Introduction to Computer Networks

CS640

L2 Reliable Transmission

https://pages.cs.wisc.edu/~mgliu/CS640/F22/

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Today

Last lecture

- How to avoid loops in the L2 switching?
- Why Ethernet dominates?

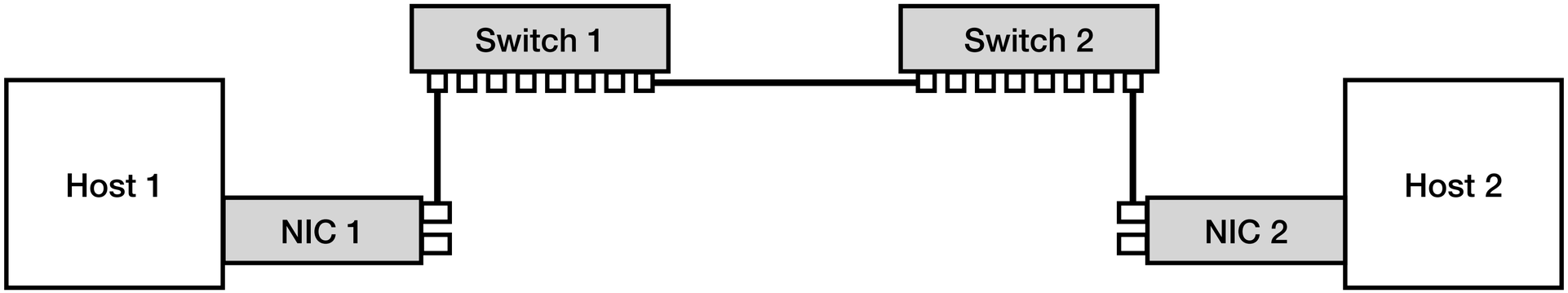
Today

- How to ensure reliable frame delivery at the data link layer?

Announcements

- Lab2 due next Tuesday

Q1: Why frame delivery is not reliable?



Q1: Why frame delivery is not reliable?

A: Common errors:

- #1: Frames are corrupted
- #2: Frames are dropped
- #3: Hardware/software failures

Q2: Do we have to handle it in the data link layer?

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A: No.

- Rely on the upper layer to handle it
- A reliable frame delivery channel simplifies the upper layer logic (we'll discuss in the transport layer)

Q3: How to ensure reliable frame delivery?

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A: Two key ideas:

- #1: Acknowledgment (ACK) — notify the sender of the receipt of a frame
- #2: Timeout — wait for a reasonable amount of time and generate a signal

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A: Two key ideas:

- #1: Acknowledgment (ACK) — notify the sender of the receipt of a frame
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Where? When?

Technique #1: Stop-and-Wait

Send the next frame only if the last one is being successfully delivered

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Acknowledgment

- Where: receiver
- When: after a valid frame is being received

Timeout

- Where: sender
- When: after the issuing frame not being acknowledged for a certain amount of time

Technique #1: Stop-and-Wait

Send the next frame only if the last one is being successfully delivered

- Discussion:
  - Frame duplication requires each frame has a unique ID
  - Make sure who is the sender and receiver
  - A frame can only be freed if it is acknowledged
  - Cannot fully utilize the bandwidth

Technique #2: Concurrent Logical Channels

Partition a physical link into multiple logical channels and apply the Stop-and-Wait for each channel

- Each channel works independently
- The maximum number of concurrent outstanding frames equals the number of channels

Technique #3: Sliding Window

Keep the communication channel full with N consecutive frames

- The ideal case is simple, but …
- What happens if the sender receives no ACKs or an out-of-order ACK?
- What happens if the receiver receives an out-of-order frame?

Sender Logic

Three states

- LAR: the sequence number of the last acknowledgment received
- LFS: the sequence number of the last frame sent
- SWS: the send window size

Invariant: LFS - LAR <= SWS

- Upon an acknowledgment, the sender transmits frames to ensure the maximum number of outstanding frames is below the window
- Each frame is associated with a timer

Receiver Logic

Three states

- LAF: the sequence number of the largest acceptable frame
- LFR: the sequence number of the last frame received
- RWS: the receive window size

Invariant: LAF - LFR <= RWS

- The receiver is able to accept an out-of-order frame, whose sequence number should stay within the window range
- The receiver sends an accumulative ACK

Sliding Window Discussion

N is decided based on the channel BDP

- Keep the pipe full

Rely on the sender to maintain minimal states

- The window size is bounded

Timeout and acknowledgment have multiple variants

- We will see more examples in the future

Terminology

1. Host
2. NIC
3. Multi-port I/O bridge
4. Protocol
5. RTT
6. Packet
7. Header
8. Payload
9. BDP
10. Baud rate
11. Frame/Framing
12. Parity bit
13. Checksum
14. Ethernet
15. MAC
16. (L2) Switch
17. Broadcast
18. Acknowledgement
19. Timeout

Principle

1. Layering
2. Minimal States

Technique

1. NRZ Encoding
2. NRZI Encoding
3. Manchester Encoding
4. 4B/5B Encoding
5. Byte Stuffing
6. Byte Counting
7. Bit Stuffing
8. 2-D Parity
9. CRC
10. MAC Learning
11. Store-and-Forward
12. Cut-through
13. Spanning Tree
14. CSMA/CD
15. Stop-and-Wait
16. Sliding Window

Summary

Today's takeaways

#1: Acknowledgement and timeout are the two key techniques to achieve reliable transmission

#2: Sliding window outperforms the stop-and-wait by allowing N concurrent outstanding frames to be transmitted

Next lecture

- IP Introduction