Principles of Model Checking
Exercise class 1

Transition systems & linear-time properties

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Problem 1

A bank uses a non-terminating program to monitor its customers' account balances (ab). For each account, a separate instance of the program is run. The account balances of interest are characterized by the following atomic propositions:

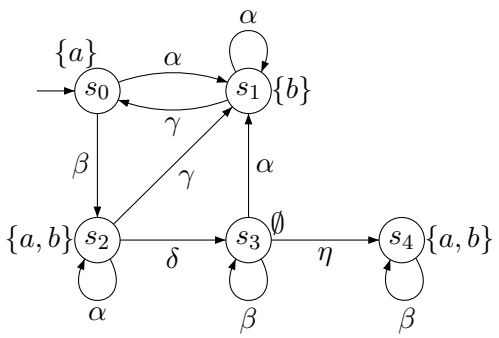
$$AP = \{ab < 0, ab = 0, ab > 100\}.$$

The program starts when an account is opened, and is updated each week. At any point in time, either precisely one of the three atomic propositions holds, or none at all (if the balance is between 0 and 100).

1. Express the following informally-stated properties as LT-properties:
   - An account with positive balance is opened.
   - The balance of an account is negative only finitely many times.
   - The balance of an account switches at least once from debit to credit.
   - Eventually, an account remains with more than €100 credit.
   - false and true.
2. Determine for each LT-property above whether it is a safety property or a liveness property. Justify your answer!

Problem 2

Consider the following transition system TS:



Let P be the set of traces of the form $\sigma = A_0 A_1 A_2 \ldots \in \left(2^{AP}\right)^\omega$ such that

$$\overset{\infty}{\exists}\, k.\, A_k = \{a, b\} \quad \wedge \quad \exists n \geq 0.\, \forall k > n.\, \big(a \in A_k \Rightarrow b \in A_{k+1}\big).$$

For the following fairness assumptions $\mathcal{F}_i$ with respect to the transition system TS, decide whether or not $TS \models_{\mathcal{F}_i} P$. Justify your answers!

1. $\mathcal{F}_1 = \Big(\big\{\{\alpha\}\big\}, \big\{\{\beta\}, \{\delta, \gamma\}, \{\eta\}\big\}, \emptyset\Big)$.
2. $\mathcal{F}_2 = \Big(\big\{\{\alpha\}\big\}, \big\{\{\beta\}, \{\gamma\}\big\}, \big\{\{\eta\}\big\}\Big)$.

Problem 3

Let P and P' be liveness properties over AP. Prove or disprove the following claims:

- $P \cup P'$ is guaranteed to be a liveness property too.
- $P \cap P'$ is guaranteed to be a liveness property too.

Answer the same question for safety properties.