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Systems and software engineering — High-level Petri nets —

Part 1: Concepts, definitions and graphical notation

Ingénierie du logiciel et des systèmes — Réseaux de Petri de haut niveau —

Partie 1: Concepts, définitions et notation graphique

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

This second edition cancels and replaces the first edition (ISO/IEC 15909-1:2004), which has been technically revised.

The main change compared to the previous edition is as follows:

— a complete redrafting of the concepts and definitions of Petri nets and Petri net types in a simpler, modular and incremental way.

A list of all parts in the ISO/IEC 15909 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO/IEC 15909 series is concerned with defining a modeling language and its transfer format, known as high-level Petri nets. This document is Part 1 of the ISO/IEC 15909 series. This document provides the mathematical definition of high-level Petri nets, called the semantic model, its execution semantics, the graphical form of the technique and its mapping to the semantic model. This document also introduces some common notational conventions for the graphical form of high-level Petri nets.

Petri nets have been used to describe a wide range of systems since their invention in 1962. The technique is mathematically defined and can thus be used to provide unambiguous specifications and descriptions of applications. It is also an executable technique, allowing specification prototypes to be developed to test ideas at the earliest and cheapest opportunity. Specifications written in the technique can be subjected to analysis methods to prove properties about the specifications, before implementation commences, thus saving on testing and maintenance time and providing a high level of quality assurance.

A problem with Petri nets is the explosion of the number of elements in their graphical form when they are used to describe complex systems. High-level Petri nets were developed to overcome this problem by introducing higher-level concepts, such as the use of complex structured data as tokens, and using algebraic expressions to annotate net elements. The use of "high-level" to describe these Petri nets is analogous to the use of "high-level" in high-level programming languages (as opposed to assembly languages), and is the usual term used in the Petri net community. Two of the early forms of high-level nets that this document builds on are predicate-transition nets and coloured Petri nets, first introduced in 1979 and developed during the 1980s. It also uses some of the notions developed for algebraic Petri nets, first introduced in the mid-1980s. It is believed that this document captures the spirit of these earlier developments (see Bibliography).

The technique has multiple uses. For example, it can be used directly to specify systems or to define the semantics of other less formal languages. It can also serve to integrate techniques currently used independently such as state-transition diagrams and data flow diagrams. The technique is particularly suited to parallel and distributed systems development as it supports concurrency. The technique is able to specify systems at a level that is independent of the choice of implementation (i.e. by software, hardware (electronic and/or mechanical) or humans or a combination). This document may be cited in contracts for the development of systems (particularly distributed systems) or used by application developers or Petri net tool vendors or users.

This document provides an abstract mathematical syntax and a formal semantics for the technique. Conformance to the document is possible at several levels. The level of conformance depends on the class of high-level net chosen.

This document is Part 1 of the ISO/IEC 15909 series. It describes definitions, semantics, execution and graphical notations for high-level Petri nets. A transfer format for the high-level Petri nets is the subject of Part 2, while Part 3 addresses techniques for enrichments, extensions and structuring mechanisms.

Reliable software development requires powerful mathematical models and tools. The usability of Petri nets has been proven for non-trivial industrial applications.

This document is written as a reference for systems analysts, designers, developers, maintainers and procurers, and for Petri net tool designers and developers.

This document defines high-level Petri nets showing common concepts for Petri nets first, and then describing several typical types of Petri nets, such as place/transition nets, symmetric nets, and Petri nets with time. Each of the Petri net types is described with its definition, semantics, and execution. Their graphical notations are provided in Annex B.

Systems and software engineering — High-level Petri nets —

Part 1:
Concepts, definitions and graphical notation

1 Scope

This document defines a Petri net modeling language or technique, called high-level Petri nets, including its syntax and semantics. It provides a reference definition that can be used both within and between organizations, to ensure a common understanding of the technique and of the specifications written using the technique. This document also facilitates the development and interoperability of Petri net computer support tools.

This document is applicable to a wide variety of concurrent discrete event systems and in particular distributed systems. Generic fields of application include:

— requirements analysis;

— development of specifications, designs and test suites;

— descriptions of existing systems prior to re-engineering;

— modeling business and software processes;

— providing the semantics for concurrent languages;

— simulation of systems to increase confidence;

— formal analysis of the behavior of systems;

— and development of Petri net support tools.

This document can be applied to the design of a broad range of systems and processes, including aerospace, air traffic control, avionics, banking, biological and chemical processes, business processes, communication protocols, computer hardware architectures, control systems, databases, defense command and control systems, distributed computing, electronic commerce, fault-tolerant systems, games, hospital procedures, information systems, Internet protocols and applications, legal processes, logistics, manufacturing systems, metabolic processes, music, nuclear power systems, operating systems, transport systems (including railway control), security systems, telecommunications and workflows.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 15909-2, *Systems and software engineering — High-level Petri nets — Part 2: Transfer format*