Exercises for LTL

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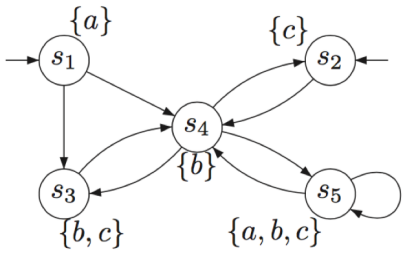
These exercises are based on material from the slides and from Chapter 5.

Question 1 Consider the following transtion system TS



Find the set of states in which each formula below is satisfied.

1. $\Diamond\Box c$
2. $\Box\Diamond c$
3. $\bigcirc\neg c \rightarrow \bigcirc\bigcirc c$
4. $\Box a$
5. $aU\Box(b \vee c)$
6. $(\bigcirc\bigcirc b)U(b \vee c)$

Question 2

Suppose we have two users, Peter and Betsy, and a single printer device Printer. Both users perform several tasks, and every now and then they want to print their results on the Printer. Since there is only a single printer, only one user can print a job at a time. Suppose we have the following atomic propositions for Peter at our disposal:

- Peter.request ::= indicates that Peter requests usage of the printer;
- Peter.use ::= indicates that Peter uses the printer;
- Peter.release ::= indicates that Peter releases the printer.

For Betsy, similar predicates are defined. Specify in LTL the following:

1. Mutual exclusion, i.e., only one user at a time can use the printer.
2. Finite time of usage, i.e., a user can print only for a finite amount of time.
3. Absence of individual starvation, i.e., if a user wants to print something, he/she eventually is able to do so.
4. Absence of blocking, i.e., a user can always request to use the printer
5. Alternating access, i.e., users must strictly alternate in printing.

Question 3

Which of the following equivalences are correct? Either prove them, or provide a counterexample transition system.

1. $G\phi \rightarrow F\psi \equiv \phi U(\psi \vee \neg\phi)$
2. $FG\phi \rightarrow GF\psi \equiv G(\phi U(\psi \vee \neg\phi))$
3. $GG(\phi \vee \neg\psi) \equiv \neg F(\neg\phi \wedge \psi)$
4. $F(\phi \wedge \psi) \equiv F\phi \wedge F\psi$
5. $G\phi \wedge XF\phi \equiv G\phi$
6. $F\phi \wedge XG\phi \equiv F\phi$

Question 4 (optional)

Transform the following LTL formula in PNF:

$$\neg\left((\Box a) \rightarrow ((a \wedge c) U \neg(\bigcirc b))\right) \wedge \neg(\neg a \vee \bigcirc \Diamond c)$$

Question 5

Compute the NBA accepting the *negation* of the following formulae (you can use a software tool)

1. $GF(a \wedge b)$
2. $G(Fa \wedge Fb)$
3. $GFa \rightarrow GFb$