BIM standards: IFC and Co.

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02.12.2019

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I

STEP

Standard for the Exchange of Product model data

History

- 1984: STEP replaces IGES
- 1994/95: ISO 10303 *Automation systems and integration — Product data representation and exchange*

Selected series of parts

- ISO 10303-1x: Conceptual modelling
- ISO 10303-2x: Implementation methods
- ISO 10303-4x: Geometric representation
- ISO 10303-2xx: Application protocols

Selected parts of ISO 10303

ISO 10303-11: EXPRESS

Description methods: The EXPRESS language reference manual

ISO 10303-21: STEP physical file

Clear Text Encoding of the Exchange Structure

ISO 103030-42: Geometry and topology

Integrated generic resources: Geometric and topological representation

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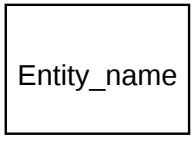
ISO 10303-11: EXPRESS

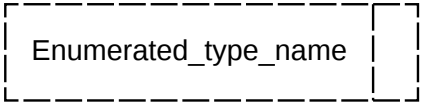
Description methods: The EXPRESS language reference manual

- part of ISO 10303-1x series: Conceptual modelling
- data type definitions
- structural constraints
- algorithmic rules
- graphical version EXPRESS-G

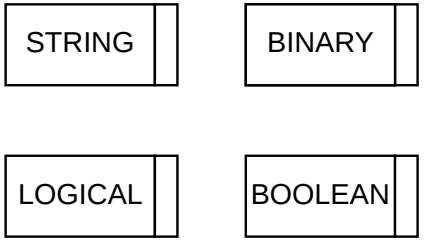
EXPRESS-G Data type symbols

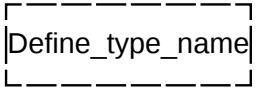


Entity Data Type Symbol
(A)

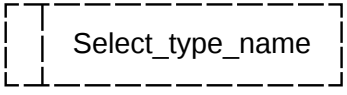


Enumerated Data Type Symbol
(B)





Defined Data Type Symbol
(C)



Select Data Type Symbol
(D)

Simple Data Type Symbols
(D)

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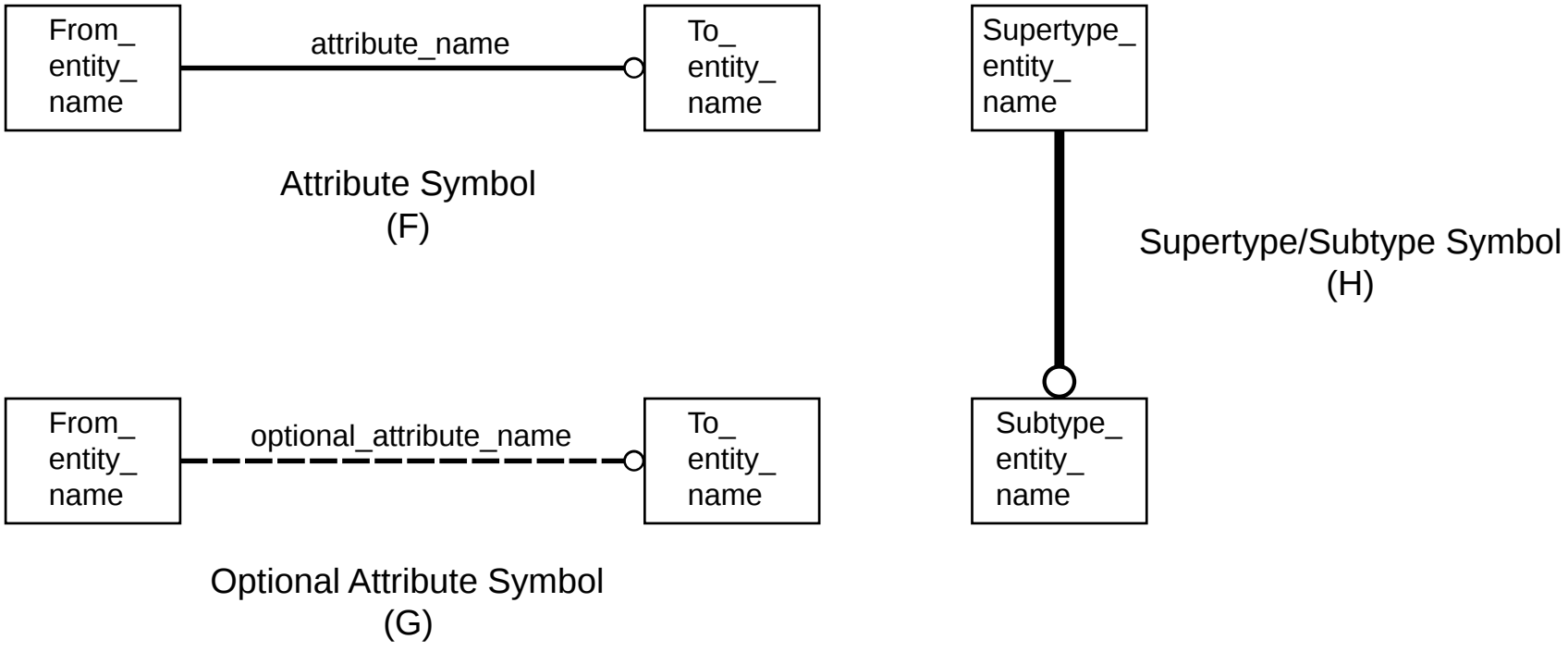
EXPRESS-G Attribute symbols



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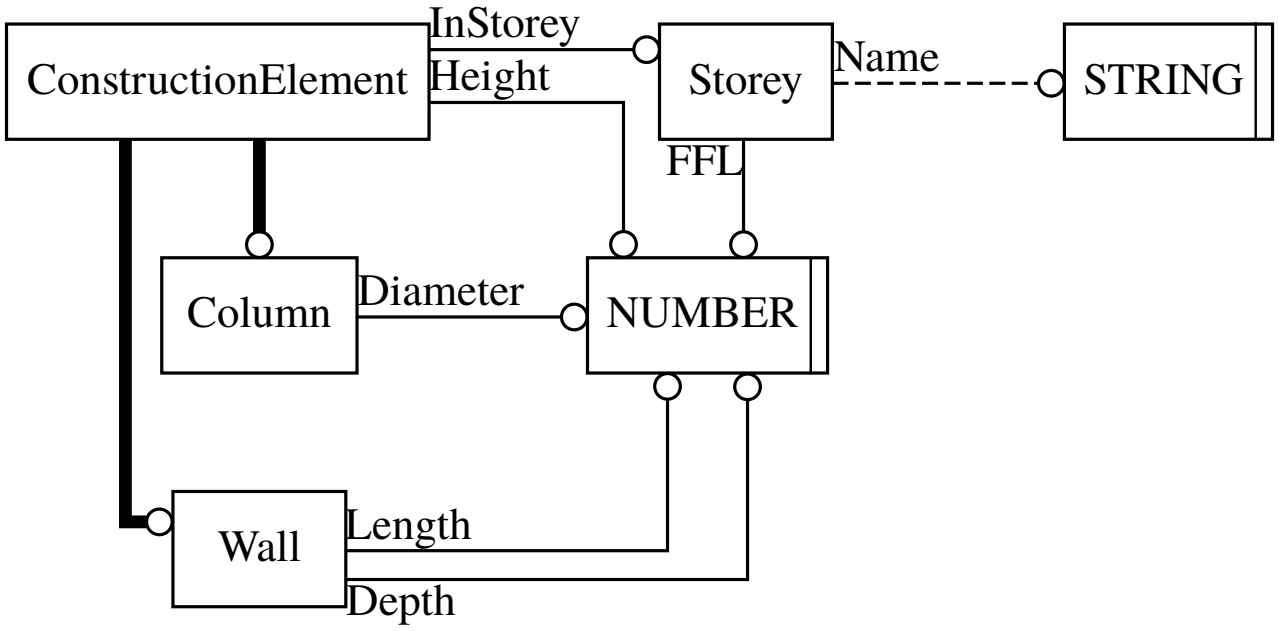
EXPRESS-G CustomBIM Example



EXPRESS Structure

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```
SCHEMA CustomBIM;

ENTITY ConstructionElement;
   ...
END_ENTITY;

ENTITY Storey;
   ...
END_ENTITY;
```

```
ENTITY Wall;
   ...
END_ENTITY;

ENTITY Column;
   ...
END_ENTITY;

END_SCHEMA;
```

EXPRESS CustomBIM example


```
ENTITY ConstructionElement
  ABSTRACT SUPERTYPE;
    InStorey: Storey;
    Height: NUMBER;
END_ENTITY;

ENTITY Wall
  SUBTYPE OF (ConstructionElement);
    Depth: NUMBER;
    Length: NUMBER;
END_ENTITY;

ENTITY Column
  SUBTYPE of (ConstructionElement);
    Diameter: NUMBER;
END_ENTITY;
```

```
ENTITY Storey;
    Name: OPTIONAL STRING;
    FFL: NUMBER;
END_ENTITY;
```

Aggregation types

	type	ordered	duplicates	all values defined
S	set	-	-	+
B	bag	-	+	+
L	list	+	+	+
A	array	+	+	-

Cardinality range constraints

- Simple attributes: cardinality `[1:1]`
- Optional attributes: cardinality `[0:1]`
- Aggregation attributes: cardinality `[p:q]` with $q > 1$ and $0 <= p <= q$

EXPRESS inverses


```
ENTITY ConstructionElement;
    InStorey: Storey;
END_ENTITY;

ENTITY Storey;
INVERSE
    ContainsElements: SET[1:?] OF ConstructionElement
                                  FOR InStorey;
END_ENTITY;
```

Domain rules

```
ENTITY Wall
  SUBTYPE OF (ConstructionElement);
    Depth: NUMBER;
    Length: NUMBER;
  WHERE
    Flat: Depth < 5*Length AND
          SELF\ConstructionElement.Height < 5*Length;
END_ENTITY;
```

Functions

- declaration in schema, call in expressions
- e.g. in rules and derived types

Selected parts of ISO 10303

ISO 10303-11: EXPRESS

Description methods: The EXPRESS language reference manual

ISO 10303-21: STEP physical file

Clear Text Encoding of the Exchange Structure

ISO 103030-42: Geometry and topology

Integrated generic resources: Geometric and topological representation

ISO 10303-21: STEP physical file

Clear Text Encoding of the Exchange Structure

- 10303-2x series: Implementation methods
- ASCII data format
- human-readable
- very compact

Structure and header of a STEP file


```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION('Example file','');
FILE_NAME('example.building','2019-05-23T10:20:07',
        ('Helga Tauscher'),('HTW'), '','Linux', '');
FILE_SCHEMA(('CustomBIM'));
ENDSEC;
DATA;
...
ENDSEC;
END-ISO-10303-21;
```

DATA section of a STEP file

List of entities, speparated by semicolon

```
#1234=ENTITYTYPE('foo',0.5,.TRUE.,$,#5,(#6,#7,#8));
```

- `#1234`: number of entity, document-wide unique
- `ENTITYTYPE`: type of entity
- `'foo'`: simple attribute value of type STRING
- `0.5`: simple attribute value of type REAL
- `.TRUE.`: simple attribute value of type BOOLEAN
- `$`: undefined attribute value
- `#5`: relation attribute
- `(#6,#7,#8)`: relation attribute with aggregate type

CustomBIM example


```
#1=STOREY('Ground floor',20);
#2=WALL(#1,320,30,400);
#3=WALL(#1,320,30,500);
#4=WALL(#1,320,15,400);
#5=WALL(#1,320,15,500);
#6=COLUMN(#1,320,20);
#7=STOREY('First floor',360);
#8=WALL(#7,320,30,400);
#9=WALL(#7,320,30,500);
#10=WALL(#7,320,15,400);
#11=WALL(#7,320,15,500);
#12=COLUMN(#7,320,20);
...
```

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Clear Text Encoding of the Exchange Structure

ISO 103030-42: Geometry and topology

Integrated generic resources: Geometric and topological representation

Constructive Solid geometry (CSG):

- Boolean operations
- primitives
- swept solids
- half-space solids

Boundary Representation (BREP)

- shells, faces, loops, edges, vertizes (integrity checks)
- faceted version with planar faces and poly loops

Geometry and topology resources

- geometry: parametric curves and surfaces
- topology: mainly for boundary representation

II

IFC

IFC history

Industry Foundation Classes

- 1994/95 Industry consortium lead by AutoDesk
  Industry Alliance for Interoperability (IAI)
- 1996 IFC1.0
- 1997 International Alliance for Interoperability
- releases every 1-2 years: IFC1.5, IFC2.0, IFC2x, IFC2x2
- 2005 IFC2x3
- 2005 buildingSMART
- 2007 IFC2x3 TC1
- 2013 IFC4, ISO 16739

IFC STEP file header


```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION('ArchiCAD 9.00','Build 63006'),'2;1');
FILE_NAME('AC90R1-niedriha-V2-2x3.ifc','2006-01-27T16:20:07'
FILE_SCHEMA(('IFC2x3'));
ENDSEC;
DATA;
...
ENDSEC;
END-ISO-10303-21;
```

IFC in EXPRESS-G und EXPRESS

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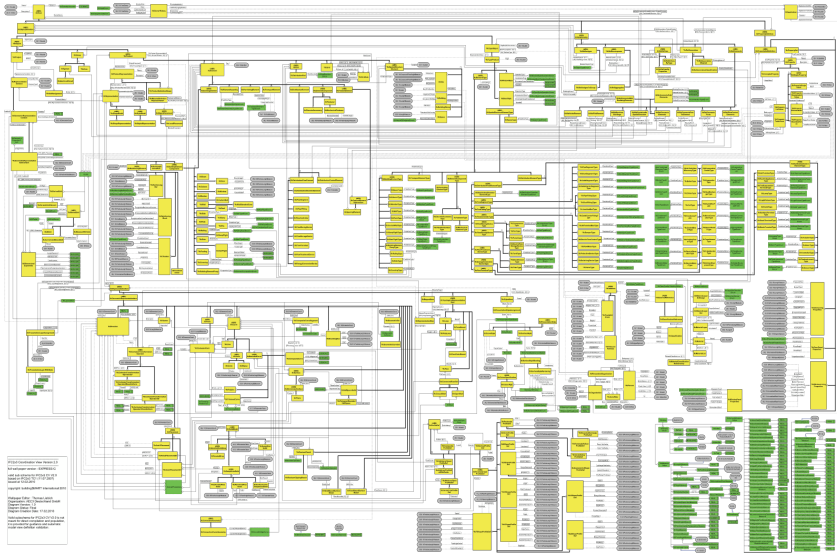
Type definitions in IFC4

- 130 defined types
- 207 enumeration types
- 60 select types
- 776 entity types

Other

- 47 functions
- 2 global rules
- 448 local rules



IFC2x3 “Wall paper”
Full IFC4 specification

IFC in EXPRESS-G

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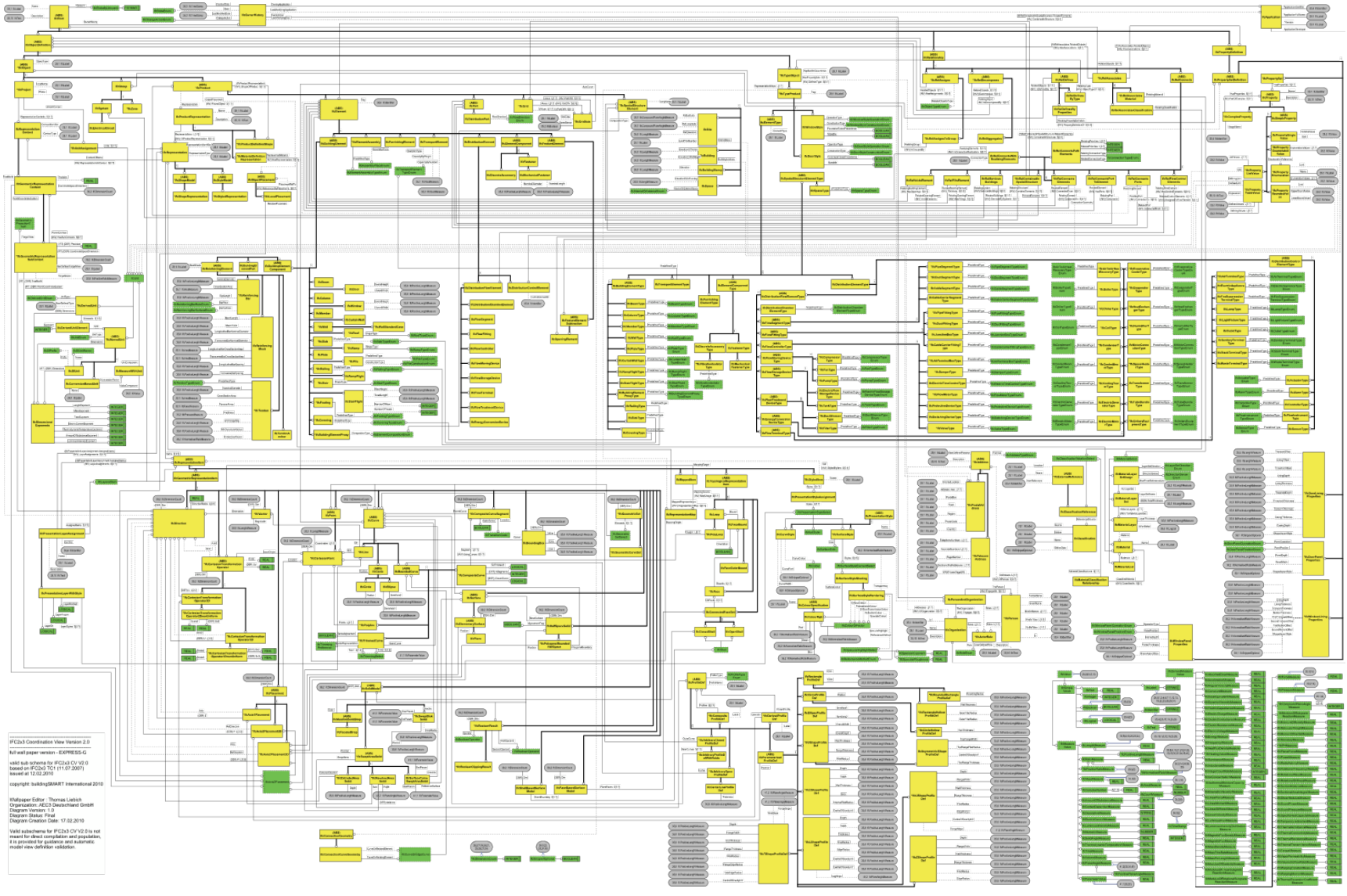
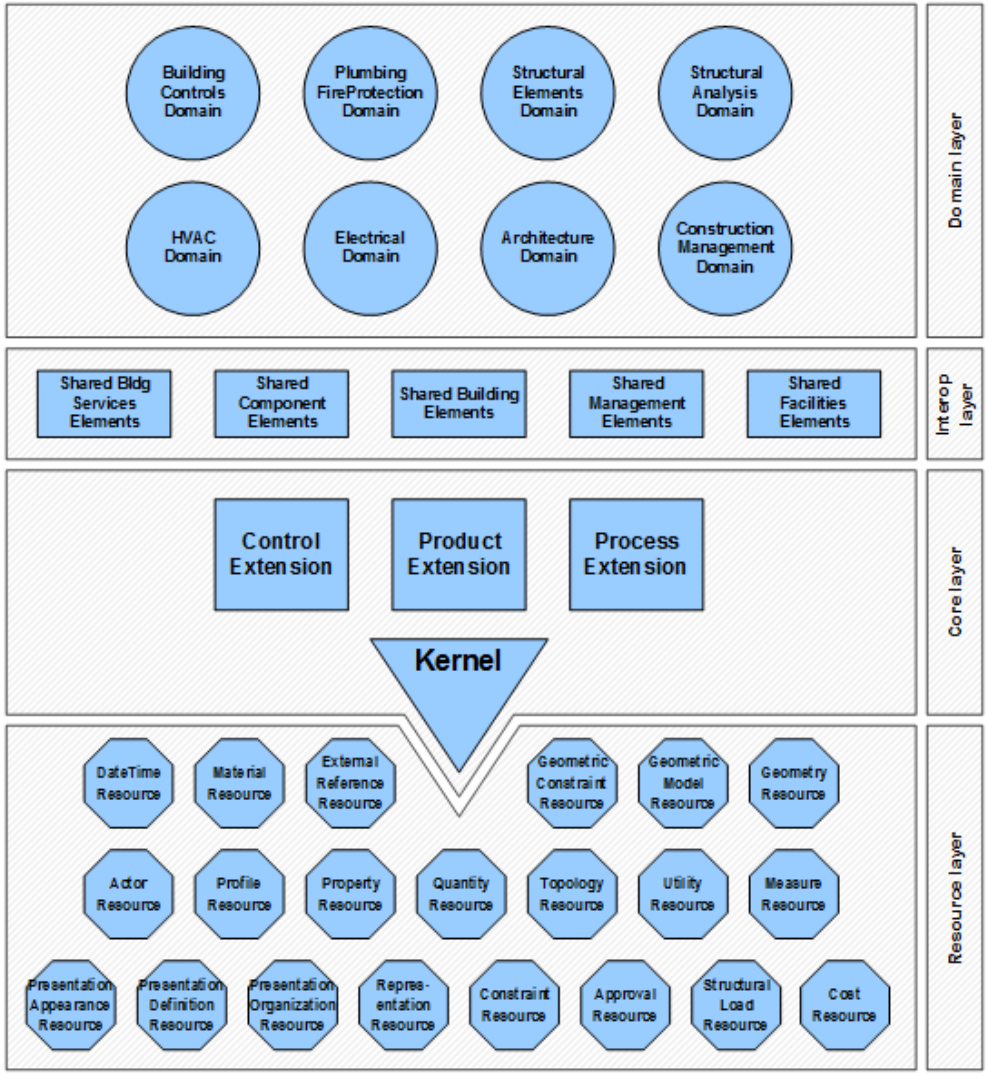


Layers

- Domain layer
- Interoperability layer
- Core layer
- Resource layer



Source: https://standards.buildingsmart.org

IfcRoot

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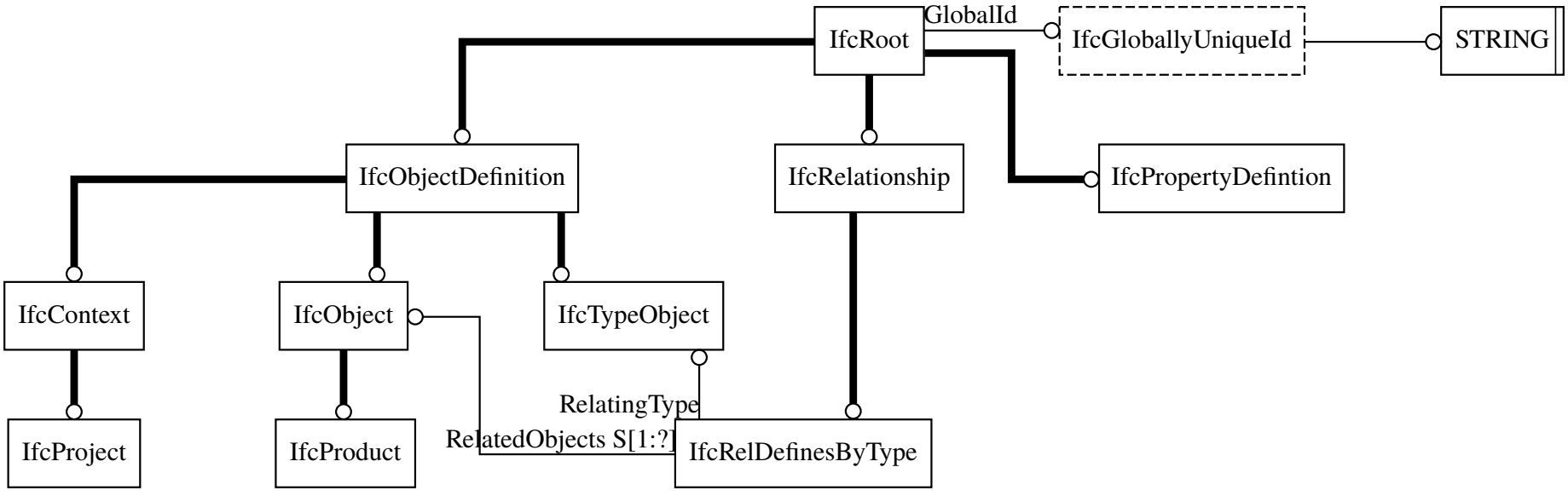
Base type for entity types in kernel and higher layers

- IfcObjectDefinition: semantically relevant things or processes
- IfcPropertyDefinition: groups of characteristic properties
- IfcRelationship: objectified relationship

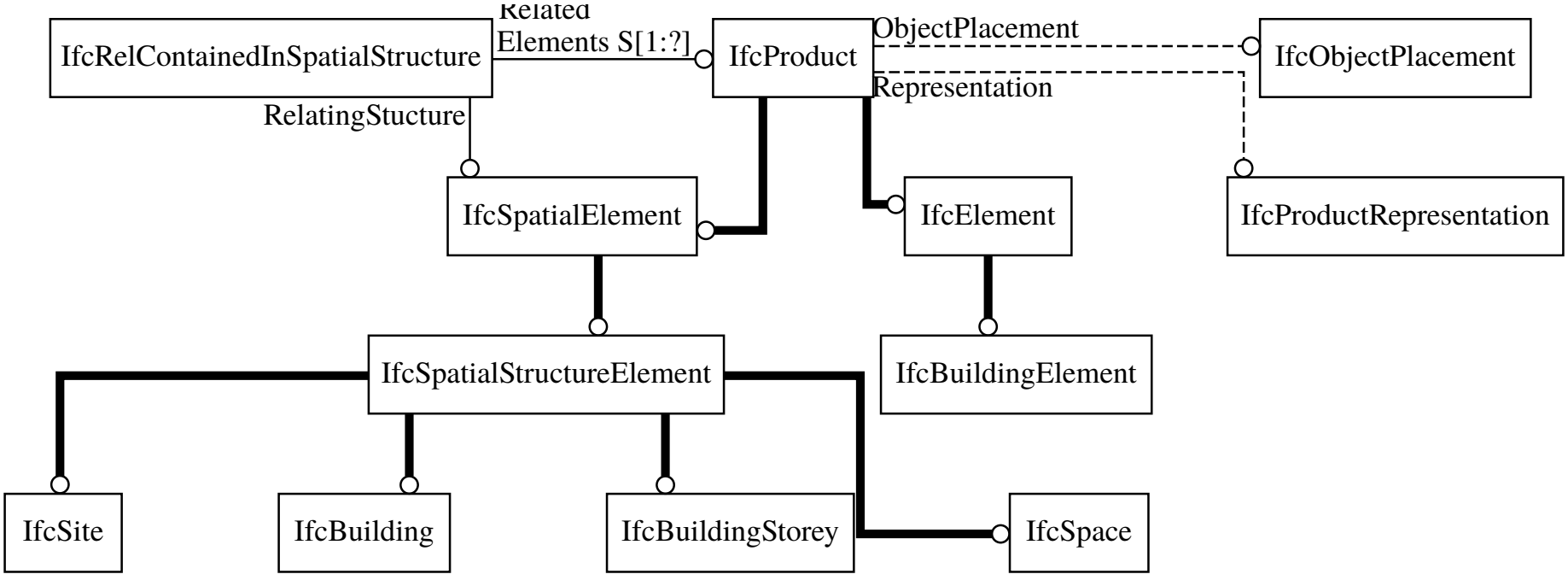


IfcRoot in IFC4

IfcProduct

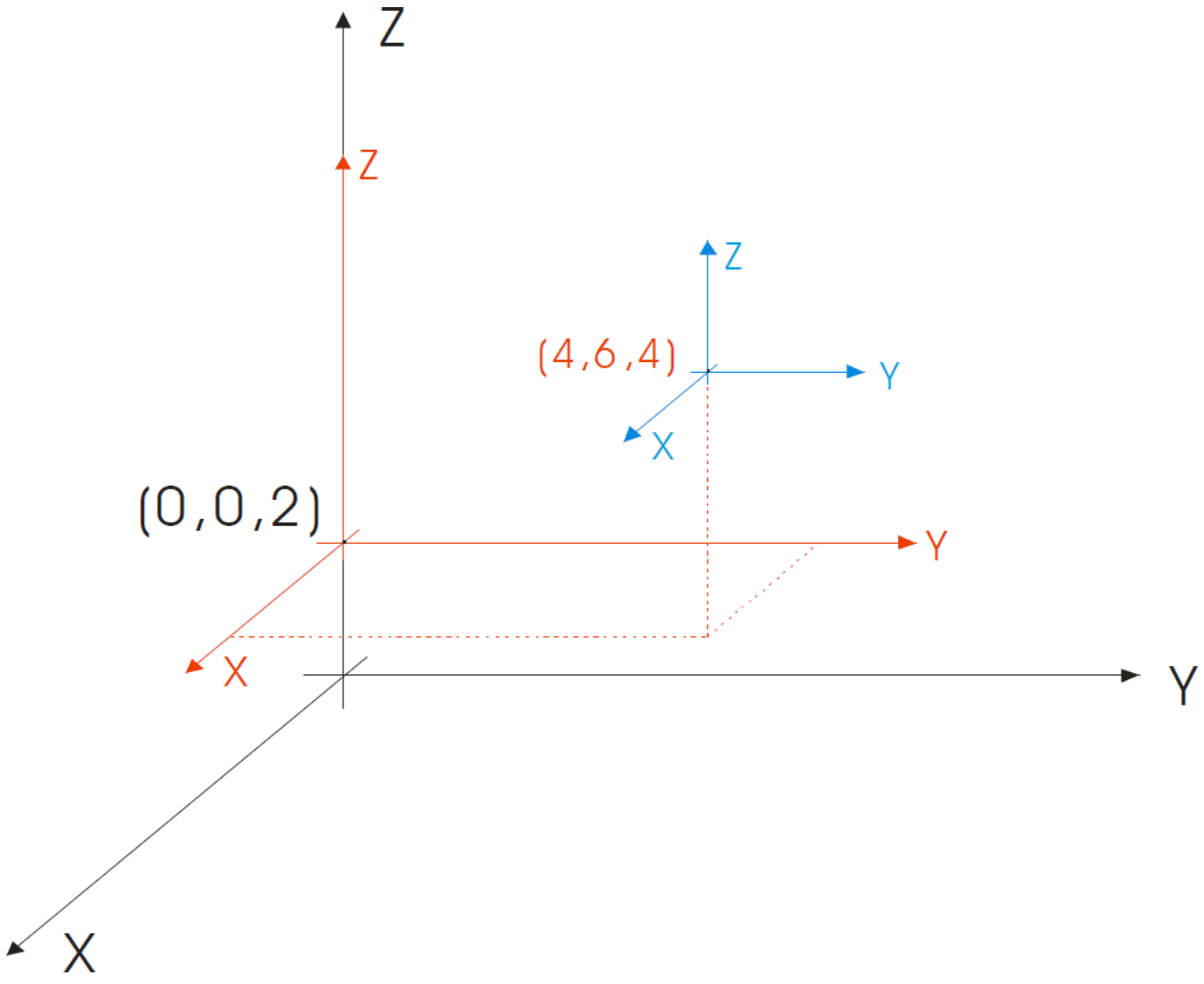
Objects with geometric or spatial context and representation

- IfcElement: physical element
- IfcSpatialElement: spatial structures or zones
- …



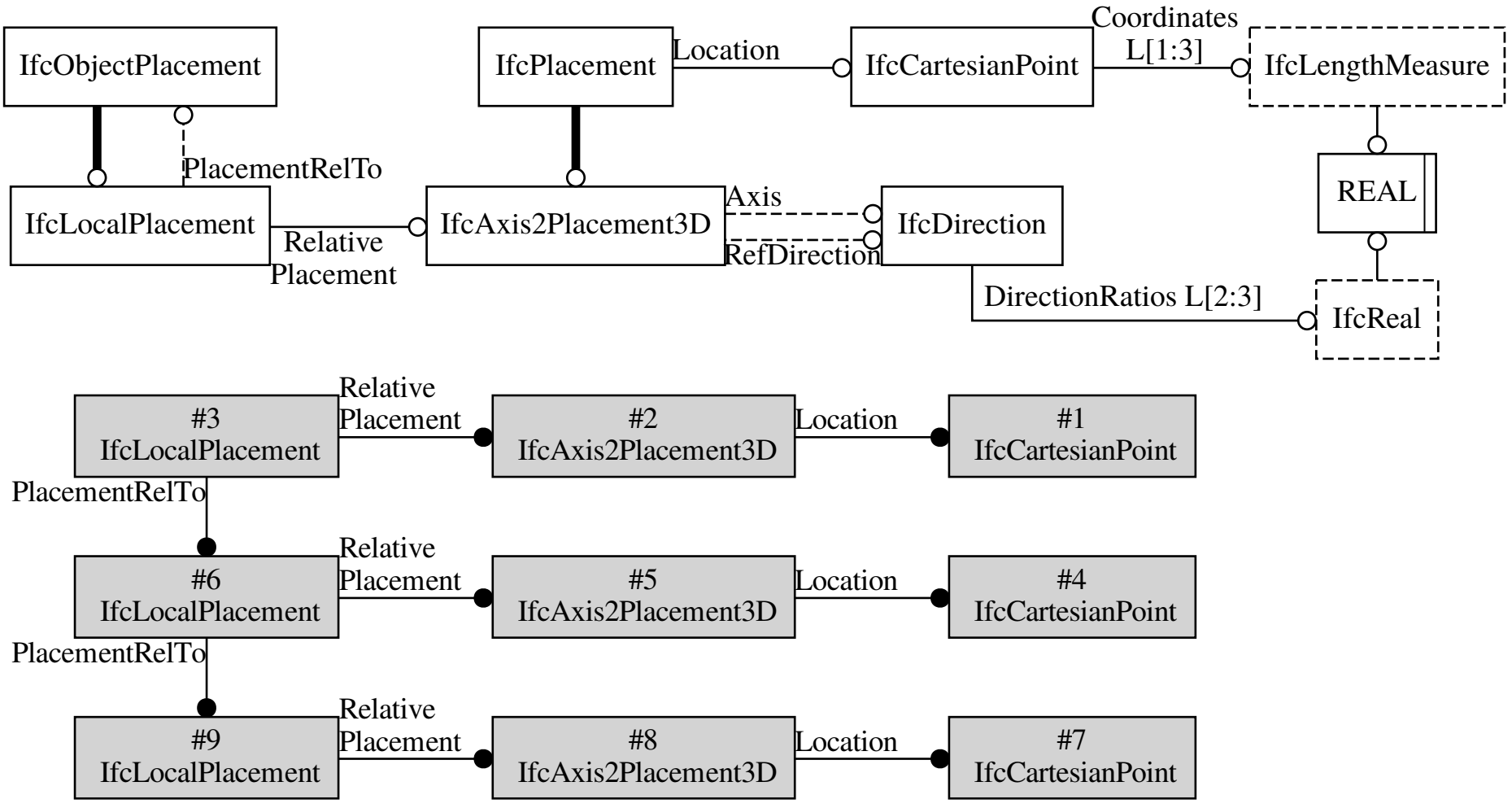
IfcProduct in IFC4, IfcSpatialStructureElement in IFC4, IfcBuildingElement in IFC4

Platzierung und Koordinatensysteme

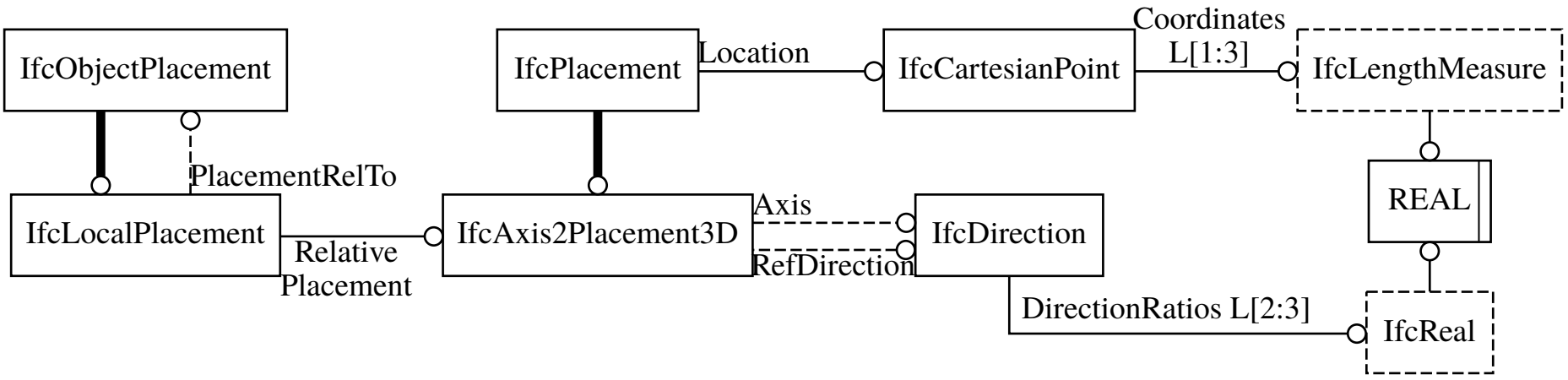


Courtesy Christian Clemen

Placement

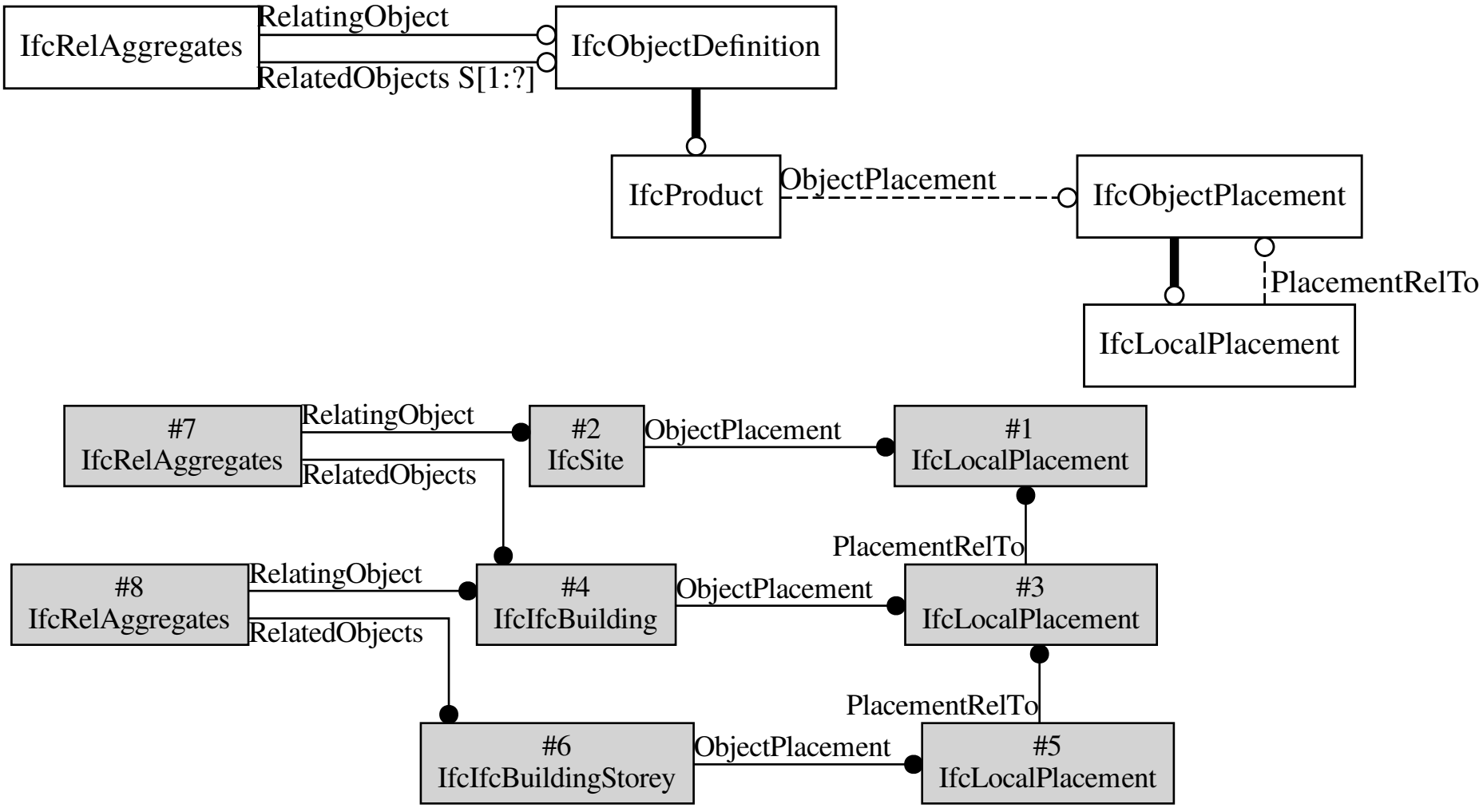

IfcObjectPlacement
PlacementRelTo
IfcLocalPlacement
Relative Placement
IfcAxis2Placement3D
IfcPlacement
Location
IfcCartesianPoint
Coordinates L[1:3]
IfcLengthMeasure
REAL
Axis
RefDirection
IfcDirection
DirectionRatios L[2:3]
IfcReal
#3 IfcLocalPlacement
Relative Placement
#2 IfcAxis2Placement3D
Location
#1 IfcCartesianPoint
PlacementRelTo
#6 IfcLocalPlacement
Relative Placement
#5 IfcAxis2Placement3D
Location
#4 IfcCartesianPoint
PlacementRelTo
#9 IfcLocalPlacement
Relative Placement
#8 IfcAxis2Placement3D
Location
#7 IfcCartesianPoint

Placement




```
#1 = IFCCARTESIANPOINT((0., 0., 0.));
#2 = IFCAXIS2PLACEMENT3D(#1, $, $);
#3 = IFCLOCALPLACEMENT($, #2);
#4 = IFCCARTESIANPOINT((400., 200., 0.));
#5 = IFCAXIS2PLACEMENT3D(#4, $, $);
#6 = IFCLOCALPLACEMENT(#3, #5);
#7 = IFCCARTESIANPOINT((0., 0., 300.));
#8 = IFCAXIS2PLACEMENT3D(#7, $, $);
#9 = IFCLOCALPLACEMENT(#6, #8);
```

Spatial structure



IfcProductRepresentation / IfcProductDefinitionShape

- Representations
  Each representation defines a valid representation of a particular type within a particular representation context.

IfcRepresentation / IfcShapeModel

- ContextOfItems
- Items

IfcRepresentationContext / IfcGeometricRepresentationContext

- CoordinateSpaceDimension
- Precision
- WorldCoordinateSystem
- TrueNorth

Property and quantity sets

IfcProperty

- IfcComplexProperty
- IfcSimpleProperty, e.g. IfcPropertySingleValue

IfcPhysicalQuantity

- IfcPhysicalComplexQuantity
- IfcPhysicalSimpleQuantity, e.g. IfcQuantityVolume

Properties and quantities in IFC4:

- 1722 individual properties
- 420 property sets
- 93 quantity sets

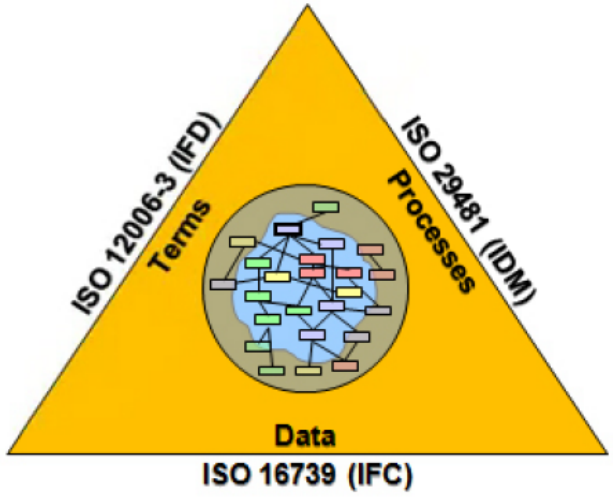
Property and quantity sets


```
#1 = IFCPROPERTYSET('1lZ4zPst55PhFcUG69u5jM',
     $, 'Pset_WindowCommon', $, (#2,#3,#4,#5,#6,#7));
#2 = IFCPROPERTYSINGLEVALUE('FireRating',
     $, IFCLABEL('F30'), $);
#3 = IFCPROPERTYSINGLEVALUE('IsExternal',
     $, IFCBOOLEAN(.T.), $);
#4 = IFCPROPERTYSINGLEVALUE('Infiltration',
     $, IFCVOLUMETRICFLOWRATEMEASURE(3.E-1), $);
#5 = IFCPROPERTYSINGLEVALUE('ThermalTransmittance',
     $, IFCTHERMALTRANSMITTANCEMEASURE(2.4E-1), $);
#6 = IFCPROPERTYSINGLEVALUE('GlazingAreaFraction',
     $, IFCPOSITIVERATIOMEASURE(7.E-1), $);
#7 = IFCPROPERTYSINGLEVALUE('SmokeStop',
     $, IFCBOOLEAN(.F.), $);
```

III

More buildingsmart standards and certification

More buildingsmart ISO standards



- ISO 16739 - Industry Foundation Classes
- ISO 12006-3 - International Framework for Dictionaries
- ISO 29481 - Information Delivery Manual

IDM

Information Delivery Manuals (IDM) describe processes and information flow during the lifecycle of a facility. Processes during planning, execution and operation are analysed and broken into steps. Exchange Requirements (ER) are derived from the information needed and generated during these process steps.

- informal specification
- Business Process Model Notation (BPMN)

IDM > ER > MVD

An IFC View Definition, or Model View Definition (MVD) defines a subset of the IFC schema, that is needed to satisfy one or many Exchange Requirements (ER) of the AEC industry.

- formal specification
- XML format

IDM > ER > MVD

MVDs defined for IFC2x3

- Coordination View
- Structural Analysis View
- Basic FM Handover View

MVDs defined for IFC4

- Reference View
- Design Transfer View

Certification 1

buildingSMART International home of openBIM

About Standards Compliance Chapters

Certified Software

Home Page > Compliance > Certified Software

Vendor	Application	Certification	Type	Date	Download
NEMETSCHEK Scia	Scia Engineer	CV2.0	import	2013/09/17	PDF
GRAPHISOFT	ArchiCAD	CV2.0	import	2013/09/20	PDF
Solideo Systems	ArchiBIM Server	CV2.0	import	2014/04/22	PDF
NEMETSCHEK Allplan GmbH	Allplan	CV2.0	import	2014/05/07	PDF
Autodesk-A	AutoCAD Architecture	CV2.0-Arch	export	2015/02/24	PDF
Autodesk-R	Autodesk Revit MEP	CV2.0-MEP	export	2013/07/11	PDF
Data Design System	DDS-CAD MEP	CV2.0-MEP	export	2014/09/10	PDF
RIB	RIB iTWO	CV2.0	import	2013/09/07	PDF
Trimble Germany GmbH	Plancal nova	CV2.0-MEP	export	2014/10/31	PDF
Autodesk-R	Autodesk Revit MEP	CV2.0	import	2015/07/26	PDF
Autodesk-R	Autodesk Revit Structure	CV2.0	import	2015/07/26	PDF
Tekla	Tekla Structures	CV2.0	import	2013/10/09	PDF

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Certification 2

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Testlist

Name test	concepts total	manually checked		
Beam_02 / 2x3	12	7	2	1
CharsetTest-01A / 2x3	2	2		
Column 01 / 2x3	11	7	2	2
CoveringFurnishing-01 / 2x3	57	17	5	34
CurtainWall-01 / 2x3	29	9	1	18
Door 01 / 2x3	22	7	2	13
Grid 01 / 2x3				11
Member_01S / 2x3	10	4	2	3
Pile 01 / 2x3	19	8	2	7
PlateFastener-01 / 2x3	67	25	4	35
RampRailing-01 / 2x3	28	11	4	11
RandomArch-X2 AC16 / 2x3	12	5	3	4
RandomMEP-X2 BENCH / 2x3	21	4		7
RandomStruc-X2 TS / 2x3	9	5	2	2
RandomStruc-X3 RST / 2x3	8	5	2	1
RandomStruc-X5 RST / 2x3	26	13	6	7
Reinforcement-01 / 2x3	94	38	6	36
Roof 01 / 2x3	15	5	1	5

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Certification 3

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105 IfcSlab	company statement	
020 Placement		
020-2 Placement Relative	■	
030 Geometry		
030-6 Geometry Body		
030-6-1 Geometry SweptSolid	■	
120 Spatial Containment	■	
403 IfcFooting	company statement	
010 Naming	■	Each element has to have a unique name in Scia Engineer. If in IFC file two or more entities have identical name, only the first one is imported with the name and the others are imported with the name + number.
030 Geometry		
030-6 Geometry Body		
030-6-1 Geometry SweptSolid	■	
040 Presentation		
040-1 Geometric Presentation	■	Import of Geometric Presentation is not supported. Scia Engineer does not support individual colours for each separate element.
050 CAD Layer	■	
120 Spatial Containment	■	

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