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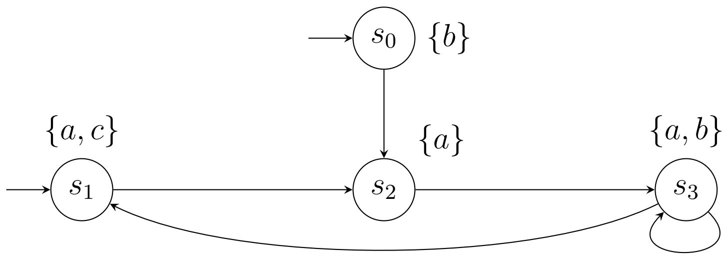
Tutorial for Cyber-Physical Systems - Discrete Models

Exercise Sheet 12

Exercise 1: LTL 3 Points

Consider the following transition system over the set of atomic propositions $\{a, b, c\}$:



Indicate for each of the following LTL-formulas the set of states for which the formula is satisfied.

(a) $a \wedge \bigcirc b$

(b) $a \mathbin{\mathsf{U}} b$

(c) $\neg(a \mathbin{\mathsf{U}} \square b)$

(d) $(\lozenge c) \mathbin{\mathsf{U}} \square a$

(e) $\lozenge \square a$

(f) $\square \lozenge c$

Exercise 2: Stating properties in LTL 3 Points

Suppose we have two users, *Betsy* and *Peter*, and a single printer device. 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*, analogous 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, the user is eventually able to do so.

(d) Bonus: Absence of blocking, i.e., if a user requests access to the printer, the user does not request forever.

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

Exercise 3: Equivalence of LTL formulas 2+2 Points

Consider the following claims about equivalences of LTL formulas.

Provide a counterexample (i.e., instantiate the formula and give a transition system or a word that shows a difference) if an equivalence does not hold.

(a) $$(\Box\,\varphi) \wedge (\Box\,\psi) \stackrel{?}{\equiv} \Box(\varphi \wedge \psi)$$

(b) $$(\Box\,\varphi) \vee (\Box\,\psi) \stackrel{?}{\equiv} \Box(\varphi \vee \psi)$$

(c) $$\Box\,\varphi \rightarrow \Diamond\,\psi \stackrel{?}{\equiv} \varphi \mathbin{\mathsf{U}} (\psi \vee \neg\varphi)$$

(d) $$\Box\,\Diamond\,\varphi \stackrel{?}{\equiv} \Diamond\,\Box\,\varphi$$

Bonus: If an equivalence holds, give a proof.