Mittuniversitetet
MID SWEDEN UNIVERSITY

Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
DT024G	T101	2018-06-07

Kursnamn	Datateknik GR (A), Datornätverk
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Exam in DT024G, Computer Networks

Time:	8:00-13:00
Permitted tools:	Arbitrary pocket calculator. An English-Swedish dictionary.
Preliminary requirement for approval:	32 out of 63 points.

Only write on one side of each sheet. You may answer in Swedish or English.

THEORY PART

1. (20 p) For each of the following five functions or duties, (i) state which protocol **layer** in the five-layer TCP/IP model that may handle the function, and (ii) give an example of a **specific protocol or a standard** that provides the given function.

a) Line coding or carrier-wave modulation
b) Collision avoidance
c) Transformation of binary data to ascii characters.
d) Three-way handshake in view to synchronize sequence numbers prior to data transmission
e) Translation of IP address to MAC address
f) Frame synchronization
g) Port numbers
h) Routing
i) Translation between IP address and name
j) Text terminal emulation

2. (10 p) Describe or illustrate the principle of each of the following multiple access methods. Also state what mobile generations (1G, 2G, 2.5G, 3G and/or 4G – one or several) that each one is utilized in. (a) TDMA, (b) FDMA, (c) CDMA (Spread spectrum), (d) OFDM (multi-carrier modulation) and (e) packet switching (also known as statistical multiplexing).

3. (10 p) Draw a copy of the following table (with numbers but not all the text). Put a tic to mark if statement 1 to 10 is valid for networks of type A, B and C. There may be one or several tics in a column or in a row. (1 point per correct row. 0.5 points for a partly correct row.)

	A: Circuit switched network	B: Virtual circuit switched network	C: Datagram network
1. May use FDM or TDM multiplexing.			
2. Based on packet switching.			
3. The bit rate and delay may vary.			
4. The data may be delivered in changed order because it does not follow a fix path.			
5. One datastream or connection can not "borrow" unused capacity from another.			
6. The resources are reserved in the network nodes during a connection phase.			
7. Limited number of channels. Blocks new connections if too many simultaneous connections.			
8. For example: X.25, Frame relay, ATM and MPLS			
9. For example: The conventional digital telephone network and SONET/SDH			
10. For example: Conventional IP networks			

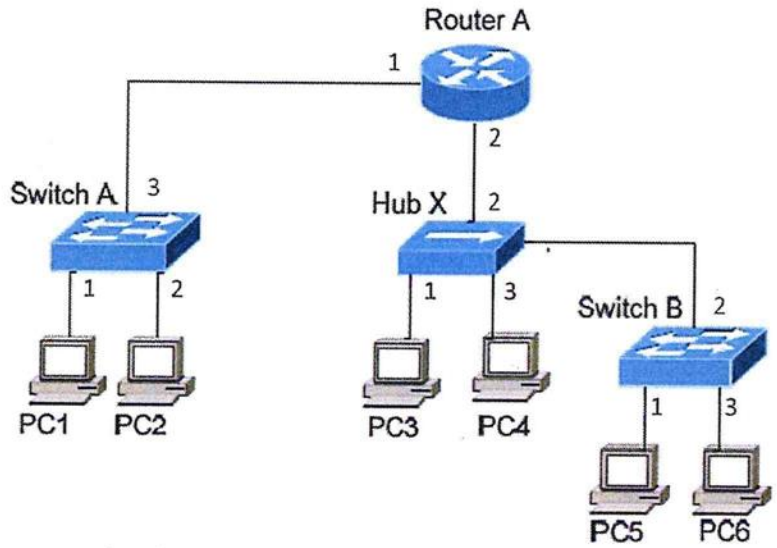
PROBLEM PART

Show all calculcations.

4. (4 p) (a) You download a video file with playback time of 2 hours and a file size of 28,8 Gbyte. What average goodput (the useful throughput measured at the application layer) in Mbit/s is required to watch the video without interrupts?

(b) Your video player should buffer 2 seconds of video to compensate for jitter (delay varations). How large should the buffer be in Bytes (assuming that the video is encoded with constant bit rate)?

5. (5 p) Ditt företag vill köpa ett så litet Ipv4-adressområde som möjligt. Adressområdet slutar på 100.204.127.255. Adressområdet ska delas in i 3 subnät. Subnät A och B ska ha utrymme för 300 värddatorer vardera, och subnät C (en punkt-till-punkt-förbindelse mellan två routrar) för 2 värddatorer. (a) Ange nätverksadress, broadcastadress och subnätmaskar för de tre näten. (b) Vilken nätverksadress och nätverksmask behöver företagets gemensamma adressområde ha för att vara minimalt, men ändå bestå av en hel tvåpotens av adresser?



6. (7 p) In the picture above, IP packets in Ethernet frames are transferred from PC1 to PC6 (in problem a to e).

a. At what other computers can a sniffer software eavesdrop the communication? (PC2, 3, 4, and/or 5?)

b. What source IP address do the sniffing software in PC3 detect? No network address translation is carried out. (The IP address of PC1, router A interface 1 or 2, etc?)

c. What destination IP address do the sniffing software in PC3 detect?

d. What source Ethernet addresses do PC3 detect? (Hint: The Ethernet address of PC1, router A interface 1 or 2, etc?)

e. What destination Ethernet address do the PC3 sniffer detect?

f. Each connection can transfer 100 Mbit/s, either in each direction using full duplex communication (if switched network) or in one direction at a time using half duplex communication (if hubbed network). Assume that PC1 is transferring a large file to PC2 simultaneously as PC2 is transferring a file to PC1. PC3 is transferring to PC4, and PC4 to PC5. What total (aggregated) throughput can be achieved in the network, if you summarize the amount of data delivered to the four nodes divide by the studied time frame?

7. (7 p) Assume that a 4G/LTE cellular phone receives a on a radio channel with upper cut-off frequency of 2700 MHz and and a lower cut-off frequency of 2600 MHz. Multi-carrier modulation is used (also known as OFDM modulation) using 100 subcarriers.

(a) Assume that 16PSK modulation is used for each sub-carrier. Sketch the constellation diagram.
(b) What is the total passband bandwidth, and what is the bandwidth in Hertz of each subcarrier (the inter-carrier separation)?
(c) What symbol rate or baud rate is possible according to the Nyquist theorem based on to the bandwidth of one sub-carrier (assuming no guard interval between the symbols)? What useful symbol time does this correspond to?
(d) Calculate the symbol time in microseconds and the symbol rate, assuming that an additional OFDM guard interval is inserted inbetween each symbol of 25% of the useful symbol time. (The aim of the guard interval is to avoid inter-symbol interference due to echoes from multi-path propagation. The receiver will only listen during the useful symbol time, but not during the guard interval.)
(e) What is the gross bit rate (the line rate or transmission bit rate inclusive of overhead such as error correcting codes) in Mbps, from all 100 sub-carriers combined, with all of the above assumptions? Assume an error correcting code of code rate 1/2, resulting in that the net bitrate (information rate or useful bit rate) is 50% of the gross bitrate. (The aim is to handle that some sub-carriers are cencells due to multipath propagation and fading.) What is the net bit rate (the information rate exclusive of error-correction ocdes) in Mbps?
(f) What signal-to-noise ratio in dB is required, in theory, to transfer this information bit rate (net bit rate exclusive of forward error correction codes from the sub-carriers all together) without errors, according to the Shannon-Hartley formula?

Formelblad Datornätverk A

Här följer ett urval av de formler som behandlas under kursens gång.

Prefix kilo (k)= 10^3. Mega (M) = 10^6. Giga (G) = 10^9. Tera (T) = 10^{12}.
milli (m)= 10^{-3}. Micro (μ) = 10^6. Nano (n) = 10^{-9}. Pico (p) = 10^{-12}.

Frekvens (Hertz) av periodisk signal: $\boxed{f = \frac{1}{T}}$, $\boxed{T = \frac{1}{f}}$ där T är signalens periodtid i sekunder.

Övertonsspektra: Grundfrekvens (first harmonic) f,
första överton (second harmonic) $2f$,
andra överton (third harmonic) $3f$, osv.
DC-komponent (likspänning) 0 Hz.

Datatakt (bit rate i bit/s): $\boxed{R = \frac{1}{T_b}}$, $\boxed{T_b = \frac{1}{R}}$ där T_b är transmissionstiden för en bit

Informationsmängd (bit): L bitar kan representera $\boxed{M = 2^N}$ olika koder.

$$\boxed{L = \log_2 M = \frac{\log M}{\log 2}}$$ (Oftast räcker huvudräkning.)

Decibelmått: Effektförstärkning (power gain) $\boxed{G_{dB} = 10\log_{10}\frac{P_{ut}}{P_{in}}}$ (ofta räcker huvudräkning)

Dämpning (attenuation) $\boxed{A_{dB} = -G_{dB} = -10\log_{10}\frac{P_{ut}}{P_{in}} = 10\log_{10}\frac{P_{in}}{P_{ut}}}$

Signal-brusförhållande $\boxed{SNR_{dB} = 10\log_{10}\frac{S}{N}}$

Kaskadkopplade förstärkare: $\boxed{G_{TotaltdB} = G_{1dB} + G_{2dB} + G_{3dB} + \ldots}$

Analog bandbredd (Hertz): Bandbredd = Övre gränsfrekvens minus undre gränsfrevens.
Basbandsbandbredd = Övre gränsfrekvens.

Nyquists formel för samplingsfrekvens (samples/s): $\boxed{f_{Sampel} > 2B}$ krävs för att undvika vikningsdistorision (aliasing). Här är B den samplade signalens basbandsbandbredd.

Nyquists formel för symboltakt: $\boxed{f_S < 2B}$ där f_S är symboltakt i baud eller symboler/s, och B är kanalens bandbredd. Gäller främst linjekoder. I praktiken är $\boxed{f_S < B}$ vid många digitala modulationsmetoder, t.ex. QAM, PSK och ASK.

Hartley's formel för digital modulation: $\boxed{R = f_S \log_2 M}$

där R är datatakt, f_S är symboltakt i baud eller symboler/s, och M är antal symboler, t.ex. vid M-QAM eller M-PSK-modulation

Shannon-Heartley's formel: $\boxed{I = B\log_2\left(1 + \frac{S}{N}\right)}$

där I är kanalkapaciteteten (max informationstakten eller net bit rate, inkl. ev. felrättande kod, i bit/s), B är bandbredden i Hertz och S/N är signal-brusförhållandet i gånger (inte decibel).

Transmissionstid: $\boxed{T_{Tx} = \frac{L}{R}}$ där L är meddelandets längd i bit, och R är datatakt i bit/s.

Överföringstid (propagation time): $\boxed{T_p = \frac{d}{v}}$ där d är avståndet, och v är utbredningshastigheten.

Ljusets och radiovågors utbredningshastighet: $\boxed{c = 3{\cdot}10^8 \text{m/s}}$