

## Concurrency Theory

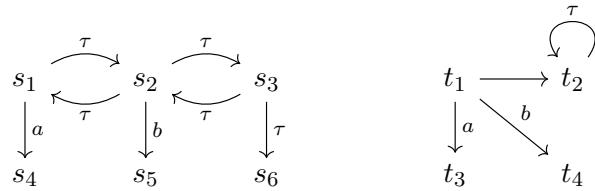
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Sheet 3  
**Due: Monday, 2025-11-17**

### Exercise 3.1

Consider the two LTS below:



Show that  $s_1 \approx t_1$  by constructing a weak bisimulation.

### Exercise 3.2

Proof or disprove the statements below:

$$a.\tau.nil \sim \tau.a.nil$$

$$a.\tau.nil \approx \tau.a.nil$$

### Exercise 3.3

Prove that  $P + \tau.P \approx \tau.P$  for all CCS processes  $P$ .

### Exercise 3.4

In the weak bisimulation game the attacker is only allowed to use  $\xrightarrow{a}$  moves, but the defender is allowed to use  $\xrightarrow{a}$  moves. Give an argument why letting the attacker use  $\xrightarrow{a}$  moves would not make the attacker more powerful.

### Exercise 3.5

Define two CCS processes  $A$  and  $B$  such that

- $LTS(A)$  has an infinite number of states,
- $LTS(B)$  has a finite number of states
- $A \sim B$  is false (no proof needed)
- $A \approx B$  is true (no proof needed)

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If you have questions, please post a message in the dedicated [chat](#).

Bonus: prove that  $A \approx B$  is true, but  $A \sim B$  is false.

### Exercise 3.6 (Bonus)

We want to model a simple communication protocol between a sender and a receiver. The sender accepts data and the receiver delivers the data. We want to implement this specification via a medium that transmits the data between sender and receiver.

Consider the following CCS definition for the specification and implementation of this communication protocol:

$$\begin{aligned}
 \text{ProtocolSpec} &\doteq \text{acc}.\overline{\text{del}}.\text{ProtocolSpec} \\
 \text{Protocol} &\doteq (\text{Send} \parallel \text{Med} \parallel \text{Rec}) \setminus \{\text{send}, \text{error}, \text{trans}, \text{ack}\} \\
 \\
 \text{Send} &\doteq \text{acc}. \text{Sending} & \text{Med} &\doteq \text{send}. \text{Trans} & \text{Rec} &\doteq \text{trans}. \text{Del} \\
 \text{Sending} &\doteq \overline{\text{send}}. \text{Wait} & \text{Trans} &\doteq \tau. \text{Err} + \overline{\text{trans}}. \text{Med} & \text{Del} &\doteq \overline{\text{del}}. \text{Ack} \\
 \text{Wait} &\doteq \text{ack}. \text{Send} + \text{err}. \text{Sending} & \text{Err} &\doteq \overline{\text{err}}. \text{Med} & \text{Ack} &\doteq \overline{\text{ack}}. \text{Rec}
 \end{aligned}$$

Show that  $\text{Protocol}$  is an implementation of  $\text{ProtocolSpec}$  by showing that  $\text{Protocol} \approx \text{ProtocolSpec}$  is true.