Master 1 Informatique **2016-2017**
Université de Rennes 1

Modélisation et Vérification Formelle par Automates

Examination April 27, 2017
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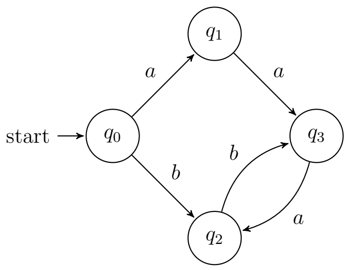
*You may **not** use written notes, published materials, testing aids, or any unauthorized material during the examination. Any of your answer should be justified. You are free to answer in French or in English. The scoring scale is indicative.*

Exercise 1 Büchi automata (3pts)

Consider the following Büchi automata:



Tell whether the ω-language recognized by the automaton above is empty for the following sets of accepting states.

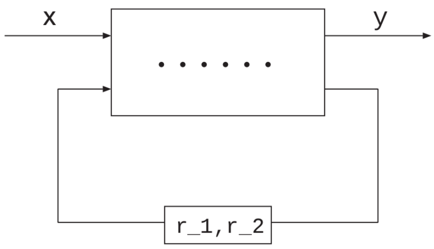
1. $F = \{q_0, q_1\}$

2. $F = \{q_2, q_3\}$

3. $F = \{q_1, q_3\}$

Exercise 2 LTL specifications (2pts)

Consider the following sequential circuit:



Let $AP = \{x, y, r_1, r_2\}$. Provide LTL formulas for the following properties:

1. "It is impossible that the circuit outputs two successive 1's."

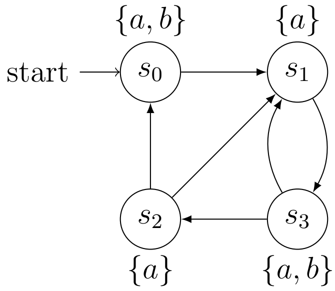
2. "Whenever the input bit is 1, in at most two steps the output bit will be 1."

3. "Whenever the input bit is 1, the registers' bit do not change in the next step."

4. "Register r_1 has infinitely often value 1."

Exercise 3 CTL properties (3pts)

Consider the following transition system over $AP = \{a, b\}$:



Compute for each CTL formula the set of states in which this formula holds.

1. $\forall\Diamond b$

2. $\forall\Box a$

3. $\exists\Box(\neg b \rightarrow \forall\bigcirc b)$

4. $\forall(a \text{ U } (\forall\bigcirc b))$

5. $\forall(a \text{ U } (\forall\bigcirc(\neg b \wedge \forall\bigcirc b)))$

6. $\forall(a \text{ W } (\forall\bigcirc(\neg b \wedge \forall\bigcirc b)))$[1]

[1]Recall: $\forall(\varphi_1 \text{ W } \varphi_2) = \neg\exists((\varphi_1 \wedge \neg\varphi_2) \text{ U } (\neg\varphi_1 \wedge \neg\varphi_2))$.

Exercise 4 (2pts)

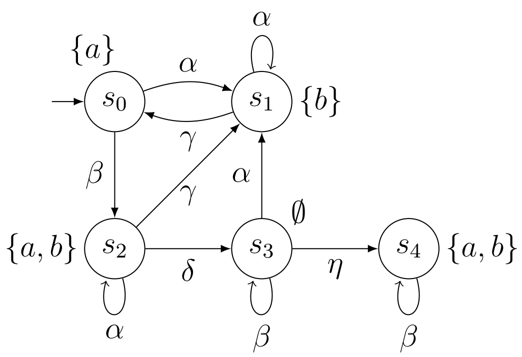
Consider the following linear time property P:

"Always if a is valid and $b \wedge \neg c$ was valid somewhere before, then neither a nor b holds thereafter."

1. Show that P is a safety property.
2. Define an NFA that characterizes the bad prefixes of Property P.

Exercise 5 Fairness, realizability (4pts)

1. Recall the definition of a fairness assumption of the form $(\mathcal{F}_{unc}, \mathcal{F}_{strong}, \mathcal{F}_{weak})$ and explain why it is useful for verification purposes.
2. Recall the definition of a realizable fairness assumption.
3. Consider the fairness assumption $\mathcal{F} = (\{\{\alpha, \gamma\}\}, \{\{\beta\}\}, \{\{\eta\}\})$ on the following TS.



Is $\mathcal{F}$ realizable in TS?

Exercise 6 Linear time properties, safety and liveness (6pts)

1. Recall the definition of a linear time property and of a regular linear time property.
2. Recall the definition of a safety property and of a liveness property.
3. Give an example of a non-trivial regular safety property.
4. Show that for a safety property, if the set of bad prefixes is regular, then the property is regular[2].
5. Give an example of a non-trivial non-regular safety property.
6. Give an example of a non-trivial regular liveness property.

[2]Recall that regular ω-languages are closed under complementation.