Glossary

Here, we sum up what has been compiled in this book. Notions and notations presented here will be applied all over the rest of this book.

A. Static Structure

Petri net $N = (P, T, F, W, m_0)$:

- $P$ finite set of places
- $T$ finite set of transitions
- $F \subseteq (P \times T) \cup (T \times P)$ flow relation
- $W : F \rightarrow \mathbb{N}$ arc weight
- $m_0 : P \rightarrow \mathbb{N}$ initial marking

Derived Notions for $N$:

$$E = \text{def } P \cup T \text{ set of elements}$$

For $e \in E$:

- $e' = \text{def } \{d \mid (d, e) \in F\}$ pre-set of $e$
- $e'' = \text{def } \{d \mid (e, d) \in F\}$ post-set of $e$

$W : E \times E \rightarrow \mathbb{N}$ “extended arc weight” with

$$W(d, e) = \begin{cases} W(d, e), & \text{if } (d, e) \in F \\ 0, & \text{otherwise} \end{cases}$$

B. Dynamics

$m : P \rightarrow \mathbb{N}$ marking.

$m$ enables $t$ iff for all $p \in \tau \ W(p, t) \leq m(p)$.

$m \Rightarrow m'$ is a step iff

(a) $m$ enables $t$, and

(b) for all $p \in P \quad m'(p) = W(p, t) + W(t, p)$.

$\sigma : m_0 \overset{u_1}{\Rightarrow} m_1 \overset{u_2}{\Rightarrow} \ldots \overset{u_n}{\Rightarrow} m_n$ is a computation of $N$ iff $m_{i-1} \overset{u_i}{\Rightarrow} m_i$ are steps ($i = 1, 2, \ldots, n$).
A marking \( m \) is \textit{reachable in} \( N \) iff some computation ends at \( m \).

\( \sigma \) \textit{reproduces} \( m_0 \) if \( m_n = m_0 \).

The \textit{counting vector} \( c : T \rightarrow \mathbb{N} \) of \( \sigma \) assigns each \( t \) the number of occurrences of \( t \) (i.e., of indices \( i \) with \( u_i = t \)) in \( \sigma \).

\section*{C. Linear-Algebraic Representation}

Assume \textit{any} order on \( P \) and on \( T \). Typically: along indices in \( P = \{p_1, \ldots, p_k\} \).

\( T = \{t_1, \ldots, t_l\} \).

For \( m : P \rightarrow T \) and \( t \in T \) let

\[
\begin{pmatrix}
m(p_1)
\vdots
m(p_k)
\end{pmatrix}
\quad \text{and} \quad
\begin{pmatrix}
\overline{W}(t, p_1) - \overline{W}(p_1, t)
\vdots
\overline{W}(t, p_k) - \overline{W}(p_k, t)
\end{pmatrix}
\]

If \( t \) is \textit{enabled} at \( m \), then \( m \xrightarrow{t} m + t \) is a step.

\( N : (t_1 \ldots t_k) \) is the \textit{matrix} of \( N \).

\section*{D. Analysis Techniques}

(a) \( i : P \rightarrow \mathbb{Z} \) is a \textit{place invariant} of \( N \) iff \( i \) solves \( x \cdot N = 0 \).

\textit{Theorem 3.1} For each reachable \( m \), \( i \cdot m = i \cdot m_0 \).

(b) \( j : T \rightarrow \mathbb{N} \) is a \textit{transition invariant} of \( N \) iff \( j \) solves \( N \cdot x = 0 \).

\textit{Theorem 3.2} If \( j \) is the counting vector of a step sequence, it reproduces the initial marking.

(c) A set \( Q \) of places is a \textit{trap} iff \( Q^\circ \subseteq Q \).

\textit{Observation} A trap never runs empty.

(d) The \textit{marking graph} of \( N \) has the reachable states and steps as vertices and edges.

\textit{Observation} If finite, this graph decides termination, divergence, liveness, weak liveness, boundedness and reversibility.
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