CSE 123 Discussion 2

10/09/2018

Sliding Window Protocol

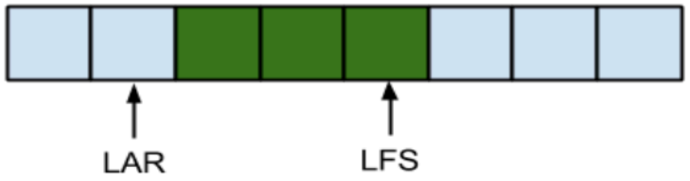
Common.h

- You can add your own data structures here.
- struct Sender_t
  - SWS – Sliding window size
  - LAR (Last Acknowledgement Received) - Sequence number of last acknowledgement received, defines lower bound of the sender window
  - LFS (Last Frame Sent)- Sequence number of the last frame sent, defines upper bound of the window
  - Window is from [LAR+1, LFS], that is all frames that have been sent but not yet Acked.

Frame Sequence Number in Window

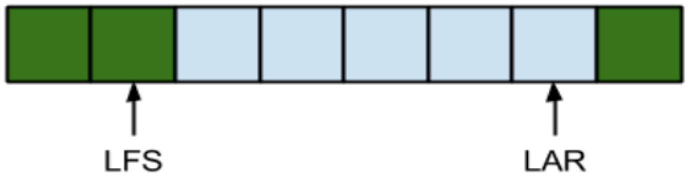
CASE 1: Usual Case
LAR <= LFS

LAR <= LFS && seqNo > LAR && seqNo <= LFS



CASE 2: Sequence Number Wrap Around
LAR > LFS

LAR > LFS && (seqNo > LAR || seqNo <= LFS)



In this case, we are not using the full window of 4.

Sender with SWS = 4, sequence number in [0,7]

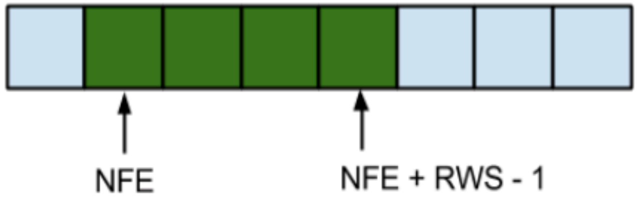
Receiver_t

- RWS - Max receive window size
- NFE - Next Frame Expected
- LFR - Sequence number of largest consecutive frame received
- LAF - Sequence number of largest acceptable frame
- LFR = NFE - 1
- LAF = NFE + RWS - 1

Frame Sequence Number in Window

CASE 1: Usual Case
NFE + RWS - 1 >= NFE

NFE + RWS - 1 >= NFE && seqNo >= NFE && seqNo <= NFE + RWS - 1

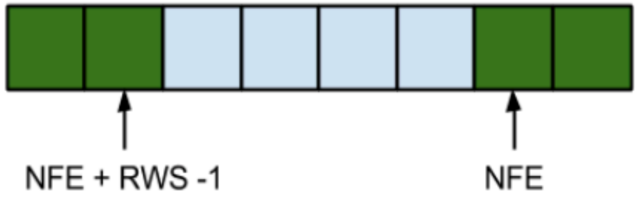


Remember NFE is just LFR + 1 and LAF is just NFE + RWS - 1.

Green sequence numbers are in window and grey are outside.

CASE 2: Sequence Number Wrap Around
NFE + RWS - 1 < NFE

NFE + RWS - 1 < NFE && (seqNo >= NFE || seqNo <= NFE + RWS - 1)



Receiver with RWS = 4, sequence number in [0,7]

Frame Not in Window On Receiver

- Send ACK with number NFE – 1
  - This tells the sender that receiver has successfully received all frames up to NFE – 1 = LFR
- Will happen when ACK is lost and needs to be re-sent

Circular Sender/Receiver Window

- Implement send and receive queue as circular array or list
- Index in to sender’s send queue using sequence number % SWS
- Index in to receiver’s receive queue using sequence number % RWS
- Take the codes from P&D as reference

Sequence Number Wrap Around

- You should NOT use more than 8 bits (unsigned char) for seq/ack numbers.
- You need to handle sequence number wrap around once the value reaches 255. Your seq/ack number should wrap back to 0.
- How to do this?
- Answer: % modulus

Homework Discussion

Due on 10/12 Friday in class

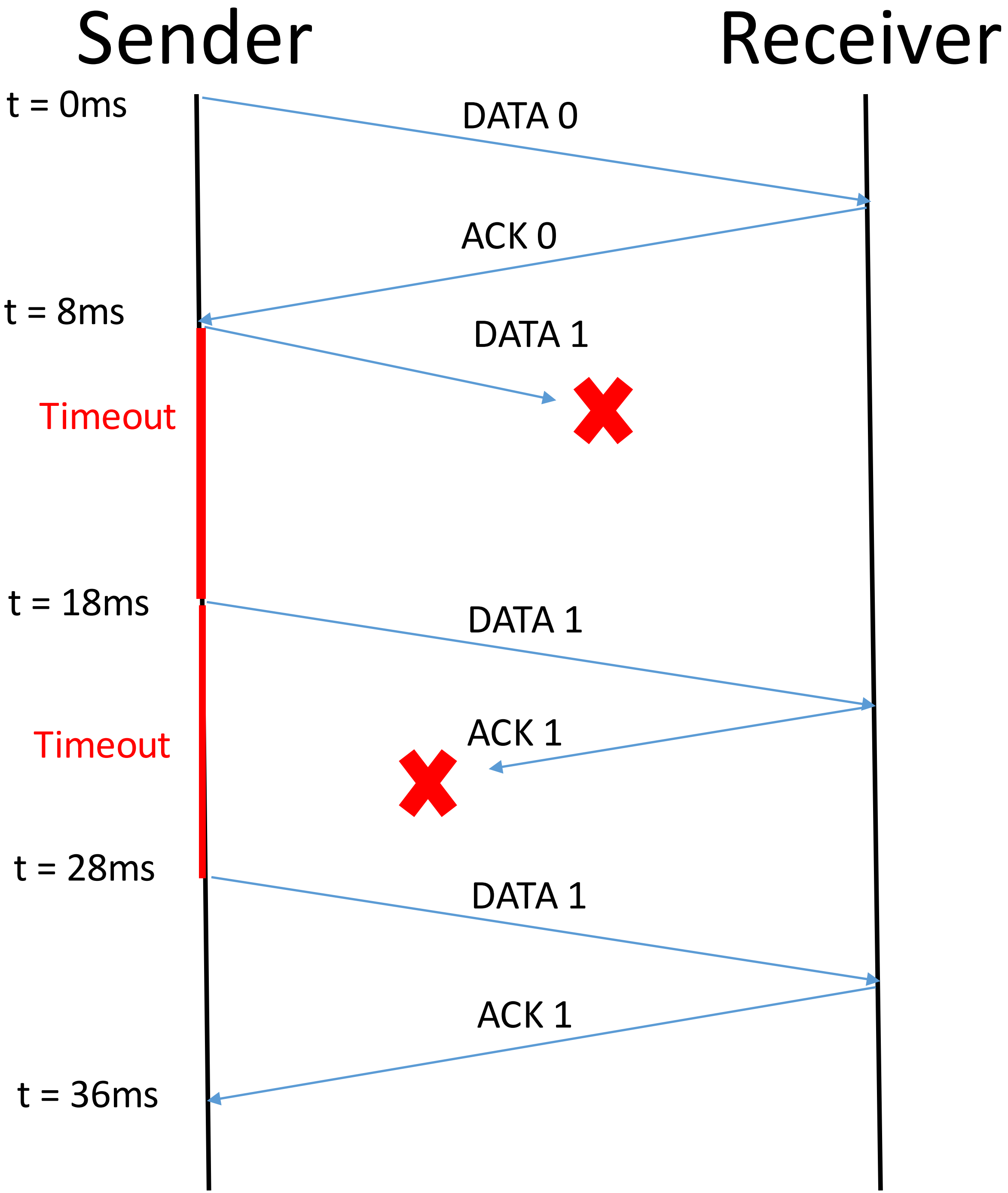
Automatic Repeat Request (ARQ) Protocol

Stop and Wait:

1. Sender transmits a data frame with a sequence number encoded

2. Receiver replies with an acknowledgement frame

3. Sender either (1) transmits a new data frame if it gets an acknowledgement of the previous frame before the timeout, or (2) retransmits the frame after the timeout.



Timeout = 10ms

Round Trip Time = 8ms

Question 5?

Question 1f?

Two-Dimensional Parity

Given below is a series of 7 7-bit items of data, with an additional bit each and an extra byte to account for parity.

First Byte

Parity Byte

1	0	1	0	1	0	1	
1	1	1	1	1	1	1	
0	0	0	0	0	0	0	
1	1	1	1	0	0	0	
1	0	1	0	1	0	1	
0	0	0	0	1	1	1	
0	1	0	1	0	0	1	

What is the original data?

How many bits are actually transmitted?

Two-Dimensional Parity

Given below is a series of 7 7-bit items of data, with an additional bit each and an extra byte to account for parity. Odd parity is applied.

First Byte

1	0	1	0	1	0	1	1
1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	1
1	1	1	1	0 1	0	0	1
1	0	1	0	1	0	1	1
0	0	0	0	1	1	1	0
0	1	0	1	0	0	1	0
1	0	1	0	1	1	0	1

Parity Byte

Can we detect/correct all 1-bit flip?

Question 2.a?

Two-Dimensional Parity

Given below is a series of 7 7-bit items of data, with an additional bit each and an extra byte to account for parity. Odd parity is applied.

First Byte

1	0	1	0	1	0	1	1
1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	1
1	1	1	1	~~0~~ 1	0	0	1
1	0	1	0	1	~~0~~ 1	1	1
0	0	0	0	1	1	1	0
0	1	0	1	0	0	1	0
1	0	1	0	1	1	0	1

Parity Byte

Can we detect/correct all 2-bit flips?

What if 2 flipped bits are in the same row, or the same column?

Question 2.b

Error checking using CRC

Sending side:

1. To detect up to k-bit burst errors, select a generator G which has k + 1 bits. (Look up Table 2.3 on Page 102 of the textbook)
2. Shift data D to the left for k bits (D << k == 2^k * D)
3. Divide (2^k * D) by generator G using Modulo-2 arithmetic, and get a remainder r
4. Actual data transmitted is (2^K * D) XOR r

Example:

Assume sender's message is 1011 0011 0101 0110, and we decide to encode this message with CRC-8 polynomial. What is the actual bit-sequence that get transmitted?

D = 1011 0011 0101 0110

G = 1 0000 0111

k = 8

Table 2.3 Common CRC Polynomials

CRC	$C(x)$
CRC-8	$x^8 + x^2 + x^1 + 1$
CRC-10	$x^{10} + x^9 + x^5 + x^4 + x^1 + 1$
CRC-12	$x^{12} + x^{11} + x^3 + x^2 + x + 1$
CRC-16	$x^{16} + x^{15} + x^2 + 1$
CRC-CCITT	$x^{16} + x^{12} + x^5 + 1$
CRC-32	$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11}$ $+ x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

Sending side:

1. To detect up to k-bit burst errors, select a generator G which has k + 1 bits. (Look up Table 2.3 on Page 102 of the textbook)
2. Shift data D to the left for k bits (D << k == 2^k * D)
3. Divide (2^k * D) by generator G using Modulo-2 arithmetic, and get a remainder r
4. Actual data transmitted is (2^K * D) XOR r

D = 1011 0011 0101 0110

G = 1 0000 0111

k = 8

Answer:

1011 0011 0101 0110 1101 0101

Error checking using CRC

Receiving side:

1. Check whether the received bit stream S (2^k * D XOR r) is divisible by the generator G.

Message = 1011 0011 0101 0110 1101 0101

G = 1 0000 0111

r = 0 → Error check PASSED

Questions?