

**MSc Examination**

**Friday 16th May 2014      10:00 - 12:30**

**ECS702P Mobile and WLAN Technologies      Duration: 2 hours 30 minutes**

**YOU ARE NOT PERMITTED TO READ THE CONTENTS OF THIS QUESTION PAPER UNTIL  
INSTRUCTED TO DO SO BY AN INVIGILATOR**

**Answer **TWO** questions of PART A AND TWO questions of  
PART B.**

**If you answer more questions than specified (in each part), only the first two questions (in the order they appear on your answer script) will be marked unless you have crossed out any answers you do not wish to be marked.**

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**EXAM PAPERS MUST NOT BE REMOVED FROM THE EXAM ROOM**

**Examiners: Prof. Xiaodong Chen and Dr Eliane L. Bodanese**

**PART A**

**Question 1**

a) Explain Flat fading and frequency selective fading. Describe their impacts on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

**[6 marks]**

b) With the help of diagrams, explain how the Direct Sequence Spread Spectrum (DSSS) works and the processing gain.

**[6 marks]**

c) Describe the operation of CSMA/CA, with the help of a diagram if necessary.

**[6 marks]**

d) Explain why the RTS/CTS Protocol is devised in the IEEE802.11 standard.

**[7 marks]**

**Question 2**

a) Describe three options of the Physical layer in the IEEE802.11 standard.

**[6 marks]**

b) Describe in detail the power management in IEEE802.11.

**[7 marks]**

c) Describe the main features in the IEEE802.11ac proposal.

**[6 marks]**

d) Describe the main features of three operation modes in IEEE802.11n standards.

**[6 marks]**

**Question 3**

a) Describe the Radio Specification of Bluetooth 2.0.

**[6 marks]**

b) With the help of a diagram, explain how data transaction is done in the Bluetooth Low Energy standard (4.0).

**[7 marks]**

c) Describe the network topology used in WiMedia.

**[6 marks]**

d) Explain the attributes of Zigbee system.

**[6 marks]**

## PART B

## Question 4

- a) Considering the basic cellular operation for mobile initialisation, i.e. when the mobile station is turned on by the user, briefly describe the general steps that occur from the moment the mobile station is turned on up to the stage the mobile station enters the *idle* state, if there is cellular service available. (Tip: base your answer on the first generation steps that are the simplest to explain.)

[4 marks]

- b) **Error! Reference source not found.** shows a section of the Erlang B Table. Assume a cell receives on average 390 calls per hour, the mean holding time of a call is 120 seconds and the grade of service is 0.02. Consider Table 1 to answer the following questions appropriately:

- Calculate the offered traffic in the cell.
- How many channels does the cell need if an omni directional antenna is used?
- Considering the offered traffic is uniformly distributed inside the cell, how many channels does the cell need if six 60 degree directional antennas are used?
- Calculate the trunking efficiency for both cases (i.e. items ii) and iii) ).

[11 marks]

**Blocked-Calls-Cleared  
(Erlang B)**

N	A, erlangs												
	B												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.9	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.53	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2

Table 1: Erlang B table

c) Considering the frequency planning of a FDMA/TDMA cellular network, answer the following questions.

- i) Calculate the *cochannel reuse ratio* ( $D/R$ ) for a cellular network with 12 cells per cluster.
- ii) Explain the steps to assemble the frequency reuse layout and the values of the *shift parameters* for these 12 cells per cluster cellular network.

[7 marks]

d) Considering the basic cellular operation for the mobile initialisation, i.e. when the mobile station is turned on by the user, briefly describe the general steps that occur from the moment the mobile station is turned on up to the stage the mobile station enters in the *idle* state, if there is cellular service available. (Tip: base your answer in the first generation steps that are the simplest to explain)

[3 marks]

### Question 5

a) **Error! Reference source not found.** shows the *Registration Procedure* in GSM. Some of the steps will use different GSM channels.

- i) For each step that uses a GSM channel, identify the step and the respective GSM channel used.
- ii) Briefly describe the functionality of each different identified GSM channel (Note: describe the functionality of each different GSM channel only once, even if it is used in more than one step).

[ 7 marks]

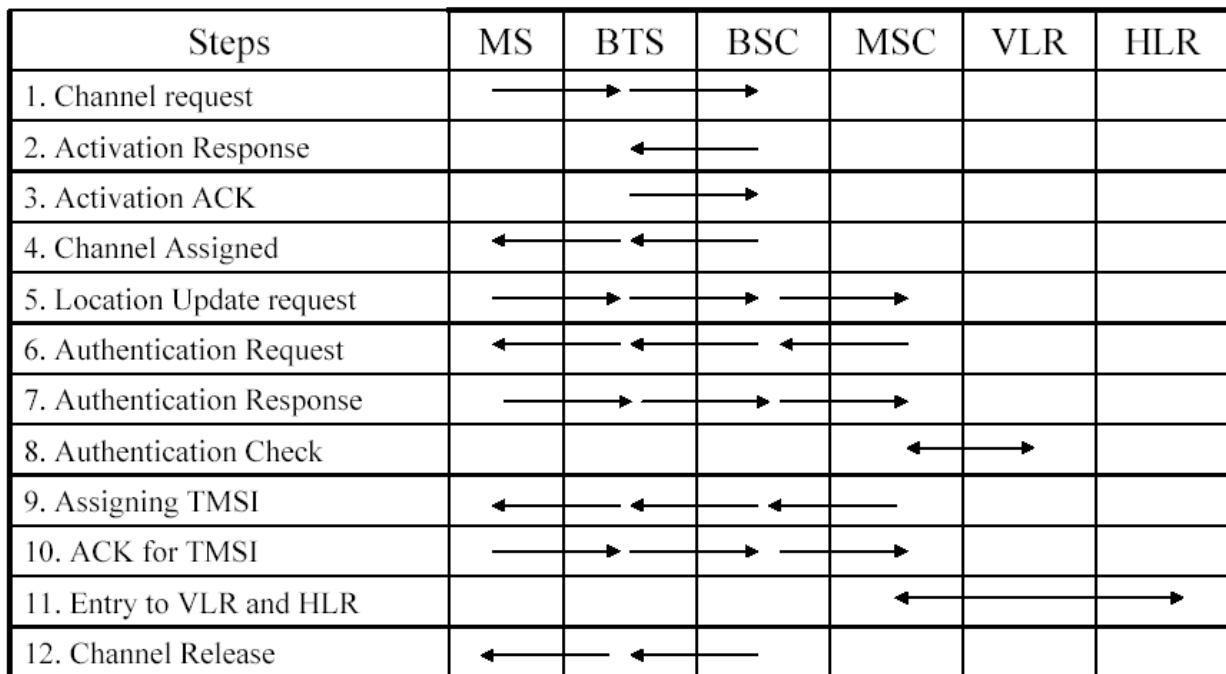


Figure 1: Registration Procedure in GSM

- b) Describe the concept of **Soft Handoff** and also describe the characteristics of the *special receiver* that makes soft handoff possible.

[10 marks]

- c) Supply the appropriate words to complete the blanks (1 to 12) in the following sentences about the GSM system (**Note: write your answers in the answer book and NOT on this page**).

GSM uses \_\_\_\_\_(1) as multiple access technique. The GSM spectrum provides \_\_\_\_\_(2) different frequency carriers, because a guard band is left between the first and the last carrier. Each frequency carrier in GSM occupies a frequency band of \_\_\_\_\_(3) accommodating \_\_\_\_\_(4) logical channels in it. Each logical channel is defined by the repetitive occurrence of \_\_\_\_\_(5) each one of them has an approximate duration of 0.577ms. In a GSM full rate traffic channel, the payload data is encrypted in blocks of \_\_\_\_\_(6) bits. The capacity in kbps of a full rate traffic channel is \_\_\_\_\_(7), this value takes in consideration that in \_\_\_\_\_(8) frames occurring in a \_\_\_\_\_(9) ms multi-frame, \_\_\_\_\_(10) slots are used for other purposes which are: \_\_\_\_\_(11) and the \_\_\_\_\_(12) logical channel.

[6 marks]

- e) Cite two of the different logical channels that can be used to transmit **Short Messaging Services** (SMS) messages.

[2 marks]

**Question 6**

a) Explain inner/closed (fast) power control as used in UMTS.

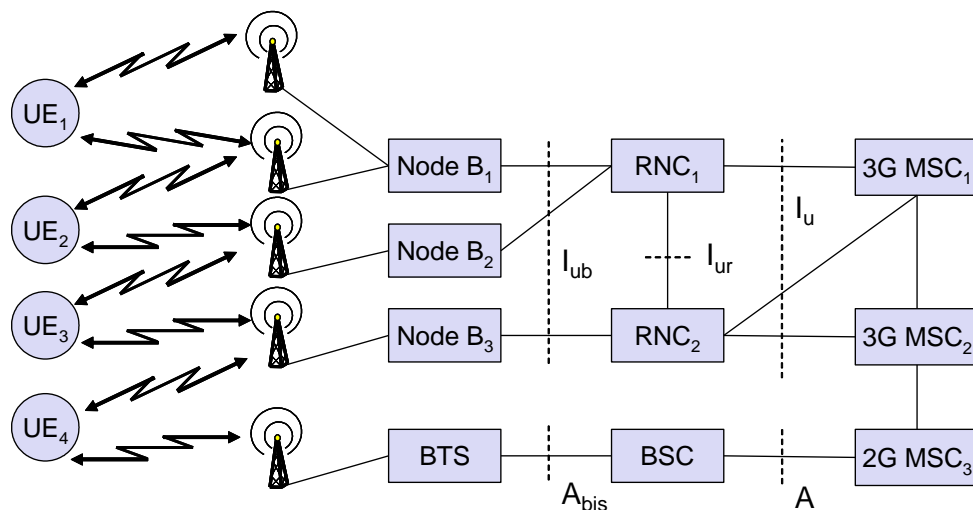
[4 marks]

b) Sketch the GPRS network architecture and describe in detail the GPRS supporting nodes.

[6 marks]

c) Figure 3 gives an overview of several types of handover in a combined UMTS/GSM network. Indicate what type of handover UE2 is performing and describe this type of handover.

[4 marks]



**Figure 3: Handovers in UMTS**

d) Answer the following questions about HSDPA:

- State the changes made in layer 1 (L1) that make the HSDPA increase the downlink packet data throughput.
- What architectural component is responsible for the actions you answered in item i) and also for the fast link adaptation?
- In UMTS, the transport channel carrying the user data with HSDPA operation, which is called High Speed Downlink Shared Channel (HS-DSCH), behaves differently than a Dedicated Channel (DCH) in terms of power control, variable spread coding and handoff. Explain these differences.

[6 marks]

- e) Supply the appropriate words to fill the blanks in the following sentences about HSUPA concepts and general functionality (**Note: write your answer in the answer book and NOT on this page**):

The technologies applied with HSUPA improve the \_\_\_\_\_ (1) packet data performance by means of fast physical layer (L1) \_\_\_\_\_ (2) and transmission \_\_\_\_\_ (3), as well as fast Node B \_\_\_\_\_ (4). HSUPA general functionality: The \_\_\_\_\_ (5) estimates the data rate transmission needs of each active HSUPA user based on the device-specific \_\_\_\_\_ (6); The scheduler in the \_\_\_\_\_ (7) then provides instruction to devices on the \_\_\_\_\_ (8) link data rate to be used at a fast pace depending on the \_\_\_\_\_ (9) received before, the scheduling algorithm and the \_\_\_\_\_ (10) prioritisation scheme.

**[5 marks]**

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**End of Paper**



**MSC Examination by course unit**

**Wednesday, 20 May 2015 10:00 am**

**ECS702P/U/D Mobile and WLAN Technologies Duration: 2 hours 30 minutes**

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**Examiners:**

Xiaodong Chen

Eliane Bodanese

**PART A**

**Question 1**

a) Explain the Rayleigh and Rician fading, respectively. Describe their impacts on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

**[6 marks]**

b) With the help of diagrams, explain how the Frequency Hopping Spread Spectrum (FHSS) works and what processing gain is.

**[6 marks]**

c) Explain three ALOHA Access techniques in wireless data networks. What are their main disadvantages?

**[6 marks]**

d) What are hidden terminals? Explain in detail how this problem is solved in the IEEE802.11 standard?

**[7 marks]**

**Question 2**

a) Describe the Physical layer specification in the IEEE802. 11a, 11b and 11g standards, respectively.

**[6 marks]**

b) Describe in detail the handoff process in IEEE802.11.

**[7 marks]**

c) Describe the improvements on security being made in IEEE802.11i.

**[6 marks]**

d) Describe the main improvements being made in IEEE802.11n standards.

**[6 marks]**

**Question 3**

a) Explain the network topology and access methods in Bluetooth.

**[6 marks]**

b) Describe the main features of the Bluetooth Low Energy standard.

**[7 marks]**

c) Describe the security improvement made in Bluetooth 2.1

**[6 marks]**

d) Describe the main features of Zigbee

**[6 marks]**

**PART B****Question 4**

a) Complete the blanks for each of the following (**write your answers in the answer book and NOT on this page**):

- i) In traffic engineering, assume a cell receives on average 630 calls per hour, the mean holding time is 120 seconds, and the grade of service is 2%. Therefore, the offered traffic in the cell is \_\_\_\_\_ (1) and the dimensionless unit is \_\_\_\_\_ (2). If the number of channels needed for this offered traffic is 28 channels, the corresponding trunking efficiency is \_\_\_\_\_ (3).
- ii) In a FDMA/TDMA system, there are two types of frequency interference. The first type is the *cochannel interference* and the second type is the \_\_\_\_\_ (1) *channel interference*. Depending of the value of the *cochannel reuse ratio* the network will have different number of cells per cluster. For example, if the *cochannel reuse ratio* is 6, the number of cells per cluster will be \_\_\_\_\_ (2). In order to avoid the second type of frequency interference, the assigned frequencies for the channels of a cell have maximum possible \_\_\_\_\_ (3) and sectorization can also help.

**[9 marks]**

b) Considering the importance of power control in cellular networks, answer the following questions.

- i) Explain Open Loop Power Control.
- ii) Why is Power Control so important in CDMA systems?

**[8 marks]**

c) Explain the multiple access technique used in GSM systems and cite the name of the random access method used in GSM .

**[4 marks]**

d) Considering basic cellular operation for mobile initialisation, i.e. when the mobile station is turned on by the user, briefly describe the general steps that occur from the moment the mobile station is turned on, up to the stage where the mobile station enters the *idle* state when there is cellular service available. (Tip: base your answer on the first generation steps which are the simplest to explain)

**[4 marks]**

**Question 5**

a) Answer the following questions about Short Messaging Services (SMS):

- i) Which network component is responsible for controlling the Short Messaging Services?
- ii) Cite the two SMS types of services?
- iii) Cite 2 different logical channels that can be used to transmit SMS messages?

**[5 marks]**

b) Supply the appropriate words to fill the blanks (1 to 10) in the following sentences (**write your answer in the answer book and NOT on this page**):

Security in GSM is implemented to prevent fraud via \_\_\_\_\_ (1) of the subscriber, not revealing the subscriber number over the air, and by \_\_\_\_\_ (2) the conversations to avoid eavesdropping. The SIM card has a microprocessor chip that can perform the computations required for security purposes. A \_\_\_\_\_ (3) key Ki is stored on the SIM card, and it is unique to the card. This key is used in two proprietary algorithms: A3 for \_\_\_\_\_ (4) and A8 for \_\_\_\_\_ (5). Ki is used in a \_\_\_\_\_ (6) response protocol using the A3 algorithm between the BSS/MSC and the MS. Ki is used to generate a privacy key \_\_\_\_ (7) that is used to \_\_\_\_\_ (8) messages (voice or data) using the A8 algorithm. Finally, the control channel signals are also \_\_\_\_\_ (9) to avoid eavesdropping by using a third algorithm called \_\_\_\_ (10).

**[5 marks]**

c) Supply the appropriate words to complete the blanks (1 to 12) in the following sentences about the GSM system (**write your answers in the answer book and NOT on this page**).

GSM uses \_\_\_\_\_ (1) as a multiple access technique. The GSM spectrum provides \_\_\_\_\_ (2) different frequency carriers, and a guard band is left between the first and the last carrier. Each frequency carrier in GSM occupies a frequency band of \_\_\_\_\_ (3) accommodating \_\_\_\_\_ (4) logical channels in it. Each logical channel is defined by the repetitive occurrence of \_\_\_\_\_ (5) each one with an approximate duration of 0.577ms. In a GSM full rate traffic channel, the payload data is encrypted in blocks of \_\_\_\_\_ (6) bits. The capacity in kbps of a full rate traffic channel is \_\_\_\_\_ (7), this value takes into consideration that in \_\_\_\_\_ (8) frames occurring in a \_\_\_\_\_ (9) ms multi-frame, \_\_\_\_\_ (10) slots are used for other purposes which are: \_\_\_\_\_ (11) and the \_\_\_\_\_ (12) logical channel.

**[6 marks]**

d) Explain why the concept of conventional frequency reuse and planning found in FDMA and TDMA systems is not used for a CDMA system.

**[5 marks]**

e) Describe how the capacity of a single CDMA cell can be calculated.

**[4 marks]**

## Question 6

a) Explain the **outer loop power control** used in UMTS.

[4 marks]

b) Figure 1 gives an overview of several types of handover in a combined UMTS/GSM network. Indicate what handover UE1 is performing and describe this type of handover.

[4 marks]

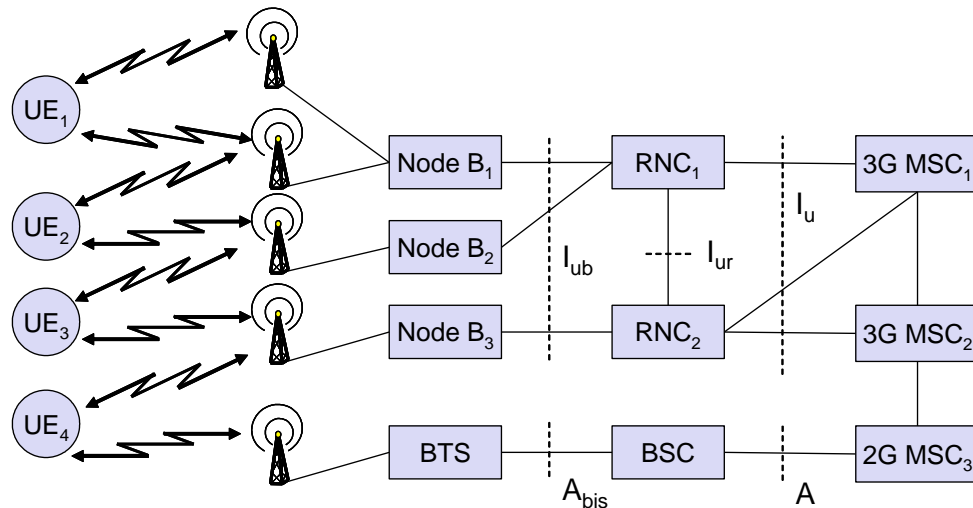


Figure 1: Handovers in UMTS

c) Explain the main concept of HSUPA and give an illustration of the general functionality of HSUPA.

[7 marks]

d) Answer the following questions about HSDPA:

- What does HSDPA stand for?
- Cite one of the means used by HSDPA to increase downlink data throughput.
- What radio entity was mainly modified to cope with and control HSDPA channels?
- Two important features of UMTS channels are disabled in HSDPA channels. Cite one of them.

[4 marks]

e) Sketch the GPRS network architecture and describe in more detail the GPRS supporting nodes.

[6 marks]



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End of Paper

Turn Over

**MSC Examination by course unit**

**Tuesday, 10 May, 2016, 2:30 pm**

**ECS702P Mobile and WLAN Technologies**

**Duration: 2 hours 30 minutes**

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**PART A**

**Question 1**

a) Explain Flat fading and frequency selective fading. Describe their impacts on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

**[6 marks]**

b) With the help of diagrams, explain how Direct Sequence Spread Spectrum (DSSS) works and what the processing gain is.

**[6 marks]**

c) Describe how CDMA works, with the help of diagrams if necessary.

**[6 marks]**

d) The RTS/CTS Protocol is defined to solve a problem in the IEEE802.11 standard. Describe the problem and explain how the RTS/CTS Protocol solves it.

**[7 marks]**

**Question 2**

a) Describe how OFDM works, with the help of diagrams if necessary.

**[6 marks]**

b) Describe in detail the power management in IEEE802.11.

**[7 marks]**

c) Describe the main features in the IEEE802.11ac proposal.

**[6 marks]**

d) Explain how the WLAN security is improved in WPA2.

**[6 marks]**

**Question 3**

a) Describe the Radio Specification of Bluetooth 2.0.

**[6 marks]**

b) With the help of a diagram, explain how data transaction is done in the Bluetooth Low Energy standard (4.0).

**[7 marks]**

c) Describe the network topology used in WiMedia.

**[6 marks]**

d) Explain what makes Zigbee a competing technology in the Wireless World.

**[6 marks]**

## PART B

## Question 4

- a) Assume a cell receives on average 360 calls per hour, the mean holding time of a call is 120 seconds and the grade of service is 0.02. Considering Table 1, answer the following questions.
- Calculate the offered traffic in the cell.
  - How many channels are needed in this cell if an omnidirectional antenna is used?
  - Considering the offered traffic is uniformly distributed inside the cell, how many channels does the cell need if three 120 degree directional antennas are used?
  - Compare and comment on the channel utilisation efficiency in sub-questions ii and iii.

[12 marks]

<b>Blocked-Calls-Cleared (Erlang B)</b>													
<i>N</i>	<i>A</i> , erlangs												
	<i>B</i>												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.9	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.53	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2

Table 1: Erlang B table

**Question 4 continued**

b) Given the following *number of cells per cluster*, find the respective ***cochannel reuse ratio***.

- i) *Number of cells per cluster* = 3.
- ii) *Number of cells per cluster* = 12.

[4 marks]

c) With the help of a diagram, describe four possible schemes in searching for a candidate cell in the handoff procedure.

[5 marks]

d) What is the carrier to interference ratio and how can it be calculated?

[4 marks]

**Question 5**

a) Describe how the capacity of a single CDMA cell can be calculated and supply an example considering an SIR between 3dB and 9dB, a data transmission rate of 9600bps and the carrier bandwidth used in IS-95.

[6 marks]

b) Describe the functionality of the Rake receiver in CDMA systems.

[6 marks]

c) Sketch the GSM/GPRS reference architecture and explain the function of the GPRS entities.

[8 marks]

d) Describe the operation of a Mobile Terminated ***Short Messaging Service*** (SMS) in GSM.

[5 marks]

## Question 6

- a) Supply the appropriate words to fill the blanks in the following sentences about the UMTS system (**Note: write your answer in the answer book and NOT on this page**):

UMTS uses \_\_\_\_\_ (1) as its multiple access technique. Each frequency carrier in UMTS occupies a frequency band of 4.4 to \_\_\_\_\_ (2) MHz. \_\_\_\_\_ (3) power control is a very important aspect in UMTS, in particular in the uplink, because of the \_\_\_\_\_ (4) problem. \_\_\_\_\_ (5) power control mechanisms make a rough estimate of path loss by means of a downlink beacon signal. In \_\_\_\_\_ (6) power control, the BS performs frequent estimates of the received Signal-to-Interference Ratio (SIR) in the \_\_\_\_\_ (7) and compares it to a target SIR. If the measured SIR is higher than the target SIR, the BS will command the MS to \_\_\_\_\_ (8) the power; if it is too low it will command the MS to \_\_\_\_\_ (9) its power. \_\_\_\_\_ (10) power control adjusts the target SIR in the BS according to the needs of the individual radio link.

[5 marks]

- b) With the help of a diagram, explain how the soft-handover works in UMTS.

[7 marks]

- c) Figure 1 gives an overview of several types of handovers in a combined UMTS/GSM network. Indicate what type of handover UE3 is performing and describe this type of handover.

[6 marks]

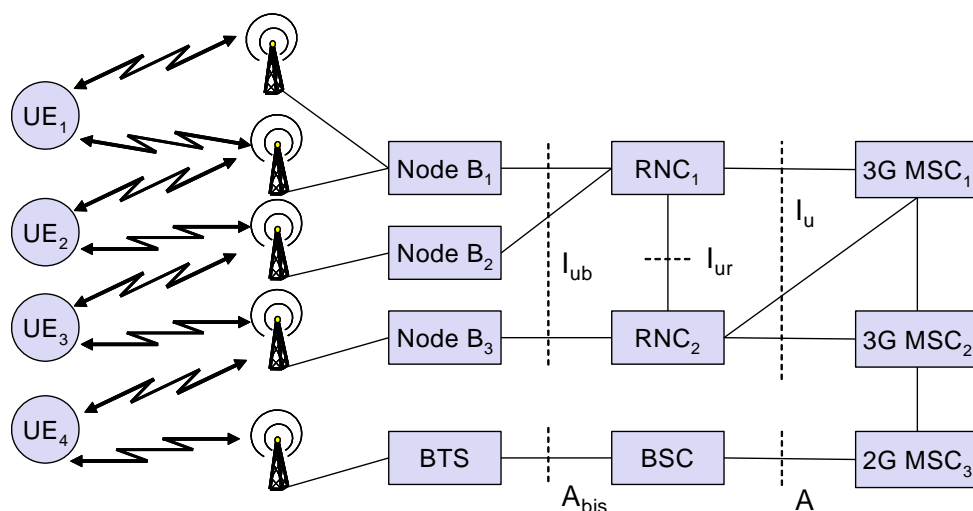


Figure 1: Handovers in UMTS

**Question 6 continued**

- d) Explain the main concept of HSDPA and give a simple illustration of the general functionality of HSDPA.

**[7 marks]**

---

**End of Paper**





**MSC Examination by course unit**

**Wednesday 3 May 2017 2:30 pm**

**ECS702P Mobile and WLAN Technologies**

**Duration: 2 hours 30 minutes**

**YOU ARE NOT PERMITTED TO READ THE CONTENTS OF THIS QUESTION PAPER UNTIL  
INSTRUCTED TO DO SO BY AN INVIGILATOR**

**There are SIX questions. Answer only Four questions.**

**If you answer more questions than specified, only the first answers (up to the specified number) will be marked.**

**Cross out any answers that you do not wish to be marked.**

Calculators are permitted in this examination. Please state on your answer book the name and type of machine used.

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**EXAM PAPERS MUST NOT BE REMOVED FROM THE EXAM ROOM**

**Examiners:**

Xiaodong Chen

Eliane Bodanese

**Question 1**

a) Explain Rayleigh and Rician fading, respectively. Describe their impacts on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

**[6 marks]**

b) Assume a cell receives on average 360 calls per hour, the mean holding time of a call is 120 seconds and the grade of service is 0.03. Considering Table 1, answer the following questions.

i) Calculate the offered traffic in the cell.

ii) How many channels are needed in this cell if an omnidirectional antenna is used?

iii) Considering the offered traffic is uniformly distributed inside the cell, how many channels does the cell need if six 60 degree directional antennas are used?

iv) Compare and comment on the channel utilisation efficiency in sub-questions ii and iii.

**[15 marks]****Blocked-Calls-Cleared  
(Erlang B)**

N	A, erlangs												
	B												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.9	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.53	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2

**Table 1: Erlang B table**

**Question 1 continue**

- c) Given the following *number of cells per cluster*, find the respective ***cochannel reuse ratio***.
- i) *Number of cells per cluster* = 4.
- ii) *Number of cells per cluster* = 7.

**[4 marks]****Question 2**

- a) Describe the Physical layer specification in the IEEE802. 11a, 11b and 11g standards, respectively.

**[6 marks]**

- b) Describe in detail the handoff process in IEEE802.11.

**[6 marks]**

- c) What are hidden terminals? Explain in detail how this problem is solved in the IEEE802.11 standard?

**[7 marks]**

- d) Describe the main improvements being made in IEEE802.11n standards.

**[6 marks]**

**Question 3**

a) Explain the network topology and access methods in Bluetooth.

[6 marks]

b) With the help of a diagram, explain how the data transaction is done in the Bluetooth Low Energy standard (4.0).

[7 marks]

c) Describe the security improvement made in Bluetooth 2.1.

[6 marks]

d) With the help of diagrams, explain how the Frequency Hopping Spread Spectrum (FHSS) works and what the processing gain is.

[6 marks]

**Question 4**

a) Describe the operation procedure in the mobile terminated call in the GSM system.

[6 marks]

b) Answer the following questions related to Short Messaging Services (SMS) in GSM:

i) Explain briefly the architecture of **Short Messaging Service** (SMS) in GSM;

ii) Describe the operation of a Mobile Terminated SMS in GSM.

[6 marks]

c) Considering the importance of power control in cellular networks, answer the following questions.

i) Explain Open Loop Power Control used in the IS-95 system.

ii) Why is Power Control so important in CDMA systems?

[7 marks]

d) Describe how the capacity of a single CDMA cell can be calculated and supply an example considering an SIR between 4dB and 10dB, a data transmission rate of 9600bps and the carrier bandwidth used in IS-95 (the channel bandwidth is 1.25MHz).

[6 marks]

## Question 5

a) Explain the **outer loop power control** used in UMTS.

[4 marks]

b) Figure 1 gives an overview of several types of handover in a combined UMTS/GSM network. Indicate what handover  $UE_i$  ( $i=1 - 4$ ) is performing and describe this type of handover.

[13 marks]

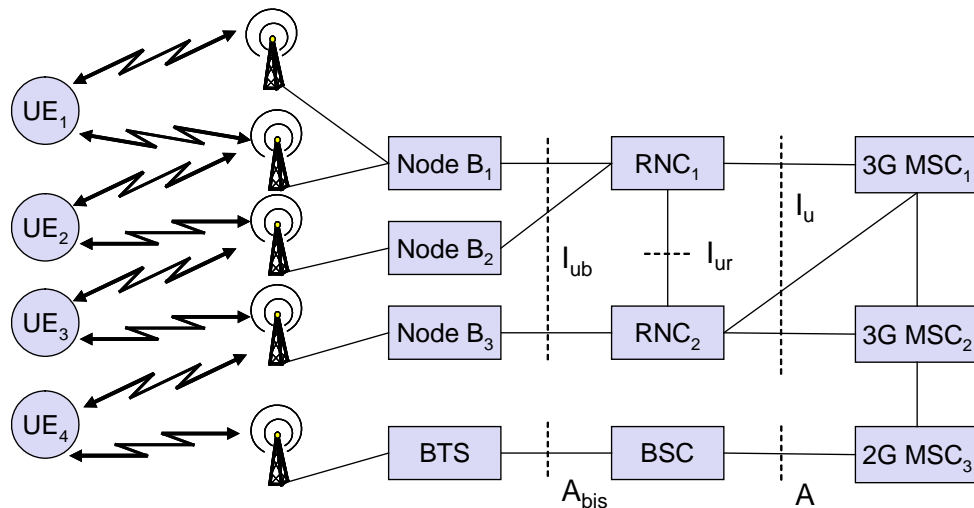


Figure 1: Handovers in UMTS/GSM Network

c) Sketch the GPRS network architecture and describe in detail two GPRS supporting nodes.

[8 marks]

**Question 6**

a) What are the improvements deployed in HSDPA.

**[7 marks]**

b) Describe the general functionality of HSUPA.

**[4 marks]**

c) With the help of diagrams, explain how the OFDMA works in LTE downlinks.

**[8 marks]**

d) Explain in detail the Carrier Aggregation in the LTE-A standard.

**[6 marks]**

---

**End of Paper**

**Main Examination Period 2018**

**ECS702P Mobile and WLAN Technologies      Duration: 2 hours 30 minutes**

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INSTRUCTED TO DO SO BY AN INVIGILATOR**

## **Answer FOUR questions**

**If you answer more questions than specified, only the first answers (up to the specified number) will be marked. Cross out any answers that you do not wish to be marked**

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**EXAM PAPERS MUST NOT BE REMOVED FROM THE EXAM ROOM**

**Examiners: Prof Xiaodong Chen and Dr Eliane L. Bodanese**

## Question 1

a) Explain Flat fading and frequency selective fading. Describe their impact on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

[6 marks]

b) Assume a cell receives on average 360 calls per hour, the mean holding time of a call is 120 seconds and the grade of service is 0.02. Considering Table 1, answer the following questions.

i) Calculate the offered traffic in the cell.

ii) How many channels are needed in this cell if an omnidirectional antenna is used?

iii) Considering the offered traffic is uniformly distributed inside the cell, how many channels does the cell need if three 120 degree directional antennas are used?

iv) Compare the channel utilisation efficiency in sub-questions ii and iii.

[14 marks]

<b>Blocked-Calls-Cleared (Erlang B)</b>													
N	A, erlangs												
	B												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
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5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
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11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2

Table 1: Erlang B table

Continues on next page...



- c) Given the following *number of cells per cluster*, find the respective ***cochannel reuse ratio***.
- i) *Number of cells per cluster* = 3.
  - ii) *Number of cells per cluster* = 12.

[5 marks]

**Question 2**

a) Explain how OFDM works, with the help of diagrams if necessary.

**[6 marks]**

b) Describe briefly three options of the Physical layer in the IEEE802.11 standard.

**[6 marks]**

c) Describe the main features in the IEEE802.11ac proposal.

**[4 marks]**

d) Explain how the WLAN security is improved in WPA2.

**[5 marks]**

e) Explain what hidden terminals are, with the help of a diagram if necessary.

**[4 marks]**

**Question 3**

a) Describe the Radio Specification of Bluetooth 2.0.

**[6 marks]**

b) With the help of a diagram, explain how the data transaction is done in Bluetooth Low Energy standard (4.0).

**[5 marks]**

c) Briefly describe the security improvement made in Bluetooth 2.1.

**[4 marks]**

d) With the help of diagrams, explain how the Frequency Hopping Spread Spectrum (FHSS) works.

**[6 marks]**

e) Explain the network topology and access methods in Bluetooth.

**[4 marks]**

**Question 4**

a) Answer the following questions in the GSM system.

- i) How many time slots are used in a TDMA frame?
- ii) How many cells are adopted in a cluster? How many sectors are divided in a cell?
- iii) What are the HLR and VLR?
- iv) What kind of random access method is used when a Mobile Station wants to access to GSM system?
- v) Explain what kind of power control is used in the GSM system.

**[8 marks]**

b) Answer the following questions related to Short Messaging Services (SMS) in GSM:

- i) Explain briefly the architecture of **Short Messaging Service** (SMS) in GSM;
- ii) Describe the operation of a Mobile Terminated SMS in GSM.

**[7 marks]**

c) Describe the functionality of the Rake receiver in CDMA systems.

**[5 marks]**

d) Describe how the capacity of a single CDMA cell can be calculated and supply an example considering an SIR between 3dB and 9dB, a data transmission rate of 9600bps and the carrier bandwidth used in IS-95 (the channel bandwidth is 1.25MHz).

**[5 marks]**

## Question 5

- a) Supply the appropriate words to fill the blanks in the following sentences about the UMTS system (**Note: write your answer in the answer book and NOT on this page**):

UMTS system uses W-CDMA as its multiple access technique. \_\_\_\_\_ (1) power control is a very important aspect in UMTS, in particular in the uplink, because of the near-far problem. \_\_\_\_\_ (2) power control mechanisms make a rough estimate of path loss by means of a downlink beacon signal. In \_\_\_\_\_ (3) power control, the BS performs frequent estimates of the received Signal-to-Interference Ratio (SIR) in the \_\_\_\_\_ (4) and compares it to a target SIR. If the measured SIR is higher than the target SIR, the BS will command the MS to lower the power; if it is too low it will command the MS to increase its power. \_\_\_\_\_ (5) power control adjusts the target SIR in the BS according to the needs of the individual radio link.

[5 marks]

- b) With the help of a diagram, explain how the soft-handover works in UMTS.

[6 marks]

- c) Figure 1 gives an overview of several types of handover in a combined UMTS/GSM network. Indicate what handover UE<sub>3</sub> is performing and describe this type of handover.

[6 marks]

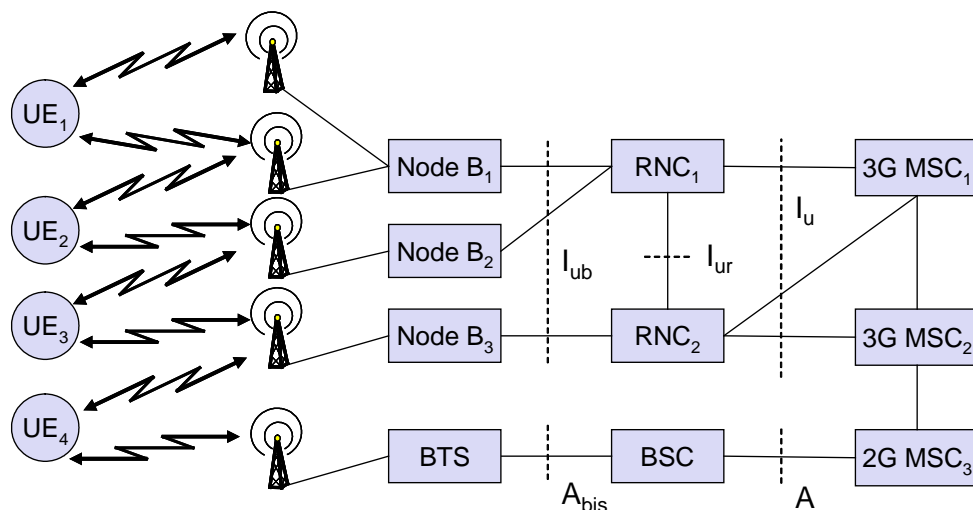


Figure 1: Handovers in UMTS

- d) The GPRS network is built on the GSM network to provide data services.

- Sketch the GPRS network architecture and name two key nodes;
- Describe the functions of two GPRS supporting nodes.

[8 marks]

Turn Over

**Question 6**

a) Describe the general functionality of HSUPA.

**[4 marks]**

b) Answer the following questions about HSDPA:

i) What does HSDPA stand for?

ii) Describe the means used by HSDPA to increase downlink data throughput.

iii) What radio entity was modified mainly to cope with and control HSDPA channels?

iv) Cite two important features of UMTS channels that are disabled in HSDPA channels.

**[6 marks]**

c) With the help of diagrams, explain how the OFDMA works in LTE downlinks.

**[8 marks]**

d) With the help of diagrams, describe the handover procedure in the LTE-A standard.

**[7 marks]**

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**End of Paper**

**Main Examination Period 2019**

**ECS702P Mobile and WLAN Technologies      Duration: 2 hours 30 minutes**

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**Examiners: Prof Xiaodong Chen and Dr Maged Elkashlan**

## Question 1

a) Explain Rayleigh and Rician fading. Describe their impact on the wireless channel, with the help of a sketch of BER vs  $E_b/N_0$  curves.

[6 marks]

b) Assume a cell receives on average 360 calls per hour, the mean holding time of a call is 120 seconds and the grade of service is 0.03. Considering Table 1, answer the following questions.

i) Calculate the offered traffic in the cell.

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iii) Considering the offered traffic is uniformly distributed inside the cell, how many channels does the cell need if six 60 degree directional antennas are used?

iv) Compare the channel utilisation efficiency in sub-questions ii and iii.

[14 marks]

**Blocked-Calls-Cleared  
(Erlang B)**

N	A, erlangs												
	B												
	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.39	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.75	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.53	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2
17	9.65	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2

Table 1: Erlang B table

Continues on next page...



- c) Given the following *number of cells per cluster*, find the respective ***cochannel reuse ratio***.
- i) *Number of cells per cluster* = 4.
  - ii) *Number of cells per cluster* = 7.

[5 marks]

**Question 2**

a) Describe briefly the Physical layer specification in the IEEE802. 11a, 11b and 11g standards, respectively.

**[6 marks]**

b) Describe in detail the handoff process in IEEE802.11.

**[7 marks]**

c) Answer the following questions about WLAN.

i) What are hidden terminals in WLAN?

ii) Explain in detail how the hidden terminal problem is solved in the IEEE802.11 standard.

**[5 marks]**

d) Describe briefly the main improvements being made in IEEE802.11n standards.

**[3 marks]**

e) Describe the network topology in Bluetooth 2.0.

**[4 marks]**

**Question 3**

a) Answer the following questions related to Short Messaging Services (SMS) in GSM:

- i) Explain briefly the architecture of **Short Messaging Service** (SMS) in GSM;
- ii) Describe the operation of a Mobile Terminated SMS in GSM.

**[7 marks]**

b) Considering the importance of power control in cellular networks, answer the following questions.

- i) Explain Open Loop Power Control used in the IS-95 system.
- ii) Why is Power Control so important in CDMA systems?

**[7 marks]**

c) Describe how the capacity of a single CDMA cell can be calculated and supply an example considering an SIR between 4dB and 10dB, a data transmission rate of 9600bps and the carrier bandwidth used in IS-95 (the channel bandwidth is 1.25MHz).

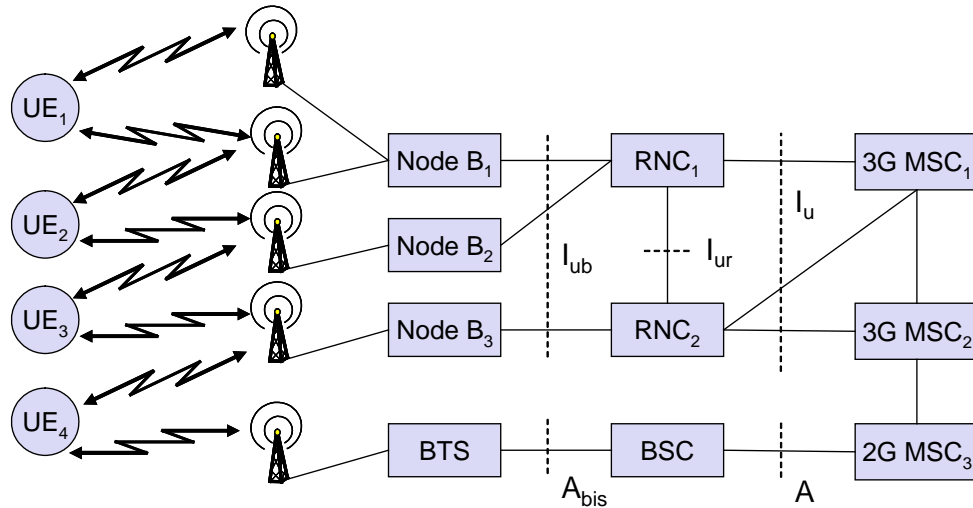
**[5 marks]**

d) The GPRS network is built on the GSM network to provide data services. Sketch the GPRS network architecture and name two key nodes.

**[6 marks]**

**Question 4**

- a) Figure 1 gives an overview of several types of handover in a combined UMTS/GSM network. Indicate what handover  $UE_i$  ( $i=1 - 4$ ) is performing and describe this type of handover.

**[14 marks]**

**Figure 1: Handovers in UMTS/GSM Network**

- b) Answer the following questions about HSDPA:

- What does HSDPA stand for?
- Explain how the transmission latency is improved in HSDPA.
- What radio entity is modified mainly to cope with and control HSDPA channels?
- What is the improvement made on the transmission error control in HSDPA.

**[6 marks]**

- c) Explain in detail the Carrier Aggregation in the LTE-A standard.

**[5 marks]**