S-72.3235 Network Access 3 cr

Exam 3.1.2013
Part A: Closed book tasks (2 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.

Problem A.1
Discuss the issues affecting the performance of the MAC protocols in wireless systems. (10 p)

Problem A.2
Consider a case, in which two operators need to share a bandwidth of 50 MHz. They have three options i) each operator gets 25 MHz excusive band, ii) they set up joint venture to operate the network hardware and act as virtual operators, iii) they use **contention based** access to share the spectrum. Compare the queue stability regions of the three approaches.

(10 p)

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Exam 3.1.2013
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 length of a time slot is T seconds and a single frame consists of N time slots. A single user generates MAC layer packets according to Poisson Process with rate λ packets per seconds.

Assume now that a single MAC layer packet of length T gets lost in the wireless channel with probability p. For simplicity the feedback channel is assumed to be error free such that ACKs or NAKs are never lost. The frame length is much longer than the coherence time of the channel. Hence the number of attempts needed per MAC layer packet is given by geometric distribution. The total message transmission in terms of frames is

$$\tilde{L} = \sum_{i=1}^{\tilde{M}} \tilde{A}_i$$

where

$$\Pr\{\tilde{A}_i = a\} = p^{a-1}(1-p), \quad a = 1,2,3,...,$$

$$\mathrm{E}\{\tilde{A}_i\} = \frac{1}{1-p}$$

$$\mathrm{E}\{\tilde{A}_i^2\} = \frac{p+1}{(1-p)^2}$$

a) Determine the mean packet transmission time $\overline{L}$ and its second moment $\overline{L^2}$. (5 p)

b) Determine the maximum offered load $\rho=\lambda \cdot T$ when the packet error probability in the channel is p=0.04. (5 p)

Problem B.2

Consider a system with N user. Packet transmission time is T and packet generation rate in the system is g packets per T seconds. Determine the mean delay - throughput relation of

a) Slotted ALOHA (4 p)
Assume that both thinking and backlogged users transmit with probability g.

b) TDMA (4 p)
Assume that time frame has N slots. Each user has dedicated time slot. A user generates a packet in a frame of length $N \cdot T$ with probability g.

What can you conclude? (2 p)

Problem B.3

Consider the IEEE 802.11 DCF CSMA/CA protocol with binary exponential backoff (BEB) and RTS-CTS handshake.

a) What are the merits and shortcomings of the BEB? How does the performance relate to protocol that would use optimal back-off window size? (4 p)

b) What are the merits and shortcomings of the RTS-CTS handshake procedure? For what applications it would be suited for? (3 p)

c) Assume that the protocol is used in radio environment that has high packet error probability. How do the packet errors affect the MAC protocol performance? (3 p)

Problem B.4

Consider a system with C orthogonal frequency channels. The transmitter can transmit using only one channel at the time and the receiver needs to select which channel to listen prior to the actual packet transmission.

a) Suggest a contention based MAC protocol that is able to utilize all the C channels. (4 p)

b) Analyze the performance of your protocol. You can assume Poisson arrivals with intensity g packet per time unit or fixed number of users and transmission probability g. (6 p)

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

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

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

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

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

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

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

$N \sim Poisson(\lambda)$:

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

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

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

$K \sim Geo(p)$:

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

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

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