Computer Aided Verification Assignment 2

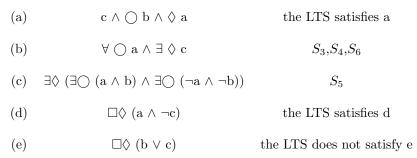
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1 For which of the two logics LTL and CTL (if any) are these legal (i.e., syntactically correct) formulae? You can assume that a, b and c are atomic propositions.

(a)	♦ □ ♦ b	LTL
(b)	$\exists (c \bigcup \forall \bigcirc a)$	CTL
(c)	$b \wedge \Box (a \to \bigcirc \neg c)$	Neither
(d)	$\neg \ ((\ \Box\Box a)\ \bigcup\ \bigcirc\ (b\ \wedge\ c))$	LTL
(e)	$\exists\Box\Diamond a$	Neither

2 For each LTL formula, state whether the LTS satisfies it and, for each CTL formula, give the set of states of the LTS that satisfy it.



- 3 Translate the following informally described properties into the specified temporal logic, explaining the meaning of any atomic propositions that you use.
- 3.a servers 1 and 2 are never both down simultaneously (in CTL)

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S_1 = \text{Server one is down}

S_2 = \text{Server 2 is down}

\neg \exists \Diamond (S_1 \land S_2)
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3.b the robot eventually reaches room A and never passes through corridor B or C whilst doing so (in LTL)

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A = \text{In room A}
B = \text{In corridor B}
C = \text{In corridor C}
\neg (B \lor C) \bigcup A
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3.c program location 1 7 is visited infinitely often and program locations 1 2 and 1 3 are visited only finitely often (in LTL)

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l_7 = \text{at program location } l_7

l_2 = \text{at program location } l_2

l_3 = \text{at program location } l_3

(\Box \lozenge \ l_7) \land (\neg(\Box \lozenge \ (l_2 \lor l_3))
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4 Using these (where needed), either prove or disprove each of the following proposed LTL equivalences. You can assume that a, b and c are atomic propositions.

4.a
$$\neg (\Box \lozenge a \rightarrow \lozenge \Box b) \equiv \Box \lozenge a \land \Box \lozenge \neg b$$

 $\neg (\Box \lozenge a \rightarrow \lozenge \Box b)$
 $\neg (\neg \Box \lozenge a \lor \lozenge \Box b)$ implication eq
 $\neg (\neg \Box \lozenge a \lor \lozenge \neg \lozenge \neg b)$ box eq
 $\Box \lozenge a \land \neg \lozenge \neg \lozenge \neg b$ DeMorgan's Law

 $\Box \Diamond \ a \land \Box \Diamond \neg b$ Box eq

$$\mathbf{4.b} \quad \Box \ (\mathbf{b} \, \wedge \, \mathbf{c}) \, \rightarrow \, \Diamond \ \mathbf{a} \equiv \, \neg \, \left(\Box \ (\mathbf{b} \, \wedge \, \mathbf{c}) \, \wedge \, \Box \ \mathbf{a}\right)$$

The trace of only a e.g. a, a, a, ... satisfies the left side of the equality but not the right. A trace exists which satisfies one side but not the other, therefore they are not equivalent.