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Automation systems and integration — Equipment behaviour catalogues for virtual production system —

Part 1: Overview

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Foreword

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*.

A list of all parts in the ISO 16400 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 16400 series introduces the concept of an equipment behaviour catalogue (EBC), addresses the requirements of EBC and proposes a guideline to generate an executable representing the dynamic behaviour of a nominal or a physical instance of a piece of equipment. Such executable plays a vital role when configuring virtual production systems used for simulation and verification of a future process as well as monitoring of a current process. Therefore, EBCs will constitute an important part of smart manufacturing evolution.

An EBC enables an efficient and standardized way for a provider of a piece of equipment to communicate its dynamic behaviour.

Automation systems and integration — Equipment behaviour catalogues for virtual production system —

Part 1: Overview

1 Scope

This document specifies the concept and structure of the ISO 16400 series. This series specify a methodology for preparing a template and items of an equipment behaviour catalogue (EBC) as a basis to structure a virtual production system.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
equipment behaviour catalogue
EBC
group of one EBC template and its EBC items

3.2
EBC template
schema representing a model for each equipment type including behaviour

3.3
behaviour
activity how an element acts and reacts in contexts of realizing its external interaction

[SOURCE: ISO 14258:1998 2.2.2, modified — "in contexts of realizing its external interaction" has been added at the end of the original definition.]

3.4
EBC item
instance of an EBC template

Note 1 to entry: An EBC item represents properties of a piece of equipment including its behaviour.

3.5
EBC repository
set of EBCs

3.6
nominal equipment instance model
executable model of a piece of equipment as designed

Note 1 to entry: An executable model is constructed from an EBC item and related data of an equipment design.

3.7
physical equipment instance model
executable model of an individual piece of equipment which exists in the physical world

Note 1 to entry: An executable model is constructed from an EBC item and related data of an equipment individual.

4 Abbreviated terms

AAS Asset Administration Shell

CDD Common Data Dictionary

JSON JavaScript Object Notation

UML Unified Modeling Language

XML eXtensible Markup Language

5 Concept of EBC

5.1 Requirements for an EBC

Requirements for an EBC are addressed as follows.

— an EBC shall provide an equipment's behaviour description to a given production system through equipment instance model.

— an EBC shall be described using common machine-readable language.

EXAMPLE XML and JSON.

— an EBC shall be bound by the terms (name) based on common taxonomy.

EXAMPLE CDD.

An EBC is the basis for the construction of an equipment instance model, whose purpose is to be implemented in a virtual production system. An equipment instance model shows its performance as the result of its behaviour. A performance can be different depending on the state of the equipment.

EXAMPLE The consumed energy for a machine is different depending on conditions such as stand-by state and in operation state. Consumed energy and spent operation time are as well dependent on the target product and the operations. They are simulated in the virtual production system. Annex A is a simple use case of EBC.

5.2 Conceptual structure of an EBC

An EBC is a group of one EBC template and its EBC items resulting from use of the EBC template. The EBCs are registered in a shared repository, as shown in Figure 1. EBC templates and EBC items shall be prepared by following the specifications.

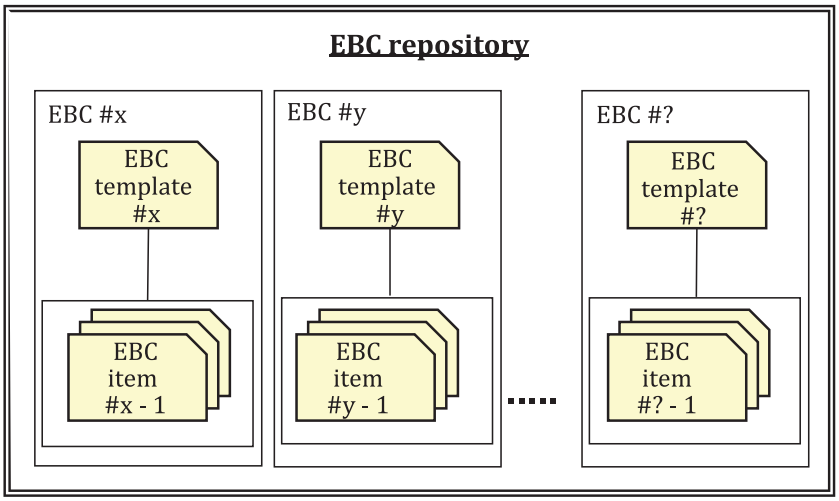

Figure 1 — Repository of EBCs

An EBC template and an EBC item are required to include descriptions which specify properties, behaviour resulting from equipment's activities, and external interactions. Figure 2 shows a conceptual structure of an EBC template.

In Figure 2, a behaviour is a composition of a state transition with each state description, operation programs, related data, calculation formulas and/or mathematical models.

EXAMPLE Consumed energy is calculated using the appropriate formula including variables. Values of variables can be provided when simulation is executed on the virtual production system.

Examples of EBC templates are shown in Annex B.

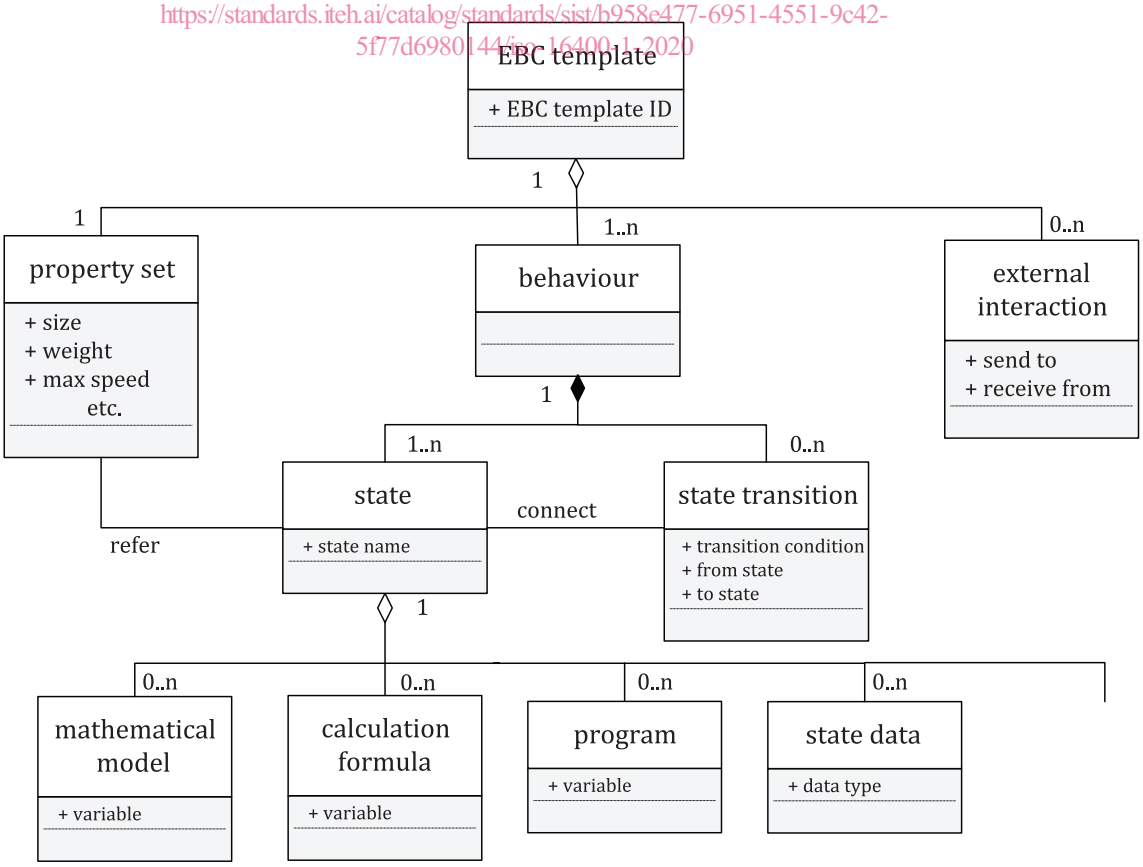

Figure 2 — Conceptual structure of an EBC template

5.3 Preparation of an EBC

An EBC provider, such as an equipment supplier and a manufacturing device vendor, develops an EBC item of an equipment using a corresponding EBC template. An EBC template shall be prepared for each equipment type by following the specifications.

6 EBC framework

EBC framework consists of a set of EBC repository and equipment instance models as shown in Figure 3. An equipment instance model is divided into two categories:

— a nominal equipment instance model, and

— a physical equipment instance model.

An equipment instance model is constructed from the selected EBC item according to ISO 16400-3. If the corresponding physical equipment exists, the physical equipment data are applied. A nominal equipment instance model is a model of an equipment as designed including the behaviour. A physical equipment instance model is a model of an equipment as physically realized including the behaviour. An equipment instance model can be installed as a software agent.

The ISO 16400 series specifies a methodology for constructing an EBC template and its EBC items. An EBC template and EBC items specific to a particular equipment are out of scope of the ISO 16400 series. An EBC is prepared by following ISO 16400-2.

This document specifies the concept and structure applied in the ISO 16400 series. ISO 16400-2 provides the formal structure of descriptions for EBC templates, a building method and rules for EBC. ISO 16400-3 specifies a guideline to construct equipment instance models using an EBC. Figure 3 shows the framework of EBC and the structure of the ISO 16400 series.

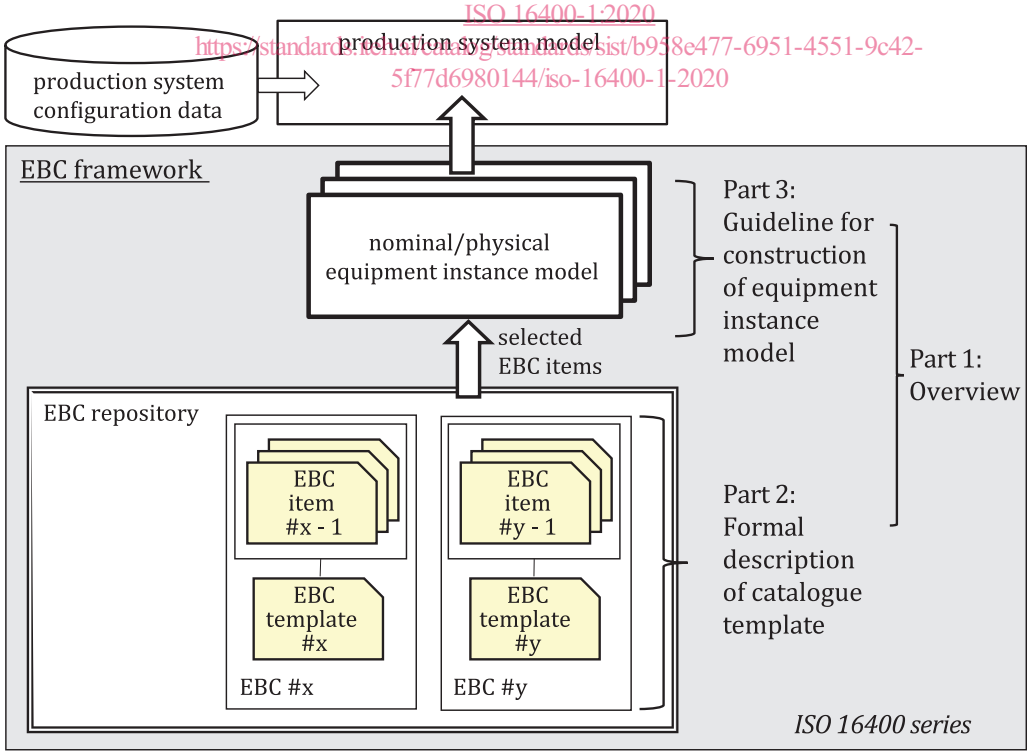

Figure 3 — Framework of an EBC and structure of the ISO 16400 series

7 Application guide for EBC

7.1 Benefits of using EBC

The EBC user such as a production system designer, an operator, or a manager, shall construct an equipment instance model from an appropriate EBC item selected from the repository for the virtual production system of interest. Then the EBC user can monitor the performance and operation method of the equipment. The benefits are as follows:

— an equipment instance model can be constructed easily, and then, a virtual production system can be structured quickly;

— performance of the equipment can be evaluated:

— performance of the existing equipment and a newly introduced equipment can be compared;

— operation of the equipment can be evaluated;

— planning and operation costs of a production system can be reduced.

The EBC framework provides the equipment manufacturer with the possibility to describe the behaviour of an equipment prior to delivery. The EBC user can specify the requisite capabilities. The benefits are as follows:

— requirements for equipment can be shared between vendors and users;

— required equipment can be selected easily;

— new customized equipment can be quickly configured.

EBC also provides benefits for smart manufacturing technology. Annex C shows use cases in smart manufacturing.

7.2 Usage procedure for EBCs

A production system consists of multiple equipment. The adopted workflow of the production system is associated with the combined behaviour of multiple equipment to produce a product. Figure 4 shows the usage procedure for EBCs.