Chapter 21
BIM and BPMN 2.0 Integration for Interoperability Challenge in Construction Industry

Hosam Al-Siah and Antonio Fioravanti

Abstract Interoperability is a growing challenge for the construction industry in general, especially for the designing process, where it is exposed to many challenges due to the most critical part of this sector that related to heterogeneous information exchange. Particularly, during the implementation of a project where there is a need for sharing and exchanging a huge amount of data among several actors to accomplish the design process. Therefore, the need for real supportive tools has emerged to facilitate the process of data collection and digitalization in order to automate the whole process. However, different kinds of issues prevent improving the interoperability in the ACE industry. This paper focuses on the barriers of improving the interoperability in this industry sector and proposes a new method of linking and collecting the data from different actors. To this objective cloud storage for flowcharts and building information model "BIM" have been used. One of the best flowcharting languages—Business Process Modelling and Notation "BPMN" 2.0—has been adopted, where the data will be collected and the process will be explained and connected directly to the BIM model to be reviewed, used, and saved.

Keywords Design process · Building management · Interoperability · BPMN · BIM

21.1 Introduction

The designing and management tools within the construction industry have been improved significantly during the last century, which could be referred mainly to process complexity, and the new level of detailed project with large number of actors' data that have to be managed. Moreover, the improvement of the computer's

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capability and the progressive introduction of ICT in Architecture Engineering and Construction "AEC" industry from one side simplified and made easier processes and checking, from the other side contributed to make work more complex and fragmented due to divergent specializations. ICT was so popular that was created the terms computer-aided design "CAD" and computer-aided manufacturing "CAM." Despite the great benefits of using the computers, it was initially limited to engineering 2D/3D drawings and "hand science" model calculations without focusing much on other aspects—a part of advanced research field. Building ICT improvement led to suggest building information modeling "BIM" as a repository of many possible information related to the building that are used in different activities related to manage, design, and control different buildings project aspects.

Since it first introduction by professor C. Eastman in the 70s, BIM helped in developing the industry, where it was supposed to be a repository of project information to facilitate the exchange of information within the same studio and then with other studios and related actors. Nowadays, BIM is a full-fledged, object-oriented, three-dimensional model that represent a digital building to track physical characteristics and functions. The adoption and implementation of BIM tools increased globally among the major players of the construction industry over the recent years, for example, it reached 99% in UK in 2020 (NBS Enterprises Ltd. 2020) (Fig. 21.1).

The adoption and implementation of the BIM tools by the stakeholders (Fig. 21.2) has emerged the benefits they got of using them; Ku and Taiebat (2011) identified seventeen BIM functions that can be used by General Contractors whereas Langar

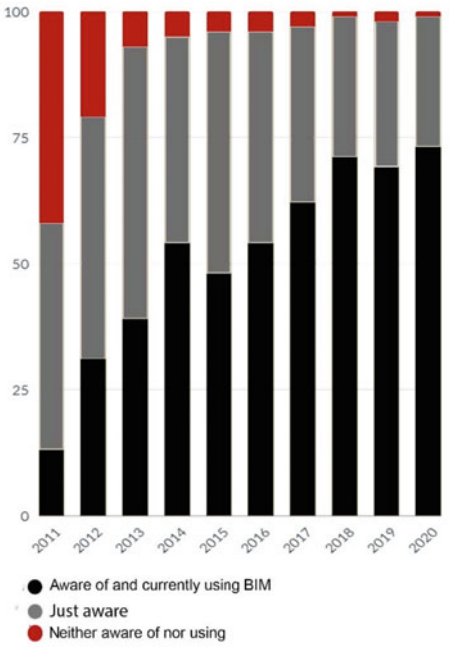

Fig. 21.1 BIM adoption in UK over time. *Source* NBS Enterprises Ltd. (2020)

and Pearce (2014) identified eighteen such BIM functions for designers. These and many other studies encourage the software houses and researchers in the digital AEC field to invest in this technologies and in the related tools; however, there is obviously a gap between the BIM utopia promised and the current available tools, where the practical experiences proved that BIM tools alone are not enough as the current situation, where during the years the vendors, developers, and researchers gave—unintentionally sometimes—a lot of promises the technology could not achieve yet. The prof. R Miettinen and his team showed four elements in order to reach the BIM utopia, firstly, solving the issue of using single BIM data or a variety of BIM models together with other software and tools, secondly improving the collaboration within BIM tools; thirdly, they discuss problems of using BIM during the whole lifecycle of the building which is a challenge has to be solve; finally, they argue that there is no conclusive evidence of increasing the productivity after using BIM tools alone which is point has to be clarified (Miettinen and Paavola 2014).

Typically, the construction project on one side involves many actors who use wide range of programs and tools to manage, design, control, and construct the projects and save different kinds of data and information. On the other side, the today technology has inadequate interoperability among the actors, and there is still a dearth of investigations addressing interoperability issues in the regarding of code point of view and the concept one. In this paper, we analyze the main interoperability challenges for the ACE industry regarding to the use of BIM tools and explained the barriers that prevent the development of the technology in the construction industry from the first point of view. Furthermore, we present the proposed solutions as have been represented in BIM literature and make a propose about the cloud storing with a central database to face this challenge.

21.2 Interoperability in Construction Industry

The development of the construction industry through history created new projects, more complex and have a lot of characteristics which makes them extremely difficult to predict their different outcomes. That convinced the stockholders in ACE industry to develop new ways and tools to control the whole project's processes and improve the exchanging of information and data among all the stakeholders of the project.

Interoperability in the context of the Information and Communication Technology—ICT—could be defined as the ability of different systems, computerized products, and/or individuals to work together and exchange information with each other even when they have divergent fields (Carrara et al. 2009b). This makes it one of the most important things for develop any industry, especially the construction industry where millions of information have to be exchanged among many actors. However, many issues prevent the development of interoperability which we named as interoperability barriers, which could be categorized into three main types: conceptual, technological, and organizational barriers.

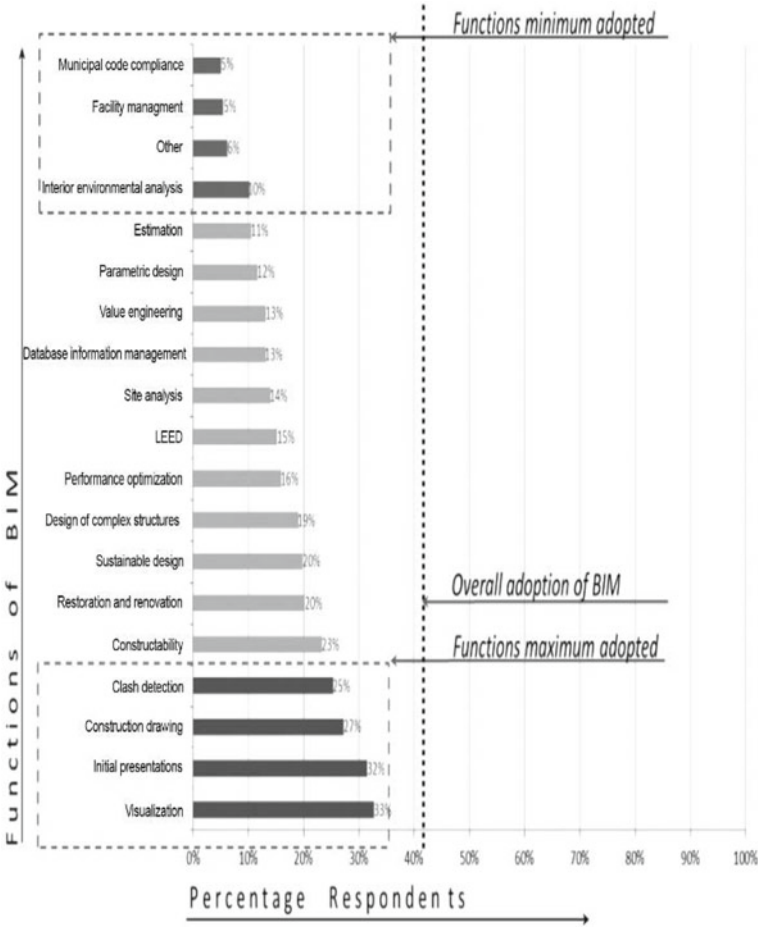

Fig. 21.2 Adoption of functions of BIM by architectural firms (Langar and Pearce 2014)

21.2.1 The Conceptual Barriers

The conceptual barriers are mainly related to the syntactic and semantic incompatibilities of information exchanged between the actors (Ullberg et al. 2009); these problems concern the modeling at a high level of abstraction and how different actor could understand the same data and information in different ways (Carrara et al. 2009a), which consider as a big challenge for the industry development, where the data mostly are collected without explanation—called implicit information which—create different kinds of problems, for example, what the architect sees as a door or a window to connect the room with the garden the energy engineer will see them as thermal bridge have to manage and take in the consideration and so on. This opens

a discussion about the actors' different goals and the future of the building information management itself where the main idea of it is to be a repository of project's data that will used during the building life cycle, which was a great idea when it first introduced, clashes the today industry situation where is required to reaches the point of knowledge exchanging instead data among the actors.

21.2.2 The Technological Barriers

The technological barriers are mainly the problems that related to the ability of the actors to effectively send, import/export, and use information and data between each other, moreover, those problems related to use the computers or ICT to communicate and exchange information (Ullberg et al. 2009). The challenges from this point of view are more related to the standardization of the files and the data formats or natural format, where through the history the number of developers increased, where almost each developer using its private data format to use their files which create the need to standardize a common standard. The first standard developed was IGES one which was use within The National Aeronautics and Space Administration—NASA—as an independent agency in the U.S. Since then, many data formats and standards have been developed and used widely like Design Web Format, Standard for the Exchange of Product Data, and Industry Foundation Classes. The last one is the most detailed, developed, and popular open standard available nowadays. IFC standard managed and developed by buildingSMART as a non-profit international organization that aims to improve the exchanging of information between software applications that used in the construction industry. BuildingSMART International has implemented the IFC standard using XML technologies as ifcXML specification (BuildingSMART 2007). XML is a platform-independent language for representing data and has been used in the development of Web service applications. However, the performance of Web services has shown a significant decrease when using XML data causing by the low efficiency of reading and parsing XML data during the execution of services.

21.2.3 The Organizational Barriers

This kind of barriers focus on the problems from the organization point of view, where the challenge here are concerned with the incompatibilities of organization structure and management techniques implemented in different enterprises and related to human problems like task distribution, responsibility, human resources management and authority (Ullberg et al. 2009).

With the first suggestion of the idea of building information modeling and during the decades of adopting it for the designing and managing the projects within the construction industry, many promises have been made about the ability of the new

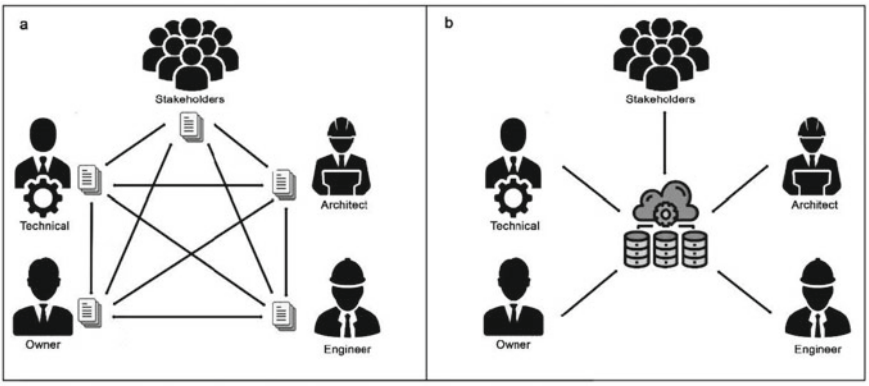

Fig. 21.3 **a** Data restricted in documents; **b** central clouding database. *Source* Own work

technology to exchange data; however, many studies established it as one of the biggest challenges for the development of the technology (Cerovsek 2011; Sattler et al. 2019; Singh et al. 2011; Tchouanguem Djuedja et al. 2019). This problem is referred to different reasons; firstly, there is a lack of multidisciplinary coordination among different stakeholders of the project; secondly, since there are many developers in this field, it become difficult to integrating different models from different sources; moreover there is a difficulty in exchanging the information between the actors of the project at the organization level; thirdly, the technology faces problem in the modifying the models using different tools due to the alternative perceptions which depend on the purpose of use; finally, different kinds of data are not easily shareable or useable, where although many documents are in electronic documents—like PDF—there is a problem in extracting the information from them; in other words, there is a rigidity in the information that is saved in this kind of files, which make them not dynamically useable. In additional to that this way required the actor to share the file with all the related actors (Fig. 21.3).

Consequently, it was understood that overcoming this challenge will bring many benefits to the entire construction industry, where it will be reflected on the efficiency and productivity within the projects on the organizational and administrative level and enhance the environmental sustainability due to better understanding and sharing models.

21.3 BIM and BPMN Integration

BPMN nowadays is one of the most advanced flowcharting tools available, where it provides an intuitive notation to represent any business process in the form of flowcharts, with a comprehensible representation of constructs defined in software-execution language and came with a clear standard which facilitates communication and understanding.

The proposed method is based on two main concepts, cloud storing and connecting, and central database, where in this method the tools are divided into three parts (Fig. 21.4). The first part—in the lift of Fig. 21.4—is the BIM model as a comprehensive repository of data related to the building during its lifecycle; the connection with this part will depend on the scripting codes to import and export data; in this part, data will be saved and used by the designers. The second part—in the right of the Fig. 21.4—part consists of the model of Business Process Model and Notation "BPMN," where this model will contain the business process description flowcharts and clarify the actor responsibilities within the process depending on the country codes where the project will be implemented. The last part will be an interface program to make the live connection between the two models allow data collected from the BIM to populate BPMN, with availability to view the entities details and description. With this connection method, we aim to overcome the rigidity of the data within the documents and speeding the designing process during the project management.

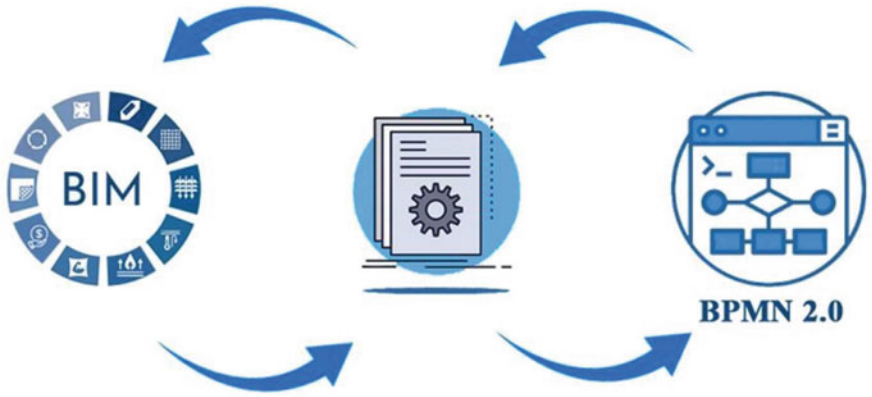

Fig. 21.4 BIM and BPMN construction data connection. *Source* Own work

21.4 Conclusion

The projects within the construction industry become more detailed through the years, which makes the right managing and exchanging information between the actors at the right time as a challenge for the industry; in this paper, we reviewed in details the types of barriers that prevent improving the interoperability within the construction industry and categorized them to three types conceptual that related to the understanding data, technological that related to the transferring data, and organizational that related to the responsibility of managing data.

In the end, we proposed a methodology adopting the idea of central database cloud connection and suggest creating link between BPMN—as a process flowcharts and collection data from the stakeholders, and BIM—as a repository of building information. This approach is supposed to overcome the data rigidity in different files and to adopt processes flowchart to increase the sharable knowledge between the actors, where the BPMN model will carry on the knowledge that will be shared.

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