Petri Nets

http://d3s.mff.cuni.cz

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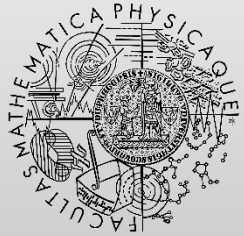

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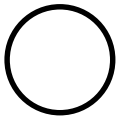
Petri nets

- 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 

Semantics

- Marking
  - Function M : P → 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:

- $A \subseteq (P \times T) \cup (T \times P)$
- $P \cap T = \emptyset$ (disjunct)
- $w: A \rightarrow N$ is a weight function
- $M_0: P \rightarrow N$ is the initial marking

Reachability graph R

- $M_0 \in R$
- $M \in R \wedge t \in T$ enabled in M s.t. $M \rightarrow_t M' \Rightarrow M' \in R$

Example: dining philosophers

- Two philosophers
- Two shared forks

Properties

- Reachability of M
  - ∃ sequence of transitions from M_0 to M
- Reachable markings R(M)

- Coverability of M
  - ∃ $M' \in R(M_0)$ such that ∀ p • $M'(p) >= M(p)$

- 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)

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

Literature

- 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