ALBERT-LUDWIGS-
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Tutorials for Cyber-Physical Systems I - Model Checking
Exercise sheet 10

Exercise 1: LTL equivalences

Which of the following equivalences are correct? If it is not, please provide a counterexample that illustrates that the formula on the left and the formula on the right are not equivalent. If you still consider it is, try to provide a proof.

(a) $\Box\varphi \rightarrow \Diamond\psi \;\equiv\; \varphi\,\mathsf{U}\,(\psi \vee \neg\varphi)$

(b) $\Diamond\Box\varphi \rightarrow \Box\Diamond\psi \;\equiv\; \Box\big(\varphi\,\mathsf{U}\,(\psi \vee \neg\varphi)\big)$

(c) $\Box\Box(\varphi \vee \neg\psi) \;\equiv\; \neg\Diamond(\neg\varphi \wedge \psi)$

(d) $\Diamond(\varphi \wedge \psi) \;\equiv\; \Diamond\varphi \;\wedge\; \Diamond\psi$

(e) $\Box\varphi \;\wedge\; \bigcirc\Diamond\varphi \;\equiv\; \Box\varphi$

(f) $\Diamond\varphi \;\wedge\; \bigcirc\Box\varphi \;\equiv\; \Diamond\varphi$

(g) $\Box\Diamond\varphi \rightarrow \Box\Diamond\psi \;\equiv\; \Box\big(\varphi \rightarrow \Diamond\psi\big)$

(h) $\neg(\varphi_1\,\mathsf{U}\,\varphi_2) \;\equiv\; \neg\varphi_2\,\mathsf{W}\,(\neg\varphi_1 \wedge \neg\varphi_2)$

(i) $\bigcirc\Diamond\varphi_1 \equiv \Diamond\bigcirc\varphi_2$

(j) $(\Diamond\Box\varphi_1) \wedge (\Diamond\Box\varphi_2) \;\equiv\; \Diamond(\Box\varphi_1 \wedge \Box\varphi_2)$

(k) $(\varphi_1\,\mathsf{U}\,\varphi_2)\,\mathsf{U}\,\varphi_2 \;\equiv\; \varphi_1\,\mathsf{U}\,\varphi_2$

Exercise 2: Mutex in LTL

Suppose we have two users, *Peter* and *Betsy*, and a single printer device *Printer*. Both users perfrm 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 properties:

(a) Mutual exclusion, i.e., only one user at a time can use the printer.

(b) Finite time of usage, i.e., a user can print only for a finite amount of time.

(c) Absence of individual starvation, i.e., if a user wants to print something, he/she eventually is able to do so.

(d) Absence of blocking, i.e., a user can always request to use the printer.

(e) Alternating access, i.e., users must strictly alternate in printing.