University of Mohamed Boudiaf M'sila
Faculty of Mathematics and Computer Science
Department of Computer Science
Master 01 SIGL

Duration: 1h30 (90 Minutes) Instructor Pr. Hichem Debbi

Formal Specification and Verification
Final Exam
May 13, 2024

True/False

(03 points) Write True if the statement is true, otherwise write False.

_____ $F\psi \equiv \psi \vee XF\psi$

_____ Method B reinforces unit testing.

_____ LTL model checking is performed by converting the Kripke structure into a tree

_____ pUq could be true, if q is always true

_____ pRq could be true, if p is true until q becomes true

_____ $r \in E_1 \leftrightarrow E_2$ which refers to ran(r) is defined formally as : $\{x | x \in E_2 \wedge \exists y.(y \in E_1 \wedge (x \mapsto y) \in r)\}$

Section 2. Short Answer(03 points)

1. Provide two examples of paths satisfying the LTL formulae FGa and GFa
2. Cite four (04) formal specification languages ?

Section 3. Method-B Specification(09 points)

3. A vending machine is an automatic dispenser that gives products in exchange for payment. We assume that payment is performed by inserting a number of *credits*. The vending machine shall have two modes of operation: on and off.

   - Write in Atelier B an abstract machine specifying the vending machine. Availability of products dispensed by the vending machine should be modeled qualitatively, as a subset of the set of all products.
   - Add in your machine the requirement that the stored number of inserted credits is zero when the vending machine is off.

   1- Complete the abstract machine **Vending** by adding invariants, initialization, and the three following operations:

   - **switch_on** and **switch_off**.
   - **insert_credit**: for inserting credits
   - **return_credit**: that returns credit.
   - **dispense**: that dispenses or gives the product.

```
MACHINE
    Vending
SETS
    PRODUCT ;
    STATE = {on, off}
CONSTANTS
    price,
    max_credit
PROPERTIES
    price : PRODUCT --> NAT1 &
    max_credit : NAT1
VARIABLES
    available,
    credit,
    state
```

Figure 1: Vending Machine

4. Write the abstract machine *Divisibility* that checks whether a number nn can be divided by a devisor dd or not.

Section 4. LTL Büchi automaton(02 points)

5. To which ltl property these Büchi automaton correspond :

   Automaton A:

   - GFa
   - FGa
   - $G(a \wedge a)$

   Automaton B:

   - $G(a \wedge b)$
   - $G(a \implies Fb)$
   - $G(bU(b \wedge a))$

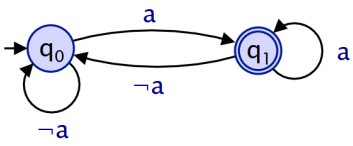

Figure 2: A

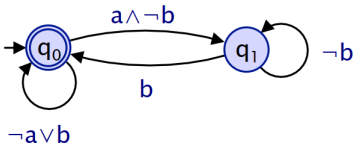

Figure 3: B

Section 5. ω-expressions(03 points)

6. Give the $\omega-$regular expressions for the following Büchi automaton :

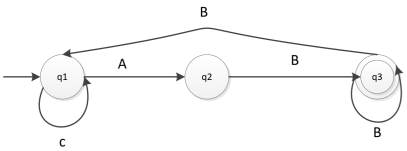

Figure 4: A

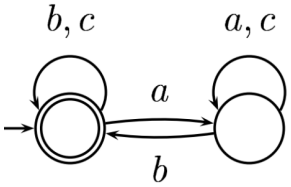

Figure 5: B

Answer Key for Exam A

True/False

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True $F\psi \equiv \psi \vee XF\psi$

False Method B reinforces unit testing.

False LTL model checking is performed by converting the Kripke structure into a tree

True pUq could be true, if q is always true

False pRq could be true, if p is true until q becomes true

False $r \in E_1 \leftrightarrow E_2$ which refers to ran(r) is defined formally as : $\{x | x \in E_2 \wedge \exists y.(y \in E_1 \wedge (x \mapsto y) \in r)\}$

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   Answer: See course.

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VARIABLES
    available,
    credit,
    state
```

Figure 6: Vending Machine

```
MACHINE
    Divisibility
DEFINITIONS
    Divides (d, n) == (#kk . (kk : NATURAL & (n) = kk*(d)))
OPERATIONS
    res <-- divides (dd, nn) =
        PRE
            dd : NAT &
            nn : NAT
        THEN
            res := bool(Divides(dd, nn))
        END
END
```

Answer:

4. Write the abstract machine *Divisibility* that checks whether a number nn can be divided by a devisor dd or not.

   Answer:

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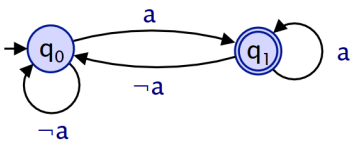

Figure 7: A

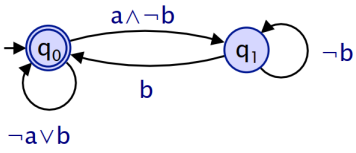

Figure 8: B

Answer:
- GFa
- $G(a \implies Fb)$

Section 5. ω-expressions(03 points)

6. Give the $\omega-$regular expressions for the following Büchi automaton :

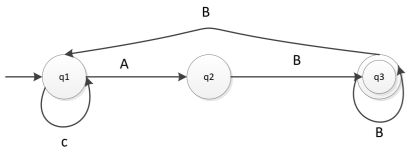

Figure 9: A

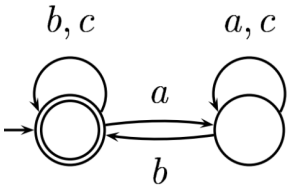

Figure 10: B

Answer:
- $C * AB(B + +BC * AB)^{\omega}$
- $(a(a+c)^*b)^{\omega} + (a(a+c)^*b)^*(b+c)^{\omega}$