EFFECT OF SLIDING WINDOW TECHNIQUES OVER A PERFORMANCE OF TCP/IP NETWORKS

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EFFECT OF SLIDING WINDOWS TECHNIQUES OVER A PERFORMANCE OF TCP/IP NETWORKS

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I certify that this thesis satisfies all requirements by way of a thesis for a degree of Master of Science.

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ABSTRACT

EFFECT OF SLIDING WINDOWS TECHNIQUES OVER A PERFORMANCE OF TCP/IP NETWORKS

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The communication channels have a variety of features in the communication system and networks, particularly wireless channels. It is used in transmissions between two nodes and deals with high error rates. Such errors that occur frequently which are not easy to be avoided, have the greatest effect on the performance of a network. So, it must be concluded that error rates are for different network conditions with use of different types of sliding windows techniques.

In this thesis, error correcting techniques have been investigated based on a retransmission technique they used. One of the famous retransmission techniques is sliding windows technique, which it has three sub-algorithms called: stop and wait, selective repeat, and go back N. In this work, selective repeat and go back N algorithms were taken into account, but a stop and wait algorithm was not considered since it doesn't use any window structure in their retransmissions. Also, it always has a high delay amount with less performance compared to the selective repeat and go back N techniques.

For this purpose, sliding window techniques have been implemented on Multi-Protocol Label Switching (MPLS) network platform which is simulated in MATLAB with all its details. In the simulation, all nodes running over a TCP/IP on MPLS network and nodes randomly send a number of data packets to any random node over the same network, which uses a path determined by the shortest path routing algorithm.

Finally, the sliding window techniques have been studied and analyzed for their performances on the MPLS for the different traffic conditions, in terms of delay, throughput and packet loss rates. Indeed, the best sliding window technique was determined and suggested for different traffic types of the MPLS networks.

Keywords: Sliding window, TCP/IP, MPLS, Selective repeat, go back N

ÖZ

KAYAN PENCERELER ALGORİTMALARININ TCP/IP AĞLARI PERFORMANSINA ETKİSİ

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Yüksek Lisans, Elektronik ve Haberleşme Mühendisliği Anabilim Dalı

Tez Yöneticisi: Asst. Prof. Dr. Barbaros PREVEZE

Ocak 2018

Veri iletiminde kullanılan iletişim kanalları, çeşitli özelliklere sahiptir ve özellikle kablosuz kanallarda, daha yüksek hata oranı içerilmektedir. Sıklıkla meydana gelen ve kaçınılması kolay olmayan bu hatalar, ağın performansı üzerinde büyük bir etkiye sahiptirler. Bu nedenle, farklı ağ koşulları için ve farklı kayan pencere teknikleri kullanılarak, hata oranlarının hangi oranlara kadar ulaştığı saptanmalıdır.

Bu tezde, hata düzeltme teknikleri kullandıkları yeniden iletim tekniğine dayanarak, incelenmiştir. En çok bilinen yeniden iletim tekniklerinden birisi olan kayan pencereler tekniğinin “Dur ve bekle”, “Seçici yeniden gönderim” ve “N’ye geri dön” alt-algoritmaları incelemeye alınmıştır. Bu çalışmada, bu alt-algoritmalardan özellikle “Seçici yeniden gönderim” ve “N’ye geri dön” algoritmaları dikkate alınmıştır. “Dur ve bekle” algoritması ise yeniden iletimlerde pencere yapısı kullanmadığı ve bu nedenle her zaman daha düşük performans ile birlikte daha yüksek gecikme miktarına sahip olduğu için, performans kıyaslamalarına alınmamıştır.

Bu amaçla, kayan pencere teknikleri, MATLAB'da bütün detaylarıyla birlikte simüle edilen Çok Protokollü Etiket Anahtarlama (MPLS) ağı üzerinde uygulanmıştır. Simülasyonda, MPLS ağı üzerinden TCP/IP kullanan tüm düğümler, en kısa yol yönlendirme algoritması tarafından belirlenen yolu kullanarak, aynı ağdaki herhangi bir rasgele düğüme rasgele sayıda veri paketi göndermektedir.

Son olarak, kayan pencere teknikleri, farklı trafik koşulları altındaki gecikme, üretilen iş (iş hacmi) ve oluşan paket kayıp oranları açısından MPLS üzerindeki performansları bakımından incelenmiş ve analiz edilmiştir. Sonuçta, MPLS ağının farklı her bir trafik türü için kayan pencere algoritmalarının en iyisi belirlenmiş ve önerilmiştir

Anahtar Kelimeler: Kayan pencereler, TCP/IP, MPLS, Seçmeli Tekrar gönderim , N’e Geri Dönme

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I also wish to thank to all my family for their support and encouragement during my studies.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

SWP	Sliding Window Protocol
BW	Band-Width
FEC	Forward Equivalence Class
FR	Frame Relay
IP	Internet Protocol
IS-IS	Intermediate System-to-Intermediate System protocol
ISP	Internet Service Provider
LDP	Label Distribution Protocol
LER	Label Edge Router
LIB	Label Information Base
LSP	Label Switched Path
LSR	Label Switched Router
MPLS	Multi-Protocol Label Switching
OSPF	Open Shortest Path First
QoS	Quality of Service
RSVP	Resource Reservation Protocol
SPF	Shortest Path First
VPN	Virtual Private Network

CHAPTER I

INTRODUCTION

1.1. Introduction

In the communication system, the data received from the sender after it has been transmitted over the channel. The channel is usually an ideal transporter to carry the data without any error. Generally, most of the data received contains error which makes the researcher to find way to recover the data from the error as much as possible. To recover the data, some action should be taken at the receiver. The action that will be taken at the receiver is called error control [1-2].

Two basic strategies have been developed by network designers to deal with errors. By adding extra information to data before its being sent, it will comprise a sufficient extra information to infer what a sent data must have been, or if it’s possible to add merely sufficient extra information to investigate the errors that had occurred. However, it will not figure out which error had occurred, then it will have to ask to re-send defected data. The previous strategy utilizes error-correcting mechanism and latter uses errors detecting mechanism. Utilize of error-correcting codes are named by way of Forward Error Correction (FEC).

Such methods may occupy a verity of environmental position. For example, channel which is extremely reliable, by way of fiber, it is possible to utilize errors detecting mechanism and just re-send infrequent block initiate to be defective. On the other hand, wireless channels for example create numerous errors, it is superior to increase extra information to every transmitted stream of data hence which is capable of discovering what originally sent block was. FEC is used for noisy channels due to re-sending is not possible for voice.

In this thesis, sliding windows techniques have been implemented over MPLS. Where MPLS is important now a day in the network due to its advantages that have reliable connection, less time for table look up in case of routing and their private connection.

1.2. Related Work

To ensure transmitting and receiving of information sliding window protocols are utilized. And packets lost are simply recognized where it can be either due to the existence of intruder or due to error from communication links. There are two techniques of sliding window protocols to include information recovery such by way of Selective Repeat protocol and go back N, they can be modeled and verified by way of efficient checking tool using NUSMV.

In [3], sliding window protocols and its operating have been analyzed. Then they planned an improved sliding window method. They have deliberated given factors: Variable timer and Dynamic buffer.

In [4], communication technique of SWP considered related parameters that affect quality system that have been described. Suggested SWP model describes throughput of protocol and requires a delay of acknowledgement. Lost packets, window size, round trip time, timeout period and packet size are examined in communication network system.

In [5], they show coding organization kinds, their benefits and drawbacks, then they discovered a development direction over applications in the future depend over ARQ's faults. Furthermore, this work also describes each ARQ applications and their latest investigation outcomes. Because earlier works, there are no accomplished studies of ARQ's organizations and their related applications, hence, they give basic conception of ARQ.

In [6], they are mostly interested in previous works that depends over model checking of sliding window protocol utilizing new symbolic model verifier (NSMV). In their work they have exposed how SWP can be showed in NSMV. Furthermore, they have verified how to write modest model for simple type of SWP and intruder in NSMV. They have also tested model for properties, information reliability and liveness idea of protocol.

In [7], they proposed a protocol to make this trade-off user-configurable. Mainly, concentrating over sliding window collections, they present AQK slack and buffer-based quality driven complaint treatment method. AQK slack controls methods from arenas of sampling based on estimated query treating and theory of control. It can regulate initial buffer size dynamically to reduce the outcome latency, however; regarding the user stated threshold upon related errors in a created demand outcome. AQK slack needs no pre-knowledge of disorder features of data streams, and executes no deviations to an enquiry operator operation or application logic. Experiments over real world out of order data streams demonstration that is related to state of art, AQK slack can decrease the buffer size hence average show latency, through 51%. On the other hand, respecting user-specified condition over precision of enquiry results. Though, all preceding work does not deliberate result of SWP over tunneling protocol.

However, all previous work did not consider an effect on sliding window protocol over tunneling protocol.

But, since tunneling network are widely beginning to be used now days effect of sliding window protocol must also be checked over tunneling protocol.

In this thesis, sliding window has been implemented over Multi-Protocol Label Switching (MPLS). Where, MPLS directs data from one network node to next based over short path labels rather than long network addresses, by not considering complex lookups in routing table. In addition to that MPLS is connection oriented compared to IP network.

1.3. Outlines

The design of thesis is as follows:

Chapter 2 gives details about architecture of MPLS. This is done because it’s necessary that the reader of this thesis is familiar with how MPLS transfer packet data inside circuit switching technology, and why MPLS is useful in network now days.

Chapter 3 in this chapter, we have considered error control technique in details. Where we explain error recovery technique types and study sliding window technique including their categories such by way of stop and wait, selective repeat and go back N. finally, we give the difference between sliding window techniques.

Chapter 4 gives results of comparison among Go Back N and Selective repeat in throughput, delay, packet lost and number of nodes employed.

Chapter 5 considered simulation program. We have designed a flow chart and explained how algorithm work in MPLS system in which gives the reader a complete picture about our work flow. Then, the result and performance of sliding window go back N and selective repeat in MPLS system considering multiple network constraints by way of throughput, delay, packet loss and number of packet transmitted are considered in this chapter.

Chapter 6 gives the conclusion and future work.

CHAPTER II

MPLS ARCHITECTURE

2.1. Introduction

The MPLS basic operations are organization and identification of IP packets in entrance node including fixed length, short, and locally indicator named by way of label, then sending packets to switches or routers that are can be operated for such labels. Routers and switches that can work including labels utilized just those labels to switch or send packets via network and avoid utilizing logical or physical addresses.

2.1.1. Separation of Control and Data Planes

The idea about MPLSs are parting of IP router's purposes based on the two parts: forwarding (data) then control [8]. Parting of two parts allows enhancement and improved individualistically.

A concept of multi hops forwarding architectures have continued unaffected meanwhile discovery of Internet architectures; verity forwarding architecture utilized through connection oriented link layer technologies aren't give option of accurate end-to-end change about whole sending design. MPLS allow an Internet architecture is to forwarding architecture which is most important change that happen to Internet architecture. MPLSs are fast forwarding mechanisms that are intended to operate including current Internet routing protocols but it is not routing protocol, for example, System-to-Intermediate System (IS-IS), Open Shortest Path First (OSPF), Intermediate or Border Gateway Protocol (BGP). The parts of control plane and data plane are given Figure 1.

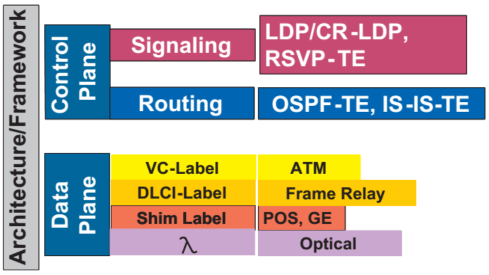

Figure 1. Control and Data plane components

Relaying packets between routers (LSRs) utilizing label swapping is data plane (forwarding plane) however, below IP layer tunnel is created for carrying client data toward to destination. Concept of tunnels (LSP tunnel) are key because utilize it means sending mechanisms aren't IP depend nevertheless label created. Furthermore, grouping at ingress or entry point to MPLS networks aren't depend only upon IP header data then put over supple standards to categorize received data.

2.1.2. Forward Equivalent Class (FEC)

The groups of packets data which are process equally likely through LSR is called Forward Equivalent Class (FEC). Hence FECs are group include IP packets which are send completed same LSP and preserved identically then can be planned to single label through LSR even when packets vary in their routing protocol header information. Figure 2 gives problems. Label reduces critical information about packet. This might comprise destination, precedence, QoS information, then whole route for packet by way of selected via entrance LSR depend over administrative policies. key result of those procedures are which sending decisions depended over some or all of those verity sources of information is attained through means of only table lookup from fixed-length label [9].

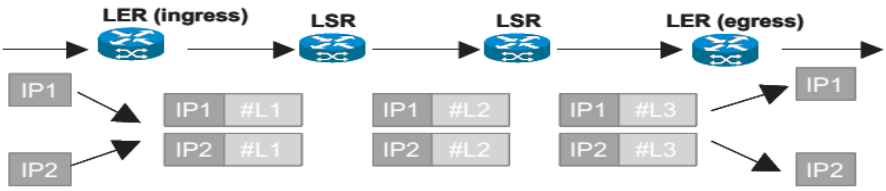

Figure 2. Forward Equivalent Class (FEC)

Those flexibilities are make MPLS so beneficial. Furthermore, allocating only label to unlike flows including same FEC have benefits resulting from such by way of flow aggregation. This enhances scalability and decreases requirement by CPU resources.

2.1.3 Definition of Label

A label named by way of shim label, or MPLS “shim” headers are small fixed-length locally significant FEC identifier. While, data over network layer header is consulted for label task, labels aren't straight encode slightly data from routing protocol header similar source or destination addresses. Label is locally significant only importance which labels are one valuable and applicable over single link, between neighboring LSRs. Figure 3 shows areas of MPLS “shim” header.

In MPLS task of specific packet to certain flow is complete impartial once by way of packet arrives at network. Forward Equivalence Class that packets are allocated to is encoded including short fixed length value named by way of label Figure 3. After packets are sent to next hop this label is directed beside including it that is, packets are labeled. The following hops there are no more analysis of packet’s routing protocol header. Labels themselves are utilized by way of hop index. This task removes requirement to execute longest prefix-match calculation for every packet at every hop, by way of shown in Figure 4. In this method calculation is done merely once, by way of shown in Figure 5 [10].

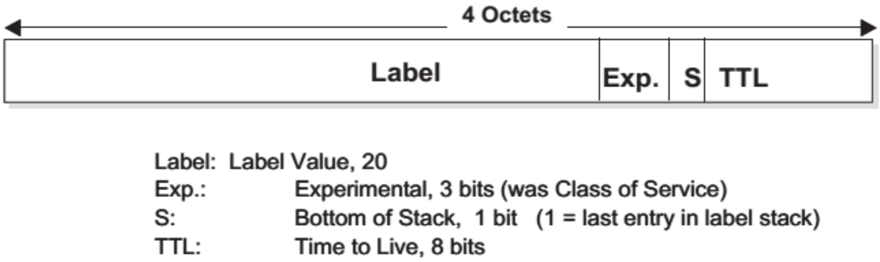

Figure 3. MPLS header format

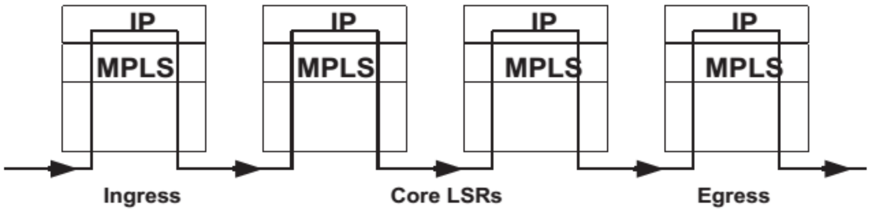

Figure 4. IP Forwarding procedure

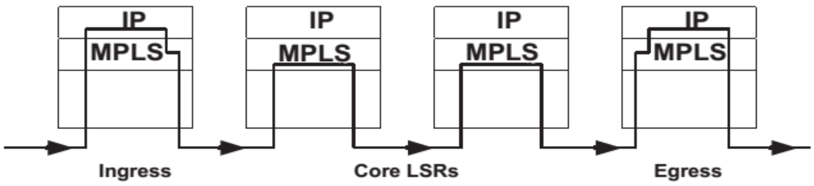

Figure 5. MPLS Forwarding procedure

2.1.4 Label Encapsulations

MPLS systems are multi-protocols due to utilize are planned to operate over multiple data link layers, for example: ATM, Frame Relay, PPP, Ethernet, etc. It is label switching due to utilize it is encapsulation protocol. Label encapsulation about MPLSs are determined via numerous media kind. Highest label over stack might utilize current plans, lower label(s) utilize different shim labels format. In IP-based MPLS shim labels are implanted prior to IP header. Regardless technology if packet requirements extra label it utilizes stack of shim labels. Figure 6 shows label encapsulation in MPLS systems.

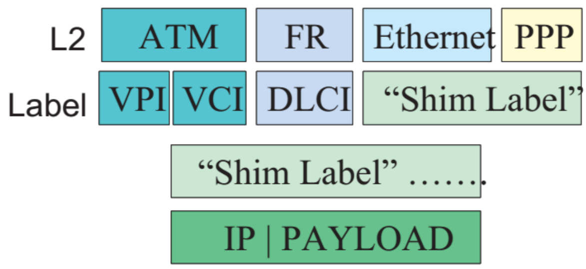

Figure 6. Label encapsulation

2.1.5 Label Swapping

Labels Swapping are set of actions that LSR aspects at label on top of label stack then utilizes arriving label map (ILM) to plan this label to Next Hop Label Forwarding Entry (NHLFE). Utilizing data about NHLFE LSR controls that send packet, and implements process over packet’s label stack. Lastly it encodes different label stack inside packet then forwards result. These ideas are appropriate in change operation of unlabeled packets to labeled packets in ingress LSR, due to utilize it inspects IP header refers NHLFE for suitable FEC (FTN) encodes new label stack inside packet and sends it.

2.1.6 Label Stacking

The series of labels over packet arranged by way of last-in, first-out stack named by way of label stack. Label stack allows packet to transmit information on greater than one FEC that lets it to traverse various MPLS domains or LSP segments inside domain utilizing consistent LSPs beside end-to-end path. A labels treating are always depend over top label, no need to concern which few number of different labels might has been “above it” in past, or that few amount of extra labels might under it at present. Lowest of stack bit “S” in shim header given in Figure 7, designates last stack level. Label stacks are key concept utilized to start LSP Tunnels and MPLS Pyramid. Where Figure 7 shows tunneling purpose of MPLS utilizing label stacks [12].

2.1.7 Label Switch Router (LSR)

Label Switch Routers are device which are able of sending packets on layer 3 and sending frames which encapsulate packet over layer 2. It is both router and layer 2 switch which are able of sending packets to and from MPLS domain. Edge LSRs named by way of Label Edge Routers (LERs).

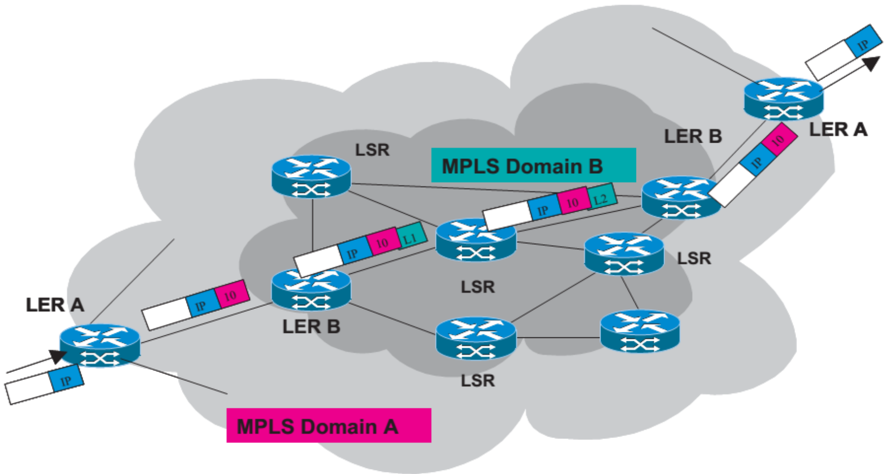

Figure 7. Label Stack.

An ingress LSR send label over top of IP packet and forwards packet to next hop. During this phase by way of arriving packets aren't labeled FEC-to-NHLFE (FTN) map modules are utilized. When packet arrives egress LSR labels are exploded and packets are provided utilizing traditional network layer routing element. whole explanations are showed in Figure 8. If egress LSR is not able of handling MPLS traffic, or for practical advantage of avoiding two lookup times which egress LSR needs to send packet, penultimate hop popping methods are utilized. Through such technique, LSR whose next hops are egress LSR will handle label stripping procedure in its place of egress LSR.

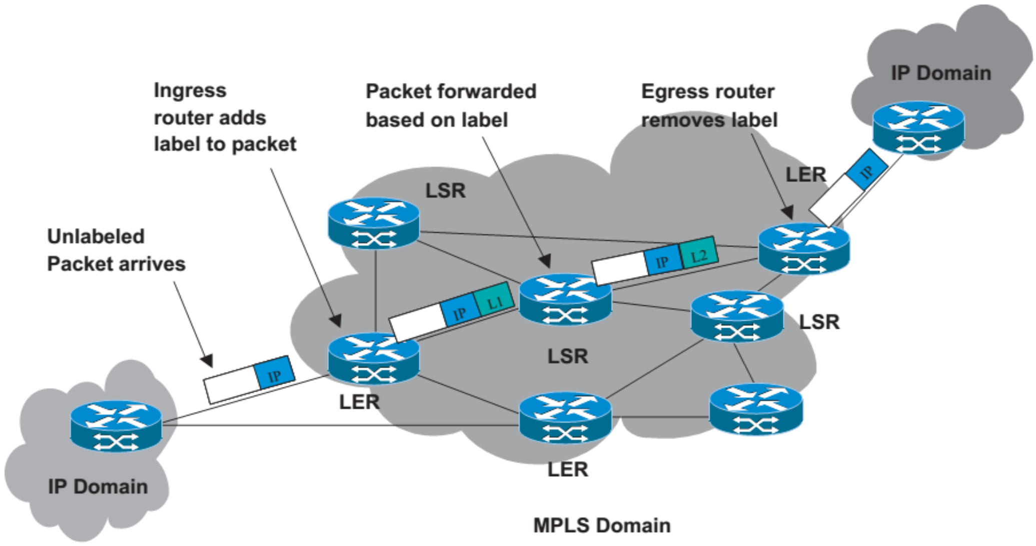

Figure 8. MPLS Architecture

2.1.8 Label Switched Path (LSP)

A Label Switched Paths (LSP) are ingress-to-egress switched path constructed via MPLS able nodes that IP packet tracks inside network and that is explained via label. Labels might be also being stacked, letting tunneling and nesting of LSPs. LSP is like to ATM and FR circuit switched paths, except which not rely over specific Layer 2 technology.

There are two types of LSP based over technique utilized for defining route: hop-by-hop routed LSPs if label distribution protocol (LDP) is utilized, then obvious routed if path should consider given limitations for example existing bandwidth QoS guarantees and administrative rules obvious routing utilizes restriction routed label distribution protocol (CR-LDP) or Resource Reservation Protocol including traffic engineering extensions (RSVP-TE) by way of signaling protocols [14].

2.2 ADVANTAGES/APPLICATION OF MPLS

2.2.1 Simple Forwarding

The MPLS utilizes not variable length label-based sending of every packets are completely selected by single indexed lookup in switching table, utilizing packet's

MPLS label. This makes label switching router sending function over to lengthiest prefix match technique needed in regular datagram forwarding [15].

2.2.2 Traffic Engineering

The key benefit of MPLS is capability to do Traffic Engineering (TE) in connectionless IP networks. TEs are essential to guarantee which traffics are routed via specified network in most effective and consistent way. Traffic engineering capable ISPs to route network traffic by way which they can be give greatest facility to their utilizers in terms of throughput and delay. MPLS traffic engineering lets traffic distributed across whole network framework[16].

2.2.3 Source based QoS Routing

Source based QoS steering is directing instrument in which LSRs are resolved in source hub (entrance LSR) based over some learning of asset accessibility in organize by method for well by method for QoS necessities of streams. As it were, it is steering convention that has extended its way choice criteria to incorporate QoS parameters such by method for accessible data transfer capacity, connection and end-to-end way use, hub asset utilization, postponement and dormancy, including jitter[17].

2.2.4 Virtual Private Networks (VPN)

Web based virtual private system utilizes uncovered, conveyed foundation of Internet to transmit information between locales, keeping up protection through use of epitome convention to set up burrows. Virtual private system can be differentiated including arrangement of possessed or rented lines that must be used by one organization. Fundamental motivation behind VPN is to give organization same capacities by method for private rented lines at much lower cost by using shared open foundation. MPLS engineering satisfies every single important prerequisite to help VPNs by building up LSP burrows using unequivocal directing [18].

CHAPTER III

SLIDING WINDOW TECHNIQUES

3.1. Errors and Correction Technique

Communication channels have variety of features in communication system. Some channels, such by way of optical fiber in communication networks, have little error rates which make sending error is infrequent happening. Nevertheless, other channels, particularly wireless channel, possess error rates that is make of magnitude not small. In such, errors are frequent happening. Such error not easy to be avoided at practical cost or expense in terms of performance. We can conclude error is usually happening, so we have to deal including it and mitigated.

Two basic strategies have developed by network designers to deal including errors. By adding extra information to data before sending. such approach is to comprise sufficient extra data to make destination to infer what a sent data must have been, or it possible to add only enough extra information that make the destination to infer that errors have been occurred, however not which error then have it ask re-send defected data. Previous strategy utilizes error-correcting codes and latter utilizes error-detecting codes. Utilize of error-correcting codes are named by way of Forward Error Correction (FEC).

Such techniques are may occupy different environmental position. For example, channel which is extremely reliable, such by way of fiber, it is possible to utilize error-detecting code and only re-send occasional block seen to be defective. over other hand, channels such by way of wireless channels which create many errors, it is better to add extra information to every transmitted stream of data so that destination is capable to discover what originally sent block was. FECs are utilized for noisy channels due to resending are not possible for voice.

In this thesis, error detecting technique are used and correcting is handle by retransmission through one of famous recovery technique such by way of selective repeat, stop and wait, and go back N.

Automatic **R**epeat re**q**uest (ARQ) is refer to sliding window which is known by way of Automatic Repeat Query. it is error control technique by which information sending which utilizing acknowledgements which are messages sent by receiver referring to correctly received information frame or packet and timeouts are indicated periods of time permitted to elapse before acknowledgment is to be received that attain reliable information sending over not reliable facility. If transmitter is not received acknowledgment before timeout then it typically re-sends data till transmitter receives acknowledgment or exceeds predetermined number of re-endings. Stop-and-wait ARQ, Go-Back-N ARQ, and Selective Repeat ARQ / Selective Reject are types of ARQ. They utilize some method of SWP to express sender to define which data need to be re-sent.

3.2. Retransmission methods

3.2.1. Stop-and-Wait Protocol

Stop-and-wait error controls are method typically related including Stop-and-wait flow control protocol. This protocol and its error-control method is eldest easiest and thus most limiting.

Let consider example about stop-and-wait technique, assume node sends one packet of data to another node B then stops and waits for answer from node B. Four things can happen at this point:

1. First, if data reaches not include any error, node B replies including positive acknowledgment such by way of ACK. When node obtains ACK, it sends next data.
2. Second, if data reaches including error node B replies including negative acknowledgment, such by way of NAK. Then node receives NAK, it retransmits earlier data. Figure 9. Shows example of these steps.

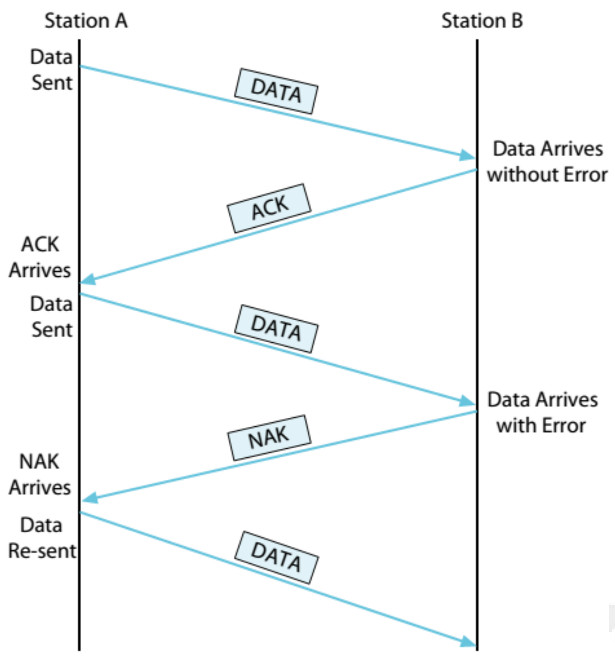

Figure 9. Stop-and-wait scenario

Drawbacks to simple Stop-and-wait error controls are its high degree of inefficiency. Stop-and-wait error controls are half-duplex protocol that means only single node send at one time. Time sending node wastes waiting for acknowledgment may better consumed sending extra data.

3.2.2. Sliding Window Error Control

In previous section, data frames are sent in single direction only. Practically, there are need to send data in both directions. Such thing can be achieved by sending is to implement two instances of one of preceding protocols then everyone utilizing different link for simplex data traffic. All links are then included of forward channel (for data) and reverse channel (for acknowledgements). Two cases capacity of inverse channel is almost completely wasted.

Hence, to beat stop-and-draw drawback SWP is proposed. SWP error controls are depend over sliding window protocol that are flow control scheme which lets node to send number of data at one time before receiving some form of acknowledgment.

For such architecture data frames from node to node B are mixed including acknowledgement frames from node to node B. through observing on kind field in header of arriving frame receiver can say either frame is data or acknowledgement. While mixing data and control frames over same transmission are big enhancement over having two distinct physical links further yet another improvement is possible. When data frame reaches and rather than directly sending distinct control frames, receiver restrains itself and waits till upper layer permits it subsequent packet. Acknowledgement is attached to outbound data frame.

3.2.2.1. GO back N Technique

Go-Back-N protocols are sliding window method. It is technique to identify and control error in datalink layer. Throughout sending of frames between transmitter and destination, if frame is corrupted, lost, or acknowledgement is lost and action made via transmitter.

destination sees number over every frame, it arrived. If frame number is hopped in sequence, and receiver simply identifies frame has been lost by way of newly received frame is arrived out of sequence. NAK is transmitted by receiver for lost frame and then all frames received are discarded after lost frame. Discarded frames will not have acknowledged by receiver. Then transmitter receives NAK for lost frame re-sends lost frame defined via NAK and also resends all frames that they have been transmitted after lost frame.

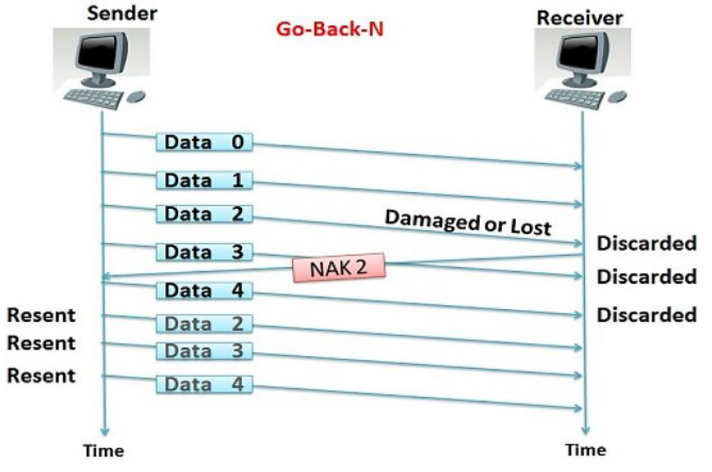

Figure 10. GO BACK N Technique

When ACK does not transmitted by receiver or if ACK is lost or smashed in between sending. Transmitter waits for time to implement and by way of time run outs, sender retransmits all frames for which it has not received ACK. transmitter identifies loss of ACK including help of timer. ACK sequence number such by way of NAK: negative acknowledgement number, indications number of frame which receiver expects to be next in sequence.

3.2.2.2. Selective Repeat Technique

Selective repeat techniques (SRP) are SWP data detects and corrects error occurred in datalink layer. SRP resends only that frames that are corrupted or lost. In SRP, re-send frames are received out of order. SRP is implemented following activities:

- Receivers are able of placing frame in proper order by way of it receives re-sent frame whose sequence is out of order of receiving frame.
- Transmitter is able of searching frames for which NAK have been arrived.
- Receiver is containing buffer to store all previously arrived frame over hold till retransmitted frame is sorted and placed in order.
- ACK number like NAK number refers to frame which is lost or damaged.
- It requires less window size by way of compared to go-back-n protocol.

When the destination gets corrupted frame, it transmits NAK for frame that errors or damages are detected. NAK number resemble in GO BACK N also show acknowledgement of before arrived frames and error in present frame. Receiver saves arriving new frames while waiting for corrupted frame to be changed. Frames that are arrived after corrupted frame are not be acknowledged till corrupted frame that is changed.

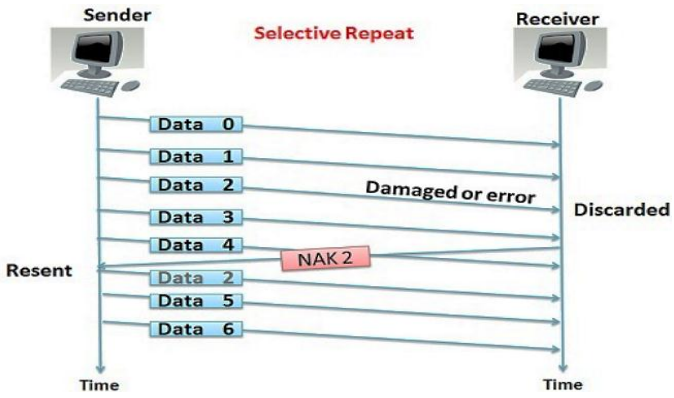

Figure 11. Selective Repeat Technique.

If transmitter does not get any ACK or ACK is lost or corrupted in between sending. transmitter waits for time to run out and by way of time run outs, transmitter re-send all frames for that it has not arrived ACK. Transmitter recognizes ACK is lost including help of timer.

GO BACK N should be compared to selective repeat to show their performance over tunneling protocol, it is verified performance differences of both protocol by using implementation of sliding window protocol.

CHAPTER IV

IMPLEMENTATION OF SLIDING WINDOW

4.1. Simulation Perspective of Sliding Window

Sliding windows error controls are depending over sliding window protocol, that flow control system that lets station to send amount of data packets over a time before receiving few form of ACK.

In previous section, data frames are sent in single direction only. Practically, they need to send data in both directions. Such thing can be achieved by sending it to run two instances of one of preceding protocols then everyone utilizes a different link for simplex data traffic. All links are then included of forward channel (information) and opposite channel (for acknowledgements). Two cases capacity of reverse channel are almost completely lost.

Hence, to beat stop-and-draw drawback SWP is proposed. SWP error controls are depended over sliding window protocol that flow control scheme which lets node to send number of data at one time before receiving some form of acknowledgment.

For such architecture data frames from node to node B are mixed including acknowledgement frames from node to node B. Through searching over kind field in the header of arriving frame destination, it can tell either frames are data or acknowledgement. While mixing data and control frames over same transmission, large enhancement over having two distinct physical links further yet additional enhancements are existing. If the frame reaches rather than directly sending distinct control frames, receiver restrains itself and waits till upper layer permits it next packet. Acknowledgement is attached to the outgoing data frame (using ACK field in frame header).

4.2. Simulation Perspective of Selective repeat protocol

Selective Repeat is part of automatic repeat-request (ARQ). Including selective repeat, transmitter sends number of frames quantified through window size even without a need to wait for individual ACK from receiver by way of in Go-Back-N ARQ. Receiver may selectively reject single frame, which may be retransmitted alone; this contrast including other forms of ARQ that are necessity to transmit each frame from that point again. Receiver takes out-of-order frames and buffers them. Transmitters independently resend frames that have timed out.

4.3. Simulation Perspective of Go Back N Protocol

It is a sliding window method that identifies and mange's error in datalink layer. Throughout sending of frames between transmitter and destination, where the frame is corrupted, lost, or acknowledgement it is lost then action made through transmitter.

Destination sees number at every frame that arrived. If frame number is hopped in sequence, then receiver simply identifies frame has been lost by way of newly received frame is arrived out of sequence. NAK is transmitted by receiver for lost frame and then all frames received are discarded after lost frame. Discarded frames will not have acknowledged by receiver. Then transmitter receives NAK for lost frame re-sends lost frame defined by NAK and also resends all frames they have been transmitted after lost frame.

4.4. Determination of a best of Sliding windows technique for different network traffic types

The question that needs to be answered is which protocol and where is a better selective repeat or go back N?

The go-back-n protocol works well if errors are less and low-density network (network not crowded), because we do not need to acknowledge each transmitted frame, only sequences of fames.

But if the line is poor and network is crowded (high density network) it reduces the bandwidth efficiency over re-sent frames. Alternative strategy, selective repeat protocol, is to allow receiver to accept and buffer frames following damaged or lost one.

The main differences between go back N and selective repeat are [9]:

- All frames are retransmitted after corrupted frames in case of GO BACK N protocol. However, it retransmits single frame that is corrupted or lost in case of selective repeat.
- If links make lot of errors, then retransmission will take place over multiple frames which makes GO BACK N un-efficient. However, re-sends merely damaged frame hence, minimum bandwidths are wasted which is an attribute of selective repeat protocol.
- Go BACK N does not require to put frame in order in case of damaged frame because all frame retransmitted and does need to be re-ordered. However, selective repeat protocol need to re-order frames because retransmission take place for corrupted frame which make technique more complex.
- Window size of selective repeat is less than or equal (n+1)/2, while, window size of GO BACK N is n-1, where n represent number of frames in window.
- Sorting is necessary in receiver for selective repeat protocol, while neither transmitter nor destination need to do sorting in GO BACK N.
- Selective repeat protocol needs to store frames in receiver to re-arrange them in propose sequence, however; in GO BACK N receiver does not require to store frames because it will transmit all frames.
- In GO BACK N NAK frame will most likely denotes to the next frame, while in selective repeat represent damaged frame.
- Usually, GO BACK N is less complex, hence is more in use than selective repeat protocol.

But this expectation should be shown by implementing techniques over MPLS through using simulation program.

CHAPTER V

SIMULATIONS AND RESULTS

5.1. Martials and Methods

A simulation program in MATLAB was established in this thesis, in which locations, and buffer states of N nodes, number of transmitted and received packets; organization and designated routes of packets in buffer of each node; instant data generation rates; and instant overall throughput values are all noticeable from screen.

The overall algorithm utilized in simulation is shown in Figure 1. In simulation, nodes are considered to communicate with each other and multichip data to other nodes in service area. Simulation parameter values are changed to any reasonable value.

5.2. Flow Chart and Implementation of Sliding Window Over MPLS

In this section, we have built a flow chart of MPLS including sliding window and all other functions. Flow is considering MPLS function.

First of all, initialization of program has been made which includes buffer size, packet generation, TTL, throughput, RTT, number of nodes, maximum number of hops, number of lost packet, number of sent packet, number of received packet.

Each node in the MPLS will generate data packet, then if the number of packet sent is 12000, node will end the process otherwise it observes the environment. Then, the node will look to the buffer if the buffer is full, the node will again observe the environment, if the buffer not full, the node will put the generated packet in the buffer.

After putting the packet that has been generated by the node in the buffer, the node will arrange the buffer and see if there is packet for itself. Then, the node will take it and increase number of the packet otherwise node will evaluate the rout to the packet node by using shortest path.

The if the arrival node at switch, then the packet forwarded to LER, otherwise the packet forwarded to destination router. At LER, either the packet labeled with MPLS label or forwarded to read their MPLS label. Then, the label is analyzed and swap the label and forward the packet and generate next packet.

At destination router, if it is true the destination router, the router calculates the number of the throughput otherwise the router will extract the label and it look if there are some packet for itself, router will take it and increase number of the packet otherwise calculate the throughput.

5.3. Implantation of Go Back N in MPLS

In this section, we are going to talk about programming Go Back N which means the idea of this thesis. The function that is responsible about Go Back N technique is make transfer function.

The idea of go back N is transmission continue even error occur, until transmitter do retransmission which make many frames retransmitted again while they are received correctly.

In figure 13. Shows go back N in MPLS. First of all, node determine or update the window size. Then, node transmit all the packet in the window, the node receives the acknowledgement of the sent packet in the duration of the time and determine acknowledged packet number. Then, node calculate lost acknowledged number in the window without loss. After that move this window by number and check if there is loss or not. If the loss occurred, retransmit all the packet in the window otherwise determine or update window size.

5.4. Implantation of Selective Repeat

In this section, we are going to talk about programming selective repeat technique which competitive technique to Go Back N. The function that is responsible about selective repeat technique makes a transfer function.

The idea of selective repeat is totally different from go back N, where transmission continues even if error occur, until transmitter does retransmission, but transmitter retransmit corrupted packet only instead of number of frames after corrupted frame.

In figure 14. Shows selective repeat in MPLS.

First, node determine or update the window size. Then, node transmit all the packet in the window, the node receives the acknowledgement of the sent packet in the duration of the time and determines the acknowledged packet number. Then the node checks, if the loss occurs, node will determine the acknowledged packet number, then it determines or updates the window size and retransmit the lost packet and finally, move window by number of the packet sent without any loss in the sequence, otherwise, in the case loss.

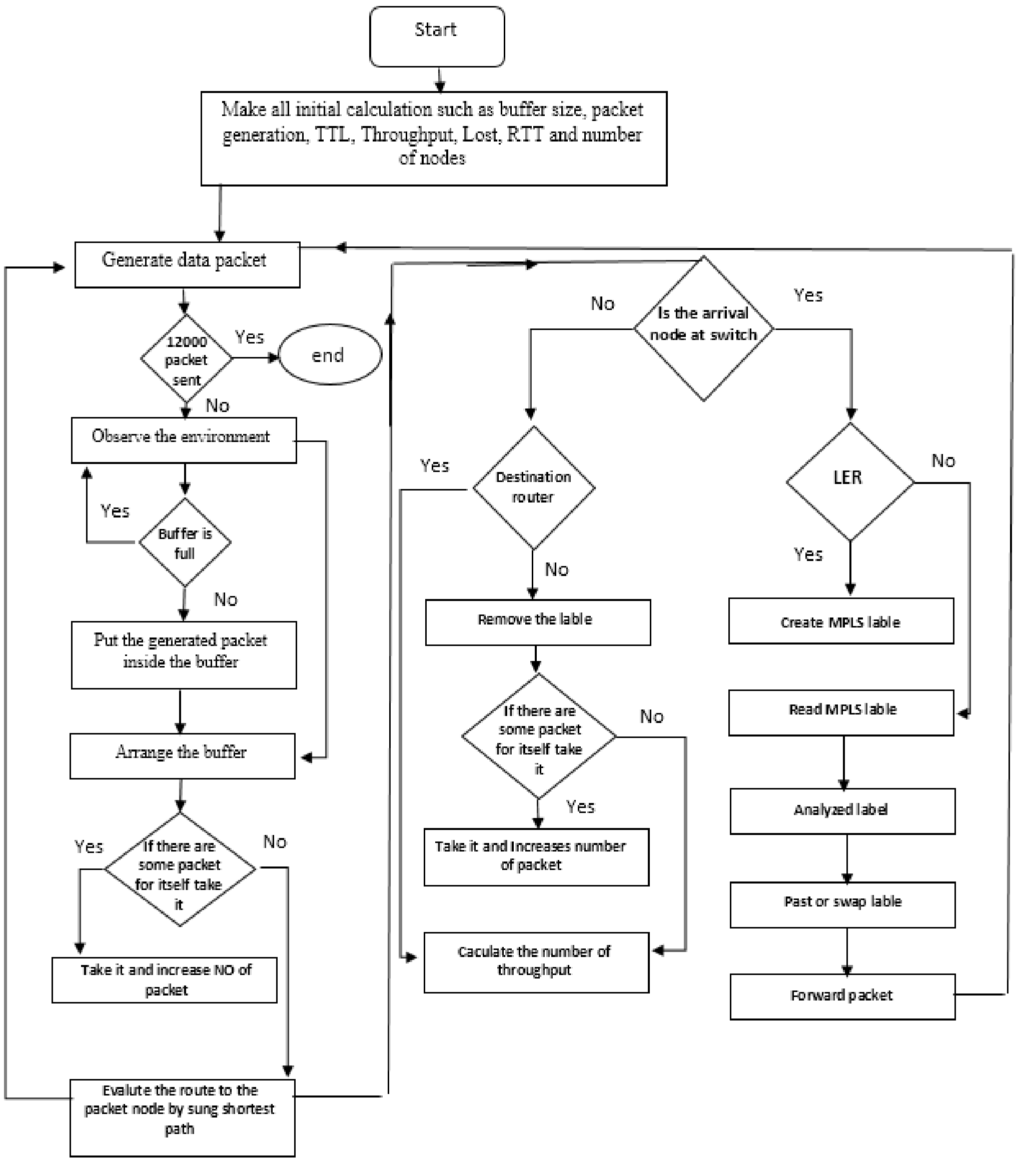

Figure 12. MPLS Flowchart

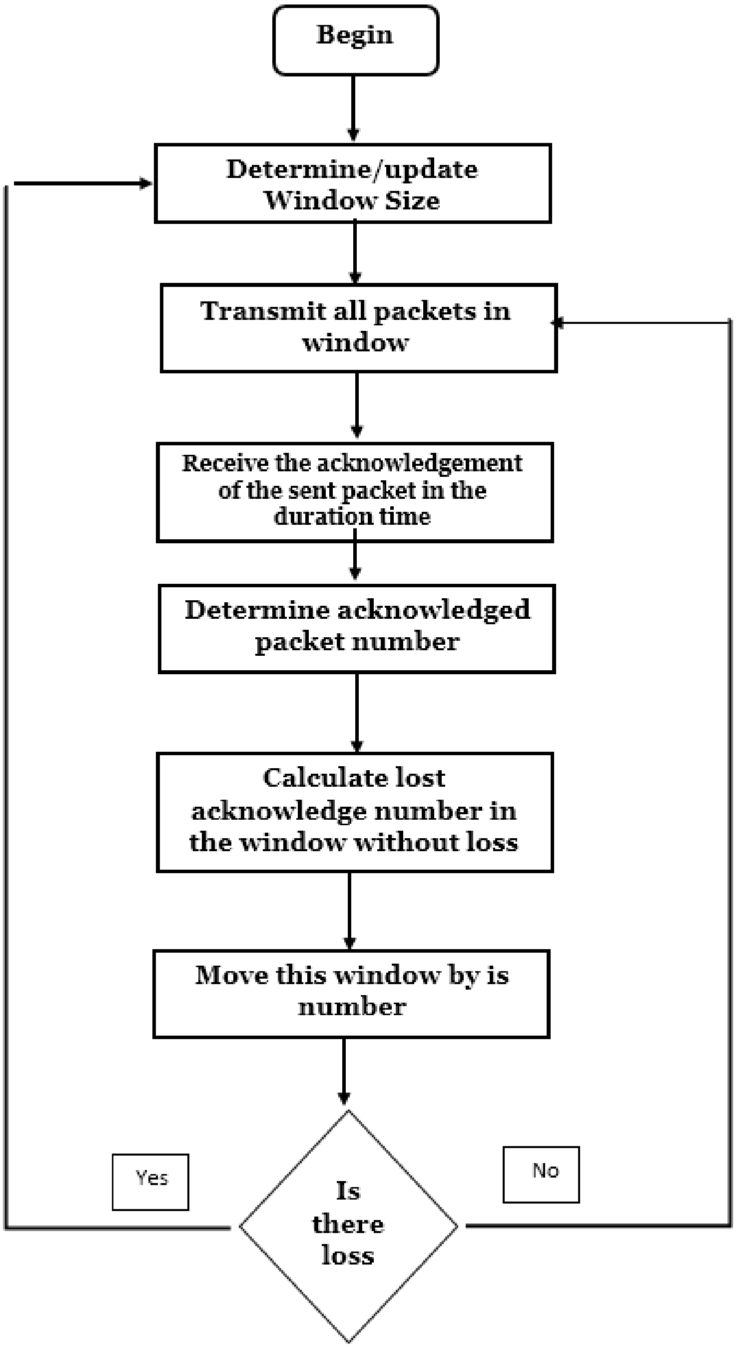

Figure 13. Flowchart of Go Back N in MPLS

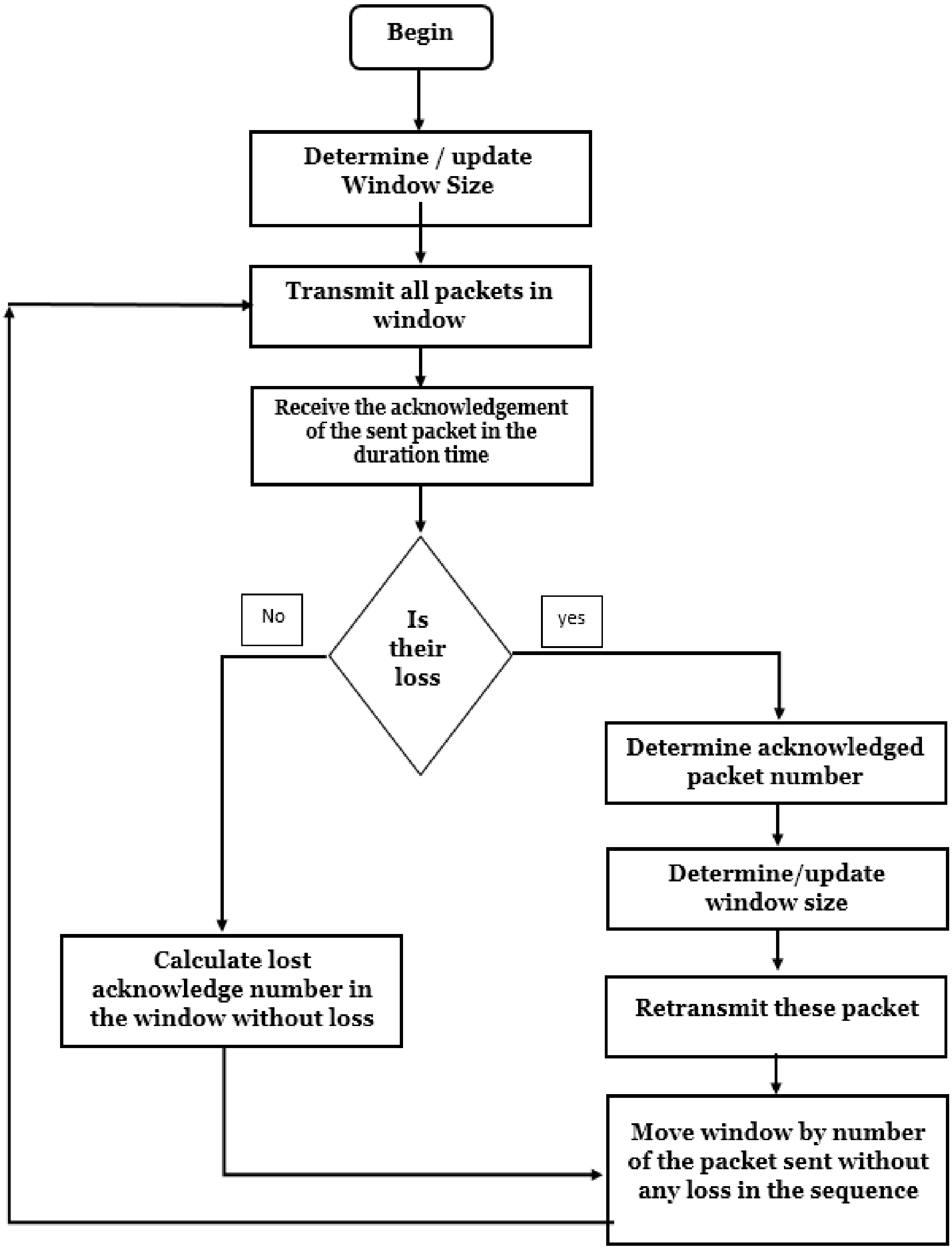

Figure 14. Flowchart of Selective Repeat in MPLS

5.5. A Performance of Go Back N and Selective repeat performance over MPLS

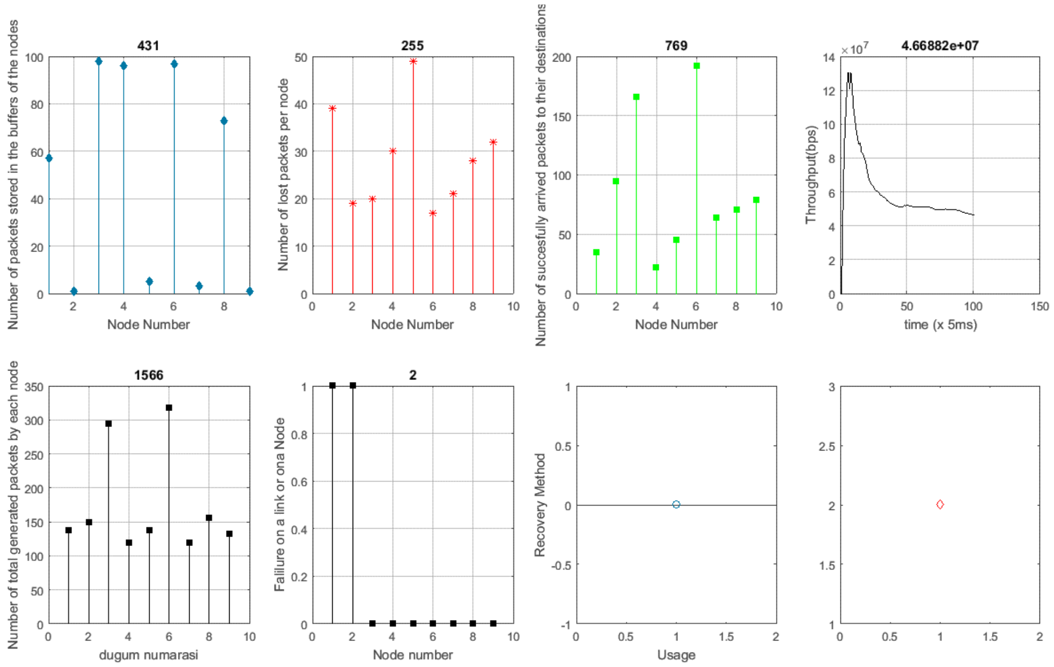

Figure 15. Go back N including number of nodes = 9 and packet generation = 6.

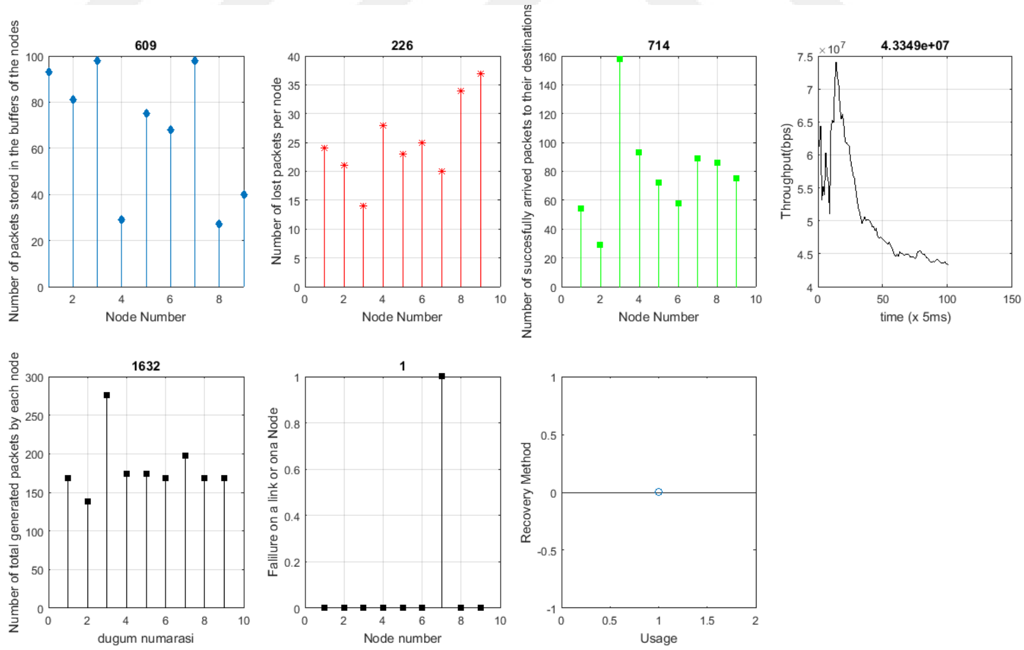

Figure 16. Selective Repeat including number of nodes = 9 and packet generation = 6.

Figure 15 and figure 16 show differences between go back N and selective repeat using number of nodes 9, and number of packet generation are 6. Where important results apparent in figure are summarized by way of follows, throughput of go back N is better than selective repeat because go back performed well in low number of nodes network, in contrast to selective repeat which performed bad in such network.

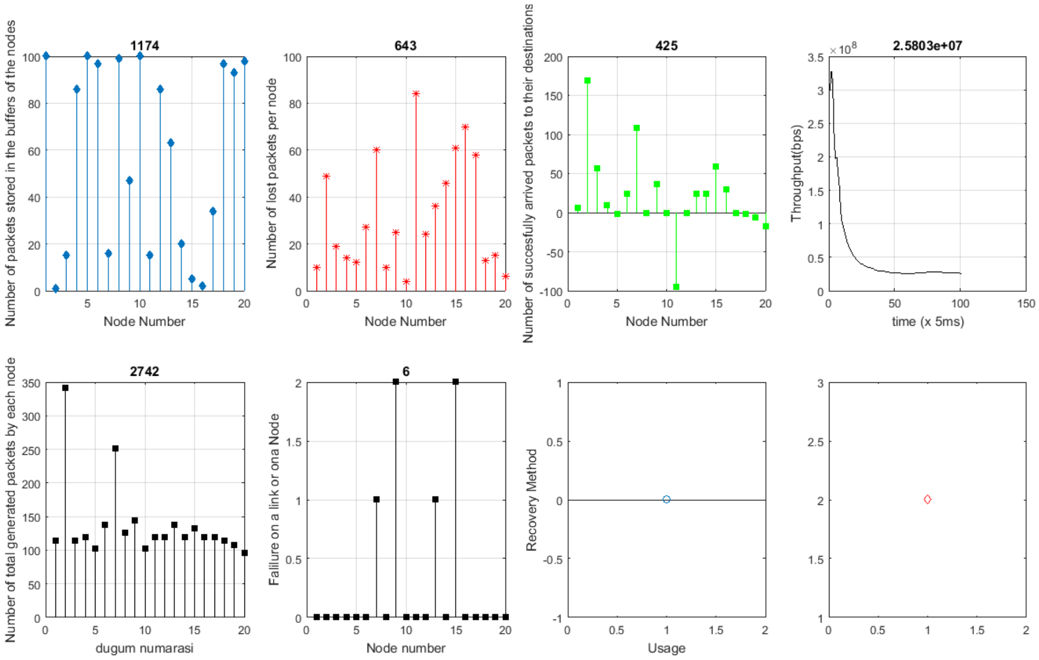

Figure 17. Go back N including number of nodes = 20 and packet generation = 6.

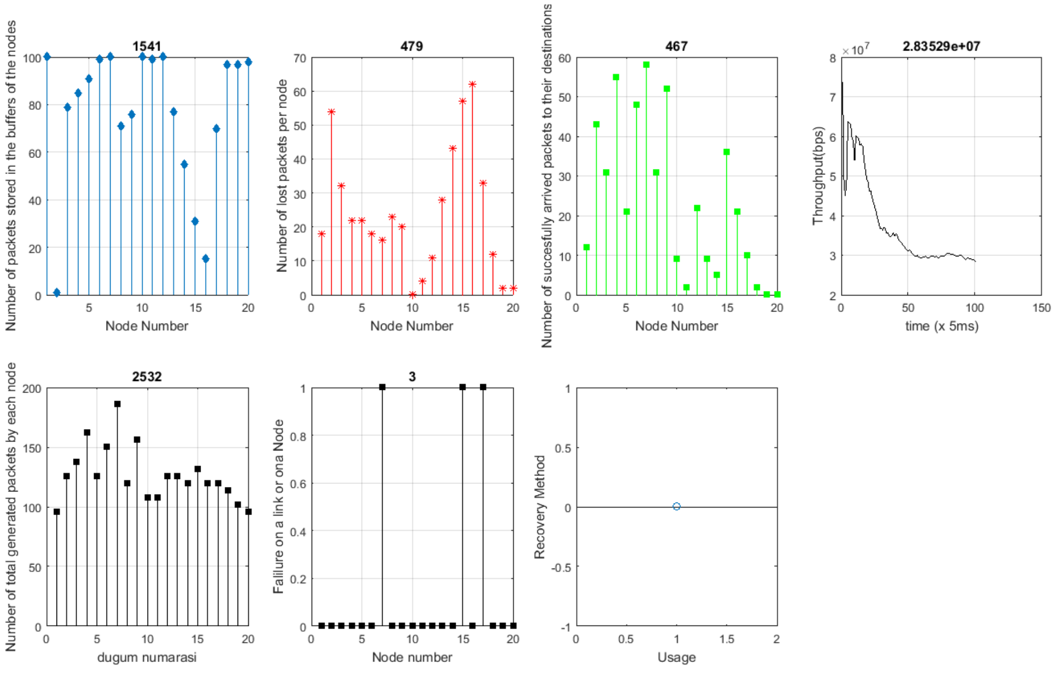

Figure 18. Selective repeat including number of nodes = 20 and packet generation = 6.

Figure 17 and figure 18 show differences between go back N and selective repeat using number of nodes 20, and number of packet generation are 6. Where important results appear in the figure are summarized by way of follows, throughput of go back N is better than selective repeat because go back performed bad in low active network, in contrast to selective repeat which performed well in such network

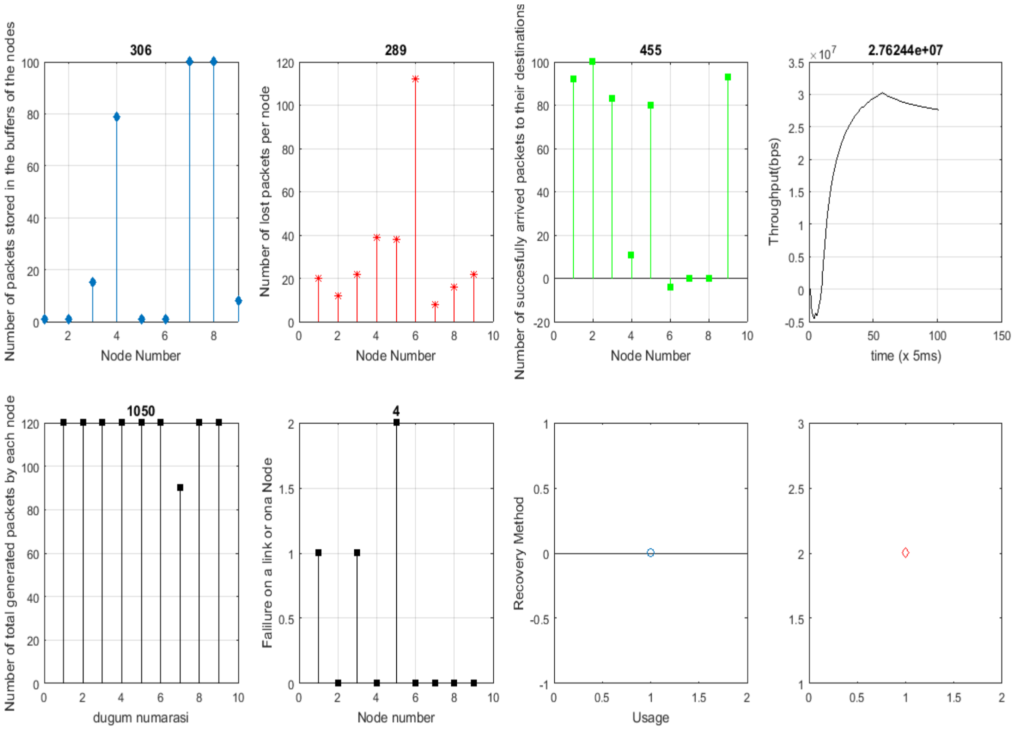

Figure 19. Go back N including number of nodes = 9 and packet generation = 30.

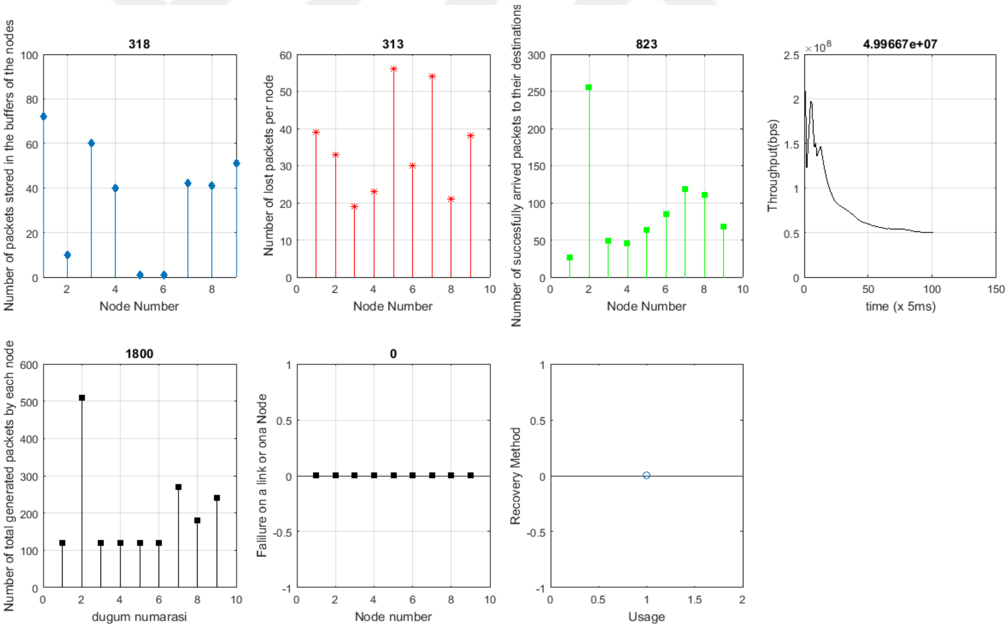

Figure 20. Selective repeat including number of nodes = 9 and packet generation = 30.

Figure 19 and figure 20 show differences between go back N and selective repeat using number of nodes 9, and number of packet generation are 30. Where important results appear in the figure and are summarized by way of follows, throughput of selective repeat is better than go back N because go back performed well in low number of nodes network, in contrast to selective repeat which performed bad in such network.

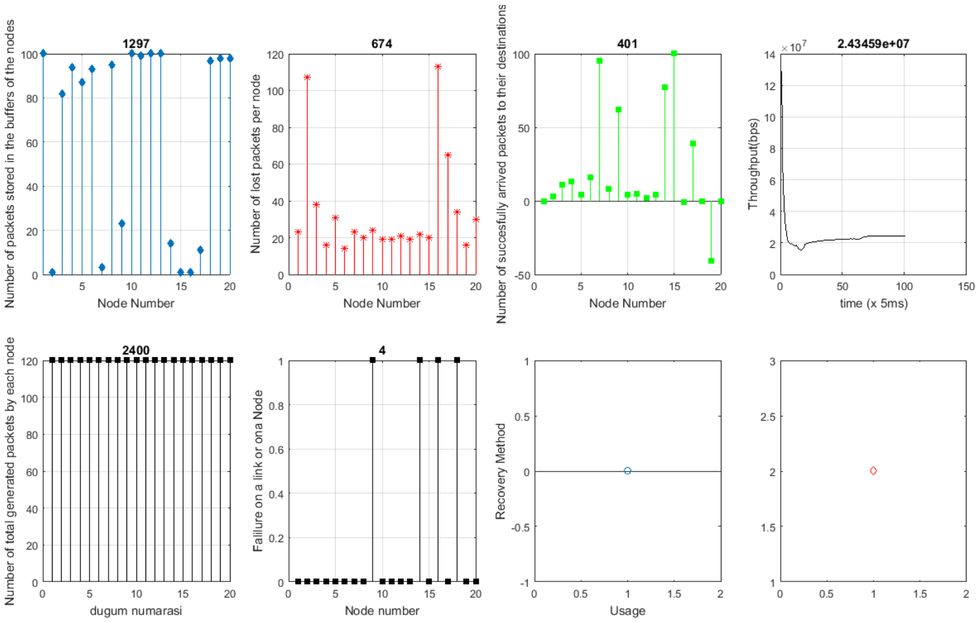

Figure 21. Go back N including number of nodes = 20 and packet generation = 30.

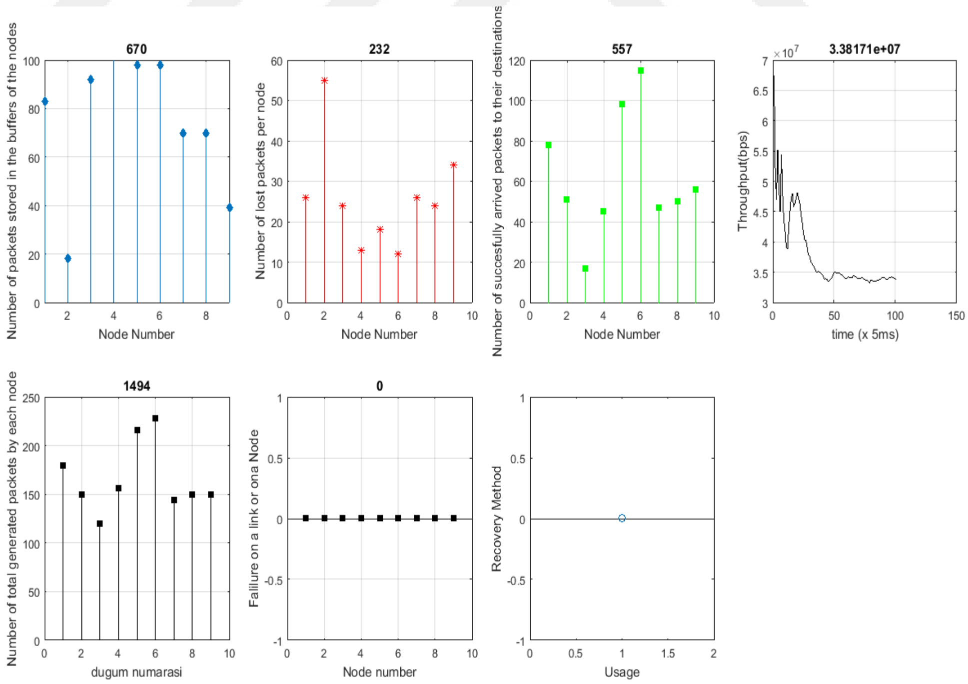

Figure 22. Selective repeat including number of nodes = 20 and packet generation = 30.

Figure 22 and figure 22 show differences between go back N and selective repeat using number of nodes 30, and number of packet generation are 30. Where important results appear in the figure are summarized by way of follows, throughput of go back N is better than Selective Repeat.

CHAPTER VI

CONCLUSIONS AND FUTURE WORK

In this chapter, the thesis's summary, contributions, main conclusions, and different ideas and suggestions that can be considered for future work are presented.

6.1. Conclusions

The purposes of this thesis have been accomplished. This work was intended to utilize sliding window technique over MPLS to gives reliability over noisy channel. Two sliding windows have been considered such by way of GO BACK N and selective repeat technique.

The main contributions are summarized in following paragraphs:

Sliding Window Technique: is a protocol for managing sent information (data) between entities over network where reliable and sequential delivery of data is compulsory. Sliding window protocol work in DLL or TCP.

Go Back N Sliding Window: is sliding window protocol, which is a method to discover and manage errors in DLL. Throughout the sending of the data between transmitter and receiver, if the data is damaged, lost, or acknowledgement is lost, an act will be implemented via transmitter and receiver, where the receiver sends NACK and discard received frame after corrupted frames**.** Sender retransmit corrupted frames and all discarded frames.

Selective Repeat Technique: is also sliding window protocol which discovers or corrects errors happened in DLL. Selective repeat protocol re-sends only the frame that has been damaged or lost.

Multi-Protocol Labeling Switching: MPLS lets most packets to be forwarded at Layer 2 instead of having to be passed up to Layer 3 which is routing level. Each packet acquires labeled over ingress into ISP through ingress router.

Sliding Window in MPLS: in this thesis, sliding window technique has been implemented in MPLS and studied for different network scenarios such by way of number of nodes, packet generation and buffer size, …, etc. Then, we have employed two sliding window techniques: such by way of go back N and selective repeat.

Selective Repeat in MPLS: in this work, selective repeat has been studied in MPLS, where selective repeat performs well by way of number of nodes and packet generation are low. This leads to a mal performing when the number of packet generation and the number of nodes are high.

Go back N in MPLS: in this thesis, go back N has been studied in MPLS, where go back N performs good by way of number of nodes and packet generation are low, and it performs bad when the number of packet generation and the number of nodes are high.

Performance of Go Back N and Selective Repeat: performance of go back N and selective repeat has been considered, where it has been shown that selective repeat has less performance compared to go back N in low number of nodes, while go back performance is bad in the dense network.

The results also showed that at time $\mathbf{50} \times \mathbf{5}\,\boldsymbol{ms}$:

- 25% of the throughput was improved of the Go Back N over Selective Repeat at 9 nodes and 6 packets generated.
- 33% of the throughput was improved of the Go Back N over Selective Repeat at 20 nodes and 6 packets generated.
- 133% of the throughput was reduced of the Go Back N over Selective Repeat at 9 nodes and 30 packets generated.

- 66.6% of the throughput was improved of the Go Back N over Selective Repeat at 20 nodes and 30 packets generated.

6.2. Future Work

It is possible to suggest several issues that are presented in this master thesis for further study. Such issues are presented in the following paragraphs bellow.

Investigation of the energy consumption in MPLS, where energy consumption is an important factor in the communication system and low battery devices. It is possible to study energy side by side including sliding window protocol inside MPLS.

Adaptive sliding window can be considered in MPLS, where adjusting sliding windows slide gives a better performance over static or fix sliding window size.

Different routing algorithms in MPLS side by side including sliding window technique can be investigated. In such proposal, we can choose appropriate sliding window technique to the given routing technique.

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APPENDICES

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