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Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
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Kursnamn	Elektronik AV, Sensornätverk
Provnamn	Skriftlig tentamen
Ort	Sundsvall
Termin	V18
Ämne	Elektronik

ARkiv

Exam in Sensor Networks (VT2018)

Course codes: EL024A

Date:	2018-06-07
Duration:	5 hours
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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 with pencil or 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

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Questions

1. You have just been hired as a sensor network expert at a local company. Your first project is in collaboration with Sundsvalls city council, who wants to measure noise pollution. For this purpose, a large number of sensors should be deployed over the inner city to measure sound levels in a distributed manner.
   (a) Your boss is skeptical about wireless technologies. Motivate what advantages an implementation based on wireless communication would have in this application scenario. (4)
   (b) Once you convinced him, you start working on the implementation. The first question you encounter is concerned with the processing of the data. You have the choice to transmit the raw data or to perform an FFT (Fourier transform) on the node and only transmit the amplitudes of the most contributing frequencies. Discuss what effect each choice would have on your node implementation and the communication in your network. (8)
2. Assuming the scenario described in 1., a microphone connected to an ADC could be used to obtain information about the sound level. The firefly node uses a CC2538 SoC, which contains a 12-bit ADC.
   (a) What is the output voltage of the microphone if the ADC uses a reference voltage of 3.3V and provides you a raw reading of 1365. (6)

(b) What importance does the sampling frequency have on identifying significantly contributing frequencies. (3)

3. LoRa is a quite recent and popular communication method for long range wireless sensor networks. LoRa allows long range communication by providing a large link-budget, that means a large output power to sensitivity ratio. A typical LoRa radio transceiver can have output powers up to 17 dBm and sensitivities down to −137 dBm, while operating at 868 MHz.

   (a) Assuming free-space propagation and neglectable antenna gains and circuit losses, what is the maximum distance between two transceivers for the provided conditions? (6)

   (b) Describe why this distance in reality typically is not reached. (4)

   (c) How would the maximum distance change if we would switch to the WLAN frequency band (i.e., 2.45 GHz)? (4)

4. By default, Contiki OS uses a CSMA protocol in its MAC layer.

   (a) What is the main task of a MAC protocol? (3)

   (b) What class of MAC protocols (contention-based/contention-free) does CSMA belong to? Describe the main operating principle of this protocol class. (4)

   (c) Describe how channel-sensing and RTS/CTS handshakes can help to reduce packet collisions. (6)

5. Contiki OS has a dedicated RDC (Radio Duty Cycling) layer as part of its MAC implementation.

   (a) What is the main reason to perform duty cycling? (3)

   (b) Describe why duty cycling of the radio is typically more challenging than duty cycling, for example, a sensor? (4)

   (c) ContikiMac implements an asynchronous radio duty cycling. Describe the main operating principle of this type of duty cycling protocol. (4)

   (d) Describe the effect of using asynchronous duty cycling on the receiver and transmitter node, respectively. (4)

6. In recent years, the usage of IP-based communication in wireless sensor networks has increased.

   (a) What is the main motivation for using IP-based communication? (3)

   (b) To make standard IP layers compatible with low-power wireless technologies, an adaption layer (6LoWPAN) is added to the network stack. One task of this adaptation layer is packet fragmentation. Explain what this means and why packet fragmentation is needed. (4)

   (c) `2001:db8:A0:7200:fe0::1` is a IPv6 address in compressed format. Provide the fully decompressed IPv6 address of this node. (4)

7. In multi-hop networks, routing is an essential function. Figure 1 illustrates an exemplar multi-hop network, in which communication between a sender (S) and a receiver (R) should take place.

(a) Describe the purpose of having a routing protocol and the two steps that every routing protocol needs to perform. (4)

(b) In the presented example, which route has the minimum hop count? Motivate. (4)

(c) In the presented example, which route has the minimum total packet cost, considering the ETX values provided for each link? Motivate. (4)

8. You have implemented a node that periodically samples values from a sensor and directly transmits each sample wirelessly. You have measured the average current consumption and required time period for sampling: ($I_{sense} = 5\,\text{mA}$, $T_{sense} = 250\,\text{ms}$) and for communication: ($I_{comm} = 35\,\text{mA}$, $T_{comm} = 3\,\text{ms}$). Whenever the node is not sampling or communicating, the node stays in a low-power state with: ($I_{sleep} = 2\,\mu\text{A}$).

   (a) What is the average power consumption of the node if one sample is taken and communicated every minute (i.e., $T = 1\,\text{min}$) and the node runs at a voltage of 3 V? (6)

   (b) What is the percentage contribution of sampling, communication and sleep to the overall energy consumption for one sample period? (4)

   (c) Assuming the node is powered from a 7.2 V battery, a buck converter would be a good choice for voltage regulation. What is the current draw from the battery under the previous conditions, if the buck converter has an efficiency of 85 %? (4)

Figures

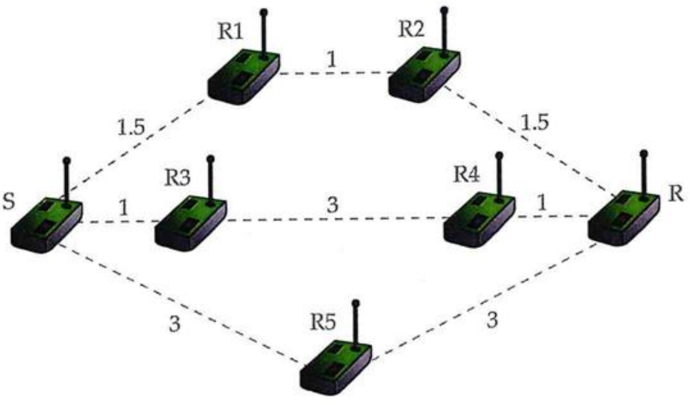

Figure 1: Exemplar routes for question 7. Gray lines indicate connectivity between nodes. Numbers represent the links ETX value.

Equations

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