Concordia University Department of Computer Science and Software Engineering

SOEN 331 Section S: Formal Methods

for Software Engineering

Assignment 4

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1 Our assignment

1. (10 pts) Find a logically equivalent formula for $\phi \ W \ \psi$ and provide a short reasoning to support your answer. Represent this equivalence between the two expressions with the appropriate logical connective, and support your reasoning.

   Solution:

   The logically equivalent formula for this would be:

   $(\phi \ W \ \psi) \equiv (\phi \ U \ \psi) \vee \Box(\psi)$

   These are equivalent, because the principle of the strong until operator U. Since the ψ is never guaranteed to be true, we would need to add an extra or statement because if the statement ψ becomes true it would mean that ϕ can't be true. This means that ϕ would be true until a certain condition (ψ is true) is met.

2. (10 pts) Find a logically equivalent formula for $\phi \ U \ \psi$, and provide a short reasoning to support your answer. Represent this equivalence between the two expressions with the appropriate logical connective, and support your reasoning.

   Solution:

   The logically equivalent formula for this would be:

   $(\phi \ U \ \psi) \equiv (\phi \ W \ \psi) \wedge \Diamond(\psi)$

   These are equivalent, because the principle of the strong until operator U. We know that this ψ will eventually become true. We then now that we can use the weak until clause with an eventually operator, because the only way that ϕ is not true is when the ψ is not true. We add the and operator, because we want to insure that we actually get ψ as being true, because this may never happen.

3. (10 pts) Find a logically equivalent formula for $\phi \ R \ \psi$ in terms of W , and provide a short reasoning to support your answer. Represent this equivalence between the two expressions with the appropriate logical connective, and support your reasoning.

Solution:

This paragraph refers to Questions 4 - 5: Consider a railroad with a single rail and a road level-crossing. We introduce the following propositions that represent events:

a : A train is approaching.

b : The barrier is down

c : A train is crossing

l: A light is blinking

4. (15 pts) Express each of the following requirements formally. For each one, proceed to find a logically equivalent formula that captures the safety property of the system (i.e. in terms of “something bad never happens”):

   (a) (5 pts) When a train is crossing, the barrier must be down.
   Solution:

   (b) (5 pts) If a train is approaching or crossing, then the light must be blinking.
   Solution:

   (c) (5 pts) If the barrier is up and the light is off, then no train is coming or crossing.
   Solution:

5. (10 pts) Express each of the following requirements formally in terms of the liveness property (i.e. in terms of “something good eventually happens”):

   (a) (5 pts) When a train is approaching, it will eventually cross..
   Solution:

   (b) (5 pts) When a train is approaching and no train is crossing, then the barrier will eventually go down before the train crosses.

Solution:

6. (45 pts) The behavior of a program is expressed by the following temporal formula: