T-106.5300 Embedded Systems Exam – 7.5.2007
Olli Seppälä, Jaakko Ala-Paavola

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 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)

The Helsinki Metro is to be fully automated in the coming years. The trains are to drive themselves safely and comfortably for the passengers. There are to be safety systems so that even careless users will survive (such as: Doors cannot close when obstructed, metro will not move when doors are open, emergency stop buttons available).

Design a simple control system to handle the Metro using the following information.

Known facts:
- Sensors
  - AreDoorsOpen – 0=closed, 1=open, ie. binary output
  - AreDoorsSafeToClose –0= obstructed, must not close, 1=safe to close
  - AtStation – 0=elsewhere, 1=positively at a station
  - NextStationComing - indicator on track for when to start deceleration
  - EmergencyStopButtonPressed (0=no, 1=yes)
- Controls
  - DoorsOpen
  - DoorsClose
  - EnterStation (Decelerate and stop)
  - LeaveStation (Accelerate from stop)
  - EmergencyStop (stop now)
- Subsystem
 - Drive (independent subsystem to handle all functions between stations)
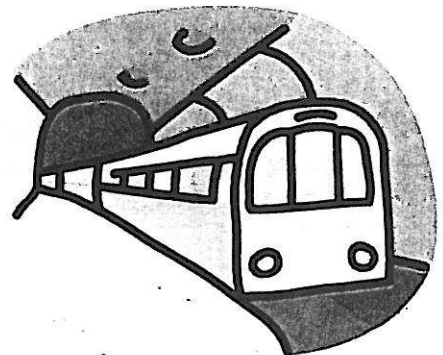
Goals:
- Safe transportation
- Avoid unnecessary complexity and cost in the control system
- System is to function smoothly, no sudden starts or stops

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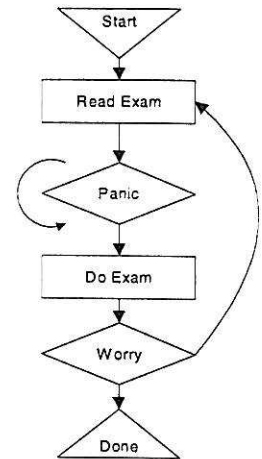
2. Fault Tolerance (40pts total)
How could the control system in Question 1 be made more fault-tolerant?
No remote-control features are needed for this question

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. Limits (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 <u>reasonable and necessary</u> to the exam problem system to ensure a <u>basic</u> 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 diagnostics 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 are control system methods (such as PI, PD, PID) useful? (5pt)

4.3. Why is the Therac-25 case significant in the embedded systems field? (**10pt**)

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

5. Any feedback about this exam or course? (this does not affect your grade)