Course Project
Data Link Layer Protocols Simulation

In this project, you will develop, simulate, and test data link layer protocols between two nodes that are connected with a noisy channel, where the transmission is not error-free, packets may get corrupted, duplicated, delayed, or lost, and the buffers are of limited sizes.
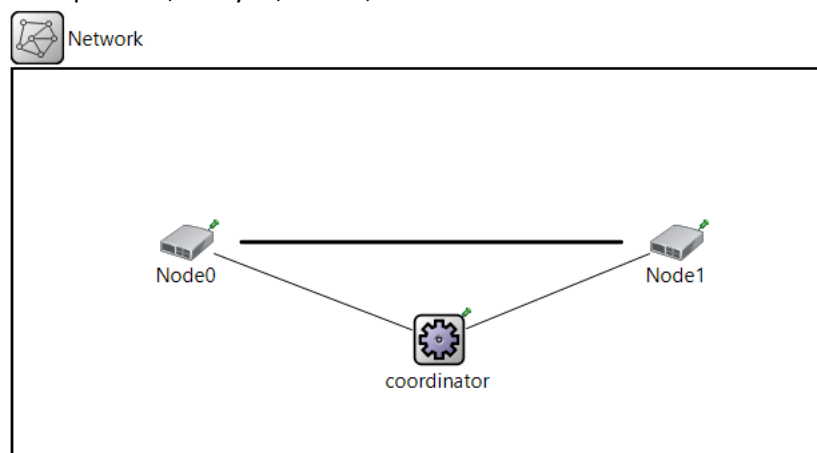

Figure 1: The design of the system's network

The system network topology is shown in figure1. It consists of one pair of nodes [Node0, Node1], and one coordinator that is connected to the pair.

In this project, the pair of nodes would communicate and exchange messages using the **Go Back N** algorithm with noisy channel and sender window of size WS, receiver window of size WR=1, using **Byte Stuffing** as a framing algorithm, and **Parity Byte** as an error detection algorithm.

System inputs

1. Each node has a list of messages to send, and each node reads its list of messages from a different input text file; i.e. 'input0.txt' for Node0 and 'input1.txt' for Node1.
2. Each message starts in a new line, and there is a 4-bits binary prefix before each message. These 4-bits represent the possibility of [*Modification, Loss, Duplication, Delay*] that would affect this message (in order). For example, "1010 Data Link" means that the message "Data Link" will have a modification to one of its bits while sending and will be sent twice. Figure2 includes an example of the input file.

```
input0.txt - Notepad                                    —    □    ×
File  Edit  Format  View  Help
1010 A flower, sometimes
0000 known as a bloom or blossom in flowering plants
0100 is the reproductive$ structure found  also called/ angiosperms$).
0000 (plants of the division Magnoliophyta,  is to facilitate reproduction,
0001 The biological function of $/a flower
0100 usually by providing a mechanism for Flowers may facilitate outcrossing$
0000 $$the union of sperm with eggs.

                                  Ln 6, Col 3      100%   Windows (CRLF)   UTF-8
```

Figure 2: Example of the input file

3. Table 1 contains the details of the errors and their priorities:

Error code [*Modification, Loss, Duplication, Delay*]	Effect
0000	No error
0001	Delay For example, using the default delays (listed below in the section "Delays in the system"): @t=0 read line @t=0.5 end processing time @t=5.5 the message is received.
0010	Duplication For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=1.5 version 1 of the message is received. @t=1.6 version 2 of the message is received.
0011	Make two versions of the message and add to theirsending time the delay error. For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=5.5 version 1 of the message is received. @t=5.6 version 2 of the message is received.
0100	Loss For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
0101	Loss and Delay For example, using the default delays:

	@t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
0110	Loss of both messages (original and duplicate) For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
0111	Loss of both messages (original and duplicate) For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
1000	Modification For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=1.5 the modified message is received.
1001	Modification and delay For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=5.5 the modified message is received.
1010	Modification and Duplication For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=1.5 version 1 of the modified message is received. @t=1.6 version 2 of the modified message is received.
1011	Modification, Duplication and Delay For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=5.5 version 1 of the modified message is received. @t=5.6 version 2 of the modified message is received.
1100	Modification and Loss For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
1101	Modification, Loss and Delay For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
1110	Modification and Loss for both messages For example, using the default delays:

	@t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)
1111	Modification, Delay and Loss for both messages For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line. (the message is already lost)

Table 1: Error codes and their meanings

4. The coordinator starts working in the initialization stage, its main job is to choose which node of the pair should start, and when to start in seconds. The coordinator gets this information from an input file "coordinator.txt".
It will contain one line contains ["*Node_id" "starting_time"*] for the starting node, and *Node_id=[0,1]*.

After the coordinator sends the initialization messages, the starting node should start reading its messages from its file at the **specified starting time**, and the receiver will respond back as will be described later. The messages between the peers don't pass through the coordinator.

Although at any session, only one file containing the messages is read and the other will not be used, we keep both files in case the coordinator chooses any one of the nodes to start freely in later sessions or runs of the program.

5. Parameters that are set in the .ini file:
   ● The sender window of size **WS**, by default=5
   ● The timeout interval **TO** in seconds for the Go Back N protocol, by default=10
   ● The sender's and receivers' processing time **PT** for each frame, by default=0.5

   ● The channel's transmission delay **TD** for any frame, by default=1.0

   ● The channel's error delay **ED** for any frame, by default=4.0

   ● The channel's duplication delay **DD** before sending the second version, by default=0.1

   ● ACK/NACK frame loss probability **LP**, by default =10%.

Delays in the system

We have several delays in the system as follows.

1. Processing delay, this happens at both pairs for any frame to be sent, and it takes a delay = **PT** as set from the .ini file.
2. Transmission delay, this happens at both ways of the channel while sending any frame, andit takes a delay = **TD** as set from the .ini file.
3. Error delay, this happens if an error delay is introduced to any frame, and it takes a delay = **ED,** as a result, the frame will have a total sending delay = **TD + ED**. This is also set fromthe .ini file.
Note that the delayed message can cause out-of-order delivery of messages. I.e., delayed messages don't lock the sender and prevent him from sending the next frame on time. The delay happens in the transmission channel and should not stop the sender from continuing.

4. Duplication Delay **DD** for any Duplicated message, the first version is sent as usual using the **PT,** and then, the second version is sent after the **DD,** not **PT**.

System outputs

- The system should print one log file named [output.txt], containing the details for each message transmission from both nodes using the following format:

1.	Upon reading each line in the sender, print the following:
	At time [.. starting processing time…..], Node[id] , Introducing channel error with code =[…code in 4 bits…] .
2.	Before transmission of any data frame, print the following (even if the message will be lost later):
	At time [.. starting sending time after processing…..], Node[id] [sent/received] frame with seq_num=[..] and payload=[….. in characters after modification…..] and trailer=[…….in bits…..] , Modified [-1 for no modification, otherwise the modified bit number] , Lost [Yes/No], Duplicate [0 for none, 1 for the first version, 2 for the second version], Delay [0 for no delay , otherwise the error delay interval].
3.	For any time-out event:
	Time out event at time [.. timer off-time…..], at Node[id] for frame with seq_num=[..] *Then, upon sending all the messages in the sender window again, print a log line for each message as indicated in 2. above.*
4.	For any control frame sending:
	At time[.. starting sending time after processing…..], Node[id] Sending [ACK/NACK] with number […] , loss [Yes/No]

- Print the details for each message transmission from both nodes to the simulation console. "I.e., the same upper messages in the log file".

Messages

Every message contains the following fields:

- Header: the data sequence number.
- Payload: the message contents after byte stuffing (in characters).
- Trailer: the parity byte.
- Frame type: Data=2/ACK=1 /NACK=0.
- ACK/NACK number.

You can choose the data types as you like, but when printing, use the format described in the table above in the "System outputs" section.

Framing
- Is done using the byte stuffing algorithm with starting and ending bytes.
- The flag byte is '$' and the escape character is '/'.
- The framing is applied to the message payload only.
- There is no specific maximum transmission size for the frame, each message is represented with one line in the input file.
- The receiver should get the original payload upon receiving the message. [de-frame] and print it.

Error detection
- This is done using the even parity byte algorithm as in lab 3.
- The parity byte checks for the payload after applying the byte stuffing.
- The parity byte is added to the message trailer field.
- The receiver uses the parity byte to detect if there is/isn't any single-bit error during the transmission and so decides to send ACK/NACK.
- The ACK/NACK number is set as the sequence number of the expected frame. So, if frame 0 is received send ACK 0 or NACK 0 (ACK if no error, NACK if error detected).
- **Note**: NACK is sent only in cases of erroneous frames.

The Go Back N protocol
- Implement the Go Back N protocol taking into consideration the time-out and the windowsize with the noisy channel.
- The coordinator reads the initialization from the 'coordinator.txt' file and sends the information to the pair.
- The starting node reads the input file and starts sending at the specific given time, and takes into account the four types of errors. It will send the frames within its sending windowsize WS with PT between frames as its processing speed.
- For simplicity reasons, we will **not** implement piggybacking in this project, i.e., the sender sends data and the receiver responds with a control frame; "ACK" if no error and with "NACK" ifthere is an error.
- Each message data/control is given an id according to the Go Back N protocol and starts from zero and up to the window size and not to infinity.
- The receiver always responds to any received packet with a control message (and no payload) with a loss probability (**LP**) as set in the .ini file.
- The session ends when the sender node finishes sending all the messages in its input file.
- There is a timer on the sender side, when the timer goes off, all the messages in the sender's window will be transmitted again as usual with the normal calculations for errors and delays except for the first frame which is the cause for the timeout, it will be sent error-free.
- There are no accumulative ACKs in this project, send a separate ACK/NACK for every frame.
- If any detail is missing from the project document about the protocol, you should use the algorithm given in the lecture as your reference.
- You can use the following animation for more visualization about the Go-Back-N algorithm.
- print the log file at the end of the session.

Delivery and Discussion time: **week 13**

Number of team members: Minimum of 3, Maximum of **4 students**