THE UNIVERSITY
OF ADELAIDE
AUSTRALIA

Examination for
Bachelor of Agricultural Science, Bachelor of Architectural Studies, Bachelor of Computer Science, Bachelor of Mathematical and Computer Science, Bachelor of Business Information Technology, Bachelor of Engineering, and the Graduate Diploma in Computer Science

Semester 2, November 2006

3675, 6263 Software Engineering and Project COMPSCI 3006, 7015

Official Reading Time:	10 mins
Writing Time:	120 mins
Total Duration:	130 mins

Questions	Time	Marks
Answer all 7 questions	120 mins	120 marks 120 Total

Instructions

- Begin each answer on a new page
- Examination material must not be removed from the examination room
- Simple, Non-programmable Calculators Allowed
- Open Book Examination

Materials

- 1 Blue book

DO NOT COMMENCE WRITING UNTIL INSTRUCTED TO DO SO

The questions in this exam paper relate to the following scenario.

The scenario

After the great success of the first few factory automation robots your company has sold; one of your existing customers comes to you with a specific problem that your system can not adequately solve. The following diagram shows this particular factory's layout:

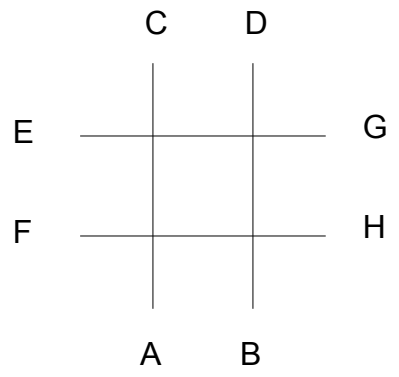

Figure 1: Layout of the new factory.

The layout is different from the layouts you have already used (no path around the perimeter) and the factory requires *two* robots to operate concurrently. One moves material in a north/south direction repeatedly following the path A-C-B-D and the other goes east/west repeatedly following the path E-G-F-H.

The two robots operate at different, unpredictable speeds — there is no automatic synchronisation between the two that would avoid collisions.

Most of this exam will explore the software engineering issues that stem from this scenario. More specific details will be given in the relevant questions.

Software Engineering Process Models

Question 1

(a) Indicate in your exam book what your project group number is, and give a description of the software engineering process model your group followed in developing your initial product.

[4 marks]

Assuming that a classic *Waterfall Model* development process was used to develop the initial system (rather than the process you described above):

(b) Give two reasons for and two reasons against using the waterfall model for the multi-robot project.

[8 marks]

(c) Your software development manager has decided that the waterfall model is now inappropriate for re-engineering the system to provide for multiple robots. Your manager has chosen to use the *evolutionary* model.

- Provide two reasons for using this model for the new project.
- Suggest two risks in moving to the evolutionary model.

Explain how you would make use of this model to achieve the goal of a functioning multi-robot system.

[8 marks]

(d) Would it be appropriate to adopt the Boehm spiral model *in addition to* the evolutionary model? What difference would this make? Give reasons for your answer.

[6 marks]

[Total for Question 1: 26 marks]

Tools

Question 2

(a) In engineering the factory robot automation code for multiple robots (as described in the scenario), your development team is one of two teams that will be doing this. The other team is located in the United Kingdom, and is linked to your team via a high bandwidth network connection. The current timezone differences between the two teams is 10.5 hours. Assuming both teams require access to the same software repository, describe *how* you would use appropriate tools to ensure everyone has access and is able to build a working system daily.

[4 marks]

(b) One day your team arrives at work, only to discover that the current build of the factory automation software is now somehow broken, a critical part of the system that is needed for your team to proceed with testing no longer works, although it did yesterday. It seems the team in the UK have modified it, not tested it properly, and now are asleep at home whilst your team needs to work. Describe how your configuration system can be used to allow your team to continue.

[2 marks]

(c) In the long term your company will be responsible for maintenance of the new two robot system code. Describe the manner in which a bug discovered by a user of the system is handled. You should address the following in your answer:

- How software with the bug fixed is created.
- How you ensure that the bug does not reappear in later releases of the software.
- How you would handle a situation where the bug actually had reappeared in a later release.

[6 marks]

[Total for Question 2: 12 marks]

Task Management

Question 3

If an evolutionary model has been chosen (as in Question 1) we need to create a project time line that reflects this chosen process.

(a) Identify a series of milestones for the new project.

[5 marks]

(b) Draw a project timeline for the new dual robot control system, assuming that the starting point for the project is the factory robot control system already developed by your group. The project timeline should include the milestones identified above and should show the important aspects of the evolutionary model.

Note that you do not need to provide any time estimates for any work unit.

[7 marks]

[Total for Question 3: 12 marks]

Risks

Question 4

For the multi-robot project, it is intended that proximity sensors will be installed on the robots to help avoid collisions. However, the sensors will only be available later in the project and you need to start working on the software now. Needless to say, there may be delays in installing the sensors and there may be unforeseen problems once they are installed.

(a) Write an appropriate entry, one that might appear in the SPMP, for this risk. The entry should cover the following:

- Risk description.
- Risk likelihood.
- Risk severity. (Justify you answer.)
- Actions in place to minimise likelihood of risk.
- Actions in place to minimise severity of risk.
- Actions to be taken if risk occurs.

[8 marks]

(b) Based upon your experience in the robot project in this subject suggest two problems that might occur in implementing the above risk management plan should the risk eventuate late in the project testing phase.

[4 marks]

[Total for Question 4: 12 marks]

Software Architectures

Question 5

Select three different software architectures which are relevant to the robot system:

(a) one architecture for the host controller

[4 marks]

(b) one architecture for the robot

[4 marks]

(c) one additional architecture for the host or the robot or both

[4 marks]

For each one, describe clearly its properties, its relevance to the robot system, and any limitations that may be pertinent to extended systems such as the use of multiple robots.

[Total for Question 5: 12 marks]

Requirements and Testing

Question 6

The presence of multiple robots on the factory floor is considered to raise issues related to Occupational Health and Safety that were not present before. People on the factory floor may take note of one robot but not the other; the operator at the console may similarly have their attention focused on only one robot and not observe a dangerous situation developing with the other; collisions of robots could lead to debris being scattered at high speed over a large area of the factory floor.

(a) Using the proforma, below, write *two* requirements that would be crucial in the implementation of this multi-robot system that are additional to those that would exist in the earlier single robot system.

- Title
- Summary
- Rationale
- Specification
- Acceptance criteria
- Source

[12 marks]

You are now required to develop acceptance tests for the newly revised requirements.

(b) State clearly whether black box or white box tests are more appropriate for the acceptance criteria you identified above. Give reasons for your answer.

[2 marks]

(c) For one of the requirements above, describe an acceptance test that can be used to determine whether or not the acceptance criteria are satisfied.

[5 marks]

(d) Describe a test that can be used to validate the *reliability* of the proximity sensors.

[5 marks]

(e) In developing a test plan you identify the following steps:

- Analysis,
- Create test cases,
- Define results of tests,
- Execute tests,
- Check results.

However tests never go smoothly. Describe the process that your test regime would use to manage the test process with particular emphasis on how you will handle tests that fail. Use a flow diagram to illustrate your answer.

[4 marks]

(f) The addition of a second robot introduces new safety issues. The safety authority insists that a hazard analysis is completed for the new system. One system-level hazard that is introduced in the new system is the collision of the two robots. Describe two component-level hazards (faults) that could cause this system-level hazard:

- One operator fault;
- One software fault.

For each of these faults, describe a control strategy that will either prevent the fault occurring or limit its likelihood and/or consequences. You may consider changes to the design, together with changes to the operational procedures.

[6 marks]

[Total for Question 6: 34 marks]

Design: Formal Methods

Question 7

(a) The complexities of this system are such that you will wish to guarantee correct operation using formal methods. In particular industry standards mandate that you must use a formal specification language for defining the behaviour of the system. Below is a partial specification for a two-robot Factory Robot Control System, written in the Z specification language. Read the specification carefully, and then describe each part of the specification.

$$Position = \mathbb{N} \times \mathbb{N}$$

$$Direction ::= North \mid South \mid East \mid West$$

FRCSState

$$robot1\_pos : Position$$
$$robot1\_dir : Direction$$
$$robot2\_pos : Position$$
$$robot2\_dir : Direction$$

$$robot1\_pos \neq robot2\_pos$$

$$MoveR1ForwNorth \mathrel{\widehat=} MoveR1ForwNorthSafe \lor MoveR1ForwNorthUnsafe$$

$$Report ::= ok \mid unsafe\_move$$

MoveR1ForwNorthSafe

$$\Delta FRCSState$$
$$out! : Report$$

$$robot1\_dir = North$$
$$(\text{first } robot1\_pos, \text{second } robot1\_pos + 1) \neq robot2\_pos$$
$$robot1\_pos' = (\text{first } robot1\_pos, \text{second } robot1\_pos + 1)$$
$$robot1\_dir' = robot1\_dir$$
$$robot2\_pos' = robot2\_pos$$
$$robot2\_dir' = robot2\_dir$$
$$out! = ok$$

MoveR1ForwNorthUnsafe

$\Delta FRCSState$

$out! : Report$

$robot1\_dir = North$

$(\text{first}\, robot1\_pos, \text{second}\, robot1\_pos + 1) = robot2\_pos$

$robot1\_pos' = robot1\_pos$

$robot1\_dir' = robot1\_dir$

$robot2\_pos' = robot2\_pos$

$robot2\_dir' = robot2\_dir$

$out! = unsafe\_move$

[12 marks]

[Total for Question 7: 12 marks]

End of exam