CSE 589
Modern Networking Concepts
Fall 2020

Programming Assignment 2
Reliable Transport Protocols - Analysis

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1. Academic Integrity

I have read and understood the course academic integrity policy.

2. Timeout Scheme

a. Alternating Bit Protocol

A timeout value of *20* is used in this scheme which is derived from trial and error, experimentation. Initially, I started with 10 and increased to 15. A timer value of 15 gave issues for a higher number of messages and a large window size. Also, considering the time for the packet to reach the other side, i.e., 5 units, I further increased the timeout to 20 which turned out to be an optimal value.

Data Structures and Implementation

For the ABT protocol, I used the *enum* variable States to decide if a sender is waiting for a packet from layer 5 or waiting for an acknowledgment from layer 3 below. This can be useful to track for any timer retransmission scenarios during timeouts in the *A_timerinterrupt* routine. I did not use a stop timer in this case, as I was able to handle all my scenarios using *starttimer* and *timerinterrupt* routines.

b. Go Back N Protocol

A timeout value of 25 is used in this scheme. Initially, I started with the values 15, 20 but the retransmission rate got higher due to early timeouts in advanced test cases thereby increasing the program runtime. The optimal timeout value in GBN protocol is not only dependent on the packet loss probability but also the window size. Thus, the performance was evaluated by varying both these parameters. Hence, I increased the values gradually and selected an optimal value of 25.

Data Structures and Implementation

For GBN protocol I used a message buffer *msg_buffer* (with size 1000) which is different from the buffer mentioned in the next section (to buffer messages from layer 5). The message buffer is specifically used to retransmit all the packets that haven't been acknowledged yet. Unlike ABT protocol I maintain both sequence and acknowledgment numbers at both ends (A & B) to track the oldest unacknowledged packet for retransmission. I used the *stoptimer* method in this protocol to stop the timer whenever all the packets in a particular window frame are acknowledged.

Note: The implementation for this protocol is largely derived from the lecture slides.

c. Selective Repeat Protocol

Unlike ABT and GBN protocols, SR protocol requires the use of multiple timers and the sender has to maintain a timer for each of the unacknowledged packets.

Additionally, multiple logical timers are required to be implemented using this single hardware timer. To implement logical timers, I created a data structure called *buffer* in my code on the sender's side (A) shown below.

```
struct buffer
{
  struct msg *m;
  float time;
  bool acked;
}
```

The structure contains 3 members - the message, the time at which the message arrived from layer 5, an acked variable indicating if the packet has been acknowledged or not. In the *A_init* routine, I start a timer initially and record the corresponding time for the first packet that arrives from layer 5 in the *A_output* routine. If the sender receives an acknowledgment for any packet, the acked field is marked as *true* else every packet will have an acked field marked as *false*. In the *A_timerinterrupt* routine, I check every packet that is not acknowledged. If the packet is not acknowledged and the difference between the *current time* and the time at which the packet arrived from layer 5 is greater than the *Timeout* value, then the packet needs to be retransmitted. In this case, I send the packet again to layer 3 and reset the time member for the buffer structure back to the current time. I did not use a *stoptimer* routine in this protocol as all the cases were handled with the *interrupts* and *starttimer.*

3. Common Routines and Data Structures

a. Make Packet

The *make_packet* method is common across all the protocols that accept the sequence number, acknowledgment number, and data as its input. This method creates the packet and returns to all the required routines to be implemented.

b. Buffer

Buffering is required when we cannot serve a message that comes from layer 5. This happens when the sender might be waiting for an earlier packet acknowledgment from the receiver or the sender's window is full.

To implement the buffer mechanism, I am using a queue data structure (variable name in code: **buffer**) provided by the C++ STL library. This is an optimal data structure as the queue follows the FIFO (first in first out) property. The earliest message in the queue is popped first and sent to the other side B.

c. Checksum

I used a method *checksum()* in all three protocols which calculates the checksum for a given packet. I add the payload, sequence number, and acknowledgment

number components of a packet to calculate the checksum and assign it to the **checksum** field before sending it to the other side. The checksum method is located under *utils.h* header file for ease of use across all the files.

4. Performance Comparison between protocols

a. Experiment 1

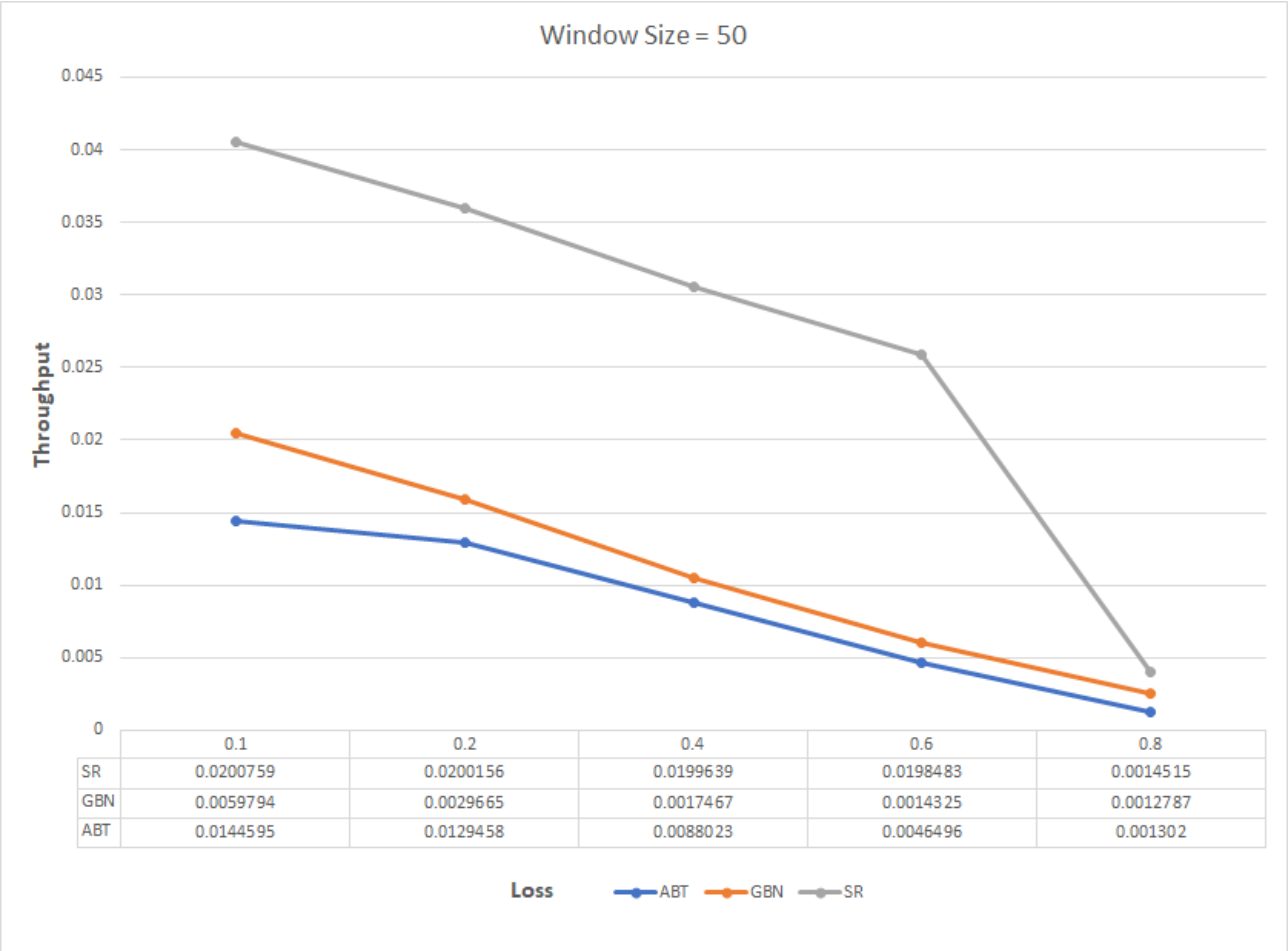
i. Window Size 10

	0.1	0.2	0.4	0.6	0.8
SR	0.0200793	0.0188627	0.0020635	0.0003104	0.0002172
GBN	0.0057271	0.0032912	0.0087609	0.003791	0.0010021
ABT	0.0144595	0.0129458	0.0088023	0.0046496	0.001302

Description: In experiment 1, on the X-axis we have the loss values – 0.1, 0.2, 0.4, 0.6, 0.8 respectively. On the Y-axis we have the throughput values.

Analysis: From the above graph we can see that the throughput of SR protocol is better than GBN and ABT, as loss increases the number of transmissions also increases, which is why we see a close graph line between SR and GBN. When we increase the loss value it reduces to *stop and wait* protocol, hence all the lines in the graph converge at 0.8 loss.

ii. Window Size 50

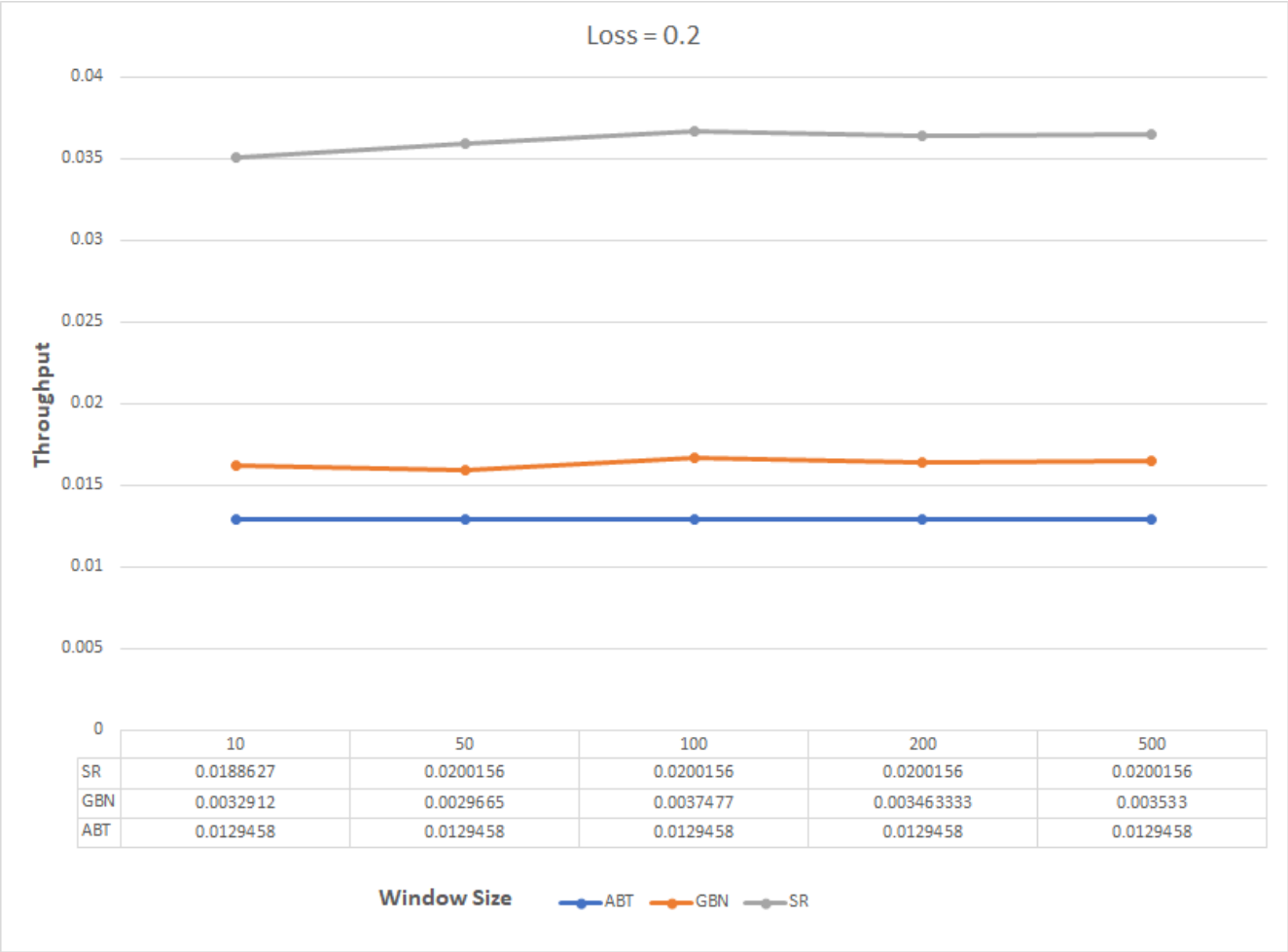


	0.1	0.2	0.4	0.6	0.8
SR	0.0200759	0.0200156	0.0199639	0.0198483	0.0014515
GBN	0.0059794	0.0029665	0.0017467	0.0014325	0.0012787
ABT	0.0144595	0.0129458	0.0088023	0.0046496	0.001302

Analysis: From the above graph we can see that GBN throughput decreases a lot as we increase the loss probability. Also, the window size is 50 and we have to send a lot of packets to B which decreases the throughput. In the case of ABT and SR protocols, the performance does not differ much from window size 10, except that we observe a steep decline in throughput for SR starting from loss probability 0.6. This is due to the high window size and an increase in loss probability value.

b. Experiment 2

i. Loss Probability 0.2

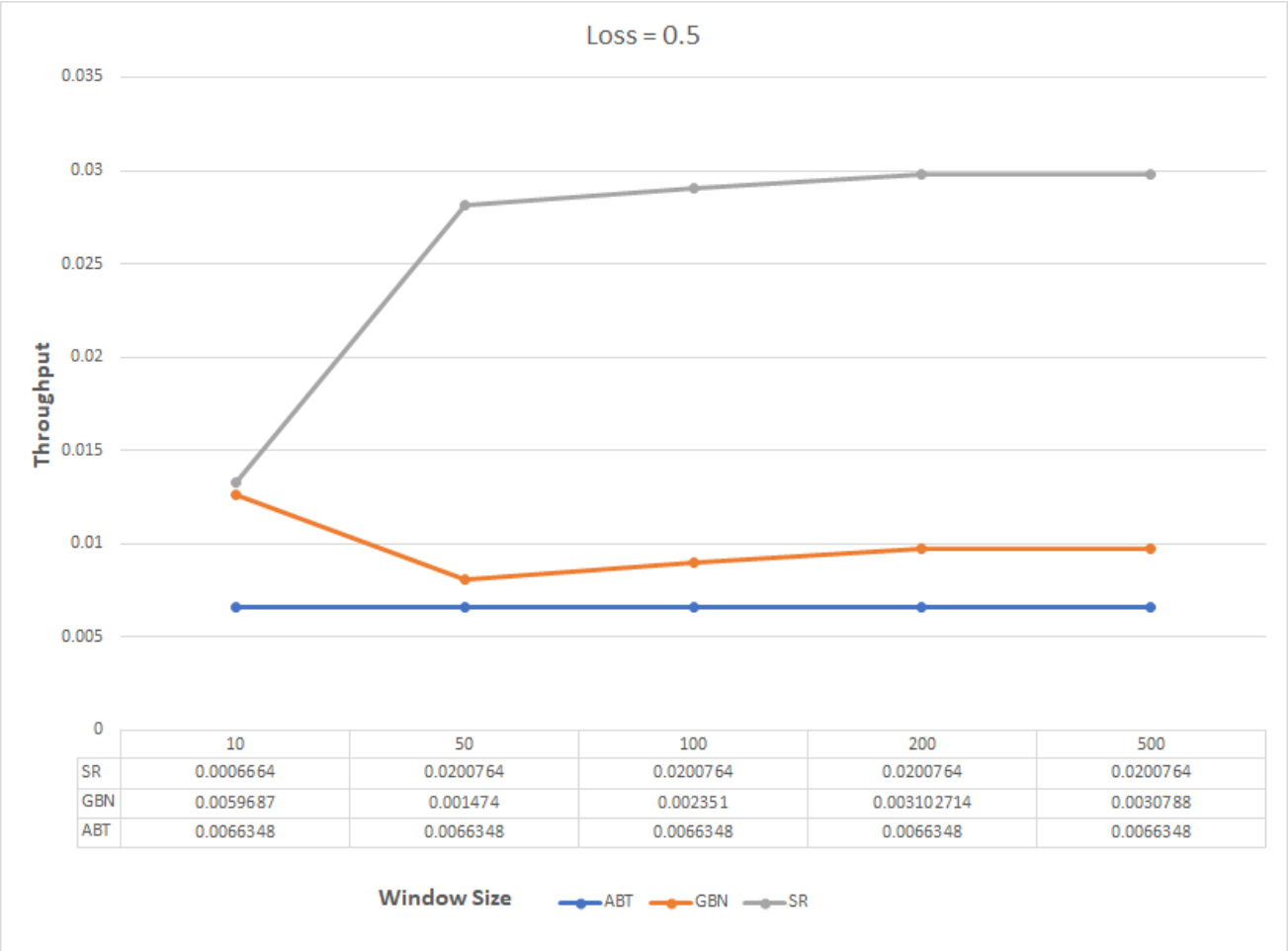


	10	50	100	200	500
SR	0.0188627	0.0200156	0.0200156	0.0200156	0.0200156
GBN	0.0032912	0.0029665	0.0037477	0.003463333	0.003533
ABT	0.0129458	0.0129458	0.0129458	0.0129458	0.0129458

Description: In experiment 2, on the X-axis we have the window size values – 10, 50, 100, 200, 500 respectively. On the Y-axis we have the throughput values.

Analysis: From the above graph we can see that at loss probability 0.2 we have the same variation in throughput for different window sizes for all the protocols. As expected, the SR protocol performs better than GBN and ABT even in this case. Also, we can state that the window sizes at a low rate of loss probability do not affect the throughput much.

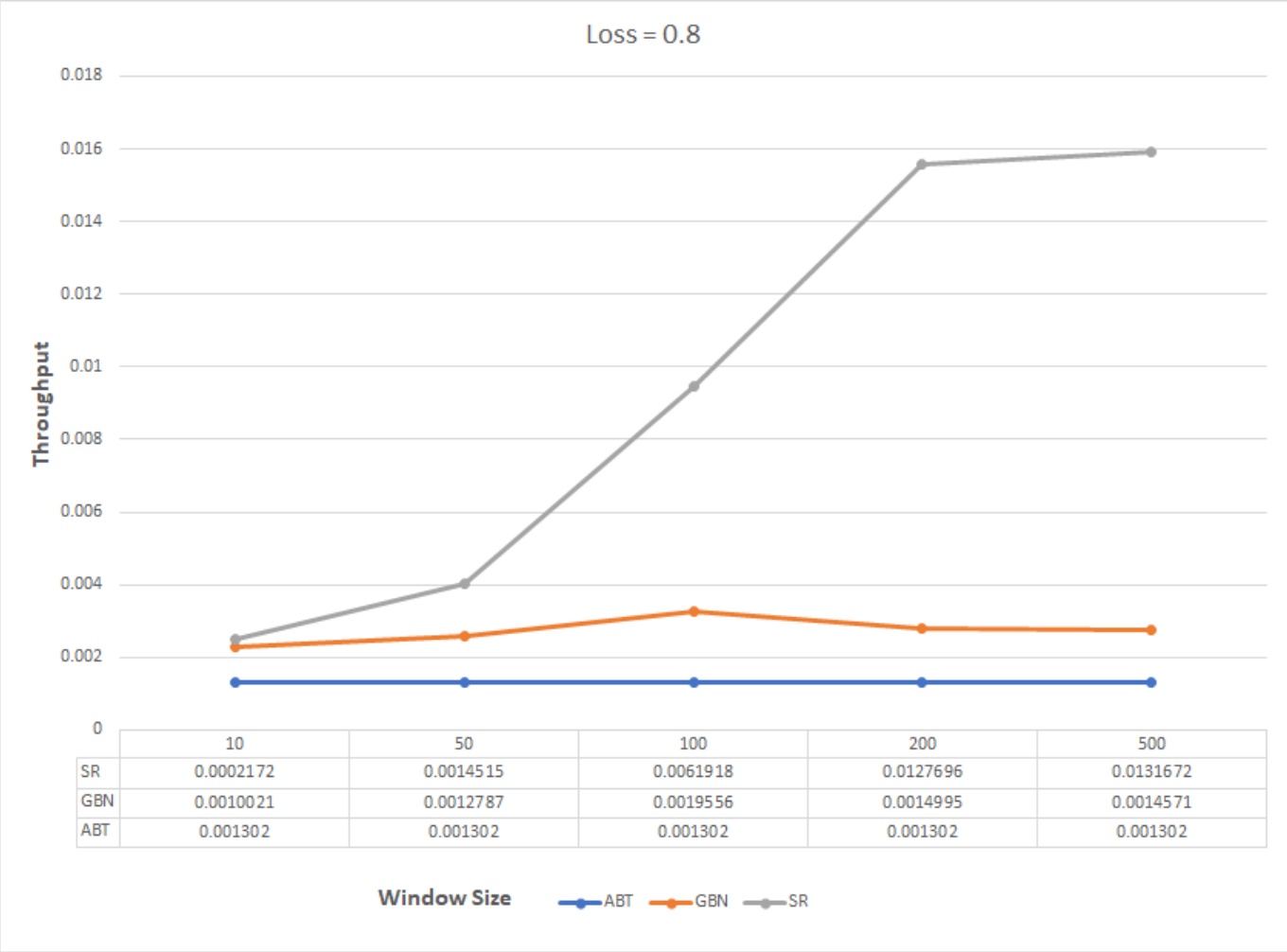
ii. Loss Probability 0.5



	10	50	100	200	500
SR	0.0006664	0.0200764	0.0200764	0.0200764	0.0200764
GBN	0.0059687	0.001474	0.002351	0.003102714	0.0030788
ABT	0.0066348	0.0066348	0.0066348	0.0066348	0.0066348

Analysis: From the above graph can see at loss probability 0.5 we have a slight variation in throughput in the case of SR and GBN for initial window sizes. For larger window sizes the variation in throughput remains the same for all three protocols. Also, we can see due to a large number of retransmissions the throughput of the GBN is decreased compared to the previous loss probability value.

iii. Loss Probability 0.8



	10	50	100	200	500
SR	0.0002172	0.0014515	0.0061918	0.0127696	0.0131672
GBN	0.0010021	0.0012787	0.0019556	0.0014995	0.0014571
ABT	0.001302	0.001302	0.001302	0.001302	0.001302

Analysis: From the above graph we can see at loss probability 0.8 the performance of the GBN protocol decreased a lot due to multiple packet drops and retransmissions. The SR protocol initially due to high probability gives low throughput eventually catches on as we increase the window size. ADT is not varying much from previous loss values.

5. Conclusion

The GBN protocol had a very high number of retransmissions when the window size is large despite the packet loss probability being low. Whereas the window size had little effect on the ratio of retransmissions in the SR protocol. This is largely due to the way of handling retransmission mechanisms in these two protocols.