Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Verified Development

Date: Thursday 22nd January 2015
Time: 09:45 - 11:45

Please answer Question ONE
and one other Question from the remaining TWO Questions available.

This is a CLOSED book examination
The use of electronic calculators is NOT permitted

[PTO]
1. **COMPULSORY**

a) Comment on the differences between purchasing software and purchasing other goods. Comment on the prospects of bringing these into line. (4 marks)

b) What is the purpose of refinement? Briefly describe the main elements of a notion of refinement. (4 marks)

c) In *Perfect*, what is the purpose of an invariant? In practice, most invariants can be omitted without damage to the program. Describe briefly the pros and cons of including versus omitting an invariant. (4 marks)

d) Briefly describe how *Perfect* uses various notions of refinement. (4 marks)

e) Write out a proof of \( \vdash ((A \Rightarrow B) \land (B \Rightarrow C)) \Rightarrow (A \Rightarrow C) \) in the RS system. (4 marks)
2. A simple aircraft landing gear lowering system works as follows. The pilot presses the Gear Down button. The button command is sent to a computer and to a hydraulic system. The computer sends an activation command to the hydraulic system. The hydraulic system, having received both button command and activation, acknowledges to the computer. The computer, having received the acknowledgement, activates the landing gear itself. Write a Perfect class to model this situation. There should be sufficient invariants to check that the dependencies of the above description are maintained.

Data structures: (3 marks)

Invariants: (5 marks)

   a) Push button down. (2 marks)
   b) Computer receives button push. (2 marks)
   c) Hydraulics receives button push. (2 marks)
   d) Computer signals hydraulics. (2 marks)
   e) Hydraulics acknowledges computer signal. (2 marks)
   f) Computer signals gear. (2 marks)

You can make reasonable simplifying assumptions, but any such assumptions must be clearly stated. Minor errors of Perfect syntax in your answer will not be penalised excessively, provided the intended meaning is clear.
3. The country of Urania is being menaced by the more powerful neighbouring country of Prussia. Urania has five cities, each of which contains four resources: a fire station, a radio station, a government building and an airfield. Starting from the normal condition in which the Uranians are in charge of a resource, irregular Prussian forces can first threaten it, and only then, occupy it. A city is under the control of the Prussians iff they occupy at least two of its resources. Urania as a whole is under the control of the Prussians iff they occupy at least three of its cities. Write Perfect classes to represent this situation as follows.

Data structures: (3 marks)

Invariants: (5 marks)

a) Report on the state of occupation of Urania. (1 marks)

b) Report on the state of occupation of all the cities. (1 marks)

c) Report on the state of occupation of an individual city. (2 marks)

d) Threaten a resource. (2 marks)

e) Occupy a resource. (6 marks)

You can make reasonable simplifying assumptions, but any such assumptions must be clearly stated. Minor errors of Perfect syntax in your answer will not be penalised excessively, provided the intended meaning is clear.

END OF EXAMINATION