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A Review of BIM Technology Based On the Cloud Used In the Construction Sector

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SUMMARY : *Cloud computing technology is recognized as a major transformative force that will bring unprecedented change in the areas of communication and business. In the building, engineering and construction industries, cloud BIM integration is seen as the second generation evolution of Building Information Management (BIM) and is expected to create a new wave of change throughout the construction industry. Nonetheless, few studies have attempted to summarize research literature on cloud BIM. This white paper explores the literature to identify important work on cloud BIM, especially related to building lifecycle management, to provide practitioners with valuable insights, and to suggest paths to further research. Thirty academic sources, including peer-reviewed journal articles and conference papers, have been researched and analyzed in terms of research focus and application type. According to reviews, most cloud BIM surveys focus on the planning / design and construction stages of the building. This result suggests that more research needs to be done towards the demolition and decommissioning stages of operations, maintenance, equipment management, energy efficiency and building lifecycle management. Further empirical research on organizational and legal issues such as cloud BIM model security, accountability, responsibility, and model ownership is also needed.*

KEYWORDS: *Cloud computing, BIM, construction sector, building life cycle.*
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I. INTRODUCTION:

1. Introduction As building information management (BIM) and visualization techniques advance traditional architectural, engineering, and construction (AEC) practices (eg Li et al., 2008; Baldwin et al., 2009; Dunston and Wang, 2005, 2011a & b; Wang and Dunston, 2011; Park et al., 2013; Wong et al., 2014a & b) and the oil and mining industry (egHou et al., 2014a, and Wang et al., 2014). Innovation Cloud and mobile technology are expected to usher in the next wave of technological development that will take the construction industry to the next level of technological advancement (Anumba and Wang, 2012a & b; Wang and Dunston, 2012; Wang). et al., 2013). According to a recent report by McGraw Hill Construction (2014), introducing BIM into a construction project not only improves collaboration between project stakeholders, but also reduces errors and omissions, which is a positive benefit to investing in BIM. Will be brought. But at the same time, BIM has been criticized as a stand-alone system framework that restricts access to common data or information sets by project stakeholders (Chunag et al., 2011). The initial investment cost of the BIM system is also high (Kim, 2012). The new cloud BIM technology is seen as a tool that can address the stand-alone nature of traditional BIM. This enables a higher level of collaboration and collaboration and provides project team members with an effective real-time communication platform. To date, there are no reviews of existing developments and research on cloud BIM. Therefore, the comprehensive overview presented in this paper is very helpful in identifying where further efforts are needed and in determining the direction of future research. This academic paper summary provides valuable insights for industry experts and BIM developers involved in implementing cloud BIM. The purpose of this white paper is to 1) research cutting-edge cloud BIM technology and provide a comprehensive literature review of its implementation in building lifecycle management, and (2) current trends and research in this area. Is to identify and emphasize the gap in. This paper is divided into the following sections. First, Section 2 describes cloud computing terminology. Section 3 shows the literature search method and literature source. The current state of cloud BIM development and academic research is summarized and explained in Section 4. Finally, we discuss research gaps and further research, and the conclusions are presented in Section 5.

2. WHAT ARE CLOUD COMPUTING AND CLOUD-BASED BIM?

Cloud computing is a rapidly evolving technology that can be used in communication devices such as PCs, tablets and smartphones. The concept of cloud computing was introduced in 2004 (Vouk, 2008), but has been recognized since October 2007 (Lohr, 2007) when IBM and Google announced a joint cloud project. Vaquero et al. (2009) Discovered more than 20 definitions of cloud computing. Of these, the National Institute of Standards and Technology (NIST) definition (Mell and Grance, 2011) is the most widely used. According to NIST, cloud computing provides ubiquitous and convenient on-demand network access to shared pools of configurable computing resources (networks, servers, storage, applications, services, etc.) that are quickly provisioned and released. A model for. With minimal effort, administrative burden or interaction with service providers. " The cloud computing architecture consists of four layers: applications, platforms, infrastructure, and hardware (top to bottom) (Zhang et al.2010).

The hardware layer consists of physical resources in the cloud (that is, computing devices such as servers). The infrastructure layer is also known as the "virtualization layer" because it manages computing resources by using virtualization technology to divide physical resources. The platform layer consists of an operating system and application framework that offloads virtual machines and acts as a kind of virtualization server. The top tier is the application tier or the actual cloud application. These layers are loosely coupled and each layer can be evolved separately (Zhang et al. 2010).There are several ways to classify cloud computing technologies. According to Kang et al. (2008), cloud computing includes private clouds (used to generate services using private IT assets), public clouds (IT ownership is extended externally in the service business), and mixed clouds (private). It can be divided into three main categories (mixed). And public cloud systems). In addition to these three delivery models, Mell and Grance (2011) proposed a community cloud model. Private clouds are used exclusively by a single organization with multiple consumers. The community cloud is only used by specific consumer communities in organizations that have a common cause. Public clouds are generally accessible open access clouds It is accessible to the public. A hybrid cloud is an infrastructure that spans two or more cloud delivery models (private, community, public, etc.). NIST has defined three service models and four delivery models for cloud computing (Mell and Grance, 2011). These models can be combined in different ways, providing different business opportunities for different organizations. The service and deployment models have different strengths and weaknesses that allow organizations to choose the right combination to suit their needs when migrating to a cloud environment. The three service models are 1) Software as a Service (SaaS), 2) Platform as a Service (PaaS), and 3) Infrastructure as a Service (IaaS) (Mell and Grance, 2011). SaaS is a service that allows users to use software applications over the Internet by connecting to a service provider through a browser. Examples of SaaS are Salesforce.com, Rackspace Google Doc, Google App, Yahoo Mail, and Microsoft Office Live (Zhangetal. 2010; Bhardwajet al., 2010; Tao et al., 2011). SaaS is suitable for small businesses because service providers maintain and manage software and hardware (Zhangetal. 2012). PaaS users can develop their own applications and transfer them to other clients over the Internet. The advantage of PaaS is that end users can develop their own applications, libraries, and tools to support their services using programming languages. Zhang. (2010) and Taoetal. (2011) shows examples of PaaS such as Google App Engine, Force.com, 800App, Microsoft Azure. With IaaS, service providers provide only hardware such as storage, virtualization, and processing power. End users can only pay for hardware and deploy software to serve their customers. IaaS can significantly reduce end-user hardware costs (Mell and Grance, 2011). Examples of IaaS are Amazon's EC2, GoGrid's Cloud Server, Joyent, and Flexiscale (Zhang et al., 2010; Tao et al., 2011).

Cloud computing technology has been widely adopted in various industries in recent years. Razak (2009) proposed the use of cloud computing technology to improve education and learning at Malaysian universities. Ercan (2010) reviewed cloud computing and considered its use in educational settings. Khmelevsky and Voytenko (2010) have developed an infrastructure prototype for using cloud computing in university education and research. Regarding the use of cloud computing in healthcare, Stein (2010) argued that it was time for genomic informatics to move to the cloud. Rolimetal. (2010) proposed the use of cloud computing to collect patient data in the medical setting, but Doukasetal. (2010) suggested that data can also be managed through cloud computing. Please read al. (2013) Proposed to share personal health records and Rosenthal et al. (2010) Information suggested to be shared with the biomedical informatics community via cloud computing.

3. Review of cloud BIM technology development in building area

3.1 Methodology:

We applied a two-step literature review method to explain and investigate the use of cloud BIM technology in construction and identify journal articles published in peer-review journals, conference minutes, and other scholarly publications. First, we performed a comprehensive literature search on Scopus, SCI, and Google Scholar using the "Title / Summary / Keywords" search method. Search terms were cloud BIM, cloud computing under construction, and so on. Articles with these specific terms in their titles, summaries, or keywords have been selected as possible publications. Then, with the support of search engines, a more targeted and comprehensive search was performed. Articles (journals and conferences) and reviews were included, including editorials, book reviews, editorial letters, discussions / conclusions and commentary. Finally, a total of 30 Cloud BIM-related articles were identified and included in the literature review. Some current trends were clear:

1.Cloud BIM is a new field of study in construction IT research. The first publication on Cloud BIM was published around 2010/11, and the number of publications has been steadily increasing since then.

2.The standards associated with 30 publications directly related to Cloud BIM (excluding internet sources) include 15 journal articles, 7 conference articles, and 8 other publications (eg, applied journal books or articles). Was included. Many of the journal articles are published in the trade journals Automation in Construction and Journal of Information Technology in Construction (ITCON).

3.2 An overview of cloud-based BIM research

The integrated cloud BIM model is considered a second generation BIM, enabling a higher level of collaboration and collaboration, and a more effective real-time communication platform for project team members (Figure 1). However, the technology for the construction industry is still relatively new. Redmond et al. (2012) We conducted semi-structured interviews with 11 experts to find out how cloud BIM can be used to improve the information exchange process. They conclude that cloud-based BIM has the potential to create a variety of discipline opportunities for sharing and exchanging data needed for critical decisions early in design. Porwal and Hewage (2013) suggested that integrating cloud computing into the BIM Partner Framework can facilitate pre-planning for sustainable construction throughout the project lifecycle. Chung et al. (2014) Review six cloud-based BIM systems, Autodesk BIM 360, CADD Force, BIM9, BIMServer, BIMx, and OnumaSystem, only three of these systems support private clouds and only two I found it to be a recognized IFC file. Chung et al. (2014) He further argued that current cloud-based BIM software may not be suitable for small contractors, and that only five types of software meet the needs of large contractors.

Some cloud BIM research focuses on developing deployment models or frameworks. Kumar and Cheng (2010) reviewed cloud computing techniques and proposed a framework for implementing cloud computing for sharing information in the construction industry. They found that interoperability was the key to a successful cloud implementation. Chuangetal. (2011) Proposed to integrate a SaaS-based visual cloud system with BIM to visualize and manipulate BIM, but did not provide details of the system deployment model. Juan and Zheng (2014) developed a framework to integrate BIM with hybrid cloud delivery and demonstrated how to apply the system to real construction projects. Meza et al. (2014) We developed a BIM-based augmented reality system and used a cloud computing environment in the data phase. However, cloud computing is only used as a platform for sharing information, and this study does not provide details on how to implement cloud computing.

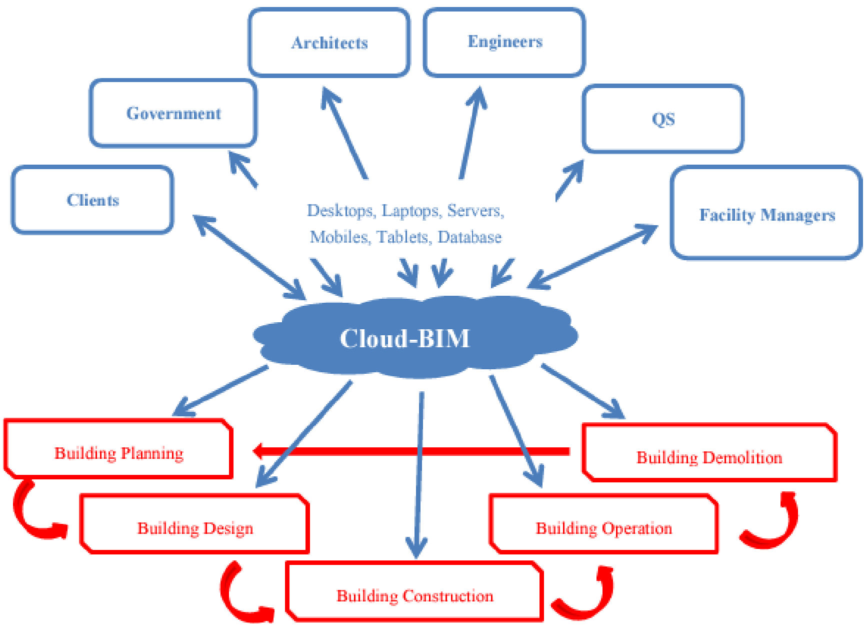

FIG. 1: Cloud-BIM Concept

Some researchers have tried to apply and test this technique in the real construction industry. For example, Wu and Issa (2012) integrated BIM and cloud computing to automate the energy and environmental design leadership (LEED) process for green building certification. They suggested using cloud services from various service providers (such as Autodesk Revit's private cloud server STRATIS) to achieve LEED automation. Sawhney and Maheswari (2013) proposed a framework for tracking the history of design information in cloud-based BIM. Grilo and Jardim-Goncalves (2011) integrated model-driven cloud computing with BIM. Some researchers have tried to apply and test this technology in the real construction industry. For example, Wu and Issa (2012) integrated BIM and cloud computing to automate the energy and environmental design leadership (LEED) process for green building certification. They suggested using cloud services from various service providers (such as Autodesk Revit's private cloud server STRATIS) to achieve LEED automation. Sawhney and Maheswari (2013) proposed a framework for tracking the history of design information in cloud-based BIM. Grilo and Jardim-Goncalves (2011) integrated model-driven cloud computing with BIM.

Jiao et al. (2013) Proposed a cloud-based BIM tool for life cycle data management in the design, construction and facility management of Shanghai Center in China. During the design phase of this project, Autodesk Revit was adopted to develop the first cloud BIM model. The BIM model was then transferred to another format (LBIM format) and imported into the cloud platform. In this case, the SaaS model was used. Since then, cloud-based BIM has been used during the design phase and all 72 models have been revised 56 times via the platform. Research has concluded that using cloud-based BIM can speed up the construction process and reduce costs (Jiao et al., 2013). Despite this positive result, it was also reported that some data was lost when transferring the BIM model to the cloud server. Jiao et al. (2013) also suggests that cloud-based BIM can be used for lifecycle data management, although no detailed validation work has been done.

Since the concept of cloud computing is new to the construction industry, only a limited number of scientific treatises have been identified in the literature. One of the observations is that the current application of cloud-based BIM focuses on the building planning / design and construction phases, while in the operations, maintenance and building management, energy efficiency, demolition and demolition phases. The application is overlooked. Jiao et al. (2013) showed that cloud computing is a useful tool for managing data throughout AEC's lifecycle and facility management, but provides no further details. Another problem with existing cloud BIM surveys is that few surveys have evaluated their effectiveness. Some kind of evaluation, such as Jiaoetal. (2013) There is a lack of details about the evaluation method and how the evaluation was performed. A structured methodology for evaluating cloud-based BIM should be developed in future research.

4. DISCUSSION AND FUTURE RESEARCH

According to literature reviews, most research efforts on cloud BIM focus on the building design and construction stages. During the building operations / maintenance and facility management phases, traditional BIM models provide visualization, access to the exact location and relationships between the building system and equipment, automatic generation of equipment inventory, and accurate information about the current state. Access is provided (Starkov, 2014)). You can extend Cloud BIM to provide an efficient means of identifying your facility's maintenance needs, original equipment manufacturer (OEM), and fast real-time access to building maintenance records. It will also allow clients and facility managers to manage real-time data on the current state of the property and extend it to facilitate analysis of alternative materials and systems, such as life and cost analysis of various building products. can also do.

The application of traditional BIM systems and cloud-based BIM for demolition and planning of existing buildings (such as demolition simulation) (Cheng and Ma, 2013, etc.) is still limited. Research on cloud BIM in this area is still new (Volk et al., 2014). Cloud BIM technology must incorporate long-lived building demolition and recycling capabilities, such as building demolition and recycling dates, waste management, and data on the assessment of material properties for recycling / reuse / landfill.Cloud BIM needs to be extended to provide cost analysis. Compare the cost of building renovation or demolition to help owners and clients make decisions.

While it is widely recognized that BIM-based technology is useful for helping project stakeholders to capture complete design and project information, it is also increasingly documented that BIM can make the best use of the available design data for sustainable design and sustainability rating analyses (e.g. Wong et al., 2013; Wong and Lau, 2013; Wong and Kuan, 2014; Wong et al., 2014a&b). Energy modelling work, however, is still considered a time-consuming and costly exercise (Yoders, 2014). Recently, a cloud-based BIM tool was developed to provide real-time building energy performance analysis (i.e Autodesk Formlt). The tool involves a Web- and mobile-based application (i.e. iPad/smart phone app) that enables users to gather instantaneous energy performance feedback on their design decisions and plans, such as the building orientation, thermal performance and massing. Another new cloud-BIM model involves a real-time cloud-based collaborative platform, which allows the architect and design consultants to work simultaneously on the data and model, and to import the results into BIM software such as Revit and Navisworks from virtually any mobile device. Further research efforts are needed to perform building sustainability analysis and explore patterns in business process modeling. B. Information flow and exchange requirements of various team members for projects aimed at achieving certification of sustainable building rating systems through cloud BIM technology (Wu and Issa, 2012).

Problems with cloud BIM model interoperability, model validation, and evaluation need to be addressed in future research (Wu and Issa, 2012).

Following the integration of cloud-based technology, BIM allows the remote exchange of data over a wireless network such as the Internet (Ijeh, 2012). However, the data management of a construction project becomes an issue that requires attention with the growing trend of cloud-BIM integration. While more data can be moved and shared amongst the project team via the Web, this type of cloud-based collaboration will require more powerful Web-based operating systems, file-sharing platforms and hardware controllers to support the consolidation and archiving of and increased access to project data (i.e. `big data`) (Yoders, 2014). In addition, the collaborative exchange model of cloud computing triggers security challenges, including the issues of responsibility, liability and model ownership arising from the system (Mahamadu et al., 2013). According to the latest report by McGraw Hill Construction on global BIM adoption (2014), contractors in many countries have expressed moderate (e.g. Germany, Japan, Brazil, Australia and New Zealand, France, Canada) to high (e.g. Korea, US and UK) levels of concern over the security of cloud technology. Contractual issues such as uncertainties about ownership of shared data and inadequate contractual relationships are currently considered the major obstacles to the adoption and integration of BIM and cloud computing (Redmond et al, 2012).). Uncertainty about security mechanisms and poor reputation of cloud providers' capabilities and capacity pose challenges in the development of secure technologies for cloud BIM integration (Pearson and Benameur, 2010; and Sengupta et al. 2011). Inadequate information division and protection, and lack of a clear relationship management approach pose a risk to those who adopt cloud computing. Mahamadu et al. (2013) have shown that further research is needed to address data security, ownership, and stability issues to ensure secure collaboration using cloud BIM technology. rice field. Logical project-based solutions need to be set up at four levels: infrastructure and engineering, information division and protection, legal and contract management, and relationship management (Mahamadu et al., 2013). Some researchers (Zhang et al., 2014, etc.) have improved the efficiency and quality of information extraction / delivery to ensure the security and legality of data exchange via cloud BIM during the building life cycle. Other researchers have tried to improve, but because BIM-related legal and organizational frameworks vary from country to country, understanding the responsibilities, responsibilities, and model ownership of cloud BIM technology (Volk et al., 2014).

Cloud BIM is still considered a new technology, and further efforts through education, training, and changing industrial culture are needed to increase understanding and acceptance of this promising technology. Cloud-based websites or apps have been recognized to help improve communication and collaboration between onsite and offsite construction team members, thereby increasing their "competitive advantage" in the industry. But an important concern is the acceptance of technology-related costs. Collaborative motivation and cultural differences are seen as the main barriers to the implementation of BIM technology, but training time and costs are hampering the adoption of cloud and BIM technology within the sector (RICS, 2013). Year). Studies show that the industry lacks qualified personnel and experts to implement BIM in new buildings (Volk et al., 2014; Bryde et al., 2013; Becerik-Gerber et al., 2012.). Industry leaders and institutions need to develop CPD training, set industry standards, and integrate cloud BIM technology into professionals and higher education.

Cloud computing technology will certainly have a profound effect on the AEC industry. Therefore, this special issue of ITcon aims to bring together some of the most recent developments in the theory and application of cloud computing technology in the AEC industry. For example, Xu et al. (2014) proposes a new concept of the City Information Model (CIM) with the aim of bringing great benefits to urban construction and city management. This model aims to improve information sharing and cooperation across departments and fields, and at the same time achieve comprehensive horizontal and vertical digital city management, improve the overall efficiency of urban management. Goulding et al. (2014) presented a new approach to support non-partitioned design teams using a Game-Like VR environment mixed with social science theory (social rule) and scientific theory. behavioral learning (decision science/communication science). This study provides new understanding and insight into the causal and influencing factors involved in successful design decision-making in non-partitioned design teams. Improving health and safety in the construction industry is a major concern. Dawood (2014) developed an approach to enable serious play in the sandbox style through the conceptual encapsulation of 4D (3D + time) in game design with the assumption that this approach would influence to students' ability to detect security risks and how they interact. with the game. Liu et al. (2014) presented a framework for creating a library of human behaviors through a BIM-based cloud game environment, allowing gamers to access games through applications. thin guests. The proposed framework is capable of collecting and collecting data on human evacuation behavior from a larger number of people. Abrishami et al. (2014) proposed a conceptual framework for a “generated design workspace” that uses BIM as the central conduit. It is acknowledged that to meet all BIM Level 3 (Cloud) requirements, a fully integrated system supports all professional and construction team members, including AEC designers , is a necessity. This study provides an example of digital integration in all phases of AEC projects and BIM Level 3 (Cloud) implementations. Hou et al. (2014b) developed a conceptual framework aimed at improving productivity in the LNG construction industry. New context-aware mobile computing framework-based approach incorporating innovative concepts and technologies, including but not limited to information and communication technology (ICT), information modeling building (BIM), advanced visualization, radio frequency identification (RFID) and laser scanning. . Finally, Yung et al. (2014) developed a BIM-compatible MEP coordination process based on the IDEF0 language, especially suitable for the construction industry in China. The document provides clear explanations of the inputs, controls, mechanisms, and outputs of each subprocess of the BIM-compatible design process so that students can easily apply the model in real projects.

5. CONCLUSION

In recent years, the number of academic works on cloud-BIM applications aimed at promoting and transferring technology to industry has increased. However, such implementation is still in its early stages, with limited industry adoption focusing heavily on the design and construction phases. Despite the rapid growth of cloud technology in the IT sector, to date only about 30 publications have presented the most advanced research and applications of cloud-based BIM. The results of our literature review show that the main challenges facing the industry with cloud-BIM adoption are i) lack of clarity on who has accountability, responsibility, and ownership of resources. cloud-BIM model, ii) lack of experts and technicians who can create, update and maintain information on BIM cloud, and iii) need for professional education and training in new technology. Organizational and legal issues are considered the main obstacles to cloud-BIM implementation. Future research should further explore the potential of cloud-BIM in building operation/maintenance and facility management. The application of cloud BIM for demolition/clearance planning is also an unexplored area of research.

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