The Future of IFC:
Rationale and Design of a SEM IFC Layer

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Precast concrete, structural steel, reinforced concrete
Functional Organization:

Addresses the full domain of constructed buildings, components for design, fabrication, operation

Highly Object oriented: inheritance, polymorphism, extensibility

Objectified relationships: attributes on relations

Multiple kinds of geometry

Open-ended kinds of properties: value-based properties
Industry Foundation Classes

Domain Layer
- Building Controls Domain
- Plumbing Fire Protection Domain
- Structural Elements Domain
- Structural Analysis Domain

Interoperability
- HVAC Domain
- Electrical Domain
- Architecture Domain
- Construction Management Domain
- Facilities Mgmt Domain

Core Layer
- Control Extension
- Product Extension
- Process Extension

Resource Layer
- Material Property Resource
- Actor Resource
- DateTime Resource
- External Reference Resource
- Geometric Constraint Resource
- Geometric Model Resource
- Geometry Resource
- Material Resource
- Measure Resource
- Cost Resource
- Profile Resource
- Property Resource
- Quantity Resource
- Representation Resource
- Topology Resource
- Utility Resource
- Presentation Dimension Resource
- Presentation Appearance Resource
- Presentation Definition Resource
- Presentation Organization Resource
- Presentation Resource
- Time Series Resource
- Constraint Resource
- Approval Resource
- Structural Load Resource
- Profile Property Resource
Why is there a need Model Views?

Example Use Cases

- precast engineering
- scheduling
- fabrication

IFC, CIS/2 or others Model Schema

Highly redundant

Schema is a rich set of structures covering most information needed for design, analysis, procurement, fabrication planning and fabrication automation.
What is the National BIM Standard?

We are following and validating the national BIM standard process, defined in:

Draft: January 14, 2008

National Institute of Building Science
BuildingSMART
Federal Facility Council
National Institute of Standards and Technology

Available in:
http://www.facilityinformationcouncil.org/bim/publications.php
Support and Enhance Workflows with Model Views

IDDS Workshop, April 2012
Overview of NBIMS process

Scope of Process Phases

Program: What is the requirement?
- organize domain experts in target area
- determine scope of coverage
- define process model of exchanges
  - specification of exchange requirements by domain experts
  6-10 Months

Design: How to solve the requirements?
- definition of model views as Concepts
- mapping required semantics to schema structures
- define IFC bindings 6-12 months

Construct: How to build it?
- binding to native data models
- verify software implementation
  - develop test model views for each exchange
  6-14 months

Deployment: Use in Industry

Time: 18-36 months
Results to date:

Completed:
- Coordination View (used in IFC Certification process) (0.95)
- COBie – handover for building operations & maintenance (0.9)
- PCI precast Model View (0.75)

Others underway: AISC, ACI, Spie,....

Large ‘mountain’ to climb

Relies on volunteer labor that is difficult to maintain

Results only weakly successful (testing not as strong as other commercial SW efforts)
Model views are full of repetitions:
Same type of geometry used in different places, for different systems; spatial structures are used globally; some components used multiple places: rebar, connection embeds

Repetitive specifications called **IFC Concepts can be re-used in specifying different exchanges**: Re-use model view specifications where possible

ISO-10303 Application Modules **allow re-use of model view specifications** : Can re-use model view specifications where possible
Current Status of Model View BIM Standards:

- Concepts defined incompletely – not general or defined to be re-usable

- Concepts too low level: many can be combined for testing without eliminating flexibility

- Concepts not formally defined so that criteria are applied to their generality or well-formedness

- MVD too time consuming to develop – 18-36 mos. multiple man years

- MVDs are very rigid: satisfactory for contractual pass-offs, poor for collaboration

- Testing is onerous; SW companies will be reluctant to support many MVDs

What is the next step in Model Exchange?
Model views are full of repetitions:
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Re-use model view specifications where possible

ISO-10303 Application Modules allow re-use of model view specifications:
Re-use model view specifications where possible

Module includes implementation of mappings to/from native model; if fully resolved once, need not be tested again: repetitive implementations should be done once and fully tested for re-use in all relevant contexts; allows re-definition of MVDs, ultimately interactively by users.
New form of Concept: Semantic Exchange Module (SEM)

SEM is Concept extended to include both IFC and native bindings; a logical structure above IFC that eliminates “plumbing connection details”; can be implemented to support dynamic composition by users, to define new MVDs for collaborative needs.

If SEMS can be combined and automatically compiled, then the mapping from IDM to MVD can be done interactively, in afternoon.

If SEMS can be tested and certified, then the total effort by SW companies is greatly reduced, because a SEM module need only be implemented & tested once
If re-use of Concepts is to be realized, they need **formal definition** that guarantees their potential re-use and can be defined and implemented widely.

Concept is potentially more than an implementation module; it defines a **semantic unit** to be defined in a model for exchange (identifying user intent and software capability)

Concepts should be **modular**, so that different concepts can be composed for re-use in different constructs without modifying module interfaces.

Concept should be at the **highest level of aggregation** that does not eliminate any re-use case

Concepts are **organized hierarchically**, as an acyclic graph, where some Concepts (like geometry, materials and other properties) qualify existing objects. Generality of implementation encourages a breadth-first implementation
SEMS provide a higher level composition of IFC, that allows definition of translators, provide semantic units of meaningfulness, supports unit testing, and re-use.

800+ IFC entities, plus appx. 800 properties, relations

Variable number of SEMs implemented and tested by each SW company

SEMS can be composed into MVDs by knowledgeable users

Concepts are tested once and validated, not requiring internal testing again
Automated Model Exchanges

Proposed extension of Concept – Implementable Concepts

Structures repeated use in Exchanges in different contexts

Modularity of substructures is used in MVD specification and testing

Includes native model bindings and mappings between public Model View and native model
A Model View is a directed sequence of Elements that incrementally map to the existing IFC structure.

Model Views can be saved, re-used and modified.
IFC would benefit from a clean-up, due to failed earlier specs, evolving best practices. Cleanup is realized by a macro layer above it;

IFC must include a dictionary, backed up by an ontology that will help in the classification of future extensions. If MVDs are to become more than black boxes, then the modules of functionality need to be associated with semantic meaning in the information.

Users should be able to take existing implemented SEMs and restructure them into a new specification – different geometry structure, different levels of assembly, properties, for the collaboration task at hand, in less than an hour.

Higher level set of definitions are learnable by users for specification, are units for unit testing and validation.
## Implementation Template for a SEM

**SEM Object #XX**

/* IFC Methods (prestructured) */
#include IFC Declarations
IFC Read Methods
IFC Write Methods

/* Native Methods Thru API (new) */
#include Native Declarations
Native Read Methods
Native Write Methods

/* Functions linking this structure to existing */
/* function to write or modify YY */

/* Testing Suite for Native Implementation */

**Dictionary** of Implemented SEMs; defining semantics for re-use

### Semantic Exchange Module

- Native Model Binding
- IFC Binding

#### Native Methods
- Support methods
  - IFC to Native
  - Native to IFC

**SEMs are compiled to DDL; are composed and linked into MVD; MVDs are stored for later use or adaptation**

Each SEM can include its own unit test suite

**Need for global namespace management**
Process models will become common in future construction contracts

Contractual deliverables will be specified as Model Views, customized as needed for the project

Collaboration workflows will be facilitated by easy customization of exchanges, possibly defined as needed

SEMS can be used for DB queries as well as specifying an exchange.

Workflows consist of model views and non-model engineering information: RFIs, Change Orders, coordinated parallel changes during virtual Design and Construction as well as during the real thing (tolerance tracking)
Workflows consist of model views and non-model engineering information: RFIs, Change Orders, during virtual Design and Construction as well as during the real thing (tolerance tracking)

**BIM Collaboration Format (BCF):**

Broader range of transactions needed & will be developed

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**Design Review/Assessment:**

XML dataset:
- Unique issue ID
- Screen image with annotation
- Camera placement in project
- Description of issue
- status
- Author/time/application

**Design Authoring Platform:**

Imported XML data:
- List of action Items (can be appended & managed)
- Resolved with editing capability
- Maintains original camera placement in project
- New proposed status
- Author/time/application
What will Interoperability be like in 2030?

- Standard exchanges can be smooth and seamless
- It will be not difficult to compose a new IfcObject (not a new IfcEntity) and compose the Object to reflect a new object type
- New exchange definition will be similar in difficulty to setting up a webpage, or forms-based Word document.
- Many services will be provided by subscription on cloud servers (with reasonable security)
- Cloud servers will become a major AEC technology.
- Many BIM/VDC applications, for authoring design data, running analyses, scheduling, etc. will be cloud based
- High level query systems for accessing desired objects are needed and will have two levels: classes desired, then instances
Thank you