wireless stations is dominated by downlink TCP traffic in extended service set mode; however, the characteristics of TCP have not been sufficiently taken into account for data transport over WLANs [5]. One characteristic of TCP transport over WLAN hotspot is the duplication of acknowledgment (ACK) functions at the MAC and transport layers. Each TCP data segment transmitted across the WLAN will cause a TCP ACK to be transmitted later, in addition to the MAC-layer ACK that is transmitted by the receiver immediately. Although TCP ACKs are small in size, when the overhead at the MAC layer is added, they are not negligible and can degrade the throughput performance significantly. We investigate a scheme that eliminates the duplication of the two acknowledgements on the WLAN. We show that this scheme produces significant performance improvements together with its algorithm, particularly in the infrastructure-mode WLAN in which all traffic flows through an access point (AP) [6].

In this work, various works will be reviewed in relation to congestion management giving basis for a proposed congestion management algorithm, LS-RSVP and its associated schemes. From our review studies, a proposed link state algorithm based on a two stage BSS model and other WLAN infrastructures considering FTP and HTTP services in a high density network is developed. This was carried out after considering a real life tested that have limitations based on generic TCP congestion control scheme for a wireless network scenario in our earlier work. A well design network testbed that provides stable data rates, excellent buffer management for APs and wireless devices with packet recycling and a fair level of Quality of Services for all traffic sources was achieved [7]. The framework for the proposed link state TCP algorithm implementation was realized with a trace file in OPNET IT guru prediction model while that of space diversity was achieved via MATLAB Simulink 2011a. The essential parameters in this research includes viz: Throughput, delay, throughput, service availability, utilization and bit error rates for OFDM blocks in the scenarios.

METHODOLOGY

Algorithm for Link State Resource Reservation Setup Mechanism

We studied various works on congestion management, identified the research gaps while formulating the algorithm considering the entire network architecture as well as some selected metrics for evaluations. The OPNET Simulator was used for the model configuration and implementation. The profile and application palettes were set up for all the intended services for a hotspot scenario. This service occurs on three levels: Application—RSVP interface process level, RSVP process level, Traffic Control process levels. The distinct parameters are shown in table 1. In our approach, LS-RSVP treats data flow from receiver to sender as logically independent from the flow from sender to receiver. Accordingly, a reservation for data from sender to receiver is independent from a reservation from receiver to sender. Since RSVP establishes a reservation for simplex flows, reservations for traffic can be made from any or both directions. RSVP is a hop-by-hop feedback QoS signaling protocol. This means that LS-RSVP messages are transmitted from one node to another through all RSVP-aware nodes along the data path. The reservation setup mechanism is shown in the algorithm below:

PDL Algorithm I: Global Feedback RSVP of Realistic WLAN

INPUT: *MN, Ap,* IP_{gw}*, Internet, Servers*

OUTPUT: *LS_prediction {QoS Parameters}*

Procedure {begin}:

Call RSVP

If (MN and Ap = = True) ***then***

Path Messages:

{Sent Periodically}&

{Destined for Internet Servers}&

{Application Description}&

Create Path &Path State

Ls_Predition = = forward path to Ap

Monitor paths

If** (Ap = = Congested) **then

RSVP = fragment packet Paths

Else

Forward to $IP_{gw;}$

Monitor Path

If *(*$IP_{gw;}$ *= Congestion)*

RSVP = fragment path

Else forward → Internet_Servers;

If** (receiver &Path State = = True) **then

Path state {receiver application}&

{decide& make reservations}&

{Send reservation request}

Ls_Predition = = path state

Receiver == Ls_Predition

Ensure full duplex confirmation

Return;

End;

From the algorithm above, the following steps show the event sequence for RSVP resource reservation in a unicast scenario, viz:

- The transmitting sender mobile node host usually knows the characteristics of the TCP traffic it generates, such as data rate and the deviation from data rate. As it transmits data, the sender's LS-RSVP module in the rate regulator periodically sends RSVP Path messages, which do the following:

a) Describe the TCP traffic generated by the sender and its characteristics.

b) Create a state on each intermediate LS-RSVP-aware node along the data path messages are sent with the destination address of the receiver host and are routed as data sent to that host.

- Path messages create a path state in each router that is traversed. Through this path setup mechanism, all devices along the path become aware of their adjacent RSVP nodes for data flow.
- When a local LS-RSVP module notifies a receiver host application that an RSVP path message has been received, the receiver host application decides if resources should be reserved.
- Once a decision is made to request network resource reservation, the host application sends a request to the local RSVP module to assist in the reservation setup.
- The LS-RSVP then carries the request as Resv messages to all nodes along the reverse data path to the data source notifying its state. The reservation is made on a hop-by-hop basis, each intermediate node checks for sufficient buffer resources and decides if the request can be granted. If the reservation is successful, a Resv state is created, and the reservation request is forwarded to the previous hop in the data path.
- The receiver can request a notification about the reservation status. In this case, once the sender receives the Resv message from the receiver, it sends the receiver a Reservation Confirmation message.
- If the receiver sends any data, it will start sending Path messages to the sender. In this case, steps 1 to 6 are repeated with the receiver acting as the sender and the sender acting as the receiver.
- In each instance, when the congestion state exceeds the device holding capacity, the path feedback as depicted in figure 2.1 is instantiated. In the implementation, the LS-RSVP is achieved through the cooperation of three processes: the RSVP—application interface process, the RSVP process, and the traffic control process as enable in

the simulation design. The supported service in LS-RSVP for our network context whose process runs only in IP-enabled nodes includes the following applications: Database, Email, FTP, Remote Login, Video Conferencing (for both unicast and multicast sessions), Voice (for both unicast and multicast sessions).

In our future work, the channelization effects in *MP-0 to MP-1* as depicted in figure 3.0 will be presented in the space diversity model while accounting for Bit Error Rates in the model. Afterwards, we shall then validate it with a cognitive hotspot model in general.

Modeling High Level Subnet Switching System

Following the block diagram overview of figure 3.0, another part of our design that focuses on the subnet switching system. This system comprises of the Minipops, locations in the subnet with mobile nodes and a virtual port. For subnet-0 location, mobile nodes *A, B, C, D, E* ,etc are connected to the MLIPG-0 via the MP-0. For subnet-1, mobile nodes *F, G, H, I, J,etc* are connected to the MLIPG-1 via MP-1. For subnet-2, the mobile nodes *K, L, M, N, O*, etc are connected to MLIPG-2 via MP-2 while for subnet-n, the mobile nodes *P, Q, R, S, T,etc* are connected to MLIPG-n. The reengineered switching model overview shown in figure 1 will aid understanding of the model specifications described in this section. The figure 3.0 model was then realized with OPNET IT guru later in this work. The figure 3 shows the Minipop packet transmission at discrete time intervals.

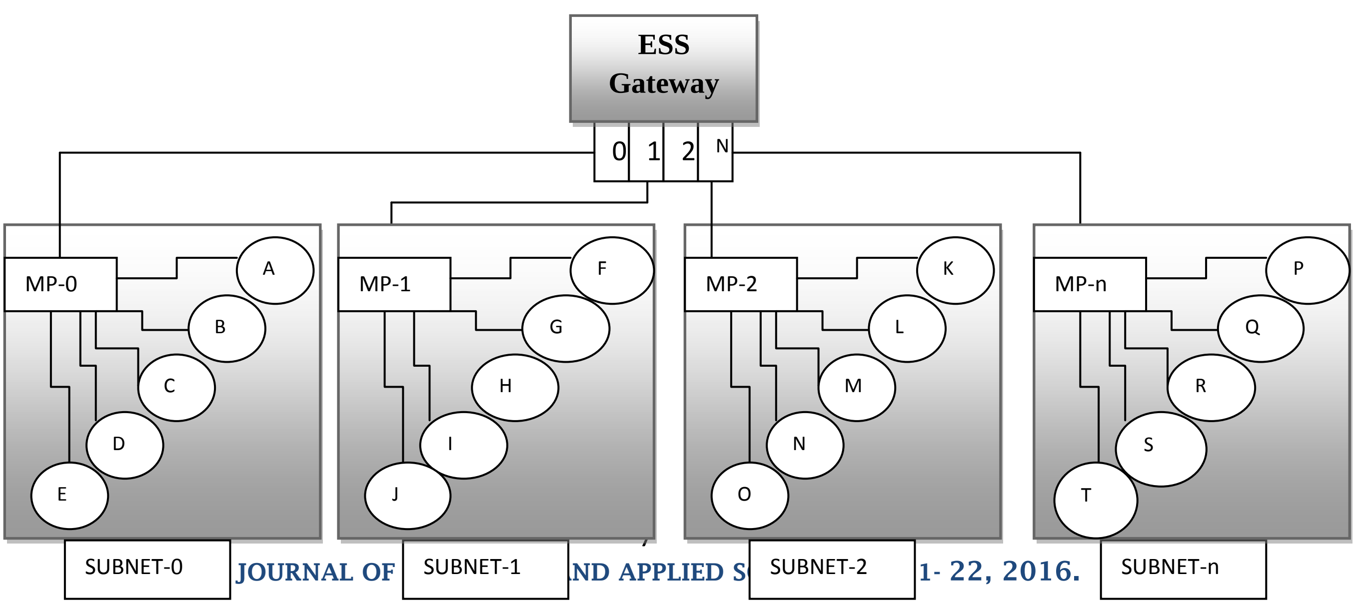

Figure 1: Access Point Mobile node Subnets with IP Gateway architecture

PERFORMANCE EVALUATIONS

SIMULATION TEST BED

To demostrate the network architecture of the hotspot environment running LS-RSVP algorithm implementation, a simulation testbed was built with OPNET IT Guru 9.1 with LS-RSVP configured in the OPNET engine, shown in figure 4.0. This consists of a two remote datacenter servers (HTTP and FTP/WEB servers), 200 mobile client nodes, 10 AP base stations and an IP gateway router, all connected to the IP cloud. In the mobile nodes including the APs, TCP LS-RSVP algorithm were all configure in a scenario. The subnet sites and IP gateway cloud emulates the FA-WAN link with the desired throughput, Delay/latency, service availability, packet data drop, FTP/HTTP latency profiles. This work implemented figure 3 in OPNET IT Guru which was used to generate the parameters for the case scenario in the simulations. Traffic attributes for the FA-WLAN are listed in Table 1. The runtime environment attribute were as follows in the OPNET simulator. In the characterization of the experimental and simulation testbed, the configured with values in in Tables 1 was leveraged.

Table 1: Basic OPNET Traffic Attributes

	CONFIGURATIONS	Values
1.	Simulation Duration for Each Scenario	120 mins
2.	Link Propagation Delays	0.5*u* secs

3.	Switch Output Buffer	100 packets
4.	Simulation Speed	128
5.	Update Interval	50000 Events
6.	Simulation Kernel	Optimized
7	TCP Variants	Configured
8	Mobile clients(Max-min)	[40-5]

Table 2: FA-WLAN Simulation Parameter Table for TCP LS-RSVP

TCP TYPE	**FA-WLAN PARAMETERS**	**5 Sources WLAN BUFFER-64K**	**10 Sources WLAN BUFFER-128K**	**15 Sources WLAN BUFFER-256K**	**20 Sources WLAN BUFFER-512K**	**30 Sources WLAN BUFFER-1024K**
Proposed LS-RSVP	**RTS-Threshold (Bytes)**	256 Bytes	256Bytes	256Bytes	256Bytes	256Bytes
	Fragmentation Threshold (Bytes)	256 Bytes	512Bytes	1024Bytes	2048Bytes	4096Bytes
	Data Rate (bps)	54	54	54	54	54
	Physical Characteristics	DSSS (D3S)	DSSS	DSSS	DSSS	DSSS (D3S)
	Packet-Reception Power Threshold(W)	7.33e-14	7.33e-14	7.33e-14	7.33e-14	7.33e-14
	Short Retry Limit	7	7	7	7	7
	Long Retry Limit	4	4	4	4	4
	AP Functionality	Active	Active	Active	Active	Active
	Buffer Size (bits)	64K	128k	256k	512k	1024K

Max-Receive Lifetime (Sec)	0.5	0.5	0.5	0.5	0.5
Large-Packet Processing	Predicted	Predicted	Predicted	Predicted	Predicted

Running the test bed, we measured the following metrics viz: throughput, Delay/latency, service availability, packet data drop, FTP/HTTP latency profiles, via template scenario of Figure 4.0, which shows the validation testbed while figure 4.1 shows the link State RSVP successful simulation run/compilation following table 5.3. Appendix B shows the simulation dataset for figures 5.0 to figure 5.5 while its analysis is discussed below.

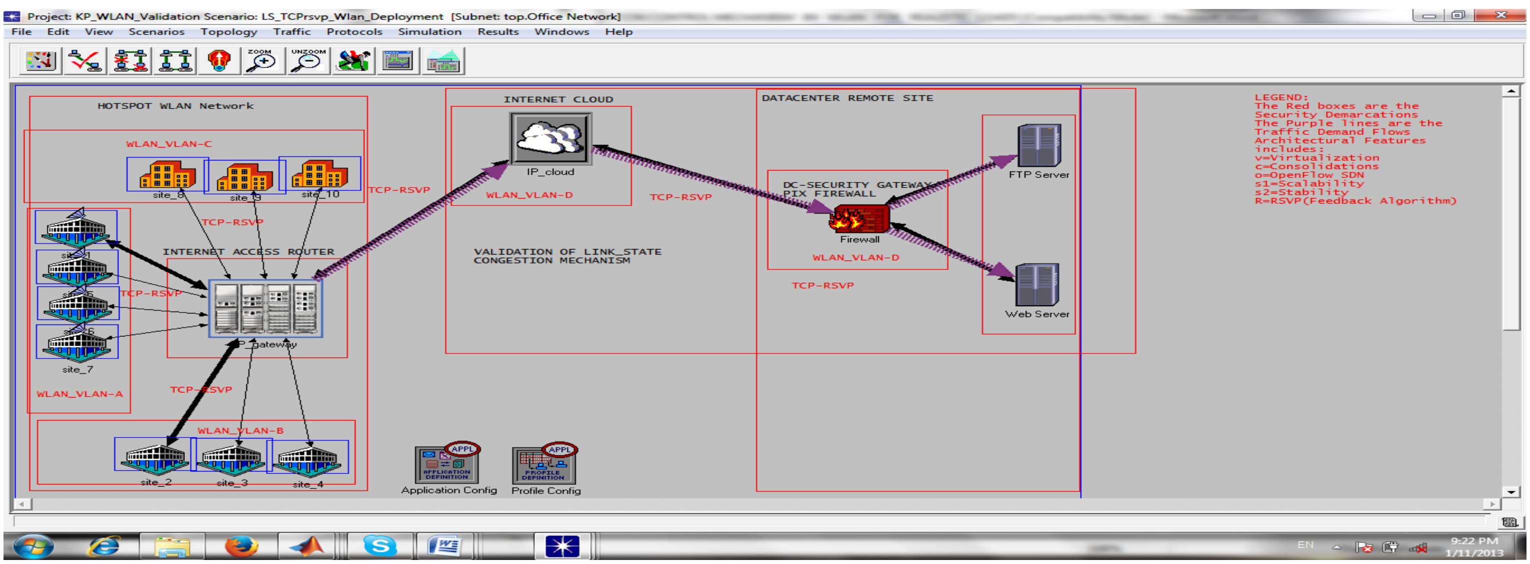

Figure 2: Validation testbed with FA-WLAN Subnet 0 to subnet 10.

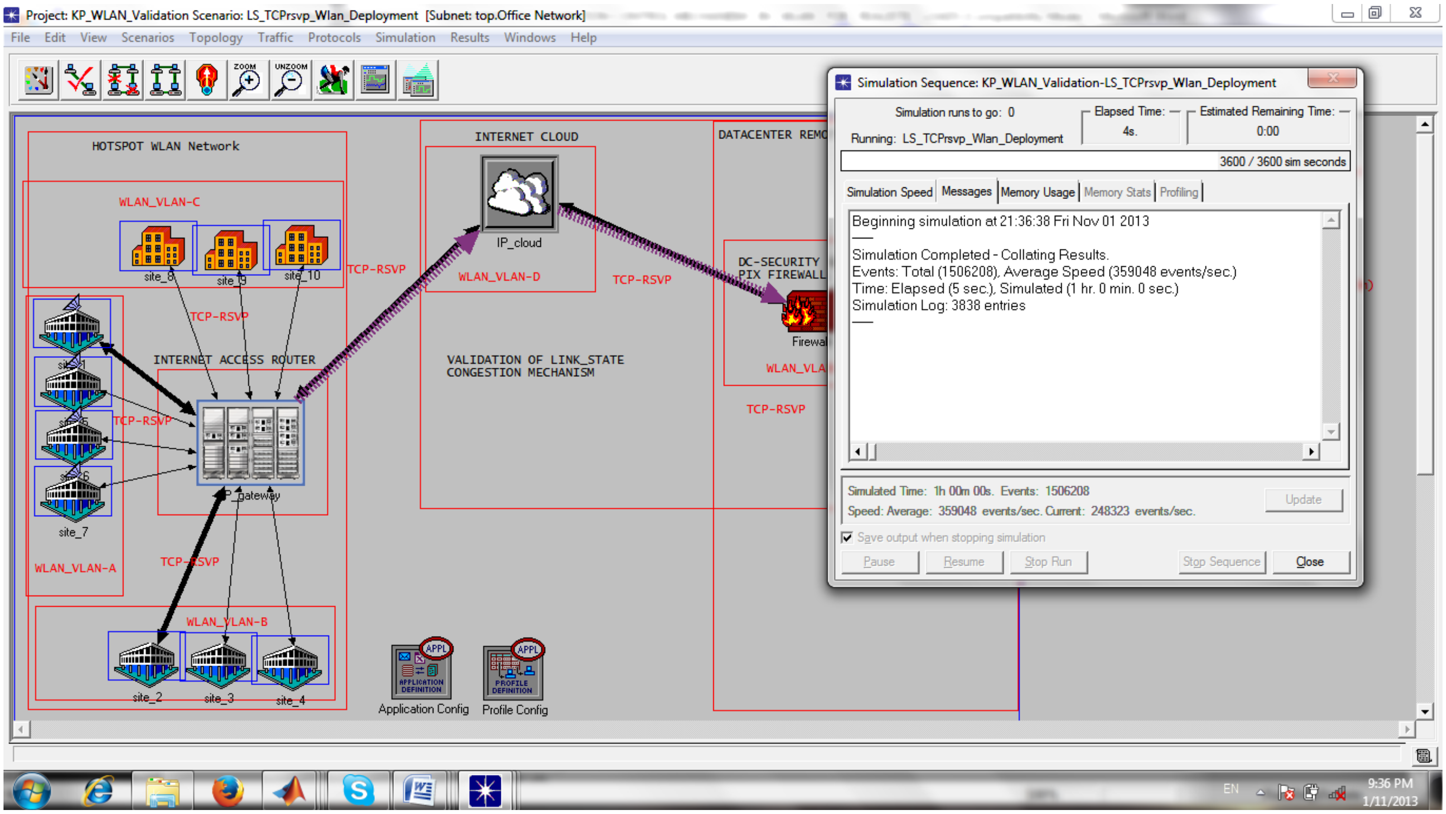

Figure 3: Link State RSVP successful simulation Run

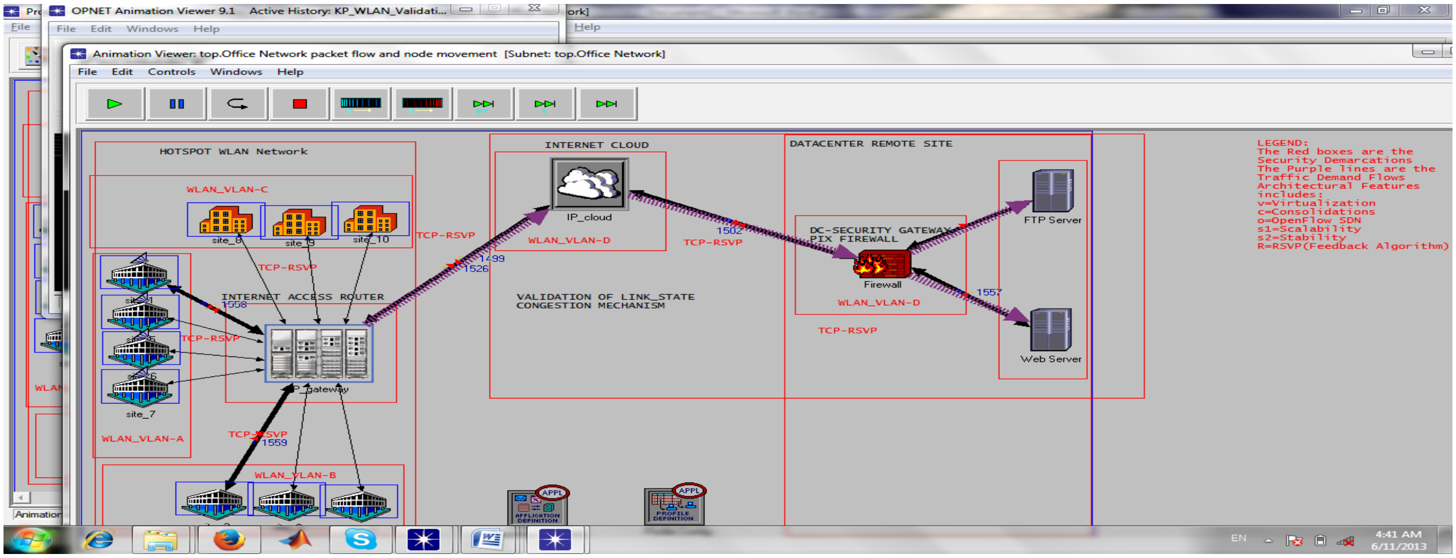

Figure 4: Hotspot WLAN Realistic Load Traffic Animation Scenario

RESULTS

PERFORMANCE EVALUATION

In this work, an evaluation on LS-RSVP TCP variant was carried out for the mobile nodes and the MiniPop_APs using the selected metrics.

i. Throughput QoS Response

Figure 5.0 compares the steady-state throughput response achieved by TCP LS-RSVP algorithm, etc under realistic loads. Interestingly, it was observed that the proposed LS_RSVP algorithm had a slightly better throughput behavior of about 3500 packet/bits compared with TCP plots etc. This is evidenced by the fact that the transmission of realistic traffic witnessed reliable frame data delivery with active connections transmitting data between the mobile nodes and the AP server, with an emulated round trip time equal to 100 ms (a near zero packet loss rates). The measures of packet sizes greater than 1200 bytes in the real scenario is validated by the results obtained by simulation (see Figure. 5.0) and provide a further support on the advantages of proposed LS-RSVP algorithm over TCP TRONVS.

Note that, in this scenario, as well as in all the simulated scenarios presented in this section, TCP LS-RSVP obtained a higher throughput than any other TCP version. Again, this behavior is due to its connection oriented behavior leading to non degradation of the network as user density increases under realistic load conditions.

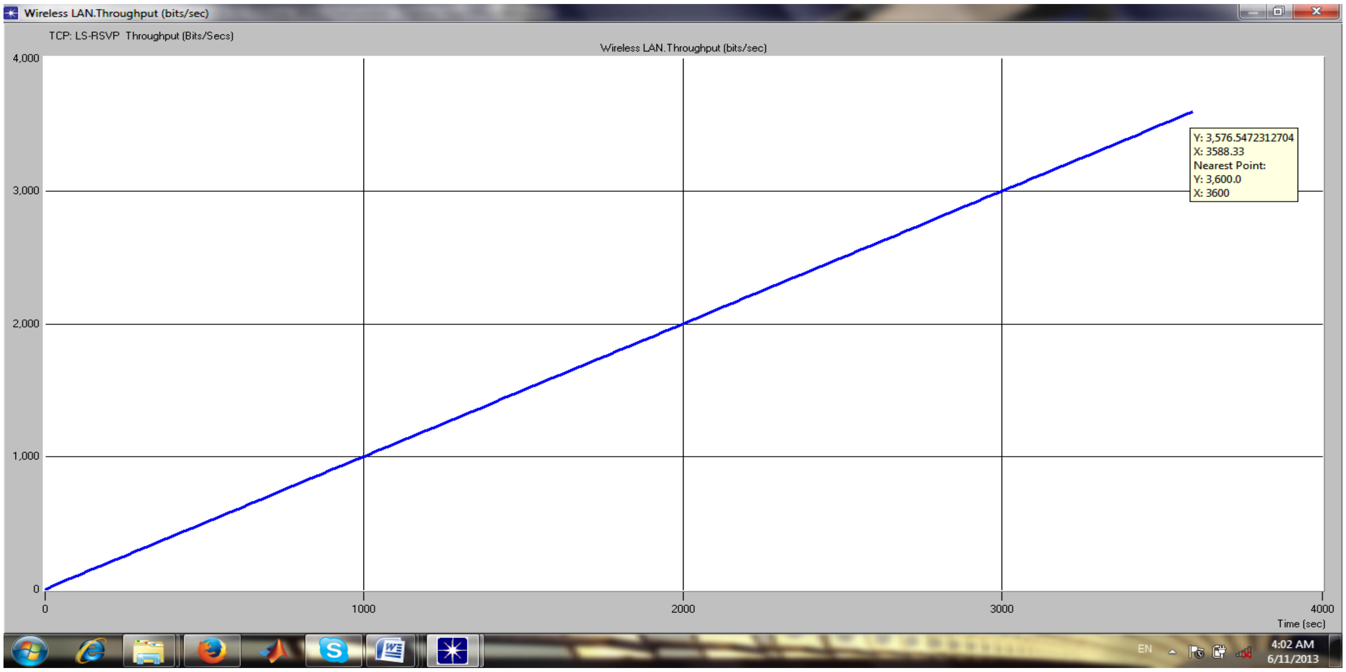

Figure 5: LS-RSVP Throughput Plot

ii. Delay QoS Response

Figure 5.1 showed the latency Plot of LS-RSVP under realistic load. Our proposed TCP variant maintains fast rise latency throughout the transitions as depicted by the trend curve beginning from 0.005s up to 0.04s for the WLAN realistic load scenario. Essentially, the propose of LS-RSVP showed a comparative latency response when with generic TCP. It maintained a steady rate of about 0.004s relative to generic TCP in figure 16 and figure 19. The both plots shows a similar trend but with LS-RSVP, a lower latency of less than 0.005secs was observed. The feedback algorithm of figure 3 and figure 5 scenarios enabled fast initialization for incremental users on the network under peak congestion states.

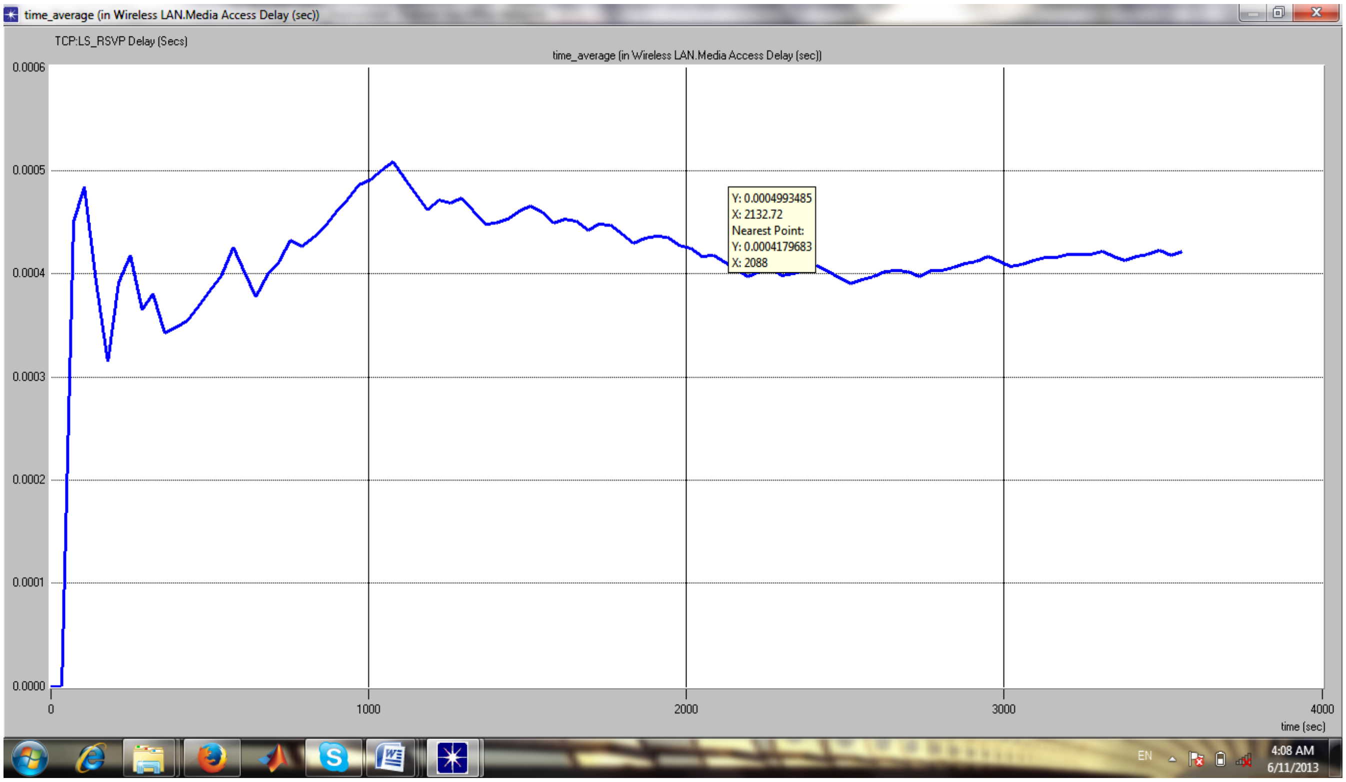

Figure 6: LS-RSVP Delay Plot

iii. Network Service Availability QoS Analysis

Figure 8 depicts the network service availability response plot regardless of the congestion state. The network availability is dependent on fault-tolerance of the hotspot network. In the simulation experiment, a TCP connection between servers at the remote core layer and the access layer was setup. Different network services for realistic including databases, E-mailing, web browsing, FTP, http and other TCP & UDP services were introduced on the experimental scenario. To study the performance under link failures (downtime),we manually unplugged the link in some selected hotspot sites and then plugged in at time 42s in the simulation panel. We also shut down the servers [1 to 2] at time 104s in order to assess the impact of congestion modes of LS-RSVP. After both failures, the routing path quickly converged and the path returned to the original status. The LS-RSVP traffic was maintained as well and the CPU utilizations are about 40%, and 45%, for senders, and receivers, respectively. This is a different scenario for generic TCP based networks. In context, this work makes two observations from the experiment. First, the context WLAN is a very resilient to congestion failures. The network throughput is recovered to the best value after only a few seconds compared to generic TCP congestion mechanism. Secondly, the WLAN implementation detects link failures and node failures much faster than generic TCP algorithm because it uses medium sensing network capacity, with its fault tolerant and suppression routing algorithm. From figure 4.1, the switching gateway maintains fault tolerance while figure 4.2 maintains logical isolation. Other factors accounting for service availability could include the logical isolation of nodes and its analytical traffic control scheme in figure 3. The plot in figure 8 shows that the LS-RSVP hotspot WLAN proposed has relatively more service availability compared with the existing TCP WLAN model as discussed in chapter 3 on the flow traffic. The peak threshold occurs at 0.009. ie 90% which is widely acceptable.

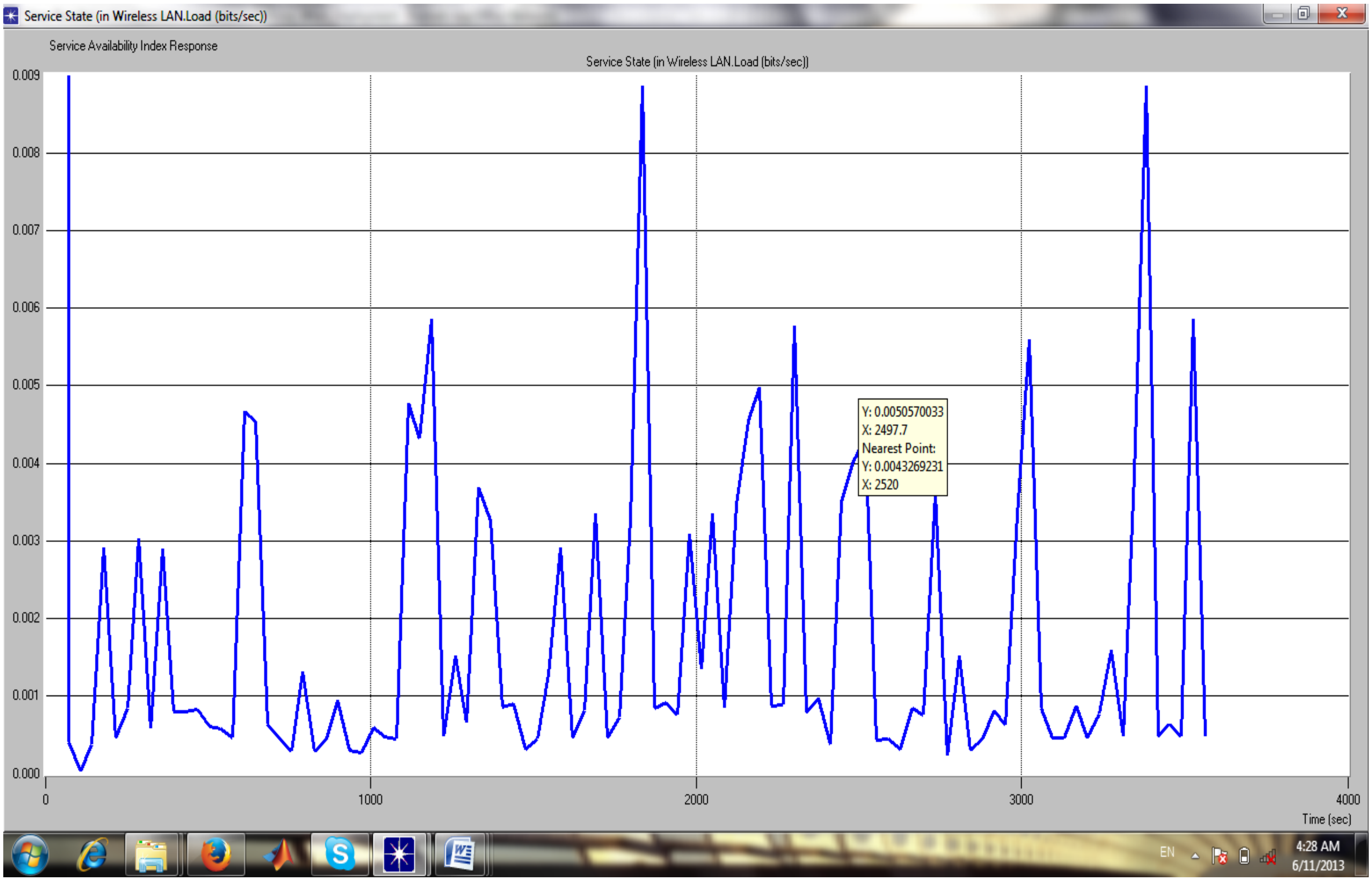

Figure 7: Network Service Availability Response Plot

Packet Drop Effects

In this case, an analysis on the network behavior with respect to the LS-RSVP algorithm in chapter 4 which was realized in simulation scenario was carried out. Figure 9 shows the end-to-end packet drop result of the LS-RSVP algorithm for two-tier topology of figure 3 topology reflecting the discussion carried out under figure 27. As depicted in the plots of figure 5.9, the packet drop response shows a great dissimilarity with the figure 26. As observed in figure 9, the packet drop response was observed to be about 0.000106 bits/sec which is much lower compared with the case with generic TCP with over 0.38 bits/sec. The reason for this is that in our proposed WLAN for realistic loads (figure 3), there is additional traffic optimization by the LS-RSVP algorithm as well as the enhanced network topology which reduces the transmission time between the access and the core layer even when the links are busty and busy. At the event of congestion, its feedback loop recycles packets avoiding congestion scenarios. The core layer is highly redundant with little routing policy in WLAN and as such can easily take packets from the access layer with very little wait states

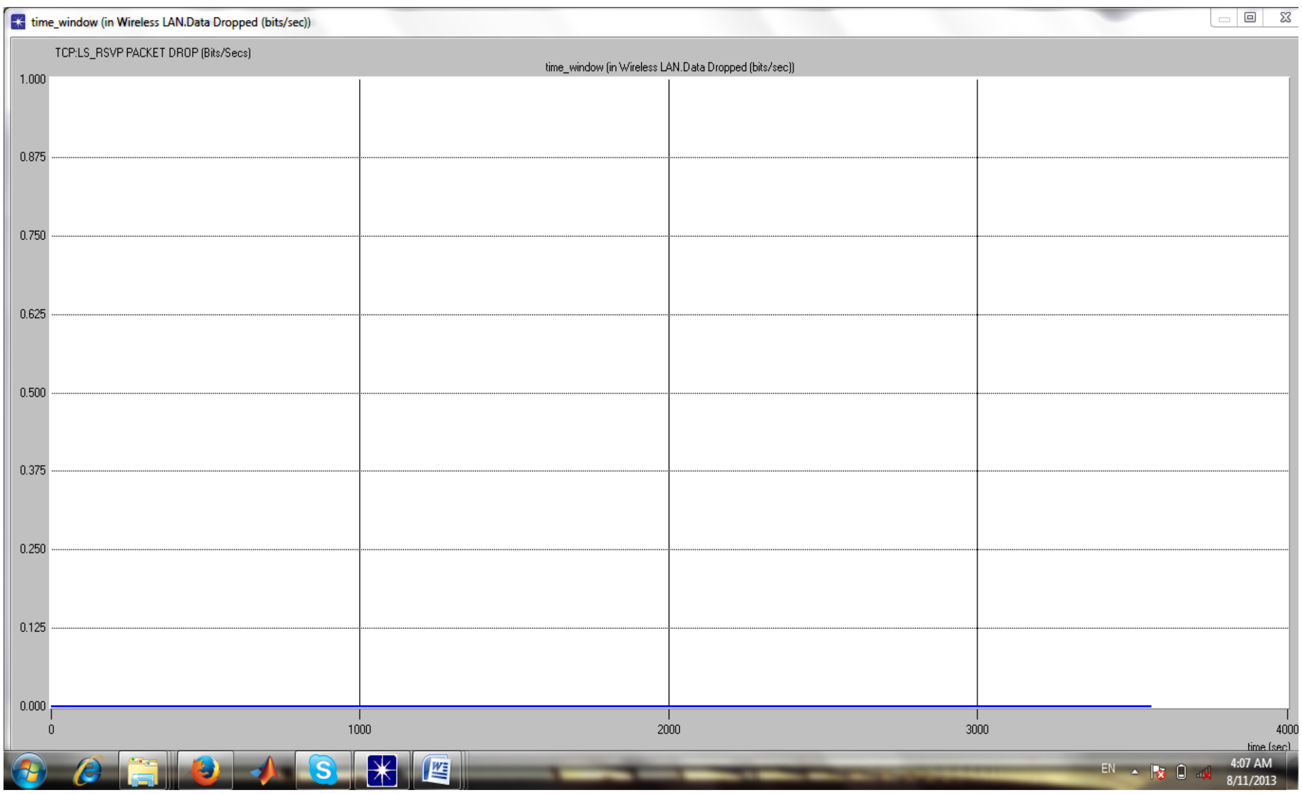

Figure 8: Packet Drop Response (Bits/Secs)

FTP, HTTP LATENCY PROFILES

Figure 10 shows the latency profile of average FTP download response to be 0.030secs with that of FTP upload response is about 0.028 sec. Figure 5.11 shows the latency profile of average HTTP page response to be 0.0389 secs. From the context of FA-WLAN, these values demonstrates efficiency and optimality for realistic loads.

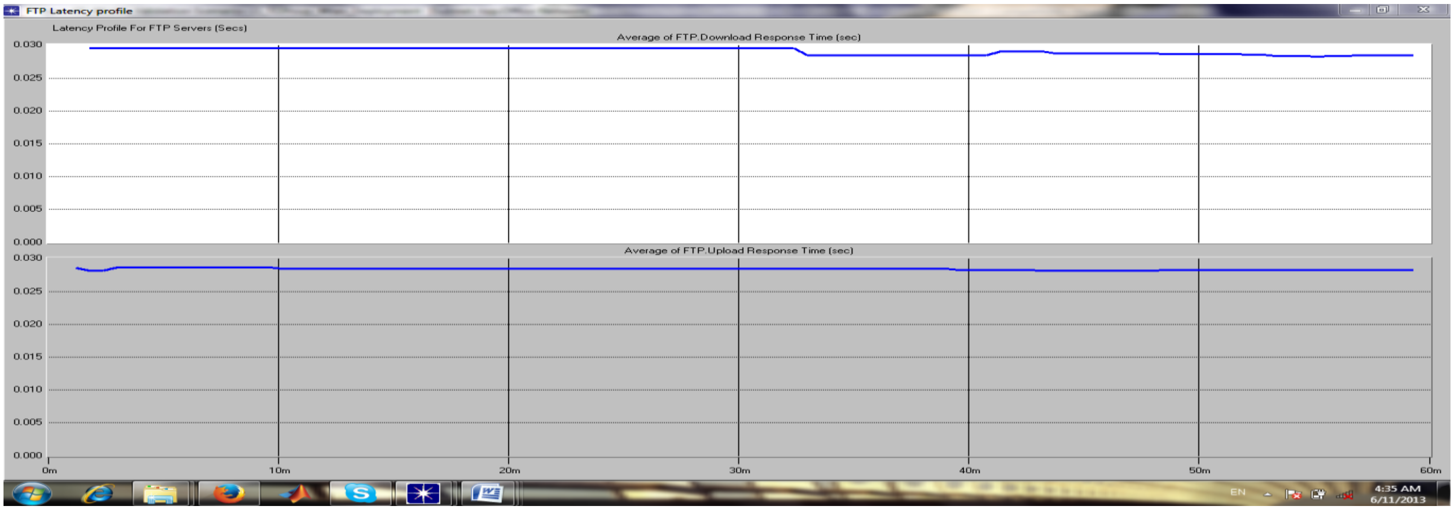

Figure 9: FTP Latency Profile

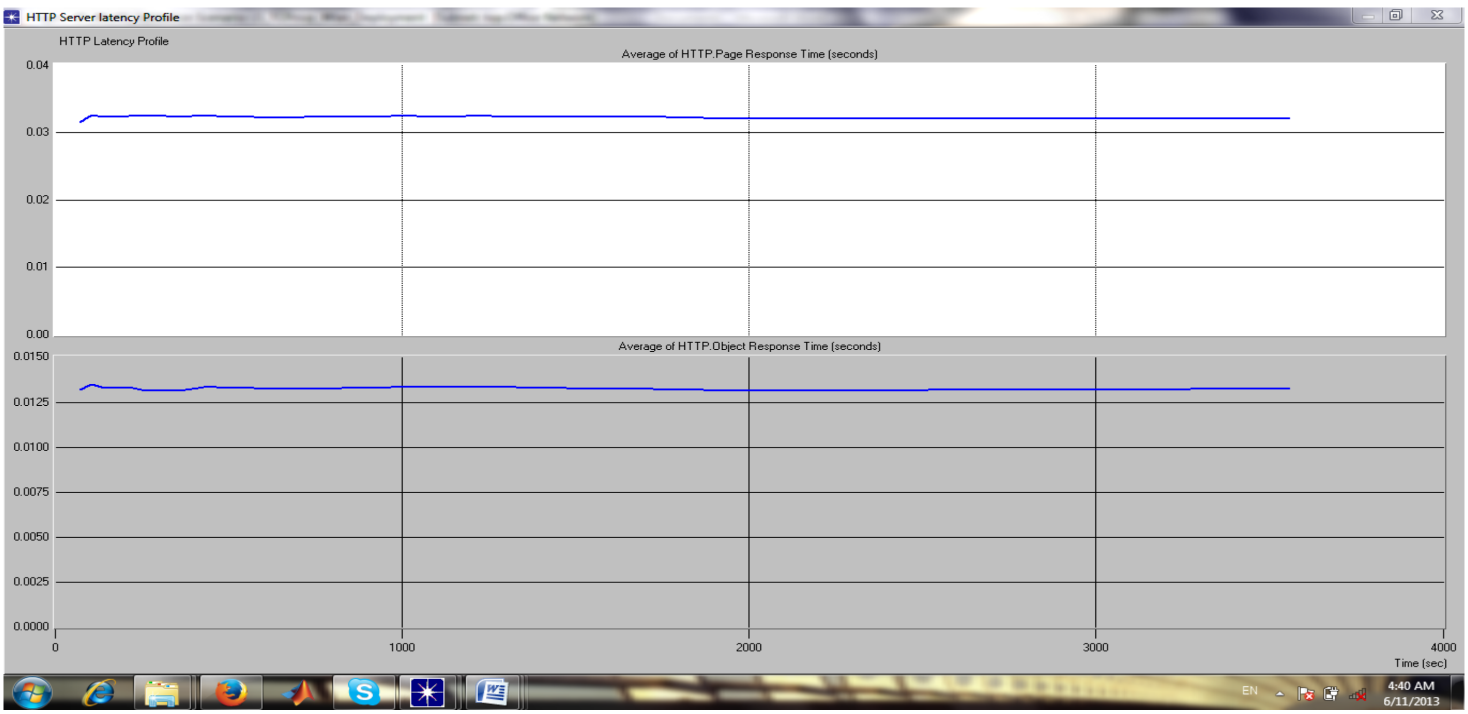

Figure 10: HTTP Latency Profile

CONCLUSION AND FUTURE WORKS

This paper have partly presented congestion managements in hotspots networks considering realistic loads using LS-RSVP for effective cooperative packet recovery in such networks. The limitations of existing works were highlighted while justifying our initial proposal, via a simulation study for our selected metrics. This paper observed that the generic TCP cannot handle traffic congestion in a Flow Aware-WLAN for scalable Internet traffic as its continual packet drops at the event of congestion is unacceptable for realistic loads. The proposed LS-RSVP as a feedback congestion control mechanism in any given hotspots environment can dynamically fit in the ESS. In our results, under realistic loads, the steady-state throughput response achieved by TCP LS-RSVP algorithm was observed to about 3500 packet/bits compared with TCP plots in our earlier empirical study. The latency Plot of LS-RSVP under realistic load maintained a steady rate of about 0.004s relative to generic TCP. Considering network service availability, this was observed to be dependent on fault-tolerance of the hotspot network. In the simulation experiment, a TCP connection between servers at the remote core layer and the access layer was setup. We observed a peak threshold occurs at 0.009. ie 90% which is widely acceptable for service availability compared with the existing TCP WLAN model. For packet drop effects, an analysis on the network behavior with respect to the LS-RSVP algorithm yielded a packet drop response of about 0.000106 bits/sec which is much lower compared with the case with generic TCP with over 0.38 bits/sec. The latency profile of average FTP download response was found to be 0.030secs, but with that of FTP upload response, this yielded about 0.028 sec. From the context of FA-WLAN, these values demonstrate efficiency and optimality for realistic loads. The methodology is enshrined in the body of the work. Future works will present our empirical results from TCP testbed and the BER analysis for diversity.

ACKNOWLEDGMENT

This part of an ongoing Msc work of which the lead author wish to appreciate Dr. Obi Okonkwo, the supervisor for his candid guidance. Also, I wish to thank the MIS Network Group of UNN for their expert and meaningful contributions. Also, I wish to thank my co-authors for contributing in publishing this research work

REFERENCES

1. S.Floyd, et.al, "The NewReno Modification to TCP's fast Recovery Algorithm", RFC 2582,IETF, 1999.
2. H.Shimonishi, J.Higuch, T.Yoshikawa, and Atsushi Iwata, "A Congestion Control Algorithm For DataCenter Area Communications,
3. M. S. Gast, 802.11 Wireless Networks: The Definitive Guides, O'Reilly, 2002.
4. IEEE Standard for Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, ISO/IEC 8802-11:1999E), Aug.1999.
5. Qixiang Pang, Soung C. Liew, Victor C.M. Leung, "Performance Improvement of 802.11 Wireless Access Network with TCP ACK Agent and Auto-Zoom Backoff Algorithm.
6. Udeze C. C, Okafor K.C, Prof. H. C Inyiama, C. C. Okezie, " A Conceptual Design Model for High Performance Hotspot Network Infrastructure (GRID WLAN)", *(IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 3, No. 1, 2012, Pp.93-99* .
7. Mahanth Gowda, Souvik Sen,Romit Roy Choudhury, Sung-Ju Lee, "Cooperative Packet Recovery in Enterprise WLANs"
8. Haniza N., Zulkiflee M., Abdul S.Shibghatullah, Shahrin S., Congestive Loss in Wireless Ad hoc Network-Network Performance Analysis" *World of Computer Science and Information Technology Journal (WCSIT) ISSN: 2221-0741 Vol. 1, No. 6, 269-273, 201. Pp.* 269-273
9. Amir Krifa, Chadi Barakat, Thrasyvoulos Spyropoulos, "Optimal Buffer Management Policies for Delay Tolerant Networks"

10. Daniele Miorandi a,Arzad A. Kherani b, Eitan Altman, “A queuing model for HTTP traffic over IEEE 802.11 WLANs, Computer Networks50 (2006) 63–79.