

Two hours

**UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE**

Verified Development

Date: Wednesday 24th January 2018

Time: 09:45 - 11:45

Please answer BOTH Questions.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

1.
 - a) Comment on the differences between purchasing software and purchasing other goods. Comment on the prospects of bringing these into line. (4 marks)
 - b) Write down two strengths and two weaknesses of conventional (i.e. main-stream) software development. Write down two strengths and two weaknesses of formal (i.e. mathematical) software development. (4 marks)
 - c) In *Perfect*, what is the purpose of an invariant? In practice, most invariants can be omitted without damage to the program. Why is this? Describe briefly the pros and cons of having more invariants versus having fewer invariants. (4 marks)
 - d) Write down the *Contract Refinement Proof Obligations*, and briefly describe what they mean in words. (4 marks)
 - e) Give a resolution proof of $A \wedge B \Rightarrow A \vee B \vee C$. (4 marks)

2. The security services of a civilised country need to monitor inhabitants' phone contacts, so that should someone perpetrate an atrocity, the people who assisted him can be quickly located and dealt with appropriately. The security services maintain a list of phones, and for each pair of phones that has been connected via a call, an active score is maintained as follows. As soon as a call is made, the score for that pair of phones becomes: 10 if they have never connected, or the score is less than 10; 2 more than the previous score if the score is 10 or more. The score is diminished by 1 on a regular basis, not going below 0. Write a *Perfect* class to model this situation, containing elements as follows.

Data structures and invariants: (4 marks)

- a) List the phones. (1 mark)
- b) List the recorded linked pairs of phones. (1 mark)
- c) Add a phone. (2 marks)

- d) One phone calls another, and the score is recorded as above. (4 marks)
- e) Time passes, and the scores are diminished as above. (2 marks)
- f) For a given phone, the direct contacts with score at least 5, and indirect contacts via one intermediate phone with both links having score at least 5, are found. (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