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The Literature Research on Ontology of BIM in a Construction Project Life Cycle

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Abstract

The paper deals with the topic of building Information Modeling (BIM) on general level. Upon extensive literature and practice research, it was discovered, that BIM ontology is not properly defined on whole project life cycle, although there are various existing definitions of BIM. BIM can be understood in three different meanings: 1) BIM as product, 2) BIM as tool or method and 3) BIM as methodology of procurement. Paper discuss such broad understanding and propose the way how to deal with it in both scientific research and practice by proposing ontology schematics with regard to both research and common practice.

Keywords

Information Modeling; BIM; ontology; project management

Introduction

There is ongoing implementation and adoption of Building Information Modeling (BIM) going on all around the world. Practice is struggling with utilization of BIM tools and methods, trying to deliver BIM product. More and more tools and standards are being developed every day. This all is supported by extensive scientific research and information sharing throughout the world. Unfortunately, there are still many disputes about what BIM actually is, although BIM was introduced to construction industry long since 2002 [[1](#Lai02)]. During following decade, many different acronyms were also introduced [[2, s. 58](#Nie16)], but only BIM prevailed and is commonly used today. Still there are many things that can be considered fully or partly BIM and the ontology of this acronym is becoming more and more complex. This results in many misunderstandings, due to generalization and misinterpretation of what BIM actually is. The paper examines this topic, especially with regard to project life cycle.

Methodology

The research is based on extensive literature research and practical experience of the authors. Various BIM definitions were examined and compared. Based on this comparison, different understandings of BIM were formulated. As the next step, BIM was examined on a project life cycle in the same manner. Special attention was paid to examination of possible BIM benefits, risks and implementation obstacles, as such specific issues explains the role of BIM in a project life cycle more thoroughly. Based on the findings, BIM ontology in a project life cycle was possible to explain. After that, the importance of findings and future progress were discussed.

The methodology is mainly based on inductive logical methods. Observation and empirical experience was used to acquire knowledge, which was then used to develop a conclusion, containing description and explanation of examined system.

Research

The main research had two parts. The first part was dealing with BIM definitions, the second part was dealing with BIM explanation in a project life cycle.

BIM definition

Eastman, the spiritual founder of BIM, does not define BIM explicitly. Instead, he characterizes it as a technology of modeling with attached processes with the aim to communication and analysis of building models. He also characterizes building models and defines object oriented parametric modeling [[3, s. 17-18](#Eas111)]. Many authors than cite Eastman, like Crotty or Epstein, when he extends his definition of parametric modeling by parameters categorization [[4, s. 84-88](#Cro12)], [[5, s. 44](#Eps12)]. Some authors try to define BIM from they own perspective, like Hardin [[6, s. 4-5](#Har15)]. There are, of course, national standards like NBIMS-US [[7](#Nat07)], PAS-1192 [[8](#The14)] or Singapore BIM Guide [[9](#Bui131)]. Of these, only NBIMS-US offers an explicit BIM definition [[10, s. 1](#Nat12)]. Other sources usually refer to BIM, but do not define it explicitly. They focus on explanation of BIM utilization throughout the whole project life cycle instead.

Many authors use NBIMS-US BIM definition, as it is often considered as the most precise. For example, this is the case of Barnes and Davies [[11, s. 1](#Bar14)], Eynon [[12, s. 3](#Eyn16)] or Shepherd [[13, s. 8](#She15)]. The problematic part is to define something, which is constantly evolving. This confirms also Race [[14, s. 14](#Rac12)] or Barnes and Davies [[11, s. 1](#Bar14)].

There are also different perspectives on the BIM definition, usually from the point of view of specialists. Designers usually define BIM as a model [[4, s. xii-xiii](#Cro12)], although they understand BIM in the greater context [[4, s. 16](#Cro12)]. Broad view of the definition usually comes from facility managers like Reddy [[15, s. 5](#Red12)] or Epstein [[5, s. 4-6](#Eps12)]. Similar understanding of definition BIM is from sustainable engineers like Lévy [[16, s. xi](#Lév11)] or Krigiel and Nies [[17, s. 27](#Kry08)].

BIM is often mixed up with Virtual Design and Construction (VDC) and various extended Computer Aided Design (CAD) tools like Computer aided Draft and Design (CADD), Computer Aided Management (CAM) or Computer Aided Design and Management (CAD/CAM). While VDC is superior category of all, BIM and CAD should not be mistaken, although there might be tools, which can be classified as both (see figure 1).



Figure 1: Relationship of VDC tools (CAD, CADD, CAM, CAD/CAM) and BIM (source: authors).

BIM explanation

As complicated BIM definition shows, it is necessary to not only define BIM, but also to explain its meaning. Only this way common understanding may be developed. The most comprehensive explanation of BIM is through its uses in construction project life cycle. Based on literature research, two basic BIM uses were discovered:

* Primary
* Secondary

While primary BIM uses are implementing something new into project, construction company or market (for example clash detection), secondary BIM uses are only extending something, which already exists, but can be done better with BIM (for example communication). This is confirmed by some of the authors [[18](#San16)]. The extensive research found many different BIM uses in various phases of project life cycle. Also, many BIM misconceptions were identified.

In the project life cycle, BIM utilization is highly dependent on procurement system, of which the most BIM friendly is Integrated Project Delivery (IPD), followed by advanced delivery systems based on Design-Build (DB), with the Construction Management at Risk (CM at Risk) and traditional procurement systems in the end. This is very important, as it helps to define BIM in the project life cycle. Although there are various procurement systems, there still is traditional chain of programming, design, construction and operation. Many authors explain, that utilization of BIM tools and methods throughout whole life cycle is crucial (for example Jernigan [[19, s. 61](#Jer08)], Eastman [[3, s. 196-203](#Eas111)], Reddy [[15, s. 6](#Red12)] etc.) This is reflected in PAS-1192 as Project Information Modeling (PIM) and Asset Information Modeling (AIM) [[8, s. 13](#The14)] (see figure 2).



Figure 2: BIM in construction project life cycle, according to PAS 1192 (source: authors).

The necessity to define BIM not only as product or tool, but also as method and methodology, led to creation of many different acronyms is used to explain BIM in various project life cycles. The most common are Building Information Management (BIM) [[14, s. 14-15](#Rac12)] and Building Information Modeling Management (BIM(M)) [[11, s. 5](#Bar14)] of the same sense. These terms did not stick since they could be easily misunderstood as BIM. There is an argumentation that PIM should not be defined by the milestone of as-build documentation and hand over of finished construction milestone and that it should cover whole project life cycle from programming to project liquidation. But the hand over milestone is considered so important not only in terms of contracting, but also in terms of interoperability, that those two phases should be differentiated. Then Project Life Cycle Information Modeling (PLIM) is proposed [[14, s. 15](#Rac12)]. There is also Facility Information Modeling (FAM), which is equivalent to AIM. For construction phase, also Virtual Construction Model (VCM) is proposed [[13, s. 76](#She15)] as a product, opposed to BIM, for purposes of differentiation. From the methodology perspective, construction is covered by PIM.

Results

Although various definitions of BIM are often very different, they are connected with common denominators, which are:

* Parametric, object oriented models
* Information sharing and collaboration
* Utilization throughout whole project life cycle

As the most comprehensive and universally acceptable definition is a definition of NBIMS-US, which can also be extended [[12, s. 3](#Eyn16)]:

*“Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.”* [[10, s. 1](#Nat12)].

The understanding of BIM may be divided into three categories, based on BIM explanation, which are:

* BIM as a product.
* BIM as a tool or method.
* BIM as a methodology of procurement.

As optimal BIM ontology in project life cycle may be considered extended PAS-1192 representation, which may be examined in figure 3.



Figure 3: Relationships of BIM, PIM, AIM and PLIM in construction project life cycle (source: authors).

Unfortunately, this ontology is often misinterpreted or generalized, especially in practice and public, as show in figure 4. Terms like PIM, AIM or PLIM are often considered *just BIM*, although there is a huge difference, especially when specific understandings of BIM, which were mentioned earlier in this paper, are discussed.



Figure 4: Misinterpreted BIM (source: authors).

Unfortunately, thanks to many misinterpretations and marketing push in the market, term BIM has become defiled. On the other hand, it is necessary to have proper governing term in case no further specification is necessary. BIM is filling this role perfectly, as long as one is not digging into its ontology too much to find multiple meanings behind it. Proposed BIM ontology in construction project life cycle with regard to common BIM generalization is shown in figure 5.



Figure 5: Proposed BIM ontology with regard to common BIM generalization (source: authors).

Conclusion and Discussion

As paper explained, there are various definitions of BIM and there are various understandings of BIM. While BIM definitions are usually in the conjunction and supplement each other, different understandings of BIM ontology are often source of many misinterpretations and misunderstandings. BIM is often referred as something, which can be described different way or with better acronyms. These acronyms are sadly not used.

The paper proposes simple ontology schema to describe BIM in construction project life cycle, addressing the most common issues of misunderstanding by defining proper relationships between BIM acronyms. The ontology definition also considers understanding BIM in broad variances of its meaning, based on various available definitions. With these important facts in mind, BIM can be used like it is used now to govern all possible related topics, but when discussed in more detailed way, it is necessary to use proposed ontology to specify BIM more.

In the future, not many related changes are expected, although new acronyms and meaning may arise. They might be simply included into ontology later on.

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