Examining the Evolution of COBie Standards in Building Information Modelling for Facilities Management

Mehmet Yalcinkaya, Mehmet.Yalcinkaya@aalto.fi
Aalto University, Espoo-Finland

Vishal Singh, Vishal.Singh@aalto.fi
Aalto University, Espoo-Finland

Abstract
As the Building Information Modelling (BIM) for facilities management (FM) research is gaining greater emphasis, the Construction Operations Building Information Exchange (COBie) standard is becoming increasingly central to the discussion. Therefore, it is timely that we seek better understanding of how COBie has evolved within both BIM and FM domain, and what it means for the development in this area. Based on the existing literature, standards can be classified in various ways. Each of these classifications has its own strengths and weaknesses, determining the long term implications of these standards in practice in their own way, and often on the maturity of the associated technologies and processes. Therefore, this paper aims to critically analyze the evolution of COBie standard using such classifications, as a means to understand how they may impact the growth of the BIM and FM capabilities.

Keywords: BIM, FM, Standards, COBie

1 Introduction

There is an increasing call to use Building Information Modelling (BIM) data in facilities management (FM). The related information is created by numerous BIM and other FM related computer applications throughout the project lifecycle (Becerik-Gerber et al. 2011). Although BIM can facilitate the existing work processes, it requires commonly agreed set of definitions and specifications for information exchange. Standardization has played a vital role in the Architecture Engineering and Construction (AEC)/FM industry in the context of engineering design, classification of materials/assets, quantity take off, etc. (Björk & Laakso 2010). In the standardization related to the use of BIM in AEC/FM industry, one of the central issues has been how to structure digital information of a facility to enable the sharing of data among different disciplines through the project lifecycle. Industry Foundation Classes (IFC) provides an open data model standard to structure and exchange the digital facility information, and support interoperability (Laakso & Kiviniemi 2011). However, IFC by itself is too generic and complex to implement directly for FM software applications. Consequently, Information Technology (IT) and data standards specific to FM information exchange is becoming central to BIM for FM research. Construction Operations Building information exchange (COBie) is one of the most predominant standards in BIM for FM. COBie is an open, vendor-neutral industry standard that describes product and process of collecting and validating building lifecycle data during design, construction and commissioning (BuildingSMART 2010; US-GSA 2011; East 2007). Although COBie is a recent development, it is being widely promoted for BIM and FM. The majority of the BIM-FM standards research is focused on implementation strategies (Kasprzak et al. 2013; Liu & Issa 2013; Ammari & Hammad 2014), practices and developments (Motamedi et al. 2014; Lucas et al. 2013), case studies (Brooks & Lucas 2014; Kiviniemi & Codinhoto 2014) and industrial surveys (Liu & Issa 2013; Becerik-Gerber et al. 2011). The studies on COBie have not gone beyond the topics of concept definition, technical development, implementation and industry adoption (Eadie et al. 2013; Kandil et al. 2014). There is a lack of studies on the standardization pathways in BIM-FM literature. This research aims to fill this gap, seeking better understanding of how COBie standards have evolved, and what could be the implications for the future. The reported findings are based on a systematic review of academic literature on BIM-based FM and standardization; as well as publicly available industry and vendor-based documents.

2 IT and Standardization

IT standardization can be defined as a process or strategy that minimizes the cost, time and direct/indirect resources within an organization by keeping its hardware and software systems as efficient as possible to maximize compatibility, sustainability, interoperability, and/or quality of information. The standardization process can be formal and/or semi-formal (De-Vries 2006). For example, based on the origin, standards can be classified as de facto standards, de jure standards, and consensus standards. De facto standards emerge through a customer/user-driven selection process. They can be widely used and even dominate without direct endorsement or contribution from government or a standardization body. In contrast, consensus standards are typically developed by non-profit organizations/consortia including multiple participants from industry, government, suppliers/developers and/or end-users to guide compliant products or services driven by mutual goals and investment in a common solution (Crargil 1989). Typically consortia-based standardization development progresses faster than the one in official standard development organizations (Laakso & Kiviniemi 2011).

The lifecycle of standardization process generally starts with initiation and identification of the need and development actors. Adoption by users, suppliers, and associated direct and indirect market/network structures the form of compliant product and services. While various models of standardization process showing different pathways have been proposed, Söderström (2004) has proposed an integrated lifecycle model after reviewing different models (Figure 1).

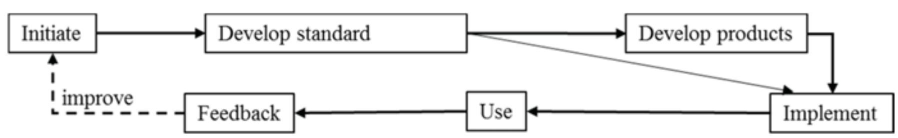

Figure 1 Generalized standard lifecycle model (re-drawn based on (Söderström 2004))

Various parameters affect the development of IT standardization in terms of process, time, actors, marketing, purpose of use, etc. These parameters can form the basis for classification of standards. For example, based on timing standards can be anticipatory for upcoming development, or framed for an existing technology or set of needs (Crargil 1989). De-Vries (2006) provides a systematic classification, Table 1, listing parameters such as the type of problem, preparation, benefits, needs, etc. under the categories: (1) Subject-matter-related, (2) related to standard development and, (3) related to the usage of standards.

Table 1. Classification of Standards (table created based on (De-Vries 2006))

Subject matter related	Related to development	Related to use of standards
Related to Entities	**Related to Actors**	**Related to Functionality**
Horizontal; Vertical	Regional; National; International	Intrinsic; Extrinsic and Subjective Functions
Related to Requirements	**Related to Organizations**	**Related to Business Models**
Basic; Requiring (design-based, Performance-based); Measurement; Interference; Quality; Compatibility; Unit and Reference; Similarity	Formal; De Facto /De Jure; Governmental; Consortium; Company	Regulatory; Business or Marketing; Operational
	Related to Process	**Extent of Availability**
	Anticipatory; Concurrent; Retrospective; Designing; Selecting; Open Standards/ Closed	Public; Non-public; Licensed; Non-licensed

2.1 Standardization and Adoption

Standards reveal invisible network between the actors, which plays a critical role in determining whether the standardization effort ends with success or failure. Network effect has been extensively studied in the economics of standards. It also provides insights into the behavior and response of end-users towards the standard. Direct benefits of networks are triggered by the increase in benefits for individual end-users with the network size. Indirect effects of networks are triggered by additional supplementary goods/services related with the main product/idea (Park 2005). In addition, the theories in diffusion of innovation explain how, why and at what rate new ideas and/or technology have an acceptance in the market/ community (Rogers 2010). Diffusion models consider the nature of adoption, communication channels, social system and time. The tipping point can affect the speed of diffusion, where tipping point is defined as "the moment of critical mass, the threshold and the boiling point" (Gladwell 2006). Such principles can be considered for studying the evolution of COBie.

2.2 IT in Facilities Management (IT-FM)

Improving the FM-based services through IT has been a common topic (Calde et al. 2002; Liu et al. 1994; Motamedi et al. 2014) with tools such as computer aided facility management (CAFM) systems, computerized maintenance management systems (CMMS), etc. Besides software-based solutions, hardware-based developments like mobile devices, wireless access technologies, scanning and monitoring tools facilitate various tasks in FM business. The exchange of accurate data among systems and actor is the most basic requirement to achieve the intended benefits. Product models with entities (assets, spaces, etc.) can enable efficient information sharing between various stakeholders. Laakso & Kiviniemi (2011) identified three key milestones in the product data exchange development, beginning with ad-hoc solutions in 1950s, Computer Aided Design standards in 1980s and STEP (standard for the exchange of product model data) standard development since 1990s (Owen & Bloor 1987).

The STEP standard was complex to understand and process, took a long time for development, and was beyond the maturity of the existing technologies at that time. The later improvements were done to obtain semantic relations between the product data entities to make them both machine and human readable (Laakso & Kiviniemi 2011). In 1994 STEP was accepted as an international standard by ISO and re-named (ISO 1994). The "ISO" title brought a more formal identity, but the rules and regulations of ISO hindered the speed of development. This necessitated the establishment of compatibility and interoperability for AEC software applications. In 1996, International Alliance for Interoperability (IAI) was established with the involvement of twelve US companies. STEP became the fundamental standard for IAI to represent the building in product models through the development of Industry Foundation Classes (IFC) since 1997 (Björk & Laakso 2010). In 2006, IAI consortium was re-named 'buildingSMART alliance' and formed as National Institute of Building Science (NIBS) council. The product data model for AEC is commonly referred to as BIM. In terms of IT standardization, FM followed the product data modeling standards of BIM. Based on the pre-defined set of rules and business process, COBie (East 2007) specifications were announced in 2007. Since 2012, it has been part of the US National Building Information Standard.

3 Background and Development of COBie

In 1983, the National Research Council Building Research Board (BRB) proposed an integrated database solution for facility information (Scarponcini 1996). Other computerized systems, such as CAFM, CMMS, etc. were already available to organize, manage and deliver FM information. The variety of software products and their versioning caused inefficiencies in automatic transfer of data. Consequently, the manual information delivery is still commonly used, even though it is inefficient, error-prone and tedious (William East et al. 2012). COBie specification were developed to overcome such challenges and establish a non-proprietary version of exchange data (East 2007). The development process began in 2006 under NIBS FM and Operations Committee with an extensive review of literature and private industrial/association efforts. The review focused on two aspects. First, to determine the useful minimum in terms of specific information requirements, responsible actors and associated lifecycle phases. Second, to define data exchange standards to eliminate existing inefficiencies in information exchange. The lifecycle information exchange were evaluated based on business cases, specific business requirements, information handover plan and implementation with software applications (East 2007). Association efforts played a vital role in the development of COBie. Machinery Information Management Open Systems Alliance (MIMOSA), an industry sponsored non-profit organization, published important specifications such as the Open Systems Architecture for Enterprise Application Integration (OSA-EAI) (MIMOSA 1998) and for Condition-Based Maintenance (OSA-CBM) (MIMOSA 2006). These standards describe how to integrate asset information and how to transfer information in a condition-based maintenance system. Similarly, IAI and its open-source framework for exchange of facility information IFC, describes the majority of components, systems, ownership and the process history. Twelve published data exchange standards for the process industry were reviewed to identify equipment, process, systems, procurement, operations and management datasets for the development of COBie (East 2007).

The practices of the public sector were also considered in the development of COBie. US Naval Facilities Engineering Command (NAVFAC), Unified Facilities Guide Specifications (UFGS) provides Operations and Maintenance Support Information (OMSI). OMSI as an information package includes the key information produced during design, construction and commissioning of a facility. The information is organized in three groups: facility information, primary systems information, and product data (NAVFAC 2011). The OMSI package is generally submitted in three formats including hard copies, electronic (PDF) format and compatible with CMMS applications. The main information types and delivery phases were evaluated in the development of COBie. The Electronic OMSI (eOMSI) provides the required facility information in a structured spreadsheet file with a specified template, during the information handover. Besides OMSI, the Department of Public Works (DPW) of US offers a specification called Operations and Maintenance Manuals which covers a variety of facility information such as system descriptions, installed equipment lists, etc. This specification was also considered in the development of COBie. Besides these, such specifications and/or submittal processes provided by US Department of Defense and National Aeronautics and Space Administration (NASA) were also considered in the development of COBie (East 2007).

3.1 IFC and COBie

COBie is not a software application. COBie provides a template based on the composition of existing information specifications and exchange standards that have been in use for years. The information structure and the delivery format of COBie specification is based on existing processes to reduce inefficiencies in facility information handover. Currently COBie can be represented using STEP, XML and spreadsheet formats. By considering the end-users' inexperience and limited familiarity with the first two file-formats, spreadsheet has become the common way to represent COBie. The COBie spreadsheet includes several workbooks and columns in which the users import the information from software and/or fill in manually. Gathering the building information from distributed sources is the key challenge in COBie implementation.

In conjunction with the emergence of BIM in the industry, IFC has become a common way to communicate with, and exchange the building information. However, the overall structure of IFC is large and complex to exchange and/or represent a specific set of domain data which includes its own hierarchy and semantics. In the IFC standardization process, there is a shift in the direction of IFC's development strategy from interoperability for all AEC/FM industry to improvement in communication, productivity, time, cost and quality for specific phases of project lifecycle (Laakso & Kiviniemi 2011). The useful minimum of IFC provided the minimum set of information packages for specific lifecycle phases, disciplines and/or business cases. As a result of this *minimalistic* approach, Information Delivery Manuals (IDM) and IFC Model View Definition formats (MVD) were developed and became the official elements of IFC standardization. While IDM provides the documentation and guidelines about the technical needs for software implementations and individual end-users' role for process workflow, MVD considers both customers and software developers needs to narrow down the complete scheme and develop the specific sub-sets of IFC which is implementable by software applications (BuildingSMART 2010; BuildingSMART 2011).

The minimalistic approach of IFC provided the functional layout for automated and digital data exchange for COBie specification, with COBie implemented strategy based on IDM and MVD that define the phases of specific business workflow, exchange of digital information requirements, and generation of data formats for software developers and the sub-sets of IFC entities for information exchange from BIM applications. The FM Handover MVD provided the conceptual format of the information as the base for COBie specification (William East et al. 2012). The FM Handover MVD provided the link-map between the specific information requirements and associated IFC entities. IFC is a rich data source to feed the various information requirements in COBie specification. However, IFC is not an all-in-one and the only source for the information requested in COBie specification.

3.2 Software Tests for COBie

The implementation of COBie by software vendors provided insightful feedback for the development and improvement of COBie. Since 2008, more than twenty planning, design, construction and FM software applications were tested to check their existing compatibility with COBie requirements. These tests were performed under the name of "COBie Challenge" (East & Nisbet 2012). With the formation of buildingSMART as a NIBS council, COBie was presented and discussed internationally in 2010. Since 2012, COBie is part of the US National Building Information Standard (NBIMS-US); and the updated version has also been approved. The collaboration with buildingSMART facilitated COBie integration tests with both leading and new IFC authoring software applications. Since IFC is not the only information source for COBie, non-IFC based software applications/platforms were also included to the tests.

4 Discussion

4.1 COBie in IT Standards Classification

This section evaluates COBie standard according to the typology listed in Table 1.

4.1.1 COBie and Subject-Matter-Related Classification

Standards provide and/or facilitate solutions for any kind of problem which includes variable interrelated entities that can be anything like person, object, event, process, etc. The solution provided by the standard can be related with matching the entities, processes, people, systems, etc. The information which are exchanged, required, delivered and/or processed were evaluated from the existing specifications and standards during the development of COBie. One can state that COBie is developed based on an extensive composition of existing specifications. Hence, COBie does not provide a set of pre-defined list which includes what information is needed/requested. Instead, COBie defines how the "useful-minimum" information should be structured and in what formats it can be delivered based on FM Handover MVD. Simply, COBie is a data format and the output format of COBie may vary. It can be via an IFC-based generator/translator which can be run with BIM-authoring tools and can be represented in EXPRESS, XML or spreadsheet formats. This feature makes COBie a *horizontal compatibility* standard since a data format becomes implementable with another software application. In contrast, manual implementation of COBie is also possible, which weakens the *horizontal compatibility* tag of COBie standard. In this case, COBie tends to be a *performance-based* standard that sets the performance criteria for entities and/or the proposed solution, including requirements for generating and representing COBie data.

4.1.2 COBie and Classification Related to Standards Development

Considering their development, IT standards are categorized under three sub-headings: interested/involved actors, organizations behind the standards (if any), and the development process. An actor can be recognized as a company, regional, national or international actor, based on its geo-political influence. NIBS FM and Operations Committee initiated the development of COBie. Thereafter, COBie has been part of the US National BIM Standard. The *national* adjective of NIBS and BIM Standard and the associations involved during the development clearly make the COBie a national standard in its origin. However, the word *national* does not mean a limit for the current uptake and implementation of COBie standard. Especially the collaboration with buildingSMART alliance and implementation tests with BIM-authoring software applications, moved the recognition of COBie Standard to an international level. Hence the *national* tag of COBie standard should be changed with *international*.

Considering the organizations behind the standards, IT standards can be classified as formal or informal. A formal standard can be issued by ISO, national standardization organizations such as American National Standards Institute (ANSI), etc. (De-Vries 1999). COBie can be considered a *formal* standard since it has been a part of a national standardization effort. The classification of COBie in terms of whether it is a *de-facto* or *de-jure* standard has a potential for further discussions. Regarding the development process, it is known that COBie was not adopted suddenly by the AEC/FM industry. There are some other factors for the international recognition of COBie; hence, it is not a *de-facto* standard. However, classifying COBie as a *de-jure* standard also leaves some ambiguities. As also specified in De-Vries (2006), the governmental or official recognition of standard-developing organization is many times questionable. On the other hand, there is a governmental recognition of COBie in US and UK for their future industry strategies. For example, standard UK government construction contracts will have a built-in requirement for COBie by 2016. This raises the question whether COBie will be implemented with a *de-jure* standard mentality in UK. In addition, COBie standard development began under NIBS and from its early years it works with buildingSMART. Given this background, COBie can be classified as a *consortium* standard.

Development process of standards is also a classification factor for IT standardization. The standard development, design, decision-making process and timing are interrelated with each other. Based on emergence and timing, standards can be classified as *anticipatory*, which provides a solution for any kind of prospective problems; *concurrent*, which provides a solution in a short period when the problem occurs; and *retrospective*, which provides a solution for previous or an existing problem/solutions. COBie can be called a *retrospective* standard since it brings a solution and clarification for an existing problem that has been covered directly and/or indirectly by other standards and specifications. In terms of its technical nature, COBie can also be classified as an *anticipatory* standard since it provides prospective solution in anticipation of increasing use of digital data for FM. Standards can also be established over an existing design. In such cases, the standardization effort should adopt a document, solution and/or process developed already. *Designing* and *selecting* standardization are other aspects of the development process. While *designing* standardization provides a limited set of solutions to problems, *selecting* standardization provides a set of preferred solutions over the existing ones for any problem. From this perspective, COBie suggests a scheme and alternative ways for facility data handover. This scheme has been developed on top of existing specifications and suggests different ways to deliver the facility information. This issue also matches the *retrospective* feature of COBie standard. In *retrospective* standardization, there are already some solutions, and standardization considers one or some of those. In addition, it is evident that COBie is an *open* standard which has been broadly supported by BIM and FM software applications and buildingSMART association.

4.1.3 COBie and Classification Related to Use of Standards

The classification based on the intended use of the standards are grouped into three main sections: (1) the functions provided, (2) the features and dynamics of the business/market, and (3) the extension of the standard to make open or limited-available to the intended users. The functionality of a standard is evaluated under three sub-groups which are intrinsic, extrinsic and subjective functionalities. In general, intrinsic refers to something that is inherent in the nature of a thing. From the perspective of COBie, it can be stated that the most basic intrinsic function of COBie is providing a set of agreed solution for a specific problem for AEC/FM industry. Extrinsic functions may vary based on the objective of standard. Based on the examples provided in (De-Vries 2006), such extrinsic functions of COBie standard are matching the lifecycle of different entities, enabling inter-changeability, facilitating information exchange between people, storing a knowledge and keep it accessible for later times, etc. These kind of functions can be enriched with subjective functions based on the interests of actors, organizations and/or end-users. According to (De-Vries 2006), subjective functions of IT standards can include enabling inter-working and portability; facilitating technological innovations, research and developments; improving quality management, reducing costs, facilitating processes and contributing knowledge management.

Based on business models, IT standards can be classified as: (1) *regulatory* standards, in which a legal force motivates the development process; (2) *business* or *marketing* standards, which are for agreed benefits to business or marketing; and (3) *operational* standards which provide solutions for periodic operations of a company, organization or government etc. COBie fits the business and marketing standards the most in this classification. First, COBie has been developed for the interest of AEC/FM industry. Second, COBie implementation and testing has also allowed collaboration with both BIM and FM-authoring software applications. COBie can also be viewed as an *operational* standard, because in COBie the data handover is planned periodically in certain phases of the project lifecycle. Another criteria for classification of standards is availability and extendibility. COBie standard, the MVD structure and related documentation are *publicly* available to all third parties such as intended users, software developers, etc. COBie cannot be classified as a commercially *licensed* standard since it does not hold any patent or copyright protection which requests a commercial right; and explicitly collaborates with software development companies for implementation and further developments.

4.2 COBie and BIM/FM Software Integration

COBie is commonly mentioned in the recent literature and other sources (websites, reports, magazines, etc.), when the subject is BIM and FM. These discussions focus around opportunities that come with COBie deliverable format, and with improving the BIM-based work process for FM or vice-versa. But is it? Is BIM the easiest, or even the most efficient way of delivering the FM information via COBie? To deliver the COBie, is BIM necessary? This section tries to draw an overall picture about the effect of collaboration between COBie and BIM-authoring applications/organizations by raising up some questions for further discussions.

4.2.1 Why did COBie mostly use IFC data format and collaborate with BIM-authoring software vendors?

IFC is a rich source for the building product data and one of the most efficient one. A certain amount of IFC information is needed for COBie delivery and with the minimalistic approach of IFC, FM Handover MVD works well as far as all the required data is in the source IFC file. To export the IFC data to a COBie spreadsheet, there are some built-in or external tools developed by BIM software vendors. One of the main challenges to automatically export the COBie data from BIM and/or FM software is the differences between structure of COBie and existing architecture of software applications, which may cause irrelevant data export for COBie. Even if the architecture matches, some data fields may require manual entry or inputs from other sources. In addition, some FM software applications can provide the relevant FM data in their internal formats such as schedules and lists in PDF or spreadsheet format. When these applications are used, users can configure the content of the output report according to the defined information requirements. Despite these possibilities, the practicality of IFC-based COBie export is indisputable. Moreover, many of the software application have individual software-structure and different versions in the market. Almost none of them are open source and their data format is not as much interoperable with other applications as IFC data format. Therefore, IFC can be considered as the most convenient source for COBie extraction.

4.2.2 Is it really necessary to handover the information in COBie format?

IFC, as a broad and international standard, is very much for an efficient and automated data export. Following the same objectives, COBie tries to automate and/or makes more efficient the old-fashioned paper-based system. However, in many of the current software-based FM tools, the information is already in digital format in a certain structure and what COBie does is exchanging the information into another format and structure. The spreadsheet format allows end-user computing capabilities such as filtering, calculations, graphs, etc. However, some FM software applications already populate their data from BIM models and provide some end-user programming features within their existing modules. Thus, COBie is potentially one of the efficient ways to provide construction data handover for FM, but it is not the only method.

4.2.3 Why the BIM/FM software integration has not been implemented before with the existing standards/specifications instead of COBie?

Several FM and IT-related information standards and specifications were evaluated during the development of COBie. Specifications like OMSI and MIMOSA have previously been used by some organizations. In addition, there are some other FM-related specifications in different countries. The FM Handover MVD describes the conceptual format of COBie dataset; and the collaboration with BIM software vendors, organizations and the market provided international level of recognition for COBie. However, a similar IFC-based development, integration and collaboration is equally feasible and likely with already existing standards and specifications. Therefore, this question should be clarified by the software vendors and standard developers.

4.3 COBie and Industrial Uptake

BIM and COBie are increasingly presented as inherent aspects of state-of-art FM information handover. Yet, there is no comprehensive research about the overall adoption of COBie. If COBie is considered as a simplified framework for FM data handover, it is reasonable to ask how COBie is different to other alternatives, and how is it the most recognized format?

4.3.1 Can there be some other reasons behind COBie-BIM integration/collaboration?

FM software applications have been in the market for years, and some of them can interpret BIM-based data. Yet, none of them are referred to as a *state-of-art* solution. So how has COBie become popular in AEC/FM industry? The potential answers for this questions may be the non-proprietary open data format, ease of use of spreadsheet, automated data export, etc. But, there may be some other factors as well which make COBie popular and acceptable. The organizations, software vendors and the existing users around BIM aspect provided to COBie an already established user network. The development of IFC and hence related software applications has been the topic of industry for decades. Thousands of companies are already using BIM, and buildingSMART has already established both national and international network of BIM community. Compared to the existing network of only FM business and software applications, the BIM network may have been found to be more strategic route.

4.3.2 Is COBie a big pie for software vendors?

Though COBie is a non-proprietary and open standard, freely available for all third parties, the commercial interests of companies and software vendors may influence industry uptake. The existing BIM network can play a vital role in the promotion and uptake of COBie standard. The intended users may also adopt the standard to ensure their participation in the future network, and the bandwagon effects of the growing network will determine the eventual uptake. BIM Software vendors are actively participating in the development of COBie standard by testing their software applications. Although there are no commercial agreements for the tests with the COBie development team and buildingSMART, software vendors may have joined the development activities considering the potential future benefits and partnership opportunities. The involvement in the development process provides first-hand experience and opportunity to guage the direction of development and initial reaction of the end-users. Currently, some of the software vendors have already used their performance results to promote their applications in the market; and released their own COBie-compatible tools/add-ins.

4.3.3 How did COBie spread through the BIM community?

The collaboration/integration of COBie with BIM can be considered a successful strategy to reach the industrial professionals, who are part of the intended users. When an innovation or standard is presented, the diffusion of this innovation/standard happens over time among the invisible network of the intended users through their communication channels. When the diffusion reaches a tipping point, it can create a domino effect within the community and the innovation/standard spreads like an epidemic. The factors which accelerate the speed of diffusion may vary for COBie. There may be some BIM-guru people who have highly-connected social and market network besides their expertise. Those people are the potential *actors* who may promote the BIM-based COBie generation like a *state-of-art* solution for FM information handover. The intended community may also consider these BIM-guru people as an information specialist or a leader whom they may feel that they need his/her *specific* or *trendy* knowledge to safeguard their self-interest. In addition, there is already the terminology "BIM" and "FM" in industry's mouth for decades. No matter whether it is used for its real purpose or as a buzz-word, in any case the stickiness factor for "BIM" and "FM" terms may have provided an opportunity for COBie to make it stay in the intended users' minds. The implementation and test of COBie with common BIM and FM software applications may have improved this issue. The timing of COBie standard effort is also an important factor. BIM has been already in use for design and construction for many years, and there is increasing interest both in industry and academy about implementation of BIM for FM. When the cost issue is the subject for construction project lifecycle, many times the cost ratio of operation and maintenance phase is stated. The industrial survey which was held by NIST stated that almost %60 of the interoperability costs cause in the operation and maintenance phase of the project lifecycle (NIST 2004). This source is one of the most cited study which can be found almost every FM/COBie-related document. The above and similar factors can be the potential aspects which strength the COBie's power of context on the intended users.

5 Conclusions

This paper presents a broad picture review of the COBie standardization effort. By using the standardization typology, COBie was evaluated under three categories. In brief, COBie is assessed as an *international*, *formal*, *consortium-based*, *performance* standard. Based on the development process, COBie can be claimed as an *anticipatory* standard since it provides a prospective solution for FM information handover processes. However, due to the origin of the problem and some existing standards, specifications and/or software outputs, COBie can be classified as a *retrospective* standard. COBie standard development has primarily been *selective* in nature. COBie standard has been established following a minimalistic trend within the IFC development. No actor holds any patent or copyright for COBie, which makes COBie an *open* standard, publicly available for all. Due to the collaboration with national and international consortium during the development process, COBie cannot be classified as a *de-facto* standard, but it is more of a *de-jure* standard especially since the recent requirement of UK government that makes COBie mandatory to use by 2016.

While an in-depth analysis of the implications of the path of evolution of COBie standard is yet to be conducted and not covered in this paper, some technical and implementation challenges have been noted, which can determine the long-term success of COBie. In terms of strategic decisions taken since the development of COBie, one can argue that COBie has been a success so far. Compared to other existing standards and specifications for the problem that COBie covers, COBie has got much greater coverage and attention in its short lifespan so far. The timing of the standardization has also been a success since BIM-based FM topics have been in interest in recent years. Thus, the time and market goals (Gielingh 2008) of COBie were reached with strategic success. The collaboration/integration of COBie with BIM provided a ready BIM-user network for COBie, facilitating quick international recognition. This may have caused some pre-anticipations about the usefulness and functionality of COBie before the end-users understood what COBie really is and how it could be implemented. The COBie related software-based efforts may lead to unrealistic optimism for many end-users who think that COBie file can be generated with one-click of a button. Offering such a promising applications may be too early when the market is still lagging behind in its understanding of the nature of the development. Therefore, this paper tries to raise relevant questions that can improve our understanding of how the market may have reacted in the view of COBie, and what it means for the future of BIM-FM research and development.

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