Examination Mobile & Wireless Networking (192620010)
April 12, 2017
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 Bear and Stalling, the reader, or any other material is not allowed.*
- *Use of a calculator is allowed but not really needed.*
- *Use of PDA, laptop, mobile phone etc. is not allowed. Please switch off your mobile phone.*
- *Indications like "[10]" at questions mean that you can obtain 10 points for that question.*

Abbreviations

ACK	-	ACKnowledgement
AODV	-	Ad-hoc On-demand Distance Vector
CDMA	-	Code Division Multiple Access
CSMA/CA	-	Carrier Sense Multiple Access with Collision Avoidance
CTS	-	Clear To Send
CW	-	Contention Window
Dest	-	Destination
DIFS	-	DCF Inter-Frame Space
e-NodeB	-	evolved Node B
FDD	-	Frequency Division Duplex
FDM	-	Frequency Division Multiplexing
FDMA	-	Frequency Division Multiple Access
IEEE	-	Institute of Electrical and Electronics Engineers
LAN	-	Local Area Network
LPL	-	Low Power Listening
LTE	-	Long Term Evolution
NodeB	-	Node B
OFDM	-	Orthogonal Frequency Division Multiplexing
QAM	-	Quadrature Amplitude Modulation
RREQ	-	Route REQuest
RTS	-	Request To Send
Rx	-	Receiver
SIFS	-	Short Inter-Frame Space
TDD	-	Time Division Duplex
Tx	-	Transmitter

1 General / Wireless Transmission [9]

a) Explain, in your own words the hidden terminal problem. [2]

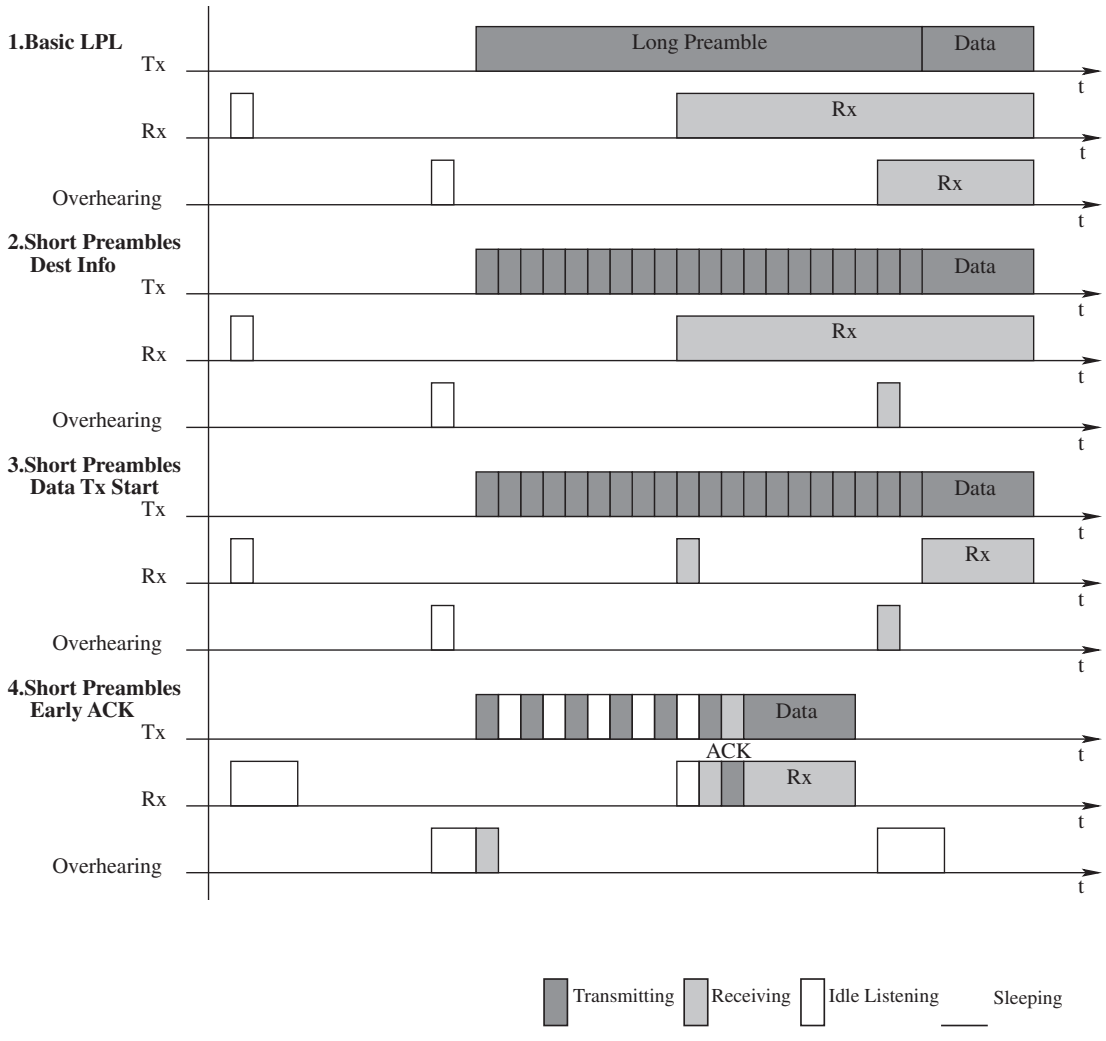
b) Which problem is solved by (space) diversity? Why is the distance between two antennas used for this type of diversity typically half the wavelength of the frequency band used? [2]

c) 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. [3]

d) Suppose we have a system that uses OFDM with 1000 subcarriers of 10 kHz in a 10 MHz band. What will be the symbol time of the system? Why? Assuming the use of 16 QAM, what would be the raw bit rate of the system? [2]

2 Medium Access Control [11]

In the picture below the operation of 4 different Preamble Sampling Protocols is shown.



a) Explain the operation of protocol 1, as shown in the picture (Basic Low Power Listening). Explain the behavior of the transmitter (Tx), the receiver (Rx), and the overhearers. [3]

b) How long should the length of the preamble be? Is there a relation between the length of the preamble and the time between two successive listen periods at the receiver? If yes, which? If not, what other considerations play a role in the choice of the preamble length? [2]

c) Explain how and why the behavior of the **transmitter** for protocol 4 (Short Preambles Early ACK) is different from protocol 1 2, and 3. [2]

Fast Channel-Dependent Scheduling may increase the throughput of a wireless system compared to a regular scheduling method (such as Round Robin). At the same time, there is a risk that it decreases fairness of the system.

d) Explain how Fast Channel-Dependent Scheduling may increase the throughput of a system, compared to regular scheduling. [2]

e) Explain how Fast Channel-Dependent Scheduling could decrease fairness of a system. Explain in your own words how the Proportional Fair Scheduling variant tries to avoid this decrease of fairness. [2]

3 Cellular Systems [15]

a) With reasoning explain the logical relationship between each pair of the following words:

1) Cell area & paging procedure [1]

2) Cell area & co-channel interference [1]

3) Soft-handover & rate of handover [1]

4) TDD/FDD & interference [1]

5) Cell breathing & FDMA/CDMA [1]

6) Network capacity & reuse factor [1]

b) What are the two main differences between NodeB and eNodeB? [2]

c) Why is there a difference between uplink and downlink transmission in LTE? [2]

d) What does the concept of a Bearer in LTE refer to? [1]

e) An area of 1300 square Km^2 is covered by a cellular system using a 7-cell reuse pattern. Each cell has a circular radius of 4 Km. For the covered area the spectrum of 40 MHz is allocated with a full duplex channel bandwidth of 60 kHz. Assume a grade of service of 2% for an Erlang B system is specified. Compute the following. (Round numbers to the lower integer):

1) The number of cells in the service area, [1]

2) The number of channels per cell, [1]

3) Traffic intensity of each cell, [1]

4) The maximum carried traffic. [1]

4 Wireless LAN [11]

The IEEE 802.11 standard for Wireless LAN does allow its transmitters to choose from different modulation schemes, resulting in different available bit rates. Typically adapting the modulation type dynamically allows for exploiting the current channel quality better, and can improve the throughput compared to a system with a fixed modulation type.

a) Design and describe a (throughput-increasing) mechanism where a transmitter dynamically adapts the modulation type without requiring the exchange of extra packets or fields in packets (compared to the packet that have been discussed in the course). [3]

b) Describe how the design in the previous subsection could be improved by exchanging additional information between receiver and transmitter. [2]

In the following exercises, we explore the IEEE 802.11 CSMA/CA access mechanism. We make the following assumptions: 1 slot = 20 μs; SIFS = 10 μs; DIFS = 2 slots + SIFS; CWmin = 7 slots; CWmax = 255 slots; transmission of a complete data frame takes 1000 μs; transmission of a complete acknowledgement frame, an RTS frame or a CTS frame takes 250 μs; propagation delay is negligible, no transmission errors occur, and RTS/CTS is used. Now, suppose two stations A and B want to transmit a data frame to an access point. The access point and all other stations do not have any data to transmit.

c) How large is the probability that a collision occurs between the RTS messages from A and B if station A and B start the access procedure at exactly the same time, when the medium is idle? Explain your answer. [2]

d) 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]

e) Now, suppose A has successfully sent its RTS packet to the access point because it has chosen a smaller number of slots from its contention window than B. What is the probability that the CTS packet returned by the access point is colliding with the RTS packet of B. Explain your answer. [2]

5 Ad-hoc networks [10]

a) In an article of the reader, it is mentioned that an important problem of multihop broadcasting in ad-hoc networks 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) Suppose that a source node has just sent a `RREQ` message to find a path to a certain destination (which we will refer to as `RREQ` 1). Now, the source node wants to simultaneously find a path to a different destination, and sends out a new `RREQ` (`RREQ` 2) with a different `Dest_Addr` field. For each of the following fields in the `RREQ` message, describe how the value in `RREQ` 2 relates to the value in `RREQ` 1 (e.g., is the same, is larger, is different, is not related), and explain why: [3]

- `Broadcast_ID`

- `Source_Seq#`

- `Dest_Seq#`

----- end of exam -------

P(B) = Trunks	0.005	0.01	0.015	0.02	0.03	0.05	0.07	0.1
81	63.574	66.293	68.158	69.648	72.059	75.838	79.007	83.297
82	64.481	67.223	69.104	70.608	73.042	76.856	80.057	84.390
83	65.387	68.153	70.051	71.568	74.024	77.874	81.107	85.484
84	66.295	69.085	70.999	72.529	75.007	78.893	82.157	86.578
85	67.204	70.016	71.947	73.491	75.991	79.912	83.207	87.672
86	68.113	70.949	72.896	74.453	76.975	80.932	84.258	88.767
87	69.023	71.882	73.846	75.416	77.959	81.952	85.309	89.861
88	69.933	72.816	74.796	76.379	78.944	82.972	86.360	90.956
89	70.844	73.750	75.746	77.342	79.929	83.993	87.411	92.051
90	71.756	74.685	76.697	78.306	80.915	85.014	88.463	93.146
91	72.669	75.621	77.649	79.271	81.901	86.035	89.515	94.242
92	73.582	76.557	78.601	80.236	82.888	87.057	90.568	95.338
93	74.496	77.493	79.553	81.202	83.875	88.079	91.620	96.434
94	75.411	78.431	80.506	82.167	84.862	89.101	92.673	97.530
95	76.326	79.368	81.460	83.134	85.850	90.123	93.726	98.626
96	77.242	80.307	82.414	84.101	86.838	91.146	94.779	99.722
97	78.158	81.245	83.368	85.068	87.827	92.169	95.833	100.819
98	79.075	82.185	84.323	86.036	88.815	93.193	96.887	101.916
99	79.993	83.125	85.279	87.004	89.805	94.217	97.941	103.013
100	80.911	84.065	86.235	87.972	90.794	95.240	98.995	104.110

Erlang B table