UNVEILING IFC2X4 - THE NEXT GENERATION OF OPENBIM

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ABSTRACT

The Industry Foundation Classes (IFC) are the only comprehensive, open and truly international standard to describe all major facets of building information. Development started back in 1996 with the release IFC1.0 and in 2005 the current and widely used release IFC2x3 has been published. IFC2x3 represents a quality assured and improved makeover of the previous IFC2x2 release completed in 2003. Meanwhile the longest and most intensive work to define a new IFC release that has been undertaken by buildingSMART. It now comes to an end. The upcoming IFC2x4 release, scheduled for final publication by end of 2010, is the first major enhancement release since 6 years and extends the capabilities of the IFC schemas into new areas of high demand, like GIS connection, 4D and 5D models, thermal simulations, environmental impact, base quantities, and many others. The completion of the building and building service element catalogs for design, commissioning and facility management had been another important task.

The main focus of the paper is to highlight what had been achieved so far with IFC based interoperability, where the current IFC schema had limitations and how the upcoming IFC2x4 release addresses those. IFC2x4 will be presented as an enabler for openBIM collaborative work; both for the research community and for the construction industry within the coming years.

Keywords: BIM, openBIM, IFC, standardization

1. INTRODUCTION

The Industry Foundation Classes (IFC) are the only comprehensive international standard for exchanging and sharing complex building information models BIM. It is developed by buildingSMART International, a global alliance of regional buildingSMART chapters, each devoted to promote smarter ways of working using building information modeling as a new paradigm combined with the use of standards within the collaboration processes of the construction and facility management industry sector.

The IFC specification is developed by the sub-committee of buildingSMART International, the Model Support Group (MSG). The primary goal is to develop and maintain IFC as the open international standard for open Building Information Modeling openBIM. The development work executed by MSG includes (1) maintaining existing specifications, (2) utilizing existing specifications, for example by creating Model View Definitions (MVD) as the subset of IFC to be implemented by software and optionally to be certified by buildingSMART, and (3) developing further major and minor releases of the IFC specification.

A major release introduces new content into the IFC specification in order to support new exchange requirements of business processes within the scope of the whole building life cycle, or significant improvements to stabilize current scope. A minor release is restricted to improve the current scope, mainly by bug fixing and documentation improvements. The IFC Release 2x Edition 4, short IFC2x4, is the next major release publication. Since the previous major release IFC2x3 had been predominately a stability release and since the IFC2x4 developments started in parallel in 2004 the new IFC2x4 reflects the first major extension of the IFC data schema for a long time.

Whereas in industry most IFC implementations support the main part of the 3D BIM core section of IFC, formalized as MVD "coordination view", others, and also many prototypes in the Research & Development

community, look into utilizing the additional sections of IFC dealing with scheduling, quantity take-off, cost estimates, or environmental impact - to mention a few.

While the core section of IFC, the building element breakdown, the spatial structure and the shape representations are now considered to be well established and stable, those additional parts had to be analyzed for necessary improvements. This, and the incorporation of new content submitted by recent buildingSMART IFC extension projects, form the basis for IFC2x4.

2. HISTORY

The development of IFC started back in 1996 with the release IFC1.0. It was only used in prototypes and helped to get first experiences to produce the stability release IFC1.5, a minor update, IFC1.5.1 had then been the first IFC release with commercial implementations. The scope was mainly the architectural part of a building model. Meanwhile the next release, IFC2.0 had been developed with support for several new exchange requirements, including a first schema for building services, cost estimation, and construction planning.

At the same time fundamental architectural issues with the structure, modularity and extensibility of the IFC schema had been discovered that led to a significant rework and finally to the platform release IFC2x. Regarding scope IFC2x can be considered a stability release with only minor scope increase. The core parts of IFC had been combined into a stable core that had been submitted to ISO for acceptance as a Publicly Available Specification (PAS). In 2005 the stable core of IFC2x obtained the ISO/PAS16739 number.

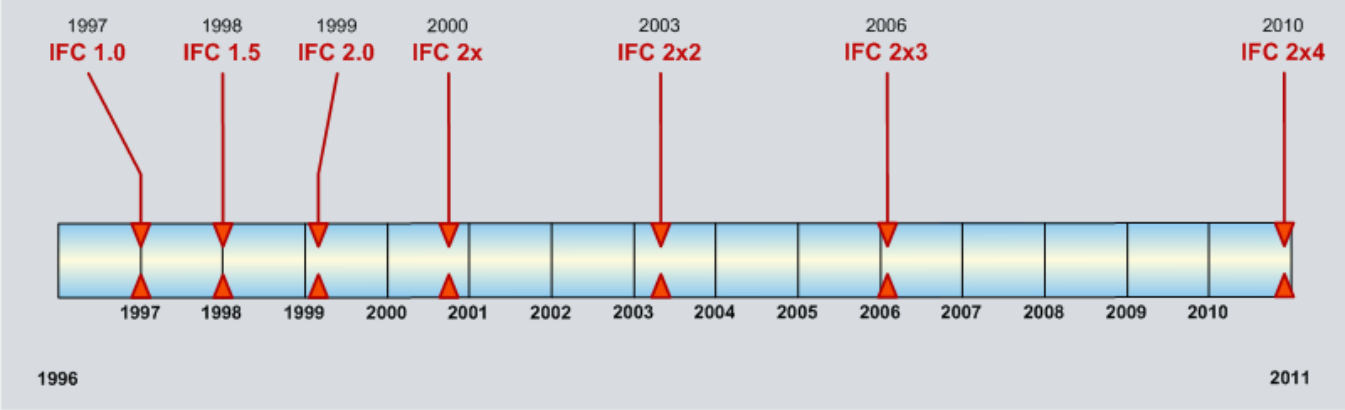

Figure 1: Publication dates of IFC releases

The next larger extension in scope had been realized with IFC2x2 published in 2003. Among the new schema extensions there had been 2D model space geometry, presentation (color, shading, hatching, etc.), extension of the building service component breakdown, structural analysis (loads, analysis model), structural detailing, support for building code checking and facility management. The extensions had been the final result of an IFC extension project framework formalized as part of the IFC2x platform development process.

During the pilot implementation program to realize support for IFC2x2 in commercial application several shortcomings became obvious. The relative short time frame of 2 1/2 year to achieve such a significant scope increase as it had been accomplished with IFC2x2 did not allow for the necessary feedback and prototype development work to validate all new concepts. Therefore the decision had been made to put the next schema extensions on hold and to concentrate on another stability release. The result had been IFC2x3 published in 2006. This release has been the first also commercially successful release of IFC with implementations in over 100 different software application (status Aug 2010).

Table 1: Release cycle of IFC with schema name, main achievements and major changes and publication date. The duration shows the development time and the main purpose the development goals.

Release	Schema name [1]	main achievements	duration	published	main purpose
1.0	note [2]	initial scope and technology proof of concept	1 year	Jan 1997	initial release
1.5	IFC150FINAL	initial 4-tiers IFC schema architecture, introduction of property set concept	1 year	Dec 1997	rework of early proof of concept
1.5.1	IFC151	bug fixes and improvements, first hyperlinked specification	<1 year	Sep 1998	stability release
2.0	IFC20_LONGFORM	major extension of scope, fully attributed view (and other improved documentation)	>1 year	May 1999	scope extension
2x	IFC2X_FINAL	major rework for modularity, new documentation format, first ifcXML schema in XSD	1 1/2 year	Oct 2000	stability release
2x add1	IFC2X_FINAL	minor bug-fixes and documentation improvements, submitted to ISO as ISO/PAS16739	-	Oct 2001	minor corrections
2x2	IFC2X2_FINAL	major extension of scope, first ISO compliant ifcXML schema in XSD	2 1/2 year	May 2003	scope extension
2x2 add1	IFC2X2_FINAL	minor bug-fixes and documentation improvements	-	Jul 2004	minor corrections
2x3	IFC2X3	stability and improvements, better implementation guidance	2 1/2 year	Feb 2006	stability release
2x3 TC1	IFC2X3	minor bug-fixes and documentation improvements	-	Jul 2007	minor corrections
2x4	IFC2X4	extension of scope, refinement of IFC2x platform by implementation experience, will be submitted to ISO as ISO16739	4 1/2 year	note [3]	moderate scope extension improved efficiency

Notes on the table 1: (1) Schema name in the IFC exchange file header; (2) There were no direct implementations of IFC1.0, the first public prototypes had been shown at the ACS show in Frankfurt, Germany in Nov 1996 based on IFC0.96. The schema name had been IFC_CORE_PI_ACS; (3) expected to be published Dec 2010 by buildingSMART, publication of ISO16739 expected in 2011 depending on the results of the ISO balloting process

Whereas the first releases, IFC151 and IFC2.0 (and also partly IFC2x) were mainly used in research and development and some early pilots, the interest and need for having an open BIM interface has increased since around 2005 in parallel with the broader acceptance on BIM in general (Gudgel 2007). Several public building clients, such as GSA in USA, Senate properties in Finland, and Statsbygg in Norway, stepped in and demand submission of building models for some processes in an open IFC format (GSA, Senate, Statsbygg 2010). The report on costs of inadequate interoperability (Gallaher et al. 2004) also highlighted the need for standards throughout the life cycle processes of buildings. As a direct result interest in IFC increased and with IFC2x3 coordination view a major breakthrough had been achieved. Numerous software applications now provide an IFC2x3 coordination view interface.

In real projects, under real conditions of project complexity, availability of software, the quality of IFC interfaces implemented, and user experience and knowledge, some of the ideal solutions of interoperability cannot yet been achieved. This issue needs to be addressed at different levels:

- easier to use for end users (simple user interface, guidelines, help files)
- achieve higher quality of software implementation (new certification procedure, more market demand)
- better implementation guideline by model view definitions, better examples of the IFC specification
- improvement of the IFC specification and its documentation format itself

All of these levels are currently addressed by buildingSMART.

- Issue 1 is in the focus of the Information Delivery Manual (IDM) developments, currently registered as ISO/DIS 29481-1. The main focus here is the creation of formal Exchange Requirements ER. Even more practical the initiative to harmonize IFC import/export user interfaces should help practitioners to understand the proper usage of IFC to support different work flows,
- Issue 2 is the main focus of the new IFC certification 2.0 procedure (buildingSMART 2010) that increases the rigidness and robustness of IFC certifications
- Issue 3 is targeted by the Model View Definition framework and the work on the "IFC2x3 Coordination View Version 2.0" (buildingSMART 2010, and
- Issue 4 as part of the objectives for the next IFC release.

The paper concentrates only on this latter part.

3. OBJECTIVES

The first objective for the development process of IFC2x4 has been "to put quality over speed". It allows the industry the time and stability to first embrace the current IFC2x3 baseline. At the same time it gives sufficient time to the IFC development team and all supporting groups to both introduce and validate the new concepts. All together IFC2x4 marks the longest development cycle and review period in IFC history (figure 2).

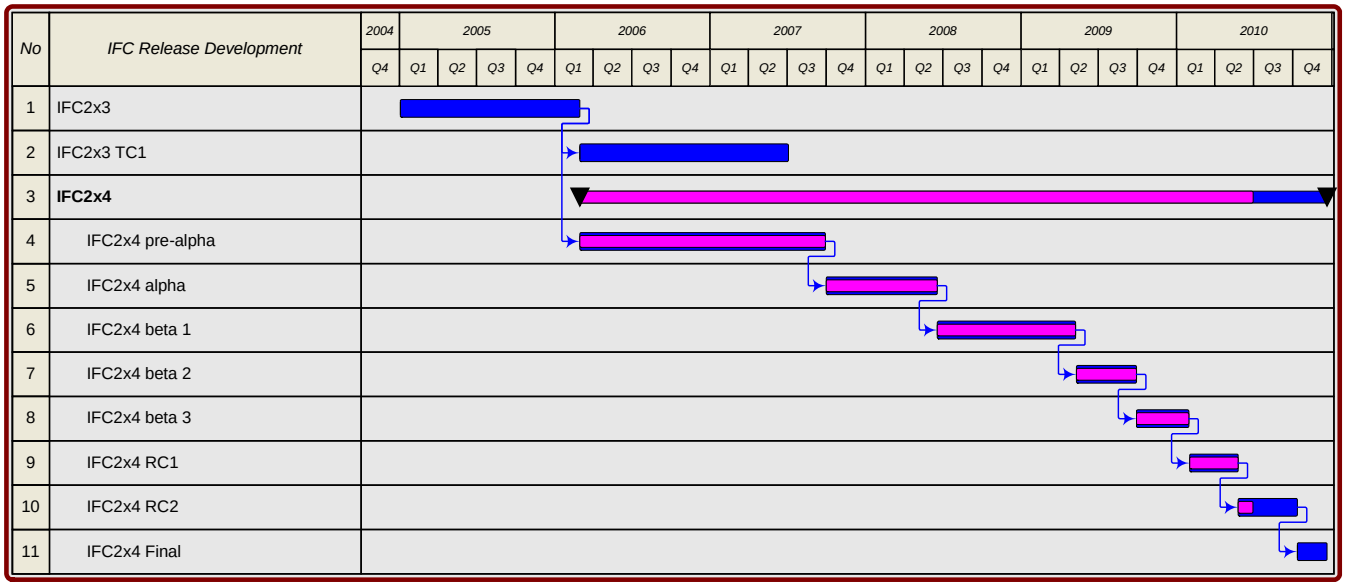

Figure 2: IFC2x4 release cycle

The second objective is to obtain the full ISO international standard recognition with IFC2x4. After obtaining the status of an ISO/PAS in 2005 with IFC2x a decision had to be made on how to continue after the 3 year period of validity of a Publicly Available Specification. In 2008 a New Work Item NWI had been requested to transpose IFC into a full International Standard IS. This process is now under way with the first release candidate of IFC2x4 and should be finished in 2011.

The third objective is to include several new concepts that had been missing from the previous IFC specifications and had been identified and prepared by IFC extension development projects:

- IFG – necessary BIM information to connect to GIS world
- IFD – extension to enable external references to dictionaries
- PM4 – standardized base quantities for spaces and building elements
- EL2 – electrical installations in buildings
- ST6 – CIS/2 to IFC harmonization and extensions for structural steel, timber and precast

The extended scope targets support for connecting building models with GIS systems and to add site layout to the building model, to enable the reference from any property to an external dictionary server, to address well defined base quantities for all building elements and spaces that are in current scope, expand the support for electrical design and for the various parts of structural modeling, analysis and detailing.

The forth objective is to validate and improve the current IFC2x3 based definitions by incorporating the lessons learnt from implementation and usage and from an intensive multi-stage review process. Until now about 1100 individual issues have been addressed, all logged in the IFC development online issue database (http://www.iai-tech.org/jira). Updates to the existing part of IFC had been made upward compatible for the scope of the IFC2x3 coordination view.

The fifth objective is to make the "non-core" parts of IFC more efficient and easier to use. This includes the scheduling part (tasks and work schedules), the construction resource part (labor, material, equipment), the construction costs part (cost schedules, cost items), and their interrelationships among each other and with the 3D BIM. Although most of the basic definitions exist already before, several research prototypes, e.g. examined in the European R&D project InPro (InPro), highlighted that the IFC schema constructs are often unnecessarily complex, not efficient and often poorly documented. Since full support of 4D and 5D models is an important part of the scope statement of IFC2x4, those parts had been extensively reworked and improved.

The sixth objective is to achieve a higher consistency throughout the whole IFC schema, i.e. to use the same modeling concepts such as composition, realization, typing, etc. relationships regardless of whether it is about building elements, distribution systems, cost items, construction schedules, etc. This let e.g. to symmetrical data schema of types and occurrences.

Finally the seventh objective is to provide easier access to the specification, better readability, more examples, in general: an improved documentation of the IFC2x4 standard. This goal is aligned with the second objective to obtain a full ISO recognition. IFC2x4 has to obey to the strict ISO documentation rules.

Related to this objective another novelty is introduced with IFC2x4 - multilingual descriptions, where the IFC specification would be visible in a user interface to an end users. This includes multilingual names and descriptions for IFC properties that are defined in an own XML based Property Set Definition PSD schema.

4. WHAT'S NEW

The following section can only provide a general overview of the enhancements that will come with IFC2x4. For more detailed descriptions see the "what's new" section of the IFC2x4 documentation (Liebich et al. 2010).

Core definitions

- synchronization of the specialization tree of object occurrences and object types where applicable
- decomposition of object types into parts and support of "deep copy", i.e. creating of decomposed object occurrences (example: the support beam type consists of a beam and a cantilever as parts, the many positioned occurrences of this support beam have a beam occurrence part and a cantilever part still connected to and sharing from the type parts)
- project library concept to register all object types (aka families, styles), property templates and external object libraries that form part of the IFC data set

Building elements

- differentiation between the parameterized subset of a building element (i.e. shape within the current range of parameterization) and the general form - i.e. standard case subtypes for all major building elements
- cardinal points and axis representation for all longitudinal elements (beams, columns, members)
- new building element entities for shading devices and chimneys
- new building element system (e.g. for transportation or fenestration system)
- provision for voids added as own definition to support the architectural / building service collaboration

Spatial elements

- new entity for spatial zone, a zone with own location, shape and functional type
- enhanced support for space boundaries and thermal surfaces
- definition of external space (for air, earth and water), and external surfaces added

Building service elements

- new distribution system definition for all major water, heating, cooling, fire protection, electrical and communication systems (among others)
- major completion of the building service component types with several new entities, such as interceptor, burner, audio visual appliance, electrical distribution board and numerous extensions to the predefined types
- major improvements of the concept of ports and system connectivity

Structural analysis

- clean up and simplification of the structural analysis definitions
- more complex members, such as curved surface members, and loads, such as distributed loads added

Connection to GIS

- own provision for geographic elements with a connection to a feature catalog
- projections of the Cartesian coordinate system of buildings onto geographic and map coordinate systems

Geometry

- manifold boundary representation to include b-spline surfaces - NURBS
- non-planar bounded surfaces
- tapered extrusions and revolutions

Property sets

- multi-lingual xml-based property set definition files

Element quantities

- base quantities, separate multi-lingual xml-based base quantity configuration files
- related to it, environmental impact indicators and values added

Material

- material assignment enhanced to address different cross section parts and general material constituents
- material definition for layered or profiled components to include vertical offsets

Processes

- addition of process types or templates to include a library of standard processes
- great simplification of assigning task time and duration to tasks, milestones, events
- addition of a work calendar to define different working times
- significant reduction of model footprint for 4D models

Costs

- great simplification of defining and assigning cost schedules and cost items
- significant reduction of model footprint for 5D models

Construction resources

- addition of construction resource types to support a library of standard resources
- improving the assignment of construction resources to schedules and costs

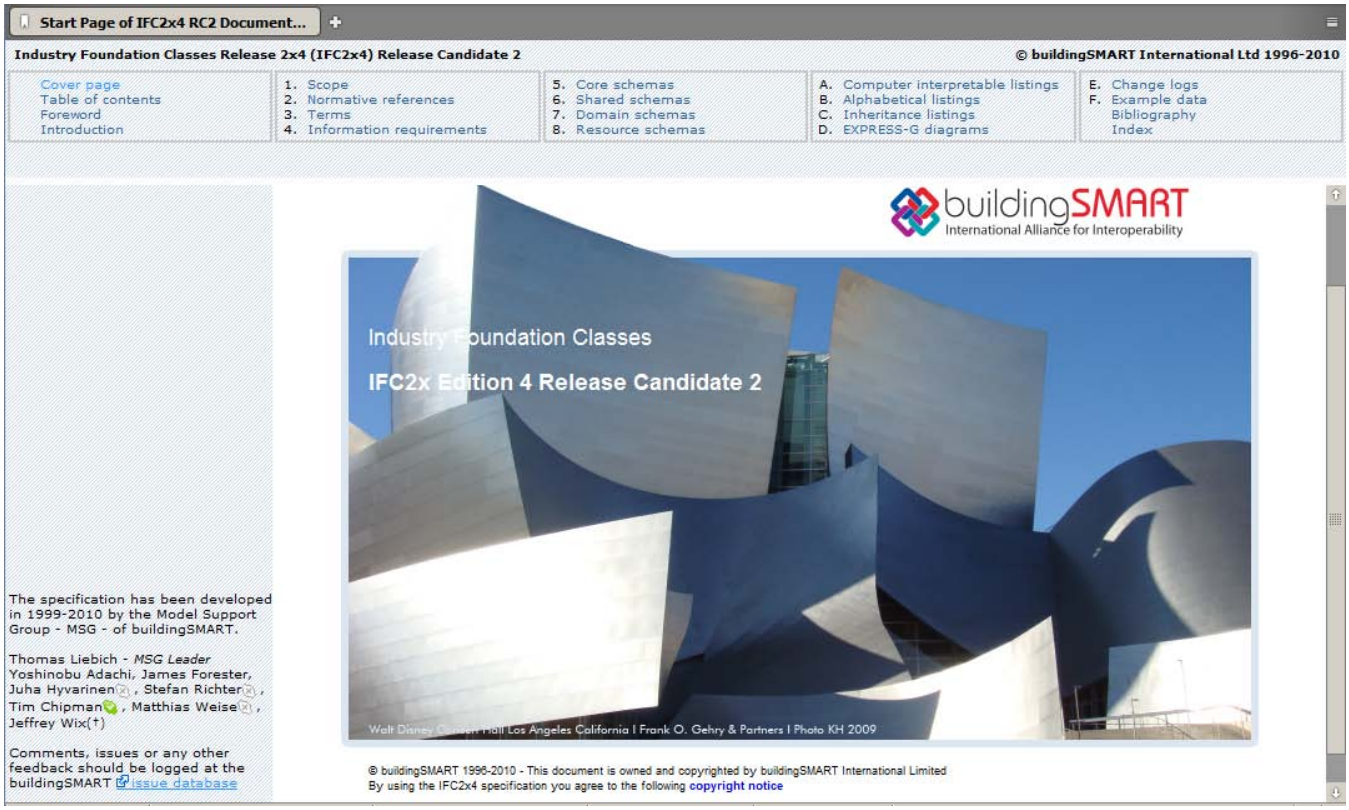

Figure 3: new documentation format for IFC2x4

Classification

- simplification of classification definitions and references
- can be assigned to properties as well

Date and time

- switch to the ISO8601 definition of date, time and duration
- significant reduction of model footprint, even more so for ifcXML implementations

A general cross area improvement has been achieved by putting great efforts into improving and extending the documentation. Numerous examples and instantiation diagrams have been added, and the new documentation format also adds a general introduction, basic definitions and general concepts supported by IFC2x4. The often mentioned steep learning curve required for an initial understanding of IFC should be lowered by the new release.

5. WHAT'S EXPECTED NEXT

The last steps until final release of IFC2x4 include a last quality assurance round with a public review process and resolving the remaining bugs identified. A major work item is to satisfy the ISO documentation requirements.

At the same time early prototypes are tested. This includes the new areas of improved support for work plans and schedules, construction resources and structural elements. Results of early prototypes will be verified and used to enhance the documentation with example data sets.

The research community is asked to contribute to the early testing programme of IFC2x4 and to report back any findings and limitations. It is also expected that those research groups that develop open-source tools would start test implementations soon.

6. ACKNOWLEDGMENTS

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