Analysis of Stop and Wait, Go-Back-N and Selective Repeat Protocol in Different Network Models

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I. Abstract

Automatic Repeat ReQuest (ARQ) is a group of error control protocols for transmission of data over unreliable communication network. It uses Acknowledgements and Timer to achieve reliable data transmission. These protocols reside in Data Link Layer and Transport Layer. IEEE 802.11 wireless networking uses ARQ Transmissions at the data link layer. ARQ Protocols are widely used in error and flow control mechanisms and are divided into two Protocols for noiseless channel and Protocols for noisy channel. The protocols are the three basic ARQ protocols: Stop and Wait, Go-Back-N and Selective Repeat and are commonly implemented in software by means of any programming language. In this paper, we study the performance of ARQ protocols which are affected by various parameters like Bandwidth, Delay, Window Size.

Keywords- ARQ, Flow Control, Error Control, Frames, Acknowledgement, Timer, Throughput.

II. Introduction

A Computer Network is a system in which multiple computers are connected to each other to share information and resourvces. Data Communication is the transmission of digital data between two or more computers and a computer network or a data network. The physical connection is established using either cable media or wireless media. The data communication system consists of five components which include Sender, Receiver, Message, Transmission medium and Protocol. Message is the data which is being sent from the sender to receiver over the transmission medium and which is governed by some standard rules called as Protocols.

OSI (Open System Interconnect) is a standard model which describes the computer communication protocols. It is a reference model for designing and understanding network architecture. The Internet Protocol suite is the widely used model and set of communication protocols used . It is commonly known as TCP/IP because the foundation protocols in the suite are Transmission Control Protocol and Internet Protocol. OSI is a generic model that is based on functionalities of each layer whereas TCP/IP model is a protocol oriented standard. Unlike OSI which has seven layers, TCP/IP has only 5 layers. Transport Layer provides logical communication between applications running on different hosts. Transport layer protocols are implemented in end systems but not in Network Routers. The transport layer converts the application layer messages into transport-layer packets known as segments. When a transport layer protocol provides a logical communication between different processes running on different hosts, a network layer protocol provides logical communication between the hosts. Unlike Network Layer, Transport Layer offer additional services and provides reliable data transfer.

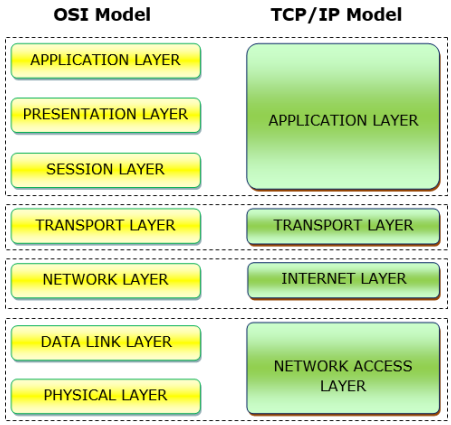

Figure 1 OSI and TCP/IP models.

III. ARQ Fundamentals

Automatic Repeat ReQuest (ARQ) protocols ensure proper transmission of data over unreliable network. These protocols reside in Data Link Layer and Transport Layer. Because if automatic retransmission of frames which are lost or corrupt, they are called as Automatic Repeat ReQuest protocols. ARP protocols implement flow and error control mechanisms. There are different protocols to initiate a call to retransmit the data packet or frame after receiving incorrect data. These protocols are divided into two categories for Noiseless and Noisy Channel. Unlike Noisy channel, in a Noiseless channel is an ideal channel in which frames are not lost, duplicated or corrupted.

Stop and Wait Protocol:

Stop and Wait protocol is also called as Alternating Bit Protocol. It ensures that information is not lost due to dropped packets and packets are received correctly on the receiver side. It is the special case of Sliding Windows protocol where the sender and receiver window size is one. Sender sends only one data packet at a time and waits for the acknowledgement from the receiver. Receiver sends the acknowledgement after consuming the data packet.

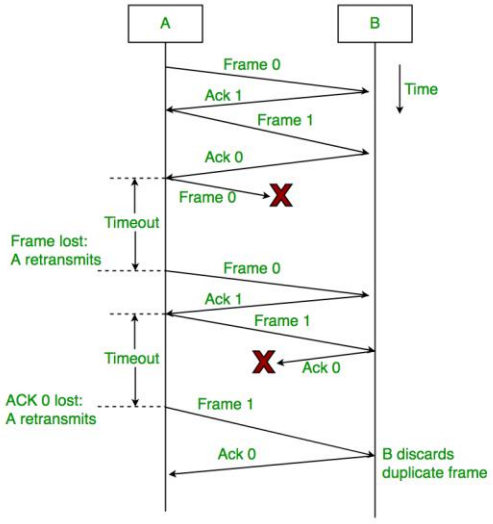

Figure 2 Stop and Wait Protocol

Go-Back-N Protocol:

Go-Back-N is the modified version of Stop and Wait protocol where the sender sends the packets without waiting for the acknowledgement from the receiver. It uses Sliding window method for reliable data transfer. It is the case of Stop and Wait protocol where the sender window size is N and receiver window size is 1. It uses the concept of protocol pipelining. Here multiple frames are sent before the acknowledgement of first frame is received. The size of sending window determines the number of outbound frames. If the sequence number of the frames is an n-bit field, then the range of sequence numbers that can be assigned is 0 to 2^n-1. Consequently, the size of the sending window is 2^n-1

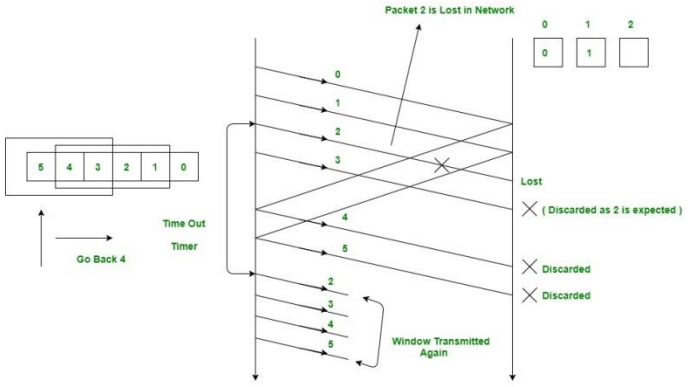

Figure 3 Go-Back-N Protocol (Receiver Side)

Selective Repeat Protocol:

Selective Repeat Protocol is modified version of Go-Back-N protocol were the buffers are used to handle out-of-order delivery and both the sender and receiver maintain a window size. Selective Repeat attempts to retransmit the packets which are lost during transmission. In SR Protocol if the packers receiver by receiver are corrupted then the situation is handled by sending the Negative Acknowledgement which allows retransmission of corrupt. In Go-Back-N ARQ if one frame is corrupted then all other N frames were resent. Also the receiver has to keep track of only one frame and does not buffer out of order frames as they are discardedSelective Repeat ARQ overcomes the drawback of Go-Back-N ARQ. In this mechanism, instead of resending N frames only the damaged frame is resented frame. It also avoids waiting for the timer to expire.

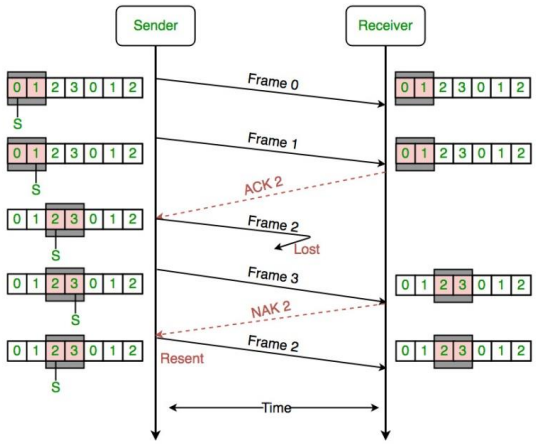

Figure 4 Selective Repeat Protocol

Piggybacking:

The protocols discussed in this paper are unidirectional. The data frames flow only in one direction though the control information such as Acknowledgements can flow in other direction. However in real scenarios, information should flow in both the direction. Piggybacking can be used to improve the efficiency of bidirectional protocols.

IV. Analysis

In this paper we analyze all the three ARQ Protocols in both nose and noiseless channel. We consider 802.11b Wireless Communication Network for our analysis.
For Wireless Communication,
Let L be the length of the Packet
Let us assume we are transmitting 10000 bits of data through wireless medium.

From 802.11b wireless standards,
R-Bandwidth- Up to 11Mbps
Range- Up to 150 feet (45.72 m)
Maximum Propagation Delay (Tp) = 45.72/ $3x10^8$ =0.5 μs
Transmission Delay (Tt) = L/R
Let P be the probability of loss of packet
We will analyze the Utilization and Throughput in different network models by changing the Bandwidth, Delay, Probability of loss of packet and Window size for all the three protocols. In noiseless channel we consider the probability of loss of packet (P) to be zero. By changing the Bandwidth, Delay and window size we plot a graph for Utilization and Throughput. In a noisy channel, we include the Probability (P) and plot a graph for Utilization and Throughput.

Stop and Wait Protocol:
Analysis of Channel Utilization:

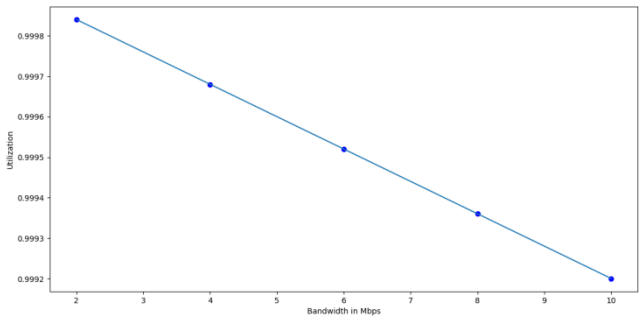

Figure 5 Utilization Vs Bandwidth (Noiseless)

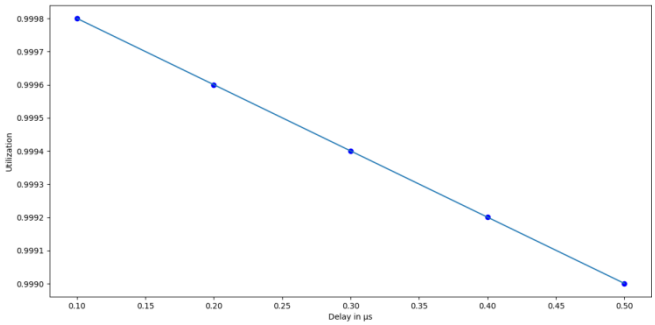

Figure 6 Utilization Vs Delay (Noiseless)

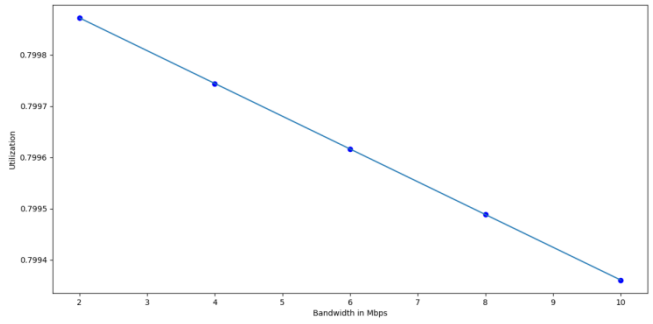

Figure 7 Utilization Vs Bandwidth (Noisy)

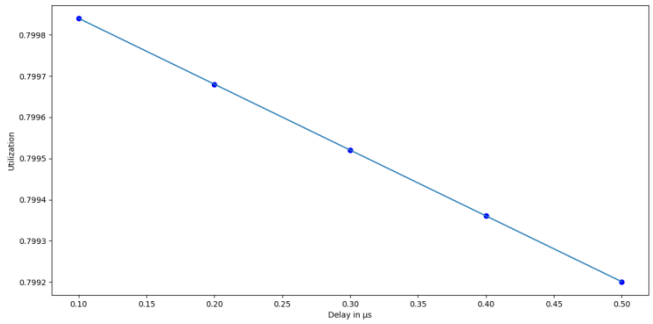

Figure 8 Utilization Vs Delay (Noisy)

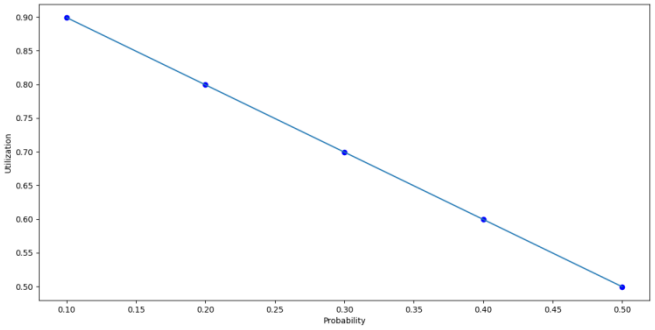

Figure 9 Utilization Vs Probability (Noisy)

Analysis of Throughput:

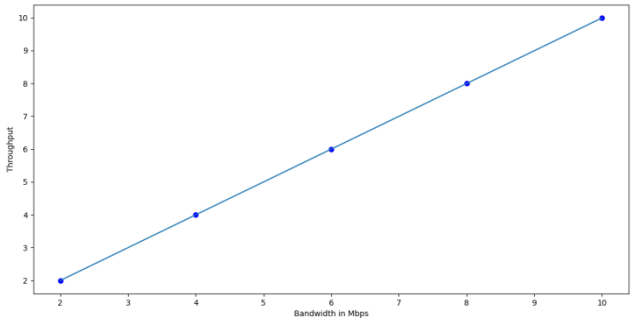

Figure 10 Throughput Vs Bandwidth (Noiseless)

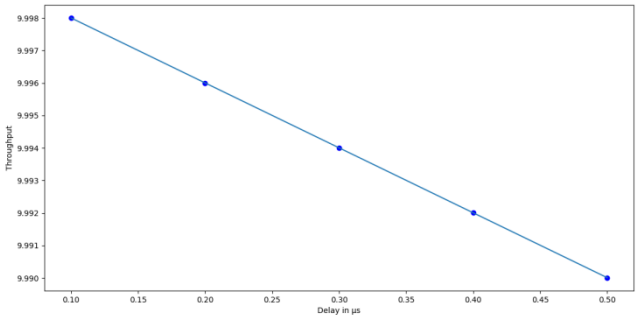

Figure 11 Throughput Vs Delay (Noiseless)

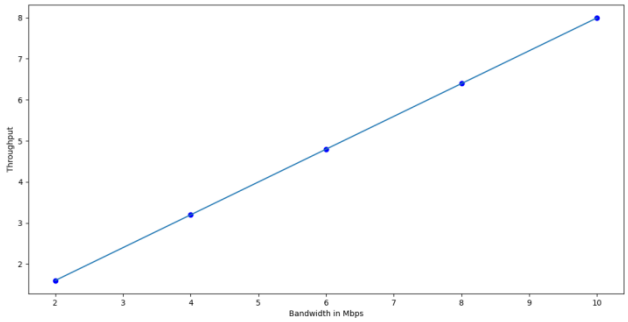

Figure 12 Throughput Vs Bandwidth (Noisy)

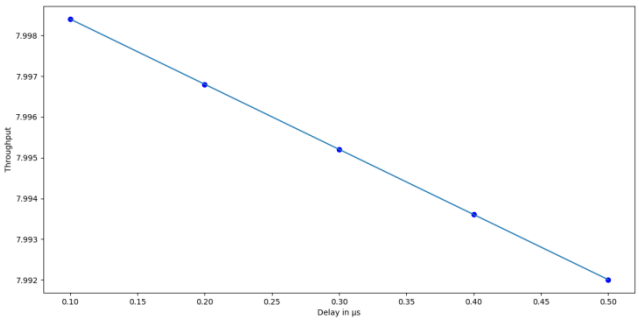

Figure 13 Throughput Vs Delay (Noisy)

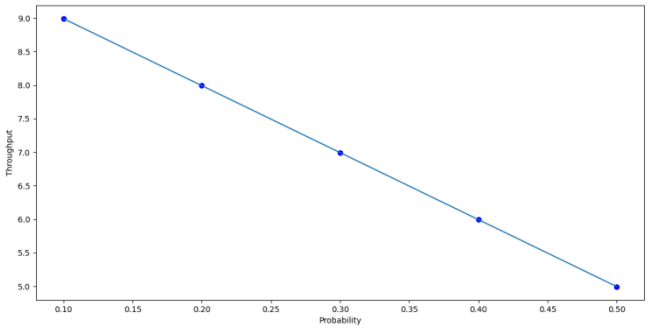

Figure 14 Throughput Vs Probability (Noisy)

Go-Back-N Protocol:
Analysis of Channel Utilization:

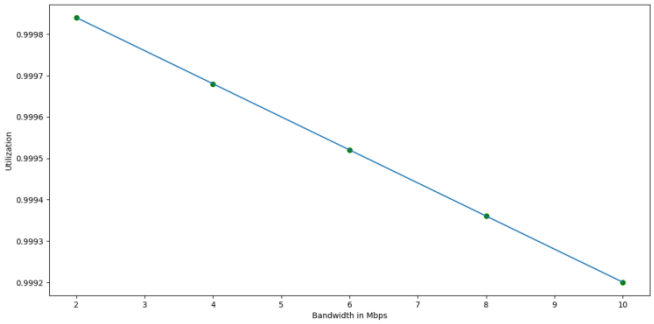

Figure 15 Utilization Vs Bandwidth (Noiseless)

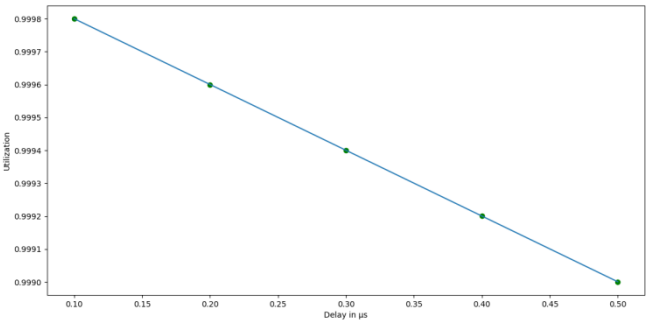

Figure 16 Utilization Vs Delay (Noiseless)

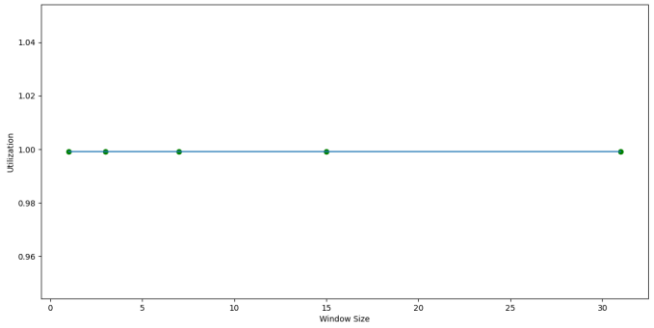

Figure 17 Utilization Vs Window Size (Noiseless)

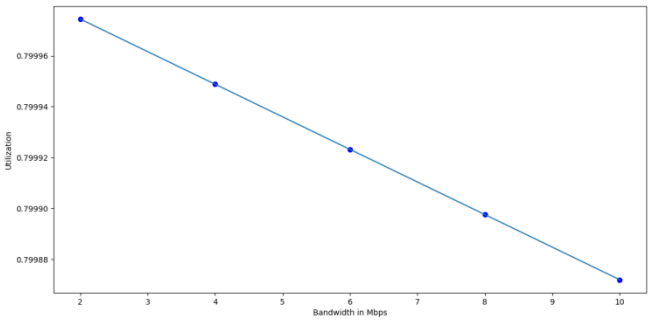

Figure 18 Utilization Vs Bandwidth (Noisy)

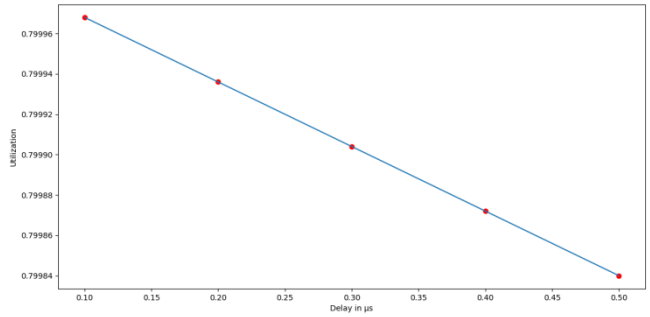

Figure 19 Utilization Vs Delay (Noisy)

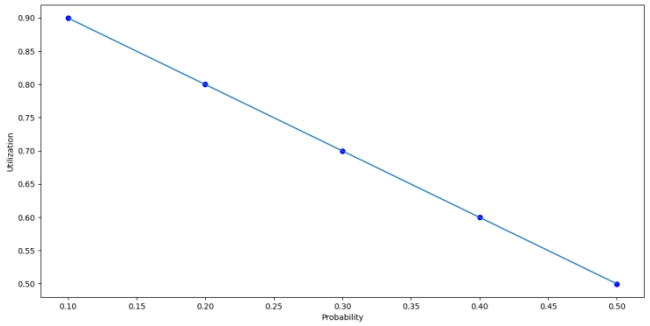

Figure 20 Utilization Vs Probability (Noisy)

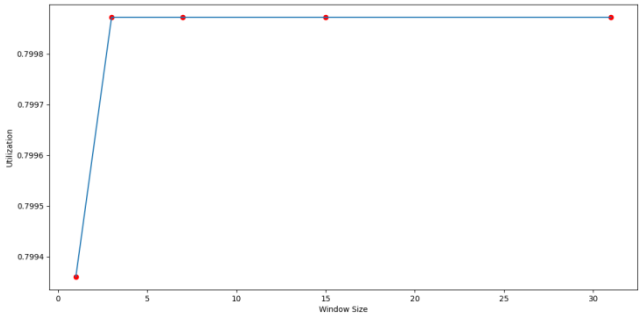

Figure 21 Utilization Vs Window Size (Noisy)

Analysis of Throughput:

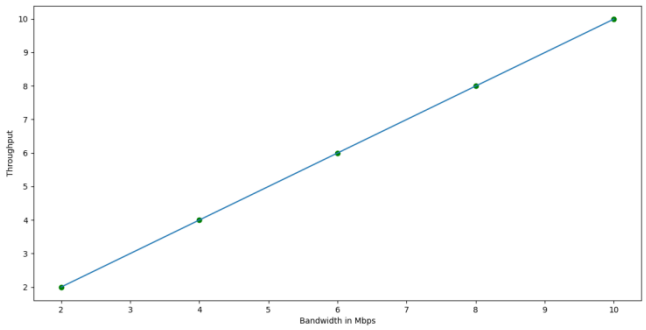

Figure 22 Throughput Vs Bandwidth (Noiseless)

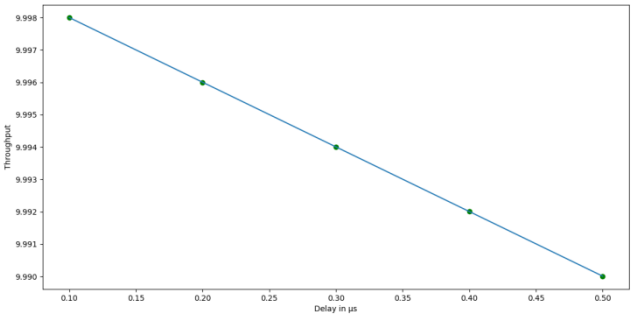

Figure 23 Throughput Vs Delay (Noiseless)

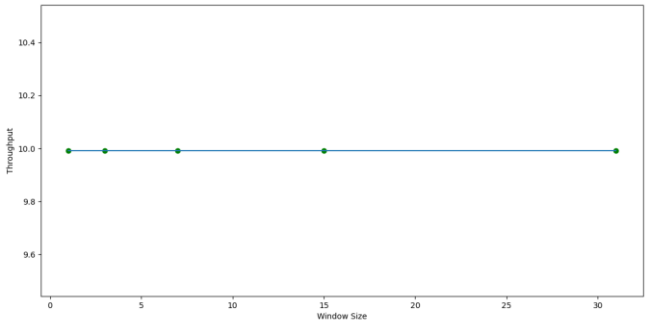

Figure 24 Throughput Vs Window Size (Noiseless)

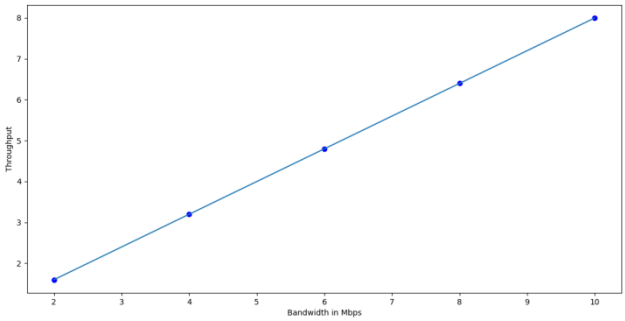

Figure 25 Throughput Vs Bandwidth (Noisy)

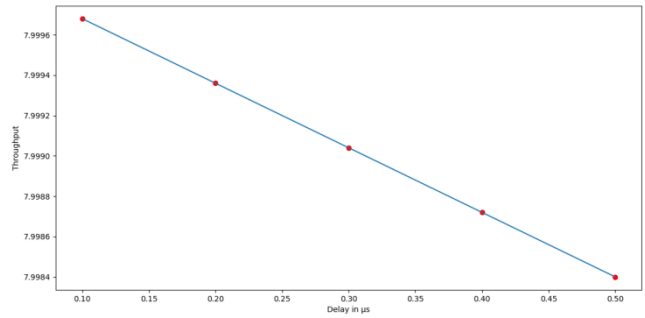

Figure 26 Throughput Vs Delay (Noisy)

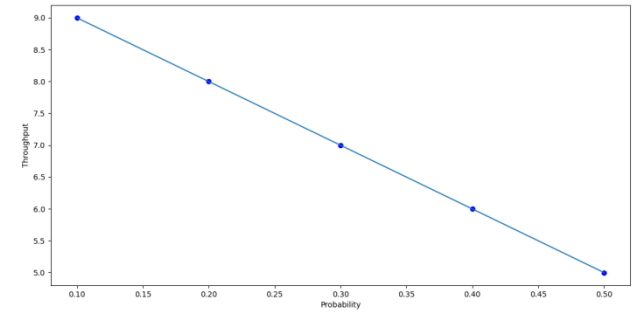

Figure 27 Throughput Vs Probability (Noisy)

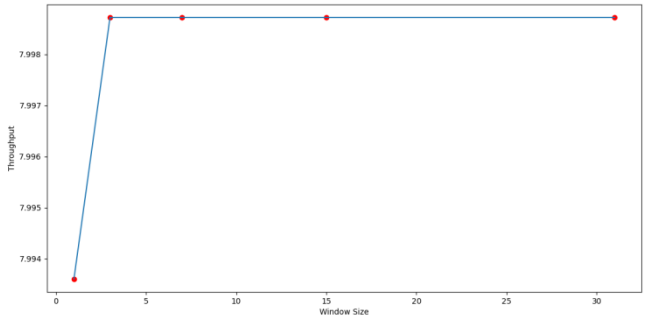

Figure 28 Throughput Vs Window Size (Noisy)

Selective Repeat Protocol:

Analysis of Channel Utilization:

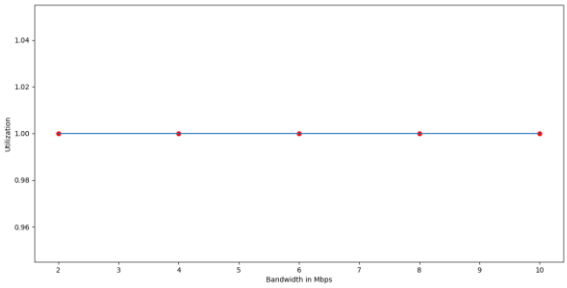

Figure 29 Utilization Vs Bandwidth (Noiseless)

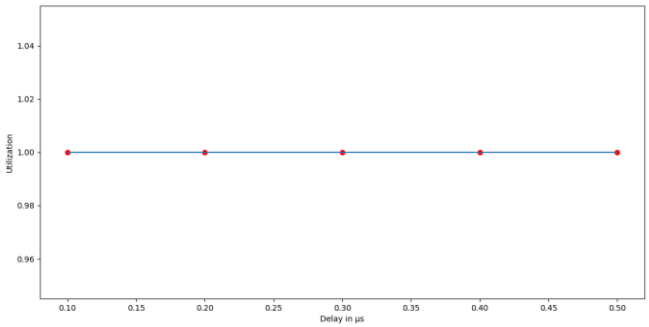

Figure 30 Utilization Vs Delay (Noiseless)

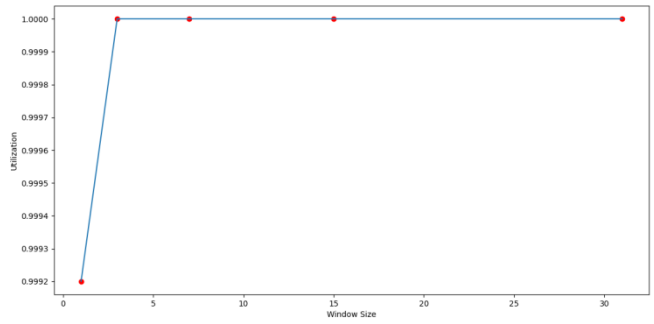

Figure 31 Utilization Vs Window Size (Noiseless)

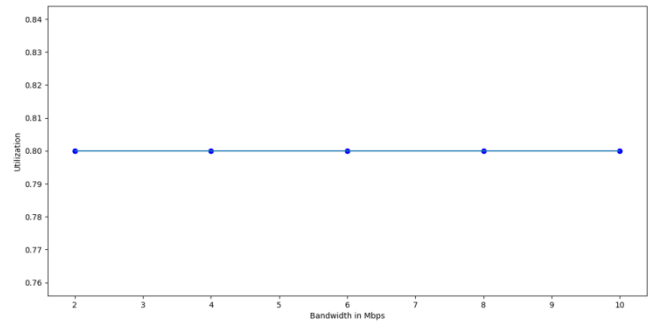

Figure 32 Utilization Vs Bandwidth (Noisy)

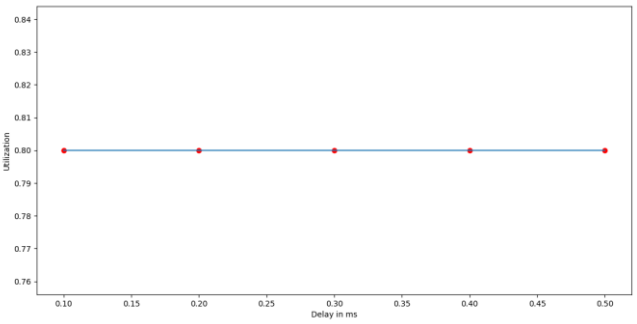

Figure 33 Utilization Vs Bandwidth (Noisy)

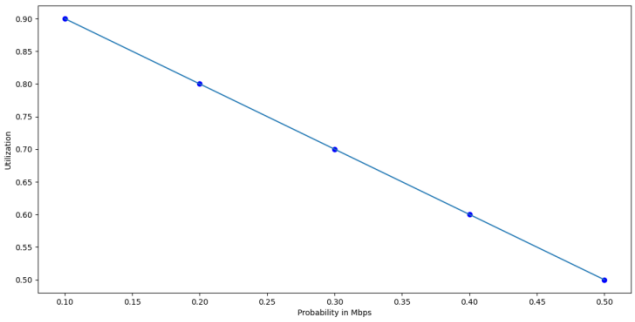

Figure 34 Utilization Vs Probability (Noisy)

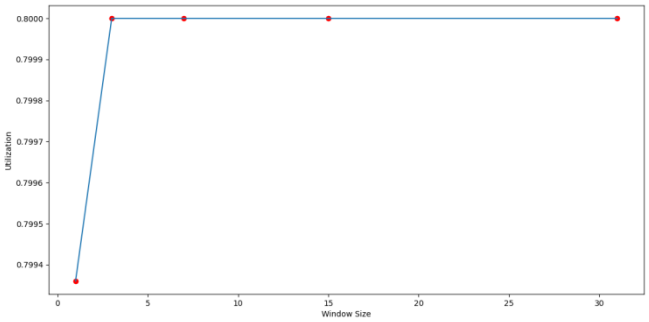

Figure 35 Utilization Vs Window Size (Noisy)

Analysis of Throughput:

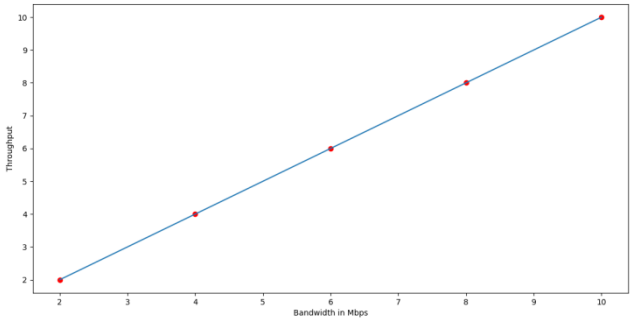

Figure 36 Throughput Vs Bandwidth (Noiseless)

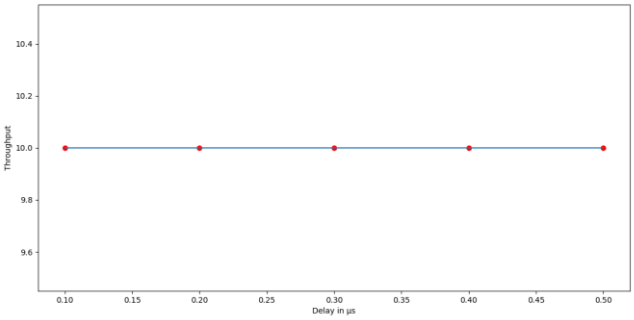

Figure 37 Throughput Vs Delay (Noiseless)

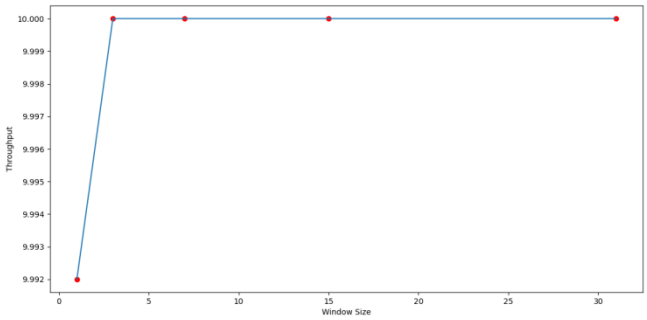

Figure 38 Throughput Vs Window Size (Noiseless)

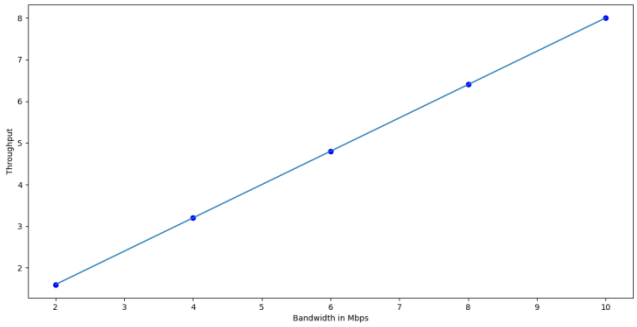

Figure 39 Throughput Vs Bandwidth (Noisy)

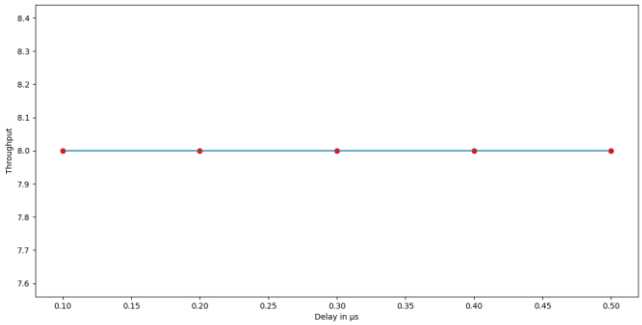

Figure 40 Throughput Vs Delay (Noisy)

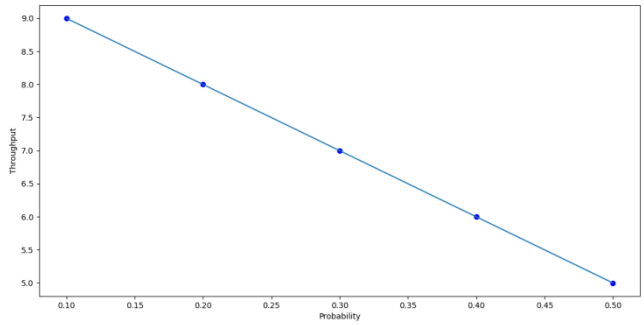

Figure 41 Throughput Vs Probability (Noisy)

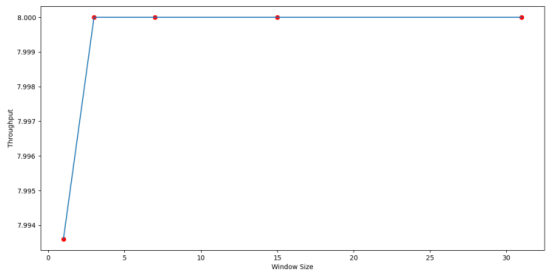

Figure 42 Throughput Vs Window Size (Noisy)

Tabulation:

Factors	**Stop and Wait**	**Go-Back-N**	**Selective Repeat**
Receiver Window Size	1	1	2^n -1
Sender Window Size	**1**	2^n -1	2^n -1
ACK	YES	YES	YES
NAK	NO	NO	YES
Frame Sequence	0,1,0,1,0,1,0…	0…….2^n - 1	0…….2^n - 1
Bandwidth Utilization	Low	Moderate	High

Table 1: Comparision of various ARQ Protocols

V. CONCLUSION

Automatic Repeat ReQuest (ARQ) ensures reliable data transfer over unreliable network layer. ARQ forms the basis for the peer to peer protocol that provides reliable transfer of information. In this paper the three types of protocols are discussed in noiseless and noisy channel.

Selective Repeat is considered to be the efficient of the three ARQ protocols because of the retransmission and high channel utilization. In Selective Repeat, retransmission tends to happen more frequently. Selectively retransmitting the frames is more efficient than retransmitting all of them which is a major drawback of Go-Back-N Protocol. However Go-Back-N is better compared to Stop and Wait Protocol as it takes advantage of Pipelining.

The protocol we choose depends on the environment and many different parameters. One needs to choose a proper protocol based on the requirement and destination. On the whole ARQ ensures reliable Data delivery.

VI. REFERENCES

[1] A Top Down Approack to Computer Networking 7th Edition

[2] International Journal of Engineering Trends and Technology (IJETT) – Volume 18 Number2- Dec 2014 ISSN: 2231-5381 http://www.ijcttjournal.org Page 64 Implementation of Data Link Control Protocols in Wired Network Sudhanshu Maurya#1, Vikas Kumar Nayak*2, Dr. A Nagaraju#3