

NATIONAL UNIVERSITY OF SINGAPORE

CS4222: Wireless Networking

(SEMESTER 2: AY 2017/2018)

Final Assessment

Time Allowed: 2 Hours

INSTRUCTIONS TO STUDENTS

1. Please write your Student Number only. Do not write your name.
2. This assessment paper contains SEVEN (7) questions and comprises TEN (10) printed pages.
3. Students are required to answer ALL questions.
4. Answer **ALL** questions within the box in this booklet.
5. This is an OPEN BOOK assessment.

STUDENT NUMBER: _____

This portion is for examiner's use only

| Question | Score | Marks | Question | Score | Marks |
|----------|-------|-------|----------|-------|-------|
| (1) | | 6 | (5) | | 10 |
| (2) | | 10 | (6) | | 12 |
| (3) | | 6 | (7) | | 10 |
| (4) | | 6 | | | |
| Total | /60 | | | | |

Question 1 (6pt)

(a) (2pt) What is the length of the half-wave dipole antenna for the frequency band at 45GHz.

(b) (2pt) Identify one important difference between 1G and 2G cellular networks. Explain the significance of this difference.

(c) (2pt) Identify one important difference between 2G and 3G cellular networks. Explain the significance of this difference.

Question 2 (10pt)

Consider a cellular system where the radius of each cell is 1km and the minimum reuse distance is 3km.

(a) (2pt) What is the smallest channel reuse factor (N) that can be used to maximize the number of calls/channels that can be supported per cell?

(b) (2pt) The total spectrum allocated is 20MHz and each simplex channel takes up 20kHz. Each simplex channel can be further divided into 12 TDM channels. If the same 600 TDM duplex channels are reserved for control across all cells, what is the average number of duplex TDM channels that can be supported in each cell? You should use the value of N calculated in part (a).

(c) (2pt) If the average number of duplex TDM channels supported by a cell needs to be increased by a factor of 2, what is the maximum possible N ?

- (d) (4pt) If the radius of each cell is reduced to 0.5km while the minimum reuse distance remains at 3km, does the total number of duplex TDM channels supported by the system increase or decrease?

Question 3 (6pt)

For each of the following applications, explain what is the most appropriate MAC protocol that should be used. Explain your choice.

(a) (2pt) Web browsing

(b) (2pt) VoIP

(c) (2pt) Low rate control traffic and carrier sensing is not performed.

Question 4 (6pt)

Assume a neighbor discovery scheme whereby time is divided into slots.

- (a) (2pt) In this scheme, a node decides to wake up at each time slot with some probability. Assume there are two nodes A and B. Node A and B wake up in each time slot with probabilities 0.02 and 0.04 respectively. What is the likelihood that A and B will meet in less than or equal to 10 time slots?

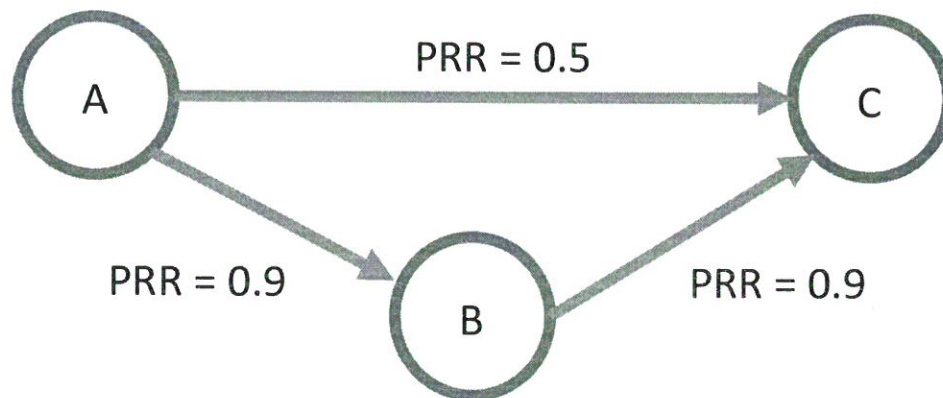
- (b) (4pt) Design an asynchronous discovery scheme such that two nodes with maximum duty cycles of 0.01 and 0.02 will be guaranteed to meet within a deterministic time. Explain how your scheme works.

Question 5 (10pt)

There are 2 sensor nodes. Node A senses data every 5s and then transmits the sensed data, of size 50 bytes, to node B. Assume that B-MAC and the IEEE 802.15.4 radio (bit rate is 250Kbps) are used. With B-MAC, receiver wakes up every 250ms to sample the channel for 5ms. The transmission, reception/listening and idle states draw 20mA, 10mA and 0.1mA respectively. Finally, assume that the time and energy used for sensing are negligible. Consider two possible approaches. (1) Node A transmits the data to B as soon as it sensed the data, and (2) node A stores the data and transmits all sensed data to node B every 50s. You can assume that a node can transmit all the packets buffered in a single cycle.

- (a) (8pt) Calculate the average current drawn (in mA) **of node B** for both approaches. Which approach is more energy efficient?

- (b) (2pt) What is the drawback of the more energy efficient approach?

Question 6 (12pt)

- (a) (4pt) In the figure above, there are two paths between A and C. There is a 1-hop path (A->C) and a 2-hop path (A->B->C). The packet reception ratios (PRR) of the links are indicated beside the links. Assume that up to 3 link retransmissions are allowed on each link, calculate the end-to-end path PRR. Based on end-to-end path PRR, what path would you pick?

- (b) (4pt) Compare your choice in part (a) to that based on selecting the path with the smallest ETX. What is/are the difference(s)?

- (c) (4pt) Why is using constant beaconing period to discover neighbors not a good option? How does CTP [1] address this problem?

[1] O. Gnawali et. al. "Collection Tree Protocol," ACM Sensys, 2009.

Question 7 (10pt)

You would like to choose a wireless technology for your IoT application that is low power, long range and can support a large number of devices communicating to a base station at very low bit rate.

(a) (2pt) Which frequency range should this wireless technology be using? Justify your answer.

(b) (4pt) Which MAC protocol would likely be used? Justify your answer.

(c) (4pt) Given the two choices made in (a) and (b), what is the expected bit rate range supported per device? Justify your answer.

End-of-Paper