Mittuniversitetet
MID SWEDEN UNIVERSITY

Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
DT137G	T101	2018-06-07
Kursnamn	Datateknik GR (B), Industriell datakommunikation	
Provnamn	Skriftlig tentamen	
Ort	Sundsvall	
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Exam in DT137G, Industrial Data Communications

Time: 8:00-13:00
Permitted tools: Arbitrary pocket calculator.
An English-Swedish dictionary.
Preliminary requirement for approval: 30 out of 60 points.

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

THEORY PART

1. (16 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

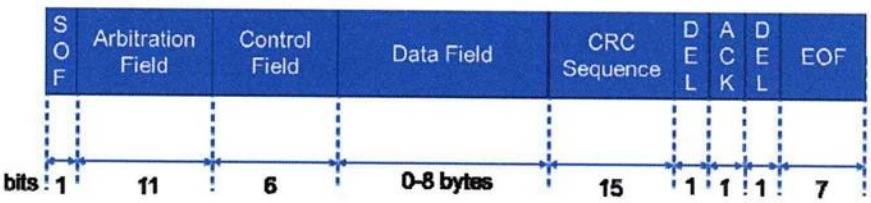
2. (10 p) Describe or illustrate the principle of each of the following multiple access methods. Which mobile generations (1G, 2G, 2.5G, 3G and/or 4G – one) is each one utilized in? (a) FDMA, (b) TDMA, (c) CDMA (Spread spectrum), (d) OFDM (multi-carrier modulation) and (e) packet switching (also known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

PROBLEM PART

Show all calculcations.

3. (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. Vilken nätverksadress och subnetmask behöver företagets nät ha för att minimalt, men ändå bestå av en hel tvåpotens av adresser?

4. (5 p) Consider the structure of a frame for CANbus as showed in figure.



All the lengths except for the Data Field are expressed in bits.

a) Calculate the Overhead (number of bits per frame that are not payload) in the transmission of a CAN frame. (Do not consider the bit stuffing mechanism.)
b) Consider a gross bitrate of 1 Mbit/s and a Data Field of 8 bytes payload. Calculate the useful bit rate for the data transmission. (Do not consider the bit stuffing mechanism)

5. (5 p) The definition of dBm is the relationship in dB between the signal power and the reference power 1 milliwatt. 0 dBm is consequently 1 milliwatt.

(a) A -50 dBm signal is detected in the receiver side of a network interface card. What is the received signal strength in microwatt?

(b) The signal was transmitted over a 20 km long cable, which attenuates the signal 0.001 dB/meter, and amplified by a 30 dB amplifier before it reached the receiver. What transmitted signal strength level in dBm was fed into the cable?

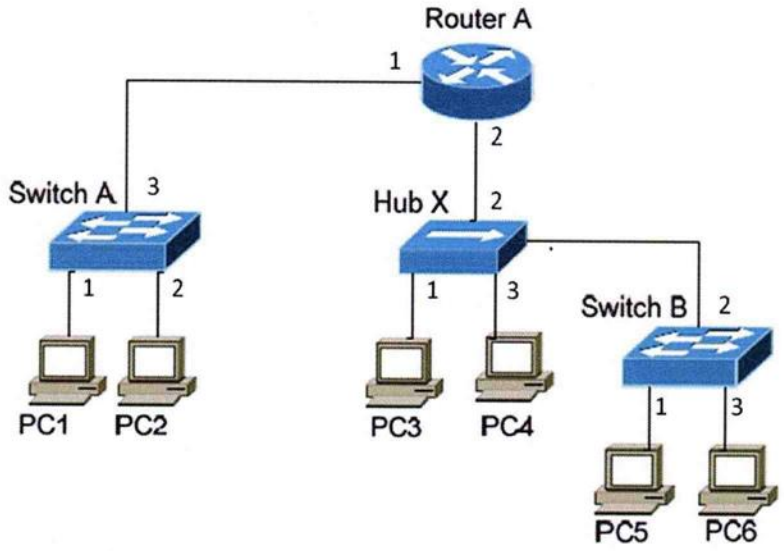
(c) The receiver side signal-to-noise ratio is 40 dB. What is the receiver noise level in dBm?

6. (5 p) Antag att du sänder följande bitsekvens: 1001 1100 1100 0010 0111, men mottagaren utsätts för brus och därför tar emot följande: 1011 1100 1100 0010 0011.

(a) Vad är bit-error rate BER under denna period? (Detta är egentligen en väldigt kort mätperiod, men låt oss ändå anta att ditt BER-värde är en god skattning av bitfelssannolikheten p_e som du behöver veta på resten av uppgiften.)

(b) Vårt system lägger till en felupptäckande kod med kodtakt $c = 0{,}95$, dvs informationstakten I (net bit rate) är 95% av rådatatakten (gross bit rate) R. Den felupptäckande koden används för automatic repeat request (ARQ). Antag att rådatatakten R är 1,6 Mbit/s, och vi behöver överföra en fil på 570 kByte inom en minut. Hur stor packet error rate PER ≈ packet error probability p_p kan vi acceptera utan för många omsändningar, dvs utan att goodput G blir för låg? Man kan visa att goodput G vid ARQ är $G = I\,(1\text{-}p_p)$.

c) Hur stor paketlängd kan vi högst ha för att inte få ett högre värde på paketfelssannolikheten p_p? (Du kan försumma att ARQ-protokollet lägger till overhead till varje paket, inklusive minst en bit för sekvensnummer i headern.)



7. (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?

8. (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

Nedan följer ett urval av de formler som behandlats under kursens gång.

Ljusets hastighet: $c = 3 \cdot 10^8$

"M-ary" digital modulation: $f_b = f_S \log_2 M$

Shannon's formel: $R \leq B \log_2\left(1 + \frac{S}{N}\right)$

Blockfelssannolikhet: $P_{Block} = 1-(1-P_e)^N$ **, där N är blockstorlek (paketstorlek) i bit, och** P_e **är bitfelsannolikheten.**

Signal- till kvantiseringsbrusförhållande: $SQR = \frac{U_{RMS}{}^2}{\Delta U^2 / 12}$

$SQNR_{dB} \approx 6N$ i dB, där N är AD/DA-omvandlarens upplösning i bit.

Entropiformeln: $H(X) = -\sum_{x \in \mathcal{X}} p(x) \log_b p(x).$

Medelvärde av periodiska signaler: $U_0 = \frac{1}{T}\int_0^T u(t)dt$

Effektivvärde (RMS) av periodiska signaler: $U_{RMS} = \sqrt{\frac{1}{T}\int_0^T \left(u(t)\right)^2 dt}$

Effektivvärde av sinusvågor: $U_{RMS} = \frac{\hat{U}}{\sqrt{2}}$

Relation mellan effektivvärde och effekt: $P = U_{RMS}{}^2 / R$

Fourierserieutveckling av periodisk vågform:

$$f(t) = A_0 + A_1 \sin(2\pi ft + \varphi_1) + A_2 \sin(4\pi ft + \varphi_2) + \mathrm{K} + A_n \sin(2\pi nft + \varphi_n)$$

Bruseffekt av vitt brus: $N = N_0 B$ [W] där N_0 är brustätheten i W/Hz och B är bandbredd.

Decibelmått:

Effektförstärkning $G_{dB} = 10 \log \frac{P_{ut}}{P_{in}}$

Spänningsförstärkning $G_{dB} = 20 \log \frac{U_{ut}}{U_{in}}$

Dämpning $A_{dB} = -G_{dB}$

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