Mittuniversitetet
MID SWEDEN UNIVERSITY

Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
EL024A	T102	2019-01-09
Kursnamn	Elektronik AV, Sensornätverk	
Provnamn	Skriftlig tentamen	
Ort	Sundsvall	
Termin		
Ämne		

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Exam in Sensor Networks (VT2018)

Course codes: EL024A

Date:	2019-01-09
Duration:	5 hours
Examiner:	Sebastian Bader
Phone:	+46 10 1428095 or +46 72 7433680
Maximum achievable points:	100
Minimum required points to pass:	50
Aids (Hjälpmedel):	Calculator, Dictionary

General Instructions

- Begin the answer to every question on a separate sheet of paper
- Do not write in red color
- For every calculation, the way towards the result has to be clearly understandable
- Direct citations from lecture slides will not be accepted as an own contribution

Questions

1. Wireless sensor nodes typically consist of four basic modules. List these four modules and shortly describe their main task(s). (8)

2. You are asked to implement a sensor network in order to monitor a road-bridge. The parameters that should be monitored are the road surface temperature (measured with a contact-based temperature sensor) and vibrations (measured with an accelerometer) at different places on the bridge structure. It is expected that close to one hundred individual sensors will be required to match the application demands.

   (a) Contrast and discuss the advantages and disadvantages of a wired and a wireless implementation of the sensor network. (4)

   (b) Describe what the fundamental difference is between the output of the temperature sensors and the accelerometers. What influence will this difference have on your system implementation? (4)

   (c) Name and discuss two examples of implementation challenges that you might expect to encounter for this application. (4)

3. A thermistor is a temperature-dependent resistor, which can be used as a simple temperature sensor.

   (a) With the help of which peripheral can you connect a thermistor to an MCU? (2)

(b) What type of input does this peripheral expect? (2)

(c) How can you, on circuit-level, convert the output of the thermistor to the expected input in the case that no information about currents is known? (6)

4. Path loss can be estimated with Friis free-space equation.

   (a) Estimate the required output power (in dBm) in order for a sensor node to transmit a packet to a receiver at a distance of 500 m. Assume a carrier frequency of 2.4 GHz, a receiver sensitivity of -95 dBm and neglectable gains and losses. (8)

   (b) List three propagation effects that will, in reality, reduce the theoretical communication range and describe why these effects lead to such a reduction. (6)

5. The energy efficiency of MAC protocols can be evaluated based on a number of undesired effects.

   (a) Explain the terms *packet collision*, *idle listening* and *overhearing*. (6)

   (b) For each of these effects, describe how the effect leads to a, so called, waste of energy. (6)

   (c) Are these effects typically easier avoided in contention-based or contention-free MAC protocols? Motivate your decision. (4)

6. IEEE 802.15.4 is a common communication protocol implementation for WSNs.

   (a) Which layer(s) does IEEE 802.15.4 implement? (2)

   (b) What is the main purpose of this layer / these layers? (4)

   (c) An 802.15.4 packet contains more information than just the data that should be transmitted. Name three other contents that are typically found in a packet and describe what these contents are used for. (4)

7. Contiki OS has a dedicated RDC layer as part of its MAC implementation.

   (a) What is the task of the RDC layer? (2)

   (b) The standard protocol for Contiki's RDC layer is ContikiMAC, which implements an asynchronous RDC layer. Describe how such an RDC implementation operates and what effects its usage has on the nodes that are involved in the communication (i.e., transmitter and receiver). (4)

   (c) Assuming a radio transceiver achieves a duty cycle of 1 %, what is its average power consumption of the transceiver if it consumes 20 mA during communication, 1 µA during sleep and it operates at a voltage of 3.3 V? (4)

8. Figure 1 depicts a wireless sensor network, in which sensor data is transferred from nodes A and B to node S.

   (a) List all potential, non-looping routes for node A and B, respectively. (2)

   (b) Which routes would be selected using a minimum-hop metric? (2)

   (c) Which of the three routers (R1-R3) has the largest impact on network operation in the case of failure? Motivate. (4)

9. You obtained a sensor node that requires a 3 V supply voltage, but the only battery available provides just 1.5 V.

   (a) What type of power converter should you select in order to provide a stable and sufficient supply to the sensor node? Motivate. (4)

   (b) Assuming a converter efficiency of 78 %, how much current will be drawn from the battery if the sensor node requires 25 mA for its operation in the case that all modules are activated. (4)

   (c) How long is the theoretical lifetime of the node if the battery has a capacity of 2000 mAh? (4)

Equations

$$P_{RX} = \frac{P_{TX} \cdot G_{TX} \cdot G_{RX} \cdot \lambda^2}{(4\pi)^2 \cdot d^2 \cdot L} \tag{1}$$

Figures

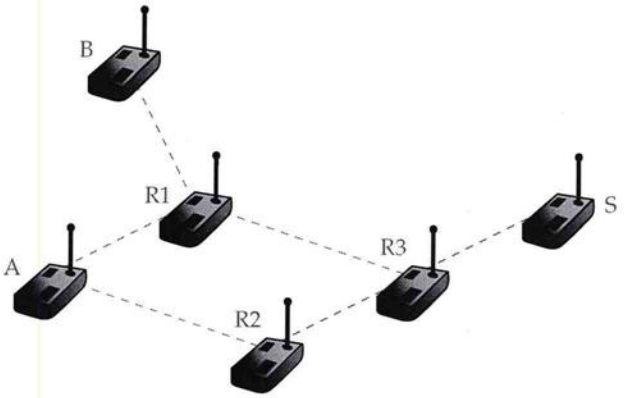

Figure 1: Network structure for question 8. Gray lines indicate connectivity between nodes.