CPSC 441

Assignment 5

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1.

a. What is the bandwidth (in bits per second) achieved when sending a single 1024-byte message to Caveman Carey's office in ICT, which is exactly 300 meters from the top of McKimmie Library?

$$\text{Bandwidth} = \frac{10\text{meters}}{1\text{second}} * \frac{1}{300\ meters} * 1024\ bytes * \frac{8bits}{byte}$$
$$= \frac{1}{30seconds} * 8192bits = \mathbf{273.067}\frac{\boldsymbol{bits}}{\boldsymbol{s}}$$

Bandwidth is 273.067 bps

b. How large a message is needed to achieve a data rate of 1 Mbps between McKimmie Library and Caveman Carey in ICT?

$$\text{Message Size} = \frac{1\text{Mbits}}{\text{s}} * 300\text{meters} * \frac{\text{seconds}}{10\text{meters}} = 1 * 10^6 \frac{\text{bits}}{\text{s}} * 30\text{seconds}$$
$$= 30\ 000\ 000\ \text{bits}$$

Converting bits into bytes:

$$30\ 000\ 000\ bits * 1\frac{byte}{8bits} = \mathbf{3\ 750\ 000}\ \boldsymbol{bytes}$$

Message Size is 3750000Bytes

c. How fast would a paper airplane need to fly to achieve 10 Mbps to Caveman Carey at his ICT office, if it was carrying a 4-kilobyte message?

$$4kilobytes\ =\ 4kilobytes * 1024\frac{bytes}{kilobyte} * \frac{8bits}{byte} = 32768\ bits$$

$$10Mbps = 10 * 10^6 \frac{bits}{s}$$

$$Distance\ to\ Travel = 300meters$$

$$10 * 10^6 \frac{bits}{s} * 300\ meters * \frac{1}{32768bits} = \mathbf{91552.734}\frac{\boldsymbol{meters}}{\boldsymbol{second}}$$

$$\textbf{Speed Paper Airplane flies is } \mathbf{91552.734} \frac{\textbf{meters}}{\textbf{second}}$$

2.

a. What end-to-end steady-state throughput (in bits per second) is achievable with a 1460-byte MSS over a network path with an RTT of 250 milliseconds, assuming that a congestion window size of 24 segments saturates the path?

Using the steady state equation:

$$\boldsymbol{Throughput} = \frac{\mathbf{0.75}\boldsymbol{W}}{\boldsymbol{RTT}}$$

$$W = 1460 \frac{bytes}{segment} * 24\ segments * \frac{8bits}{bytes} = 280320\ bits$$

$$RTT = 250milliseconds = 0.250\ seconds$$

$$Throughput = 0.75 * 280320bits * \frac{1}{0.250seconds} = \mathbf{840960} \frac{\boldsymbol{bits}}{\boldsymbol{second}}$$
$$= \mathbf{840960}\boldsymbol{bps}$$

Throughput of is 840960bps

b. What end-to-end throughput (in bits per second) is achievable with a 1460-byte MSS over a lossy network path with an RTT of 250 milliseconds, if the average packet loss rate is 1%?

Using The Equation:

$$\boldsymbol{Throughput} = \frac{\mathbf{1.22} * \boldsymbol{W}}{\boldsymbol{RTT} * \sqrt[2]{\boldsymbol{L}}}$$

$$W = 1460bytes * 8 \frac{bits}{bytes} = 11680bits$$

$$RTT = 250milliseconds = 0.250\ seconds$$

$$L = 1\%\ loss\ rate = 0.01$$

$$Throughput = \frac{1.22 * 11680bits}{0.250seconds * \sqrt[2]{0.01}} = \mathbf{569984}\boldsymbol{bps}$$

Throughput is 569984bps

c. What end-to-end throughput (in bits per second) is achievable with a 1460-byte MSS over a lossy network path with an RTT of 250 milliseconds, if the average packet loss rate is 4%?

Using The Equation:

$$\boldsymbol{Throughput = \frac{1.22 * W}{RTT * \sqrt[2]{L}}}$$

$$W = 1460bytes * 8\frac{bits}{bytes} = 11680bits$$

$$RTT = 250milliseconds = 0.250\ seconds$$

$$L = 4\%\ loss\ rate = 0.04$$

$$Throughput = \frac{1.22 * 11680bits}{0.250seconds * \sqrt[2]{0.04}} = \boldsymbol{284992bps}$$

Throughput is 284992bps

3.

a. What is the maximum efficiency for a classic 10 Mbps Ethernet LAN segment that is 2.0 km in length, if all frame transmissions are 64 bytes in size?

Using the Following Equation:

$$\boldsymbol{Efficiency = \frac{1}{1 + 5 * \frac{T_{Prop}}{T_{Trans}}}}$$

$$T_{Prop} = 2.0km * \frac{seconds}{200000km} = 0.00001\ seconds$$

$$T_{Trans} = \frac{seconds}{10 * 10^6 Bits} * 64bytes * 8\frac{bits}{bytes} = \frac{seconds}{10 * 10^6 Bits} * 512bits$$
$$= 0.0000512\ seconds$$

$$Efficieny = \frac{1}{1 + 5 * \frac{0.00001 seconds}{0.0000512 seconds}} = \frac{1}{1.9765625} = 0.50592885 = \mathbf{50.59}\%$$

Maximum Efficiency is 50.59%

b. What is the maximum efficiency for a classic 10 Mbps Ethernet LAN segment that is 2.0 km in length, if all frame transmissions are 1500 bytes in size?

Using the Following Equation:

$$\boldsymbol{Efficiency = \frac{1}{1 + 5 * \frac{T_{Prop}}{T_{Trans}}}}$$

$$T_{Prop} = 2.0km * \frac{seconds}{200000km} = 0.00001\ seconds$$

$$T_{Trans} = \frac{seconds}{10 * 10^6 Bits} * 1500 bytes * 8 \frac{bits}{bytes} = \frac{seconds}{10 * 10^6 Bits} * 12000 bits = 0.0012\ seconds$$

$$Efficieny = \frac{1}{1 + 5 * \frac{0.00001 seconds}{0.0012 seconds}} = \frac{1}{1.041\overline{6}} = 0.96 = \mathbf{96}\%$$

Maximum Efficiency is 96%

c. What is the maximum efficiency for a 100 Mbps Fast Ethernet LAN segment that is 2.0 km in length, if all frame transmissions are 1500 bytes in size?

Using the Following Equation:

$$\boldsymbol{Efficiency} = \frac{\mathbf{1}}{\mathbf{1} + \mathbf{5} * \frac{\boldsymbol{T_{Prop}}}{\boldsymbol{T_{Trans}}}}$$

$$T_{Prop} = 2.0km * \frac{seconds}{200000km} = 0.00001\ seconds$$

$$T_{Trans} = \frac{seconds}{100 * 10^6 Bits} * 1500bytes * 8\frac{bits}{bytes} = \frac{seconds}{100 * 10^6 Bits} * 12000bits = 0.00012\ seconds$$

$$Efficieny = \frac{1}{1 + 5 * \frac{0.00001seconds}{0.00012seconds}} = \frac{1}{1.41\overline{6}} = 0.705882353 = \mathbf{70.59}\%$$

Maximum Efficiency is 70.59%

4.

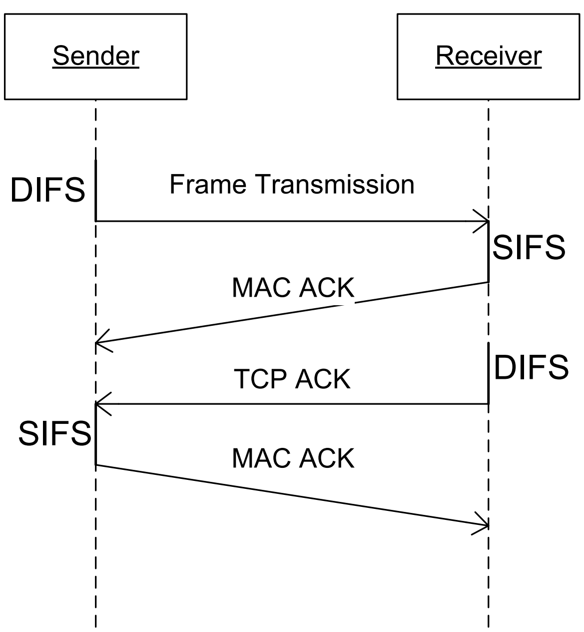

Figure 1. Diagram of Transmission

a. What is the maximum user-level throughput (in bits per second) achievable for a large FTP download from a wireless AP to your laptop, assuming a 1500-byte MTU for TCP/IP packets, and per-segment acknowledgements at the transport layer? You can assume standard 40-byte TCP/IP headers, and a total of 34 bytes of headers at the MAC, LLC, and PLCP layers. Don't forget to consider the time consumed for DIFS, SIFS, PLCP headers, and MAC-layer ACKs. Drawing a diagram for the successful exchange of a single TCP data packet (and its corresponding TCP ACK) between the AP and the laptop AP might be very instructive

$$Throughput = \frac{bits}{second} = \frac{size}{time}$$
$$= \frac{TCP\ Segment\ Payload}{Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi}$$

From Figure 1 we can see time for complete Transmission of a TCP packet over Wifi is:

$$\begin{aligned} Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi \\ &= DIFS + Frame\ Transission + SIFS + MAC\ ACK + DIFS \\ &+ TCP\ ACK + SIFS + MAC\ ACK + PLCPheaderDelay \\ &= 2(DIFS + SIFS + MAC\ ACK) + Frame\ Transission \\ &+ TCP\ ACK + PLCPheaderDelay \end{aligned}$$

From the Question we can obtain the TCP Payload:

$$TCP\ Payload = 1500\ Bytes - 40\ Byte = 1460\ Byte$$

Converting into Bits:

$$TCP\ Payload = 1460\ Bytes\ * 8\frac{bits}{Bytes} = 11680\ bits$$

From Tutorial Slides:

$$DIFS = 128\ \mu s = 0.000128 seconds$$

$$SIFS = 28\ \mu s = 0.000028 seconds$$

From The Question:

$$MAC, LLC, PLCP\ layer\ headers = 34 bytes, so$$

$$Delay_{Mac,LLC,PLCP} = 34 Bytes * 8\frac{bits}{byte} * \frac{second}{1000000 bits} = 0.000272 seconds$$

$$Frame\ Transmission = 1500 Bytes * 8\frac{bits}{byte} * \frac{second}{11000000 bits}$$
$$= 0.001\overline{09}\ seconds$$

$$TCP\ ACK = 40Bytes * 8\frac{bits}{byte} * \frac{second}{11000000bits} = 0.00002\overline{909}second$$

Assuming:

$$MAC\ ACK = 0.000064seconds$$

$$Throughput = \frac{TCP\ Segment\ Payload}{Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi}$$

$$= \frac{TCP\ Segment\ Payload}{2(DIFS + SIFS + MAC\ ACK) + Frame\ Transission + TCP\ ACK + PLCPheaderDelay}$$

$$= \frac{11680\ bits}{(2 * (0.000128 + 0.000028 + 0.000064) + 0.001\overline{09} + 0.00002\overline{909} + 0.000272)seconds}$$

$$= \frac{11680bits}{0.00044 + 0.001392} = \frac{11680bits}{0.001832seconds} = \mathbf{6375545.851528}\frac{\boldsymbol{bits}}{\boldsymbol{seconds}}$$

$$\boldsymbol{Throughput\ is\ 6375545.852\ bps}$$

b. What is the maximum user-level throughput (in bits per second) achievable for the same file download if you use the maximum IEEE 802.11 payload size (i.e., 2312-byte MTU) for the transfer?

From the Question we can obtain the TCP Payload:

$$Throughput = \frac{bits}{second} = \frac{size}{time}$$

$$= \frac{TCP\ Segment\ Payload}{Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi}$$

From Figure 1 we can see time for complete Transmission of a TCP packet over Wifi is:

$$\begin{aligned} &Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi \\ &\quad = DIFS + Frame\ Transission + SIFS + MAC\ ACK + DIFS \\ &\quad + TCP\ ACK + SIFS + MAC\ ACK + PLCPheaderDelay \\ &\quad = 2(DIFS + SIFS + MAC\ ACK) + Frame\ Transission \\ &\quad + TCP\ ACK + PLCPheaderDelay \end{aligned}$$

From the Question we can obtain the TCP Payload:

$$TCP\ Payload = 2312\ Bytes - 40\ Byte = 2272\ Byte$$

Converting into Bits:

$$TCP\ Payload = 2272\ Bytes\ * 8\frac{bits}{Bytes} = 18176\ bits$$

From Tutorial Slides:

$$DIFS = 128\ \mu s = 0.000128 seconds$$

$$SIFS = 28\ \mu s = 0.000028 seconds$$

$$MAC, LLC, PLCP\ layer\ headers = 34 bytes, so$$

$$Delay_{Mac,LLC,PLCP} = 34 Bytes * 8\frac{bits}{byte} * \frac{second}{1000000 bits} = 0.000272 seconds$$

$$Frame\ Transmission = 2312 Bytes * 8\frac{bits}{byte} * \frac{second}{11000000 bits}$$
$$= 0.00168 1\overline{45}\ seconds$$

$$TCP\ ACK = 40 Bytes * 8\frac{bits}{byte} * \frac{second}{11000000 bits} = 0.000029\overline{09} second$$

Assuming:

$$MAC\ ACK = 0.000064 seconds$$

$$Throughput$$
$$= \frac{TCP\ Segment\ Payload}{Time\ ForA\ Complete\ Transmssion\ of\ a\ TCP\ packet\ over\ Wifi}$$
$$= \frac{TCP\ Segment\ Payload}{2(DIFS + SIFS + MAC\ ACK) + Frame\ Transission + TCP\ ACK + PLCPheaderDelay}$$
$$= \frac{18176\ bits}{\left(2 * (0.000128 + 0.000028 + 0.000064) + 0.00168 1\overline{45} + 0.000029\overline{09} + 0.000272\right) second}$$
$$= \frac{18176 bits}{0.00044 + 0.001982 5\overline{45}} = \frac{18176 bits}{0.002422 5\overline{45} seconds}$$
$$= \mathbf{7502851.996397}\frac{\boldsymbol{bits}}{\boldsymbol{seconds}}$$

$$\boldsymbol{Throughput} = \mathbf{7502851.99}\ \boldsymbol{bps}$$

c. Assuming 1500-byte MTUs, which would be "faster" in terms of user-perceived throughput for this transfer: a 10 Mbps Ethernet LAN, or an 11 Mbps IEEE 802.11b WLAN? By how much?

Ethernet LAN 96% efficiency from Question 3.b)

10Mbps * 96% = 9.6Mbps

$$\frac{10Mbits}{second} * \frac{1000000bits}{Mbits} * 0.96 = \mathbf{9600000}\frac{\boldsymbol{bits}}{\boldsymbol{second}}$$

$$\boldsymbol{Ethernet\ Lan\ Throughput\ is\ 9600000}\frac{\boldsymbol{bits}}{\boldsymbol{second}}$$

$$\frac{9600000bits}{second} - \frac{6375545.852bits}{second} = \mathbf{3224454.148}\frac{\boldsymbol{bits}}{\boldsymbol{second}}$$

$$\boldsymbol{Difference\ of\ 3224454.148}\frac{\boldsymbol{bits}}{\boldsymbol{seconds}}$$