SOEN 331 - S and U: Introduction to Formal Methods for Software Engineering

Assignment 3 on Temporal Logic

Dr. Constantinos Constantinides, P.Eng.

constantinos.constantinides@concordia.ca

2 April, 2020 (Updated)

Contents

1 General information

Date posted: Monday 30 March, 2020.

Date due: Monday 13 April, 2020, by 23:59.

Weight: 20% of the overall grade.

2 Introduction

This assignment should be done by teams of 3 or 4. Each team should designate a leader who will submit the assignment electronically.

3 Ground rules

This is an assessment exercise. You may not seek any assistance while expecting to receive credit. **You must work strictly within your team and seek no assistance for this project (from the instructor, the teaching assistants, fellow classmates and other teams or external help)**. Failure to do so will result in penalties or no credit.

Problem 1 (20 pts): Analyzing program behavior

The behavior of a program is expressed by the following temporal formula:

$$\Box \left[\begin{array}{c} 1.\ \textbf{start} \rightarrow \neg a \vee \neg b \\ 2.\ \textbf{start} \rightarrow c \\ 3.\ b \wedge c \rightarrow \bigcirc^2 (d \oplus e) \\ 4.\ a \vee c \rightarrow \bigcirc (k\ \mathcal{R}\ g) \\ 5.\ (d \vee e) \rightarrow \bigcirc^2 k \\ 6.\ c \rightarrow (h\ \mathcal{U}\ (e \wedge g)) \\ 7.\ (d \wedge g \wedge h) \rightarrow \bigcirc^3 m \\ 8.\ (m\ \mathcal{R}\ h) \\ 9.\ e \wedge \bigcirc^2 (k \wedge g) \rightarrow \bigcirc^2 m \\ 10.\ (e \wedge g) \rightarrow \bigcirc^3 c \\ 11.\ k \wedge m \rightarrow \bigcirc h \\ 12.\ (e \wedge \bigcirc^2 k) \rightarrow \bigcirc^3 b \end{array} \right]$$

1. (10 pts) Visualize all models of behavior.

2. (3 pts) Specify conditions (model of behavior), if any exist, under which the program can terminate.

3. (7 pts) For the expressions below, indicate (true/false) whether there exists a model where the expression holds. When true, cross reference your particular model:

PROPERTY	**TRUE/FALSE**
$(a \wedge c) \rightarrow \Diamond\Box(g \wedge h)$	
$h \; \mathcal{U} \; m$	
$h \; \mathcal{U} \; (k \wedge g)$	
$(b \wedge c) \rightarrow \Box\Diamond(b \wedge c)$	
$(k \wedge \bigcirc(k \wedge g)) \rightarrow \bigcirc m$	
$h \; \mathcal{S} \; c$	
$((g \wedge h) \wedge \bigcirc d) \rightarrow \bigcirc^2(g \wedge h)$	
$e \; \mathcal{R} \; h$	
The program has the following stability property: $\Diamond\Box(b \wedge \ c \wedge h)$	
The program has the following recurrence property: $\Box\Diamond(b \wedge \ c \wedge h)$	
$(g \wedge h)$ is an invariant property of the program.	
There is a guarantee that $(g \wedge k \wedge h)$	
The program has the following property: $(b \wedge c \wedge h) \rightarrow \Diamond(b \wedge c \wedge h)$.	
The program has the following precedence property: $(b \wedge c \wedge h) \rightarrow ((g \wedge h) \; \mathcal{U} \; b \wedge c \wedge h))$	

Problem 2 (20 pts) : Visualizing temporal expressions

1. $\Box(\phi \rightarrow \bigcirc^2 \psi)$
2. $\Box\phi \rightarrow \bigcirc\psi$
3. $\phi \rightarrow \bigcirc\Diamond\Box\psi$
4. $(\phi \wedge \bigcirc\psi) \rightarrow \bigcirc^2\Diamond\Box\omega$
5. $\Box((\phi \wedge \bigcirc\psi) \rightarrow \bigcirc^2\Diamond\Box\omega)$
6. $(\phi \wedge \bigcirc\psi) \rightarrow \tau \ \mathcal{R} \ \upsilon$
7. $(\phi \wedge \bigcirc\psi) \rightarrow \bigcirc(\tau \ \mathcal{R} \ \upsilon)$
8. $(\phi \wedge \bigcirc\psi) \rightarrow \bigcirc(x \ \mathcal{U} \ \tau)$
9. $(\phi \wedge \Box\psi) \rightarrow \bigcirc^2\Diamond\omega$
10. $(\phi \wedge \bigcirc^2\psi) \rightarrow \bigcirc\Box\omega$

4 What to submit

You must use LaTeX to produce a **pdf** file named after the id of the person to submit, e.g. `123456.pdf`.

Section S

Please submit on Moodle. Your instructor will provide you with more details.

Section U

Please submit your `pdf` file at the Electronic Assignment Submission portal

(`https://fis.encs.concordia.ca/eas`)

under **Theory Assignment 3**.

END OF ASSIGNMENT.
