Automated generation of an MVD by linking IDM and bSDD

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Outline

• Background and Problems
• Proposed solution
• Implementation
• Demonstration
Background and Problems
The information management process

ISO 19650-1:2018 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) -- Information management using building information modelling -- Part 1: Concepts and principles
The information management process

ISO 19650-1:2018 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) -- Information management using building information modelling -- Part 1: Concepts and principles
ISO 19650-1 and IDM

ISO 19650-1

Information submission and management requirements

mandates

Information Delivery Manual (IDM)

ISO 29481-1

Information requirements
ISO 19650-1, IDM, and IFC/MVD

ISO 19650-1 mandates information submission and management requirements.

ISO 29481-1 formalizes information requirements.

ISO 16739-1 formalizes IFC and its views (MVDs).
ISO 19650-1, IDM, IFC/MVD, and bSDD

- **ISO 19650-1**: Information submission and management requirements
- **ISO 29481-1**: Information requirements
- **ISO 16739-1**: IFC and its views (MVDs)
- **ISO 12006-3**: buildingSMART Data Dictionary (bSDD)

**ISO 19650-1** mandates the use of **ISO 29481-1** Information requirements.

**ISO 29481-1** formalizes the **ISO 16739-1** IFC and its views (MVDs).

**ISO 29481-1** provides terminology that is used in the **buildingSMART Data Dictionary (bSDD)**.
ISO 19650-1, IDM, IFC/MVD, and bSDD

ISO 19650-1
Information submission and management requirements

ISO 29481-1
Information requirements

ISO 16739-1
IFC and its views (MVDs)

ISO 12006-3
Data dictionary (schema)

buildingSMART Data Dictionary (bSDD)

<Cause>
IDM not machine-readable

<Impacts>
IDM not reusable and exchangeable
Broken connections between standards
Proposed Solution
ISO 29481-3 IDM Schema

<Goal>
To make an IDM a standard that is machine-readable, applicable, and transferrable (SMART)

<Status>
Initiated in April, 2019
Currently in the CD phase
Method 1: Mapping IDM and IFC

1. Information unit (IDM, ISO 29481-1, ISO 29481-3)

2. IFC element (IFC ISO 16739-1)

3. Concept-based MVD generation algorithm (Lee 2009)
Method 1: Mapping IDM and IFC

1. IDM (ISO 29481-1, ISO 29481-3)
   - Information unit

2. IFC (IFC ISO 16739-1)
   - IFC element

3. MVD (IFC ISO 16739-1)
   - Concept-based MVD generation algorithm (Lee 2009)
     
     SCHEMA myMVD;
     ENTITY IfcRoot
     END ENTITY
     ...
     ENTITY IfcSlab
     ...
     END ENTITY

Concepts:
- slab
- ifcSlab
(1) Specification of information units

ISO 29481-3 idmXSD

"slab"
(2) Linking an ER and a standard data model and its subschemas (MVDs)

A schema name of an open standard data schema (e.g., IFC4.0, cityGML...)

A subschema (MVD) name of the data dictionary (Design Coordination View, COBie...)

<ISO 29481-3 idmXSD>
"IfcSlab"

The name of the referenced schema or MVD (e.g., IFC4.0, cityGML, DCV, COBie...)

The name of the element in the reference schema (e.g., IfcDoor, IfcDoor.OverallHeight, IfcBuildingElement> IfcDoor...)

<ISO 29481-3 idmXSD>
Concept-Based Method for Extracting Valid Subsets from an EXPRESS Schema

Ghang Lee, Ph.D.¹

Abstract: An EXPRESS schema is a data schema defined in EXPRESS, an international standard language for defining product data schemas. This technical paper proposes and formally defines a set of conditions for generating a minimum valid subset of an EXPRESS schema corresponding to a concept, where a concept is a general idea and a subset is a partial model of a data schema. We introduce a notion of “minimal set” to define the relationships between a subset and other subsets, and also between a subset and concepts. A minimal set is the smallest complete subset of a schema that corresponds to a concept. Using IFC, an international standard data model for the architecture, engineering, and construction industry, the proposed conditions have been implemented in a software application developed for extracting subsets from the IFC schema matching the concepts. A number of examples are demonstrated.


CE Database subject headings: Computation; Computer software; Data processing; Standardization.

Condition 1. (Mapping between concepts and minimal sets). By the definition of “minimal set,” there must be one and only one minimal set \( M \) corresponding to each element \( c \) in a set \( C \) of concepts

\[ \forall c \in C \rightarrow \exists x[f_{\text{m}}(c) = x \land \forall y[f_{\text{m}}(c) = y \rightarrow y = x]] \]

Condition 2. (Forming new concepts). Let \( c_i \) and \( c \) denote concepts or sets of properties:
1. \( \cap c_i = c \) iff \( c \) is a generalized concept such that each \( c_i \) is a \( \cap \land \) subtype of \( c \);
2. \( \cup c_i = c \) iff \( c \) is an aggregated concept such that each \( c_i \) is a \( \cup \land \) part of \( c \); and
3. If \( i = 0 \), then \( c_0 = c \) such that they are synonymous.

By the same token, a new minimal set can be defined as the intersection or union of other minimal sets.

Condition 3. (Forming new minimal sets). Let \( m_i \) denote a minimal set:
1. \( \cap m_i = m \) iff \( m \) is a minimal set corresponding to a new \( \cap \land \) generalized concept; and
2. \( \cup m_i = m \) iff \( m \) is a minimal set corresponding to a new \( \cup \land \) aggregated concept.

Proof for Condition 3

Let \( c_1 \), \( c_2 \), and \( c_3 \) be concepts and \( M_1 \), \( M_2 \) and \( M_3 \) be a minimal set:

1. If \( c_1 \rightarrow M_1 \land c_2 \rightarrow M_2 \), then \( c_1 \cap c_2 \rightarrow M_1 \cap M_2 \) by the definition of the intersection operation.
2. If \( c_1 \rightarrow M_1 \land c_2 \rightarrow M_2 \), then \( c_1 \cup c_2 \rightarrow M_1 \cup M_2 \) by the definition of the union operation.

(3) Derivation of a full valid MVD from individual elements

Concept-based MVD generation algorithm (Lee 2009)

ifcSlab

```plaintext
SCHEMA myMVD;
ENTITY IfcRoot
END ENTITY
...
ENTITY IfcSlab
...
END ENTITY
...
END SCHEMA
```
Method 2: Mapping IDM and IFC through bSDD

1. Information unit
   - IDM (ISO 29481-1, ISO 29481-3)

2. Concept
   - bSDD (ISO 12006-3)

3. IFC element
   - MVD (IFC ISO 16739-1)

4. Concept-based MVD generation algorithm (Lee 2009)
Method 2: Mapping IDM and IFC through bSDD

1. Information unit
   - concrete floor

2. Concept
   - concrete floor

3. IFC element
   - ifcSlab

4. Concept-based MVD generation algorithm (Lee 2009)

SCHEMA myMVD;
ENTITY IfcRoot
END ENTITY
...
ENTITY IfcSlab
...
END ENTITY
(1) Specification of information units

ISO 29481-3 idmXSD

"concrete floor"
(2) Linking ER and ISO 12006-3

A schema name of a data dictionary (e.g., bSDD) defined according to ISO 12006-3

A subschema (MVD) name of the data dictionary, if available

<ISO 29481-3 idmXSD>
Search for an IFC element that corresponds to “concrete floor” in bSDD —> “IfcSlab”

The name of the referenced schema (e.g., bSDD defined according to ISO 12006-3)

The name of the element in the reference schema

<ISO 29481-3 idmXSD>
(4) Derivation of a full valid MVD from individual elements

Concept-based MVD generation algorithm (Lee 2009)

```plaintext
SCHEMA myMVD;
ENTITY IfcRoot
END ENTITY
...
ENTITY IfcSlab
...
END ENTITY
...
END SCHEMA
```
Implementation
System Architecture

- Log In
- IDM Mgt.
- Search Module
- Search List Module
- Recent IDM Module
- Add/Delete IDM Module
- Document Status
- Project Phase
- Language
- Region
- Basic Code Mgt.
- MVD Generation
- idmXML Export
- Basic IO

.NET Framework 4.6.1
C#.NET
Demonstration
(1) Specify information units.
(2) Search an IFC element using a keyword
(3) Search an IFC element using a concept
(4) Generate an MVD
(5) Review the generated MVD.
Thank you.