Building Information Modeling and Interoperability

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Abstract. *Interoperability is the ability of two or more systems to exchange information. It is one of the pillars of BIM because the information contained in a BIM model needs to be exchanged to be useful. IFC is cited as the best option for achieving interoperability in Construction but, although several applications have been certified to be IFC-compliant, flawed exchanges are too common yet. Behind IFC, some other less known standards play an important role to make BIM interoperability a reality. Among them are IDM, MVD and IFD. This paper will briefly show how these standards take part in data exchange and discuss the reasons why AEC interoperability is still such an elusive goal.*

Keywords. *BIM, interoperability, IFC, IDM, IFD, MVD.*

Introduction

After decades of slow IT adoption and being stuck on outdated technologies like 2D CAD, the AEC (Architecture/Engineering/Construction) sector is now looking for Building Information Modeling (BIM) as a way for helping it to catch up with the other industries regarding Information Technology use. This delay is reflected in the well-known low productivity, lack of incentives for coordination and the high cost of inadequate interoperability (Gallaher et al., 2004; Allen, 1985; Teicholz, 2001; Eastman & Sacks, 2008) featured in the construction industry.

BIM refers to the 'virtual representation of the physical and functional characteristics of a facility throughout its lifecycle, serving as a shared information repository for collaboration' (NIBS, 2007). It is based on advanced 3D parametric object-based modeling, and promises benefits for all stakeholders. To fulfill most of these promises, BIM depends on interoperability.

Interoperability is the ability of two or more systems to exchange information (needed and available) and use it (IEEE, 1990; Hietanen & Lehtinen, 2006). It is one of the pillars of Building Information Modeling because the information contained in a BIM model needs to be exchanged to be useful (Fallon & Palmer, 2007). All stakeholders (architects, engineers, designers, surveyors, contractors, etc.), working in a given project phase, use computer applications which consume and/or supply information processed by different software employed by other collaborators on that phase. Each pair of communicating applications must be able to access (insert, extract, update or modify) a subset of the information created by the other (one- or two-way). Likewise, BIM information must flow along the building lifecycle, being dealt by a full range of professionals with their software. Interoperability is key to preventing re-creation or re-input of data and to enable efficient use of information.

Beyond the most basic use of BIM, interoperability starts to be perceived as an import issue. BIM experts realize more easily than other users that the software incompatibilities are the most important factor impacting data sharing (McGraw-Hill Construction, 2007).

IFC (Industry Foundation Classes), a developing standard by buildingSMART International, is often cited as the prominent means by which BIM interoperability can be achieved. Several software applications have been certified to be IFC-compliant but actual use shows that flawed exchanges are too common yet. Indeed, many experiments show that the interoperability goal has not yet been reached, as IFC alone is not enough. Behind IFC, some other less known standards play an important role to make BIM interoperability a reality. Among them are IDM, MVC and IFD. Together, they can tell how, which and when AEC information is transferred and what this information means.

This paper briefly presents the concepts and standards involved in BIM interoperability, uncovering the reasons why it is such an elusive goal today.

How: IFC – Industry Foundation Classes

IFC specifies HOW information is to be exchanged. It is one of the very few public and internationally recognized standards (ISO/PAS 16739:2005) for exchange of information in the AEC domain (Eastman et al., 2008). Simply put, it is 'a specification of the things (physical items or abstract ideas) used in building construction so that they can be represented in a model and the relationships (grouping, association, connection, etc.) that exist between them'. (Wix, 2008).

IFC development started in late 1994 with the creation of the (then-named) Industry Alliance for Interoperability. On becoming worldwide, IAI changed its name to International Alliance for Interoperability and now it is called buildingSMART International. Therefore, IFC, named after the first IAI denomination and now in this ninth version (2x4 alpha), is more than a decade-old initiative, whose first version was published in 1997 (Khemlani, 2004). However, IFC-based exchange is not yet a reliable operation, even between IFC-certified software, fact confirmed by numerous reports (Fischer & Kam, 2002; Pazlar & Turk, 2008; Steel & Drogemuller, 2009). The blame is not all on IFC, which is usually considered to be of high quality (Kiviniemi et al., 2008), but on its implementations in software. Also guilty is the lenient IAI IFC-compliance certification process.

AEC is a huge domain and, as such, 'IFC cannot (and does not try to) specify everything in building construction' (Wix, 2008). Nevertheless, it is a challenge for application developers to figure out the full IFC specification (more than 620 classes, not always well documented), or even a restricted subset as defined by the relevant View Definition. It is common to find misinterpretations of

the standard or IFC functionality not debugged sufficiently by software developers (Fischer & Kam, 2002). Those problems would not have a significant impact on interoperability if an effective IFC certification process were in place. To date, buildingSMART certifies IFC 2x3 compliant software with a battery of simple test cases. After passing this initial phase, applications are supposed to be tested by end-users during a 6-month period and, if they are considered of sufficient quality, they are tested again with data from real projects (Groome, 2007; Pazlar & Turk, 2008). Only 11 applications have been certified on both phases. Of course, this process cannot guaranty the quality of the IFC import/export functions of any software and, although IAI explicitly dismiss its responsibility in quality assurance, users not always perceive it that way.

Realizing how flawed-but-certified implementations were hurting the image of IFC, a new and improved certification procedure is being planned (Häfele et al., 2009). The focus will move from checking software IFC ability to checking its quality on handling IFC. Also, automated testing and restricting today's endless export alternatives are directives for the new process. Therefore, it is expected that IFC 2x4 certified applications will be worth trusting for IFC-based exchanges.

It is important to note, as put by Bazjanac (2002), that software interoperability is only possible if all these three ingredients are present: i. a data model; ii. software implementations of the data model and iii. deployment of that software. IFC constitutes the first and the applications and servers able to import and export in IFC format are the second. The third ingredient is people using IFC as a de-facto standard on their daily AEC data exchanges. Only general adoption and use can make standards progress. It was only after GSA adopted IFC that most application developers started to support this standard (Drogemuller, 2009).

Which and When: IDM/MVC – Information Delivery Manuals / Model View Definitions

IDM specifies WHICH and WHEN the AEC information is to be exchanged.

IDM is essentially a methodology for identifying and describing the processes and related information within a construction project. It indicates the information that needs to be exchanged using IFC.

IDM methodology starts with a mapping of the business processes related to a particular data exchange between agents or their applications. Those processes are recorded as Process Maps represented in BPMN - Business Process Modeling Notation (White & Miers, 2008) and describe the activities and actors involved, as well as the information and its sequence in the process. Exchanged information is further described as Exchange Requirements and mapped to Functional Parts. Detailed information, as well as developed IDMs, can be found at the buildingSMART IDM website: http://www.iai.no/idm/

The importance of IDM is to effectively define which data is needed in a transaction between applications and how it should be communicated.

The MVD - Model View Definition is a methodology mainly used for specifying how information pointed out by IDM is to be mapped to IFC classes. It concerns primarily developers but, as it defines the IFC subsets that need to be implemented by each application, users should check what View(s) Definition(s) cover(s) their exchange requirements and if their software is certified on that particular MVD. To date, only one official MVD exists (Extended Coordination View) and it was not created based on a previous IDM; this MVD is the one used on the IFC certification process and this is also a reason for current unreliable IFC exchanges.

What: IFD – International Framework for Dictionaries

IFD specifies WHAT the exchanged information means.

IFD is another ISO standard (ISO 12006-3:2007), whose development started in 1999, and is used to add semantic to part of the information present in a BIM model so that it can be understood and processed regardless of language and nationality.

As stated before, the semantics represented in IFC are limited. For example, IFC can record that a certain object is a Window and that it is made of a material (registered in its "Material" property). But the Material property can hold only (any) text string. It could be 'wood', 'PVC', 'aluminum' or even 'sugar'. Its content holds no semantic, as far as IFC is concerned. This is where IFD enters. The implementations of IFD are able not only to describe (to humans) what a material is, but also to offer its translation to different languages, working as a multilanguage dictionary. It can also describe its relationships with other concepts, acting as a taxonomy. In IFD, each name is associated with a global unique identifier (GUID), allowing the computer to understand its meaning and to be able to perform searches on product catalogues, briefing documents, specifications, matches in bid results, etc.

Several efforts for creating implementations of IFD are in place now (Norway's BARBi Library, Netherland's LexiCon, France's EDIBATECH and IAI's IFD Library). Those efforts will allow the computer to fully understand a building information model, helping on many tasks of its users. But those benefits will be only available in countries that have developed an implementation of IFD (or cooperated on international efforts like the IFD Library), because of its very regional character.

Like with the other enablers of BIM interoperability (IFC/IDM/MVC), the current unfinished status of IFD implementations are also a stumbling block for achieving true AEC interoperability. From version 2x4, IFC supports IFD.

Conclusion

Opposite to what many practitioners think, IFC is not the only technology necessary to reach interoperability in BIM. In reality, IFC works only as the language used to describe a building model. If one doesn't know what to say, the ability to speak a language is of little use. Information Delivery Manuals and Model View Definitions are the two official methodologies that must be used to establish what needs to be IFC-coded in a BIM model, guarantying that two applications will exchange the needed data between them. Likewise, as IFC cannot foresee all concepts in the vast AEC domain, especially those with a regional nature, IFD-based libraries should be in place to add semantic (and computer awareness), to all terms and concepts present in a building model but not standardized in IFC.

IFC is one of the most mature of those aforementioned technologies and it has a general nature, not being too much concerned with regional concepts (which can be handled by extensions). This makes it ready to use in many software applications. On the other hand, IDM/MVC are used to describe AEC processes, which usually vary from country to country and are, by its nature, difficult to map due to its complexity. The same applies to IFD implementations. Until these other components are fully available, complete BIM interoperability cannot be expected. Therefore more efforts should be invested by national organizations to also advance IDM and IFD implementations.

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