Petri Nets

http://d3s.mff.cuni.cz

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Petri nets

- Modeling language
  - concurrent and distributed SW systems
  - reactive systems (asynchronous events)

- Notations: graphical, mathematical

- Many variants and extensions
  - Basic (ordinary)
  - Colored (CPN)
  - Hierarchical nets
Basic elements

- Places
- Transitions
- Arcs
- Tokens
Semantics

• Marking
  ▪ Function $M : P \rightarrow \mathbb{N}$

• Transitions
  ▪ Enabled: when input places contain enough tokens
  ▪ Firing (execution)
    ▪ Removing tokens from input places
    ▪ Adding tokens to output places
Examples

- Conflicting transitions
- Independent transitions
- Synchronization
Petri net is a tuple \((P, T, A, w, M_0)\), where:

\[
A \subseteq (P \times T) \cup (T \times P)
\]

\[
P \cap T = \emptyset \text{ (disjunct)}
\]

\(w: A \rightarrow N\) is a weight function

\(M_0: P \rightarrow N\) is the initial marking

Reachability graph \(R\)

\[
M_0 \in R
\]

\[
M \in R \land t \in T \text{ enabled in } M \implies M' \in R
\]
Example: dining philosophers

- Two philosophers
- Two shared forks
Properties

- Reachability of M
  - \( \exists \) sequence of transitions from \( M_0 \) to \( M \)

- Reachable markings \( R(M) \)

- Coverability of \( M \)
  - \( \exists M' \in R(M_0) \) such that \( \forall p \cdot M'(p) \geq M(p) \)

- Applications: verification, simulation, analysis
Variants

- Ordinary Petri net
  - every arc has the weight 1

- State machine
  - every transition has exactly one input place and one output place

- Colored Petri Nets
Colored Petri Nets (CPN)

- Support for data types and manipulation

- Multiple types of tokens (colors)
  - data type = set of values ≈ set of colors
  - token value ≈ token color

- New elements
  - Places: color sets (allowed token types)
  - Transitions: guard conditions (enabling)
  - Arcs: arc expressions (transferring values)
Example
- Distributed storage system with a very simple protocol for synchronization
  - Entities: client, server, data storage

Applications
- Communication protocols
- Distributed algorithms
- Control for embedded systems
Tools

- Popular editors for creating diagrams
  - [https://app.diagrams.net/](https://app.diagrams.net/) (former draw.io)

- PetriDotNet

- CPN Tools
  - [http://cpntools.org/](http://cpntools.org/)
  - [http://cpntools.org/download](http://cpntools.org/download)

- PIPE 2
• Basic Petri Nets
  - Further details and references to various literature

• Colored Petri Nets