Term 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.

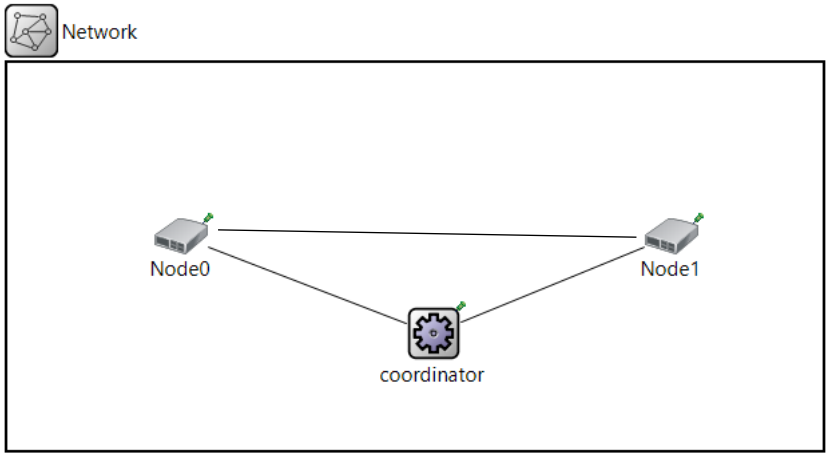

Figure 1: The design of the system's network

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 **Selective Repeat** algorithm with noisy channel and sender and receiver windows of size WS, using **Byte Stuffing** as a framing algorithm, and **CRC** 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; namely '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. 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.

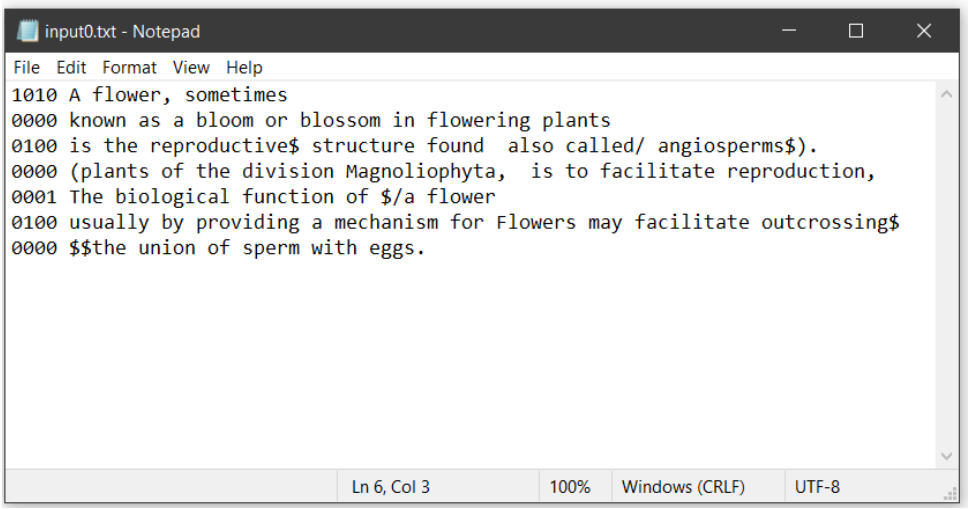

Figure 2: Example of the input file

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 their sending 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.
0101	Loss For example, using the default delays:

	@t=0 read line @t=0.5 end processing time @t=0.5 read the next line.
0110	Loss of the 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.
0111	Loss of 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.
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 and 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	Loss For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line.
1101	Loss For example, using the default delays: @t=0 read line @t=0.5 end processing time @t=0.5 read the next line.
1110	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.
1111	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.

Table 1: Error codes and their meanings

4. The coordinator starts working in the initialization stage, its main job is to assign 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 on the **specified starting time**, and the receiver will respond back as will be described later. The messages between the peer 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 would choose 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 and receiver window of size **WS**, by default=4
   - The maximum sequence number **SN**, by default= 7
   - The timeout interval **TO** in seconds for the Selective Repeat 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 =0% but can be increased in the discussion.

Delays in the system

We have several delays in the system as follows.

1. Processing delay, and 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, and this happens at both ways of the channel while sending any frame, and it takes a delay = **TD** as set from the .ini file.
3. Error delay, and this happens at if an error delay to be 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 from the .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 send 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** after the first version not just **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] 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]
5.	After receiving correct data in sequence and after de-framing it:
	Uploading payload=[…..] and seq_num =[…] to the network layer

- 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 CRC algorithm.
- The CRC checks for the payload after applying the byte stuffing.
- The CRC is added to the message trailer field.
- The receiver uses the CRC 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 are set as the sequence number of the next correct expected frame.
- NACKs are sent for errored but **in order** messages only.

The Selective Repeat protocol

- Implement the Selective Repeat protocol taking into consideration the time-out and the window size with the noisy channel. Where the max seq number = the windows size
    - 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 window size WS with PT between frames as its processing speed.
    - We will not implement piggybacking in this project, i.e., the sender sends data and receiver responds with control frame; “ACK” if no error and with “NACK” if there is an error, or keep silent.
    - Each message data/control is given an id according to the Selective Repeat protocol and starts from zero and up to the window size and not to infinity.
    - The receiver responds for received packets with control messages only (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 in the sender side, when the timer goes off, the causing message in the sender’s window will be transmitted again, but this time it will be sent error free.
    - After the timeout event, the sender will have to send the message again, taking into account the processing time before the frame.
    - There is accumulative ACKs in this project, also normal ACK/NACKs should be implemented.
    - When we receive a NACK or time out on a certain frame

    a. the sender will stop his normal sequence,
    b. and start by sending the errored message again “error free this time”
    c. the causing message is sent after the processing time +0.001 (to break any possible ties).
    d. and then the following messages proceed as normal.
- 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 Selective Repeat algorithm.
- print the log file at the end of the session.
- At the end of the transmission session, print the number of frames (accepted and uploaded to the network layer) and print the last time a frame is accepted to the network layer.

Delivery and Discussion time: Sunday of week 13

Number of team members: Maximum of four