Petri Nets

http://d3s.mff.cuni.cz

Pavel Parízek

Department of Distributed and Dependable Systems

CHARLES UNIVERSITY IN PRAGUE
faculty of mathematics and physics
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 $M : P \rightarrow N$

• 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:

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

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

\[ w : A \rightarrow N \text{ is a weight function} \]

\[ M_0 : P \rightarrow N \text{ is the initial marking} \]

Reachability graph \( R \)

\[ M_0 \in R \]

\[ M \in R \land t \in T \text{ enabled in } M \Rightarrow M \rightarrow_t M' \Rightarrow M' \in R \]
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 $\forall p \cdot M'(p) \geq M(p)$

- 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

- CPN Tools
  - http://cpntools.org/
  - http://cpntools.org/download

- PIPE 2
  - http://pipe2.sourceforge.net/
Literature

- Basic Petri Nets
  - Further details and references to various literature

- Colored Petri Nets