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Industrial automation systems and integration — Manufacturing software capability profiling for interoperability —

Part 3: Interface services, protocols and capability templates

Systèmes d'automatisation industrielle et intégration — Profil d'aptitude du logiciel de fabrication pour interopérabilité —

Partie 3: Services d'interface, protocoles et gabarits d'aptitude

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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.

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

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.

ISO 16100-3 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 5, *Architecture, communications and integration frameworks*.

ISO 16100 consists of the following parts, under the general title *Industrial automation systems and integration — Manufacturing software capability profiling for interoperability*:

— *Part 1: Framework*

— *Part 2: Profiling methodology*

— *Part 3: Interface services, protocols and capability templates*

In addition, the following part is envisaged:

— *Part 4: Conformance test methods, criteria and reports*

Introduction

The motivation for ISO 16100 stems from the industrial and economic environment, in particular:

a) a growing base of vendor-specific software intensive solutions;

b) increasing user difficulty in applying independently-developed standards;

c) a need to move to modular and interoperable sets of system integration tools;

d) a recognition that application software and the expertise to apply that software are assets of the enterprise.

This part of ISO 16100 is an International Standard for the computer-interpretable and human readable representation of a capability profile. Its goal is to provide a method to represent the capability of manufacturing application software relative to its role throughout the life cycle of a manufacturing application, independent of a particular system architecture or implementation platform.

Certain diagrams in this part of ISO 16100 are constructed following UML conventions. Because not all concepts embodied in these diagrams are explained in the text, some familiarity with UML on the part of the reader is assumed.

In this part of the ISO 16100, references to classes (objects) and services use a specific naming convention as shown in the following examples:

ServiceAccessPoint	a service access point object
registerProfile	a service primitive for profile registration

Industrial automation systems and integration — Manufacturing software capability profiling for interoperability —

Part 3: Interface services, protocols and capability templates

1 Scope

This part of ISO 16100 specifies requirements for interface services and protocols used to access and edit capability profiles and associated templates used in the capability profiling method defined in Clause 5 of ISO 16100-2.

The detailed services for accessing capability profiles and performing the matching process on these profiles are defined in this part of ISO 16100.

This part of ISO 16100 is applicable only for the interoperability of software units used in the manufacturing domain. Concerns regarding interchangeability of manufacturing software units are outside the scope of this standard.

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 16100-1:2002	*Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 1: Framework*
ISO 16100-2:2003	*Industrial automation systems and integration — Manufacturing software capability profiling for interoperability — Part 2: Profiling methodology*
IEEE 1320.1-1998	*Standard for Functional Modeling Language — Syntax and Semantics for IDEF0*
OMG ad/2003-04-01	*Unified Modeling Language; Superstructure v2.0*
REC-xml-19980210	*Extensible Markup Language (XML) 1.0 W3C Recommendation*
REC-soap12-20021219	*SOAP Version 1.2 — Part 1: Messaging Framework*
REC-xmlschema-1-20010502	*XML Schema Part 1: Structures*

3 Terms and definitions

For the purposes of this part of ISO 16100, the following terms and definitions apply.

3.1 ISO 16100-3 definitions

3.1.1
capability profile interface
functional (implementation-independent) service access point that provides a set of services described in 5.4 of this part of ISO 16100 to handle capability profiles

NOTE In some implementations as noted in ISO 16100-2 the CPI can be implemented by a database server.

3.1.2
capability profile service provider
software that implements the capability profile interface

3.1.3
cluster
set of manufacturing resource units

3.1.4
component
part of a manufacturing software unit, including manufacturing software components.

3.1.5
consumer
<profile>
user of profile or Matching Level result

3.1.6
matcher
mechanism to compare an offered capability profile with a required capability profile.

3.1.7
matching level
<profile>
qualitative measure of how closely a capability profile of a MSU meets the software functional requirements of a manufacturing activity

3.1.8
MSU interoperability
capability of a MSU to support a particular usage of an interface specification in exchanging a set of application information with another MSU

3.1.9
MSU interchangeability
capability of a MSU to replace another MSU in performing a required function within a particular manufacturing activity

3.1.10
producer
<profile>
generator of profile or Matching Level result for consumption

3.1.11
reference capability class structure
schema representing a hierarchy of capability classes to be used for capability profiling.

3.1.12
reference dictionary
list of capability classes used in the reference capability class structure

3.1.13
schema
XML meta-data definition

3.1.14
template
schema for a manufacturing software capability profile

3.1.15
type I matcher
matcher that can process profiles derived from the same capability class structure

3.1.16
type II matcher
matcher that can process profiles whether they are derived from the same or from different capability class structures

3.2 Applicable definitions from ISO 16100-1

For the purposes of this document, the following terms and definitions from ISO 16100-1 apply. The reference to the specific subclause in ISO 16100-1 appears in brackets after the definition. Following clause C.1.4 of ISO / IEC directives, part 2 some definitions are repeated here with notes added as required.

3.2.1
capability
<software>
set of functions and services with a set of criteria for evaluating the performance of a capability provider

[3.3]

3.2.2
capability profiling
selection of a set of offered services defined by a particular interface within a software interoperability framework

[3.4]

3.2.3
manufacturing software
type of software resource within an automation system that provides value to a manufacturing application (e.g. CAD/PDM) by enabling the flow of control and information among the automation system components involved in the manufacturing processes, between these components and other enterprise resources, and between enterprises in a supply chain or demand chain

[3.10]

3.2.4
manufacturing software capability
set of manufacturing software functions and services against a set of criteria for evaluating performance under a given set of manufacturing conditions

[3.14]

3.2.5
manufacturing software capability profile
concise representation of a manufacturing software capability to meet a requirement of a manufacturing application

[3.15]

3.2.6
manufacturing software component
class of manufacturing software resource intended to support the execution of a particular manufacturing task

[3.11]

3.2.7
manufacturing software unit
class of software resource, consisting of one or more manufacturing software components, performing a definite function or role within a manufacturing activity while supporting a common information exchange mechanism with other units

[3.12]

3.3 Applicable definitions from ISO 16100-2

For the purposes of this document, the following terms and definitions from ISO 16100-2 apply. The reference to the specific subclause in ISO 16100-2 appears in brackets after the definition.

3.3.1
capability class
element within the capability profiling method that represents software unit functionality and behaviour with regard to the software units role in a manufacturing activity

[3.3]

3.3.2
capability profile integration
process in which two or more software units interoperate using equivalent interfaces that are configured in a compatible manner as indicated by their capability profiles

[3.4]

3.3.3
interface
abstraction of the behaviour of an object that consists of a subset of the interactions of that object together with a set of constraints on when they may occur

[3.8]

3.3.4
profile
set of one or more base specifications or sub-profiles or both, and, where applicable, the identification of chosen classes, conforming subsets, options and parameters of those base specifications, or sub-profiles necessary to accomplish a particular function, activity, or relationship

[3.10]

4 Abbreviated terms

CPI	Capability Profile Interface
DTD	Document Type Definition
ML	Matching Level
MSU	Manufacturing Software Unit
UML	Unified Modeling Language
XML	eXtensible Markup Language

5 Manufacturing software information model and profile

5.1 Manufacturing activity and information exchange model

A manufacturing application shall be modeled as a set of manufacturing processes that are enabled, controlled and automated by a set of manufacturing resources through a series of information exchanges, along with transfers of materials and energy. This is shown in Figure 4 of ISO 16100-1.

A manufacturing process shall be modeled as a sequence of scheduled manufacturing activities, where each manufacturing activity is associated with a set of manufacturing functions (see 5.3 of ISO 16100-1 and Annex C of this part).

In order to meet the requirements of a manufacturing application, a set of MSUs shall be sequenced and scheduled to accomplish the combined set(s) of required manufacturing functions for all the manufacturing activities associated with the set of manufacturing processes that constitute a manufacturing application.

Per the manufacturing software interoperability framework in Clause 6 of ISO 16100-1, each manufacturing activity shall be associated with a set of MSUs. As shown in Annex A of ISO 16100-1 that is based on IEC 62264, a complex manufacturing activity can be modeled as a combination of a set of simpler manufacturing activities. A simple manufacturing activity shall correspond to a single function and the activity shall be enabled by a single MSU.

Each manufacturing function can be accomplished by a set of manufacturing software units (MSUs). A set of manufacturing functions may be accomplished by one MSU (see 6.2 of ISO 16100-1).

EXAMPLE A simple manufacturing application (e.g. pick-and-place) can be modeled as a set of three manufacturing process (e.g. load an item, move an item, unload an item). Each manufacturing process can be associated with a single activity composed of a particular sequence of functions from the following set – locate item, identify item, identify place, go to item, acquire item, locate place, go to place, release item to place, notify process coordinators. In one case, two classes of MSUs (load/unload, move) with two capability templates can be profiled into three MSU instances (one for each activity). In another case, there maybe four lower level activities or MSU classes (locate, identify/notify, acquire/release, go to target) and nine MSU instances.

As shown in Figure 1 a MSU provides several interfaces to its capabilities, including its capability profile. The capability profile can be accessed at a Capability Profile Interface (CPI). Information about the other interfaces is included in the capability profile and therefore the information is accessible via the CPI.

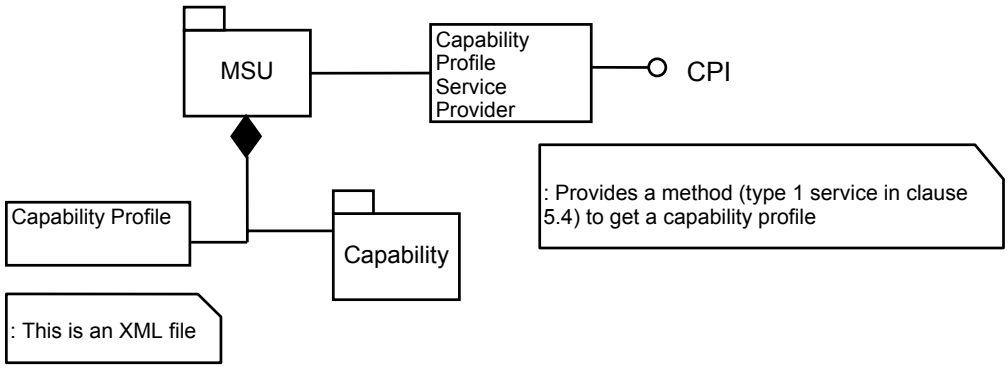

Figure 1 — MSU with its capability and corresponding capability interfaces, especially the Capability Profile Interface

5.2 Manufacturing software unit

A manufacturing software unit (MSU) shall be modeled as a type of manufacturing resource that can satisfy a set of interoperability criteria. These criteria shall be determined by the required sequence and timing of the specific set of manufacturing functions that have to be accomplished by a MSU and the information exchanges that it has to support.

As shown in Figure 4 of ISO 16100-1 a MSU shall be associated with a manufacturing activity and its corresponding capability. A software component shall not be associated with a capability profile.

A manufacturing function associated with a capability class of a manufacturing activity shall be modeled as being enabled by one or more MSUs.

EXAMPLE A manufacturing function associated with manufacturing activity N in Figure 2 is enabled by MSU 3. On the other hand, a manufacturing function associated with manufacturing activity M is enabled by both MSU 1 and MSU 2.

The manufacturing capability classes supported by a set of MSUs shall be determined by the manufacturing function of a manufacturing activity and the related information exchanges among the other manufacturing resources deployed to enable the manufacturing process.

A particular class of MSU may be used in different activities. Each MSU shall provide a set of interfaces. The interoperability criteria between MSUs shall be determined only by the requirements of the interoperable activities. Interoperability criteria between manufacturing processes shall not be considered in this International Standard. Interoperability criteria involving groups of MSUs associated with manufacturing processes shall not be considered in this part of ISO 16100.

At each level, the manufacturing software requirements can be modeled as a set of capability classes organized in a similar structure as shown in Figure B.1.

NOTE 1 In Figure 4 of ISO 16100-1, a manufacturing process is composed from a set of manufacturing activities. A manufacturing process can have a nested or hierarchical structure of manufacturing activities. The interoperability of MSUs only applies to the latter set (i.e. activities).

When two or more MSUs provide the required manufacturing software function within a manufacturing activity, these MSUs shall satisfy a set of interoperability criteria. The required interface(s) for interoperability of a set of MSUs within a particular activity shall be designated in a software capability profile of that activity.

NOTE 2 In Figure 2, an interface A provided by MSU 1 from vendor A interoperates with interface B provided by MSU 2 from vendor B. The interoperability criteria is denoted by interoperability I based on requirements of activity M. The capability profile for interface A should match the capability profile for interface B to support interoperability I. This profile can differ for different manufacturing activities.

NOTE 3 In Figure 2, when two activities such as M and N have to cooperate, another set of interoperability criteria can be used. The interoperability criteria denoted by interoperability J is based on common requirements of activities M and N. The set of MSUs that enable both activities have capability profiles that support interoperability J.

A combined behaviour of multiple MSUs shall be equivalent to the situation in which the manufacturing software requirements of the activity were being provided by a single MSU. This combined behaviour (of a single equivalent MSU) depends on the compatible use of an interface specification common to a set of MSUs. Conversely, a MSU can be composed of a set of MSUs to reflect a decomposition of a single activity into a set of activities.

When a MSU is modelled as a set of manufacturing software components, this MSU shall not contain another MSU. These MSU components shall be considered to belong only to that MSU. The information exchange and associated interfaces among the components within a MSU are outside the scope of this standard.

NOTE 4 In Figure 2, a MSU 2 provided by vendor C may replace a MSU 2 provided by vendor B in providing the manufacturing function required within manufacturing activity M. Although interface A provided by MSU 1 from vendor A interoperates with interface C provided by MSU 2 from vendor C, the full interchangeability of both MSU 2s cannot be realized. The capability profile for interface B matches the capability profile for interface C to support interoperability but not their interchangeability.

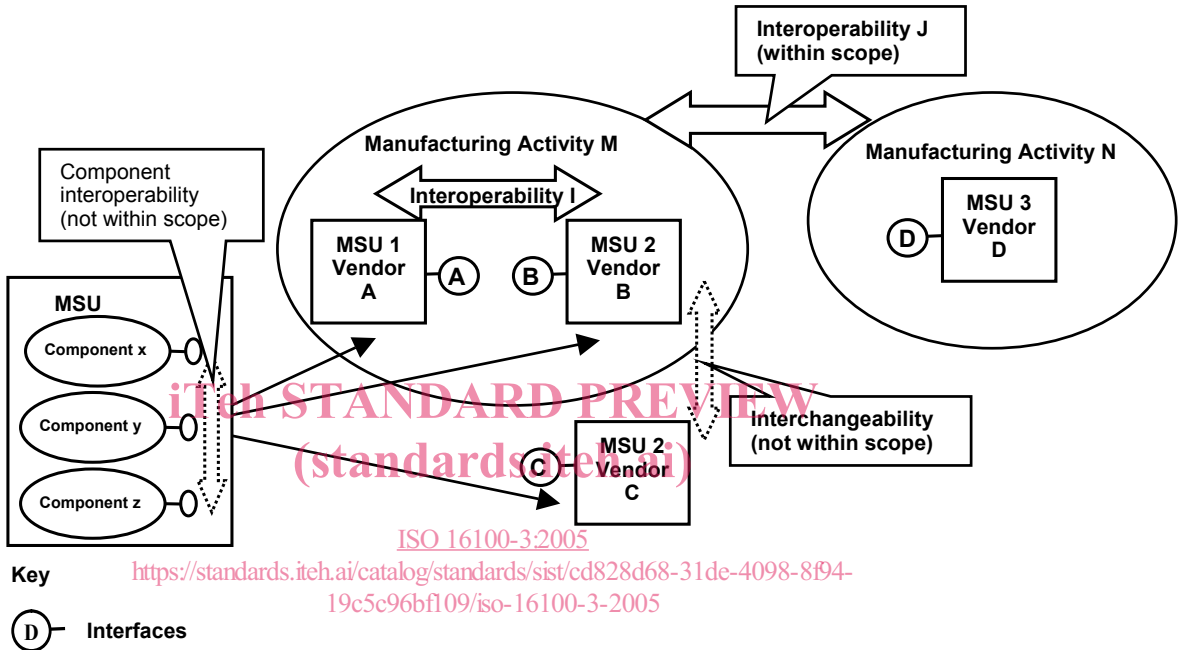

Figure 2 — MSUs within a manufacturing activity

5.3 Matching capability profiles

5.3.1 General

The structure of a MSU capability template shall be derived from the manufacturing capability class structure (see 6.3 of ISO 16100-2). Capability profiles pertaining to a MSU or a capability requirement for a manufacturing activity shall be matched according to the rules of 6.3 of ISO 16100-2. Capability profiles are capability templates with, at a minimum, the profiled software unit name instantiated; other items in the capability template shall be filled according to the desired Matching Level (see 6.4 of ISO 16100-2).

The attribute of a manufacturing capability class are defined in 6.2.1 of ISO 16100-2, while a conceptual structure is defined in 6.2.3 and 6.2.4 of ISO 16100-2.

NOTE 1 See Figure 4 of ISO 16100-1 regarding relationships between manufacturing application, manufacturing activities, and manufacturing resources. See 6.2 of ISO 16100-2 regarding the relationship between capability classes and manufacturing activities.

NOTE 2 Reference capability class structure is represented as a reference schema. See Annex A for “Reference Class Structure”.

A matching MSU capability profile shall represent the following required aspects of a manufacturing activity:

a) handling the input and output information associated with the required manufacturing function;

NOTE 3 The elements in the “part specific to the capability profile” portion of the template can be categorized as input or output elements of the manufacturing function associated with the activity (see 6.3 of ISO 16100-2). A match between the MSU profile and the required capability implies that these elements are included in the MSU profile.

b) corresponding MSUs with compatible interfaces, expressed by their capability profiles, where two activities are interoperable.

NOTE 4 A MSU’s interface services and protocol settings that match the corresponding settings of the interfaces of the other MSU(s) associated with the other manufacturing activities enables the MSUs to be interoperable, as well as their respective manufacturing activities.

Figure 3 models the matching of a MSU’s capability profile to a required capability profile of a manufacturing activity.

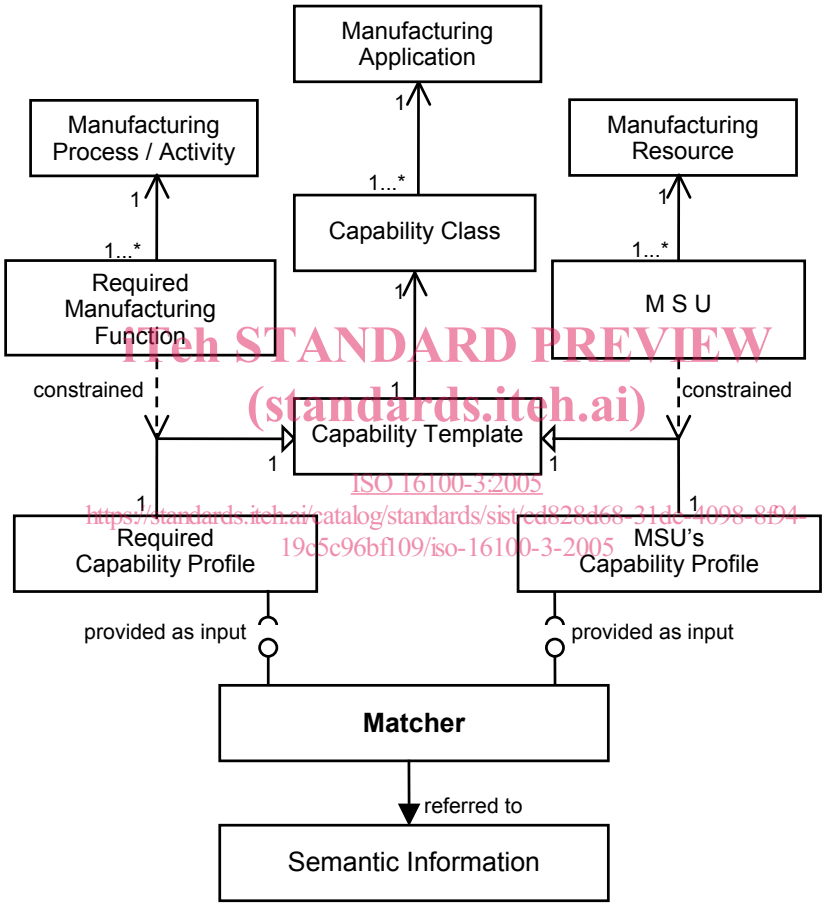

Figure 3 — Matching capability profiles

All matchers use additional semantic information about application specific domain. This semantic information can include identity information that is generated on the basis of a set of taxonomies that can be stored in the Software Unit Capability Profile Database.

5.3.2 Type 1 Matcher

A Type 1 Matcher is distinguished from a Type 2 Matcher (see (5.3.3) in that a Type 1 Matcher can only match capability profiles that were generated from a capability template derived from the same capability class.

5.3.3 Type 2 Matcher

A Type 2 Matcher can match capability profiles that were generated from templates derived from the same capability class or derived from different capability classes. In the case of different capability classes, the classes can either be from the same manufacturing application or from different manufacturing applications.

Different capability classes exist because different enterprises classify manufacturing functions on the basis of different activity domains and various functional boundaries as shown in ISO 16100-1, annex A.1. In this case, the same manufacturing functions belong to different capability classes.

The Type 2 Matcher uses semantic information that includes the identity information about the same manufacturing functions in different capability classes to perform the matching process.

In the case of a Type 2 Matcher matching profiles generated from templates derived from two different capability classes both of the same manufacturing application, a customer describes a certain manufacturing function by completing a capability template derived from a certain capability class to produce the required capability profile. A supplier describes the same manufacturing function by completing a capability template derived from a different capability class to produce the MSU's capability profile. The Type 2 Matcher then matches the generated required capability profiles to generated MSU capability profiles (see Figure 4).

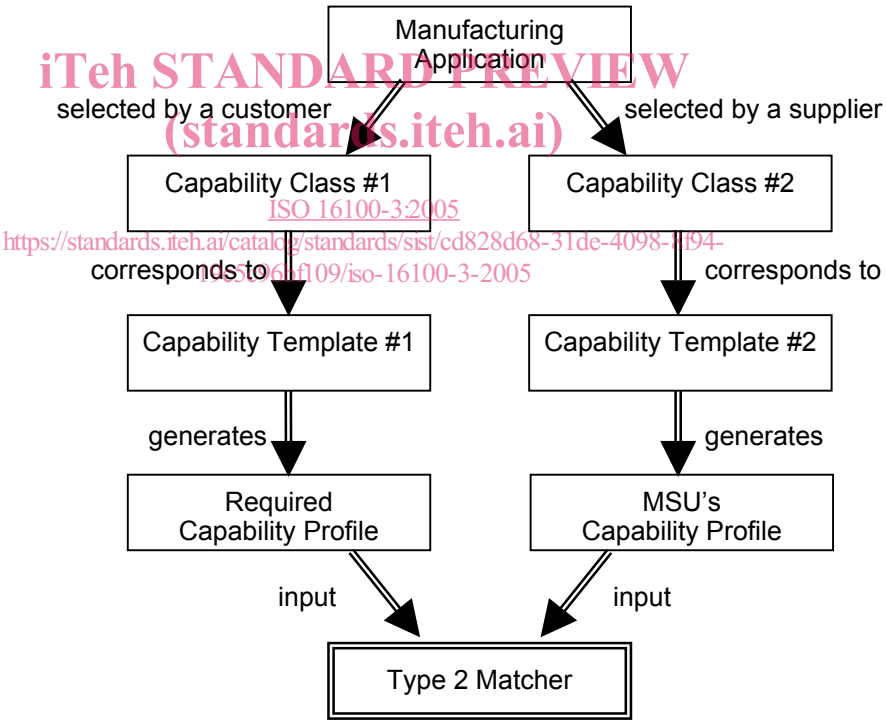

Figure 4 — Different capability classes from same manufacturing application

In other cases a Type 2 Matcher handles profiles generated from templates derived from two different capability classes from different manufacturing applications.