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UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2004/2005

March 2005

CPT314 - Automata Theory & Formal Languages

Duration : 3 hours

INSTRUCTIONS TO CANDIDATES:

- Please ensure that this examination paper contains **FIVE** questions in **FIVE** printed pages before you start the examination.
 - Answer **ALL** questions.
 - This is an 'Open book' examination.
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ENGLISH VERSION OF THE QUESTION PAPER

1. Answer both 1(a) and 1(b) below.

(a) Let $V_1 = \{a, b, c, d\}$, $V_2 = \{a, d, e, f\}$, $V_3 = \{0, 1\}$, and $V_4 = \{b, d, e, g\}$. Solve the following expressions based on the given sets:

(i) $V_1 \cap V_3$

(ii) $2^{V_1} \cap 2^{V_2}$

(iii) $2^{V_1 \cap V_2}$

(iv) $|V_1 \cup V_4|$

(v) $|\{V_3, \{V_3\}\}|$

(50/100)

(b) Let $\Sigma = \{0, 1\}$. Give regular expressions generating the following languages:

(i) $P = \{w \mid w \text{ has exactly a single } 1\}$

(ii) $Q = \{w \mid w \text{ has at least one } 1\}$

(iii) $R = \{w \mid w \text{ is a string of even length}\}$

(iv) $S = \{w \mid w \text{ starts and ends with the same symbol}\}$

(v) $T = \{w \mid \text{the length of } w \text{ is at most } 5\}$

(50/100)

1. Let L be the language consisting of all words over the symbols 0 and 1 that have a '0' in the third-to-last place.

(a) Give **two** strings that belong to L and two strings that do not belong to L .

(10/100)

(b) Construct a non-deterministic finite state automaton N that accepts the strings belonging to L .

(20/100)

(c) Convert NFA N into DFA M .

(30/100)

- (d) Give the formal description of DFA M and draw its state diagram.

(20/100)

- (e) Try to minimize DFA M into a smaller DFA M' (if any). What can you say about M and M' ?

(20/100)

3. Consider the grammar $G = (\{S, A, B\}, \{a, b, c\}, P, S)$, where P is given by

$$S \rightarrow aABb$$

$$A \rightarrow bAb \mid c$$

$$B \rightarrow aB \mid b$$

- (a) Give a leftmost and rightmost derivation of the string $abcbabb$ in G .

(10/100)

- (b) Give two strings that are not in G .

(10/100)

- (c) What is the shortest string in G ? Give its length.

(10/100)

- (d) Give the equivalent PDA M and draw its transition diagram.

(50/100)

- (e) Simulate M for the string $abcbabb$.

(20/100)

4. Let $\Sigma = \{0, \dots, 9, +, -, *, /, ^,), \{ \}$. The language of all strings over the alphabet Σ represents syntactically correct arithmetic expressions on integers involving the following operators.

| Operators | Precedence | Associativity | |
|-----------|------------|---------------|----------------|
| - | 3 | | Negation |
| ^ | 2 | Right | Exponentiation |
| * | 1 | Left | Multiplication |
| / | 1 | Left | Division |
| + | 0 | Left | Addition |
| - | 0 | Left | Subtraction |

In the table above, the precedence of operators is listed from highest (3) to lowest (0) precedence. We say that operator p has precedence over operator q if an expression is of the form:

$expr1 \ p \ expr2 \ q \ expr3$ is interpreted only as $(expr1 \ p \ expr2) \ q \ expr3$.

In arithmetic expressions, (well balanced) parentheses are used to modify the order of precedence and associativity of operators.

In arithmetic expression, except for 0 (zero), integers cannot start with zero. For example, 002 is not an integer.

Samples of well formed arithmetic expressions:

$$69*2+5^2$$

$$2*5+4/(4+5)$$

$$-(346-3)*-2$$

$$-0+10+687^{(2+1)}/5+7$$

Samples of not well formed arithmetic expressions:

$$45**23 + 2$$

$$234+((45*67)+2$$

$$00234+34^{(2+1)}$$

$$823++/4$$

- (a) Add parentheses to the following expressions to make clear the precedence of the operators.

e.g: $2*4+22+452+-1 \rightarrow ((2*4)+22)+452)+(-1)$

(i) $20+---20+68^2/23-23 \rightarrow$

(ii) $2+-2*3^3^4*8+2^4^3+2*5 \rightarrow$

(20/100)

- (b) Find a grammar G that can generate all arithmetic expressions described above.

(40/100)

- (c) Convert the grammar G into a PDA M that can recognise all well formed arithmetic expressions.

(40/100)

5. Let $L = \{0^{2^n} \mid n \geq 0\}$.

- (a) Design a Turing machine T for the language L .

(50/100)

- (b) Draw the state diagram of T .

(30/100)

- (c) Show the ID's of the Turing machine T if the input tape contains the string "0".

(20/100)