Manufacturing Software Interoperability and Assurance using Standardized Capability Profiling: An ISO 16100 Proposal

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Major changes in the area of manufacturing software systems

- Trend to the open system architecture from a software embedded type system architecture.
- Globalization from building a manufacturing system by developing all software units by themselves to building a manufacturing system by combining software units which are provided by various vendors.
- Conversion of the optimization target from local optimization of each system unit to total optimization of the whole manufacturing system.

Key technologies to reduce development time and development cost:

- how to find and use skillfully manufacturing software units which are provided by various vendors and how to reuse existing software units.
Objectives of ISO 16100

*International Standard ISO 16100:*
Manufacturing Software Capability Profiling for Interoperability
developed by ISO/TC 184/SC 5/WG 4

- To provide a standardized mechanism to search for good and proper manufacturing software.
- To provide a standardized mechanism to show the precise capability of the manufacturing software.
- To provide a standardized methodology for the interoperability and assurance of manufacturing software units using capability profiling.
History of ISO 16100 Series

Development of ISO 16100
1998 Dec.: ISO/TC 184/SC 5 Study Group proposed
   NWI : Manufacturing Software Capability Profiling
1999 Jun.: New work item proposal was accepted
2000 Nov.: ISO/TC 184/SC 5/WG 4 started to develop ISO 16100

Title of ISO 16100:
Manufacturing Software Capability Profiling for Interoperability
   Part 1: Framework (editor from USA) 2002
   Part 2: Profiling methodology (editors from Japan) 2003
   Part 3: Interface protocols and templates (editor from Germany) 2005
   Part 4: Conformance test method, criteria and reports
      (editor from China) 2006
   Part 5: Methodology for profile matching using
      multiple capability class structures
      (editors from Japan) under DIS ballot
Manufacturing Application Model

- Manufacturing Application
  - Manufacturing Process
    - 1..* Manufacturing Information
  - Manufacturing Resource
    - 1..* Manufacturing Automation Device
      - 1..* Equipment & Infrastructure
      - 1..* Raw Material & Manufactured Part
    - 1..* Manufacturing Personnel
    - 1..* Manufacturing Software Unit
A Manufacturing Software Unit and Its Surroundings

Manufacturing Domain contains 1..* Manufacturing Application

Manufacturing Information enables 1..* Manufacturing Process

Manufacturing Process sequences 1..* Manufacturing Activity

Manufacturing Activity constrains Manufacturing Function

Manufacturing Function constrains Manufacturing Activity

Manufacturing Resources enables 1..* Computing System

Computing System operates 1..* Software Environment

Software Environment enables Software Architecture

Software Architecture enables Software Design Pattern

Manufacturing Software Unit

Interface / Protocol

Datatype 1..*

Role

A Manufacturing Software Unit and Its Surroundings
MSU Capability Profiling Based on the Activity Tree

Activity Tree
- **Manufacturing Application**
  - Activity #A
    - Activity #A1
      - Activity #A11
      - Activity #A12
  - Activity #B
    - Activity #A2
      - Activity #A12

Capability Class Structure
- **Capability Class**
  - Capability Class #A
    - Capability Class #A1
    - Capability Class #A11
    - Profile Template #A11
    - Capability Profile x
  - Capability Class #B
    - Capability Class #A2
    - Capability Template #A2
    - Capability Profile y

Profile Template = Concrete class for profile
Capability Template and MSU Profile
Relationship between manufacturing domain and manufacturing application

Manufacturing Domain Model

- contains 1

- describes 1..*

Manufacturing Domain Data

- represents 1

- constrains 1..*

Capability Class Structure

- describes 1

- constrains 1..*

Capability Class

- constrains 1..*

- constrains 1

Manufacturing Application

- contains 1..*

Manufacturing Process

- sequences 1..*

Manufacturing Function

- organizes 1..*

Manufacturing Information

- constrains 1..*

- describes 1

- represents 1..*

Exchanged Application Information

- constrains 1..*

Manufacturing Resource

- constrains 1..*

Manufacturing Activity

- maps 1..*

MDD

MDM

CCS
Relationship between MDD and MDM
Multiple Capability Classes Described Using MDDs
Conceptual Framework for Interoperability and Assurance

[Software Vendor]

- Manufacturing Software Unit Development
- Search and Fulfill Template (Profiling)
- Manufacturing Software Unit Profile
- Registration

[System Integrator]

- Manufacturing Application Requirements
- Software Requirement Analysis
- Required Software Unit Profile
- Profile Selection and Verification
- Required Software Units

Database

- Capability Class Structure
- Capability Profiles

Matching of Profiles

Capability Class Structure

Application System Development
Conceptual Structure of Templates for MSU Capability Profiling

**Capability Profile Template**

**Common Part**
- Template ID
- Capability Class Name and **Reference CCS**
- Software Unit ID
  - Vendor Name
  - Version Number & History
  - Computing Facilities Required
  - Processor

- Capability Class Reference Dictionary Name
- Number Of Profile Attributes
- Number Of Methods
- Number Of Resources

**Specific Part**
- **Reference MDM Name**
  - Capability Definition Format
  - Capability Definition
    - List of Capability Class Attributes
    - List Of Capability Class Methods
    - List Of Capability Class Resources

**MDM Template**
- MDM Name
- Domain Reference Dictionary Name
- List of MDD Packages
  - MDD Package
    - MDD Name
    - List of Relationships
      - Relationship
        - Relationship Type
        - Relationship Name
        - Destination MDD Name
        - Direction
        - Role Name for MDD
        - Role Name for Destination MDDs
        -Multiplicity
        - Type

**MDD Template**
- MDD Name
- Reference MDM Name
- List of Attributes
  - Attribute Name
  - Attribute Type

**CCS Template**
- CCS Creator Name
- CCS ID
- CCS Root Node ID
- Capability Class ID
  - Parent Node ID(s)
  - Child Node ID(s)
Example of MSU Profile

```xml
<Common>
  <ReferenceClassStructure id="coe_1001" name="TestEvaluationActivity" version="001" url="/"/>
  <MSU_Capability id="MS_102-001" version="V01.05.020c"/>
</Common>

<Owner>
  <name>MSU Developer Inc.</name>
  <street>Winter Ave.7</street>
  <city>Softcity</city>
  <zip>4712</zip>
  <state>OK</state>
  <country>USA</country>
  <comment>Only best experiences!</comment>
</Owner>

<ComputingFacilities type="required">
  <--- type is octoval! →
  <--- see Fig 6 part 2 →
  <Processor type="INTEL"/>
  <OperatingSystems>
    <OperatingSystem>WINDOWS</OperatingSystem>
    <OperatingSystem>JAVA</OperatingSystem>
  </OperatingSystems>
  <Languages name="EN"/>
  <Memory size="7F" unit="MB"/>
  <DiskSpace size="32" unit="GB"/>
</ComputingFacilities>

<Performance>
  <ElapsedTime value="51ms"/>
  <TransactionsPerSecond value="621"/>
</Performance>
```

---

```xml
<Specific>
  <ReferenceClassStructure id="coe_1001" name="CEA_TestActivity" version="001" url="/"/>
  <TestActivities>
    <Formula level="3" D="ABAAB"/>
  </TestActivities>
</Specific>
```
Example of Required MSU Profile

```xml
<Common>
  <Requirement id="AMS-001-001" version="V01.01.01a"/>
  <Name>
    <name>MSU User Ltd</name>
  </Name>
  <street>Spring 5X2</street>
  <city>Suffield</city>
  <zip>09156</zip>
  <country>France</country>
  <Comment>Never seen before</Comment>
</Common>

<Common>
  <ComputingFacilities type="offered">
    <see fig 6 part 2 --> Processor type="INTEL"/>
    <OperatingSystem>Linux</OperatingSystem>
    <Language>EN</Language>
    <Memory size="25" unit="MB"/>
    <DiskSpace size="50" unit="GB"/>
  </ComputingFacilities>
  <Performance>
    <Elapsed Time value="200ms"/>
    <Transactions PerSecond value="200"/>
  </Performance>
</Common>
```

The screenshot shows a portion of an XML file with some data highlighted. The highlighted section appears to be an `InputDataType` element with a `level` attribute set to `4` and an `ID` attribute set to `BA`. This suggests that the highlighted part is focusing on an input data type with a specific level and identifier.
Matching Level in Profile Matching Report

**Complete Match** — all the manufacturing functions referenced in the required capability profile match completely with all the corresponding functions referenced in the MSU capability profile. This means that both sets of manufacturing functions are fully equivalent in terms of both the MDD objects being equivalent and the time ordering of these objects being equivalent.

**All Mandatory Match** — all the mandatory functions in the required capability profile are completely matched with a corresponding set of manufacturing functions referenced in the MSU capability profile. The matching level report includes information about the details of the MSU functions in the corresponding set.

**Some Mandatory Match** — the required capability profile is matched partially by the MSU capability profile. The matching level report includes information about the details of the MSU functions that matched the functions referenced in the required capability profile.

**No Mandatory Match** — none of the mandatory functions referenced in the required capability profile match the functions referenced in the MSU capability profile.
Demonstration of Conformance Testing for ISO 16100

presented by
Prof. Qian Wang
(Southeast Univ., CHINA)

Main Interface

Capability Profile Matching
Future plans for ISO 16100 Project

Intent of ISO 16100

- To provide methodologies and technologies together into solutions that dramatically reduce the time and cost associated with the development and integration of software capability and assurance.
- To manage interoperability and assurance of manufacturing software units through their profiles which describe their capabilities.

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