CSP Semantics & Method

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Semantics

Methods seen in the Lab

- Simulation (with the `:probe` command)
- Transition system (with the `:graph` command)

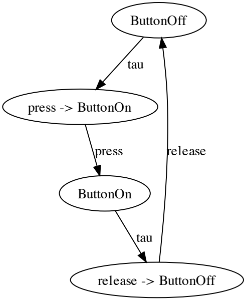
are methods that allow to validate a process against a narrative.

Question: how can one realise such methods?

Modelling switch buttons in Csp

```
channel press, release
ButtonOFF = press -> ButtonON
ButtonON = release -> ButtonOFF
```

Transition system for ButtonON/ButtonOFF



Operational semantics of CSP

General idea of operational semantics:

- specification is ‘translated’ into a labelled transition system
- labelled transition system:
  $(\mathit{States}, \mathit{Labels}, \rightarrow \subseteq \mathit{States} \times \mathit{Labels} \times \mathit{States})$
  - States : a set
  - Labels : a set
  - $\rightarrow$: a relation

Operational semantics of CSP:

- States : all CSP processes
- Labels : the chosen alphabet
- $\rightarrow$: defined by so-called firing rules

Method: there are many algorithms analysing transition systems, e.g., model-checking.

Firing rules for action prefix, recursion

Provided that the preconditions (the text above the line and besides the rule) of such a rule are fulfilled, there is a labelled transition between the two states shown in the conclusion (the text below the line).

$$\frac{}{(a \to P) \xrightarrow{a} P}$$

$$\frac{}{PN \xrightarrow{\tau} P} \text{ if there is an equation } PN = P$$

Example on whiteboard: deriving the transition system for

```
ButtonOFF = press -> ButtonON
ButtonON = release -> ButtonOFF
```

Operational semantics of $P \,[\!| X |\!]\, Q$

Internal actions can be performed independently:

$$\frac{P \xrightarrow{\tau} P'}{P \,[\!| X |\!]\, Q \xrightarrow{\tau} P' \,[\!| X |\!]\, Q} \qquad \frac{Q \xrightarrow{\tau} Q'}{P \,[\!| X |\!]\, Q \xrightarrow{\tau} P \,[\!| X |\!]\, Q'}$$

Actions outside the synchronization set X can be performed independently:

$$\frac{P \xrightarrow{a} P'}{P \,[\!| X |\!]\, Q \xrightarrow{a} P' \,[\!| X |\!]\, Q}\ a \in A \backslash X$$

$$\frac{Q \xrightarrow{a} Q'}{P \,[\!| X |\!]\, Q \xrightarrow{a} P \,[\!| X |\!]\, Q'}\ a \in A \backslash X$$

Actions in the synchronization set X need to be synchronized:

$$\frac{P \xrightarrow{a} P' \quad Q \xrightarrow{a} Q'}{P \,[\!| X |\!]\, Q \xrightarrow{a} P' \,[\!| X |\!]\, Q'}\ a \in X$$

Example: Transition system for two parallel processes

```
a -> b -> Stop [[ {b} ]] b -> c -> Stop
```

Operational semantics of $P \square Q$

The external choice operator chooses based on a visible event $a \in A \cup \{\checkmark\}$:

$$\frac{P \xrightarrow{a} P'}{P \square Q \xrightarrow{a} P'}\ a \neq \tau \qquad \frac{Q \xrightarrow{a} Q'}{P \square Q \xrightarrow{a} Q'}\ a \neq \tau$$

An internal event leaves the choice unresolved:

$$\frac{P \xrightarrow{\tau} P'}{P \square Q \xrightarrow{\tau} P' \square Q} \qquad \frac{Q \xrightarrow{\tau} Q'}{P \square Q \xrightarrow{\tau} P \square Q'}$$

Operational semantics of $P \sqcap Q$

$$\frac{}{P \sqcap Q \xrightarrow{\tau} P} \qquad \frac{}{P \sqcap Q \xrightarrow{\tau} Q}$$