

INFO0064 - Embedded Systems
Examination session of January 2015

Notes or documents of any kind forbidden. Duration: 3 h 30.

All questions must be answered on different sheets, labeled with your name and section.

1. [3 points]
 - Describe (briefly) the arbitration mechanism of I²C.
 - Why is it a good idea to always write interrupt routines that execute quickly?
 - What is the main advantage of preemption? Give an example of a problem that cannot be satisfactorily solved with non-preemptive scheduling.
2. [4 points] Prove that every schedulable set of periodic tasks remains schedulable with a rate-monotonic assignment of priorities.
3. [6 points] The onboard microcontroller of a homemade quadcopter has to receive and execute instructions sent by the pilot via a wireless link (such as taking off, landing, flying in a specified direction, ...). In addition to processing those instructions, it constantly stabilizes the vehicle. In order to monitor and control stability, the quadcopter is equipped with two 3-axis accelerometers and one gyroscope. Moreover, it includes a camera whose signal, along with others monitoring data, has to be sent back to the pilot. The microcontroller has to perform the following tasks:
 - receiving and processing instructions: 10 times per second, execution time = 5 ms;
 - controlling the motors: 100 times per second, execution time = 2 ms;
 - acquiring data from sensors: period of 4 ms, execution time = 1 ms;
 - sending the video signal and other data: period of 40 ms, execution time = 20 ms.
 - (a) What is the best software architecture for this system? Justify.
 - (b) Using pseudocode, give a suitable global structure for this software.
4. [7 points] A microcontroller controls two security doors at the entrance of a bank, located 4 meters apart. Both doors are equipped with a sensor that is able to detect people. The range of the sensors is depicted in Figure 1.

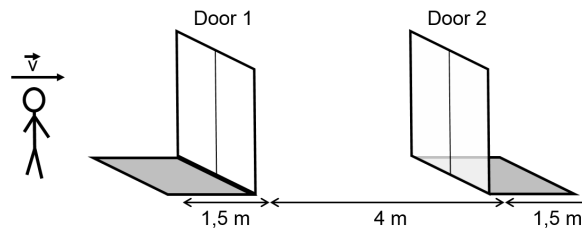


Figure 1: Security doors. The range of the sensors is represented in grey.

It is assumed that people always move from left to right, i.e., that they first go through door 1 and then through door 2.

The microcontroller controls the doors as follows:

- Door 1 opens as soon as its sensor detects someone, at a rate of 67% per second (in other words, it takes about 1.5 s for it to become fully open). It closes, at a rate of 50% per second, when the sensor of door 2 picks up someone.
- Door 2 starts to open, at a rate of 50% per second, exactly 2 seconds after the sensor of door 1 has detected someone. It closes, at the same rate, when the sensor of door 2 stops sensing.

A person can pass through a door only if it is at least 50% open. Otherwise, he/she waits for the door to open enough. It is assumed that at most one person can use the doors at any time, in other words, a new person may approach door 1 only after the previous one has left the sensing area of door 2.

- (a) Describe a hybrid system modelling this situation.
- (b) Give the first 3 steps of the space-state exploration of this system, in the case of a person moving at a speed of 1.75 m/s.