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12SCS21

Second Semester M.Tech. Degree Examination, June/July 2013
Formal Models in Computer Science

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Define what are declarative sentences. **(02 Marks)**

b. For the declarative sentences below, discuss how are they capable of being declared 'true' or 'false' :
i) The sum of the numbers 3 and 5 equals 8.
ii) Jane reacted viotently to Jack's accusations.
iii) Every even natural number >2 is the sum of two prime numbers.
iv) All martians like pepperoni on their pizza. **(08 Marks)**

c. Prove that $2^n \geq n+12$ for all natural numbers $n \geq 4$ using mathematical induction. Is the statement true for any $n < 4$? **(10 Marks)**

2 a. Construct a formula in CNF based on each of the following truth tables: **(10 Marks)**

i)

p	q	ϕ_1
T	T	F
F	T	F
T	F	F
F	F	T

ii)

p	q	r	ϕ_2
T	T	T	T
T	T	F	F
T	F	T	F
F	T	T	T
T	F	F	F
F	T	F	F
F	F	T	T
F	F	F	F

iii)

r	s	q	ϕ_3
T	T	T	F
T	T	F	T
T	F	T	F
F	T	T	F
T	F	F	T
F	T	F	F
F	F	T	F
F	F	F	T

b. Write the algorithms CNF, NNF and IMPL – FREE. **(06 Marks)**

c. Apply the Horn algorithm on the following formula and state if it is satisfiable or not. $(p \wedge q \wedge w \rightarrow \perp) \wedge (t \rightarrow \perp) \wedge (r \rightarrow p) \wedge (T \rightarrow r) \wedge (T \rightarrow q) \wedge (u \rightarrow s) \wedge (T \rightarrow u)$ **(04 Marks)**

3 a. Define the following in predicate logic: i) Terms ii) Formulas iii) Free and bound variables. **(06 Marks)**

b. Translate the following into predicate logic:
i) Every student is younger than some instructor.
ii) Not all birds can fly.
iii) No animal is both a cat and a dog. **(06 Marks)**

c. Let ϕ be $(\forall x(p(x) \wedge Q(x))) \rightarrow (\neg p(x) \vee Q(y))$
i) Draw the parse tree of ϕ.
ii) Identify all bound and free variables leaves in ϕ. **(08 Marks)**

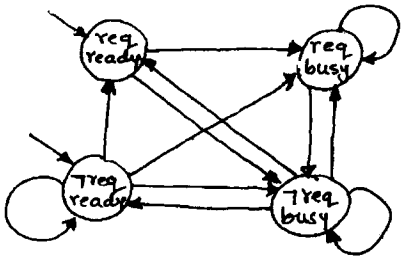
4 a. Prove the validity of the following sequents:
i) $\forall x \forall y P(x,y) \vdash \forall u \forall v P(u,v)$
ii) $\exists x \forall y P(x,y) \vdash \forall y \exists x P(x,y)$ **(08 Marks)**

b. Define a model in predicate logic. **(04 Marks)**

c. Explain the model of a software package dependency system and express the components as a signature in alloy. **(08 Marks)**

5 a. Explain the classification criteria for approaches to verification. **(10 Marks)**

b. Consider the following model below: **(04 Marks)**



Verify that G(req →F busy) hold in all initial states.

Fig. Q5 (b)

c. Explain what is LTL? Define the syntax and semantics of LTL. **(06 Marks)**

6 a. What is computation tree logic? Define the CTL formulas in BNF. **(04 Marks)**

b. Write the syntax of CTL*. Describe LTL and CTL as subsets of CTL* and draw a figure to show the relationships among the expressive powers of CTL, LTL and CTL*. **(10 Marks)**

c. Write a note on new symbolic model verifier. **(06 Marks)**

7 a. With an example, explain what are program variables and logical variables. **(10 Marks)**

b. Prove the validity of the sequent $\vdash_{par} (|T|)P(|Z = \min(x, y)|)$, where mm(x,y) is the smallest number of x and y. e.g. min(7, 3) = 3 and the code of P is given by,

```
if(x > y) {
      z = y ;
} else {
      z = x ;
 }
```

(10 Marks)

8 Write short notes on the following :

a. Formal methods.

b. CICS experience.

c. The z notation.

d. The importance of proof. **(20 Marks)**

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