UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE AND ENGINEERING

COMPUTER SCIENCE 2Ah

Monday 2 September 2002

9:30 to 12:00

Examiners

D.K. Arvind (Chair)

R. Dyckhoff (External)

INSTRUCTIONS TO CANDIDATES

Section A questions are worth 10 marks each.

Section B questions are worth 30 marks each.

Answer all FOUR questions in Section A.

Answer any TWO of the three questions in Section B.

If you are in the third or later year of your degree course, please tick the box on the front cover of the script book.

Section A

1. (a) What is multi-tasking in modern computer systems and how can it improve processor utilisation?

   [5 marks]

   (b) Using a state diagram show how the Operating System manages processes under multi-tasking. (Limit your diagram to states of processes residing in main memory.)

   [5 marks]

2. Here is short textual description of a tiny I/O language.

   > "A program is a bracketed sequence of one or more **read** and **write** commands on variables, possibly involving **if**-tests. The command following a test may be a nested list of commands. The **flush** command can appear whenever a **read** immediately follows a **write**."

   Here is a formal grammar G derived from this description.

Start symbol	P
Nonterminals	P B S C
Terminals	**read** **write** **flush** **if** **then** **fi** var { ; }

$$
\begin{aligned}
P &\rightarrow B \\
B &\rightarrow \{\ S\ \} \\
S &\rightarrow C \mid C\,S \\
C &\rightarrow \textbf{read}\ \text{var};\ \mid\ \textbf{write}\ \text{var};\ \mid\ \textbf{if}\ \text{var}\ \textbf{then}\ C\ \textbf{fi} \\
\textbf{write}\ \text{var};\ \textbf{read}\ \text{var}; &\rightarrow \textbf{write}\ \text{var};\ \textbf{flush};\ \textbf{read}\ \text{var}; \\
\textbf{then}\ C\ \textbf{fi} &\rightarrow \textbf{then}\ B\ \textbf{fi}
\end{aligned}
$$

   (a) Explain what makes this grammar *context sensitive*. When is a grammar *context free*?

   [4 marks]

   (b) Give an equivalent grammar G' that is context free.

   [6 marks]

3. (a) Provide a brief description of the *elaboration* phase of the Rational Unified Process. Your description should summarise: (i) the purpose of the elaboration phase (ii) the outcomes of the elaboration phase and (iii) the evaluation criteria to verifiy the milestone at the end of the phase has been achieved.

[5 marks]

(b) Provide a brief outline of the *Project Management* workflow of the Rational Unified Process. Your description should summarise: (i) the purpose of the Project Management workflow and (ii) the key artifacts created within the workflow.

[5 marks]

4. (a) Describe how the execution of the MIPS instruction `lw r1,n(r2)` (load word) can be broken down into 5 microsteps. State the actions taken by the processor in each step.

[5 marks]

(b) Using a timing diagram show how the execution of multiple MIPS instructions can be streamlined using the technique of "pipelining". Explain how this technique improves processor performance.

[5 marks]

Section B

5. Let $\Sigma = \{\mathtt{a}, \mathtt{b}\}$, and consider the NFA

$$N = \Big(\{p, q, r, s, t\}, \Sigma, p, \{s, t\}, \Delta\Big),$$

where the transition function Δ is given by the following table:

Δ	a	b
p	$\{p\}$	$\{p, q\}$
q	$\{t\}$	$\{r, s\}$
r	$\{t\}$	$\{p, r\}$
s	$\emptyset$	$\emptyset$
t	$\emptyset$	$\emptyset$

(a) Draw a transition diagram for the NFA N.

[4 marks]

(b) Informally describe the language $L(N)$ accepted by N.

[4 marks]

(c) Give a regular expression for the language $L(N)$.

[4 marks]

(d) Convert N into a DFA M accepting the same language as N using the powerset construction. Give the transition table of the resulting DFA M and indicate which state is the start state and which states are the final states.

[9 marks]

(e) State which of the following languages L_1, L_2, L_3 over the alphabet $\Sigma = \{\mathtt{a}, \mathtt{b}\}$ are regular.

$$\begin{aligned} L_1 &= \big\{w \in \Sigma^* \mid w \text{ is either in the language } L(\mathtt{aab}^*) \text{ or in the language } L(\mathtt{bba}^*)\big\}, \\ L_2 &= \big\{(\mathtt{abab})^n \mid n \text{ non-negative integer}\big\}, \\ L_3 &= \big\{w \in \Sigma^* \mid \text{The length of } w \text{ is even, and either the number of } \mathtt{a}\text{s in } w \text{ is even or the number of } \mathtt{b}\text{s in } w \text{ is odd}\big\}. \end{aligned}$$

For each of the three languages, if it is regular give a regular expression, a DFA, or an NFA accepting it. If a language is not regular, prove this.

[9 marks]

6. This question is concerned with the Computer Systems part of the course.

   (a) What is an exception? Describe the steps taken by the processor and Operating System (OS) to handle an external exception (interrupt).

   [12 marks]

   (b) How can the processor guarantee that only the OS can perform certain restricted operations (such as I/O)?

   [6 marks]

   (c) Explain why modern computer systems use the exception mechanism to perform I/O for user processes.

   [2 marks]

   (d) What is Direct Memory Access (DMA)? How is it implemented and how can it help increase the processor utilisation?

   [10 marks]

7. (a) i. Provide definitions of *risk*, *product risk* and *project risk*.

[3 marks]

ii. Provide a brief explanation of the approach to the control of project risk in the Rational Unified Process. In particular you should discuss how the phases of the RUP help in controlling risk and the strategies to risk contol that are considered in the Project Management Workflow.

[7 marks]

(b) Provide a brief description of another software development process you are familiar with and write short notes comparing the RUP approach to Project Risk Management with your chosen development method.

[10 marks]

(c) Construct two contrasting software development project scenarios that are intended to exemplify the strengths and weaknesses of the RUP and your chosen process described in part 7b in dealing with aspects of project risk.

[10 marks]