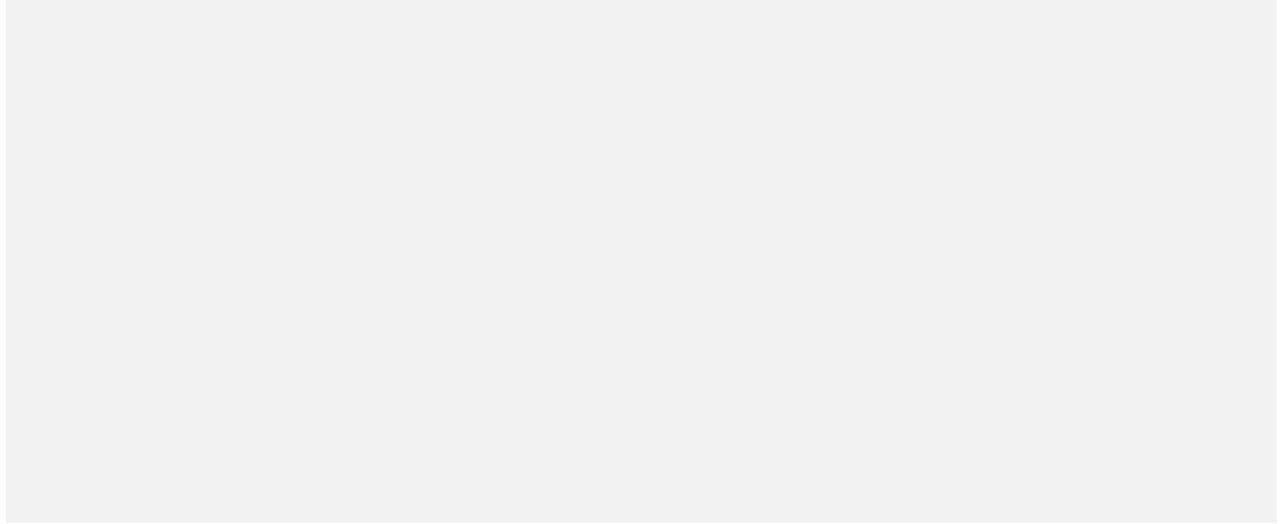
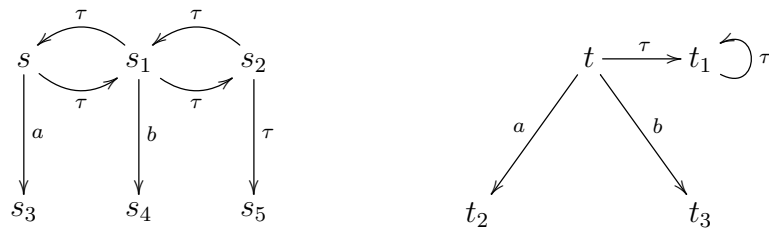


Exercise 1

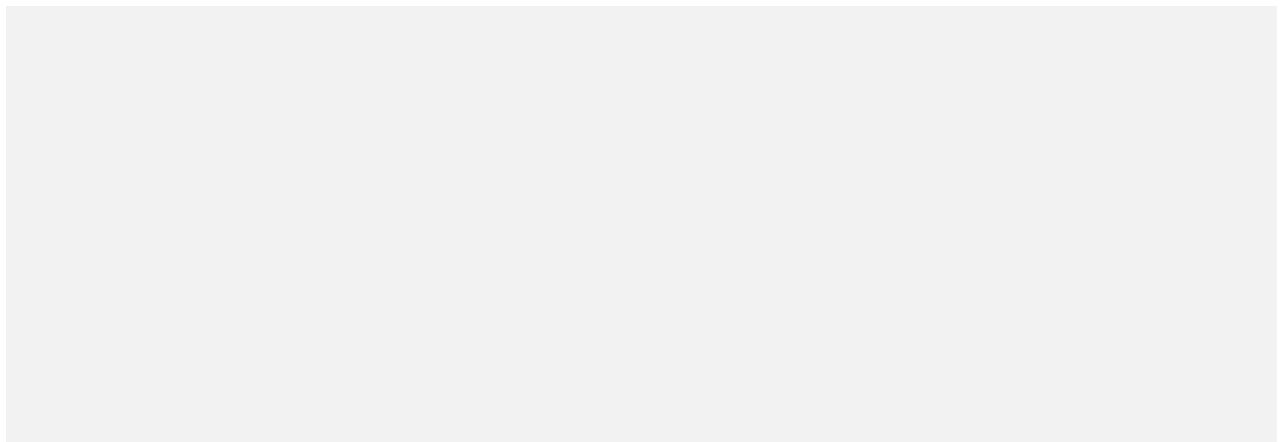
Assume an arbitrary CCS defining equation $K \stackrel{\text{def}}{=} P$ where K is a process constant and P is a CCS expression. Prove that $K \sim P$. (Hint: by using SOS rules for CCS, examine the possible transitions from K and P .)

**Exercise 2***

Consider the following labelled transition system.



Show that $s \approx t$ by finding a weak bisimulation R containing the pair (s, t) .



Exercise 3*

Decide whether the following claims are true or false. Support your claims either by using bisimulation games or directly the definition of strong/weak bisimilarity.

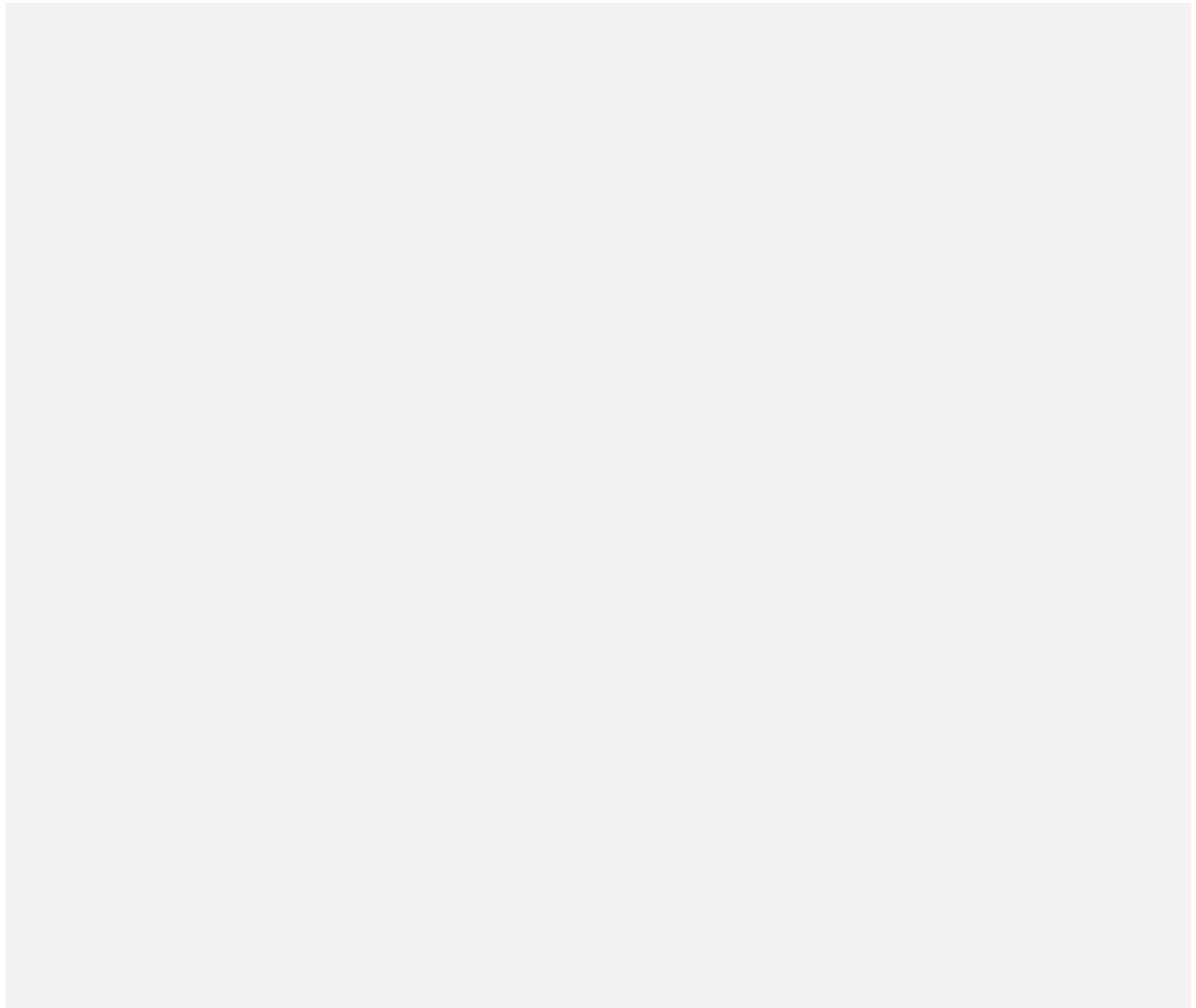
- $a.\tau.Nil \stackrel{?}{\sim} \tau.a.Nil$
- $\tau.a.A + b.B \stackrel{?}{\sim} \tau.(a.A + b.B)$
- $\tau.Nil + (a.Nil \mid \bar{a}.Nil) \setminus \{a, b\} \stackrel{?}{\sim} \tau.Nil$
- $a.(\tau.Nil + b.B) \stackrel{?}{\sim} a.Nil + a.b.B$

The same processes but weak bisimilarity instead of the strong one.

- $a.\tau.Nil \stackrel{?}{\approx} \tau.a.Nil$
- $\tau.a.A + b.B \stackrel{?}{\approx} \tau.(a.A + b.B)$
- $\tau.Nil + (a.Nil \mid \bar{a}.Nil) \setminus \{a, b\} \stackrel{?}{\approx} \tau.Nil$
- $a.(\tau.Nil + b.B) \stackrel{?}{\approx} a.Nil + a.b.B$

Hint: draw first the LTS generated by the CCS processes.

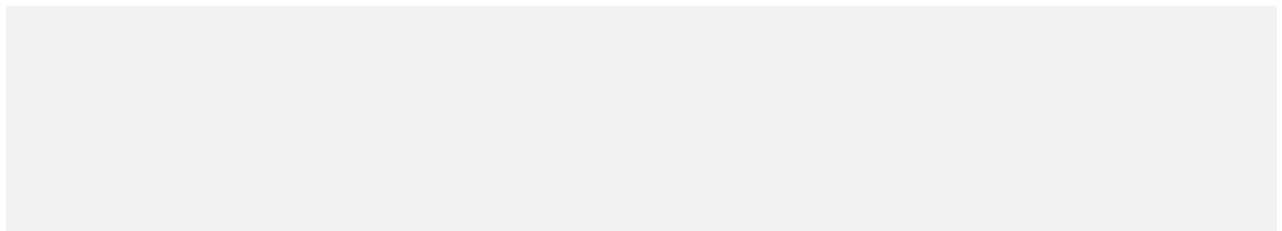
Home exercise: try to verify your claims by using the tool CAAL.

**Exercise 4**

Prove that for any CCS process P the following law (called idempotency) holds.

- $P + P \sim P$

By using the fact that $\sim \subseteq \approx$ conclude that also $P + P \approx P$.



Exercise 5

In the weak bisimulation game the attacker is allowed to use \xrightarrow{a} moves for the attacks and the defender can use \xRightarrow{a} in response. Argue that if we modify the game rules so that the attacker can also use the long moves \xRightarrow{a} then this does not provide any additional power for the attacker. Conclude that both versions of the game provide the same answer about bisimilarity/nonbisimilarity of two processes.

Exercise 6 (optional)

Define two CCS process constants A and B such that

- A has infinitely many reachable states,
- B has only finitely many reachable states, and
- $A \sim B$.

Challenging continuation of the exercise:

Can you think of a CCS process C with infinitely many reachable states such that there is no CCS process with only finitely many reachable states strongly bisimilar to it? How would you support your claim?

Exercise 7 (optional)

Consider the simple communication protocol from Lecture 4.

- Draw the labelled transition system generated by the processes $Spec$ and $Impl$.
- Devise a strategy for the defender showing $Spec \approx Impl$. (Hint: CAAL is your friend).