แนวการเขียนรายงานการไปฝึกอบรม ดูงาน ประชุม / สัมมนา
ตามระเบียบมหาวิทยาลัยสุโขทัยธรรมาธิราช ว่าด้วยการให้ทุนฝึกอบรม ดูงาน
และประชุมทางวิชาการแก่บุคลากรของมหาวิทยาลัย

รายงานผล

ประชุมวิชาการ
เรื่อง “A Study of Workflow with Synchronization of Design Process on Autodesk Construction Cloud”

ตำแหน่ง อาจารย์ประจำสาขาวิชาวิทยาการจัดการ
สังกัด สาขาวิชาวิทยาการจัดการ โทร. 8181 - 6

โครงการนี้ได้รับการสนับสนุนจากทุนพัฒนาบุคลากรเพื่อการศึกษาทางไกล
ประจำปีงบประมาณ 2568

1. โครงการประชุมวิชาการ 1st International Conference on Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions CEES 2024 เรื่อง“A Study of Workflow with Synchronization of Design Process on Autodesk Construction Cloud” **(รูปแบบออนไลน์)** ณ Prince Mohammad Bin Fahd University, KSA ณ ราชอาณาจักรซาอุดีอาระเบีย ตั้งแต่วันที่ 3 – 5 พฤศจิกายน 2567 รวมระยะเวลา (ปี เดือน วัน) 3 วัน

2. รายละเอียดเกี่ยวกับการไปฝึกอบรม ดูงาน ประชุม และสัมมนา ควรรายงานให้มีรายละเอียดและเนื้อหามากที่สุด เท่าที่จะทำได้ โดยบรรยายสิ่งที่ได้สังเกต รู้ เห็น หรือได้รับถ่ายทอดมาให้ชัดเจนในหัวข้อต่าง ๆ เช่น

2.1 <u>รายงานการประชุม/สัมมนา</u>

(1) หัวข้อเรื่อง “A Study of Workflow with Synchronization of Design Process on Autodesk Construction Cloud” วัตถุประสงค์ของการประชุม เพื่อการเผยแพร่ผลงานวิชาการในเวทีระดับนานาชาติ

(2) ผู้เข้าร่วมประชุม/สัมมนา (ระบุจำนวนรวมและสังกัด เช่น เจ้าหน้าที่จากกระทรวงมหาดไทย 5 คน อาจารย์/ผู้เชี่ยวชาญจากมหาวิทยาลัยต่าง ๆ 10 คน)

(3) วิธีการประชุม/สัมมนา รูปแบบออนไลน์

(4) เข้าประชุมเป็นการเข้าร่วมประชุมในรูปแบบออนไลน์

(5) กรณีเข้าร่วมประชุม/สัมมนา ควรประมวลชื่อบทความทางวิชาการและเอกสารประกอบการประชุม/สัมมนา ที่เห็นว่าน่าจะเผยแพรให้ผู้อื่นได้ทราบ

(6) ผลการประชุม เป็นการนำเสนอบทความ เรื่อง “A Study of Workflow with Synchronization of Design Process on Autodesk Construction Cloud”

(7) ประโยชน์ที่ได้รับ

7.1 การเผยแพร่ผลงานวิชาการในเวทีระดับนานาชาติ โดยอาจารย์ประจำหลักสูตรฯ เกี่ยวกับการประยุกต์ใช้ Autodesk Construction Cloud สำหรับการปรับปรุงกระบวนการทำงานและการออกแบบก่อสร้าง ซึ่งมีส่วนสำคัญที่ช่วยส่งเสริมการพัฒนาโครงสร้างพื้นฐานที่ยั่งยืนในปัจจุบัน ที่เป็น State – of – the – art ตลอดจนการเผยแพร่เกี่ยวกับการสร้างความตระหนักรู้ในนวัตกรรมของอุตสาหกรรมก่อสร้างความตระหนักรู้ในนวัตกรรมของอุตสาหกรรมก่อสร้างในประเทศไทย โดยชี้ให้เห็นถึงกระบวนการทำงานร่วมกันอย่างมีประสิทธิภาพ ช่วยลดความยุ่งยากในขั้นตอนของการจัดการข้อมูล รวมทั้งการมีส่วนสนับสนุนต่อการเพิ่มผลิตภาพและความสามารถในการประสานงานระหว่างทีมงานต่าง ๆ โดยเฉพาะสำหรับช่วงเวลาของการออกแบบที่ส่งผลต่อเนื่องในกระบวนการก่อสร้างต่อไป ซึ่งเป็นส่วนหนึ่งของขั้นตอนการบริหารและจัดการโครงการก่อสร้างที่สำคัญ

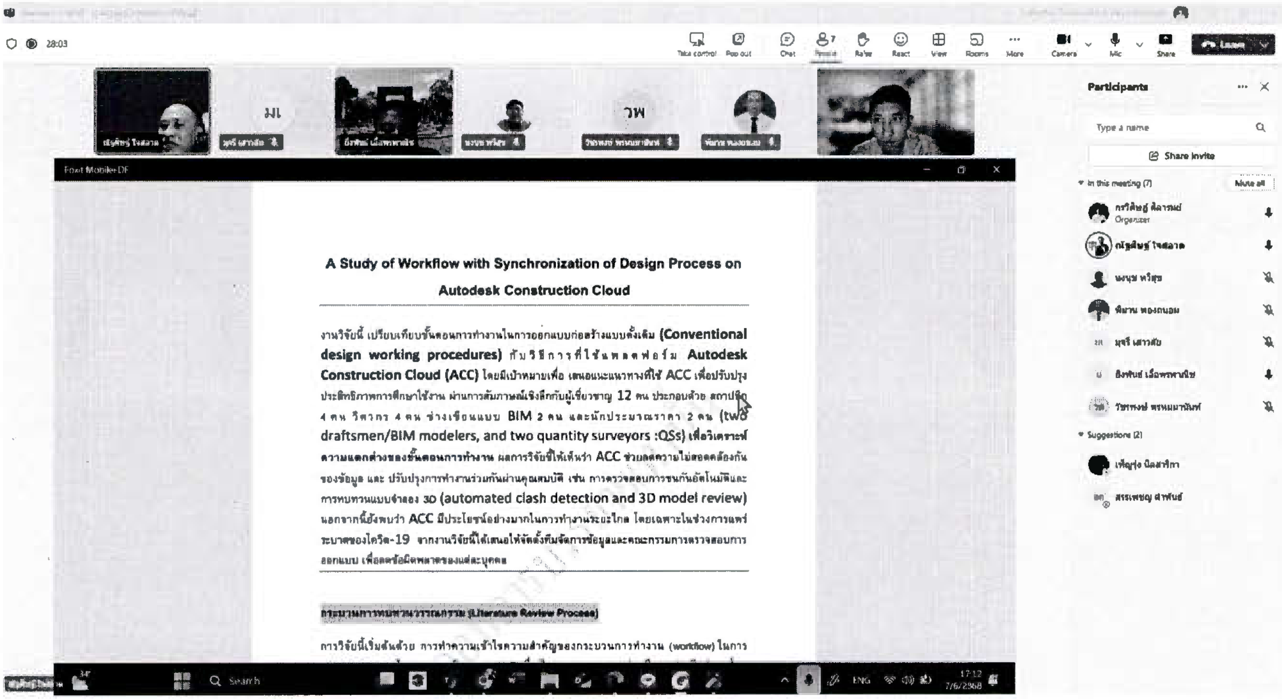
7.2 มีส่วนช่วยสร้างความตระหนักรู้และชื่อเสียงให้กับหลักสูตรฯ ว่าด้วยการนำเสนอผลงานในระดับนานาชาติ ที่เป็นความร่วมมือของอาจารย์นักวิชาการร่วมกับส่วนงานภาคปฏิบัติในอุตสาหกรรมก่อสร้างของประเทศไทย โดยผลงานนี้ได้รับการตรวจสอบตามมาตรฐานกระบวนการ Peer Review แบบ Double Blind ผ่านการตอบรับให้นำเสนอผลงานได้ โดยงานประชุมวิชาการ CEES 2024 ดังกล่าวรับการยอมรับในแวดวงก่อสร้างตลอดจนหน่วยงานในระดับนานาชาติที่มีชื่อเสียง ทั้ง McGrawHill, ASCE (American Society of Civil Engineers), SCOPUS, WILLY, Clarivate (Web of Science Conference Proceeding Citation Index)

(8) ข้อเสนอแนะ (โดยเฉพาะอย่างยิ่งข้อเสนอแนะที่จะเป็นประโยชน์ต่อการดำเนินงานของมหาวิทยาลัยถ้าเป็นข้อเสนอของผู้เขียนรายงานให้ระบุไว้ด้วย)

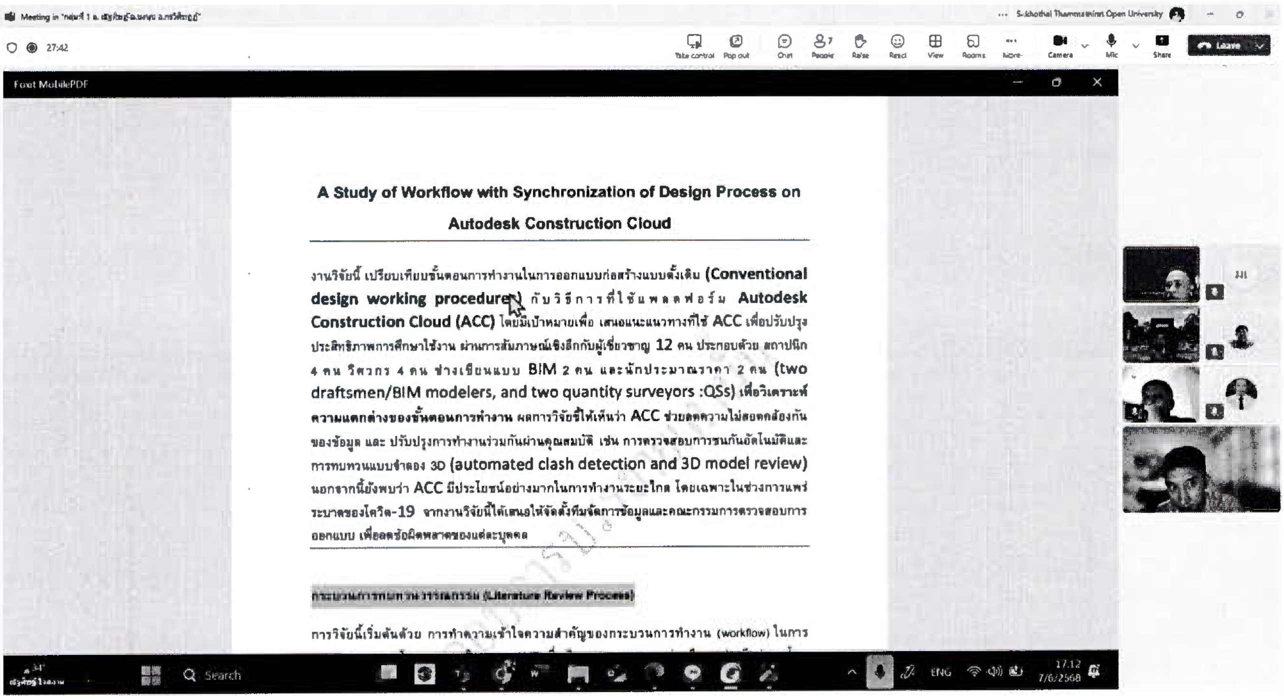
<u>หมายเหตุ</u> 1. กรณีไปฝึกอบรม ดูงาน ประชุม/สัมมนา เป็นหมู่คณะโปรดระบุชื่อผู้ไปร่วมกิจกรรมดังกล่าวทั้งหมดและเสนอรายงานในชุดเดียวกัน

2. รายงานควรมีความยาวประมาณ 5 - 10 หน้า และถ้ามีรายงานต่างหากเพิ่มเติมก็ให้แนบไปด้วย ทั้งนี้เพื่อที่ผู้สนใจซึ่งมิได้ไปฝึกอบรม ดูงาน ประชุม/สัมมนา จะสามารถหาความรู้จากเนื้อหาสาระดังกล่าวได้ตามสมควร

3. ให้ผู้ที่ได้รับทุนส่งรายงานการฝึกอบรม หรือดูงาน หรือประชุมทางวิชาการ จำนวน 1 ชุด



A Study of Workflow with Synchronization of Design Process on Autodesk Construction Cloud
งานวิจัยนี้ เปรียบเทียบขั้นตอนการทำงานในการออกแบบก่อสร้างแบบดั้งเดิม (Conventional design working procedures) กับวิธีการที่ใช้แพลตฟอร์ม Autodesk Construction Cloud (ACC) โดยมีเป้าหมายเพื่อ เสนอแนะแนวทางที่ใช้ ACC เพื่อปรับปรุงประสิทธิภาพการศึกษาใช้งาน ผ่านการสัมภาษณ์เชิงลึกกับผู้เชี่ยวชาญ 12 คน ประกอบด้วย สถาปนิก 4 คน วิศวกร 4 คน ช่างเขียนแบบ BIM 2 คน และนักประมาณราคา 2 คน (two draftsmen/BIM modelers, and two quantity surveyors :QSs) เพื่อวิเคราะห์ความแตกต่างของขั้นตอนการทำงาน ผลการวิจัยชี้ให้เห็นว่า ACC ช่วยลดความไม่สอดคล้องกันของข้อมูล และ ปรับปรุงการทำงานร่วมกันผ่านคุณสมบัติ เช่น การตรวจสอบการชนกันอัตโนมัติและการทบทวนแบบจำลอง 3D (automated clash detection and 3D model review) นอกจากนี้ยังพบว่า ACC มีประโยชน์อย่างมากในการทำงานระยะไกล โดยเฉพาะในช่วงการแพร่ระบาดของโควิด-19 จากงานวิจัยนี้ได้เสนอให้จัดตั้งทีมจัดการข้อมูลและคณะกรรมการตรวจสอบการออกแบบ เพื่อลดข้อผิดพลาดของแต่ละบุคคล
กระบวนการทบทวนวรรณกรรม (Literature Review Process)
การวิจัยนี้เริ่มต้นด้วย การทำความเข้าใจความสำคัญของกระบวนการทำงาน (workflow) ในการ



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A Study of workflow with synchronization of design process on autodesk construction cloud

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Keywords: Autodesk Construction Cloud, Workflow, Design Working Procedures, Synchronization, BIM Maturity

Abstract. This research aims to accomplish two primary goals: (1) To compare workflows in the design department between conventional design working procedures and collaborative processes driven by ACC-supported approaches. Understanding the key distinctions and similarities between these two approaches is crucial. (2) To suggest replacing the current workflow with one that utilizes synchronization of the design process on the ACC platform. Five key semi-structured interview questions were developed using qualitative research methods. These questions guided the analysis of content from in-depth interviews with twelve professionals. They included four architects, four engineers, two draftsmen/BIM modelers, and two quantity surveyors (QSs). QDA Miner Lite was selected as the research software to facilitate data analysis. This research identified key differences between conventional design processes and those using Autodesk Construction Cloud (ACC), particularly in data workflow. Cloud-BIM, like ACC-supported approaches, utilizes a centralized, administrator-managed process for data transmission, minimizing inconsistencies. This streamlined approach from ACC saves time and improves collaborative design efficiency. In addition, ACC workflows also offer a significant advantage in monitoring and synchronization. They incorporate automated clash detection and 3D model review. Combining A/E Drawings is another area where ACC excels. Conventional design processes typically require complete DWGs upfront, which can easily lead to inconsistencies. In contrast, ACC utilizes an automatic 3D inspection system, enhancing clarity and ensuring initial accuracy. Additionally, ACC generates complete DWGs as the final deliverable. Finally, the research recommends using ACC-Synchronized Design to minimize human error. To achieve this, it suggests establishing two key measures: (1) A data management team to handle data reception, transmission, and centralized storage. (2) An expert-led design review committee to conduct a comprehensive assessment of the design to ensure its constructability.

Introduction

When project requirements are clearly understood in architectural and engineering (A/E) design, a collaborative process involving various teams is triggered. These teams primarily consist of architects, structural engineers, building systems engineers, quantity surveyors, and BIM modelers (formerly draftsmen). Within this process, a workflow emerges, a structured representation of tasks, activities, and steps needed to complete a specific process or achieve a particular goal. This workflow outlines the sequential order of tasks, the conditions for their execution, and the interactions among different components or participants in the process. A General Workflow Management System (GWMS) architecture fosters interoperability across applications and platforms. This is achieved through integrated application coordination, system enhancements, and

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user/third-party developer utilities [1].Workflow management centers on information processes through a system based on coordination among users of networked computers.This system was known at the time as "Computer-Supported Cooperative Work (CSCW) [2, 3]." Consequently, workflow originally defined as a series of operations on information objects like forms or stored images, relies on user routing and providing information for automated actions within that routing. This forms the core organizational structure [2].The need for workflow systems arises from this definition. In work operations, especially in the construction industry, each team's roles, responsibilities, task scope, and timeline are clearly defined. Additionally, formalized review and verification processes ensure the accuracy of drawings and component lists before finalizing submissions for the subsequent construction phase. A conventional design methodology is used in the workflow. Every team has its work stream, and collaborative design evaluations occasionally call for internal meetings. Data preparation for design tasks, such as the occasional compilation of integrated drawings, is required for these meetings. Errors in the construction drawing process can affect the latter phases of construction if there are no internal meetings or effective coordination management in place. In addition, the global Coronavirus Disease 2019 (COVID-19) epidemic occurred between 2020 and 2022, which had a significant effect on the overall construction industry. Lockdown procedures and restrictions on physical presence at work sites were major causes of temporary work stoppages and irregular disruptions [4]. It can be mentioned that office-based design teams are particularly affected by this limitation. Interruptions in the design division's construction drawing production process prevent them from following the usual workflow during construction coordination. To address this challenge, a shift to remote work is necessary. Leveraging human-centered work process data [18] can further optimize remote collaboration and workflow design for design teams. However, since some construction data remains at the office , certain tasks cannot be completed. As a result, for the design division's work process to continue without interruption and to be completed on time, as well as the increasing complexity of projects and the large workload, some projects cannot be done by individual or single division, so it is necessary to collaborate with other teams in the design section. Beach et al. [22] mentioned that the Architecture, Engineering & Construction (AEC) sector is a highly fragmented, data-intensive, project-based industry, involving some very different professions and organizations. In the relevant work collaboration, the architecture, engineering, and construction (AEC) industry [23]. The emergence of Cloud-BIM, which integrates cloud computing technology with Building Information Modeling (BIM), has opened up key research areas aimed at improving various aspects of the construction industry [19, 20, 21, 24]. It aims to improve efficiency, effectiveness, and quality management during different phases of construction projects by offering robust databases, interoperability, and active BIM systems supported by the Internet of Things (IoT) [24]. And it can be mentioned that Cloud-BIM is considered the second generation of BIM development [21]. Nevertheless, the design process portion will be addressed in this section. Additionally, BIM and IoT integration research is still in its infancy. Therefore, it is necessary to understand the current situation of integrating BIM and IoT devices [24], and especially in Thailand where the application is still limited and in the development stage, as well as acceptance for professional use. Cloud solutions, recognized for their flexibility and essentiality, are increasingly adopted to support the rise of hybrid work models following the COVID-19 pandemic [4].The rise of hybrid work models, prompted by the COVID-19 pandemic, has significantly impacted how the construction design works and communicates. As mentioned, Hybrid work and/or workplace can connect teams, data, and workflows, as well as provide insights to help organizations deliver projects faster, save time, and increase profits [5]. To ensure that several A/E designers or teams can work together efficiently on a project without interfering with each other's work, synchronization of the design process is essential. Here are some essential elements of coordinating the design process, which are influenced by the hybrid work style and the COVID-

19 pandemic. Particularly, the term synchronization of the design process refers to the coordination and alignment of different aspects of the design process to ensure a smooth and efficient workflow [25,26]. When working on collaborative design projects with numerous designers sharing files and assets, synchronizing the design process is essential. It guarantees that everyone is using the most recent versions, that modifications are appropriately tracked and integrated, and that the iterative process preserves the overall integrity of the design [25,26]. This is concerning a state-of-the-art software platform called Autodesk Construction Cloud is set to transform the construction sector. This cloud-based solution attempts to increase collaboration, expedite project management, and boost overall efficiency in construction projects with its extensive feature set. Construction project management may be revolutionized with Autodesk Construction Cloud's real-time data analysis, enhanced collaboration features, and Building Information Modeling (BIM) functionality [10].Additionally, there is an alternative to using Autodesk BIM Collaborate Pro: collaborating on the Autodesk Construction Cloud (ACC) platform. The application of the Autodesk Construction Cloud (ACC) platform, particularly the workflow with a synchronized design process, is rarely the subject of academic research, especially in Thailand. Despite this, few studies have attempted to summarize the research literature on Cloud-BIM to date. Therefore, conducting a pilot study in this field is of great interest to the research team.

Research background

The National Institute of Building Sciences (NIBS, 2007) defines Building Information Modeling (BIM) as the creation of an electronic model that represents the construction of a building. It refers to the "virtual representation of the physical and functional characteristics of a facility throughout its lifecycle, serving as a shared information repository for collaboration [6, 7]." The primary purpose of BIM is to provide a visualization that aids in engineering analysis, resolution of design conflicts, verification, budget estimation, and other related aspects. The generated model serves as a pivotal data source for information management as well as for developing the Building Life Cycle of the project. The term "Virtual Building" is a popular name that is synonymous with the concept of Building Information Modeling (BIM), as defined by Chuck Eastman (1970) [8]. This term refers to an electronic model that simulates a building's attributes and functions. It serves as a central information repository, restructuring various stages throughout a construction project's lifecycle. Succar (2009) provides a comprehensive compilation of the meanings and related terminology concerning Building Information Modeling (BIM), as described in **Figure 1** [9]. This compilation encompasses various terms used in research and the construction industry that are associated with BIM, which constitutes an extensive knowledge domain within the Architecture, Engineering, Construction, and Operations (AECO) sector. To enable a systematic examination of the diverse facets within BIM, it becomes essential to precisely define its constituent knowledge elements and establish the ever-expanding parameters [9]. A digital procedure called building information modeling (BIM) is used to create and manage 3D models of buildings that are rich in data. Throughout a project's lifecycle, it enables cooperation, increased productivity, and decreased waste (Autodesk 2016, NIBS 2010). According to NIBS (2010), BIM is becoming more popular worldwide, especially in Europe and Singapore [6, 9. 15].

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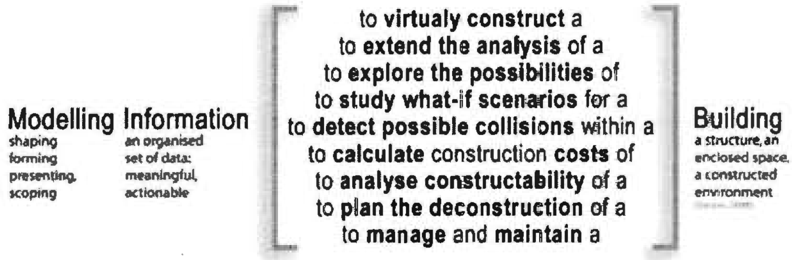

Figure 1 *Some common connotations of multiple BIM terms [9].*

As previously mentioned, the ACC platform is made for effectively managing construction projects. It acts as a hub for project teams to communicate quickly and securely, ensuring on-time and cost-effective project delivery. With the support of cloud-based technology, decision-making and efficiency may be improved since it provides real-time insights into project progress, including costs and schedules [10]. Therefore, this study focuses on exploring collaborative workflows within the design division on state-of-the-art ACC, to compare cloud-based BIM workflows [16] versus traditional workflows that are still typical for the design process. That will be taken into consideration to determine the advantages and disadvantages so that it can be used to make decisions about using ACC within the organization. According to ACC, Autodesk Construction Cloud is developed from BIM360 [10, 11]. ACC Unified Platform comes with 5 Cloud Software Products (Autodesk Docs, Autodesk BIM Collaborate, Autodesk BIM Collaborate PRO, Autodesk Build, and Autodesk Takeoff) that can fully collaborate on design and construction work on the cloud. This allows teams to work together on the design and construction of the ACC Platform more efficiently [10]. It provides actionable insights and predictions [10,16]. When additional settings are required, the data connection window can easily link project data and data repositories to the Common Data Environment (CDE), a single source of up-to-date information [10]. It is clearer that ACC can improve work items with a simple, easy-to-use interface and use design data from a single data source, the CDE. Teams can collaborate on design workflows and data, as well as carry out various operations efficiently in the ACC platform [10]. Project teams need to work together to access important documents and data from a single source, the CDE, to prevent data leaks and miscommunication. That can be mentioned that ACC was designed and developed with an understanding of the workflow of each relevant party to enable full cloud-based design and construction collaboration. This includes the design, planning, construction, and operation stages [10]. This research will focus on the important moments of collaboration within the design division. Aligned with this, it can be stated that the movement of data among participants engaged in BIM constitutes essential and discernible parameters for gauging BIM maturity, in the terms described by the degree to which an enterprise has embraced BIM and incorporated it into their operations. In essence, it is a means of gauging an organization's level of BIM competency [9]. These BIM data flows encompass a diverse range, encompassing the transmission of structured and computable data (e.g., databases), semi-structured data (e.g., spreadsheets), and non-structured or non-computable data (e.g., images) between distinct computer systems [9, 11, 12]. This data transfer could manifest as file-based exchanges or through data synchronization involving servers and client devices [13,16]. Consequently, BIM data flows encompass not only the exchange of semantically enriched entities essentially the core constituents of BIM Models, but also the interchange of information within documents [9, 13]. In correlation with this, it is important to highlight the interlinkage with BIM maturity, encompassing the constituents of Technology, Process, And Policy (TPP) [9], which are further categorized into three progressive stages: **BIM Stage 1: Object-Based Modeling**, this phase centers on the creation of models structured around individual objects. **BIM Stage 2:Model-Based Collaboration,** as the progress to this stage, the emphasis is shifting toward collaborative endeavors, made possible by shared models that centralize data and analysis. Then **BIM Stage 3: Network-Based Integration** [9,16], in the advanced stage, integration expands beyond models to encompass networked collaborations. The inherent connection between BIM data flows and project lifecycle phases extends to the ACC Unified Platform. This study examines the design department's collaboration process on ACC by comparing BIM workflows on the platform, leveraging existing research.

Research method

Considering that this issue was relatively new in Thailand at the time of the research and still has a narrow range of applications, the researchers opted for a qualitative approach. The researchers developed the semi-structured questions. After gathering information from some informants, the researchers collected and double-checked the information to make sure it was correct. This led to a more extensive content analysis [14,17]. With each informant playing a distinct role, the content analysis procedure was carried out using QDA Miner Lite software to look through the data that emerged from the important communications from key informants who were actively participating in the ACC platform for all 5 cloud products [10].

It was composed of **(1) Autodesk Docs:** It allows users to work from a single source, connecting data, workflows, and teams from design to construction. Users are classified as the owner's department, the design department, the construction department, and the group of project consultants, respectively. **(2) Autodesk BIM Collaborate:** This solution enables departmental collaboration and model linkage by allowing teams to manage workflows and models from a single location. The design and construction departments are the users. **(3) Autodesk BIM Collaborate Pro:** A sophisticated feature for collaboration that lets users enhance design quality, automate model coordination, and co-author designs. It works with some Autodesk design programs, such as Revit and Civil 3D. Users are both of the design and construction departments. **(4) Autodesk Build:** A comprehensive field and project management software that offers engineers and designers on the job site an integrated toolset for effective cooperation. The main users are the owner's department, construction department, and group of project consultants. Lastly, **(5) Autodesk Takeoff:** Accurate 2D takeoff and automatic quantity takeoff from 3D models are provided. Users are the construction department [10]. In this research, the qualifications of key informants must work directly and indirectly within the design department by (1) being personnel who have used the ACC platform, especially in the areas of Autodesk Docs, Autodesk BIM Collaborate, and Autodesk. BIM Collaborate Pro for more than 1 construction project (2) A qualitative research protocol involving in-depth interviews and content analysis [14,17], a total of twelve professionals from four categories were interviewed: 4 architects, 4 engineers, 2 draftsmen or BIM modelers, and 2 quantity surveyors (QSs), respectively. That focuses on the range of responses obtained by gathering information directly from individuals who have worked in both conventional design working procedures and collaborative processes driven by ACC-supported approaches. The practice of recognizing the needs of project owners is given special attention in this research method. till the construction drawing delivery process is completed. It is only applicable to a portion of the project delivery procedure as Design-Bid-Build (DBB), particularly the initial design phase. Proceed to produce research tools, including key questions for semi-structured interviews, along with the study of related documents and academic research topics. That is mentioned in the research background. After that, construct a thorough list of five crucial interview questions that are specific to each of the four personnel groups and their particular working environments.

- Question for finding out general information of the twelve informants. To understand the backgrounds of the twelve informants in gender classification, education level, current job role, professional experience, and experience with Cloud-BIM projects (including the specific ACC platforms used and the duration of their involvement).
- Questions concerning procedures and methods for the workflow of information between groups engage in the design process. This study focuses on the evolution of workflow between key personnel throughout the design process by comparing conventional design procedures with the new protocols, particularly ACC platforms.
- Questions about work monitoring and synchronization among the four personnel groups (architects/engineers, draftsmen/BIM modelers, and quantity surveyors) in both ACC platforms and conventional design processes. This aims to compare the roles and responsibilities of those involved in monitoring and synchronization, as well as the methods and tools employed for these tasks.
- Questions that are comparatively specific to the process and issues of combining architectural and engineering drawings between the four groups of personnel during work in the ACC platforms and conventional design processes. In addition, the semi-open-ended questions furthermore inquire at issues and their resolutions that arise in their workflow throughout the design process.
- Questions about conducting a comparative analysis of the four personnel groups from the previous Coronavirus Disease 2019 (COVID-19) pandemic, in addition to open-ended semi-structured questions with overlapping topics regarding the coordination process, internal meetings, and adapting remote work practices.

Then, the researchers will review the preliminary qualitative interview subjects to ensure accuracy and completeness. In the meanwhile, the twelve informants have been categorized and classified. To create the answering guidelines for each of the aforementioned personnel groups, start with the first question about general information and include responses to additional questions from questions 2–5, respectively. Lastly, QDA Miner Lite, an existing program designed for qualitative data analysis, will be utilized to conduct content analysis on the in-depth interview data gathered from twelve key informants representing four personnel groups focusing on their roles, duties, and collaborative practices within their workflow. The process will adhere to the recommendations of Smith and Sparkes (2009) and Bengtsson (2016) and involve tasks such as collecting data, organizing and coding data, creating notes, annotations, and memos, linking data, generating ideas, and writing reports. Particularly the section emphasizing the value of categorization and synthesis provides an organized method for qualitative content analysis [14,17].

Results

General information of the twelve informants

Validating Informant Group Data Classification

Twelve informants from four categories were interviewed, as indicated by the results of Question 1's interview: four architects, four engineers, two draftsmen or BIM modelers, and two quantity surveyors (QSs), in that order. Of the twelve individuals, approximately 85% (10 individuals) have a bachelor's degree or higher. This includes four architects, four engineers, two draftsmen/BIM modelers, and two QSs, all with more than nine years of professional experience. Additionally, approximately 85% (10 individuals) of the twelve have worked on three or more Cloud-BIM projects. Due to the short duration (less than a year) of each Cloud-BIM project, 75% (9 out of 12) informants were able to provide in-depth responses to all issue-related questions categorized by the four informant groups. The answers to these questions will be presented and described later.

The concerning procedures and methods for the workflow of information between groups engage in the design process

The analysis's findings are shown below.

The design process seriously relies on information exchange between groups. Essentially, it involves receiving data from outside sources and then communicating it internally. The architect acts as the primary point of contact, collecting project requirements directly from the owner. This includes recording and drafting designs, followed by uploading the information into the organization's system. Once in-depth interviews were conducted, this initial information flow was confirmed through interviews. In terms of obtaining and distributing external information, there is no inherent difference between conventional design procedures and the ACC-supported approaches as considered in **Figure 2.** For the remaining steps from the start, receiving and sending internal information, access to information, departmental performance review, and proceeding before submitting the drawing, respectively, there are differences between conventional design procedures and the ACC-supported approaches. The conventional design procedures were found to have redundant steps and details, such as the organization's commanding hierarchy, approval from the department commander, and supervisor-coordinated retrieval requiring verification before approval as shown in **Figure 2.** One might state that all conventional design processes seem ineffective and tedious, and can lead to misunderstandings. This component has been verified from the design process's upstream side as well. Draftsmen and QSs are among those who receive work-related information, along with architects and engineers. However, the ACC-supported approaches (via the ACC platform) differ from conventional design procedures in numerous ways. Architects act as custodians of central information, and participants are granted direct access to information through the Cloud-BIM system. This approach offers substantial benefits, particularly in the area of automated clash detection, which leads to more accurate results and helps reduce constructibility issues from drawings. Additionally, the need for a final design review meeting before drawing submission is eliminated, as design issues are synchronized in real-time, as confirmed by the twelve informants.

Issues of monitoring and synchronizing work among the four groups of personnel in the design process

The analysis identified the following issues.

Through in-depth interviews conducted in Section 4.2, the researchers identified two information sources: external (architects, receiving requirements directly from project owners) and internal (design department). In conventional workflow, all four engineers agreed on using 2D drawing overlays for clash detection. Three architects and one engineer also mentioned printing final drawings for internal review, while draftsmen and QSs emphasized printing only construction clashes for consultation with the Architecture and Engineering (A/E) team. In contrast, ACC Platform workflow utilizes automated clash detection and 3D model review for a comprehensive evaluation, favored by 6 out of 8 A/E team associates and all four draftsmen and QSs, as depicted in **Figure 2.**

This section analyzes a specific process for combining architectural and engineering drawings in ACC platforms, highlighting the challenges faced by the four personnel groups involved

The analysis findings are presented below.

According to specific conventional design procedures, the following order of responses was found. (1) The drawing must be completed before continuous processes can start. It was in response to questions from 2 of the 4 engineers and unanimous among the 4 draftsmen and QSs.(2) The designer must first check the drawings. They answered questions from two of the four architects and engineers, as well as one draftsman. (3) The occurrence of personal mistakes causes redundancy and waste of time. This was in response to questions from both the architect and 2 of the 4 engineers, including 1 QS. (4) Repeated printing of drawings for inspection causes wastage in the use of resources. Responses were from 2 architects and 1 draftsman. (5) An out-of-date 2D perspective makes it difficult to understand. One draftsman specifically mentioned this. Based on a particular ACC-supported approaches, the following order of responses was found. (1) An automated checking system with 3D for easy understanding, which answered questions from all 4 engineers, 2 out of 4 architects, 2 draftsmen or BIM modelers, while the 2 QSs did not express an opinion. (2) It provides convenience, high accuracy, and efficiency, which was the opinion of 2 out of 4 engineers, 1 out of 4 architects, and all 4 draftsmen or BIM modelers and QSs agreed unanimously. (3) BIM Modelers need to have expertise, which was answered by 2 out of 4 architects and 1 draftsman or BIM modeler. (4) Problems with Cloud-BIM users still lacking knowledge of the system are still found, which was answered by one each from the A/E side. (5) Drawings for all work categories must be completed, which was only answered by 1 architect, as illustrated in **Figure 2.**

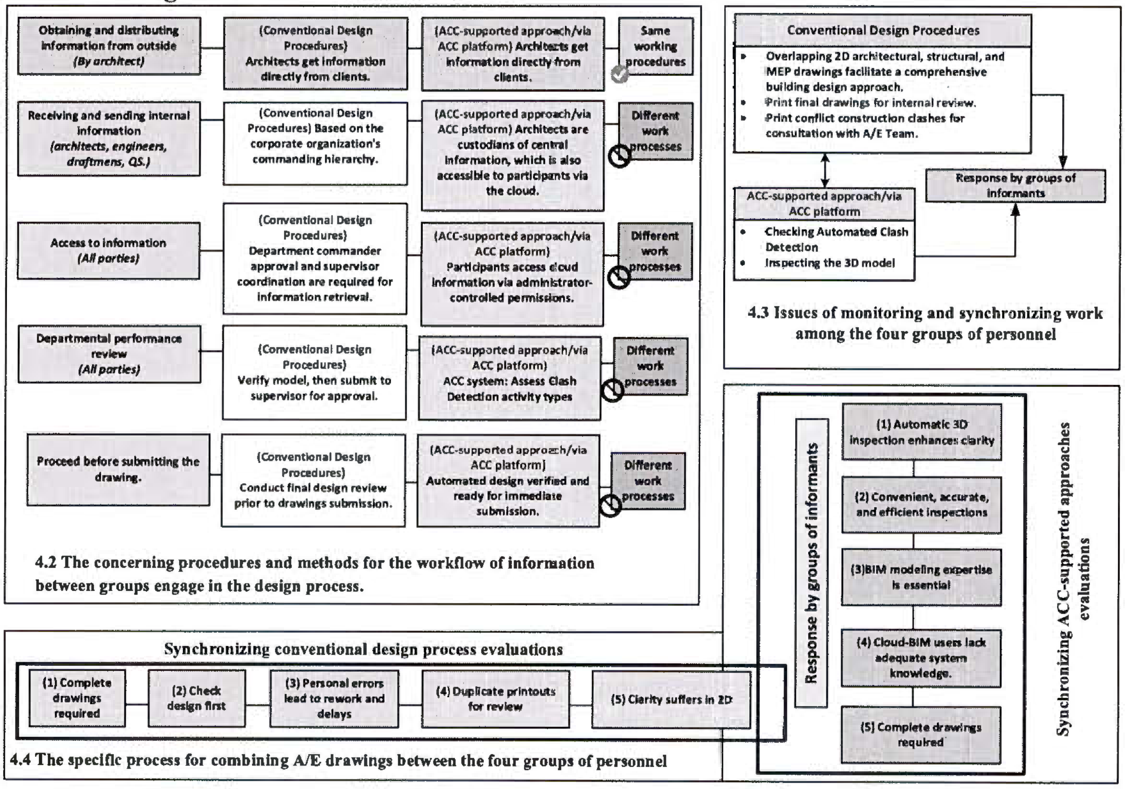

Figure 2. Evaluation of conventional design workflows against ACC platform implementation.

This section analyzes key findings from in-depth interviews regarding the impact of the COVID-19 pandemic on coordination processes, internal meetings, and remote work practices

The analysis findings are presented below.

Design work was temporarily suspended during the 2019 coronavirus pandemic. This suspension was necessary because it was impossible to operate in accordance with standard operating procedures (SOPs), particularly when the design department's production procedures were interfered with. Consequently, the protocols for remote work needed to be altered.Projects using conventional work systems are part of the design department's collaborative approaches. An analysis of projects using both conventional and ACC-supported approaches found that the ACC-supported approaches, favored by 9 out of 12 participants across all informants, was the most effective method for addressing remote work challenges. While email with online meetings was the unanimous choice for both QSs and two architects, only 2 out of 4 engineers preferred a design file sharing platform for coordination. These are key findings for remote work practices during the COVID-19 pandemic. Based on these findings, this proposal recommends a workflow utilizing the ACC system for construction design projects. This approach aims to implement a more efficient and collaborative process. After studying and comparing both methods, the research identified that the ACC-supported approaches offer enhanced data storage and accurate verification capabilities. The ACC system incorporates software tools that significantly facilitate design team operations, thereby reducing individual errors in the design department. Leveraging these advantages, along with qualitative data from in-depth interviews, the research team has developed a proposed workflow diagram (**Figure 3**). This workflow showcases the step-by-step process for construction design projects, emphasizing the integration of ACC's strengths.

A data management team will be established to handle data reception, transmission, and centralized storage. The data will be organized into distinct categories within a central repository. Data exchange will be unidirectional, controlled by a single operator, with meticulous records kept of all data received and transmitted throughout the project.

An expert-led design review committee will be established to conduct a comprehensive assessment of the design. Chaired by an expert, this committee will consist of 3 to 5 members who will jointly evaluate all aspects of the design. The committee may include external members not involved in the project to provide additional independent verification. This process will involve reevaluation in case of doubts to ensure the constructibility of the design concept. The reviewed design will then be forwarded to the data management team for further action. Designs deemed incomplete will be returned to the responsible unit for necessary corrections before proceeding.

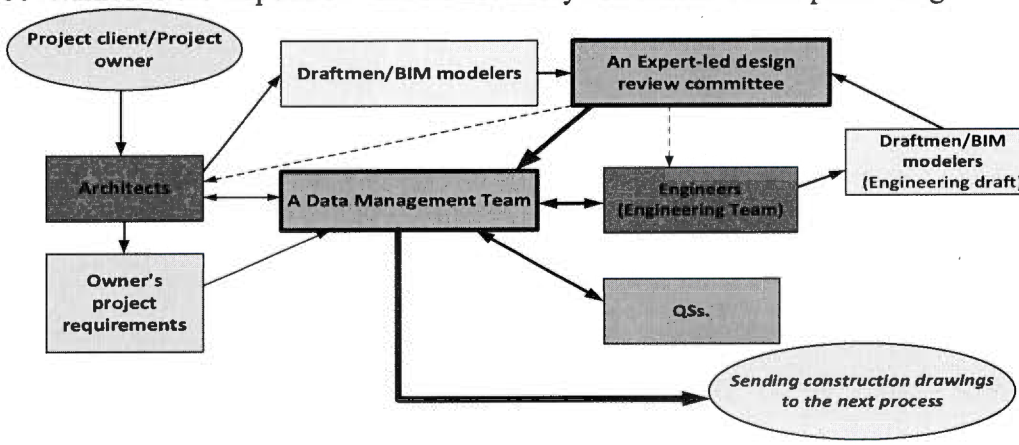

Figure 3 illustrates how the ACC-Synchronized Design replaces conventional procedures.

Conclusions

This study compares design workflows between conventional design process and Autodesk Construction Cloud (ACC) platforms, finding a distinct collaborative workflow on the ACC platform. Leveraging existing research in Computer-Supported Cooperative Work (CSCW) [1,2,3], semi-structured interviews with twelve professionals (architects, engineers, BIM modelers, quantity surveyors) were analyzed by QDA Miner Lite [14,17] revealing the benefits of

ACC. Cloud-BIM, considered the second generation of BIM [19, 20, 21, 24], utilizes a centralized process on the ACC platform. This minimizes inconsistencies and streamlines collaboration, as confirmed by participants. These findings correspond with the research of Bagrodia (1989) and Coudert et al. (2011), who offer insightful explanations of synchronization methods and their real-world uses. By carefully choosing and implementing appropriate synchronization techniques, developers can ensure optimal design, performance, and reliability in distributed systems. Furthermore, ACC-supported approaches offer further advantages: (1) automated clash detection and 3D model review for fewer errors, (2) efficient A/E Drawing combination with upfront 3D inspection for better accuracy and final DWGs generation, and (3) facilitation of remote work fulfilling hybrid needs [5, 11, 16]. To further minimize individual errors in the design department, the study recommends a data management team and an expert-led design review committee. This can be achieved, as highlighted by Schmailzl et al. (2023), by utilizing BIM-based planning approaches to integrate human-centered design processes within the AEC industry. While this study is partial to qualitative analysis, it serves as a pilot study specifically for the design process in the Thai construction industry, where the ACC platform usage was still relatively underutilized during data collection in the post-COVID-19 era. As the platform's adoption is expected to expand in the near future, research in other contexts, not limited to the Design-Bid-Build (DBB) project delivery procedure or just the design process, or employing quantitative statistical analysis, would help build confidence and further validate the strengths of using Synchronization of Design Process on Autodesk Construction Cloud.

References

[1] Dogac, A. (Ed.). (1998). Workflow management systems and interoperability (Vol. 164). Springer Science & Business Media.

[2] Medina-Mora, R., Winograd, T., Flores, R., & Flores, F. (1992, December). The action workflow approach to workflow management technology. In Proceedings of the 1992 ACM conference on Computer-supported cooperative work (pp. 281-288). https://doi.org/10.1145/143457.143530

[3] Baecker, R. M. (Ed.). (1993). Readings in groupware and computer-supported cooperative work: Assisting human-human collaboration. Morgan Kaufmann.

[4] Chaisaard, N., Ngowtanasuwan, G., & Doungpan, S. (2020, August). A review of construction project management guidelines under the impact of COVID-19 epidemic dispersal: a case study of Thai construction projects. In SUT international virtual conference on science and technology, Nakhon-Ratchasima, Thailand (Vol. 28).

[5] Iqbal, K. M. J., Khalid, F., & Barykin, S. Y. (2021). Hybrid workplace: The future of work. In Handbook of research on future opportunities for technology management education (pp. 28-48). IGI Global. https://doi.org/10.4018/978-1-7998-8327-2.ch003

[6] NIBS. (2007). National Building Information Modeling Standard™.

[7] https://buildinginformationmanagement.files.wordpress.com/2011/06/nbimsv1_p1.pdf

[8] Santos, E. T. (2009, November). Building information modeling and interoperability. In XIII Congress of the Iberoamerican Society of Digital Graphics-From Modern to Digital: The Challenges of a Transition Sao Paulo, Brazil.

[9] Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2008). BIM handbook introduction. BIM handbook: A guide to building information modeling for owners, managers, architects, engineers, contractors, and fabricators, 1-63. https://doi.org/10.1002/9780470261309.ch1

[10] Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in construction, 18(3), 357-375. https://doi.org/10.1016/j.autcon.2008.10.003

[11] Autodesk Construction Cloud https://synergysoft.co.th/products/construction-cloud-solutions

[12] Kosovac, B., Froese, T., & Vanier, D. (2000). Integrating heterogeneous data representations in model-based AEC/FM systems. Proceedings of CIT, 2, 556-567.

[13] Halfawy, M. R., & Froese, T. (2002, June). Modeling and implementation of smart AEC objects: an IFC perspective. In Proceedings of the CIB w78 Conference: Distributing Knowledge in Building, Aarhus School of Architecture, 12-14 June (2002) (pp. 1-8).

[14] Froese, T. (2003). Future directions for model-based interoperability. In Construction Research Congress: Wind of Change: Integration and Innovation (pp. 1-8). https://doi.org/10.1061/40671(2003)101

[15] Sparkes, A. C., & Smith, B. (2009). Judging the quality of qualitative inquiry: Criteriology and relativism in action. Psychology of sport and exercise, 10(5), 491-497. https://doi.org/10.1016/j.psychsport.2009.02.006

[16] Ullah, K., Lill, I., & Witt, E. (2019, May). An overview of BIM adoption in the construction industry: Benefits and barriers. In 10th Nordic conference on construction economics and organization (pp. 297-303). Emerald Publishing Limited. https://doi.org/10.1108/S2516-285320190000002052

[17] Afsari, K., Eastman, C. M., & Shelden, D. R. (2016). Cloud-based BIM data transmission: current status and challenges. In ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction (Vol. 33, p. 1). IAARC Publications. https://doi.org/10.22260/ISARC2016/0129

[18] Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. NursingPlus open, 2, 8-14. https://doi.org/10.1016/j.npls.2016.01.001

[19] Schmailzl, M., Spitzhirn, M., Eder, F., Krüll, G., Linner, T., Obergrießer, M., ... & Lafhaj, Z. (2023). Towards interfacing human centered design processes with the AEC industry by leveraging BIM-based planning methodologies. In ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction (Vol. 40, pp. 325-332). IAARC Publications. https://doi.org/10.22260/ISARC2023/0045

[20] Wu, K., & Tang, S. (2022). BIM-Assisted Workflow Enhancement for Architecture Preliminary Design. Buildings, 12(5), 601. https://doi.org/10.3390/buildings12050601

[21] Oraee, M., Hosseini, M. R., Edwards, D. J., Li, H., Papadonikolaki, E., & Cao, D. (2019). Collaboration barriers in BIM-based construction networks: A conceptual model. International Journal of Project Management, 37(6), 839-854. https://doi.org/10.1016/j.ijproman.2019.05.004

[22] Wong, J., Wang, X., Li, H., & Chan, G. (2014). A review of cloud-based BIM technology in the construction sector. Journal of information technology in construction, 19, 281-291.

[23] Beach, T. H., Rana, O. F., Rezgui, Y., & Parashar, M. (2013). Cloud computing for the architecture, engineering & construction sector: requirements, prototype & experience. Journal of Cloud Computing: Advances, Systems and Applications, 2, 1-16. https://doi.org/10.1186/2192-113X-2-8

[24] Abdelhai, N. (2022). Integration BIM and emerging technologies in architectural academic programs. IntechOpen.

[25] Tang, S., Shelden, D. R., Eastman, C. M., Pishdad-Bozorgi, P., & Gao, X. (2019). A review of building information modeling (BIM) and the internet of things (IoT) devices integration: Present status and future trends. Automation in Construction, 101, 127-139. https://doi.org/10.1016/j.autcon.2019.01.020

[26] Bagrodia, R. (1989). Process synchronization: Design and performance evaluation of distributed algorithms. IEEE Transactions on Software Engineering, 15(9), 1053-1065. https://doi.org/10.1109/32.31364

[27] Coudert, T., Vareilles, É., Aldanondo, M., Geneste, L., & Abeille, J. (2011, September). Synchronization of system design and project planning: Integrated model and rules. In 2011 5th International Conference on Software, Knowledge Information, Industrial Management and Applications (SKIMA) Proceedings (pp. 1-6). IEEE. https://doi.org/10.1109/SKIMA.2011.6089969