Examination Mobile & Wireless Networking (192620010)
April 11, 2013
13.45 – 17.15

Notes:

- *Only the overhead sheets used in the course, 2 double-sided sheets of notes (any font size/density!), and a dictionary are allowed as reference material. Use of the book by Schiller or any other material is not allowed.*
- *Use of PDA, laptop, mobile phone etc. is not allowed. Please switch off your mobile phone.*
- *Although the questions are stated in English, you may answer in English or Dutch, whichever you are more comfortable with.*
- *Indications like "[10]" at questions mean that you can obtain 10 points for that question.*

Abbreviations

AODV	-	Ad-hoc On-demand Distance Vector
ARQ	-	Automatic Repeat request
CDMA	-	Code Division Multiple Access
CSMA	-	Carrier Sense Multiple Access
CSMA/CA	-	Carrier Sense Multiple Access with Collision Avoidance
CSMA/CD	-	Carrier Sense Multiple Access with Collision Detection
CTS	-	Clear To Send
CW	-	Contention Window
DCF	-	Distributed Coordination Function
DIFS	-	DCF Inter-Frame Space
FDMA	-	Frequency Division Multiple Access
FEC	-	Forward Error Corrections
GSM	-	Global System for Mobile Communication
IEEE	-	Institute of Electrical and Electronics Engineers
LTE	-	Long Term Evolution
OFDMA	-	Orthogonal Frequency Division Multiple Access
QoS	-	Quality of Service
RREQ	-	Route REQuest
RTS	-	Request To Send
SIFS	-	Short Inter-Frame Space
TDMA	-	Time Division Multiple Access
UMTS	-	Universal Mobile Telecommunication System

1 Cellular Systems [14]

a) In a cellular system, what is the effect of increasing the location area size on the volume of signaling traffic for the location update procedure? And for the paging procedure? [3]

b) Explain how the reuse distance in a cellular system is affected by the required signal to interference ratio of the mobile receiver. [3]

c) Why can the reuse distance be decreased when sectorized antennas are used? [2]

Wireless systems, in particular cellular systems, are always limited in the number of simultaneous active users they can support. This limit is mainly determined by some scarce resource that has to be allocated to users for their communication. Assume a single base station that can use a given frequency band. Further, for simplicity assume that all active users use the same average data rate.

d) What is limiting the number of users that can be supported in a TDMA/FDMA system, such as GSM? Does the location of active users in the cell have an effect on this? If yes, how? If no, why not? [2]

e) What is limiting the number of users in a CDMA system, such as UMTS? Does the location of active users in the cell have an effect on this? If yes, how? If no, why not? [2]

f) What is limiting the number of users in an OFDMA system such as LTE? Does the location of active users in the cell have an effect on this? If yes, how? If no, why not? [2]

2 LTE [10]

a) LTE is based on OFDMA. Explain the basic principles of OFDMA. What is the essential difference between OFDMA and FDMA? Explain the meaning of the word "orthogonal" in the acronym. [3]

b) The bandwidth used by an LTE system can vary from 1.4 MHz to 20 MHz. What is are the advantages of this flexible bandwidth? How does the LTE system realize its bandwidth flexibility? [2]

c) What is the role of the scheduling function in LTE? It is mentioned in the lecture slides that for LTE scheduling a trade-off exists between efficiency on the one hand, and fairness / QoS on the other hand. Explain this trade-off. [2]

d) In the article in the reader about LTE, some practical limitations (constraints) for LTE scheduling are listed. For each of the mentioned limitations, repeated below, describe briefly how it influences LTE scheduling: [3]
- Uplink limitations: contiguous sub-channels
- Control overhead for signaling resource block allocation
- Resolution of channel info
- Energy consumption

3 Medium Access Control / Hybrid ARQ [12]

a) What is the essential difference between Aloha and CSMA? What are the advantages of CSMA, and why can it not always be used? [3]

b) Why can CSMA/CD, as used in Ethernet not be used in Wireless Systems? [2]

c) Explain the hidden terminal problem. [2]

d) To what extent is *hidden terminal* a problem in Bluetooth? Consider potential problems both within a piconet and between piconets. [2]

e) Explain the concept of (Type II) Hybrid ARQ. How does it work? What is the advantage of Hybrid ARQ over a system using just FEC or just ARQ? [3]

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4 Wireless LAN [14]

a) In the IEEE 802.11 CSMA/CA access mechanism, how does a station know if a frame it transmits experiences a collision or not? [2]

b) Why does the IEEE 802.11 CSMA/CA access mechanism use a number of different inter-frame spaces, such as SIFS and DIFS. [2]

In the following subquestions, we explore the IEEE 802.11 CSMA/CA access mechanism further. We make the following assumptions: 1 slot = 20 μs; SIFS = 10 μs; DIFS = 2 slots + SIFS; CW_{min} = 7 slots; CW_{max} = 255 slots; transmission of a complete data frame takes 1000 μs; transmission of a complete acknowledgement frame takes 250 μs; propagation delay is negligible, no transmission errors occur, and no RTS/CTS is used. Now, suppose two stations A and B want to transmit a data frame to an access point.

c) How large is the probability that a collision occurs between the frames from A and B if the medium is idle when station A starts the access procedure, and station B starts the access procedure 20 μs after station A? Explain your answer. [2]

d) How large is the collision probability if station A and B start the access procedure at exactly the same time, when the medium is idle? Explain your answer. [2]

e) What is the collision probability if station A and B start the access procedure at exactly the same time, and the medium is still busy (used by some third station) at this time? Explain your answer. [2]

Let us now consider the maximum access delay for these two stations, A and B. We again assume that both stations have (only) one data frame to transmit, and that the medium is busy at the moment they start the access procedure. A while later, at a time that we will denote as t_0, the medium becomes idle. We consider the case that no collision occurs, i.e., that one of the stations, let's say A, gets access to the channel first.

f) What is the maximum (worst case) delay from the moment the medium becomes idle until the moment that the first node, A, gets access to the channel (starts transmitting its data frame)? Explain your answer. [2]

g) What is the maximum delay from the moment the medium **first** becomes idle (t_0) until the moment that the second node, B, gets access to the channel? Note that this delay includes the time that the medium is busy because of the transmission of node A. Explain your answer. [2]

5 Ad-hoc Networks [12]

a) Explain what the principles are of proactive and reactive routing protocols and under what circumstances one is better than the other. [2]

b) Explain why the fact that ad-hoc networks often contain many redundant links is considered a problem for routing protocols in general? Explain in detail how redundant links make standard link state protocols less efficient in ad-hoc networks. [3]

c) In AODV, why does a route request (RREQ) packet contain a `broadcast_id` field? What is it used for? [2]

d) In AODV, a route request (RREQ) packet contains a `source_sequence_number` and a `destination_sequence_number` field. What are these sequence numbers used for? Why does a RREQ contain both a `source_sequence_number` and a `destination_sequence_number`? [3]

e) Explain why a routing table in AODV contains an entry `active neighbours`. [2]

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