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RESEARCH ARTICLE

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# Petri nets semantics of $\pi$-calculus



**Abstract** As $\pi$-calculus based on the interleaving semantics cannot depict the true concurrency and has few supporting tools, it is translated into Petri nets. $\pi$-calculus is divided into basic elements, sequence, concurrency, choice and recursive modules. These modules are translated into Petri nets to construct a complicated system. Petri nets semantics for $\pi$-calculus visualize system structure as well as system behaviors. The structural analysis techniques allow direct qualitative analysis of the system properties on the structure of the nets. Finally, Petri nets semantics for $\pi$-calculus are illustrated by applying them to mobile telephone systems.

**Keywords** Petri nets, $\pi$-calculus, concurrency, structural characteristics, analysis

## 1 Introduction

Petri nets and $\pi$-calculus are promising mathematical modeling tools for describing, analyzing and verifying concurrent systems [1]. $\pi$-calculus [2] is employed to model concurrent systems with dynamic topology, and supports formal analysis of systems in a variety of well-established techniques. However, the processes of $\pi$-calculus are complicated, and they cannot visually model the system architecture or depict the true concurrency. Moreover, $\pi$-calculus has few supporting tools, such as MWB and HAL. While Petri nets are a graphical and mathematical modeling tool, which are suitable for describing concurrent, distributed and asynchronous systems [3]. Petri nets put emphasis on modeling system structure and analyzing system properties, and they can effectively depict the true concurrency. Besides, there are many tools available for simulating, analyzing and verifying Petri nets model (http://www.informatik.uni-hamburg.de/TGI/PetriNets/tools/).

To remedy the deficiencies of $\pi$-calculus, $\pi$-calculus is translated into Petri nets. Consequently, the structural analysis techniques and supporting tools for Petri nets can be adopted to analyze and verify the concurrent systems with dynamic topology. In recent years, there is work aiming at translating $\pi$-calculus into Petri nets [4–7]. However, the methods present some especial Petri nets that cannot use existing supporting tools of Petri nets. Furthermore, most methods are too complicated to efficiently describe systems.

In this paper, $\pi$-calculus is divided into basic elements, recursive, sequence, concurrency and choice modules. These modules are translated into Petri nets, and then construct a complicated system.

## 2 Petri nets semantics for $\pi$-calculus

The Petri nets model of the process $P$ is called $N_P$ in which colored tokens, arcs with arc expression function, and transitions with guard functions are employed. Channels in $\pi$-calculus are divided into restricted channels and unrestricted channels. The restricted channels are only used in the interior of the process. According to the work in Ref. [7], the transitions and arcs associated with the restricted channels are labeled and cannot interact with the other Petri nets models. Places are labeled by their status symbols (entry places by $e$, internal places by $i$, and exit places by $x$) [7]. The preset of $e$ is empty and the post-set of $x$ is empty. Actions in $\pi$-calculus correspond to transitions in Petri nets. Transitions have two different kinds of labels: ordinary transitions and communication transitions $\tau$. Allelomorph names are mapping into transitions $\tau$.

To describe the characteristics of dynamic actions in $\pi$-calculus, the trace is introduced from the communicating sequential processes (CSP) [8].

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