Asynchronous games on Petri nets

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Concurrent systems

- A user interacts with an environment
- The user knows the structure of the system
- The user may not observe everything
- The user has a goal (perform an action, avoid a state, ...)
- The environment is hostile or indifferent

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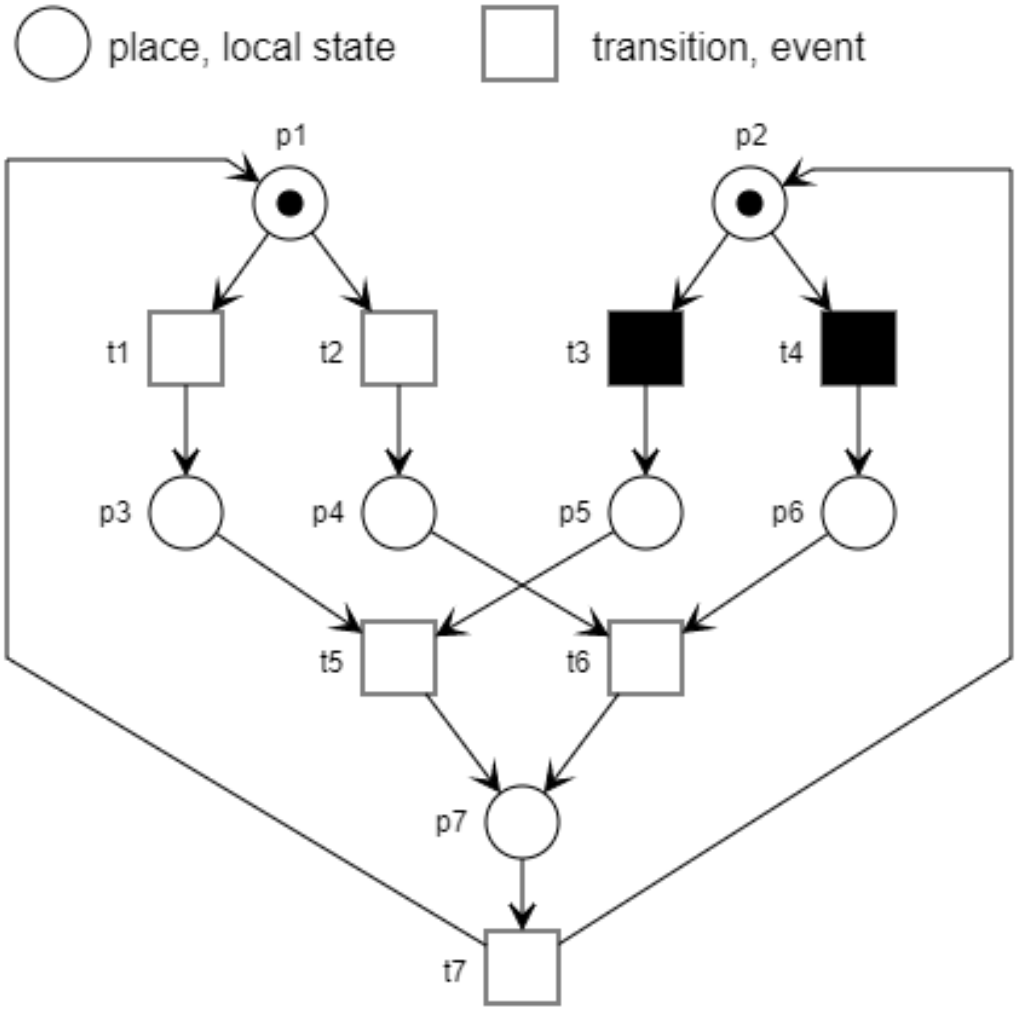
Applications

System control, model-checking, ...

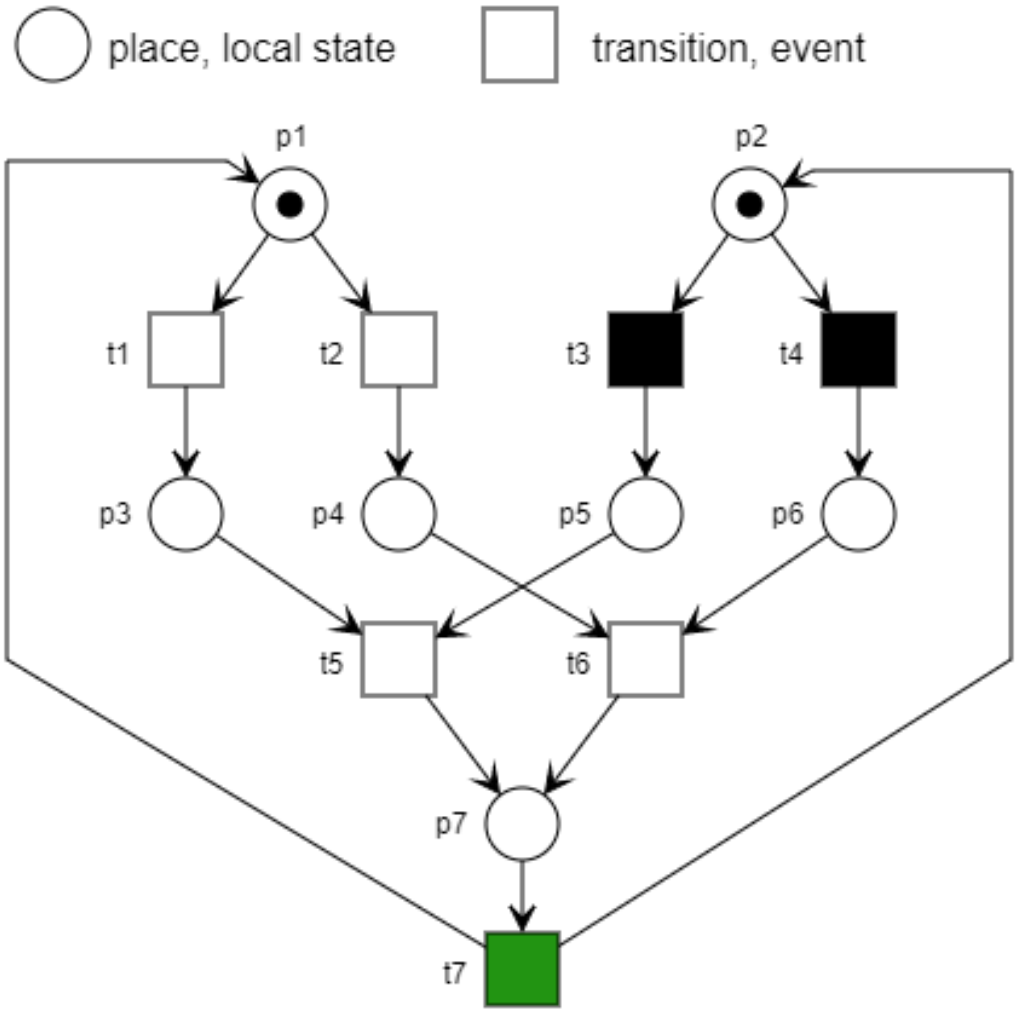
Modelling language: Petri nets



1-safe distributed nets

□ uncontrollable
■ controllable

Modelling language: Petri nets



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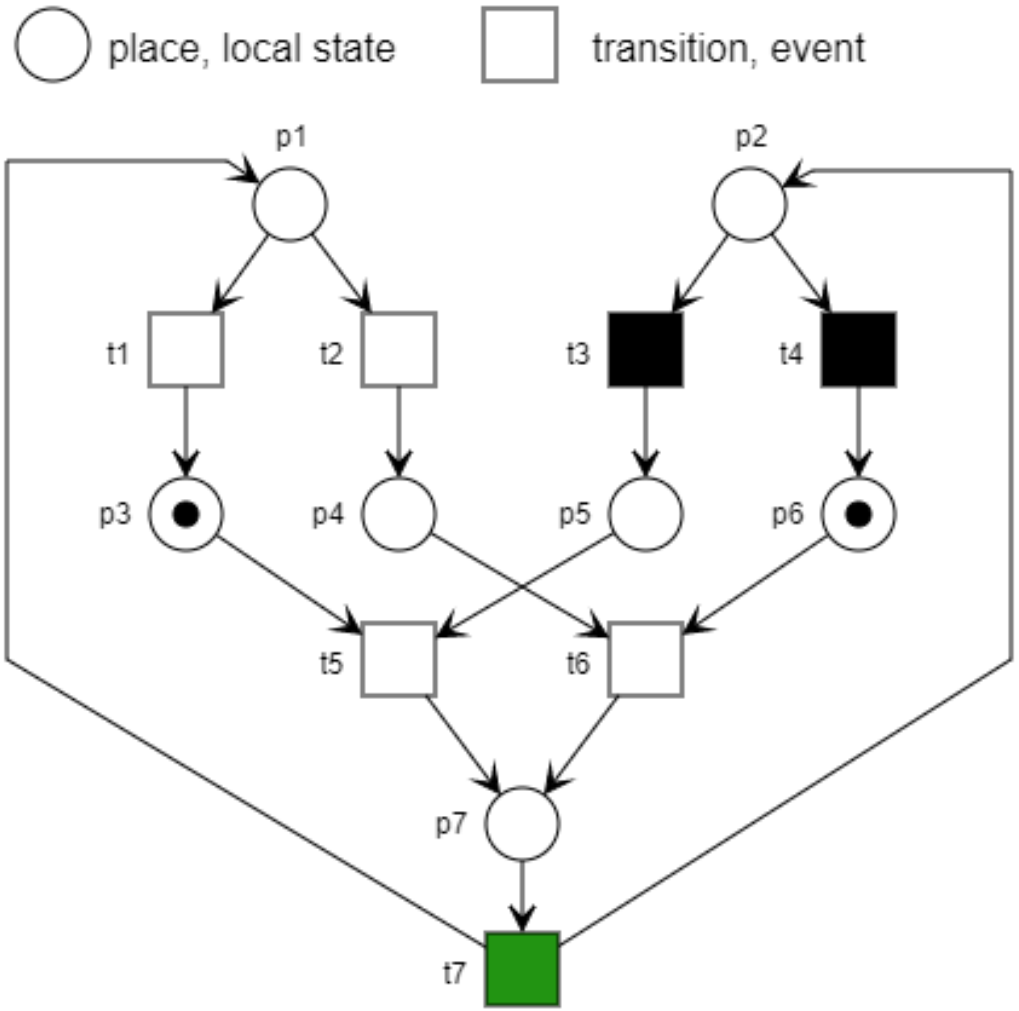
Example

Can the user force the occurrence of transition t_7, by controlling only black transitions?

Modelling language: Petri nets



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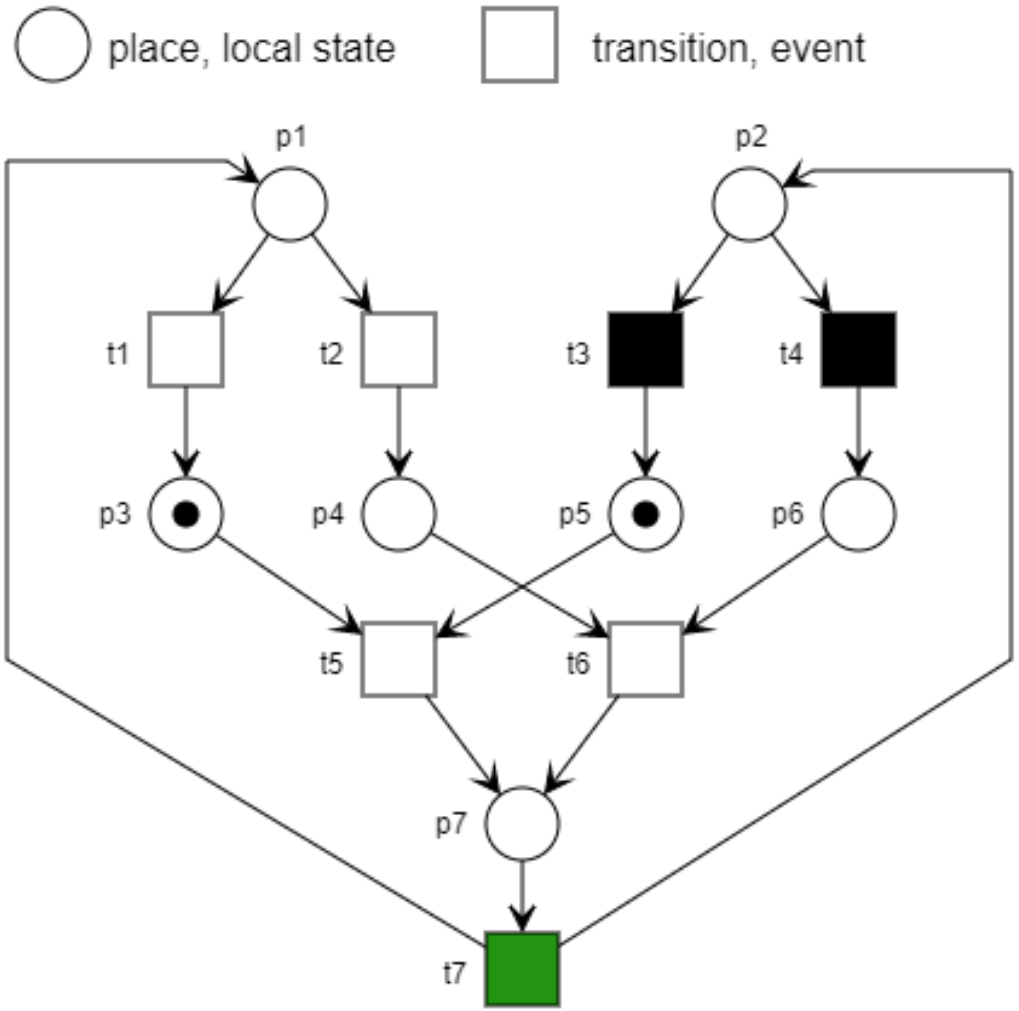

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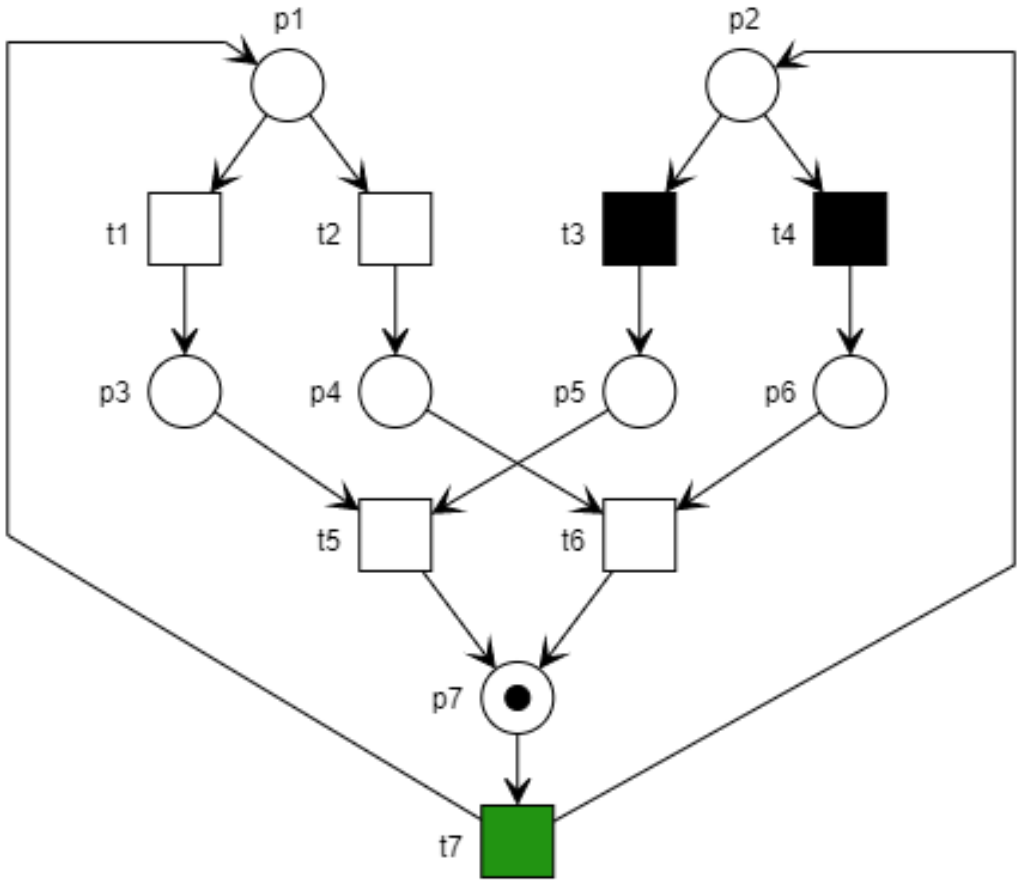

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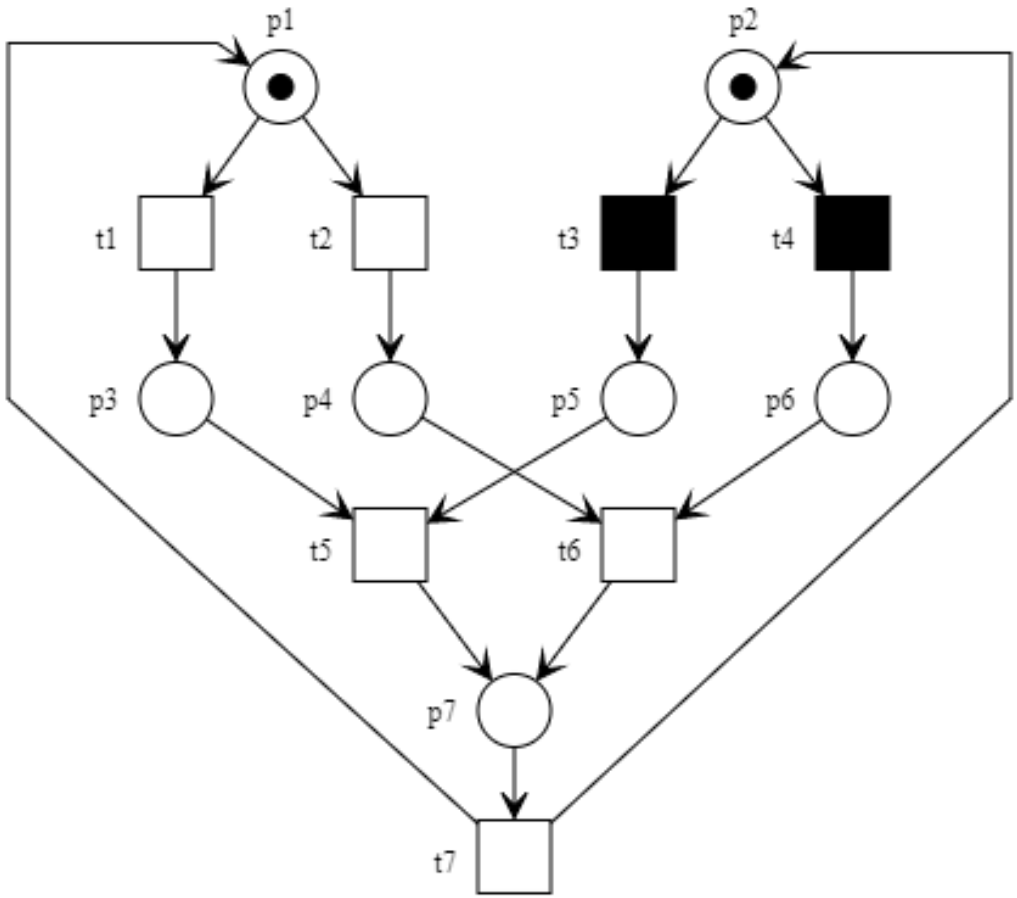


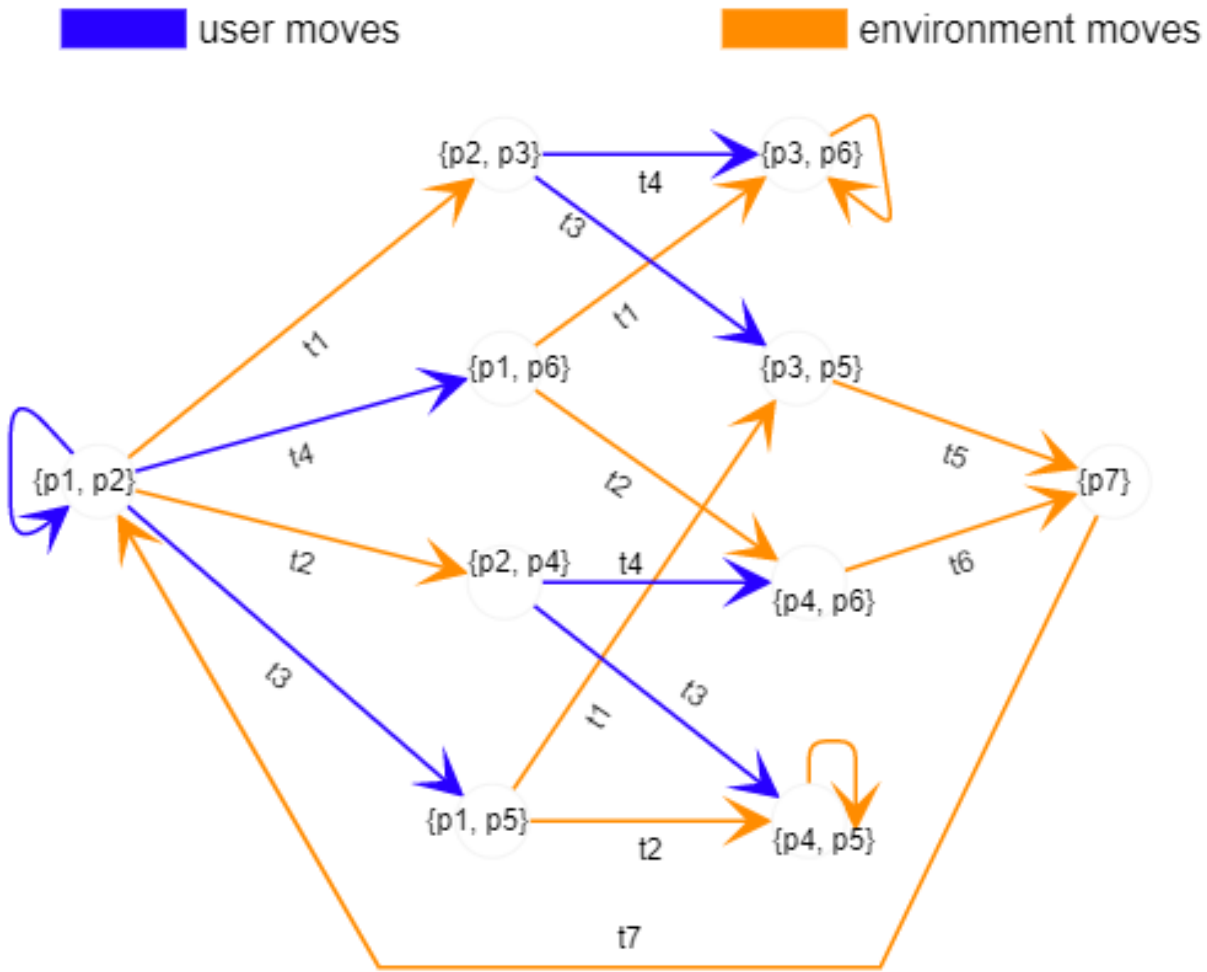
Rules

- Whenever a transition is enabled, its owner can decide to 'fire' it
- The Environment must guarantee the progress of the system

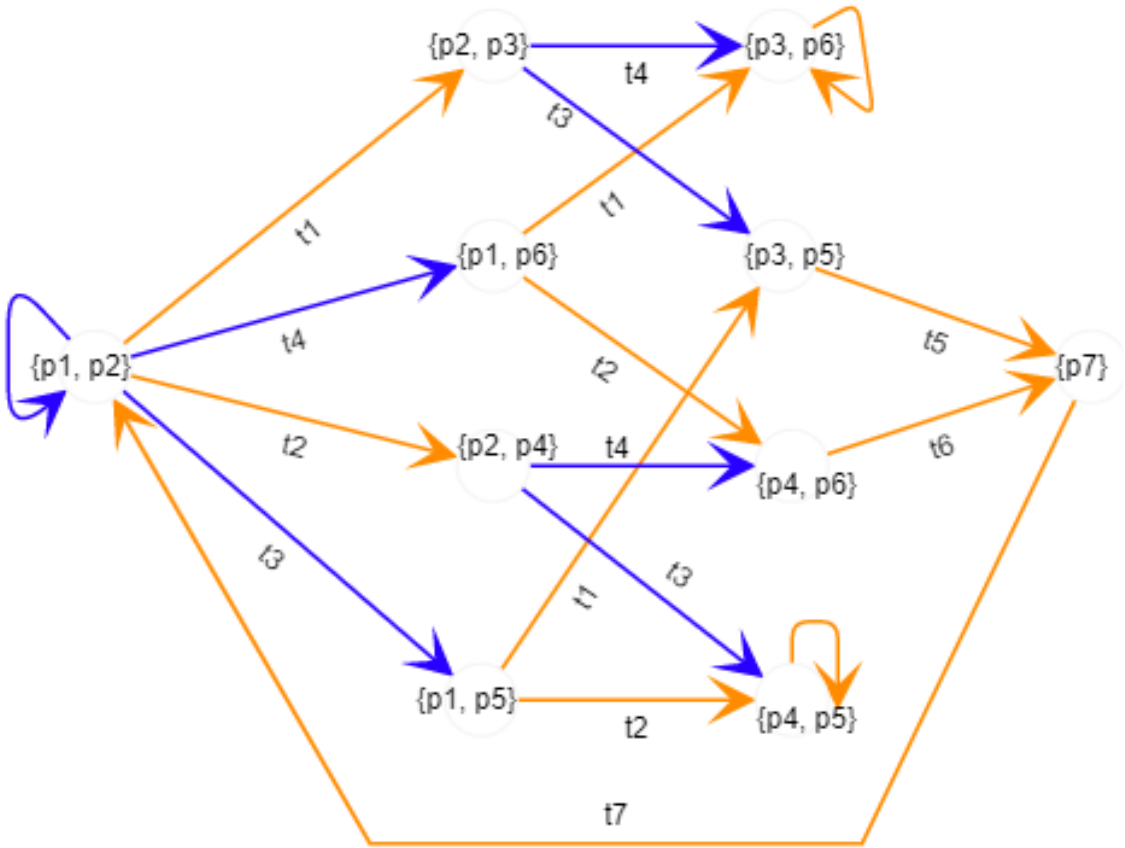
Strategy

$\alpha : Mark(N) \rightarrow 2^K$

Asynchronous game on concurrent game structure



ATL (Alur, Henzinger, Kupferman 2002)



Syntax

An ATL formula is one of the following:

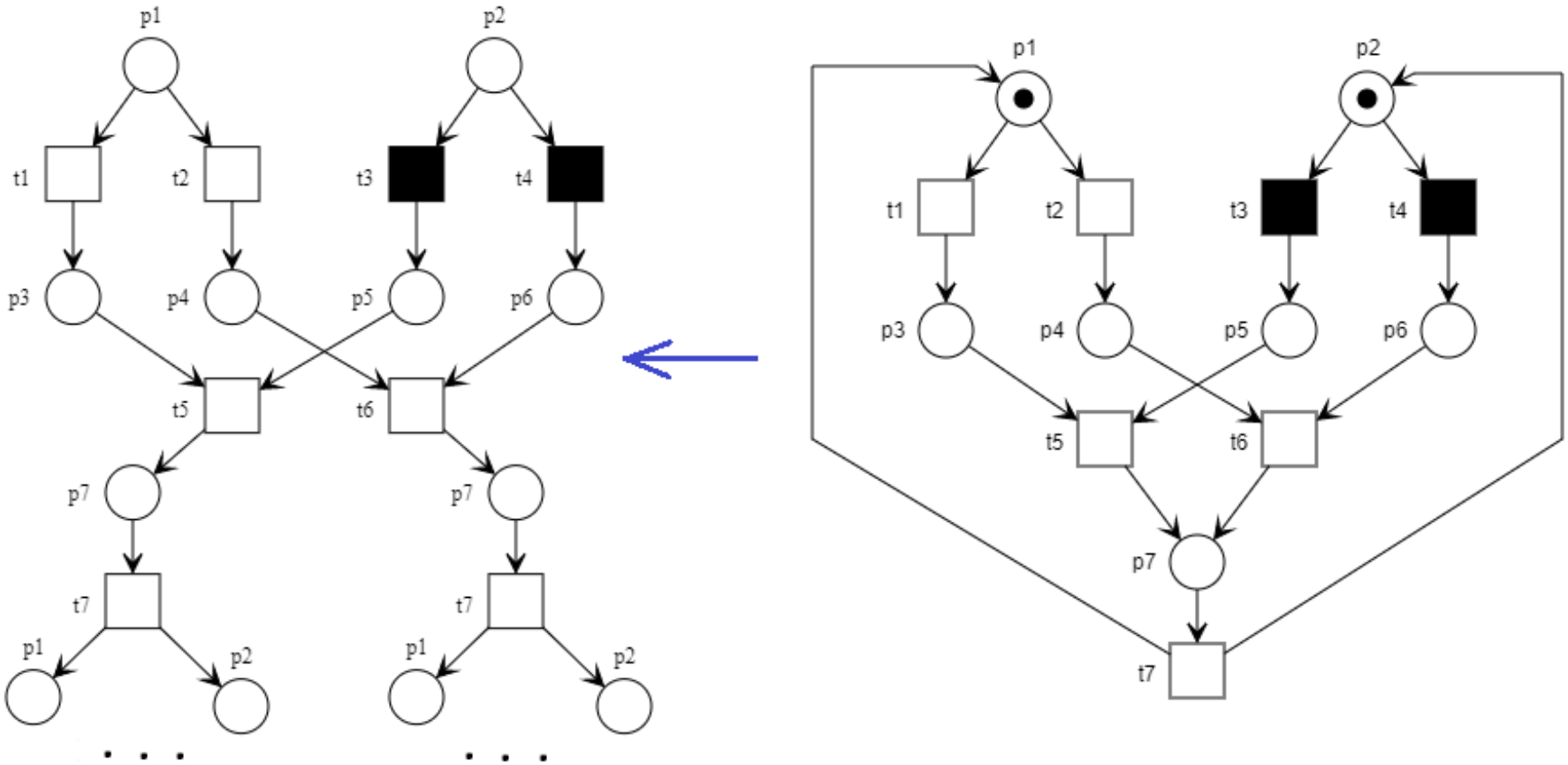
- a proposition p
- $\neg\phi$ or $\phi_1 \vee \phi_2$
- $\langle\langle A\rangle\rangle X\phi$, $\langle\langle A\rangle\rangle G\phi$, $\langle\langle A\rangle\rangle F\phi$, or $\langle\langle A\rangle\rangle \phi_1 U \phi_2$, with A set of players

ϕ, ϕ_1, ϕ_2 ATL formulas

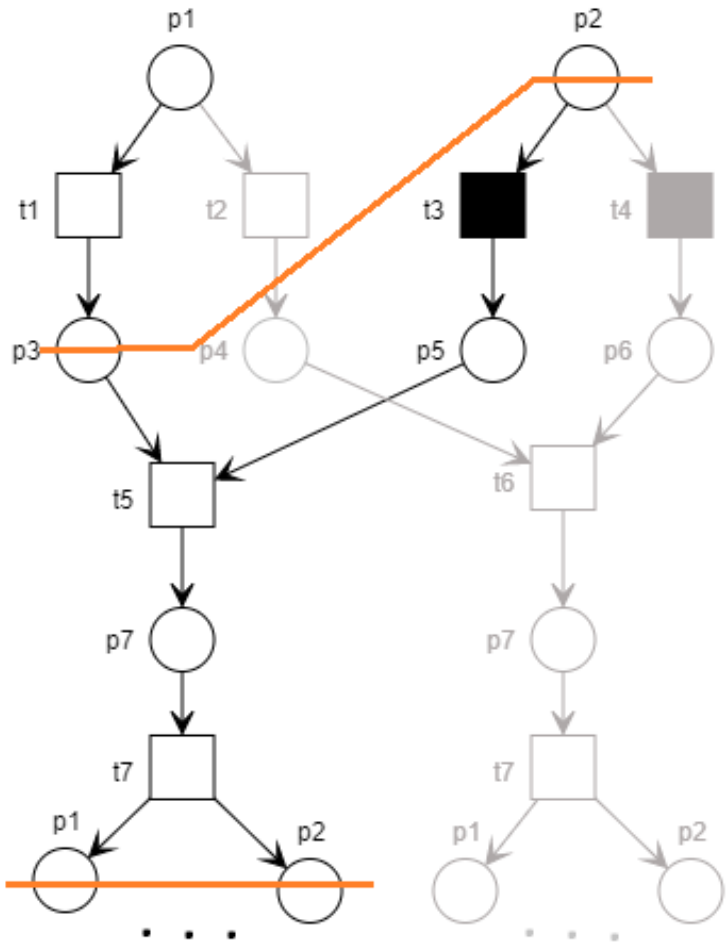
Example

Is $\langle\langle user\rangle\rangle Fp_7$ satisfied on this system?

Game on the unfolding

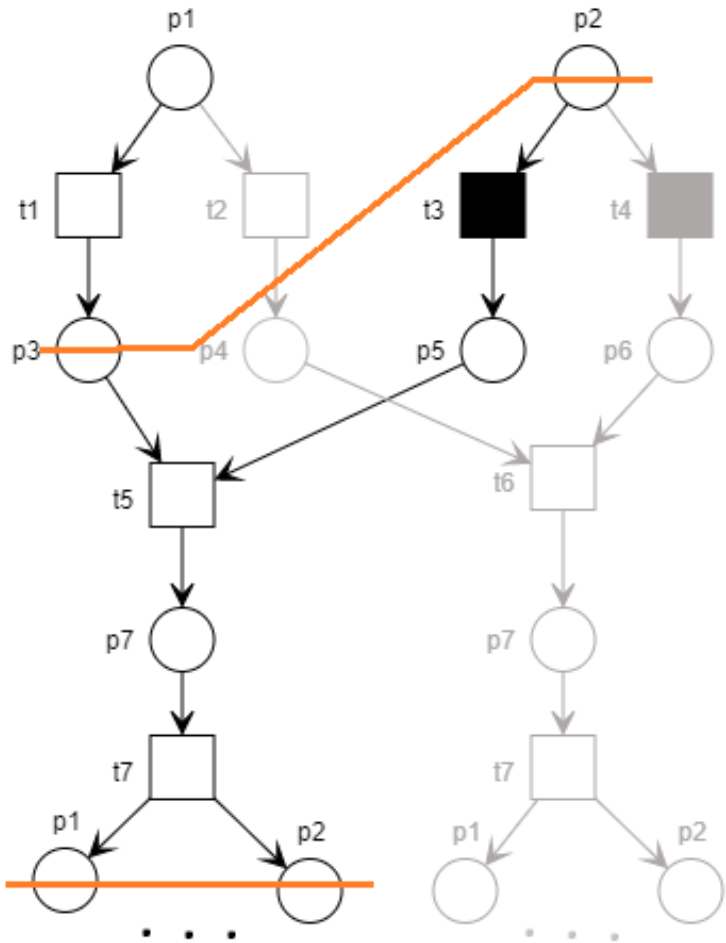


Game on the unfolding



- Run: a possible history of what happened in the net
- B-cut: a maximal set of pairwise concurrent places

Game on the unfolding



- Run: a possible history of what happened in the net
- B-cut: a maximal set of pairwise concurrent places

- Play: a run on the unfolding
- Strategy: $\alpha : Mark(N) \rightarrow 2^K$

The user has a **winning strategy** iff he wins all the plays that are consistent with the strategy

Algorithm for the reachability of a target transition

Goal

The user reaches a target transition

General idea

- Recursive algorithm on the unfolding, with backtracking
- Generation of a finite prefix of the unfolding
- In every marking, the strategy selects all the controllable transitions that are 'useful' to reach the target

Mechanism of the algorithm

Unfolding_Exploration

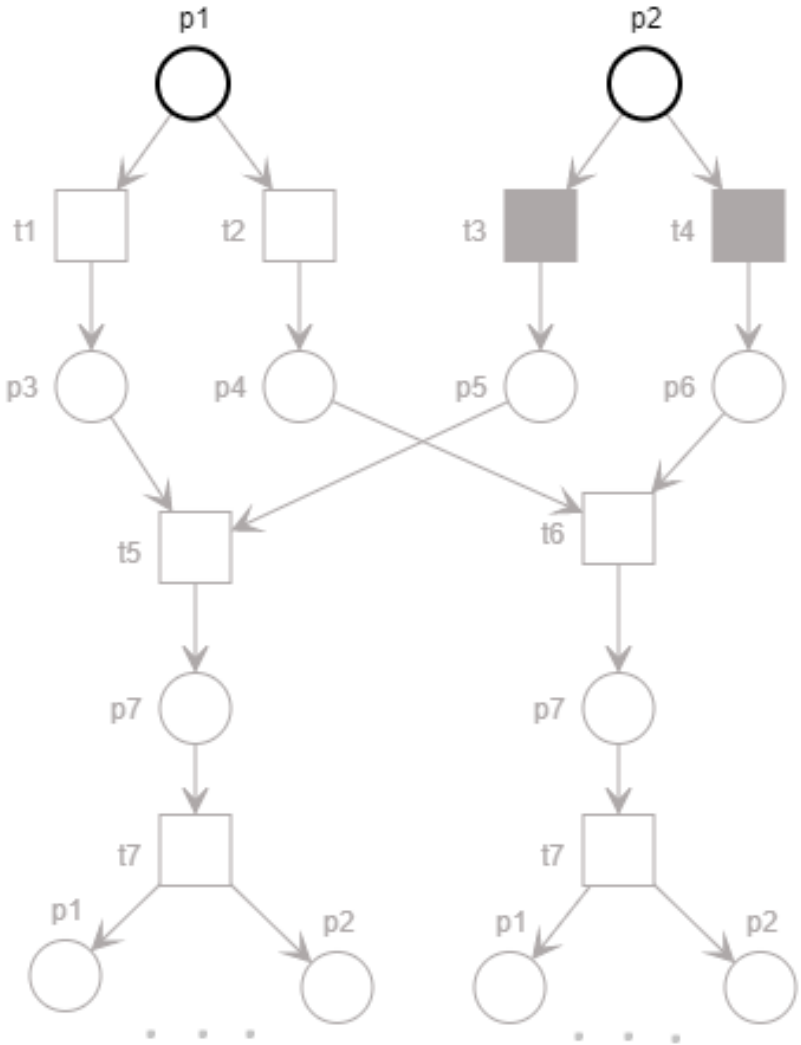
From B-cut γ add events until:

- Deadlock reached (the user tries to backtrack)
- Target fires (the environment tries to backtrack)
- Cycle detected (either no winning strategy or go to Explore_Cycle)

Explore_Cycle

- Add a transition concurrent with the cycle
- Restart with Unfolding_Exploration

Simulation of an execution



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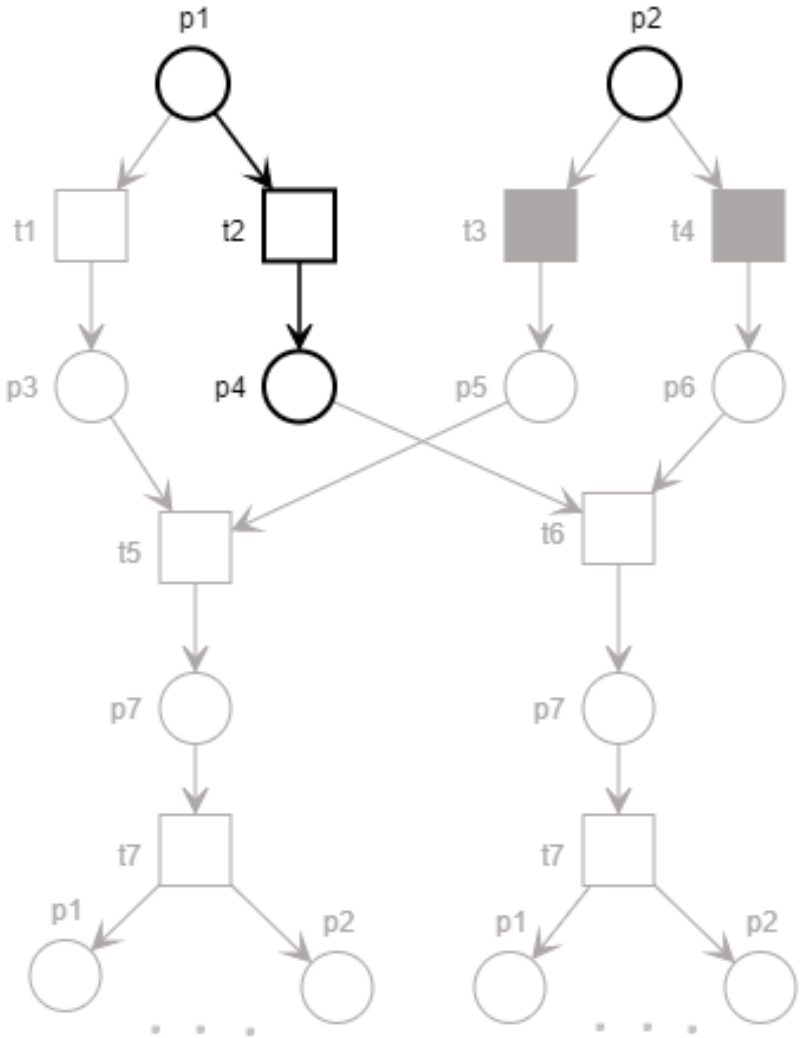

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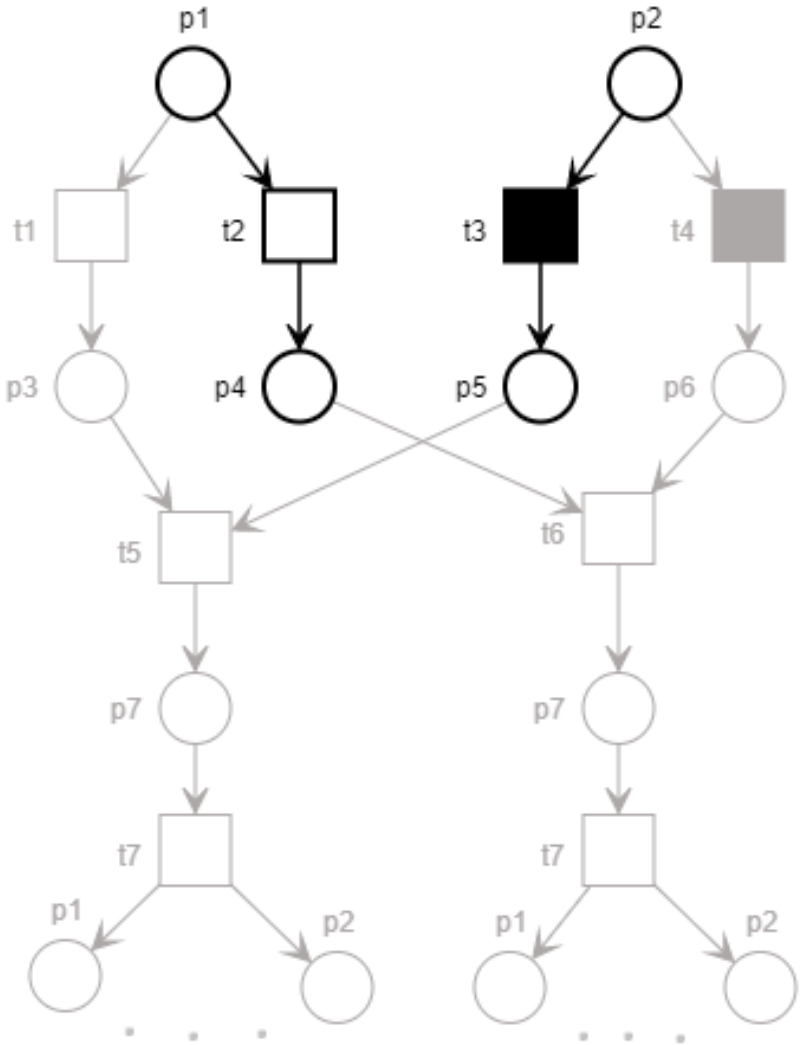

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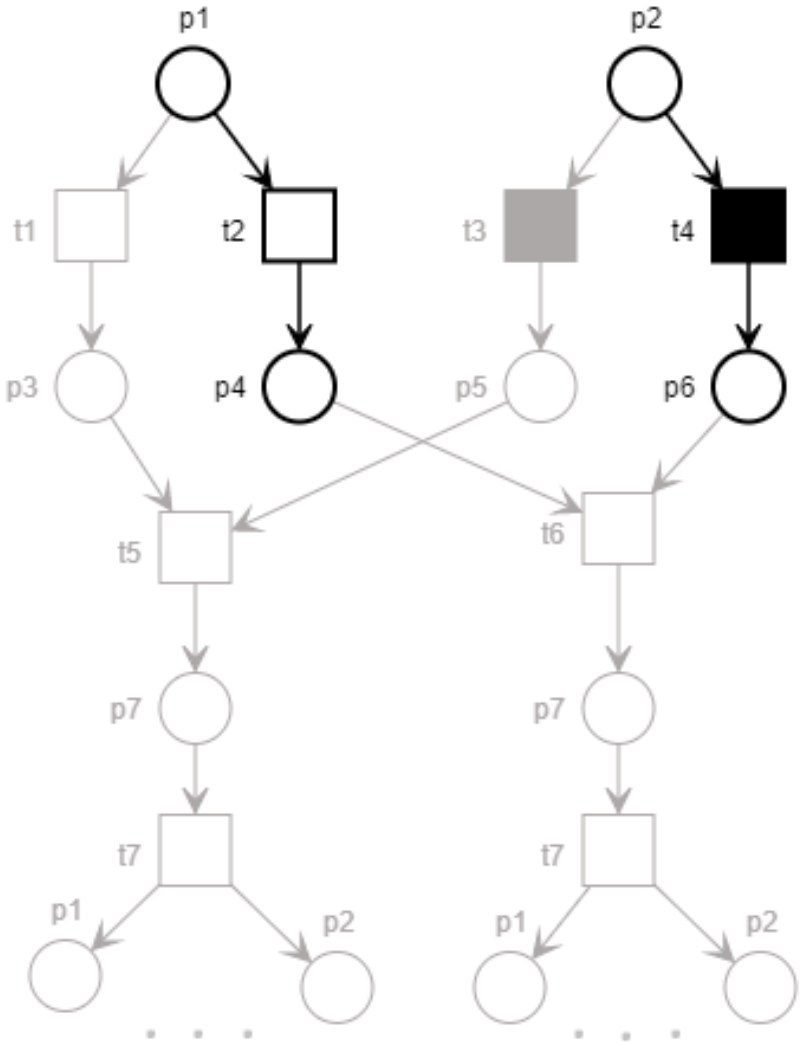

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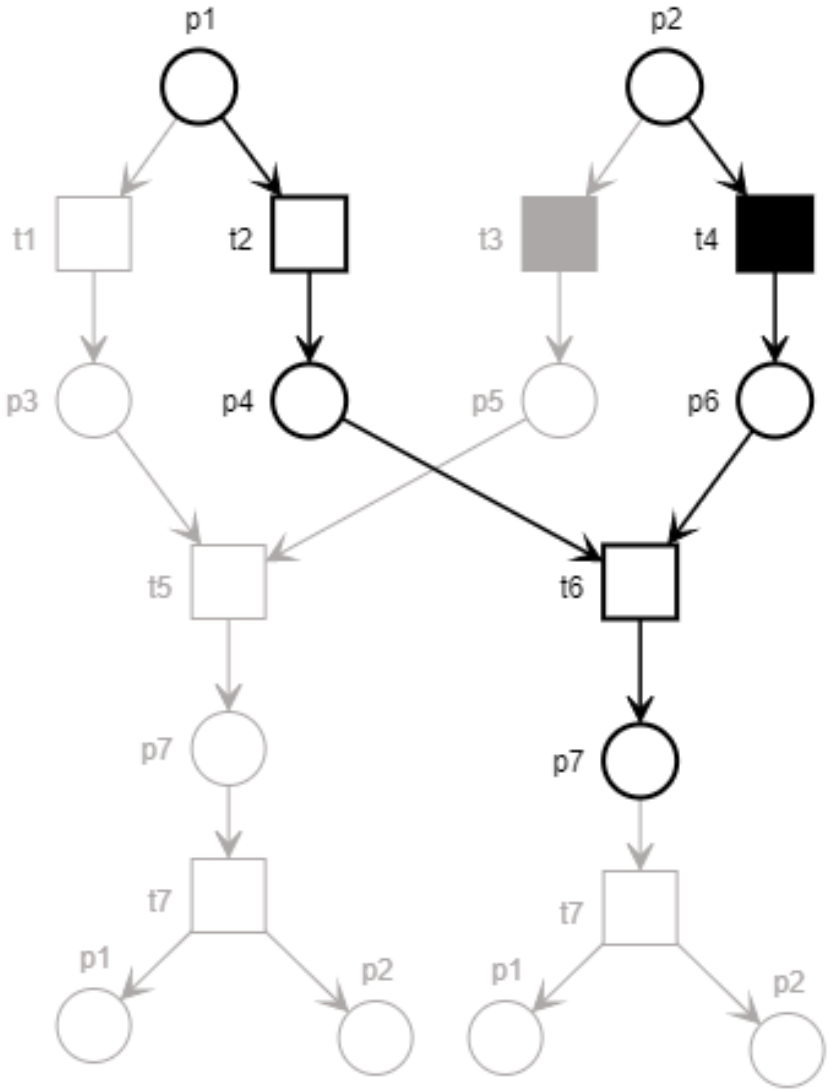

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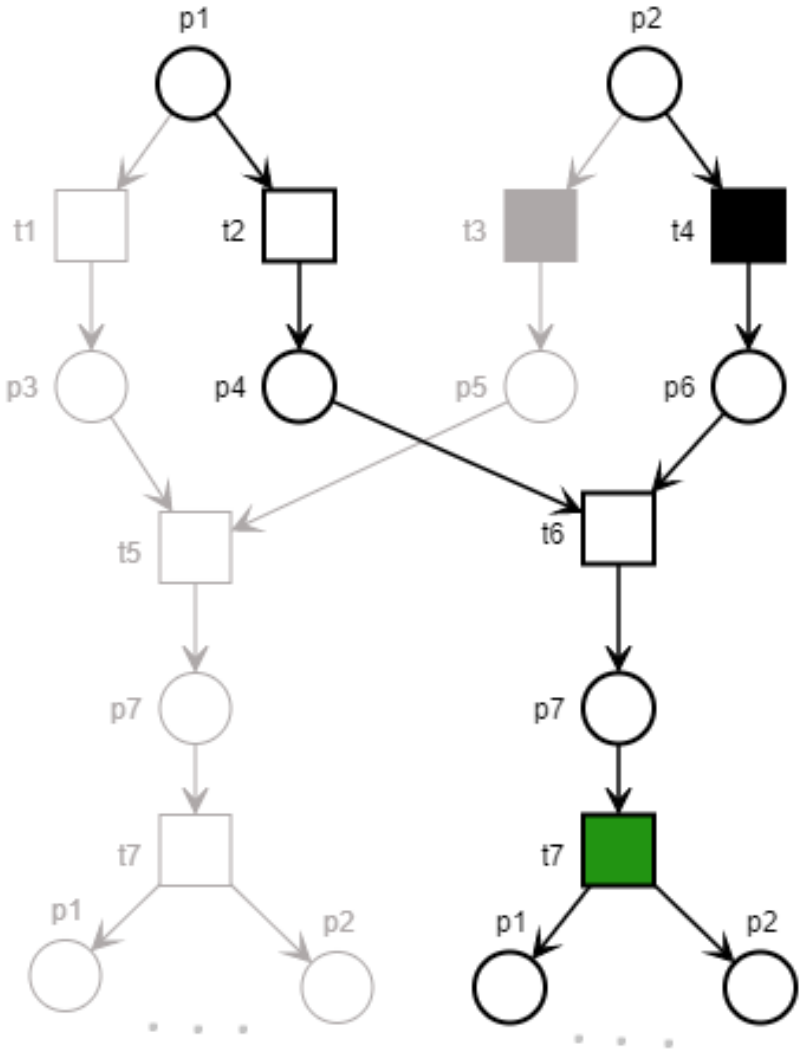
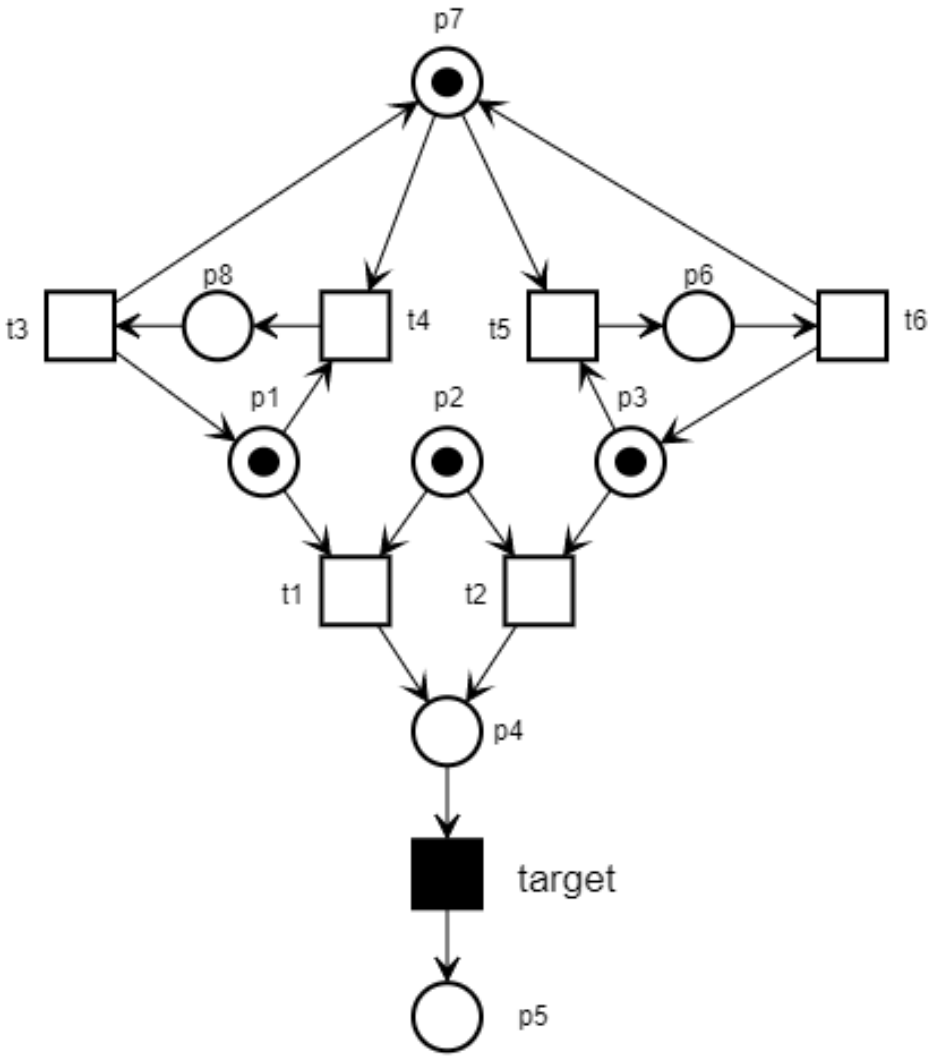


Critical example

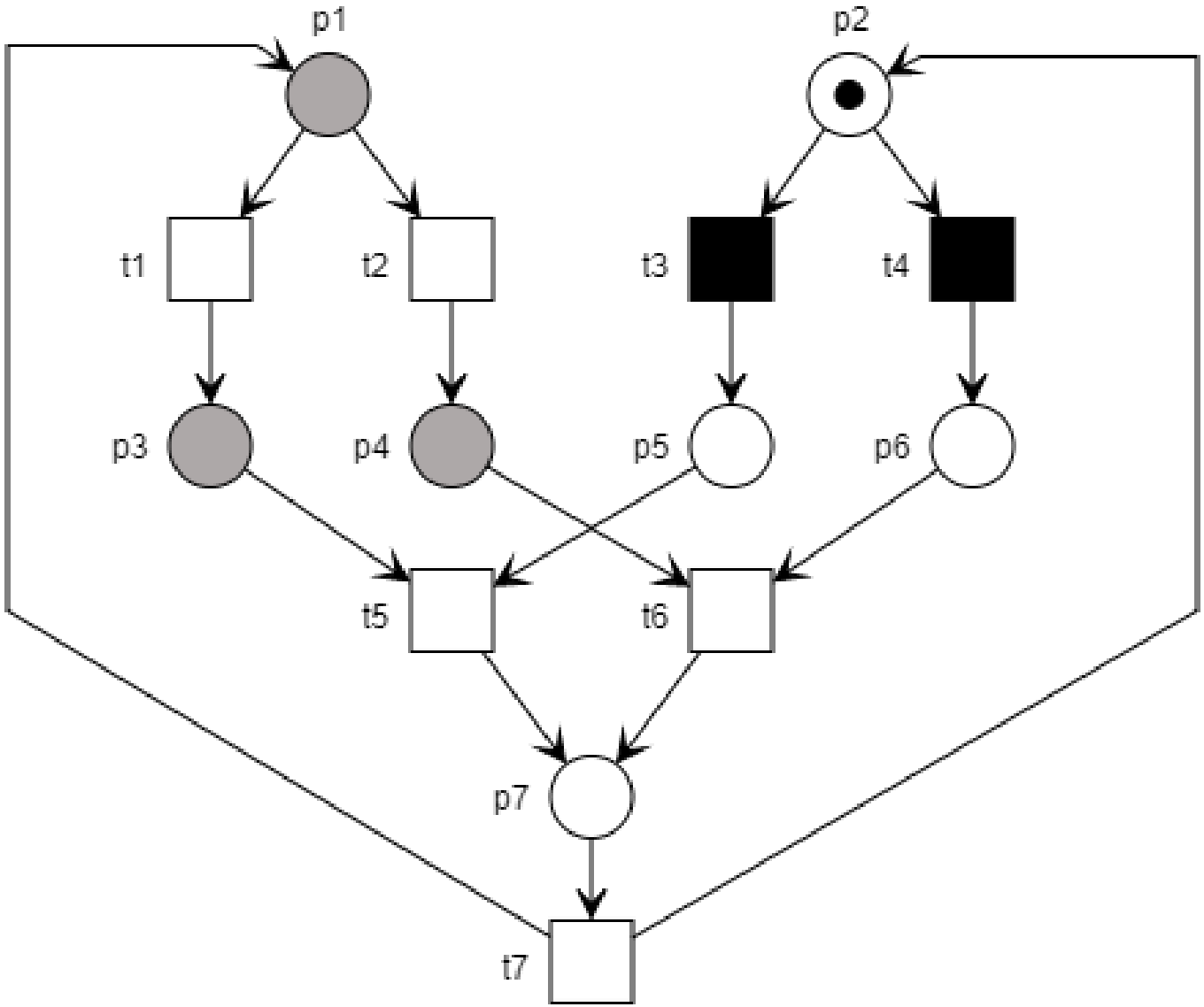
Solved with backtracking



Ongoing works and future developments

- Correctness and complexity of the algorithm
- Partial observability
- Implementability of the strategy

Partial observability



Implementable strategies