Syntax Translation from CSP to CSP-Prover

Csp	Csp-Prover	Name
`SKIP`	`SKIP`	successful terminating process
`STOP`	`STOP`	deadlock process
`a` $\rightarrow$ `P`	`a -> P`	action prefix
`? x : X` $\rightarrow$ `P(x)`	`? x : X -> P(x)`	prefix choice
`P` $\Box$ `Q`	`P [+] Q`	external choice
`P` $\sqcap$ `Q`	`P |~| Q`	internal choice
$\bigsqcap$`{ P(x) | x∈X }`	`! x : X .. P(x)`	replicated internal choice
if `b` then `P` else `Q`	`IF b THEN P ELSE Q`	conditional
`P` $[\![$`X`$]\!]$ `Q`	`P |[X]| Q`	generalized parallel
`P` $\setminus$ `X`	`P -- X`	hiding
`P` $[\![$`R`$]\!]$	`P [[R]]`	relational renaming
`P ; Q`	`P ;; Q`	sequential composition

Semantic Clauses for the model $\mathcal{F}$ in CSP-Prover

$$
\begin{aligned}
\mathit{traces}(\texttt{SKIP}) &= \{\langle\rangle, \langle\surd\rangle\} \\
\mathit{traces}(\texttt{STOP}) &= \{\langle\rangle\} \\
\mathit{traces}(\texttt{a -> P}) &= \{\langle\rangle\} \cup \{\langle \texttt{a}\rangle \frown \texttt{s} \mid \texttt{s} \in \mathit{traces}(\texttt{P})\} \\
\mathit{traces}(\texttt{? x : X -> P}) &= \{\langle\rangle\} \cup \{\langle \texttt{a}\rangle \frown \texttt{s} \mid \texttt{s} \in \mathit{traces}(\texttt{P}[\texttt{a/x}]), \texttt{a} \in \texttt{X}\} \\
\mathit{traces}(\texttt{P [+] Q}) &= \mathit{traces}(\texttt{P}) \cup \mathit{traces}(\texttt{Q}) \\
\mathit{traces}(\texttt{P |~| Q}) &= \mathit{traces}(\texttt{P}) \cup \mathit{traces}(\texttt{Q}) \\
\mathit{traces}(\texttt{! x : X .. P}) &= \{\langle\rangle\} \cup \{\texttt{s} \mid \texttt{s} \in \mathit{traces}(\texttt{P}[\texttt{a/x}]), \texttt{a} \in \texttt{X}\} \\
\mathit{traces}(\texttt{IF b THEN P ELSE Q}) &= \text{if } \texttt{b} \text{ then } \mathit{traces}(\texttt{P}) \text{ else } \mathit{traces}(\texttt{Q}) \\
\mathit{traces}(\texttt{P |[X]| Q}) &= \{\texttt{s |[X]| t} \mid \texttt{s} \in \mathit{traces}(\texttt{P}),\ \texttt{t} \in \mathit{traces}(\texttt{Q})\} \\
\mathit{traces}(\texttt{P -- X}) &= \{\texttt{s -- X} \mid \texttt{s} \in \mathit{traces}(\texttt{P})\} \\
\mathit{traces}(\texttt{P [[R]]}) &= \{\texttt{t} \mid \exists\, \texttt{s} \in \mathit{traces}(\texttt{P}).\ (\texttt{s}, \texttt{t}) \in \texttt{R}^*\} \\
\mathit{traces}(\texttt{P ;; Q}) &= (\mathit{traces}(\texttt{P}) \cap A^*) \\
&\quad \cup \{\texttt{s} \frown \texttt{t} \mid \texttt{s} \frown \langle\surd\rangle \in \mathit{traces}(\texttt{P}),\ \texttt{t} \in \mathit{traces}(\texttt{Q})\} \\
\hline
\mathit{failures}(\texttt{SKIP}) &= \{(\langle\rangle, \texttt{X}) \mid \texttt{X} \subseteq A\} \cup \{(\langle\surd\rangle, \texttt{X}) \mid \texttt{X} \subseteq A^{\surd}\} \\
\mathit{failures}(\texttt{STOP}) &= \{(\langle\rangle, \texttt{X}) \mid \texttt{X} \subseteq A^{\surd}\} \\
\mathit{failures}(\texttt{a -> P}) &= \{(\langle\rangle, \texttt{X}) \mid \texttt{a} \notin \texttt{X}\} \\
&\quad \cup \{(\langle \texttt{a}\rangle \frown \texttt{s}, \texttt{X}) \mid (\texttt{s}, \texttt{X}) \in \mathit{failures}(\texttt{P})\} \\
\mathit{failures}(\texttt{? x : X -> P}) &= \{(\langle\rangle, \texttt{Y}) \mid \texttt{X} \cap \texttt{Y} = \emptyset\} \\
&\quad \cup \{(\langle \texttt{a}\rangle \frown \texttt{s}, \texttt{Y}) \mid (\texttt{s}, \texttt{Y}) \in \mathit{failures}(\texttt{P}[\texttt{a/x}]), \texttt{a} \in \texttt{X}\} \\
\mathit{failures}(\texttt{P [+] Q}) &= \{(\langle\rangle, \texttt{X}) \mid (\langle\rangle, \texttt{X}) \in \mathit{failures}(\texttt{P}) \cap \mathit{failures}(\texttt{Q})\} \\
&\quad \cup \{(\texttt{s}, \texttt{X}) \mid (\texttt{s}, \texttt{X}) \in \mathit{failures}(\texttt{P}) \cup \mathit{failures}(\texttt{Q}), \texttt{s} \neq \langle\rangle\} \\
&\quad \cup \{(\langle\rangle, \texttt{X}) \mid \texttt{X} \subseteq A,\ \langle\surd\rangle \in \mathit{traces}(\texttt{P}) \cup \mathit{traces}(\texttt{Q})\} \\
\mathit{failures}(\texttt{P |~| Q}) &= \mathit{failures}(\texttt{P}) \cup \mathit{failures}(\texttt{Q}) \\
\mathit{failures}(\texttt{! x : X .. P}) &= \{(\texttt{s}, \texttt{Y}) \mid (\texttt{s}, \texttt{Y}) \in \mathit{failures}(\texttt{P}[\texttt{a/x}]), \texttt{a} \in \texttt{X}\} \\
\mathit{failures}(\texttt{IF b THEN P ELSE Q}) &= \text{if } \texttt{b} \text{ then } \mathit{failures}(\texttt{P}) \text{ else } \mathit{failures}(\texttt{Q}) \\
\mathit{failures}(\texttt{P |[X]| Q}) &= \{(\texttt{u}, \texttt{Y} \cup \texttt{Z}) \mid \texttt{Y} - (\texttt{X} \cup \{\surd\}) = \texttt{Z} - (\texttt{X} \cup \{\surd\}) \\
&\quad \wedge\, \exists\, \texttt{s}, \texttt{t}.\ (\texttt{s}, \texttt{Y}) \in \mathit{failures}(\texttt{P}), (\texttt{t}, \texttt{Z}) \in \mathit{failures}(\texttt{Q}), \\
&\quad \wedge\, \texttt{u} \in \texttt{s|[X]|t}\} \\
\mathit{failures}(\texttt{P -- X}) &= \{(\texttt{s -- X}, \texttt{Y}) \mid (\texttt{s}, \texttt{Y} \cup \texttt{X}) \in \mathit{failures}(\texttt{P})\} \\
\mathit{failures}(\texttt{P [[R]]}) &= \{(\texttt{t}, \texttt{X}) \mid \exists\, \texttt{s}.\ (\texttt{s}, \texttt{t}) \in \texttt{R},\ (\texttt{s}, \texttt{R}^{-1}(\texttt{X})) \in \mathit{failures}(\texttt{P})\} \\
\mathit{failures}(\texttt{P ;; Q}) &= \{(\texttt{s}, \texttt{X}) \mid \texttt{s} \in A^*,\ (\texttt{s}, \texttt{X} \cup \{\surd\}) \in \mathit{failures}(\texttt{P})\} \\
&\quad \cup \{(\texttt{s} \frown \texttt{t}, \texttt{X}) \mid \texttt{s} \frown \langle\surd\rangle \in \mathit{traces}(\texttt{P}), \\
&\qquad\qquad \wedge\, (\texttt{t}, \texttt{X}) \in \mathit{failures}(\texttt{Q})\}
\end{aligned}
$$

where A is a given set of alphabets (communications), $A^{\checkmark} := A \cup \{\checkmark\}$, and A^* is the reflexive transitive closure of A. Furthermore, $\texttt{(s |[X]| t)}$, $\texttt{(s -- X)}$, $\texttt{R}^*$, and $\texttt{R}^{-1}$ are defined as follows:

- $\texttt{(s |[X]| t)}$ is inductively defined by:

$$\begin{array}{rl}
\langle \texttt{x} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{x} \rangle \frown t & = \{\langle \texttt{x} \rangle \frown \texttt{u} \mid \texttt{u} \in \texttt{s} \,|[\texttt{X}]|\, \texttt{t}\} \\
\langle \texttt{x} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{x}' \rangle \frown \texttt{t} & = \emptyset \\
\langle \texttt{x} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle\rangle & = \emptyset \\
\langle\rangle \,|[\texttt{X}]|\, \langle \texttt{x} \rangle \frown \texttt{t} & = \emptyset \\
\langle\rangle \,|[\texttt{X}]|\, \langle\rangle & = \{\langle\rangle\} \\
\langle \texttt{y} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{x} \rangle \frown \texttt{t} & = \{\langle \texttt{y} \rangle \frown \texttt{u} \mid \texttt{u} \in \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{x} \rangle \frown \texttt{t}\} \\
\langle \texttt{y} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle\rangle & = \{\langle \texttt{y} \rangle \frown \texttt{u} \mid \texttt{u} \in \texttt{s} \,|[\texttt{X}]|\, \langle\rangle\} \\
\langle \texttt{x} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{y} \rangle \frown \texttt{t} & = \{\langle \texttt{y} \rangle \frown \texttt{u} \mid \texttt{u} \in \langle \texttt{x} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \texttt{t}\} \\
\langle\rangle \,|[\texttt{X}]|\, \langle \texttt{y} \rangle \frown \texttt{t} & = \{\langle \texttt{y} \rangle \frown \texttt{u} \mid \texttt{u} \in \langle\rangle \,|[\texttt{X}]|\, \texttt{t}\} \\
\langle \texttt{y} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{y}' \rangle \frown \texttt{t} = & \{\langle \texttt{y} \rangle \frown \texttt{u} \mid \texttt{u} \in \texttt{s} \,|[\texttt{X}]|\, \langle \texttt{y}' \rangle \frown \texttt{t}\} \\
& \cup \{\langle \texttt{y}' \rangle \frown \texttt{u} \mid \texttt{u} \in \langle \texttt{y} \rangle \frown \texttt{s} \,|[\texttt{X}]|\, \texttt{t}\}
\end{array}$$

  where $\texttt{x}, \texttt{x}' \in \texttt{X} \cup \{\checkmark\}$, $\texttt{y}, \texttt{y}' \notin \texttt{X} \cup \{\checkmark\}$, and $\texttt{x} \neq \texttt{x}'$,
- $\texttt{(s -- X)}$ is inductively defined by:

$$\begin{array}{rl}
\langle\rangle \texttt{ -- X} & = \langle\rangle \\
(\langle \texttt{x} \rangle \frown \texttt{s}) \texttt{ -- X} & = \texttt{s -- X} \\
(\langle \texttt{y} \rangle \frown \texttt{s}) \texttt{ -- X} & = \langle \texttt{y} \rangle \frown \texttt{(s -- X)}
\end{array}$$

  where $\texttt{x} \in \texttt{X}$ and $\texttt{y} \notin \texttt{X}$.
- $\texttt{R}^*$ is the smallest set satisfying the following inference rules:

$$\begin{array}{rl}
\texttt{True} & \Rightarrow (\langle\rangle, \langle\rangle) \in \texttt{R}^* \\
\texttt{True} & \Rightarrow (\langle\checkmark\rangle, \langle\checkmark\rangle) \in \texttt{R}^* \\
(\texttt{a}, \texttt{b}) \in \texttt{R} \wedge (\texttt{s}, \texttt{t}) \in \texttt{R}^* & \Rightarrow (\texttt{a} \frown \texttt{s}, \texttt{b} \frown \texttt{t}) \in \texttt{R}^*
\end{array}$$

- $\texttt{R}^{-1}(\texttt{X})$ is defined as:

$$\texttt{R}^{-1}(\texttt{X}) = \{\texttt{a} \mid \exists \texttt{b} \in \texttt{X}.\ (\texttt{a}, \texttt{b}) \in \texttt{R} \vee \texttt{a} = \texttt{b} = \checkmark\}$$