

Petri Nets

<http://d3s.mff.cuni.cz>

Department of
Distributed and
Dependable
Systems



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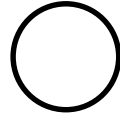
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Petri nets

- 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



- Marking
 - Function $M : P \rightarrow N$
- 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

Definition

Petri net is a tuple (P, T, A, w, M_0) , where:

$$A \subseteq (P \times T) \cup (T \times P)$$

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

$w: A \rightarrow \mathbb{N}$ is a weight function

$M_0: P \rightarrow \mathbb{N}$ is the initial marking

Reachability graph R

$$M_0 \in R$$

$$M \in R \wedge t \in T \text{ enabled in } M \text{ s.t. } M \rightarrow_t M' \Rightarrow M' \in R$$

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 $\forall p \bullet M'(p) \geq M(p)$
- 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 \approx set of colors
 - token value \approx token color
- New elements
 - Places: color sets (allowed token types)
 - Transitions: guard conditions (enabling)
 - Arcs: arc expressions (transferring values)

CPN: usage

- 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/> (draw.io)
- PetriDotNet
 - <http://inf.mit.bme.hu/en/research/tools/petridotnet>
- CPN Tools
 - <http://cpntools.org/>
 - <http://cpntools.org/download>
- CPN IDE
 - <https://cpntools.org/cpn-ide/>
- PIPE 2
 - <http://pipe2.sourceforge.net/>

- Basic Petri Nets

- https://en.wikipedia.org/wiki/Petri_net

- Further details and references to various literature

- Colored Petri Nets

- K. Jensen. A Brief Introduction to Coloured Petri Nets. Invited talk at TACAS 1997, LNCS 1217