

SoRTES Project: Time-Synchronized Embedded Device

October 2019

1 Assignment

Smart environmental monitoring consists of a network of small, embedded devices that monitor a physical property in their environment, e.g. temperature. These sensing devices are typically connected through a wireless network with a gateway, to which they regularly transmit their measurements. In order to minimize the frequency of battery replacements, which can be costly and tedious, the deployed sensors enter a sleep mode in between transmissions to preserve energy consumption. The gateway transmits beacons that inform the sensing devices when to wake up next to transmit their measurement. It is thus crucial that the sensing device respects this real-time deadline, since failure to wake up at the specified time causes the sensing device to lose its time synchronization with the gateway.

2 Requirements

When booted, your microcontroller (sensing device) must keep its radio open until it receives a beacon. **A beacon is sent by the gateway between every 2 to 10 seconds. Each beacon specifies the exact transmission time of the next beacon (The first four bytes(characters) are gateway identifier(gw id), and the rest of the beacon message defines the next transmission time in seconds. I.e. A sample message can be "GW0210"(gw_id=GW02, next transmission=10seconds)).** The Gateway sends 20 beacons consecutively in each interval and prints out information such as number of beacons sent, acks sent via serial port(you need to use a serial monitor either on arduino IDE or external program such as coolterm and set the baudrate to 9600). The gateway will then wait 10 seconds and start a new interval. Each team is assigned separate frequency to not interfere with other teams gateway. You should only flash the gateway hex file that belongs to your team number(the information about how to flash a hex file can be found on session 1 sildes). You should set the correct frequency

assigned to your team to be able to receive the beacons(you should also set spreading factor(sf) to 7(in case you changed it already, it's set to sf7 default)).

Once it receives the beacon, your microcontroller should write its contents (next wake up time) to the database in the microcontroller's EEPROM memory, and b) read the value of the built-in temperature sensor, which it should also write to the EEPROM and transmit to the gateway. Upon completing the above two tasks, the microcontroller should enter a sleep mode until the next transmission interval, as specified in the received beacon from the gateway. After receiving 20 beacons from the gateway, the sensing device must enter an ultra low-power operation mode, where you should strive to minimize power consumption. Waking up from this mode should occur through an external interrupt. Additionally, your microcontroller should support three commands listed below, through a serial interface:

1. A command to read the latest temperature value and beacon details from database and print the output to serial port.
2. A command to read all temperature values and beacon details from database and print the output to serial port.
3. To enable low power operation mode. In this mode, you should strive to minimize the power consumption. Exiting this mode will be through an external interrupt.

These three commands will be sent through the serial port using numbers 1,2 and 3 for the first, second and third commands respectively. Access to the database needs to be synchronized by means of synchronization primitives (i.e. mutex, semaphores) in order to ensure its consistency at all times.

Its mandatory to use FreeRTOS for implementing your system and different tasks carrying the systems responsibilities.

3 Report

As part of the assignment, we expect you to write a report of up to 4 pages that describes in detail how your system satisfies:

1. the varying real-time constraint, specified by the gateway
2. task synchronization to ensure database consistency
3. low power consumption when
 - in low-power operation mode, between consecutive transmissions
 - in ultra low-power mode, after receiving 20 beacons

4 Submission

You can submit your project by sending an email containing a .zip file (named lastname1_lastname2.zip) that includes your report and source code to sortes@ls.kuleuven.be. The subject of this email must be [SoRTES: Submission]. Only one student per group should send this email. The deadline is on 03 December 2019, at 23:59 PM. For other questions regarding the project, you can send an email to sortes@ls.kuleuven.be Good luck!

The SoRTES team.