Instructions

- No late submission will be accepted.
- You must submit your exam electronically only in .pdf format via Canvas no later than 11:59 pm September 25, 2022. Files submitted after this time will be discarded.
- The university has important rules for exams. Please carefully read the instructions below. Failure to comply with any of the instructions below may result in our being unable to accept or grade your exam or initiating disciplinary actions
- The exam must be taken completely alone. Showing it or discussing it with anybody is forbidden, including (but not limited to) the other students in the course in current or previous years. It is also forbidden to use any solutions to similar problems from previous years as reference material.
- Given your final grade depends on your rank in the class, you don't want to penalize yourself dis- cussing your solutions with the other students.
- You may use any publicly available material you want, including books, the internet, etc. However, You are NOT allowed to submit questions to internet discussion groups, though!
- Show your work. You need to demonstrate your understanding by showing the detail of your work.
- Consent: By submitting this exam I declare I am aware of the Kent State Administrative Policy Regarding Student misconduct and I acknowledge that any academic misconduct on this exam will lead to a grade "F" for the course and that the misconduct will be reported to the Center for Student Conduct.

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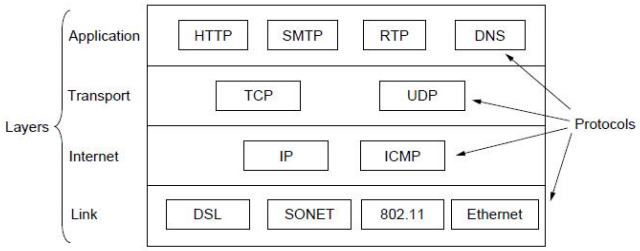
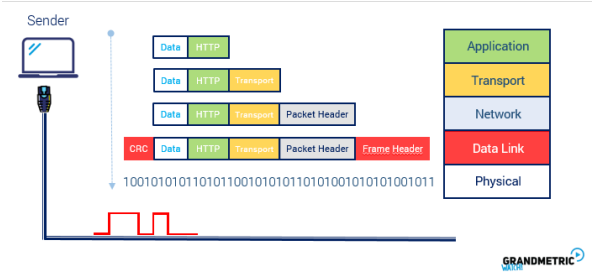
1) Consider the layers in TCP/IP reference model (Figure 1.22) of your text Assume that the user data is 1 KB, HTTP header is 128 bytes, TCP header is 20 bytes, IP header is 20 bytes, and Ethernet header is 18 bytes. Assume that the maximum payload for Ethernet is 1500 bytes excluding the header.





- Calculate the efficiency of each layer.
  - HTTP
  - TCP
  - IP
  - Ethernet

  3.5 pts
- In practice, the data is much larger than 1 KB. Assume that the data is 6 KB and the payload of Ethernet is only 1500 bytes including its header. Recalculate the efficiency of each layer again. Note that Ethernet has to break large packets into 1500 bytes, hence, more overhead.
  - HTTP
  - TCP
  - IP
  - Ethernet
  - Ethernet
  - Ethernet
  - Ethernet

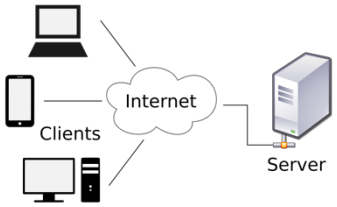
  3.5 pts

  In effect we are transmitting 6000 bytes but with 4 × (128 + 20 + 20 + 18) overhead which results in 6000/4(1500 + 128 + 20 + 20 + 18) = 0.84

- Explain which layer is End-to-End (E2E) connection and which layer is Point-to-Point (P2P) connection and why?
  - HTTP
  - TCP
  - IP
  - Ethernet 3.5 pts
- Explain which layer is connection-oriented and which layer is connection-less-oriented and why?
  - HTTP
  - TCP
  - IP
  - Ethernet 3.5 pts

Show the detail of your work.

2) During the pandemic, remote communication tools such Zoom, Blackboard, Team, etc. became the only option for remote instruction with some hurdles including scalability. All these technologies are based on a client- server architecture, in which multiple clients communicate to a video server via the Internet. From user's (client) perspective, delay/latency is the major performance factor, but where are the causes of delay? The delay can be incurred by the server due to its load, and by links due to the amount of traffic load on each link.



Each link is associated with a buffer (queue). From queuing theory the queuing delay for each queue is formulated by $1/(\mu - \lambda)$, where λ is the rate of packet (frame) arrival per second, and μ is the delivery speed of the link in packets/sec.

Assume the server displays 32 video frames per second per client (connection), and each frame is 1024 x 1024 pixels, and each pixel is 16 bits. Assume also the server's speed is 4 Gbps (4×2^{30}) bps.

(a) How many clients can be supported by the server. 2.5 pts

(b) Assume we use mpeg4 with 50:1 compression rate, how many clients can be supported. 2.5 pts

(c) Assume the server serves 100 clients with compression, and the Internet delay is negligible, then how much the queuing (buffer) delay is per link 5 pts

i. From the server to a client

ii. From a Client to a server

Show the detail of you work.

3) Consider a noisy 10 MHz channel with a signal-to-noise ratio of 20 dB. 2.5 pts each

(a) What is the maximum data rate of this channel.

(b) What is the maximum data rate of the channel when there is no noise and we are transmitting 8 bits at a time.

(c) Can we use $C = B \log_2(1 + S/N)$ and assign $N = 0$ for a noiseless channel? If yes, how?

If no, why?

(d) Is signal-to-noise ratio of 20 dB adequate to transmit 100 Mbps on this channel? Explain why?

Show the detail of you work.

4) Consider a 25 MHz noise-less channel between two nodes that are 100 km apart. Assume that we send 4 bits at a time. Assume that the speed of light is 2×10^8 meters/s. For calculation simplicity, we use 1 Mbps = 10^6 bps instead of 2^{20}bps. 2.5 pts each

(a) What is the length of one bit in time on this channel?

(b) What is the length of one bit in meters on this channel?

(c) Now, consider a frame (packet) of 1 KB (10^3 bytes), what is the length of the packet in time and in meters?

(d) How long does it take to transmit the packet over the 100 km distance from the time the first bit is trans- mitted to the time the last bit is received.

Show the detail of you work.

5) We have 10 users sharing a 100 Mbps channel, which of the multiplexing techniques (FDM, TDM, CDM, and WDM) is suitable for each of the following scenarios and why? Assume 1 Mbps = 1 MHz

2.5 pts each

(a) Each user randomly transmits with an average 50 Mbps and peak rate 80 Mbps.

(b) Each user continuously transmits 8 Mbps.

(c) Each user randomly transmits with an average 4 Mbps and peak rate 10 Mbps but want to conceal their transmission.

(d) User randomly transmits with an average 4 Mbps and peak rate 10 Mbps but they are geographically located far from each other.

Show the detail of you work and justify your answers.

6) For the following bit streams , sketch the digital signal for each encoding technique. form for the following formats. 2 pts each
   a) 00000000001111111111
   b) 01110100100111011101

(a) Non-return-to-Zero (NRZ).
(b) Manchester coding.
(c) Differential Manchester coding.

7) Consider a 10 KHz noiseless channel that transmits signals. Each signal carries 3 bits of data. What is maximum channel capacity in bits/s? 7 pts

8) Now, consider a 10 KHz noisy channel with signal-to-noise ratio of 20 dB. What is maximum channel capacity in bits/s? 7 pts

9) Consider a 1 Mbps point-to-point connection between a computer in NY and a computer in LA which are $4096 = 2^{12}$ Km apart. Assume the signal travels at the speed of $2.6 \times 10^5 \approx 2^{18}$ Km/s in the cable.

5 pts each

(a) What is the length of a bit (in time) in the cable? 1 Mb = 2^{20} bits

(b) What is the length of a bit (in meters) in the cable?

(c) Assume that we are sending packets that are 2 KB (2×2^{10} bytes) long,

i. How long does it take before the first bit of the packet arrives to the destination?

ii. How long does it take before the transmission of the packet is completed?

(d) How many packets can fill the 1M bps × 4, 096 Km pipe (RTT)?