PERFORMANCE ANALYSIS OF BASIC AUTOMATIC REPEAT REQUEST PROTOCOLS

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Abstract- *The size of network and internet traffic is rising spontaneously by the day, with data usage at zettabyte to petabyte scale at an exponential high rate and therefore considered to generate huge traffic along the way which causes the chance of error in transmission to be high as well. Automatic Repeat Request (ARQ) protocol is an error control function for data transmission that uses acknowledgements. These protocols exist in Data link or Transport layers. ARQ is categorize into three major types such as Stop and wait, Go Bank N and Selective Repeat. Hybrid automatic repeat (HARQ) request which is an advancement to earlier mentioned protocols to detect error via cycle redundancy check was later developed. This paper evaluates the performance of these basic ARQs and HARQ protocols in consideration of the current state of high signal interference and collision during competitive accesses, more especially in highly densely networks.*

Keywords: - *Automatic Repeat Request, Flow Control, Error Control, Protocol, Data Transmission*

INTRODUCTION

Communication is a medium of sharing information or data between two or more devices, devices exchange data via some transmission medium like wired cable, wireless medium etc. Data communication includes five major components which are Sender, Receiver, The Message, Transmission Medium and lastly the Protocol. The Sender transmits to other nodes in the given network, the Receiver receives the transmitted message from the sender, Message is the data being transmitted, Transmission medium is the path in which the message travels across from one node to other, finally Protocol is the set of rules that dictates the rules in which communication takes place between the devices. During the process of data transmission, frames of data might get lost, the process of detecting and correcting this loss is termed as error correction. Automatic repeat request (ARQ) is a technique that ensures an accurate delivery of data despite the occurrence of an error. Today is the era of fast and dynamic internet and communication technologies which make communication readily available and convenient compared to the past. Communication technology, through different channels, such as mobile phones and computers, has become pervasive. In almost every means of telecommunication, retransmission protocols have played a significant role in the protocol stack layers. The primary aim of this study is to compare Automatic Repeat Request protocols and solve the Buffer problem. Automatic Repeat Request (ARQ) Protocols is an efficient approach for improving the data transmission efficiency of wireless communication system [1]. In basic ARQ protocol, same data is retransmitted, and the receiver decode the message based on the received signal in each round. It is important to note that a reliable transport layer protocol such as Transmission Control Protocol (TCP) is needed for successful incorporation of Automatic Repeat Request (ARQ) and wireless data link protocols [4]

This paper will discuss on the four different ARQ schemes such as Stop and wait, Go Back N, Selective Repeat and Hybrid ARQ (H ARQ) in details. Hybrid ARQ can be classified into three categories, HARQ as error packet is detected via the cycle redundancy check, the transmitter will transmit the same packet either until the packet is successfully decoded at the receiver or maximum retransmission unit is reached [2]. The HARQ is regarded as the full incremental redundancy technique [3]. Decrease the coding rate in each retransmission HARQ considered as a partial IR scheme, not only decrements the coding rate but also maintain the self-decoding capability in each retransmission [3]. Therefore, the paper would checkmate the performance of these protocols in order to identify the best they can offer with respect to performance. After an introduction, the paper laid a good foundation on the idea of flow control, followed by error control and then the analysis of automatic repeat request protocols.

MATERIAL AND METHOD

The paper utilizes an extensive review through several online databases such IEEE and Science direct among others. Among the fifty papers initially downloaded, papers were screened through abstract reading and out of which 19 qualified for this review.

LITERATURE REVIEW

Flow Control

This simply means to manage the transmitted data between the sender and receiver. Data is conveyed to the receiver. Once it's received by the receiver an acknowledgement will be sent to the sender, the sender sends the following data. The flow control is liable for adjusting the amount of transmitted data the receiver is limited [4]. The data send is not permitted to overwhelm the receiver. The receiver needs time to check and process the incoming data and store before it can be used. The procedure is too slow compared to the transmission speed, when the receiver buffer memory is about to be fill, the receivers inform the sender to slow down the transmission or even pause.

Transmission Control Protocols

Transmission Control Protocol (TCP) is one of the main protocols in the transport layer in ISO/OSI (International Standards Organization / Open System Interconnection) model. Connection-oriented of TCP protocol TCP is a connection-oriented protocol It establishes a pragmatic path between the source and the destination of data transfer and close the connection [8]. There is a three-way handshake that creates a connection in the first part that opens connection This sends a segment with a random initial sequence number, and SYN Flag is set between send and receive windows. TCP utilizes two windows for each direction of data transfer.

- A Send Window The receiver changes the window size as flow control using congestion control mechanism.

- TCP works by default cumulative acknowledgment by advertising the following expected byte to receive.
- Most TCP implementations are implemented without Selective acknowledgment and only cumulative acknowledgments sent
- In this case, it mimics the GoBack-N ARQ method though with temporary storing of out-of-order segments, it is combined with the behavior of Selective-Repeat ARQ

Error Control

Error control is a mechanism for detecting and correcting errors if a frame gets lost during the transmission process, Error Control is in data link layer. Error control can be error detection or error correction, when data is lost or damaged during transmission error control which will tell the sender to retransmit the detected frames. In reality acknowledgement (ACK) sent to the sender can be lost or damaged [4]. There exist two types of errors, which are frame injury and frame loss, Errors occurs mainly due to network congestion or packet loss, different causes of errors exist in both wireless and wired networks

Automatic Repeat Request Protocols

Automatic repeat request protocols are technique used to guaranteed the transmission of data stream to the user despite the error in the transmission that may occur. ARQ protocols are divided into two main categories, Protocols for Noisy Channel and Protocols for Noiseless Channels, but the most popular among them is in the area of data transmission is the noisy transmission line, in real life scenarios the Noiseless protocols are not available, Noisy channels employs the Flow Control and Error Control Mechanisms. ARQ is been deployed to guaranteed the utmost level of reliability within the single transmission hop. It is also important to note that as communication channel become less noisy, the deployment of ARQ protocols would be at the edges of the network, so that it can gives end-to-end guarantee of packets transmission over different multiple hops in the network and of course over different communication channels and some network equipment. Apart from error detection code, some of the common elements of ARQ are as follows; Information frames (I-frames), which is responsible for transmitting the user packets, timeout mechanism and control frames. Control frames also consist of ACKs for correct acknowledgement, NAKs for negative acknowledgement meaning an error occurs at the course of transmission and that the receiver end is taking some steps and that is prompted by enquiry frames ENQ. Timeout mechanisms are also needed to make some actions in order to maintain the flow of the frames. There are three most common types of ARQ protocols which are Stop-N-Wait, Go-Back-N, and Selective Repeat protocols which the paper would look at one after another. [8, 5]

Figure 1 captured the basic elements of automatic repeat request protocols.

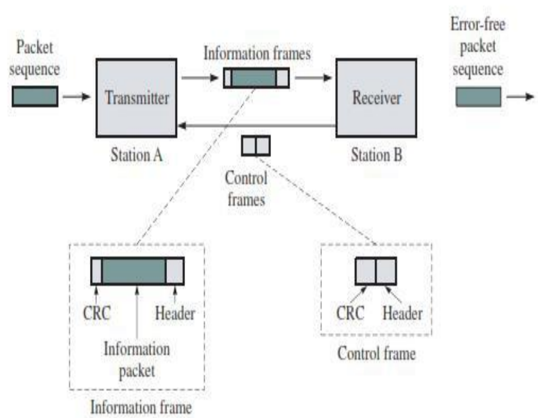
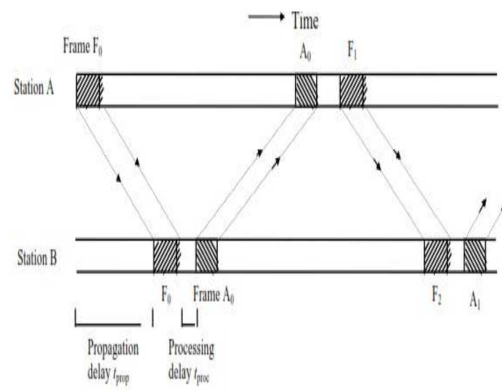


Figure 1: Elements of ARQ [8]

Stop-N-Wait ARQ

This is a very easy protocol in such a way that a sender transmits a frame and then wait for the receiver to acknowledge the received and request for another frame to be send this is by acknowledging the first frame. Although it is very simple but not that efficient, as in the case of WAN links it will be idle for most time more especially when several hops are needed. Another disadvantage of this ARQ protocol is that, only one frame can be send at a time, making it ineffective if the propagation delay is much higher than the transmission delay. It is a one directional flow of data between sender and the receiver and during the error the receiver would be looking for a frame with the sequence number Rnext. The figure below shade more-light on the protocol. [8, 6]



Go-Back-N ARQ

Go-Back-N, builds on the inefficiency of Stop-N- Wait by allowing the flow of frames from the receiver to continuously send frame in order for the transmitter channel to be busy engage while waiting for the acknowledgement. In case of negative acknowledgement while transmitting the frames, the receiver will ignore the frame with the error and all subsequent frames after it and then go back to retransmit from the frame with the error. In Go-Back- N the receiver will be looking for a particular frame with a specific frame sequence number Rnext, and in case of the oldest outstanding frame that is transmitted but not acknowledged frame in Go-Back-N frame with the Slast frame in Stop-N-Wait, from here we can deduce that the right operation of Go-Back-N protocol depend solely on making sure that the last frame is been successfully delivered. The Protocol will prompt- up a retransmission of Slast frame together with the subsequent frames Ws – 1frame any time the send window is exhausted. More so, as long as there is a possibility of error-free frame transmission, then the sudden error-free transmission of Slast frame is guaranteed and the protocol will operate perfectly. The figure below explains the protocol much. [5, 6, 7, 8]

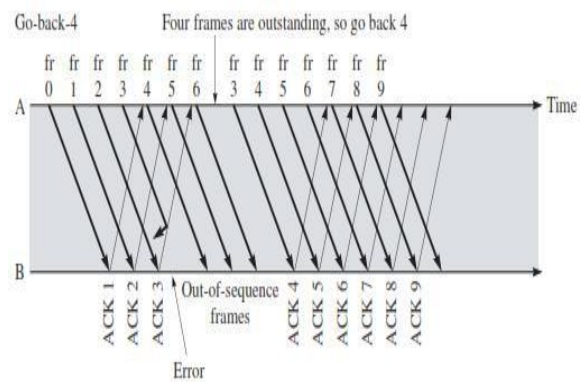


Figure 3 Go-Back-N ARQ [8]

Selective-Repeat ARQ

In any transmission channel that has high number of error frames, Go-Back-N is inefficient due to the need of retransmission of the frame with error and other subsequent frame. So, in order to overcome this challenge, two other features are added to the features of already discussed ARQs. The receive window is made wider than a single frame in order for the receiver to accommodate frames that are out of sequence but free from error. Second feature added is that the retransmission mechanism is also modified in such a way that only frame with error is retransmitted that is why the protocol is termed Selective-Repeat ARQ protocol. The figure below sums it up on the protocol. [7, 8]

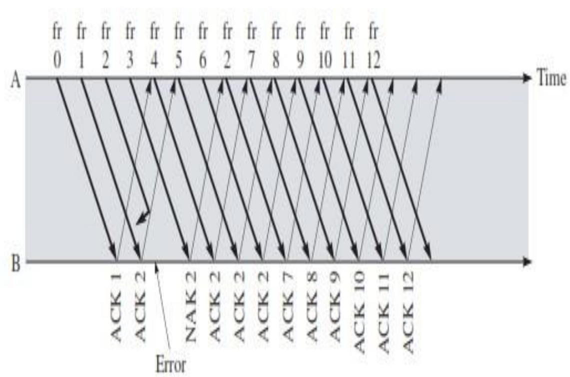
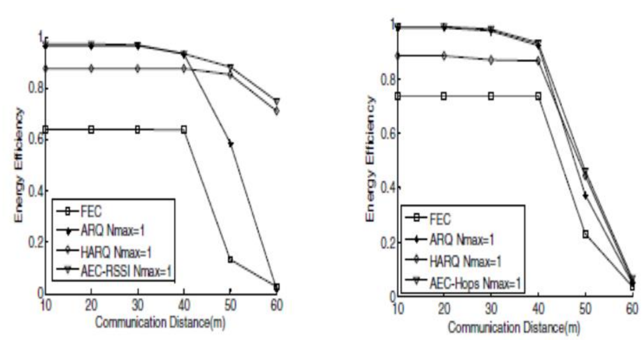


Figure 4 Selective Repeat ARQ [8]

Hybrid ARQ Protocol

Hybrid ARQ protocol is the product of basic ARQ and forward error coding (FEC) at either the transmitter or receiver. There exist various ways of combining retransmission and error coding detection with regards to hybrid ARQ and the most common are "Chase combining", which says that same coded packet is retransmitted and then the receiver add many copies in order to enhance the quality of the decoding. The second way is the "Incremental redundancy" scheme which encode the initial transmission with a very high-rate code (at low overhead with low protection) and the subsequence transmission has additional redundancy so that it will decrease the code rate experienced by the receiver. Hybrid ARQ improve the channel performance of a system despite the fact that it is very difficult to achieve. [5, 9,18]. In [9], the study developed an energy efficient hybrid adaptive error control method FEC, the 'AEC-RSSI' which consists the two data link layers of ARQ and HARQ, when a transmitter receives an NAK data, the said data is used to compute the location of the sending node. Their novel method was compared against ARQ with a constant length data frames for various communication distances, with a maximum retransmission set to 1, results shows that FEC outperforms both ARQ and HARQ when the distance between the nodes is over 40 meters, this can be attributed to the fact FEC has inherent multiple redundancy capacity, which inhibits channel encoding soft combining to retransmit during the link layer frames.



a) Length of link layer frame is 750 bytes. b) Length of link layer frame is 1500bytes.

CONCLUSION

This paper evaluates the efficiency of ARQ protocols and found Stop-N-Wait to be easy to achieve with a lot of time wasting which at the end affect the efficiency of transmission in general. Go-Back-N builds on the inefficiency of stop-n–wait in terms of time wasting but there is need for the receiver terminal to have a complex technology to achieve it. Although Selective-Repeat ARQ protocol proved to be most efficient of all the rest two but it requires an unlimited buffer register which add to the fact that it is very expensive to deploy. Interestingly, Hybrid Automatic Repeat Request (HARQ) is utilized in communication systems for reliable data transmission. As reported by this paper, it is basically a combination of Automatic Repeat Request (ARQ) along with Forward Error Correction (FEC). Hybrid ARQ has proved beyond doubt to be the most outstanding among all in terms of efficiency but with certain constrain to achieve. Based on the finding of this paper, it is recommended to explore more options of combining HARQ with certain standards such IEEE 802.11ax standards for a better connection and increase throughput in a dense network scenario.

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