Departament d'Enginyeria Telemàtica
entel
UNIVERSITAT POLITÈCNICA DE CATALUNYA

telecom BCN

INTRODUCCIÓ A LES XARXES TELEMÀTIQUES

PROBLEMES AMB SOLUCIÓ

Tema 3 (LAN i WLAN)

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TEMA 3. XARXES D'ÀREA LOCAL.

Exercici 3.1. Consideri una xarxa d'àrea local Ethernet on estan connectats un grup de 20 ordinadors. Consideri que no hi ha pèrdua de capacitat de transmissió per col·lisions. Suposi que cada ordinador envia la mateixa quantitat de bits a cadascun dels altres ordinadors.

Per als següents casos, trobi la velocitat total de transmissió que té disponible cadascun dels ordinadors:

a) Si s'utilitza un hub a 10 Mbps. (Solució: 500 Kbps).

b) Si s'utilitza un switch full-duplex a 100 Mbps. (Solució: 100 Mbps).

c) Si s'utilitza un switch half-duplex a 10 Mbps. (Solució: 5 Mbps).

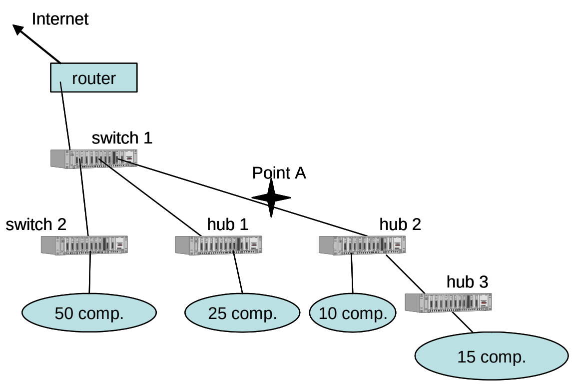
d) Si s'utilitza un switch half-duplex a 10 Mbps i es té en compte que del trànsit total que genera el node, un 10% és broadcast de nivell 2 (per exemple ARP). (Solució: 2,63 Mbps).

Exercici 3.2. Consideri una xarxa d'àrea local (LAN) Ethernet on hi ha connectats un grup de 10 ordinadors. La interconnexió a la LAN es realitza mitjançant un bridge i dos hubs de 10 Mbps. Cada hub connecta la meitat dels ordinadors, i cadascun d'ells està connectat al bridge.

a) Raoni per què serveix en general la seqüència de jamming i quan i com s'utilitzarà en aquesta xarxa d'àrea local.

b) Considerant que no hi ha pèrdua de capacitat de transmissió per col·lisions i que cada ordinador envia la mateixa quantitat de bits a cadascun dels altres ordinadors, trobi la velocitat total de transmissió de què disposa cadascun dels ordinadors. (Solució: 1,28 Mbps).

Exercise 3.3. Taking into account the network of the following figure, which is the occupation level of point A? (Solution: 79,16%).



We know that:

- All Hubs work at 10 Mbps.
- All Switches work at 100 Mbps half-duplex.
- All computers have an outgoing traffic at MAC level equal to 200 Kbps, where:
  - 1% is broadcast.
  - 40% is to Internet.
  - 25% equally shared to other computers of the same group of computers (circle).
  - The rest equally shared to other computers of other groups.

- The router sends 2 Mbps of incoming traffic to the network, equally shared between all computers of the network. Suppose that the router does not send broadcast.

Exercise 3.4. An IEEE 802.11 network has 4 mobile stations (MS), whose packet arrival instants (in μs) are:

MS1 = (0; 936), MS2 = (80), MS3 = (205) and MS4 = (1006).

Moreover, we know the sequence of backoff times that they will take in case they need it (in μs):

B1 = (200; 250), B2 = (250; 400), B3 = (350; 300), B4 = (50; 350).

The system does not use channel reservation and the destination of the data is always the AP. We know that DIFS = 140 μs, SIFS = 40 μs, transmission time of data packets is 368 μs and transmission time of ACK is 188 μs.

Plot the sequence of the transmission of all five packets and compute the total time needed to transmit the packets. (Solution: It lasts 4838 μs).

Considerations for the next exercises:

- MS = Mobile Station; AP = Access Point; BSS = Basic Service Set.
- Consider an averaged backoff after hearing the medium busy and after two consecutive frames of the same MS.
- Suppose that the data transmission is only from MS to AP and that processing and propagation times are negligible.
- Do not consider collisions. Then the backoff does not increment.
- Use header information that you can find at the end of this document.
- Do not use the QoS Control field in the MAC frame.
- Suppose that RTS and CTS are sent at minimum data rate of the used PHY specification.
- IP header = 20 bytes; UDP header = 8 bytes; RTP header = 12 bytes.
- As many calculations will be similar, it is worth to build an Excel table to compute 3.5a and 3.5c, and use it for the rest of the exercises.

Exercise 3.5. Compute the maximum throughput and the link efficiency (Tpayload/Tobservation) for a IEEE WLAN that has a single mobile station (MS) and an access point (AP) in the following cases:

a) 802.11b short format; No RTS/CTS; Data rate = 11 Mbps; Payload length = 1500 bytes. (Solution: Th=7,104 Mbps; Ef=0,646).

b) 802.11b short format; RTS/CTS; Data rate = 11 Mbps; Payload length = 1500 bytes. (Solution: Th=5,890 Mbps; Ef=0,535).

c) 802.11g; No RTS/CTS; Data rate = 54 Mbps; Payload length = 1500 bytes. (Solution: Th=30,926 Mbps; Ef=0,573).

d) 802.11g; RTS/CTS; Data rate = 54 Mbps; Payload length = 1500 bytes. (Solution: Th=23,376 Mbps; Ef=0,433).

e) 802.11g; No RTS/CTS; Data rate = 54 Mbps; Payload length = 100 bytes. (Solution: Th=4,429 Mbps; Ef=0,082).

f) 802.11g; RTS/CTS; Data rate = 54 Mbps; Payload length = 100 bytes. (Solution: Th=2,615 Mbps; Ef=0,048).

g) Same as f) but now the communication is between 2 mobile stations of the same BSS. (Solution: Th=1,307 Mbps; Ef=0,024).

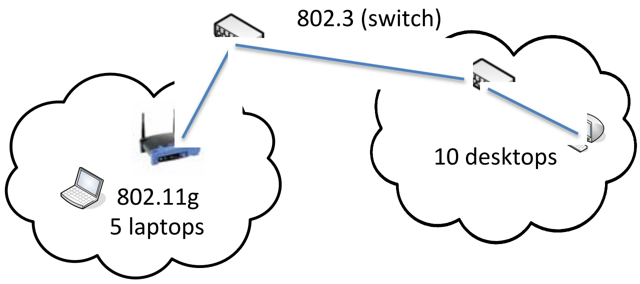
Exercise 3.6. Suppose a BSS working with IEEE 802.11g, No RTS/CTS and data rate = 54 Mbps. Users are maintaining Skype communication with voice flows of 16 Kbps, sending 10 packets/s, with IP-UDP-RTP-Voice encapsulation. How many of such voice flows can a BSS support? Suppose that in each communication one person is inside the BSS and the other is outside. As the medium is supposed to work in saturation conditions, use the average backoff in your calculations. (Solution: Voice flows=496; that is 248 bidirectional conversations).

Exercise 3.7. Suppose a BSS working with IEEE 802.11g, No RTS/CTS and with a payload length = 1500 bytes. Inside the BSS there are two users sending as many packets as possible, one is working with a data rate = 54 Mbps, the other with a data rate = 6 Mbps. What is the throughput of each user? Reason the result. (Solution: Both users have the same throughput, Th=4,58 Mbps).

Exercise 3.8. Suppose a BSS working with IEEE 802.11g and No RTS/CTS. Inside the BSS there are two users sending as many packets as possible, both working with a data rate = 54 Mbps, but one is sending packets with a payload length = 1500 bytes and the other with a payload length = 100 bytes. What is the throughput of each user? Reason the result. (Solution: Th(100 B)=1,40 Mbps; Th(1500 B)=21,10 Mpbs)

Exercise 3.9. Suppose a BSS working with IEEE 802.11g, No RTS/CTS, with a payload length = 1500 bytes and a data rate of 54 Mbps. Inside the BSS there are 3 users sending as many packets as possible towards computers outside the BSS and receiving as many packets as possible from computers outside the BSS. What is the upload throughput and the download throughput of each user? Reason the result. (Solution: Th(upload)=7,731 Mbps; Th(download)=2,578 Mbps).

Exercise 3.10. A company has a computer network with the following topology:



We know that:

- Ethernet network has a data rate of 100 Mbps.
- Each computer transmits 10 packets/second of data towards each one of all other computers.
- Each computer transmits 1 packet/second of broadcast.
- Broadcast packets are transmitted at 6 Mbps using 802.11g.

- Laptops transmit at 54 Mbps using 802.11g.
- Data packets have 1500 bytes of payload.
- Broadcast packets have 500 bytes of payload.
- No RTS/CTS is used.
- As the network will not work under saturation conditions do not consider averaged backoff.

Calculate the utilization (percentage of temporal occupation) of the IEEE 802.11 network. (Solution: 46,42%).

Information about IEEE 802.11:

Standard	DIFS (μs)	SIFS (μs)	SLOT (μs)	CW_{min}	CW_{max}
802.11	50	10	20	32	1024
802.11b	50	10	20	32	1024
802.11a	34	16	9	16	1024
802.11g	28 / 50	10	9 / 20	16	1024
802.11n	28 / 50 (2,4 GHz) 34 (5 GHz)	10 (2,4 GHz) 16 (5 GHz)	9 / 20 (2,4 GHz) 9 (5 GHz)	16	1024
802.11ac	34	16	9	16	1024

Standard	Data rates (Mbps)
802.11	1; 2;
802.11b long	1; 2; 5,5; 11;
802.11b short	2; 5,5; 11;
802.11a	6; 9; 12; 18; 24; 36; 48; 54;
802.11g	6; 9; 12; 18; 24; 36; 48; 54;
802.11n	20 MHz: (from 6,5 Mbps to 288,9 Mbps) [Std 802.11-2012, pag: 1771] 40 MHz: (from 13,5 Mbps to 600 Mbps)
802.11ac	20 MHz: (from 6,5 Mbps to 693,3 Mbps) [Std 802.11ac-2013, pag: 324] 40 MHz: (from 13,5 Mbps to 1600 Mbps) 80 MHz: (from 29,3 Mbps to 3466,7 Mbps) 160 MHz: (from 58,5 Mbps to 6933,3 Mbps)

PHY – 802.11	MAC – 802.11	LLC – 802.2	DATA	FCS

Physical Headers

Standard	Physical header duration
802.11 802.11b (long)	192 μs
802.11b (short)	96 μs
802.11a	26 μs + (22 bits + padding)* in MAC header
802.11g	26 μs + (22 bits + padding)* in MAC header
802.11n	30 μs + variable (depending on the number of MIMO streams) + (variable number of bytes in MAC header)
802.11ac	40 μs + variable (depending on the number of MIMO streams) + (variable number of bytes in MAC header)

*** Assume 3 Bytes in the MAC header**

MAC Headers

Octets:	2	2	6	6	6	2	6	2	4	0–7951	4
	Frame Control	Duration /ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	QoS Control	HT Control	Frame Body	FCS

MAC Header (Frame Control through HT Control)

Figure 8-1—MAC frame format

QoS Control field only if 802.11e/n/ac is used.

HT Control field only in 802.11n/ac.

Octets:	2	2	6	4
	Frame Control	Duration	RA	FCS

MAC Header (Frame Control through RA)

Figure 7-8 ACK frame

Octets:	2	2	6	6	4
	Frame Control	Duration	RA	TA	FCS

MAC Header (Frame Control through TA)

Figure 7-6 RTS frame

Octets:	2	2	6	4
	Frame Control	Duration	RA	FCS

MAC Header (Frame Control through RA)

Figure 7-7 CTS frame

LLC Header

DSAP	SSAP	Control	Protocol Organization	Protocol ID
8 bits	8 bits	8 bits	24 bits	16 bits