Examination Mobile & Wireless Networking (192620010)
October 30, 2014
13.45 – 16.45

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

ACK	-	ACKnowledgement
AIFS	-	Arbitrary Inter-Frame Space
AODV	-	Ad-hoc On-demand Distance Vector
ARQ	-	Automatic Repeat reQuest
CSMA	-	Carrier Sense Multiple Access
CTS	-	Clear To Send
CW	-	Contention Window
DIFS	-	DCF Inter-Frame Space
EDCA	-	Enhanced Distributed Channel Access
eNodeB	-	Evolved Node B (LTE Base Station)
EPS	-	Evolved Packet System
FDM	-	Frequency Division Multiplexing
FEC	-	Forward Error Correction
GPRS	-	General Packet Radio Service
GTP	-	GPRS Tunneling Protocol
IEEE	-	Institute of Electrical and Electronics Engineers
IP	-	Internet Protocol
LAN	-	Local Area Network
LTE	-	Long Term Evolution
OFDM	-	Orthogonal Frequency Division Multiplexing
OVSF	-	Orthogonal Variable Spreading Factor
PDN	-	Packet Data Network
PGW	-	PDN GateWay
QoS	-	Quality of Service
RREQ	-	Route REQuest
RTS	-	Request To Send
SIFS	-	Short Inter-Frame Space
TXOP	-	Transmit OPportunity
UE	-	User Equipment
UMTS	-	Universal Mobile Telecommunication System

1 General [18]

a) Why is reflection of radio waves both useful and harmful in a wireless system such as LTE? [2]

b) Explain the basic principles of OFDM in your own words. In your answer, also explain why OFDM systems suffer less from Inter-Symbol Interference (compared to other systems with the same data rate), and explain the essential difference between OFDM and traditional FDM. [4]

c) In wireless systems, e.g., Wireless LAN, the user throughput is often lower than specified in the standards. For each of the following factors, describe how, why, an to what extent they affect the throughput as experienced by a user: (i) distance to the access point, (ii) other users using the same access point, (iii) other users using a different access point, (iv) IP packet length. [4]

d) To what extent is pose hidden terminals a problem in systems that use carrier sensing (CSMA)? And in Aloha? Explain your answer. [3]

e) Compare Hybrid ARQ to standard ARQ and to FEC. Under which conditions does Hybrid ARQ have better performance than the others, and why? [3]

f) In UMTS, is the OVSF code 1, 1, -1, -1, -1, -1, 1, 1 orthogonal to 1, 1, -1, -1? [1]

g) In UMTS, is the OVSF code 1, 1, -1, -1, -1, -1, 1, 1, -1, -1, 1, 1, 1, 1, -1, -1 orthogonal to 1, 1, -1, -1? [1]

2 Cellular systems and LTE [14]

a) What are the advantages and disadvantages of having small cells in cellular systems, compared to large cells? [3]

b) What are the advantages and disadvantages of having small tracking (or paging) areas in a cellular system? [3]

c) In the protocol stack for user-plane protocols of the LTE core network (Evolved Packet System, EPS), one can identify 2 IP layers. IP is used between PDN GateWay (PGW) and base station (eNodeB). IP is also used between the PGW and the mobile (User Equipment, UE). Tunneling (GPRS Tunneling Protocol, GTP) is used to carry the upper IP layer packets in the lower IP-layer packets. What is the most important reason to use two IP layers and tunneling? [2]

d) 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]

e) 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: [4]
- Uplink limitations: contiguous sub-channels
- Control overhead for signaling resource block allocation
- Resolution of channel info
- Energy consumption

3 Wireless LAN [14]

a) Describe exactly how, and to what extent the RTS/CTS mechanism avoids the hidden terminal problem in IEEE 802.11 Wireless LANs. [3]

b) In Wireless LAN, many packet types, including RTS and CTS have a "duration" field. What is it used for, and is this field specified in time (μs) and not in bits? [2]

c) In Wireless LAN, if the medium is found busy on first access, regular data packets are only transmitted after the medium has been sensed free for a DIFS period plus a random number of back-off slots. Why are some packets, e.g., ACK and CTS already sent after sensing the medium free for a SIFS period, which is shorter than a DIFS period? What is the reason that for regular packets a random delay is added, whereas these special packets are sent immediately after the free SIFS period? [3]

d) Explain why and under which circumstances fragmentation of data packets helps to improve user-level throughput. [2]

e) The IEEE 802.11e Enhanced Distributed Channel Access (EDCA) provides differentiation between different access categories, by means of four different parameters: (`AIFS`, CW_{min}, CW_{max}, and `TXOP limit`). Suppose that we have an 802.11e system with two sending stations A and B, with each 1 transmission queue, filled with packets. For each of the differentiation parameters, describe precisely what happens in the system when station A has a higher value for the parameter than station B (and the 3 other parameters are the same). Will A have an advantage, compared to B or a disadvantage? Why? (Note that you will have to provide 4 answers, one for each differentiation parameter). [4]

4 Ad-hoc Networks [12]

a) In the lecture slides, it is mentioned that an important problem of multihop broadcasting is the broadcast storm problem. Three causes are mentioned for this problem: redundant transmissions, synchronization of transmissions, and lack of feedback from the medium. Explain for each of these causes how it affects the broadcasting, and how it contributes to the broadcast storm problem. [3]

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

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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