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Introduction
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References

Lecture R1
Review Chapter 1-2
(Computer Communication Networks)

CS 35201
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The contents of this lecture have been composed from various resources including those listed at the reference section.

Reading List

- Chapters 1-2 [Tanenbaum and Wetherall, 2011]

§R1.0.0 Glossaries

CDM	Code Division Multiplexing 25
DSSS	Direct Sequence Spread Spectrum 25
FDM	Frequency Division Multiplexing 25
FHSS	Frequency Hopping Spread Spectrum 25
TDM	Time-Division Multiplexing 25
WDM	Wave Division Multiplexing 25

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§R1.1.0 Introduction I

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Question R1.1

What are the major principles behind layering?

Answer:

1. *Layers created for different abstractions*
2. *Each layer performs a set of well-defined functions*
3. *The function of a layer is chosen with definition of international standard protocols in mind*
4. *Minimize information flow across interfaces between boundaries*
5. *Goal: optimizing the number of layers*

§R1.1.0 Introduction II

Question R1.2

What are the advantages of layered architecture?

Answer:

1. *Modification/upgrading of layers is easy*
2. *Modulation simplifies the overall design*
3. *Different layers can be assigned to different standards*
4. *Different mechanisms (packet-switching, circuit-switching) may be used independently*
5. *The relation between different control functions can be better understood*
6. *Common lower levels may be shared by different higher levels*
7. *Functions (especially at lower levels) may be removed from software to hardware and microcodes*
8. *Increases the compatibility of different machines*

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§R1.1.0 Introduction III

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Question R1.3

What are the disadvantages of layered architecture?

Answer:

1. *Total overhead is higher*
2. *Two communicating machines may have to use certain functions which they could do without layers*
3. *As technology changes, the functions may not be in the most cost-effective layer*

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Question R1.4

Describe the major functionality of each OSI layer?

Answer:

Application	*ftp, e-mail rlogin*
Presentation	*ASCII text, sound*
Session	*Establish/manage connection*
Transport	*End-to-end communication: TCP*
Network	*Routing, Addressing: IP*
Datalink	*Two part communication: Ethernet*
Physical	*How to transmit signal: Coding*

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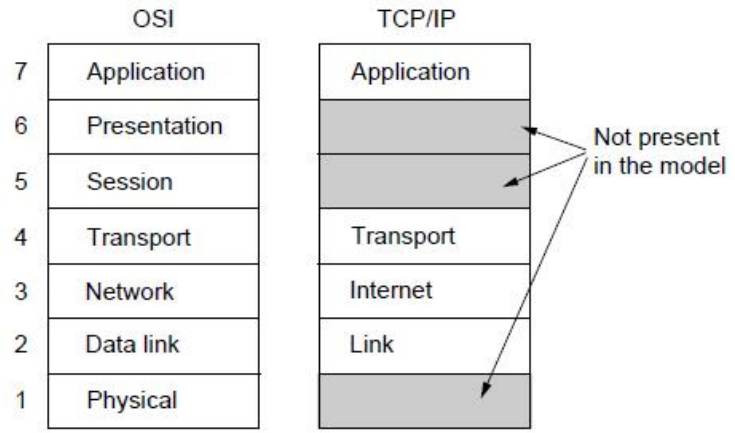
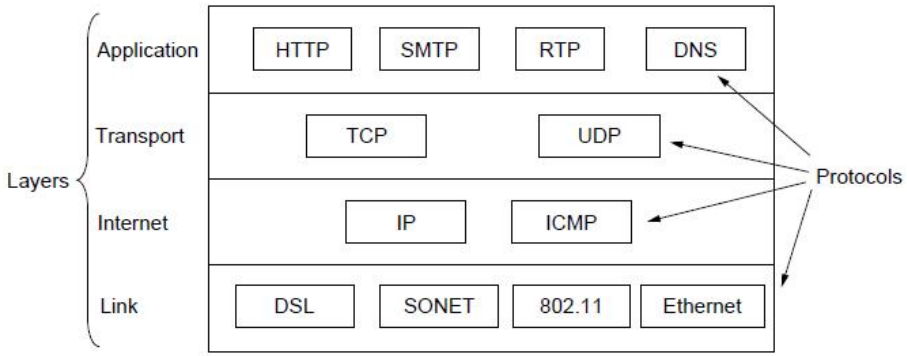
Question R1.5

Compare the OSI and TCP/IP protocol stacks

Answer:





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Question R1.6

Describe the major characteristics of a signal

Answer:

1. *Frequency(f): The rate of change of a signal $\Rightarrow$ in Hz*
2. *Period (t): The time for one repetition of the signal $\Rightarrow$ $t = 1/f$*
3. *Phase (ϕ): The relative position of the signal in time*
4. *Wavelength (λ): The distance occupied by one cycle*
5. *Spectrum: The range of frequencies contained in a signal*

Question R1.7

What is the difference between analog and digital signals?

Answer:

1. *Analog: Continuous values of a signal within some interval*
2. *Digital: Discrete values of a signal within some interval*

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Question R1.8

Describe the differences between analog and digital transmissions

Answer:

	Digital	*Analog*
Signal level	*Discrete*	*Continuous*
Wave	*Square*	*Other form*
Content	*Sensitive*	*Insensitive*
Data	*Analog/Digital*	*Analog/Digital*
Technology/cost	*Expensive*	*Inexpensive*
Noise	*Less susceptible*	*More susceptible*
Attenuation	*Less*	*More*

R1.10

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Question R1.9

Define the following

Answer:

1. *Attenuation: Decrease in signal strength (amplitude) as a function of distance*
   - *Increase in attenuation as a function of frequency* Why?
2. *Delay Distortion: Different frequency components travel at different speed*

Question R1.10

How signals can be boosted

Answer:

1. *Analog: by amplification* $\Rightarrow$ *it also amplifies noise* $\Downarrow$
2. *Digital: by repeaters* $\Rightarrow$ *it does not amplify noise* $\Downarrow$

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Question R1.11

What are the advantages of digital transmission

Answer:

1. *Lower cost with LSI/VLSI technology*
2. *Better data integrity*
3. *better capacity utilization*
   - *High bandwidth links economical*
   - *High degree of multiplexing easier with digital techniques*
4. *Security and Privacy through digital encryption*
5. *Integration ⇒ can co-exist with analog technology*

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Question R1.12

What are the major transmission impairment?

Answer:

1. *Attenuation ⇒ signal strength weakens with distance and higher frequency*
2. *Delay distortion ⇒ Propagation velocity varies with frequency*
3. *Noise*
   - *Thermal noise ⇒ white noise, uniform*
   - *Inter-modulation ⇒ sum of frequencies*
   - *Crosstalk*
   - *Impulse ⇒ irregular noise*

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Question R1.13

What is channel capacity?

Answer:

1. *Bandwidth* *in terms of channel frequency* $\Rightarrow$ *cycles/s*
2. *Data Rate* *in terms of bits/s, depends on:*
   1. *Channel frequency*
   2. *Modulation rate*
   3. *Noise*

Question R1.14

Describe the difference between bandwidth, data Rate, throughput, capacity. Give an example

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Question R1.15

How do we measure channel capacity?

Answer: *Depends on the condition of the noise on that channel*

1. *Noiseless channel*

$$C = 2\,B\,\log_2 M \tag{1}$$

2. *Noisy channel*

$$C = B\,log_2\,(1 + \frac{S}{N}), \qquad 10\,log_{10}\,\frac{S}{N}\;\;dB \tag{2}$$

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Question R1.16

Calculate the maximum data rate of a 16-kHz

1. noiseless channel with 4-level encoding
2. 30 dB noisy channel

Answer:

1. $C = 2\,B\,\log_2 M = 2 \times 16,000\,\log_2 4 = 64$ *kbps*
2. *30 dB* = $10 \log_{10} \frac{S}{N}$, $\Rightarrow \frac{S}{N} = 1000$
   $C = B\,log_2\,(1 + \frac{S}{N}) = 16,000 log_2(1 + 1000) \leq 159.47$ *kbps*

R1.16

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Question R1.17

Describe single mode and multi-mode fiber optics

Answer:

- *Single mode*
  1. *A small core*
  2. *Support a single pathway of light*
  3. *Realigns the light toward the center of the core*
- *Multi mode*
  1. *A large-diameter core that is much larger than the wavelength of light transmitted*
  2. *Supports multiple pathways of several wavelengths of light*
  3. *Less bandwidth per wavelength*

Why?

R1.17

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Question R1.18

What are advantages/disadvantages of satellite communications?

Answer:

- *Larger coverage area* ⇑
- *Transmission cost is independent of distance* ⇑
- *Satellite to Satellite communication is very precise* ⇑
- *Higher bandwidth are available* ⇑
- *Launching satellites into orbit is costly* ⇓
- *Satellite bandwidth is gradually becoming used up* ⇓
- *Large propagation delay* ⇓

R1.18

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Question R1.19

What is modulation? What are their classifications?

Answer:

1. *Modulation is a process of encoding source data onto a carrier signal with frequency f*
2. *Classified based on one or more of the three fundamental frequency domain parameters*
   - *Amplitude $\Rightarrow$ Amplitude modulation*
     - *Two different amplitudes are used to represent 0/1*
   - *Frequency $\Rightarrow$ Frequency modulation*
     - *Two different tones are used to represent 0/1*
   - *Phase $\Rightarrow$ Phase modulation*
     - *Two carrier wave shift used to represent 0/1*

   In all we can use more discrete values to represent mor digits per sample

R1.19

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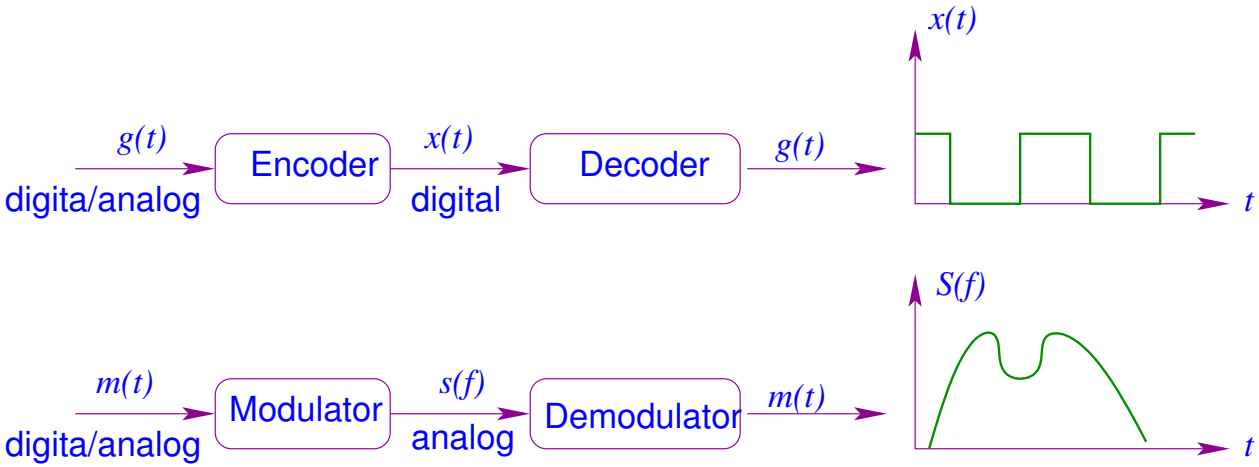
Question R1.20

How does modulation work?



Answer:

Question R1.21

What is Modulation Rate?

Answer: *A rate at which the signal level changes. It is Measured in baud*

⇒ *signal elements per second*

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Question R1.22

What are the major components of a delay suffered by a packet?

Answer:

1. *Propagation delay* $\Rightarrow$ *depends on distance* $\Rightarrow$ *deterministic*
2. *Transmission delay* $\Rightarrow$ *depends on modulation rate* $\Rightarrow$ *deterministic*
3. *Queuing delay* $\Rightarrow$ *depends on queue (buffer) size/length* $\Rightarrow$ *non-deterministic*
4. *Access delay* $\Rightarrow$ *depends on LAN access policy* $\Rightarrow$ *deterministic/non-deterministic*

R1.21

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Question R1.23

What is the E2E delay a 64KB packet suffers on a fiber at 1Gbps crossing NY to LA, given there is no queuing or access delay. Assume NY-LA is 4000 km.

Answer:

- *Transmission delay =* $\frac{64\times1024\times8}{2^{30}} = 2^{-11}$ *sec.*
- *Propagation delay =* $\frac{4\times10^6}{3\times10^8} = 0.013$ *sec.* $\Rightarrow$ *dominates*
- *E2E delay = 0.01333333333 + 0.00048828125 = 0.01382161458 sec.*

Question R1.24

What is the length of a bit in time and space in the above question

Answer:

- *Bit time =* $\frac{1}{2^{30}} = 2^{-30}$ *sec.*
- *Bit space=* $3 \times 10^8 \times 2^{30} = 0.279$ *meters*

R1.22

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Question R1.25

At each instance, how much data is being carried by the above pipe?

Answer:

- *Delay* $\times$ *Bandwidth* = $2^{30} \times 0.01382161458 = 14840846 = 14.8$ *Mb*

Question R1.26

What is QoS? What are the major QoS metrics?

Answer:

- *Delay, throughput, loss, jitter*

Question R1.27

What is the percentage of T1 overhead? What is the efficiency?

Answer:

- *Bandwidth* = $(24 \times 8 + 1) \times 8000 = 1544000$ *bps*
- *Throughput* = $24 \times 7 \times 8000 = 1344000$ *bps*
- *Efficiency* = $1344000/1544000 = 87\%$

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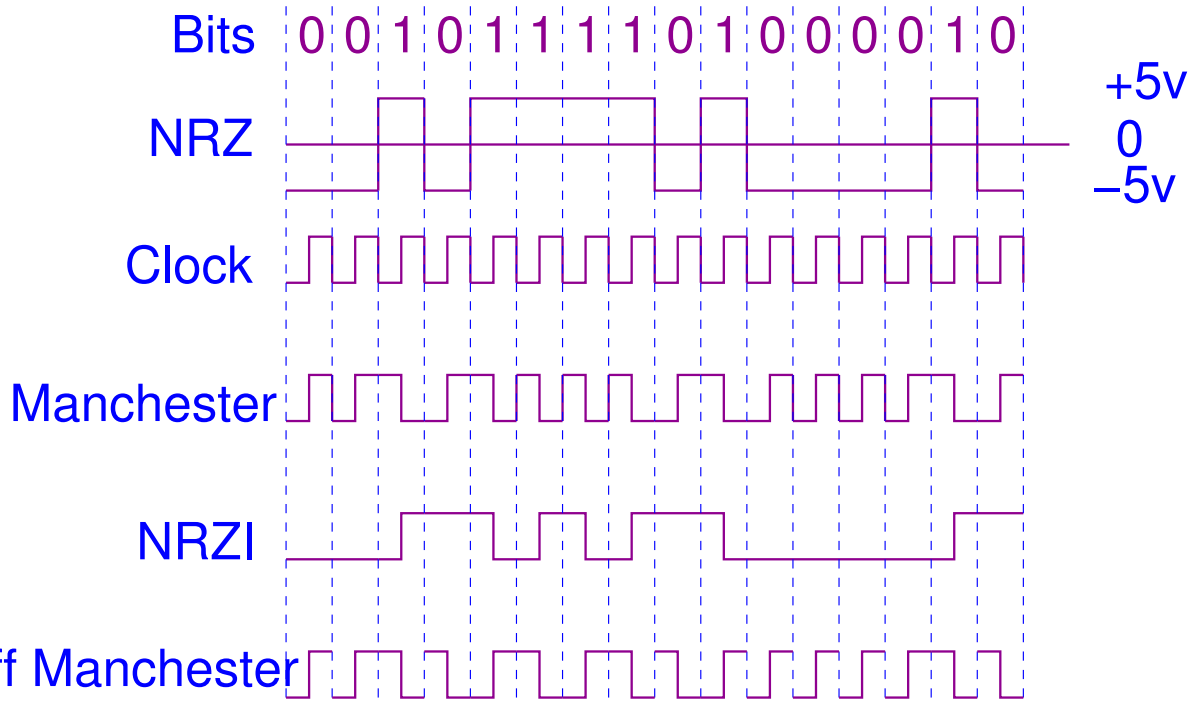
Question R1.28

Show the four major encoding schemes for 0010111101000010.

Answer:



Transition in middle of interval ⇒ easy to synchronize

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Question R1.29

1. How does Frequency Division Multiplexing (FDM) work? Give an illustrated example.
2. How does Time-Division Multiplexing (TDM) work? Give an illustrated example.
3. How does Code Division Multiplexing (CDM) work? Give an illustrated example.
4. How does Wave Division Multiplexing (WDM) work? Give an illustrated example. Reuse distance

Answer: *Read Section 2.15 of the lecture notes*

Question R1.30

1. What is the difference between Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS)

Answer: *Read Section 2.15 of the lecture notes*

§R1.2.0 Physical Layer XVIII

Question R1.31

Describe the basic multiplexing techniques, advantage/disadvantages

Answer: Read Section 2.16 of the lecture notes

Question R1.32

Discuss the difference between Frequency Hopping and Direct Sequence and show how they work

Answer: Read Section 2.16 of the lecture notes

Question R1.33

1. Reuse distance
2. Asymmetric traffic
3. Orthogonal FDM (ODFM)
4. Clock-based framing

Answer: Read Section 2.16 of the lecture notes

§R1.2.0 Physical Layer XIX

Question R1.34

Consider a 10 Kbps point-to-point connection between two devices 20 kilometers apart. Assume that the signal travels at the speed of 2×10^8 meters/s in the medium. $1Kb = 2^{10}\ b$

1. What is the length of a bit in time in the medium?

$$\frac{1}{10 \times 2^{10}} = .000097656250\ s = 97.65\ \mu s$$

2. What is the length of a bit in space (in meters) in the medium?

$$2 \times 10^8 \times \frac{1}{10 \times 2^{10}} = 19531.25\ m = 19.531\ km$$

3. Assuming we transmit 64KB packets, what is the transmission time of the packet.

$$\tau = \frac{64 \times 2^{10} \times 8}{10 \times 2^{10}} = 51.2\ s$$

4. What is the end-to-end (round-trip time) delay for the packet? Assume no queuing (buffer)delay and no access delay.

$$delay = transmission\ delay + round\ trip\ delay$$

$$delay = \frac{40}{2 \times 10^5} + 51.2 = 0.0002 + 51.2 = 51.2001\ s$$

5. How much data (MB) is lost if the pipe breaks suddenly. Assuming we keep the pipe full all the time.

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§R1.3.0 Some Advice

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- There are a lot material. You should have read the book in piece-meal fashion
- This review, by no means, is complete, but guides you to read more efficiently
- Strategy $\Rightarrow$ order of importance
  1. Review notes
  2. Lecture notes
  3. Problems at the end of each chapter
  4. The book itself

§R1.4.0 References

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References

[Tanenbaum and Wetherall, 2011] Tanenbaum, A. S. and Wetherall, D. J. (2011).
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