

计算机系统分析与性能评价

Computer Systems Analysis and Performance Evaluation

陈进才 周健 李国宽 武汉光电国家研究中心

光电信息存储研究部



Petri Nets



Overview

Introduction

Basic Definitions

Modeling with Petri Nets

Analysis of Petri Nets



- Model introduced by C.A. Petri in 1962
 - Ph.D. Thesis: "Communication with Automata"
- Applications: distributed computing, manufacturing, control, communication networks, transportation...
- PNs describe explicitly and graphically:
 - sequencing/causality
 - conflict/non-deterministic choice
 - concurrency



- There is no need for Net Theory to exist if there is no real application of it.
- There could be no real applications of Net Theory if there is no General Net Theory.

Petri Net Theory



- Petri net theory allows a system to be modeled by a Petri net, a mathematical representation of the system.
- Analysis of the Petri net can then, hopefully, reveal important information about the structure and dynamic behavior of the modeled system.
- This information can then be used to evaluate the modeled system and suggest improvements or changes.
- Thus, the development of a theory of Petri nets is based on the application of Petri nets in the modeling and design of systems.

Applying Petri Net Theory









2022年秋





• A Japanese manufacturing system in which the supply of components is regulated through the use of an instruction card sent along the production line.

- What to produce?
- How to produce?
- For whom to produce?



Queueing System Recap





"Queueing System"

Features of Systems



- Features of a useful model of complex systems.
 - One fundamental idea is that systems are composed of separate, interacting components.
 - The state of a component is an abstraction of the relevant information necessary to describe its (future) actions.
 - Often the state of a component depends on the past history of the component.
 - Thus the state of a component may change over time.
 - The concept of "state" is very important to modeling a component.
- The components of a system exhibit concurrency or parallelism.
 - Activities of one component of a system may occur simultaneously with other activities of other components.
- The concurrent nature of activity in a system creates some difficult modeling problems.
 - Since the components of the systems interact, it is necessary for synchronization to occur.
 - The transfer of information or materials from one component to another requires that the activities of the involved components be synchronized while the interaction is occurring.
 - This may result in one component waiting for another component.

Abstraction in Computer Science

- Computer programmers use abstraction to simplify their work.
- Abstraction in computer science is the process of removing elements of a code or program that aren't relevant or that distract from more important elements.
 - Data abstraction
 - Control abstraction

Unsolvable Math Problem



• Determine the age of a ship's captain if there were 26 sheep and 10 goats on his vessel

- https://www.thepaper.cn/newsDetail_forward_1971117
- https://www.rt.com/news/417231-china-math-problemsheep-goats/

Holger Dambeck







Overview

Introduction

Basic Definitions

Modeling with Petri Nets

Analysis of Petri Nets

Places/Transitions



- Weighted Directed Graph:
 - Places: circles
 - Transitions: bars or boxes
 - Arcs: arrows labeled with weights
 - Tokens: black dots
- Places/Transitions: Conditions/Events
- Firable and Firing



Elementary Net Systems



- Elementary Net System
 - Condition/Event System
 - Place/Transfer System

Elementary Net Systems

Grzegorz Rozenberg and Joost Engelfriet

Department of Computer Science, Leiden University P.O.Box 9512, 2300 RA Leiden, The Netherlands e-mail: {rozenber | engelfri}@wi.leidenuniv.nl

Definition 1



- A net is a triple N = (P, T, F), where
 - P are called places
 - T are called transitions
 - F is called flow relation of N

Definition 2



- A Petri net structure, C, is a four-tuple, C = (P, T, I, O), where
 - $P = \{ p_1, p_2, \dots, p_n \}$ is a finite set of places, $n \ge 0$.
 - $T = \{ t_1, t_2, ..., t_m \}$ is a finite set of transitions, $m \ge 0$.
 - The set of places and the set of transitions are disjoint, $P \cap T = \emptyset$.
 - I: P[∞] → T is the input function, a mapping from bags of places to transitions.
 - O: T → P[∞] is the output function, a mapping from transitions to bags of places.

Example Net



с		=	(P, T, I, O)				
P			=	$\{p_1, p_2, p_3, p_4, p_5\}$			
T			=	$\{t_1, t_2, t_3, t_4\}$			
$I(t_1)$	=	{ p ₁ }			<i>O</i> (<i>t</i> ₁)	=	{ <i>p</i> ₂ , <i>p</i> ₃ , <i>p</i> ₅ }
<i>l</i> (<i>t</i> ₂)	=	{ p ₂ , p ₃ , p ₅ }			O(t ₂)	=	{ p ₅ }
<mark>I(t</mark> 3)	=	{ p ₃ }			O(t ₃)	=	{ p ₄ }
$I(t_4)$	=	{ p ₄ }	94 E		<i>O</i> (<i>t</i> ₄)	=	{ p ₂ , p ₃ }



Petri Net with Weights



• Define for your need



Test Condition Greater





Equal but not Greater





Avatar: Na'vi Language









• LoongArch is a RISC ISA which is different from any other existing ones, while Loongson is a family of processors.







Conflict and Concurrency





Deadlock





Timed Petri Net





Timed Petri Net with Conflict





State Transition







Overview

Introduction

Basic Definitions

Modeling with Petri Nets

Analysis of Petri Nets

Producer & Consumer







系统分析与性能评价

Mutual Exclusion





Resource Sharing





Allocated Resource





Timed Petri Net with Semaphore 🐼 🕊



2022年秋

2022年秋

Instruction Level Parallelism

- Hardware dependency
- Data dependency
 - Register dependency
 - Memory dependency







Overview

Introduction Basic Definitions

Modeling with Petri Nets

Analysis of Petri Nets





- Safeness
- Boundedness
- Conservation
- Liveness

Safeness







Boundedness







系统分析与性能评价

Conservation



Petri nets can be used to model resource allocation systems.
For example, a Petri net can model the requests, allocations, and releases of input/output devices in a computer system.
In these systems some tokens may represent the resources.





• Resource allocation for two processes and two resources







• Petri net theory has developed considerably from its beginnings with Dr. Petri's 1962 Ph.D. dissertation. However, much of the work on Petri nets is hard to obtain, being available only as reports and dissertations scattered among many sources. Despite the difficulty in learning about Petri nets, however, their use is constantly increasing. It is becoming expected that every computer scientist know some basic Petri net theory.