Wireless Networking

Course code: CS4222/5422, Tutorial session: #8

Brief Instructions regarding the tutorial session

1. The attendance to tutorial sessions would contribute towards the determination of final grade
2. Please review the questions before coming to the tutorial session
3. Make an effort to solve the questions before attending tutorial. The teaching assistants will help in case of issues
4. The designated time for the tutorial session is one hour. Please contact the teaching assistants or the instructor if you need any further clarification regarding the tutorials outside the allocated period. Please send them an email.

Question 1: A node running BMAC spends its time in the following 4 states: (1) sleeping (consumes 1mW), (2) idle listening (consumes 10mW), (3) receiving (consumes 20mW), and (4) transmission (consumes 20mW). Note that in the idle listening state, a node detects channel activity but does not receive data. In the receiving state, there is actual packet reception. By default, the node wakes up every 250ms to sample the channel for a duration of 5ms. Every 5s, the node transmits or receives a packet with equal probability. Packet transmission or reception duration is always 5ms. On average, what is the percentage of the energy spent on:

a) sleeping
b) idle listening
c) receiving
d) transmission

If the battery used provides 1 KJ of energy, what is the lifetime of the node?

Question 2: Assume you have an IoT device equipped with ZigBee, LoRa, and Wi-Fi radios, powered by a coin cell battery with a capacity of 240 mAh. Given the radio configurations below, please calculate the energy per bit for each technology. Based on the results, discuss the advantages and disadvantages of each wireless communication method.

Communication Technology	Bitrate	Transmit Current (mA) @ 3 V
Wi-Fi (802.11b)	11 Megabits/ second	170 mA (at 17 dBm)
ZigBee	250 kilobits/ second	9.1 mA (5 dBm)
LoRa	27 Kilobits/second	87 mA (17 dBm)

a) What is the transmission time for a data packet?

b) What is the maximum number of data packets the transmitter would need to send?

c) What is the average power consumption of one radio cycle when no transmission is occurring, and when there is a data transmission?

Question 3: You have been provided with an IoT device that utilizes an active radio and highly energy-efficient wake-up receivers. These receivers facilitate low-power idle mode and channel sensing. Ordinarily, the nodes remain in sleep mode for the majority of the time, briefly waking up (for 1 data packet duration) to use the wake-up receiver for looking/sensing for active transmission. If a transmission is detected, they transition into reception mode. The transmitter employs a mechanism akin to X-Mac and Contiki MAC, repeatedly sending data packets rather than transmitting an explicit preamble message.

Radio Mode	Transmit Current (mA) @ 3 V
Sleep	0.01
Active (Transmission)	10
Active (Reception)	10
Channel Sensing	0.1

The device employs a transceiver with PHY supporting a 250 kilobits/second bitrate. The size of a data packet (with all fields included) is 127 bytes. The device performs channel sensing every 100 milliseconds. Given the power consumption, please perform the following calculations:

Please note: We define one radio cycle as period between two channel sensing events, i.e., one radio cycle is 100 milliseconds long.

a) What is the transmission time for a data packet?
b) What is the maximum number of data packets the transmitter would need to send?
c) What is the average power consumption of one radio cycle when no transmission is occurring, and when there is a data transmission?