Aalto - Helsinki University of Technology

T-106.5300 Embedded Systems Exam

INSTRUCTIONS:

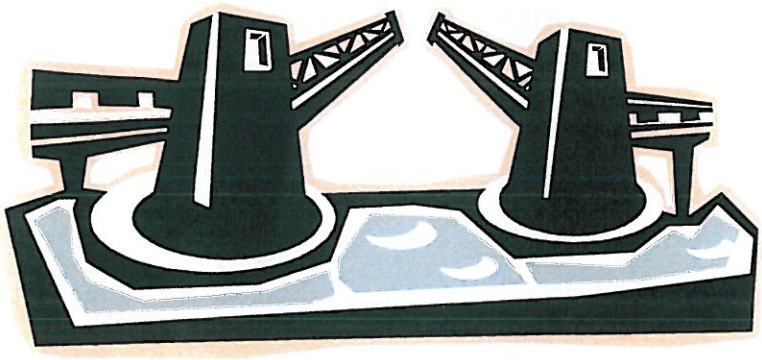
- Read the **entire** exam before starting
- Stay in the scope of the question
- Answer all questions in any way possible.
- Justifications and explanations are considered
- The time available for the exam is three hours
- The total point value of the exam is 110. You need 100 points to score 100%

- If you are an exchange student leaving the country very soon, and need to know quickly if you passed the exam, please write "EXCHANGE STUDENT" near your name on the answer sheet

BACKGROUND INFORMATION FOR THE QUESTIONS:
(Referred to as 'the system' or '<Exam Problem> system' in later mentions)

A busy port city has a bridge over a river. Large ships must pass the bridge, so the bridge must be able to open. The road that crosses the bridge has traffic lights on both ends of the opening section. There are traffic sensors to indicate if cars are waiting and if the bridge is empty of traffic so it can be safely opened. There are also sensors to indicate if a ship is approaching and separate sensors to indicate that the ship is no longer under the bridge so it is safe to close the bridge.

Note that this is still just an intersection of two different roads.



Design a simple control system to automate the drawbridge using the following information:

Known facts:

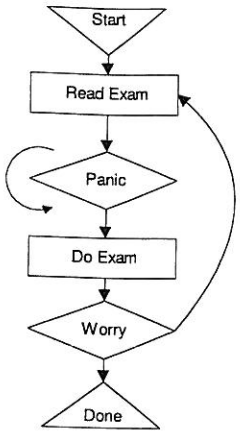
- Sensors (all are binary, true or false)
  - CarsOnBridge
  - TrafficWaitingForBridgeToOpen
  - ShipUnderBridge
  - ShipComingToBridge
  - BridgeUp
- Controls
  - StopCarTraffic (Red lights, close gates)
  - RaiseBridge (break road, ships can pass)
  - LowerBridge (resume road mode, no ships can pass)
  - ResumeCarTraffic (Green lights, open gates)
  - EmergencyStop (stop now)
- Ship traffic has priority over cars
- If the system is missing some critical feature, add it yourself

Goals:

- Safe transportation
- Avoid unnecessary complexity in the control system

---------- THE EXAM STARTS BELOW ----------

1. **Kernels** (40pts total)
NOTE: No fault tolerance or remote-control features are needed for this question



1.1. Draw the flowchart of the program structure to describe the operation and sequence of operation if the control system for the device described on the first page was built with a:

1.1.1. polling kernel (10pt)

1.1.2. interrupt kernel (10pt)

1.1.3. process kernel (10pt)

1.2. Which of the above is best suited to implement the control system according to the goals listed in the beginning? Explain why? (10pt)

2. **Fault Tolerance** (40pts total)
How could the control system in Question 1 be made more fault-tolerant?
No remote-control features are needed for this question

2.1. Define fault-tolerance in general (4pt)

2.2. Briefly describe how you could use each of the following mechanisms to enhance fault-tolerance in the exam problem:

2.2.1. Sanity checks (4pt)

2.2.2. Fail-safe (4pt)

2.2.3. Interlocks (4pt)

2.2.4. Watchdog timer (4pt)

2.3. Briefly describe what changes are reasonable and necessary to the exam problem system to ensure a basic level of fault tolerance in normal operation. (10pt)

2.4. Which of the types of systems in Question 1 is best suited for these modifications? Describe and justify. (10pt)

3. **Remote control** (10pts total)

3.1. What control system or related changes are needed to add remote control ability to the system in questions 1&2 (the physical method of remote controlling has been accomplished for you by unspecified means, ie. You have a black box)? (5pt)

3.2. How does that affect your choice in question 2.4? Describe and justify. (5pt)

4. **General questions.** Answer briefly: (20pts total)

4.1. What specific car hardware improvements would have made your programming tasks easier for the car project? (5pt)

4.2. Why is the Therac-25 case significant in the embedded systems field? (**15pt**)

---------- THE EXAM ENDS HERE ----------

Please give feedback about this course either on paper or on the web form