UNIVERSITY OF
OXFORD

Embedded Software and Systems, ESS

22nd – 26th January 2024
ASSIGNMENT

The purpose of this assignment is to test the extent to which you have achieved the learning objectives of the course. As such, your answer must be substantially your own original work. Where material has been quoted, reproduced, or co-authored, you should take care to identify the extent of that material, and the source or co-author.

Your answers to the questions on this assignment should be submitted using the Software Engineering Programme website — www.softeng.ox.ac.uk — following the submission guidelines. When submitting the assignment online, it is important that you formally complete all three assignment submission steps: step 1, read through the declaration; step 2, upload your files; step 3, check your files. **Please ensure your submission is anonymous: do not include your name or any other identifying information on the assignment, nor in accompanying material such as source code, nor within the file names of anything submitted.**

The deadline for submission is 12 noon on Tuesday, 12th March 2024. You are strongly encouraged to submit a version well before the deadline. You may update your submission as often as you like before the deadline, but no submissions or changes will be accepted after the deadline.

We hope to have preliminary results and comments available during the week commencing Monday, 22nd April 2024. The final results and comments will be available after the subsequent examiners' meeting. Exam Conventions can be found here https://www.softeng.ox.ac.uk/handbook/

ANY QUERIES OR REQUESTS FOR CLARIFICATION REGARDING THIS ASSIGNMENT OR PROBLEMS INSTALLING SOFTWARE SHOULD, IN THE FIRST INSTANCE, BE DIRECTED TO THE PROGRAMME OFFICE WITHIN THE NEXT TWO WEEKS.

ESS: Assignment

The purpose of this assignment is to test your knowledge of embedded software and systems. Please submit a report of up to 20 pages, excluding any appendices. There is one question, with sub-parts to guide your answer. Justify your statements, and where you have made assumptions, state these clearly. If you consult any material, make clear (i.e. cite) the source and the extent of any derivative material.

Question 1:

You work as a firmware engineer at a startup which is seeking to disrupt the market by creating a new and exciting device. You are free to choose any application you like, as long as it has the basic features of:

- At least one analog sensor
- A wireless communication interface of your choice
- Embedded computation
- Not powered by the mains
- Has some form of human interface of your choice (keypad, touchscreen or just a single LED)

Some examples include structural health sensors (e.g. measuring the vibrations on a bridge), precision agriculture sensors (e.g. measuring soil moisture and other parameters) or occupancy sensors (e.g. a device that counts the number of people in a room). Choose a product that will allow you to demonstrate your mastery of embedded systems. Think clearly about key engineering dimensions of power, cost, size etc. Justify why you have chosen a particular approach over competing alternatives.

Following the VEE diagram, this a rough outline of how you could structure your answer:

a) Derive a set of requirements and specifications for your product.

b) Design and discuss your architectural and component choices. Which microcontroller is most suitable and why? How are you going to obtain your sensor readings? What sampling frequency and resolution will you require? Which wireless interface have you chosen and why?

c) Design your firmware – will you use an RTOS? Why/Why not? In particular, show a detailed state machine for your prototype.

d) Discuss, with the aid of examples, how you would go about implementing and unit testing your code. In particular, discuss how you could go about testing the analog sensor without having access to it (e.g. whilst it is being fabricated). Note that you do not need to write syntactically accurate C/C++/Assembler – you can use pseudocode if you prefer.

e) Carefully consider possible failure modes of your system and what risk mitigation you could take.

f) Discuss various approaches that could be used to reduce power consumption for your device. Consider in particular how power optimization techniques impact sensing, computation and communication.

Guidance

The assessment will be based on the following criteria:

• Have you understood the design criteria, functionality and resource constraints of embedded devices?

• Can you apply software engineering principles, techniques and tools to guide the design and implementation of an embedded system?

• Do you understand the interplay between hardware and software, and how to create reactive embedded systems?