
**Industrial automation systems and
integration — Formal semantic
models for the configuration of global
production networks**

*Systèmes d'automatisation industrielle et intégration — Modèles
sémantiques formels pour la configuration des réseaux de production
mondiaux*

ITeH Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 20534:2018

<https://standards.iteh.ai/catalog/standards/iso/8083c655-3130-4145-9f12-6af7b82d988f/iso-20534-2018>



iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 20534:2018

<https://standards.iteh.ai/catalog/standards/iso/8083c655-3130-4145-9f12-6af7b82d988f/iso-20534-2018>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	vi
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	8
5 Formal semantic models for the configuration of global production networks	8
5.1 Formal semantics	8
5.2 Overview of the levels of specialization	8
6 System functionality formal semantics — Level 1	10
6.1 Overview	10
6.2 Level 1 formal semantics — Context	12
6.2.1 Context	12
6.3 Level 1 formal semantics — Properties	13
6.3.1 Property — Basic	13
6.3.2 Property — Entity	13
6.3.3 Property — Activity	13
6.3.4 Property — System function	13
6.3.5 Property — Energy	14
6.3.6 Property — Material	14
6.3.7 Property — Information	14
6.3.8 Property — Role	15
6.3.9 Property — Input	15
6.3.10 Property — Output	15
6.3.11 Property — Resource	15
6.3.12 Property — Control	15
6.3.13 Property — Scenario	16
6.4 Level 1 formal semantics — Relationships	16
6.4.1 Relationship — Affects state	16
6.4.2 Relationship — Basic affects role	16
6.4.3 Relationship — Role affects the state of role	17
6.4.4 Relationship — Plays role	17
6.4.5 Relationship — Role requires a context provided by an activity	17
6.4.6 Relationship — Basic composed of a basic	17
6.4.7 Relationship — Role composed of a role	18
6.4.8 Relationship — Activity contains a role	18
6.5 Level 1 formal semantics — Axioms	18
6.5.1 Axiom — Role requires an activity to provide a context	18
6.5.2 Axiom — An activity cannot contain a role and play the role	19
6.6 Level 1 formal semantics — Rules	19
6.6.1 Rule — Role requires an activity	19
6.6.2 Rule — Activity containing a role	19
7 Designed systems formal semantics — Level 2	19
7.1 Overview	19
7.1.1 Level 2 Systems overview	20
7.1.2 Level 2 Role overview	20
7.1.3 Level 2 Network overview	21
7.1.4 Product overview at levels 2 and 4	22
7.1.5 Overview of Location	23
7.2 Level 2 formal semantics — Context	24
7.2.1 Context — Designed systems	24
7.3 Level 2 formal semantics — Properties	25

7.3.1	Property — Network.....	25
7.3.2	Property — Product.....	25
7.3.3	Property — PhysicalProduct.....	25
7.3.4	Property — Physical product with service	25
7.3.5	Property — Service	25
7.3.6	Property — Service using physical product.....	26
7.3.7	Property — Prototype.....	26
7.3.8	Property — Organization function.....	26
7.3.9	Property — Facility function.....	26
7.3.10	Property — Actor type.....	26
7.3.11	Property — Actor	27
7.3.12	Property — Customer	27
7.3.13	Property — Supplier	27
7.3.14	Property — Gateway	27
7.3.15	Property — Diverging gateway.....	27
7.3.16	Property — Converging gateway.....	28
7.3.17	Property — Inclusive diverging gateway.....	28
7.3.18	Property — Inclusive converging gateway.....	28
7.3.19	Property — Exclusive diverging gateway.....	28
7.3.20	Property — Exclusive converging gateway.....	28
7.3.21	Property — Condition.....	29
7.3.22	Property — Business event.....	29
7.3.23	Property — Start event.....	29
7.3.24	Property — End event.....	29
7.3.25	Property — Decision event.....	29
7.3.26	Property — Plan.....	30
7.3.27	Property — Project.....	30
7.3.28	Property — Location.....	30
7.3.29	Property — Zonetype.....	30
7.3.30	Property — Area/city.....	31
7.3.31	Property — State/province.....	31
7.3.32	Property — Country.....	31
7.3.33	Property — Region.....	31
7.3.34	Property — Global.....	31
7.4	Level 2 formal semantics — Relationships.....	32
7.4.1	Relationship — Plays role actor	32
7.4.2	Relationship — Plays role Service.....	32
7.4.3	Relationship — Plays role physical product.....	32
7.4.4	Relationship — Flow occurs from an output to an input.....	33
7.4.5	Relationship — Gateway contains role.....	33
7.4.6	Relationship — Start event has an output role.....	33
7.4.7	Relationship — End event has an input role	34
7.4.8	Relationship — Define a project.....	34
7.4.9	Relationship — Project contains scenario.....	34
7.4.10	Relationship — Project has chosen scenario	34
7.4.11	Relationship — Physical product with service	35
7.4.12	Relationship — Service contains physical product.....	35
7.4.13	Relationship — Physical product has a prototype	35
7.4.14	Relationship — Organization function is composed of facility functions	36
7.4.15	Relationship — System function location.....	36
7.4.16	Relationship — Facility function location.....	36
7.5	Level 2 formal semantics — Axioms.....	37
7.5.1	Axiom — A system function cannot both play a role and contain the same role.....	37
7.5.2	Axiom — A network shall contain a flow between two system functions.....	37
7.5.3	Axiom — A flow can only exist between an input and an output or an output and an input.....	37
7.5.4	Axiom — A flow can only exist from a target to a source or a source to a target but not in both directions.....	38

7.5.5	Axiom — In a flow relation the source basic shall flow to a target.....	38
7.5.6	Axiom — A basic playing the role of an output in an network shall play the role of an input.....	38
7.5.7	Axiom — A start event is a specialized type of basic which shall have an output role only.....	39
7.5.8	Axiom — An end event is a specialized type of basic which shall have an input role only.....	39
7.5.9	Axiom — A gateway shall have at least one input and one output.....	39
7.5.10	Axiom — A diverging gateway shall have only one input and two or more outputs.....	40
7.5.11	Axiom — A converging gateway shall have has two or more inputs and only one output.....	40
7.5.12	Axiom — An inclusive diverging gateway has one input and two or more outputs.....	41
7.5.13	Axiom — An inclusive converging gateway has one default output and two or more inputs.....	41
7.5.14	Axiom — An exclusive diverging gateway inherits from an inclusive diverging gateway.....	41
7.5.15	Axiom — An exclusive converging gateway inherits from an inclusive diverging gateway.....	41
7.5.16	Level 2 formal semantics — Rules.....	42
8	Manufacturing business systems formal semantics — Level 3.....	42
8.1	Overview.....	42
8.2	Level 3 formal semantics — Context.....	42
9	Global production systems network formal semantics — Level 4.....	43
9.1	Overview.....	43
9.2	Level 4 formal semantics — Context.....	44
9.3	Level 4 formal semantics — Properties.....	44
9.3.1	Property — Production network.....	44
9.3.2	Property — GPN.....	44
9.3.3	Property — Producer.....	44
9.3.4	Property — Manufacturer.....	44
9.3.5	Property — Manufactured product.....	45
9.3.6	Property — Manufactured product service.....	45
9.3.7	Property — BOM.....	45
9.4	Level 4 formal semantics — Relationships.....	45
9.4.1	Relationship — gpn in scenario.....	45
9.4.2	Relationship — Manufacturer produces manufactured product.....	46
9.4.3	Relationship — Manufactured product has a bill of materials.....	46
9.4.4	Relationship — Manufactured product service contains service.....	46
9.5	Level 4 formal semantics — Axioms.....	47
9.5.1	Axiom — The role producer shall be played in a production network.....	47
9.5.2	Axiom — The role product shall be played in production network.....	47
9.5.3	Axiom — The role supplier should be played in a production network.....	47
9.5.4	Axiom — A supplier shall have an output.....	48
9.5.5	Axiom — A producer shall have an output.....	48
9.5.6	Axiom — A customer shall have an input.....	48
9.5.7	Axiom — A facility in a GPN shall have a location/city/country.....	49
9.5.8	Axiom — A GPN shall have facilities located in more than one country.....	49
	Annex A (informative) Highfleet Ontology Library Reference.....	51
	Annex B (informative) Ontologies in Knowledge Framework Language (KFL).....	74
	Annex C (informative) ECLIF language reference.....	89
	Annex D (informative) FLEXINET overview and approach.....	111
	Bibliography.....	120

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ISO documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 4, *Industrial data*.

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.

<https://standards.iteh.ai/catalog/standards/iso/8083c655-3130-4145-9f12-6af7b82d988f/iso-20534-2018>

Introduction

In reacting to change, competitive manufacturing industry aims to best understand the balance of possible options when making decisions on complex multi-faceted problems. Understanding how best to configure and re-configure a global production network, set against rapidly changing product-service requirements is one such complex problem area. Decisions consider multiple existing product and service variants, multiple new products and services to embrace the implications of new technological, economic, social, environmental and political requirements, and current production and service loads, as well as harmonizing and synchronizing production networks spread throughout the world, considering factors such as local supplier capabilities, transportation constraints, plant energy usage and production load forecasts.

While current Information and Communication Technology (ICT) tools play a significant role in support of such business development decisions, they need to do this in a well-integrated, trans-disciplinary way, with holistic solutions being critical to long-term competition (Huber 2014). Part of the solution to this problem lies in the exploitation of semantic technologies that provide a formal, logic base route to sharing meaning. This has been recognized as offering the potential to support interoperability across multiple related applications (Borgo et al. [23]; Chungoora et al. [24]). These provide formal, computer-based, methods of interpreting the meaning of concepts, their relationships to other concepts, and the constraints and rules that apply to their use.

The range of work in the use of formal semantics can be categorized into domain ontologies, foundation ontologies and reference ontologies. Domain ontologies tend to be limited to fairly narrow domains of applicability and so do not meet the holistic requirements mentioned above. Foundation ontologies are developed with a view to defining the semantics of everything but are too generic to offer positive constraints on any particular area of interest. The aim of reference ontologies for manufacture is to bridge the gap between these two and offer an effective support for interoperability, but in a targeted area or interest, i.e. in manufacturing. This document provides a contribution to such a manufacturing reference ontology by providing a formal semantic modelling approach to support the configuration of global production networks. It exploits the understanding gained from ISO 15531 and ISO 18629.

The manufacturing industry focus of this document is on how to design and configure a global production network (GPN) to produce and operate a new physical product or product-service. It does not address any operational aspects of production facilities, but rather models the flow relations between facilities in a production network. Future standards can build on this document to develop standard semantic models for in-factory systems.

The approach taken is based on exploiting the specialization capabilities of formal logic in order to progressively develop and constrain concepts and their relationships from foundation level descriptions to a level where the semantic models can be exploited by domain level software services and applications. The modelling approach starts from a systems functionality context as base from which to progressively represent global production systems, their relationships, constraints and related rules. The use of formal logic enables these semantic models to not only capture hierarchical relationships but also to capture and computationally exploit the constraints and rules that have been defined within these models.

The levels described in this document are different from the layered operational functionality of IEC 62264. The levels in this document are focused on levels of concept specialization. This starts from the key concepts from the context of any type of system through to specializations that are specific to manufacturing business systems. This is distinct from the layered operational functionality of IEC 62264, which is focused on the operational hierarchy of the business from higher-level production management down to shop floor.

This document uses some concepts that are common to supply chain models such as the Supply-Chain Operations Reference (SCOR) Model (Supply Chain Council 2014) and some concepts that follow from ISO 19440. SCOR is of limited relevance to this document as operational support is beyond its scope. Concepts from ISO 19440 have the greatest synergy with this document, which shares a business process oriented approach to enterprise modelling. While ISO 19440 provides model views to allow the identification of relevant object hierarchies and relationships between the different classes and