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Industrial automation systems and integration — Industrial manufacturing management data —

Part 42: Time Model

Systèmes d'automatisation industrielle et intégration — Données de gestion de fabrication industrielle —

Partie 42: Modèle du temps

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Foreword

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Attention is drawn to the possibility that some of the elements of this part of ISO 15531 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

This part of ISO 15531 was prepared by the Technical committee ISO/TC 184 *Industrial automation systems and integration,* Sub-Committee 4 *Industrial data.*

A complete list of parts of ISO 15531 is available from the Internet.

http://www.tc184-sc4.org/titles

Introduction

Software applications related to factory or enterprise production, such as scheduling software, manufacturing management software, cost evaluation software, maintenance management, purchasing software, delivery software..., strongly require a reference to time related features such as point in time (date) and duration (interval of time). These references are needed to ensure the necessary time related relationships between the events dealt with by the applications.

The availability of standardised time related references is particularly important for complex applications with multi-process environments, what is an environment commonly met in manufacturing.

In most of the standards, the time features are not independent from the events and the manufacturing management data they address. This leads to some difficulties in the way to handle time related relationships between events or data that include their own time relation and representation. In some of them the time related features may depend on events or objects addressed and their representation may change depending on the context, without any simple tool to identify the relation between them. This may be crucial in an environment where various processes are performed simultaneously or where many closely related software tools are used at the same time.

Developed in compliance with the "System theory" approach this part of ISO 15531 identifies the time as a constraint of the system environment and provides time related features included in a time model fully independent from the events handled by the manufacturing system. This time model is also fully independent from any manufacturing management data used by the manufacturing applications.

Note: For further explanations on time related concepts in system theory see ISO 15531-31 annex D.

Furthermore the time domain makes use of a domain property schema that, as one dimension domain, is generic enough to be usable separately from time specific properties.

In addition, the time model provided in this standard is written in EXPRESS to ensure better compatibility with ISO 10303.

Note: The background of this standard comes from the initial work developed in the JWG8 by Professor Dangelmaier from the Hans Nixdorf Institute of the Paderborn University, Germany.

Industrial automation systems and integration — Industrial manufacturing management data —

Part 42: Time Model

1 Scope

This part of ISO 15531 specifies a generic framework for the description of topological properties applicable to a wide range of one dimension domains.

However, and given the needs of the other parts of ISO 15531, the developments made in this part are focused on the time domain, thus providing a universal, self consistent model, independent of any event that may occur, or has already occurred, at a given point in time.

The time model specified in this part enables any software application to provide an accurate time reference to any related event, or sequence of events, whether in the past, in the present, or in the future. This time model may be used by any application that needs to reference events, actions, or sequences of action linked to time or intervals of time simultaneously.

According to this, the scope of this part of ISO 15531 includes the following:

— the description of the topological properties of an one dimension domain;

— the description of the time model and of the related definitions;

— the EXPRESS definitions of entities, attributes and schemas as prescribed in ISO 10303-11 (the reference manual of the EXPRESS language);

— the EXPRESS-G diagrams of the model as prescribed in ISO 10303-11.

The following are out of the scope of this part of ISO 15531:

— the description of any kind of measure theory or measure method

— elements and domains of more than one dimension

— the modelling of any event as described in ISO 10303-41

EXAMPLE Since their domain dimension is greater than one, squares, rectangles, triangles,..as well as cubes and spheres are out of the scope of this part of ISO 15531.

2 Normative references

The following referenced documents are indispensable for the application 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 8824-1: *Information Technology — Abstract Syntax Notation One (ASN.1) — Specification of Basic Notation — Part 1.*

ISO 10303-11: *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual.*

ISO 10303-41: *Industrial automation systems and integration — Product data representation and exchange — Part 41: Integrated generic resource: Fundamentals of product description and support.*

ISO 15531-1*: Industrial automation systems and integration — Industrial manufacturing management data — Part 1: General overview.*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
discrete manufacturing
production of discrete items.

[ISO 15531-1]

3.1.2
domain
collection of one dimension elements, that can be ordered and positionned applying a given measure method

NOTE Since the purpose of this document is the description of a “time model” the restriction of “one dimension” element in the definition only applies to this document that excludes domain such as rectangle, triangle, cubes and spheres. Whithout the restriction to “one dimension” element the definition may apply to any kind of domain.

EXAMPLE a domain can be specified as a list of integers such as 1, 2, 3,4….

3.1.3
domain point
point in a domain
domain element for which any defined measure of it in the domain is zero

3.1.4
element
static representation of a part of the universe of discourse that may be identified and characterised by its behaviour and attributes

NOTE A static representation is a snapshot of the part of the universe of discourse under consideration at a given time. It may include dynamic attributes as, for example, behaviour. Those attributes characterise the element as it is or as it is expected to be at a given time.

[ISO 15531-1]

3.1.5
entity
a class of information defined by common properties

[ISO 10303-11]

3.1.6
environment
part of the universe of discourse that does not belong to the system itself

EXAMPLE inputs and outputs of the systems such as raw material, final products etc., belong to the environment of the system as well as constraints that apply to it or time

3.1.7
event_occurrence
fact of an existence of a state at some point in time

NOTE the point in time of the existence may not be known in term of calendar date before the event_occurrence actually happens. One reason, why the event_occurrence cannot always be expressed as a calendar date, is that the event_occurrence is not possible to plan, for example a breakdown of machine.

EXAMPLE "Start of production", "breakdown of machine A"

[ISO 10303-41ed2 clause 16.4.7]

3.1.8
flow
motion of a set of physical or informational objects in space and time

[ISO 15531-1]

3.1.9
flow control
specific production control system that is based primarily on setting production rates and feeding work into production to meet these planned rates, then monitoring and controlling production.

NOTE That includes the act of checking and driving the flow according to a given purpose. The term may also apply to the function or service.

3.1.10
duration
interval of time
length of a period of time, measured using a given unit of time

EXAMPLE 1 the 24 hours between Monday 1.00 p.m. and Tuesday 12.00 a.m.

EXAMPLE 2 every Monday of every week between January and July.

NOTE interval of time measures the distance between two points in time. In that case it is the length of the time domain that is bounded by the two points in time under consideration.

3.1.11
measure
result of a quantitative evaluation of a given property of any physical or mathematical object

NOTE 1 the term measure may also be utilised for the operation that leads to this result.

EXAMPLE measure of length, area, volume, mass distribution, probability distribution, period of time, etc.

NOTE 2 any measure implies the definition of a method (procedure, theory) to get it, that includes the definition of the correponding unit of the measure. In particular any measure of an interval of time shall imply the definition of a unit of time and shall refer to it.

NOTE 3 From a mathematical point of view a measure is sometimes defined as a way to determine the distance between two points of the space under consideration (the length of the segment that joint these two points) as well as the result . In that sense duration is the measure of a period of time.

NOTE 4 For information the generic mathematical definition of the measure is : nonnegative function of subsets of a space completely additive in the sense that the measure of the union of a sequence of mutually disjoint sets is the sum of the measures of the sets.

3.1.12
method of measure
set of rules and intermediate steps, including the definition and the use of a unit of measure to be observed to achieve the considered measure

NOTE 1 Methods of measure often result from theories and principles that implicitly or explicitly derive from mathematical theories of the measure theories and from theoritical or experimental considerations on the property to be assessed.

NOTE 2 Mathematical theory of the measure theory is the study of measurable sets and functions, introduced by Lebesgue in order to generalize the Riemann integral.

3.1.13
point in time
location of something noticeable within a time domain

NOTE another equivallent definition may be : point in the time domain, applying definition 3.4.1 and 3.4.2 to the time domain

EXAMPLE 1 Wednesday, 15th of March, 2003.

EXAMPLE 2 9.30 a.m.

3.1.14
scheduling
act, function or result of planning occurrences of manufacturing activities

[ISO 15531-1]

3.1.15
time
feature of the enterprise universe of discourse that enables the location of noticeable things along an infinite oriented axis and allows the ordering of their succession or the identification and characterisation of this succession

EXAMPLE noticeable things may be events that have occurred, that may occur or are expected to occur. That may also be tags along the time axis.

NOTE Two main enterprise entities are related to the time. The first one is the point in time that enables the identification or assessment of location along the time axis. The second one is the interval of time that enables the determination of the distance between two points in time. See ISO 15531-31 annex D and IEC 62264-1 annex F.

3.1.16
time domain
period
set of points in time

EXAMPLE 1 the worked period within a year.

EXAMPLE 2 the maintenance period of a machine tool.

NOTE 1 A time domain may be finite or infinite. It may be bounded or not by one or two points in time.

NOTE 2 A time domain may be composed of other time domains.

3.1.17
time_interval
Identification of an intervening time

EXAMPLE "strike duration", "delay of production", "Christmas holydays"

[ISO 10303-41ed2 clause 16.4.14]

3.1.18
time model
model of the enterprise environment feature "time"

[ISO 15531-1]

3.1.19
unit of time
unit, that is implicitly or explicitly a multiple of the internationally defined second, to which a measure of time in a time domain has to refer

NOTE 1 in other words unit of time is the quantity of time chosen as a reference in terms of witch other quantity of time may be expressed. The second is the unit of time defined in the SI system of units.

NOTE 2 the multiplication ratio may be either greater or smaller than one.

3.1.20
universe of discourse
the collection of concrete or abstract things that belong to an area of the real world, selected according to its interest for the system to be modelled and for its corresponding environment

[ISO 15531-1]

3.2 Abbreviated terms

MANDATE MANufacturing DATa Exchange

STEP STandard for the Exchange of Product model data

4 Overview of the whole ISO 15531 scope

ISO 15531 specifies the characteristics for a representation of manufacturing management information over the entire industrial process with the necessary mechanisms and definitions to enable manufacturing management data to be shared and exchanged within the factory, with other plants or with companies.

Exchanges are made through different computer systems and environments associated with the complete industrial process. The standard is focused on discrete manufacturing but not limited to it. Nevertheless any extension to industrial processes which does not belong to discrete manufacturing is always under consideration when it does not imply any contradiction or inconsistency with the initial objective of the standard.

The following are within the scope of ISO 15531:

— the representation of production and resources information including capacity, monitoring, maintenance constraints and control;

NOTE - Maintenance constraints and relevant maintenance management data are taken into account from the point of view of their impact on the flow control.

— the exchange and sharing of production information and resources information including storing, transferring, accessing and archiving.

The following are outside the scope of ISO 15531:

— enterprise modelling;

NOTE - That means that tools, architecture and methodologies for the modelling of an enterprise in its whole are not in the scope of ISO 15531.

— product data (representation and exchange of product information);

— component data (parts library: representation and exchange of computer-interpretable parts library information);

— cutting tools (electronic representation for exchange of cutting tool data);

— technical maintenance information (technical information such as those included in devices repair, operation and maintenance manuals).

ISO 15531-1 provides a full overview of the whole ISO 15531 and of the relationship between its different parts.

The modelling language used to model the manufacturing management data addressed by ISO 15531 is EXPRESS that is defined in ISO 10303-11.

5 Domain property

5.1 Preamble

The domain property schema provides a generic structure applicable to any one dimension domain, enabling a hierarchical decomposition at the upper level of the tree, becoming then a network at the lower levels of the decomposition.

The root of the tree is made of an abstract entity called domain. This domain is considered as a set of domain points. This entity defines, in turn, the abstract supertype of three other abstract entities: complete or composite domain, discrete or continuous domain and bounded domain, characterizing the three basic categories from which the different kinds of domains are built. These four entities define the fundamental elements on which the domain property schema is built.

At the third level of the hierarchy, the three abstract entities of the second level are split into two sub-categories, leading to the entities of the fourth level. The entities belonging to the fourth level are related in between them through a network structure. This network structure comes from fundamental topological features of a domain, mentioned below.

5.2 Fundamental concepts and assumptions

Basically, the fundamental properties of a given domain are aimed at providing the possibility of covering the following range of topological structures for a set of domain points:

— complete;

— composite;

— discrete;

— continuous;

— upper-bounded;

— lower-bounded.

Combining the entities of each of the three initial branches with entities of the other branches leads to a network of combinations. the combinations are made in order to keep sense to the resulting entity.

EXAMPLE: possible combinations are:

— lower bounded composite discrete domain

— upper bounded complete continuous domain

In parallel to the definition of all possible domains, another concept enables the definition of domain points the domain is made of. This concept is necessary to bring a lower bound to a lower bounded domain, an upper bound to an upper bounded domain and to provide a reference to the origin of the complete domain entity.

5.3 Domain property schema definition

The following EXPRESS declaration begins the **domain_property_schema** and identifies the necessary external references.

EXPRESS specification

```
*)
SCHEMA domain_property_schema;

REFERENCE FROM measure_schema                -- ISO 10303-41
(unit);
REFERENCE FROM support_resource_schema       -- ISO 10303-41
(label);

(*
```


NOTE 1 The schemas referred to above can be found in the following parts of ISO 10303-41:

measure_schema: clause 21
support_resource_schema: clause 20

NOTE 2 See annex C.1 for a graphical presentation of this schema using the EXPRESS-G notation.

5.4 Domain property type definitions

5.4.1 type_of_identifier_of_dom_gen_struct

A **type_of_identifier_of_dom_gen_struct** is an alphanumeric string which may be used for something to be identified. It does not need to be understandable through the natural language.

EXPRESS-specification:

```
*)
TYPE type_of_identifier_of_dom_gen_struct = STRING;
END_TYPE;
(*
```

5.4.2 type_of_domain

A **type_of_domain** is an alphanumeric string which may be used to identify the domain.

EXPRESS-specification:

```
*)
TYPE type_of_domain = STRING;
END_TYPE;
(*
```

5.5 domain_property subtype constraint definitions

5.5.1 covered_range

A **covered_range** is the subtype constraint used to define subtypes of **domain**s for which a topological structure is needed.

EXPRESS-specification:

```
*)
SUBTYPE_CONSTRAINT covered_range FOR domain;
     ABSTRACT SUPERTYPE;
     ONEOF (time_domain);
END_SUBTYPE_CONSTRAINT;
(*
```


5.5.2 complcompos_discrcont_bounded

A **complcompos_discrcont_bounded** is the subtype constraint used to define subtypes of **domain_generic_structure** related to the property of being either complete, or composite, or discrete, or continuous, or bounded.

EXPRESS-specification:

```
*)
SUBTYPE_CONSTRAINT complcompos_discrcont_bounded FOR
     domain_generic_structure;
     ABSTRACT SUPERTYPE;
     ONEOF (complete_or_composite_domain, discrete_or_continuous
     _domain, bounded_domain);
END_SUBTYPE_CONSTRAINT;
(*
```

5.5.3 complete_composite

A **complete_composite** is the subtype constraint used to define subtypes of a **complete_or_composite_domain** related to the property of being either complete or composite.