

LAB 5: Sliding Window Protocols

Introduction:

The goal of this assignment is to:

- Implement the Go-back-N and Selective Repeat protocols for reliable data transfer by translating their FSM descriptions into Python code
- Perform simulations to validate the implementation
- Use simulations to gain insights on how the performance of these protocols varies with various parameters.

Submission Instructions:

- This is an **individual** assignment. You may discuss concepts with other students, but sharing of code or reports with others is not permissible. Any form of copying or collusion will be treated strictly as a plagiarism case and reported to the Institute's disciplinary committee, with grade penalties levied on **all** students involved.
- This is a **take-home** assignment. The final report and code for all the questions have to be submitted on Google classrooms. Your final submission should consist of the following files, uploaded on Google classroom:
 - A typeset report in pdf format. The file should be named **<ROLL NUM>.pdf**, for example "18000123.pdf". The quality of the report carries significant weightage. Your report should be complete, correct, clear and concise. In the report, you can paste images/screenshots/plots where appropriate.
 - A Python file named **Protocol_SR.py** containing your implementation of the Selective Repeat protocol as asked in question 2. The code should contain comments where appropriate to explain your logic. Do not include any other files in your submission (such as the template files provided by the instructor). Your implementation of the protocols must adhere to the interface provided in the template. It should be possible for anyone to run the simulation with the existing template, by only adding your protocol files to the existing template folder and changing the name in the "import <protocol-file>" line in the testbench.

Go-Back-N Protocol

1. **[10 marks]** You are provided with a Template that consists of Python code for simulating the Go-Back-N Protocol. Go through the code carefully and try to understand the behavior of each block in the Template.
 - a) Check if the implementation of the `rdt_Sender` and `rdt_Receiver` classes matches the *Finite State Machine* (FSM) description given in the textbook¹.
 - b) List at-least one major difference you observe between the Python implementation for the rdt sender/receiver classes and the FSM description in the textbook.
 - c) Simulate the system by running the command

```
$ python3 Testbench.py
```

Check if the simulation runs without any errors for the case where P_c (probability of packet corruption) and P_l (probability of packet loss) are non zero for both the DATA and ACK channels.
2. **[10 marks]** Assuming the parameter values for the DATA channel and the ACK channel are identical, set the parameter values (in file `Testbench.py`) as follows:
 - $P_c=0.2$, $P_l=0.2$, channel propagation delay = 2 seconds
 - Packet_length for DATA packets = 1000 bits, packet length for ACK packets = 10 bits
 - Transmission rate = 1000 bits per second
 - Window size(N)=10, Range of sequence numbers(K)=16

Modify the file `Testbench.py` so that a single simulation is run exactly until the receiving application receives the first 1000 messages.

 - a) Report the time at which the receiving application receives the first 1000 messages, averaged across five such simulation runs.
 - b) Measure and report channel utilization on the sender side (for the DATA channel) averaged across five simulation runs.
 - c) Measure and report (across five simulation runs) the fraction of the packets sent by the `rdt_Sender` that are simply retransmissions of previously sent packets.

1 Section 3.4 in Computer Networking: A Top-down Approach, by Kurose and Ross (6th or 7th Edition)

3. **[10 marks]** We wish to study the effect of channel parameters (such as P_c and P_l) and the protocol parameters (such as the Window size N) on the performance of this protocol. It is reasonable to believe that as P_c and P_l increase, more and more re-transmissions will occur that will increase the channel utilization.

Answer the following questions keeping all parameter values the same as those listed in question 2 (changing *only* those parameter values as asked) and assuming that the parameter values for the DATA and ACK channels are identical.

- a) Let T be the simulation time at which the receiving application receives the first 1000 messages. Draw a plot to show how T varies with P_l (as P_l ranges from 0.1 to 0.9).
- b) Let x be the percentage of packets sent by the `rdt_sender` that are just retransmissions of previously sent packets. Draw a plot to show how x varies with P_l (as P_l ranges from 0.1 to 0.9, for a simulation performed until the receiving application receives the first 1000 messages).
- c) Let U be the channel utilization on the sender-side. Draw a plot to show how U varies with P_l (as P_l ranges from 0.1 to 0.9, for a simulation performed until the receiving application receives the first 1000 messages).

4. **[10 marks]** As an engineer, suppose you are tasked with deploying such a protocol in a real world scenario where P_c/P_l values for the channel have been estimated beforehand. The following information is known:

Channel transmission rate is 1000 bits per second, $P_c=0.5$, $P_l=0.5$, propagation delay = 2, Packet_length for DATA packets = 1000 bits, packet length for ACK packets = 10 bits.

You need to tune your protocol parameters (Window size N , K and `timeout_value`) for achieving the best performance.

- a) How would you define/quantify “best performance” in this case?
- b) What would happen if the window size N is too small or too large? What limits its value?
- c) List the values for N , K and `timeout` that you would choose for achieving the best performance, and explain your reasoning behind this choice.

Selective Repeat Protocol

5. **[10 marks]** Describe the Sender-side and Receiver-side logic for the Selective Repeat protocol as a Finite State Machine (in a format similar to the FSM description of the Go-Back-N protocol).
6. **[10 marks]** Keeping the rest of the template as it is, modify only the `rdt_Sender` and `rdt_Receiver` classes to implement the Selective Repeat Protocol, and save this as file `Protocol_SR.py`.
Debug and validate your implementation by running a long enough simulation (say, until the receiving application receives 1000 messages). Your simulation should run with no errors for each of the following cases:
 - a) $P_l=0$, $P_c=0$ for both DATA and ACK channels
 - b) $P_l=0$, $P_c=0.5$ for both DATA and ACK channels
 - c) $P_l=0.5$, $P_c=0.5$ for both DATA and ACK channels
 - d) Various values of the Window size N in the sender and the receiver.**Submit the file `Protocol_SR.py`** and paste a screenshot or partial simulation log for one of the simulations.
7. **[10 marks]** For the same values of channel parameters (p_c , p_l , transmission rates etc), does the SR protocol show a better performance as compared to the GBN protocol? Describe your observations.
8. **[10 marks]** For the SR protocol to work correctly, the value of K (representing the range of sequence numbers) must be at-least twice as large as N (the Window size). That is, $N \leq K/2$. Try setting $N=K$ and check if you get any errors during simulation. Explain why setting $N \leq K/2$ would avoid these errors.