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Software and system engineering — High-level Petri nets —

Part 1: **Concepts, definitions and graphical notation**

Ingénierie du logiciel et du système — Toiles de Petri de haut niveau —

Partie 1: Concepts, définitions et notation graphique

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Contents

Foreword vi

Introduction vii

1 Scope 1
1.1 Purpose . . . 1
1.2 Field of Application . . . 1
1.3 Audience . . . 2

2 Terms, Definitions, Abbreviations and Symbols 2
2.1 Glossary . . . 2
2.2 Abbreviations . . . 5

3 Conventions and Notation 5

4 Semantic Model for High-level Petri Nets 6
4.1 Definition . . . 6
4.2 Marking of HLPN . . . 6
4.3 Enabling of Transition Modes . . . 7
4.3.1 Enabling of a Single Transition Mode . . . 7
4.3.2 Concurrent Enabling of Transition Modes . . . 7
4.4 Transition Rule . . . 7

5 Concepts Required for High-level Petri Net Graphs 8
5.1 Introduction . . . 8
5.2 High-level Petri Net Graph Components . . . 8
5.3 Net Execution . . . 8
5.3.1 Enabling . . . 9
5.3.2 Transition Rule for a Single Transition Mode . . . 9
5.3.3 Step of Concurrently Enabled Transition Modes . . . 10
5.4 Graphical Concepts and Notation . . . 10
5.5 Conditionals in Arc Expressions, and Parameters . . . 11

6 Definition of High-level Petri Net Graphs 13
6.1 Introduction . . . 13

6.2 Definition 13
6.3 Marking 14
6.4 Enabling 14
6.4.1 Enabling of a Single Transition Mode 14
6.4.2 Concurrent Enabling of Transition Modes 15
6.5 Transition Rule 15

7 Notation for High-level Petri Net Graphs **16**
7.1 General 16
7.2 Places 16
7.3 Transitions 16
7.4 Arcs 17
7.5 Markings and Tokens 17

8 Semantics of High-level Petri Net Graphs **17**

9 Conformance **18**
9.1 PN Conformance 18
9.1.1 Level 1 18
9.1.2 Level 2 19
9.2 HLPN Conformance 19
9.2.1 Level 1 19
9.2.2 Level 2 19

Annex A: Mathematical Conventions (normative) **20**
A.1 Sets 20
A.2 Multisets 20
A.2.1 Sum Representation 20
A.2.2 Membership 20
A.2.3 Empty Multiset 21
A.2.4 Cardinality and Finite Multiset 21
A.2.5 Multiset Equality and Comparison 21
A.2.6 Multiset Operations 21
A.3 Concepts from Algebraic Specification 21
A.3.1 Signatures 21

A.3.2 Boolean Signature 22
A.3.3 Variables 22
A.3.4 Terms built from a Signature and Variables 22
A.3.5 Many-sorted Algebras 23
A.3.6 Assignment and Evaluation 24

Annex B: Net Classes (normative) **25**
B.1 Place/Transition Nets 25

Annex C: High-level Petri Net Schema (informative) **27**
C.1 Introduction 27
C.2 Definition 27

Annex D: Tutorial (informative) **28**
D.1 Introduction 28
D.2 Net Graphs 28
D.2.1 Places and Tokens 28
D.2.2 Transitions 29
D.2.3 Arcs 30
D.2.4 The Net Graph 30
D.3 Transition Conditions 31
D.4 Net Dynamics 31
D.5 Flow Control Example 34

Annex E: Analysis Techniques (informative) **36**

Bibliography **37**

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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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ISO/IEC 15909-1 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and system engineering*.

ISO/IEC 15909 consists of the following parts, under the general title *Software and system engineering — High-level Petri nets*:

— *Part 1: Concepts, definitions and graphical notation*

Introduction

This International standard is Part 1 of a multi-part standard concerned with defining a modelling language and its transfer format, known as High-level Petri Nets. Part 1 defines a semi-graphical technique for the specification, design and analysis of discrete event systems.

The technique is mathematically defined and may 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 may 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.

Petri nets have been used to describe a wide range of systems since their invention in 1962. A problem with Petri nets is the explosion of the number of elements of 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 standard 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 standard captures the spirit of these earlier developments (see bibliography).

The technique promises to have multiple uses. For example, it may be used directly to specify systems or to define the semantics of other less formal languages. It may 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 International Standard 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.

Part 1 of this International Standard provides an abstract mathematical syntax and a formal semantics for the technique. Conformance to the standard is possible at several levels. The level of conformance depends on the class of high-level net chosen and the degree to which the syntax is supported. The basic level of conformance is to the semantic model.

Clause 1 describes the scope, areas of application and the intended audience of Part 1 of this International Standard. Clause 2 provides a glossary of terms and defines abbreviations. The main mathematical apparatus required for defining the semantic model and its graphical form is developed in normative Annex A and referred to in clause 3. The basic semantic model for High-level Petri Nets is given in clause 4, while the main concepts behind the graphical form are in formally introduced in clause 5. Clause 6 defines the High-level Petri Net Graph, the form of the standard intended for industrial use. Components of the graph are annotated. The annotations are defined at a meta-level allowing many different concrete syntaxes to be used. Clause 7 describes several syntactical conventions. Clause 8 maps the graphical form to the basic semantic model. The conformance statement is given in clause 9. Normative Annex B defines Place/Transition nets (without capacities) as a restriction of the definition of Clause 6. Place/Transition nets is often what is meant when the term Petri nets is used. Three informative annexes are included: Annex C defines a High-level Petri Net Schema, which allows classes of systems to be described at a syntactic level; Annex D is a tutorial on the High-level Petri Net Graph; and Annex E provides pointers to analysis techniques for High-level Petri Nets. A bibliography concludes this International Standard.

Software and system engineering — High-level Petri nets —

Part 1:
Concepts, definitions and graphical notation

1 Scope

1.1 Purpose

This International Standard defines a Petri net technique, called High-level Petri Nets, including its syntax and semantics. It provides a reference definition that can be used both within and between organisations, to ensure a common understanding of the technique and of the specifications written using the technique. This International Standard will also facilitate the development and interoperability of Petri net computer support tools.

Part 1 of this International Standard defines a mathematical semantic model, an abstract mathematical syntax for annotations and a graphical notation for High-level Petri Nets, known as the High-level Petri Net Graph. A mathematical mapping is provided that defines the graphical form in terms of the semantic model. A transfer format for the High-level Petri Net Graph is the subject of Part 2 of this International Standard, while Part 3 addresses techniques for modularity (such as hierarchies) and the augmentation of High-level Petri Nets with time.

1.2 Field of Application

This International Standard 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;
- modelling business and software processes;
- providing the semantics for concurrent languages;
- simulation of systems to increase confidence;
- formal analysis of the behaviour of systems; and
- development of Petri net support tools.

This International Standard may 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, defence command and control, distributed computing, electronic commerce, fault-tolerant systems, 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 workflow.