CSE 461 Midterm Review

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Slides borrowed from last year
Physical layer
Latency

Transmission delay: time to put message on the wire.

\[ T_{\text{delay}} = \frac{\text{Message (bits)}}{\text{Rate (bits/sec)}} \]

Propagation delay: time for bits to propagate across wire.

\[ P_{\text{delay}} = \frac{\text{Length (m)}}{\text{Speed of signal (m/sec)}} \]
Latency

Assume 100-Mbps bandwidth, two store-and-forward switch, packet size of 100000 bits, each link introduce a propagation delay of 5ms, calculate latency.
BD product

A measurement of the amount of data in flight.

BD = Rate * Delay
Shannon Capacity

Maximum rate information can be transmitted over a channel of a specified bandwidth in the presence of noise.

\[ C = B \log_2(1 + S/(BN)) \text{ bits/sec} \]
Link layer
Framing methods

Byte count
Byte stuffing
Bit stuffing
Byte stuffing

- Have a special flat byte value
- Replace the flag inside the frame with an escape code
- Need to escape the escape code too

**Diagram:**

<table>
<thead>
<tr>
<th>Original bytes</th>
<th>After stuffing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  FLAG  B</td>
<td>A  ESC  FLAG  B</td>
</tr>
<tr>
<td>A  ESC  B</td>
<td>A  ESC  ESC  B</td>
</tr>
<tr>
<td>A  ESC  FLAG  B</td>
<td>A  ESC  ESC  ESC  FLAG  B</td>
</tr>
<tr>
<td>A  ESC  ESC  B</td>
<td>A  ESC  ESC  ESC  ESC  B</td>
</tr>
</tbody>
</table>
Hamming distance

- Hamming distance of a code is the minimum distance between any pair of valid codewords.
Hamming distance

Error detection:
For a code of distance \(d+1\), up to \(d\) errors will always be detected.

Error correction:
For a code of distance \(2d+1\), up to \(d\) errors will always be corrected by mapping to the closest codeword.
Hamming distance

Assume a code has hamming distance 5

How many errors it can detect?
How many errors it can correct?
### 2D Parity

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
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</table>

The parity of the 2D matrix is calculated by checking if the total number of 1s is even or odd. In this case, the parity is odd because there are 9 ones.
Internet checksum - sender

Add using one’s complement

0010
1101
1110
0011

0010

Negate to get sum

1101
Internet checksum - receiver

Add using one’s complement

0010
1101
1110
0011
1101

Negate and check it is 0 0000
Internet checksum

Assume 4-bit works, is the following frame received correct?

0010, 1101, 0111, 0010, 0110
Cyclic Redundancy Check

Sender:
1. Extend \( n \) data bits with \( k \) zeros
2. Divide by generator value \( C \)
3. Keep remainder, ignore quotient
4. Adjust \( k \) check bits by remainder

Receiver:
Divide and check for zero remainder
Multiplexing

Time Division Multiplexing (TDM)
User take turns on a fixed schedule

Frequency Division Multiplexing (FDM)
Put different users on different bands
CSMA/CD in classic Ethernet
Exponential back-off

- Whenever a collision is detected, wait a random number between 0 and $2^n - 1$ inclusive before sending again.
- $n$ is usually 10 at max
Wireless
Hidden terminals
Exposed terminals
MACA

Protocol:
1. Sender transmits RTS (Ready to send)
2. Receiver replies with CTS (Clear to send)
3. Send transmits frame while nodes hearing CTS stays silent
What is network Hub?

- Works at Physical layer
- Replicates data on all interface
- Cheap and simple, waste bandwidth
What is network Switch/Bridge?

<table>
<thead>
<tr>
<th>Interface</th>
<th>Mac address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AA-AA-AA-AA-AA-AA-AA</td>
</tr>
<tr>
<td>2</td>
<td>BB-BB-BB-BB-BB-BB-BB</td>
</tr>
<tr>
<td>3</td>
<td>CC-CC-CC-CC-CC-CC-CC</td>
</tr>
</tbody>
</table>
What is network Switch/Bridge?

- Works at Link layer
- Learns Mac address
- Forwards packet using switch table
- Connects devices together
Forwarding loops
Spanning tree Algorithm

Outline:

1. Elect a root node of the tree. (Switch with lowest address)
2. Grow tree as shortest distances from root
3. Turn off port for forwarding if they aren’t on the spanning tree
Spanning tree Algorithm

- A: (A, A, 0)
- B: (B, B, 0)
- C: (C, C, 0)
- D: (D, D, 0)

Diagram:
- A connected to B and D
- B and D connected to A
- C connected to A and C
Spanning tree Algorithm

(A, A, 0)

(B, A, 1)

(D, A, 2)

(C, A, 1)
Network layer
What is network Router?
What is network Router?

- Works at Network layer
- Gateway between local network/private network to Internet
- Carries functions like wifi transmission, NAT, DHCP and routing
Let’s talk about DHCP

Private address

192.168.1.2
192.168.1.3
192.168.1.4

public address

12.11.8.1

Router
Let's talk about DHCP

Protocol:
1. DHCP Discover
2. DHCP offer
3. DHCP request
4. DHCP ACK
NAT

Private address

192.168.1.2

Router

public address

12.11.8.1

NAT forwarding table

<table>
<thead>
<tr>
<th>Private address</th>
<th>Public address</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.1.2:12345</td>
<td>12.11.8.1:22222</td>
</tr>
</tbody>
</table>

18.21.9.22
Forwarding methods

- Datagram model
- Virtual circuit model
Routing methods

- Dijkstra’s Algorithm
- Distance vector (Distributed version of Bellman Ford)
- Link-State Algorithm
## Longest prefix matching

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Next hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.24.0.0/18</td>
<td>C</td>
</tr>
<tr>
<td>192.24.12.0/22</td>
<td>B</td>
</tr>
</tbody>
</table>
Good luck!