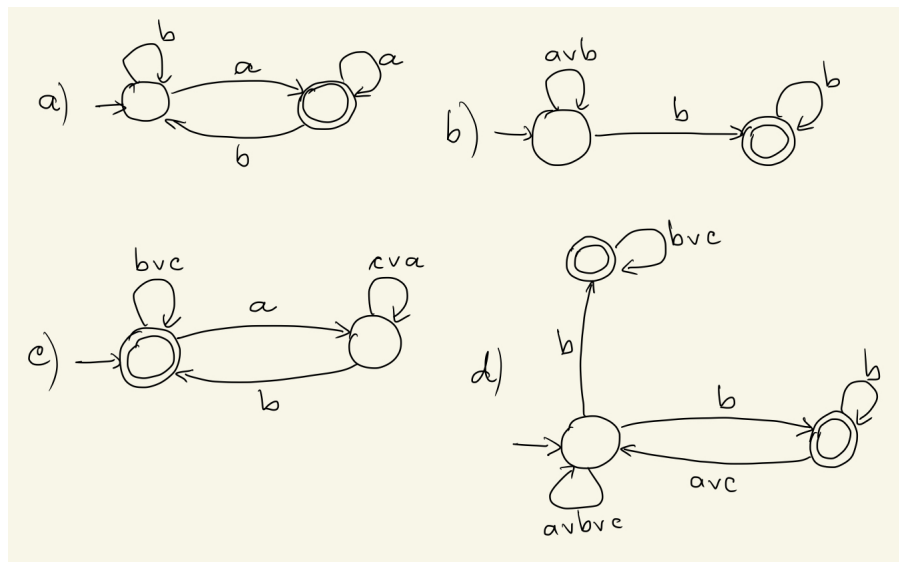


System Specification and Verification

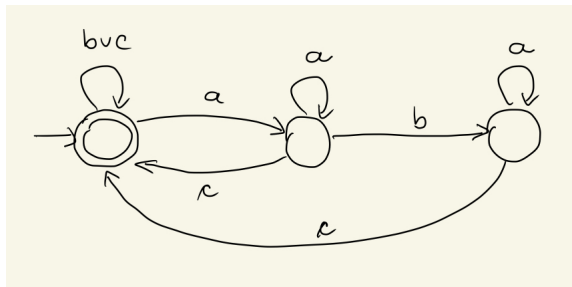
- Seminar - Week 5 -

Spring 2026

1. Let consider the following transition systems:

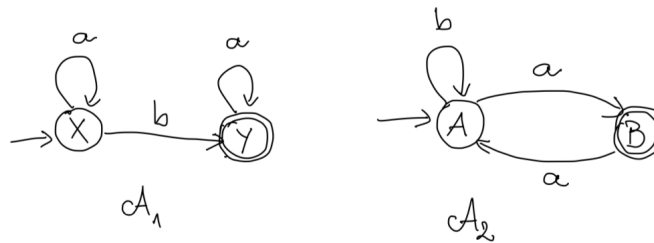


- Give the set of atomic propositions used.
 - What is the language of each automaton?
 - Give the LTL formula such that the language of the automaton corresponds to the language of the formula.
2. What are the words accepted by the following automaton? Give the LTL formula such that the language of the automaton coincides to the language of the formula.



- (a) $w_1 = (bac)^\omega$
- (b) $w_2 = aab(ac)^\omega$
- (c) $w_3 = ba(abab)^\omega$
- (d) $w_4 = a^\omega$
- (e) $w_5 = (abc)^\omega$

3. Let consider the following two automata:



Build the automaton A_\cap s.t. $\mathcal{L}(A_\cap) = \mathcal{L}(A_1) \cap \mathcal{L}(A_2)$

4. (Ultimately Periodic Words) An *ultimately periodic word* over $2^{\mathcal{A}^P}$ is a word of the form $u \cdot v^\omega$ with $u \in (2^{\mathcal{A}^P})^*$ and $v \in (2^{\mathcal{A}^P})^+$.

Prove that any nonempty recognizable language by a Büchi automaton contains an ultimately periodic word.

5. (Deterministic Büchi automata) A Büchi automaton $\mathcal{A} = \langle 2^{\mathcal{A}^P}, Q, Q_0, \delta, T \rangle$ is *deterministic* if $|Q_0| \leq 1$ and for each state q in Q and symbol $a \in 2^{\mathcal{A}^P}$, holds $|\{(q, a, q') \in \delta \mid q' \in Q\}| \leq 1$.

- (a) Give a nondeterministic Büchi automaton for the language in $\{a, b\}^\omega$ described by the expression $(a + b)^* a^\omega$.
- (b) Prove that there does not exist any deterministic Büchi automaton for this language.

6. Is there a natural number $k \geq 1$ s.t. if $\mathcal{L} \subseteq (2^{\mathcal{A}^P})^\omega$ is a language recognizable by a nondeterministic Büchi automaton, then

- (a) there is a Büchi automaton \mathcal{A} with at most k states with $\mathcal{L} = \mathcal{L}(\mathcal{A})$?
- (b) there is a Büchi automaton \mathcal{A} with at most k *accepting* states with $\mathcal{L} = \mathcal{L}(\mathcal{A})$?