S-72.3235 Network Access 3 cr

Exam 13.1.2011
Part A: Closed book tasks (3 tasks)

The examination consists of two parts. When you have done the tasks in Part A (closed book) you should give the answers to the exam supervisor, and then you will get Part B (open book) including 4 problems, out of which 3 best will be graded. You are allowed to use any literature that you feel useful in part B.

You can decide yourself the time you spend with each part, but the total exam duration is 3 h. You can leave the exam room 1 hour after the exam start.

You can answer in Finnish, Swedish or English.

Which homework problems (if any) you have submitted?

Problem A.1
Describe briefly the following concepts/abbreviations/standards

a) Truncking loss (2 p)
b) Binary exponential backoff (BEP) (2 p)
c) IEEE 802.11e (2 p)
d) Collision resolution (2 p)
e) Hidden and exposed node problem (2 p)

Problem A.2
Consider a sensor network where a set of sensors transmit data to a central gateway. The network follows star topology and all sensors are within radio range from each other. The system designer has to make choice between CSMA and TDMA protocol. Consider different cases in terms number of sensors and the traffic patterns of the sensors and give recommendations which MAC should be selected in which case. (10 p)

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Part B: Open book tasks (4 tasks)

There are four problems in this part, out of which three best are taken into consideration in the grading.

You are allowed to use any literature that you feel useful.

You can answer in Finnish, Swedish or English.

Problem B.1

Consider a TDMA system. The channel is subject to fast fading and noise. A MAC layer packet is lost in the channel with probability p. Assume that stop-and-wait ARQ protocol is utilized on the MAC layer for ensuring error free communications. Consider the case, in which the receiver can signal NAK/ACK message before the start of the next frame. If ACK is lost, the packet is retransmitted again, but this won't affect the packet delay directly. However, the unnecessary retransmissions will increase the overall load (channel occupancy) in the system.

a) Determine the probability that retransmission occurs (2 p)
b) Determine the probability density function of the number of time slots it takes to transmit single MAC layer packet (2 p)
c) Determine the probability generating function of the number of slots requires to transmit the packet L(z) (2 p)
d) Determine the Laplace transform of the packet transmission time (service time) distribution L*(s) (2 p)
e) Determine the Laplace transform of the packet delay distribution D*(s) (2 p)

Problem B.2

Consider a circuit-switched IS-95 CDMA system. Network planning is based on the requirement that uplink load η_{ul} stays below η_{ul}^{max}=0.5. The uplink load is given by

$$\eta_{ul} = (1+i)M\alpha \le \eta_{ul}^{max}$$

where M denotes the number of users in a cell, $i=0.5$ denotes the other-to-own cell interference ratio and α=0.1 denotes the load factor.

i) Determine the maximum number of users $M_{\max}$ that a cell can serve if all cells are equally loaded. That is, the factor i is constant. (2 p)

ii) New calls arrive according to Poisson process with intensity λ and calls departure with rate μ.

a) Determine the outage probability in case the capacity is assumed to be fixed in each cell. $\Pr_{out} = \Pr\{M > M_{max}\}$ (3 p)

b) Assume that also the number of users in the neighbouring cells is varying. Now the effective number of uses $(1+i)M$ follows Poisson distribution with parameter $(1+i)\lambda/\mu$. Determine the outage probability $\Pr_{out} = \Pr\{(1+i)M\alpha > \eta_{ul}^{max}\}$

(3 p)

c) Compare the case a) and b) (2 p)

Problem B.3

Consider a multi-channel MAC protocol with common control channel (CCC) for resource reservations. The CCC operates in FDD mode such that requests (REQ) are transmitted with CCC Uplink channel and Acknowledgements (ACK) with CCC Downlink channel. The REQ packets are transmitted using slotted ALOHA protocol. Assume that the number of channels is large such that the capacity is limited by the resource reservation process.

Assume that REQ packets arrive according to Poisson process with intensity g. Transmission of REQ and ACK packet take each one slot of length T_s. The packet length is T_p.

a) Determine the probability that two or more REQ packets collide (5 p)

b) Determine the throughput S of the system (5 p)

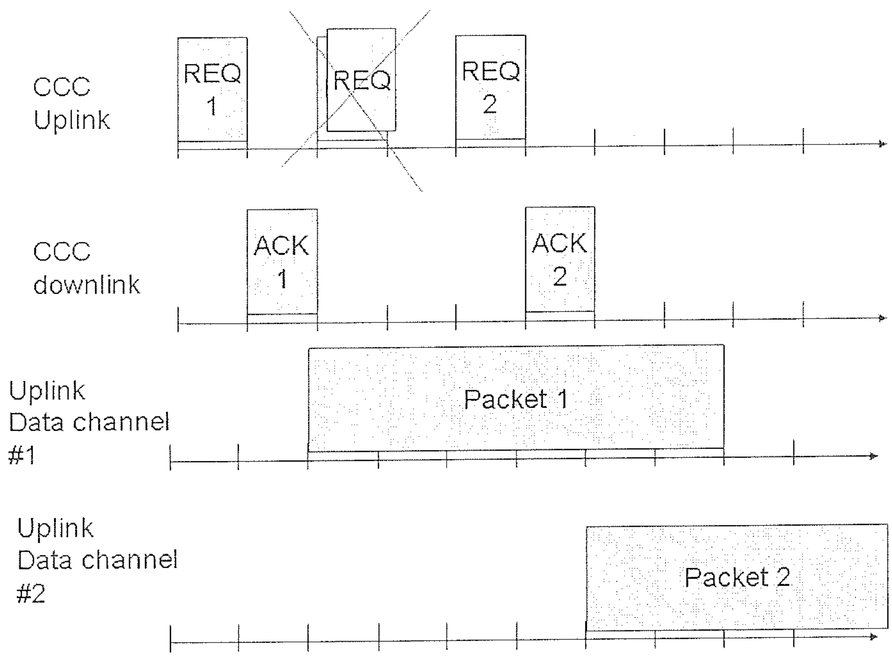

Figure 1. Operation principle of the multi channel MAC.

Problem B.4

Consider the <u>slotted</u> non-persistent CSMA protocol. The sensing slot is equal to the propagation time τ. Packets of length T arrive according to Poisson process with intensity g packets per time unit. Assume that in case two packets collide, there is probability p that one of the packets is still captured by the receiver.

a) Determine the average idle time (2.5)

b) Determine the average busy time (2.5)

c) Determine the probability of successful transmission (2.5)

d) Determine the throughput S. (2.5)

In case you have time, please provide course feedback. Use also the OODI system for giving feedback. Especially, all suggestions how the course could be improved in the future are welcome.

Some useful formulas

$$\sum_{k=0}^{\infty} \frac{x^k}{k!} = e^x, \quad \lim_{n\to\infty}\left(1+\frac{x}{n}\right)^n = e^x$$

$$\sum_{k=0}^{\infty} x^k = \frac{1}{1-x}, \quad |x|<1$$

$$\sum_{k=0}^{\infty} kx^k = \frac{x}{(1-x)^2}, \quad |x|<1$$

$$\sum_{k=0}^{\infty} k^2x^k = \frac{3x^2-2x+1}{(1-x)^2}, \quad |x|<1$$

$$\sum_{k=1}^{K} k = \frac{K(K+1)}{2}$$

$$E\{A|B\} = \frac{E\{A,B\}}{E\{B\}}$$

$N \sim Poisson(\lambda)$:

$$\Pr\{N=n\} = \frac{\lambda^n}{n!}e^{-\lambda}, \quad n = 0,1,2,\ldots$$

$$E\{N\} = \lambda$$

$$E\{N^2\} = 2\lambda$$

$K \sim Geo(p)$:

$$\Pr\{K=k\} = (1-p)^k p, \quad k = 1,2,\ldots$$

$$E\{K\} = \frac{1}{p}$$

$$E\{K^2\} = \frac{2-p}{p^2}$$