ArchCloudChain Dapp: The efficient Workflow for Interior designers

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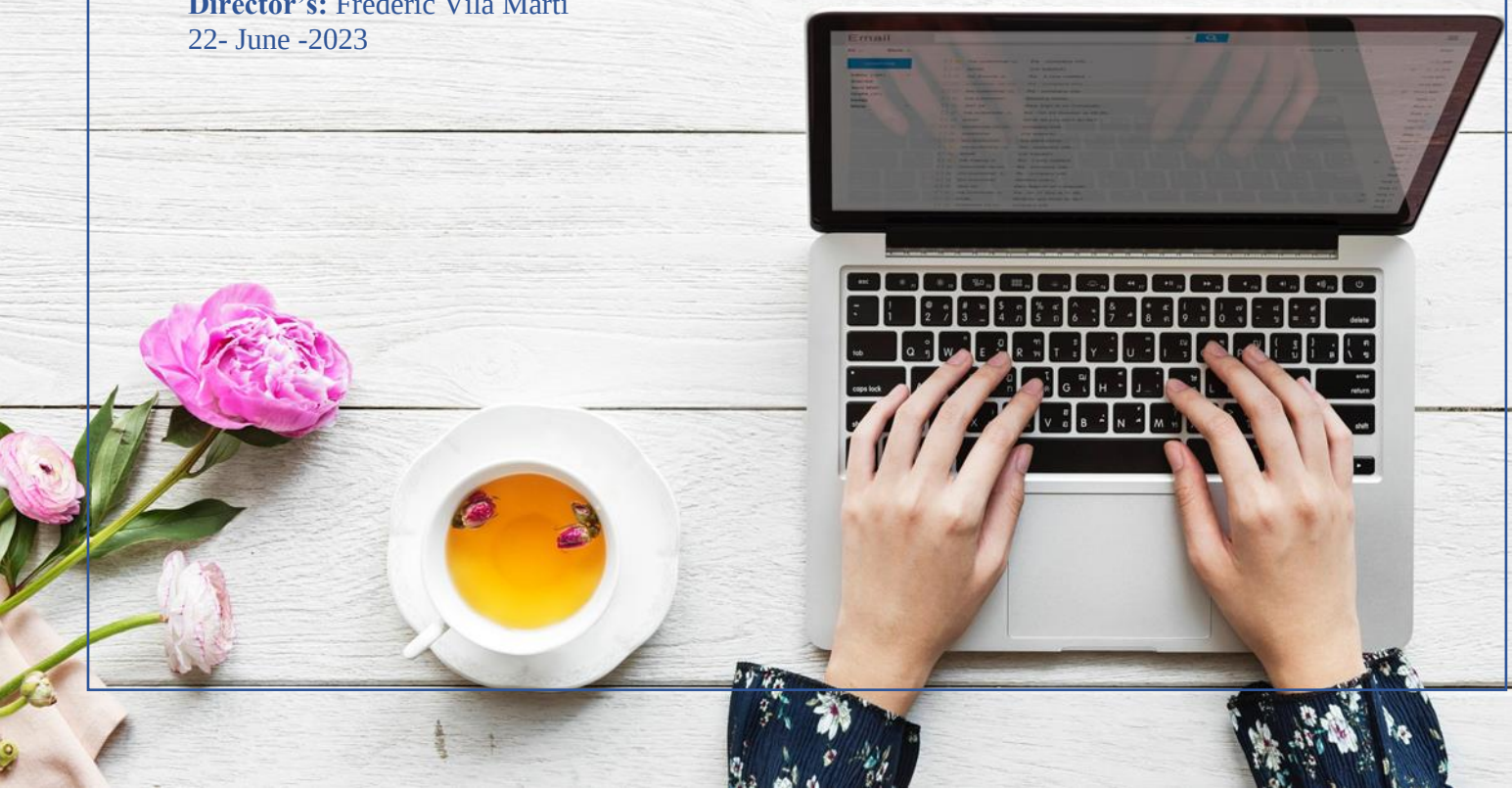

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ABSTRACT

The interior design and construction industry involves various stakeholders who must collaborate and coordinate effectively to ensure the successful realization of projects. However, the existing workflow often suffers from fragmentation and inefficiency, leading to delays, errors, and increased costs. To address these challenges, this paper introduces the Arch Cloud Chain Dapp project, a decentralized software application that leverages blockchain technology and Building Information Modeling (BIM) to establish a transparent, secure, and efficient platform for stakeholder collaboration in interior design projects. The primary objective of this project is to reduce interior design costs while upholding high standards of quality and transparency.

By integrating BIM and blockchain technology, the Arch Cloud Chain Dapp enables stakeholders to collaborate in real-time, significantly mitigating the risk of errors and miscommunication. Smart contracts play a crucial role in ensuring the enforceability and transparency of agreements, while the blockchain serves as an immutable ledger, providing an auditable record of all project transactions. These innovative features present a novel solution to the challenges faced by the interior design and construction industry.

The Arch Cloud Chain Dapp project holds significant potential to revolutionize the industry by streamlining processes, enhancing collaboration, and reducing costs. Through its adoption, stakeholders can benefit from improved project outcomes, streamlined communication, and enhanced efficiency, ultimately leading to a more sustainable and prosperous interior design and construction sector.

Keywords: Interior design, Dapp, BIM, Blockchain

چکیده

صنعت طراحی داخلی و ساخت و ساز شامل ذینفعان مختلفی است که باید برای اطمینان از تحقق موفقیت آمیز پروژه ها همکاری و هماهنگی مؤثری داشته باشند. با این حال، گردش کار موجود اغلب از پراکندگی و ناکارآمدی رنج می برد که منجر به تاخیر، خطا و افزایش هزینه ها می شود. برای پرداختن به این چالش‌ها، این مقاله پروژه برنامه غیر متمرکز آرک کلود را معرفی می‌کند، یک برنامه نرم‌افزاری غیرمتمرکز که از فناوری بلاک چین و مدل‌سازی اطلاعات ساختمان (بیم) برای ایجاد یک پلت فرم شفاف، ایمن و کارآمد برای همکاری سهامداران در پروژه‌های طراحی داخلی استفاده می‌کند. هدف اصلی این پروژه کاهش هزینه های طراحی داخلی در عین حفظ کیفیت با استانداردهای بالا و ایجاد شفافیت بین اعضای پروژه است.

این برنامه با ادغام بیم و فناوری بلاک چین، اعضای پروژه را قادر می‌سازد تا به صورت همزمان با یکدیگر همکاری کنند و خطاها و ارتباطات نادرست را به میزان قابل توجهی کاهش دهد. قراردادهای هوشمند نقش مهمی در تضمین قابلیت اجرا و شفافیت توافقات دارند، در حالی که بلاک چین به عنوان یک دفتر کل غیرقابل تغییر عمل می کند و یک رکورد قابل بازرسی از تمام تراکنش های پروژه ارائه می کند. این ویژگی های نوآورانه راه حل جدیدی برای چالش های پیش روی صنعت طراحی داخلی و ساخت و ساز ارائه می دهد.

این پروژه دارای پتانسیل قابل توجهی برای متحول کردن صنعت ساختمان با ساده‌سازی فرآیندها، افزایش همکاری و کاهش هزینه‌ها است. با پیاده سازی آن، ذینفعان می توانند از نتایج پروژه بهبود یافته، ارتباطات ساده و کارایی بیشتر بهره مند شوند که در نهایت منجر به طراحی داخلی و بخش ساخت و ساز پایدارتر و موفق تر می شود.

کلید واژه: معماری داخلی، فناوری بیم، برنامه غیرمتمرکز، بلاک چین

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01. INTRODUCTION

01.01 Context

The present study begins with the question of how to act or face the problem of interior design within the context of collaboration and coordination among stakeholders in the design and construction process.

This document reflects on what should be “a new solution for interior design”, and on the need of today’s society to reduce the cost of interior design and keep its quality high.

Interior design involves multiple stakeholders, such as architects, designers, contractors, suppliers, and clients, who need to work together to ensure that the final product meets the requirements of all parties involved. However, the current workflow can be fragmented and ineffective, leading to delays, errors, and cost overruns.

BIM is a process that involves creating a 3D digital model of a building, that contains information about the physical and functional characteristics of the building. This data can include details such as the size and location of walls, windows, and doors, as well as information about materials, lighting, and other building components.

In the context of interior design, BIM can serve as a central platform for all stakeholders to collaborate and coordinate on the design of an interior space. By using a shared digital model, stakeholders can work together in real-time, reducing the risk of errors or miscommunication. BIM

can also provide a framework for tracking changes, approvals, and updates to the design, which can improve project management and reduce the risk of delays.

Blockchain technology is known for its ability to provide a tamper-proof and transparent record of transactions, that can be shared among multiple parties without the need for a central authority or intermediary. In the context of interior design, blockchain can serve as a secure platform for storing and sharing data related to the interior design process.

The combination of BIM and blockchain technology can provide a powerful solution for the interior design workflow, enabling stakeholders to collaborate more efficiently, transparently, and securely. By leveraging the powers of these two technologies, the project can help address some of the challenges faced by stakeholders in the interior design and construction industries.

01.02 Objective

The main objective is to develop a decentralized app for interior design based on BIM workflow and blockchain technology, with the aim of enhancing collaboration, transparency, and security in the interior design and construction industries. According to achieve to this objective, there are several sub-objectives that must be considered in this Project:

1. Design and develop the user interface and user experience of the decentralized app for interior design.
2. Integrate BIM workflows into the app to enable real-time collaboration and coordination among stakeholders.
3. Implement blockchain technology to provide a secure and transparent platform for sharing and storing data related to the interior design process.
4. Implement smart contracts to automate certain aspects of the interior design process, such as payments and approvals.
5. Evaluate the effectiveness of the decentralized app in improving collaboration, transparency, and security in the interior design workflow.

01.03 Hypothesis

The building industry operates as a complex and collaborative process involving numerous stakeholders, each with their specific requirements and specifications. While the implementation of Building Information Modeling (BIM) workflows has proven effective in enhancing collaboration and reducing project errors, it falls short in establishing trust among stakeholders due to its reliance on centralized control. This paper proposes the integration of blockchain technology to introduce transparency to the project environment, thereby fostering trust among stakeholders.

Interior design was selected as the focus of this study due to its subjective nature compared to building construction. Despite its relative simplicity, the outcomes of interior design projects can have far-reaching implications and may serve as a blueprint for future large-scale endeavors.

By leveraging blockchain technology, this research aims to create a trustable environment within the interior design process. Blockchain's inherent transparency, immutability, and decentralized control can contribute to a reliable platform for stakeholders to collaborate and engage in transactions securely. The distributed ledger system provided by blockchain ensures that project data and agreements are tamper-proof and can be audited, fostering accountability, and mitigating potential disputes.

The results of this study have the potential to transform the building industry by augmenting BIM workflows with blockchain technology. The establishment of trust and transparency among stakeholders can yield improved collaboration, reduced errors, and increased efficiency throughout the interior design process. Consequently, the findings of this research lay the groundwork for the implementation of blockchain technology in future building projects, paving the way for enhanced project outcomes and a more sustainable industry.

01.04 Methodology

The methodology of this project is qualitative methodology which includes Literature review, Case studies, and proposal. It begins with the investigation about the interior design workflow, BIM workflows, and blockchain technology. This review will help to identify the key challenges and opportunities associated with the interior design process, and to understand the current state-of-the-art in blockchain and BIM technologies.

In the next section, identify relevant interior design software products that are widely used in the industry. Consider factors such as popularity, user base, features, and availability of documentation. Then, collect data about the selected interior design software products, including their features, capabilities, user interfaces, and user feedback. This could involve using a combination of sources such as product websites, user forums, and online reviews.

Develop an evaluation framework that identifies key criteria for evaluating the effectiveness of the interior design software products. This could include criteria such as usability, functionality, compatibility, user support, and value for money. Then, Compare the performance of each software product against the evaluation criteria, and identify strengths and weaknesses of each product.

In the next part, according to literature review and requirements gathering phase, design and develop the decentralized app for interior design. This could involve creating wireframes, mockups, and user stories to illustrate the key features and functionalities of the app. Then, analyze the data collected during the simulation and validation phase to draw insights and conclusions about the effectiveness of the app.

Based on the results of the simulation and validation phase, draw conclusions about the effectiveness of the app and make recommendations for future improvements. These recommendations could include technical improvements to the app, as well as changes to the interior design workflow more broadly.

02. BUILDING INFORMATION MODELLING

02.01 Introduction

Building Information Modelling (BIM) is an innovative technology for transforming data in the whole construction industry. It has changed the way of design, construction and operation of projects, which has various benefits in the industry (Doan, et al., 2019).

As defined by the National Building Information Modelling Standard-United States (NBIMS-US), “BIM is a digital representation of a building’s geometric and non-geometric data, and is used as a reliable, shared knowledge resource to make decisions on a facility throughout its lifecycle” (Charef, 2022).

BIM is defined in three different types which are "Building information Model", "Building Information Modelling" and "Building Information Management".

Building Information Model (BIM) is a digital representation of a building or structure and all its associated information, such as dimensions, materials, and systems. It is a collaborative process that involves the creation and management of a virtual 3D model that enables architects, engineers, contractors, and owners to work together more effectively throughout the entire building lifecycle, from design to construction and operation.

Building Information Modelling (BIM) is the process of creating and using a Building Information Model (BIM) throughout the entire lifecycle of a building. It involves the use of specialized software and tools to create a comprehensive digital model of a building, which includes all relevant information such as geometry, materials, systems, and other data. The model is then used for various purposes, such as design, analysis, simulation, coordination, and communication among project stakeholders.

Building Information Management (BIM) is the process of managing the information generated by the Building Information Modelling (BIM) process. It involves the collection, organization, and distribution of data throughout the lifecycle of a building. The goal of BIM is to ensure that all stakeholders have access to accurate, up-to-date information about the building, which can help to reduce errors, improve communication, and increase efficiency.

02.02 BIM DIMENSIONS

Building life cycle includes planning, designing, construction, operation and maintenance, which in each phase, lots of information is exchanged between different participants of the projects. This information is categorized into graphical and non-graphical information. Graphical information refers to drawing in two dimensions and three dimensions; however, non-graphical information refers to information which is related to graphical data (Meadati, 2009).

In the traditional building industry, these two types of information are not linked to each other, and it decreases project productivity which leads to time consuming and increasing cost of project.

However, in BIM Workflow, participants of project can easily access those type of information which are linked to each other. Accordingly, BIM is divided into different dimensions based on type of data and information (Meadati, 2009).

In the context of Building Information Modeling (BIM), 3D dimension of BIM refers to the spatial dimensions of a building or structure. This includes the length, width, and height of the building, as well as the location of various components, such as walls, columns, beams, and other building systems. 3D dimension of BIM is an essential aspect of BIM because they enable designers and builders to create a comprehensive digital model of the building, which can be used to simulate various scenarios, identify conflicts, and optimize the design and construction process.

Connection of this 3d dimension with the pre-construction schedule will develop four dimensions of BIM which is time dimension and integration of 3d dimension with time and cost lead to 5D dimension of BIM which refers to the cost dimension (Meadati, 2009). However, cost estimation of projects is not enough today and considering environment and maintenance are located more on center of attention, so these aspects compose 6D and 7D dimension of BIM. It is important to note that there are infinitive dimensions in BIM Workflow and each user can add a dimension according to its data and needs (Charef, 2022).

02.03 BIM USES

As function of Building Information modelling as a digital model of a building which its main purposes are visualization, building analysis, collision detection, code checking, cost estimation, and etc. BIM Use is a method where building information modeling can be applied according to variety of objectives in different phases of Project (Kreider & Messner, 2013).

According to BIM project Execution Planning guide, which is published by America building SMART alliance, BIM uses in different stages of project which are plan, design, construct and operate stages and are explained in table below (**Error! Reference source not found.**).

STAGES	THEMES	
PLAN	Existing conditions modelling	Phase planning
DESIGN	Cost estimation	Site analysis
	Design reviews	Mechanical analysis
	Design authoring	Other Eng. Analysis
	Energy analysis	LEED evaluation
	Structural analysis	Code Validation
	Lighting analysis	
CONSTRUCT	3D coordination	Digital fabrication
	Site utilization planning	3D control and planning
	Construction system design	
OPERATE	Record Model	Asset management
	Maintenance scheduling	Space management/tracking
	Building system analysis	Disaster Planning

Table 1: BIM Uses throughout the building lifecycle (Shou, Wang, Wang, & Chong, 2015)

According to this guide, the main goal of BIM uses is to understand the needs of BIM in the project and how to use its function in different stages of the project.

However, most use of BIM is for 3d of architecture, MEP, and structure model, it is used mostly in 4d and 5d dimensions as well which are schedule and cost estimation respectively.

There are BIM guidelines and standards all around the world and in this research, one of them is explained briefly to understand BIM uses in whole stages of the building industry.

According to BIM guideline of America, the building lifecycle is divided to 4 phases that are definition, planning and pre-design phase, design phase, construction phase, and facility management phase. It explains how BIM can be used in these different stages. In the first phase, it is related to implement planning and site analysis, the second phase, is architecture, structure, and MEP design, cost estimation of Project and clash detection and coordination, in the phase of construction, BIM use in construction system design, scheduling, and model recording, and in the last phase, as-built model, asset management, and space management and tracking are significant in BIM uses (Table 2).

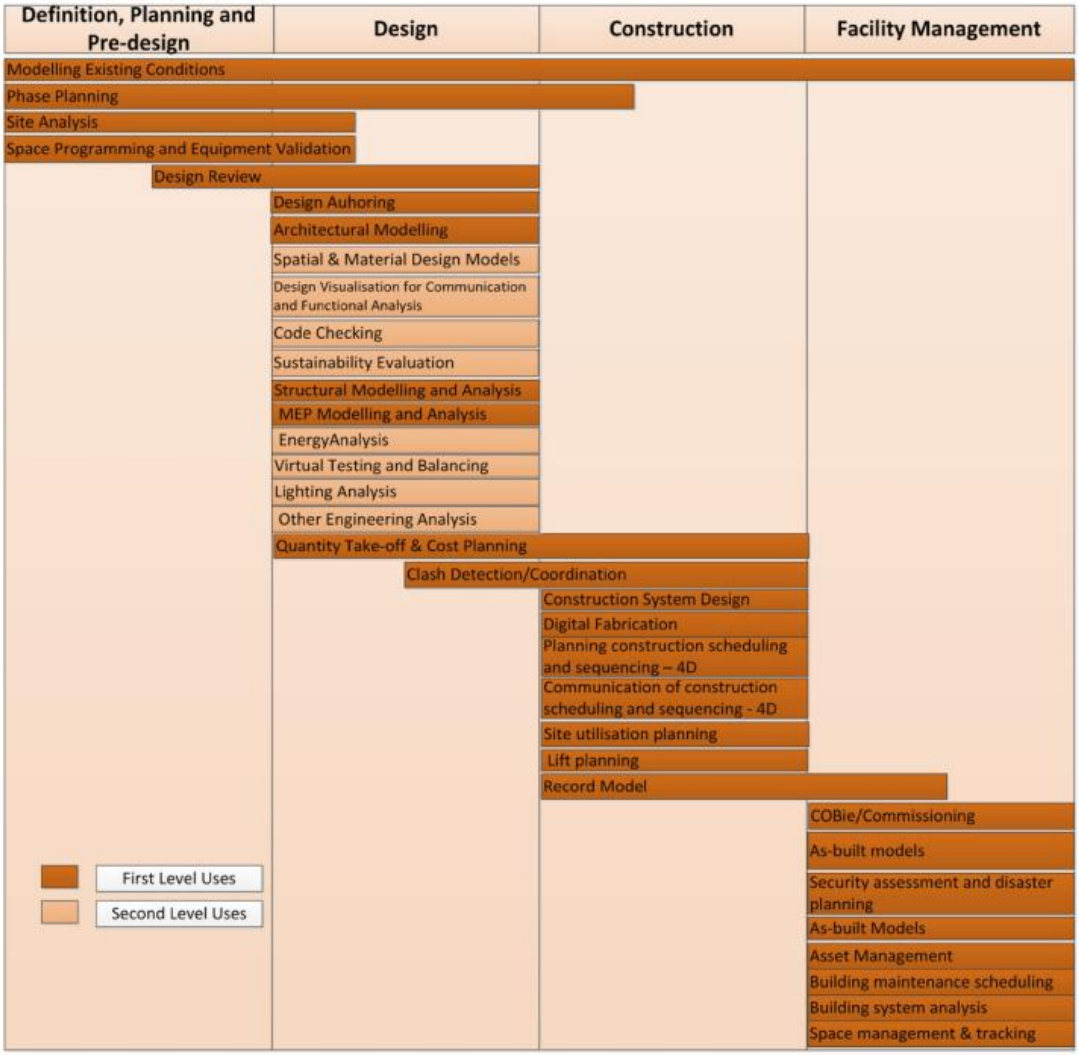

Table 2: BIM uses in BIM guideline standards (Shou, Wang, Wang, & Chong, 2015)

BIM uses are categorized according to its purposes and its characteristics. As it is shown in figure, the objectives and attributes can be delineated at different degrees of detail based on the level of precision necessary for different applications of the Uses (Kreider & Messner, 2013) (Figure 1).

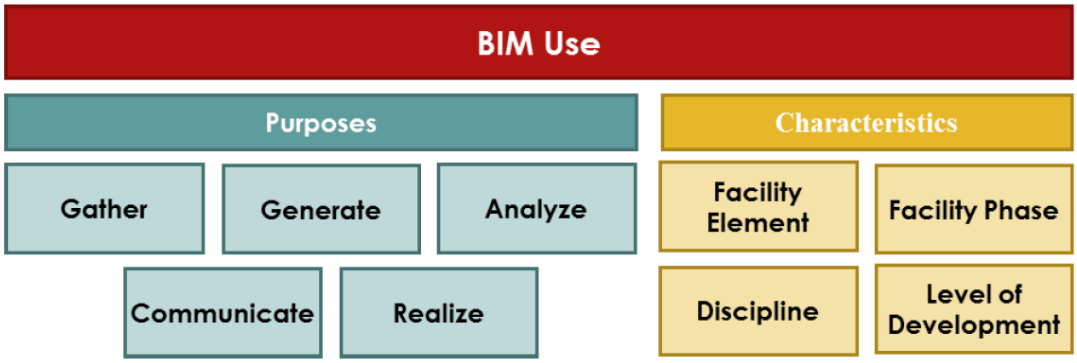

Figure 1: The components of a BIM Use (Kreider & Messner, 2013)

The purposes of BIM use are **gathering information which** is to collect information about the building which is divided to four specific purpose that are qualify, monitor, capture and quantify, generating which is to create information and organize it in different stages of the project. As it is obvious, designers are the ones that create the information at the first stage, but other parties such as contractors make information during construction phase that should be added to BIM data, analyzing which is to check the coordination between different building elements and validate them. One of the main purposes of using BIM is facilitating the **communication** between different parties in the project and the last purpose of using of BIM is visualization to show better the project to people who are in the making decision process (stakeholders).

The BIM Use Characteristics enable users to specify the BIM Use in more detail by taking into account typical building and project attributes, such as facility element, facility phase, discipline, and Level of Development. Once these factors have been identified, as illustrated in Table 3, a particular BIM Use can be classified under a specific approach.

Characteristics	Description
Facility Element	The system of the facility on which the BIM Use will be implemented.
Facility Phase	The point in the facility's lifecycle at which the BIM Use will be implemented.
Discipline	The party by whom the BIM Use will be implemented.
Level of Development	The degree of granularity to which the BIM Use will be implemented.

Table 3: BIM Uses Characteristics (Kreider & Messner, 2013)

In the BIM workflow, users always must pay attention to which purpose they use it. It means the team should decide that BIM should use in which facility elements. In facility phases, the disciplines and their BIM uses that are assigned to them, will be determined. For example, the design team will be specified and their responsibilities according to BIM workflow will be determined. It includes inception phase, concept design phase, criteria definition phase, design phase, coordination phase, implementation phase, handover phase, operation phase, and closure phase. In discipline characteristics the discipline will be defined and organized. According to the BIM use, there are levels of development (LOD) which represent the level of details that the model needs to develop that is between LOD 100 and LOD 500.

02.04 BIM Implementation

For have a successful project with benefits for clients during whole life cycle of the building, implementation of Collaborative BIM with appropriate processes, and standard of data exchange is essential.

To begin with, it is essential to clarify the main objective of a BIM strategy in any adoption plan. The primary goal is to establish a digital information management system that all project stakeholders and workers must adhere to, promoting consistency and facilitating collaborative work, ultimately leading to reduced waste and non-compliance. Therefore, the strategy should encompass the overall BIM-enabled project process, as depicted in the figure 2 (Kumar & Hayne, 2016).

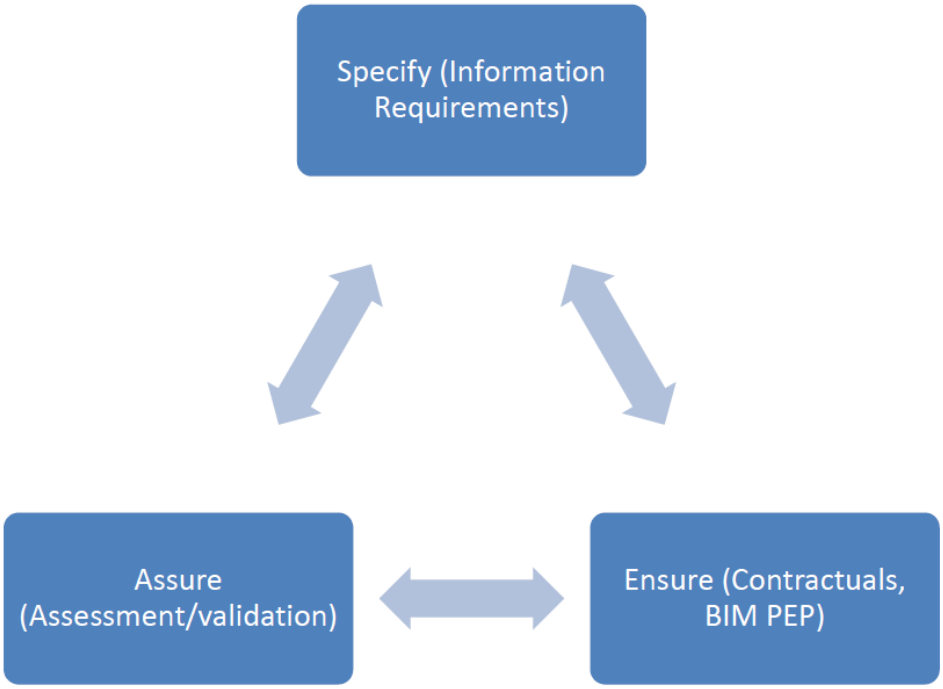

Figure 2: The schematic diagram outlines the comprehensive Asset Procurement Process based on BIM (Kumar & Hayne, 2016)

In this section, the various components of the BIM-focused procurement approach are explained. The initial step is to create a process diagram that corresponds with the standard information delivery cycle. Following this, supporting materials such as instruction manuals and templates should be established in line with the BIM-based process diagram. These resources will aid in defining the necessary information requirements and verifying that they are provided by the project team. The process of BIM implementation starts with a set of requirements of clients which is documented in Information requirement data (Kumar & Hayne, 2016).

Once the Information Requirements (IRs) have been established, the project procurement process can begin. The IR document will guide the procurement route selection and inform the tender documents. The information included in this stage may be more general but could involve BIM Execution Plan (BEP) documents, including the bidder's suggested methodology and their capacity and skills regarding BIM. Subsequently, the contract will be granted after going through several negotiations and clarifications (Kumar & Hayne, 2016).

At this stage, BIM Execution Plan (BEP) which outlines the process and procedures that will be followed throughout the project to ensure that BIM is being implemented effectively and should include project goals, software and hardware requirements, and a timeline for BIM deliverables, will be prepared. In addition to BEP, Information Delivery plan (IDP) should be provided (Kumar & Hayne, 2016).

An Information Delivery Plan (IDP) is a document that outlines how digital information will be produced, exchanged, and managed throughout a construction project's lifecycle. It describes the data exchange process between project stakeholders, the format and level of detail required, and when the information should be delivered. The IDP ensures that the right information is delivered at the right time, reducing confusion and errors while improving collaboration and efficiency throughout the project (Kumar & Hayne, 2016).

In this phase, the BIM (Building Information Model) will be form which consists graphical and non-graphical documents. In this stage, the BIM model is set up with all the relevant information, including the building's geometry, construction systems, and components. The model should be created in a BIM software that is compatible with other software being used by the project team (Kumar & Hayne, 2016).

It is noted that BIM is a collaborative process, and all project team members should have access to the BIM model and be able to contribute to it. Coordination meetings should be held regularly to ensure that everyone is working together effectively.

After phase of construction, the BIM Model changed to Asset Information model (AIM) which is useful for facility and asset management.

02.05 BIM Cloud Collaboration

The data can be exchanged in real time through Cloud in different phases of project in a BIM workflow which is the main concept of BIM. Some of the examples of Cloud BIM are Graphisoft BIM Cloud or Autodesk BIM360. It improves the collaboration between different sections of building projects. The key to success in this collaboration is interoperability. The main challenge here is the type of software and cloud that are used by different parts of the building project, so sharing information needs an application for exchange regardless of its format and vendors. In accordance with, there is a format that are common between the whole BIM tools, and it is named Industry Foundation Classes (IFC) (Figure 3) (Afsari, Eastman, & Shelden, 2016).

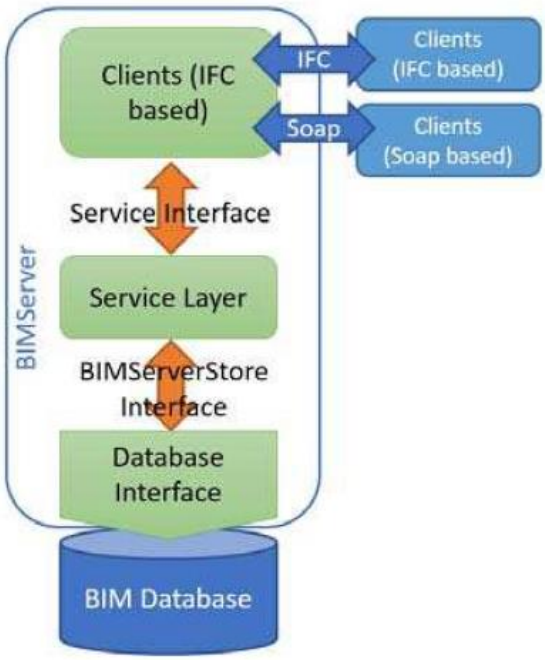

Figure 3: Architecture of BIM Cloud (Afsari, Eastman, & Shelden, 2016)

In the process of sharing a model between different parties, the sender should define which data should be included in the exported file which is called model view definition (MVD) and export it as IFC format in a BIM application, then the receiver can get the IFC format file and import it in a BIM tool and its IFC importer translate the model into native language of the software and whole these are done manually which is shown in figure 4 (Afsari, Eastman, & Shelden, 2016).

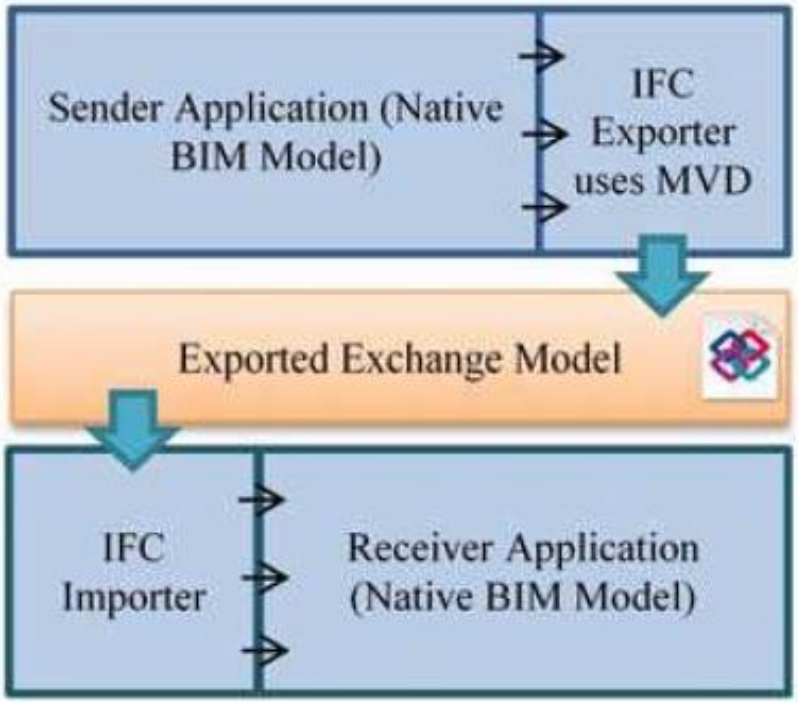

Figure 4: IFC Format (Afsari, Eastman, & Shelden, 2016)

As stated before, interoperability is the main key in the BIM based cloud collaboration and it decreases the manual interaction between different sections. BIMSie provides an interface for automatic collaboration in BIM cloud platform by introducing application programming interface (API) for Cloud BIM software. In this system, the main common file format that is exchanged is based on IFC format. The current Cloud-BIM data integration solutions available in the market predominantly focus on the concept of centralizing BIM data. This centralized BIM server is based on the IFC format which shares the data with clients through different interfaces. It is theoretically a good solution, but there are some challenges that should be considered such as scalability. The BIM cloud technology is not strong enough and there are some issues in data exchanges through combining different models. It is important to take note that this solution needs powerful operating system, file sharing platforms and hardware controllers (Afsari, Eastman, & Shelden, 2016).

Figure 5 illustrates that the primary input and output mechanism for these systems is file-based. Notably, BIMServer.org relies on IFC files for its input and output. Moreover, current BIM servers are unable to function with the decentralized, heterogeneous, and ever-changing design data, thereby failing to support the complete project lifecycle (Afsari, Eastman, & Shelden, 2016).

Figure 5: BIM Server Solution (Afsari, Eastman, & Shelden, 2016)

There is three type of BIM data exchange based on the cloud which are manual file transfer, BIM server technology and Data interchange HUB.

Manual file transfer is based on Open-BIM standard which the main file format is IFC, the problem in this method is the validation of imported model against the initial exchange needs and as managing data is difficult in this method, it is not recommended for implementing in BIM workflow (Afsari, Eastman, & Shelden, 2016).

BIM server technology is a centralized server for collaboration, but its main problem is scalability and in the big projects, it faces scalability and performance issues. In this methodology, users can access to project at any time and from anywhere, but the problem is that it supports only one format that is the format of the software company that provides this service, so if the data is generated by different software, the centralized model will be delinked from the original model and the model exchange rely mostly on manual file transfer (Afsari, Eastman, & Shelden, 2016).

Data interchange HUB provides automated data flow between different applications in real time. This methodology provides a real time change in a model which each user can see them when they connect to server. Its main problem is that it supports many few applications.

In table 4, these three methodologies is compared with each other and their pros and cons are explored.

Cloud-BIM Data Inegration Technique	Pros	Cons
Manual File transfer	Could be based on establsihed standards, and MVDs Can use netural data format	One-way data transfer, and data import issues Repeat for each design iteration
BIM server technologies	Centralizes BIM data Improves collaboration in an integrated model	Scalability and performance issues Depond on the server platform and not completely connected to the origin of data
Data interchange Hub	Automates data flow Reflect design changes in Real-time within each BIM application	Support very few applications Depond on the interchange platfrom

Table 4: Comparison of the methodologies for integrating Cloud-BIM data (Afsari, Eastman, & Shelden, 2016)

In addition to these three interdisciplinary solutions, there is another one which is based on third party BIM cloud service solution. Third-party solutions based on the cloud use plug-ins to extract data from BIM models in BIM authoring tools. This extracted data is then published in a new environment, which enables the provision of specialized services like analysis. This solution eventually brings back the changes to the original BIM model (Figure 6) (Afsari, Eastman, & Shelden, 2016).

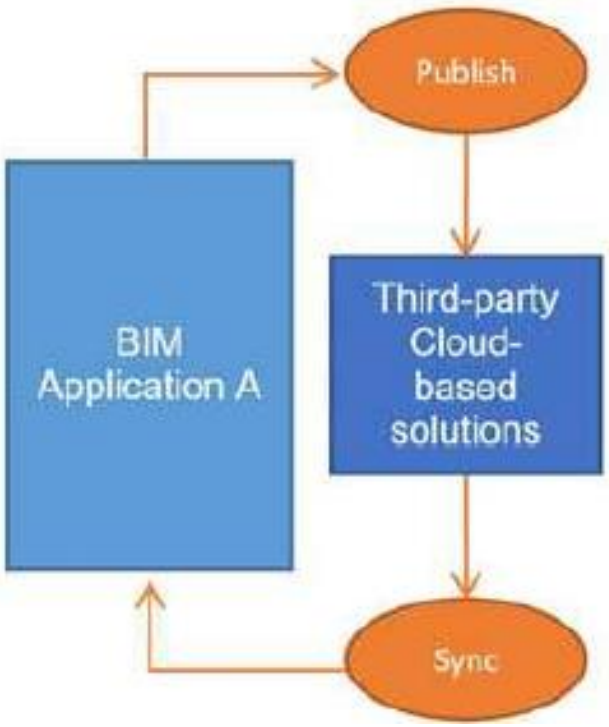

Figure 6: The data flow of third-party Cloud-based BIM solutions (Afsari, Eastman, & Shelden, 2016)

As explained before, BIM implementation needs software that is named BIM software. There are 4 main BIM Software that two of them are mostly used in Architecture and they are ArchiCAD which is belong to Graphisoft and Revit which is belong to Autodesk. Each of these software uses different BIM cloud strategy, but they have some common feature as well. In here, the BIM cloud of Graphisoft will be explored in order to understand what the main features of BIM cloud are.

The Graphisoft BIM cloud caters to the industry's demand by facilitating remote collaboration and efficient handling of large files. It also enables offline work and supports working from virtually any location, giving team members the flexibility to log in and work from anywhere. Furthermore, the Graphisoft BIM cloud can transmit any project data that is compatible with ArchiCAD. It comprises the BIM Cloud Manager, which serves as the interface for managing every aspect of the BIM cloud, BIM Cloud server, which is the component of BIM cloud and can be installed to the same computer or different one, and BIM cloud Delta Cache, which is an optional feature for transferring the data between ArchiCAD and the BIM cloud server.

The various components of BIM cloud employ the standard HTTP (or HTTPS) protocol for communication, providing a centralized channel for remote collaboration and work on BIM cloud (Figure 7) (Graphisoft, 2023)

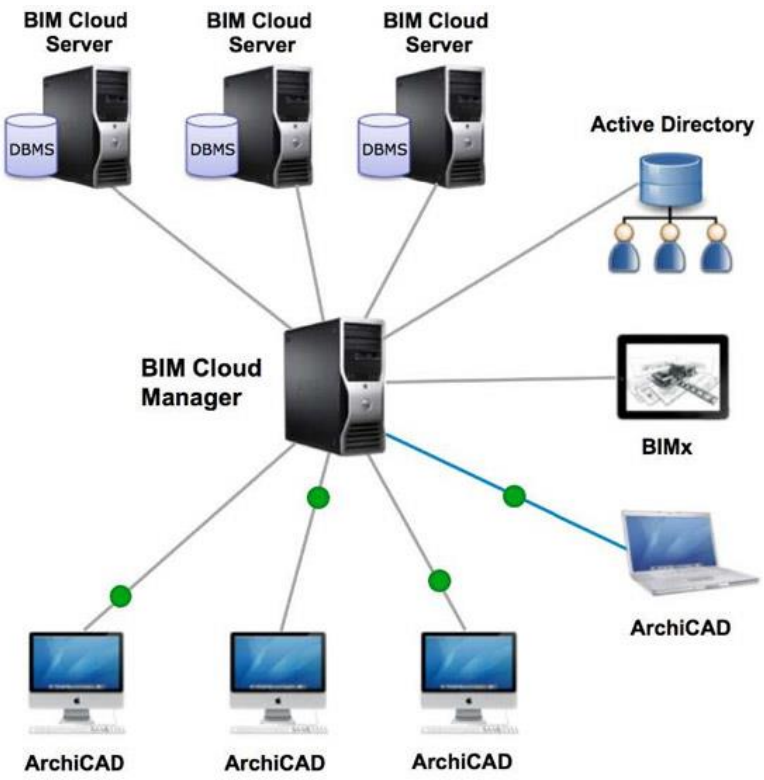

Figure 7: Component of BIM Cloud (Graphisoft, 2023)

Within the BIM cloud, users establish a connection to the BIM cloud servers via the BIM cloud Manager. The main model is stored in the cloud, and any modifications made during work are reflected in real-time on the main model located in the cloud. It is the main feature of BIM and enables different parts of the project access to the Building Information modelling, but it has some disadvantages as well that in below, will be explained.

Standardization: with development of BIM cloud solution, it is lack of specific standards for interoperability. It is important to define standards for exchange data and modeling through cloud between different software.

Dependency of data: Current BIM integration solutions that address Cloud interoperability focus on either centralized model federation or the interconnection of a small number of on-premises design applications using plug-ins in a Cloud-based platform. Rather than establishing a loosely coupled aggregation where each system retains its self-contained nature, these solutions integrate two or more systems into a third new system, as depicted in Figure 8 (Afsari, Eastman, & Shelden, 2016).

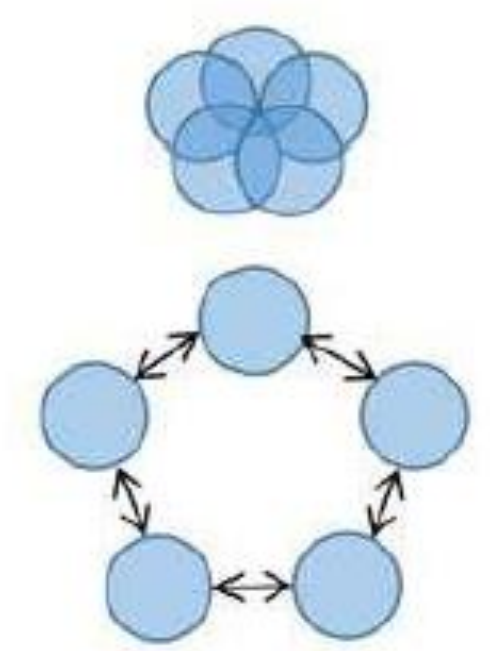

Figure 8: A comparison between tight coupling (top) and loose coupling (bottom) in the integration of Cloud applications (Afsari, Eastman, & Shelden, 2016)

Security and type of access to BIM data: in the BIM cloud-based collaboration, there is an issue of security and reliability and the topic of who owns the BIM model. In BIM cloud collaboration, the authentication and level of access to data is obligatory, therefore the role of each user is important. According to that, the safety and security services are needed for BIM cloud platforms.

02.06 BIM INSIGHT

Over the course of recent years, the utilization of Building Information Modeling (BIM) in construction projects has been improved and has evolved from 3D to 4D, 5D, and other dimensions.

To overall, BIM is a workflow that has changed the building industry and it can be used in different phases of building projects for different purposes. The main core of BIM use is collaboration of different stakeholders through a cloud which enables them to simulate the building before construction. Here, its benefits and drawbacks will be explored which can be considered for developing the project in this research. The features of BIM include:

3D Modeling: BIM software allows architects, engineers, and contractors to create 3D models of buildings and structures, giving a detailed representation of the design.

Collaboration: BIM software enables real-time collaboration among stakeholders, allowing them to share information and work together seamlessly.

Data Management: BIM facilitates the management of all project data, including design specifications, schedules, and costs, in a centralized location.

Clash Detection: BIM allows for the detection of conflicts and interferences between different systems and components, reducing the chances of errors and rework.

Simulation: BIM enables the simulation of various scenarios, such as lighting and HVAC systems, allowing for the optimization of energy efficiency and building performance.

Asset Management: BIM allows for the tracking and management of building assets throughout their lifecycle, from construction to demolition.

Cost Estimation: BIM facilitates cost estimation by providing accurate and detailed information on materials, labor, and other project costs.

Sustainability: BIM software enables the analysis of the environmental impact of a building, facilitating the design of sustainable and energy-efficient structures.

Despite its advancements, however, the implementation of BIM is not without challenges. Its processes are slow, and only large corporations can implement it effectively. Moreover, using BIM workflows requires the use of specific software, and each company may have different tools for implementing BIM. In general, the implementation of BIM requires significant changes within companies, including the adoption of BIM software and the training of personnel in the implementation of BIM workflows. Such changes necessitate time and cost investments (Sakib, 2021).

Some of the key challenges of BIM include:

Cost: The adoption of BIM software and the training of personnel in BIM workflows can be costly for companies, especially for small and medium-sized enterprises.

Complexity: BIM workflows are complex and require significant knowledge and expertise. Companies need to invest in training their employees to use BIM software and to implement BIM workflows effectively.

Standardization: There is a lack of standardization in the use of BIM software and workflows across the construction industry. Different companies may use different BIM tools and workflows, making it difficult to collaborate effectively.

Resistance to change: Implementing BIM requires significant changes within companies, including the adoption of new software and workflows. Some employees may resist these changes, leading to difficulties in implementation.

Technical challenges: BIM software can be complex and may require high-performance hardware and network infrastructure to function effectively. This can add to the overall cost of implementing BIM.

BIM cloud challenges: the main benefit of BIM is collaborating through BIM cloud; however, it has some challenges that must be considered here. Data is important and it should be secure, however Storing and accessing BIM data in the cloud may pose security risks, such as data breaches and unauthorized access. Another important aspect in collaboration is compatibility, but BIM cloud services may not be compatible with all BIM software tools, leading to difficulties in data transfer and collaboration. In BIM workflow, data ownership and control are another issue. Companies may be hesitant to store sensitive BIM data in the cloud and may prefer to keep such data in-house.

According to the drawbacks and features of BIM, in the next chapter, blockchain technology will be explored which combination of it with BIM can help improve feature of the project of this research.

03. BLOCKCHAIN

03.01 Introduction

Blockchain is a database, which stores and organizes data. It consists of many long lists of transitions that include transactions, NFT ownerships, or Smart contracts. The first Blockchain was introduced by Satoshi Nakamoto which was named Bitcoin (BTC). Bitcoin is a distributed network of computers that share the file (In this case, file is blockchain). Each single computer or device in this peer-to-peer network that keep all the blockchain´s history is named node. After each block is full, the node creates a new block by proof of work methodology. Proof of work refers to miners that solve complicated math puzzles and add a block in a consensus mechanism (It is used to get acceptance in a decentralized network). Miners share the information about the new block to all nodes and the nodes validate the block by voting. Every 10 minutes one block adds to blockchain and the miner who solve the puzzle, get reward (Ammous, 2016).

Data in blockchain is irreversible, it means that any data added to the blockchain cannot be changed, removed, or undone.

03.02 Proof of Work (POW) VS Proof of Stake (POS)

As explained before, Blockchain is a decentralized network where transactions and data are managed across all the computer networks. This configuration is set through peer-to-peer network without needing to validate by third party. In this network, data is not stored in a single computer, but it is kept in the whole of the nodes in the network.

The main advantages of blockchain technology are its ability to provide transparency and traceability. These benefits are particularly strengthened in the context of public blockchains, where all computers can access the information and participate in its verification through a cryptographic system that relies on trust. This feature makes it difficult for anyone to compromise and attack the network, because to do that, they must change all the information on all nodes of the network which needs lots of energy and investment that are not profitable.

According to the proof of work, it needs a lot of high-power infrastructure, and it is expensive to run, and its main problem is that it needs a lot of energy. As explained before, whenever a new block of data is generated, an associated cryptographic puzzle is created by the algorithm. This puzzle must be solved to validate and add the new entry. All the computer nodes or "miners" participating in the network then compete to solve the puzzle, with the successful miner earning both the transaction fees and a small amount of cryptocurrency as a reward. According to that, miners that have more powerful computers can have more chance to get rewards. Out of all the public permissionless blockchains, the proof-of-work (POW) system is the only one where security and traceability can be assured without any human involvement in the process (Figure 9).

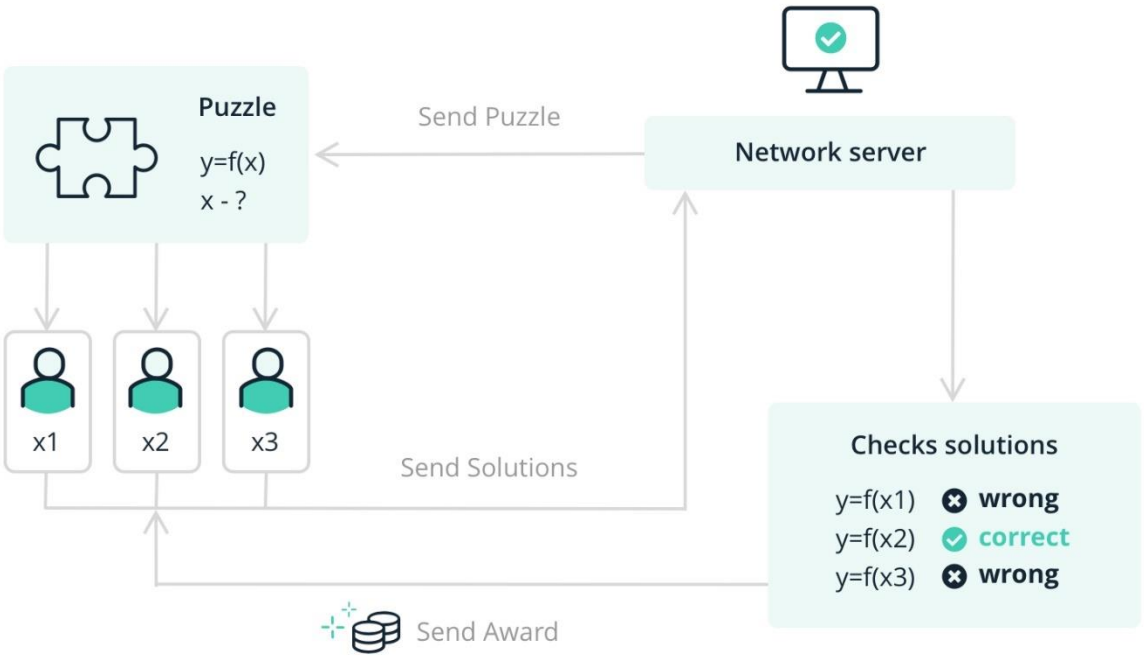

Figure 9: Proof of Work (Moreland, What is Proof-of-Work, 2019)

So, in the proof of work, needs in computation power leads to two main problems according to environment and energy which are pertains to the disposal of electronic devices that are discarded and intended for refurbishment or reuse and the second issue concerns electricity consumption associated with the use of these devices (Schinckus, 2021).

As previously expounded, the functionality of blockchain technology is contingent upon consensus mechanisms which enable the attainment of concurrence among all nodes on the updated distributed ledger. The most employed consensus mechanism in blockchain technology is the proof of work (POW). However, a major drawback associated with the utilization of this mechanism is the extravagant and ineffectual use of energy resources (Li, Andreina, Bohli, & Karame, 2017).

This issue has led society to seek alternative solutions, among which proof of stake (POS) has emerged as a more energy-efficient and environmentally friendly alternative. Proof of Stake (PoS) is a consensus algorithm wherein validators are randomly selected to generate and verify blocks based on their stake in the network. To participate in this process, validators are required to hold a certain amount of the native token of the network, which is then "frozen" or locked up as collateral. The amount of the token held and staked by a validator directly influences their chances of being

selected to validate the next block in the chain. Besides its fast transaction and its security, this mechanism wastes less energy than proof of work (Figure 10).

Figure 10: Proof of Stake (Moreland, What is Proof-of-Stake?, 2019)

03.03 Coin and Token

In the context of blockchain technology, a token refers to a digital representation of an asset or interest that has been tokenized on an existing blockchain. Tokens do not possess their own blockchain, unlike coins which have their own blockchain and are primarily used for exchanges.

Tokens are commonly created for a particular project and are typically generated, distributed, sold, and circulated through an initial coin offering (ICO) process. This process involves the creation of a new cryptocurrency or token, which is then made available to investors in exchange for existing cryptocurrencies such as Bitcoin or Ethereum. The purpose of creating tokens is to provide a means of generating funding for a specific project, as well as enabling investors to participate in the project's success.

Crypto tokens are frequently utilized as units of transaction on blockchains that are developed using established models such as the Ethereum network, which provides users with the ability to create tokens. These blockchains are founded on the principles of smart contracts or decentralized applications (dapps), which utilize self-executing, programmable code to oversee and execute various transactions.

03.04 Ethereum and Smart Contract

Ethereum is an economy that operates in a decentralized manner, leveraging blockchain technology to empower its users to create decentralized applications (dapps), smart contracts, tokens such as ERC20 tokens, non-fungible tokens (NFTs), and decentralized autonomous organizations (DAOs). Ethereum can also be viewed as a decentralized world computer that serves as a global ledger, accurately tracking the ownership of digital assets. It is also used POS (Power of Stake) for Conesus mechanism.

One of the primary applications of the Ethereum blockchain is the utilization of smart contracts. These contracts are digital, computerized agreements between multiple parties that do not require intermediaries and are executed automatically (Metcalfe, 2020).

Smart contracts are comprised of code that is executed on the blockchain, enabling parties to trigger performance based on the terms of the electronically stored agreement. The use of cryptography in smart contracts necessitates that every interaction with them requires a digital signature or keys.

For instance, when purchasing a residential building, a smart contract may be established with conditional acceptance from the buyer(s) and the seller (Figure 11).

Smart contracts operate based on Boolean logic, which involves a computation that results in a value of either true or false. This characteristic provides a greater level of certainty than that offered by traditional contracts.

```
Purchase of Residential Property {
        salePrice = $1,000,000
        purchaser = Mary Jones
        vendor = Peter Smith
        asset = 88 Smith Street, Brisbane
        expiryDate = 30 November 2017
    function exercise ( ) {
        If Message Sender = purchaser, and
        If Current Date < expiryDate, then
            purchaser send(salePrice) to vendor, and
            vendor send(asset) to purchaser
        }
}
```

Figure 11: Coding for the purchase of a Residential Property (Catchlove, 2017)

Due to its automatic agreement capability, smart contracts are applicable in numerous fields. One such use is in transactions between two parties. For instance, a building contractor in need of raw materials for construction may establish payments via a smart contract, while the supplier arranges for shipments. Depending on the type of agreement, payment can be automatically transferred either after shipment or after delivery.

Smart contracts can also be used in real estate transactions, stock and commodity trading, lending, corporate governance, supply chain management, dispute resolution, and healthcare.

Besides its advantages such as autonomy and cost saving, backup, safety, speed, and accuracy, it has some disadvantages such as difficult to change, third party involvement, and difficulty in ensuring about the terms are met according to what is supposed to agree or not (Catchlove, 2017).

03.05 Decentralization App (DApp)

A decentralized application, commonly known as a Dapp, is a type of application that operates on a distributed and peer-to-peer network of computers, rather than a single centralized computer. The benefits of using smart contracts and blockchain technology in Dapps are well-established. To better understand the distinction between centralized and decentralized applications, we will first explore the characteristics of centralized applications.

A centralized application typically involves at least one user interface (UI), which could be a mobile or desktop application, and is usually dependent on data provided by a single entity, whether an individual or a company. The data present in such an application is usually subject to manipulation or computation. On the other hand, Dapps leverage blockchain technology as a storage and processing database, with smart contracts being used to implement this functionality. In modern times, the UI of Dapps often resembles that of a traditional website, with smart contract features being integrated. While the performance of Dapps is comparable to that of centralized applications, their key difference lies in the storage and processing of data, which takes place in a decentralized network on a blockchain (Figure 12) (Metcalfe, 2020).

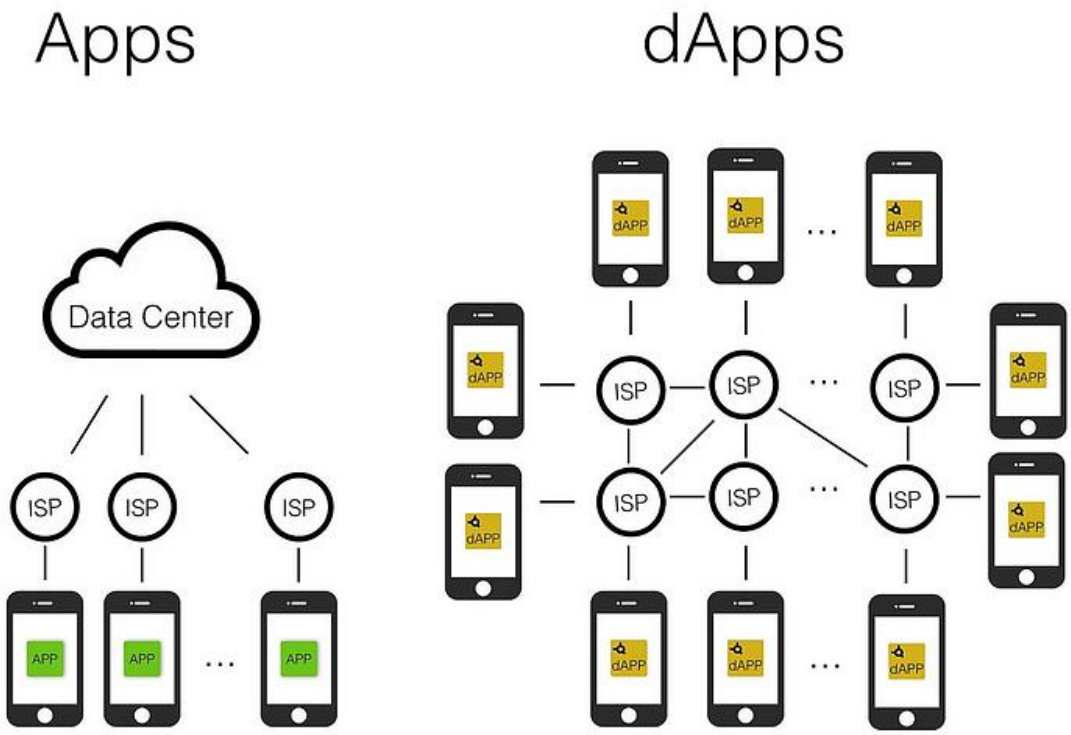

Figure 12: Apps VS dApps (Ray, 2018)

According to definition of blockchain, the key features of dapps can be understand easier which are:

1. Open source: In an ideal scenario, the dApp should possess a self-governing mechanism where modifications are made based on the agreement of most users. Additionally, the source code of the dApp should be open to examination.
2. Decentralized: The blockchain technology records all the activities and functions of dApps, ensuring that no external entity has control over it.
3. Protocol: The decentralized applications community must reach a consensus on the cryptographic algorithm utilized for demonstrating proof of value (Takyar).

According to type of blockchain, there is 3 types of decentralized app:

Type 1: These dapps have their own blockchain.

Type 2: These types of dapps use other blockchain and they are protocols which need tokens for their operation.

Type 3: these dapps use the protocol of dapps type 2 (Takyar).

The key features of dapps compare with traditional app are:

1. Decentralized apps are inherently secure as they cannot be tampered with, and their records are unchangeable. They are also highly resistant to hacking, intrusions, and any other form of potential sabotage.
2. The lack of intermediary applications such as integrated payment gateways facilitates quicker payment processing.
3. The decentralized apps encourage greater anonymity by eliminating the need for users to go through lengthy registration processes.
4. Users can access the public blockchain to verify transaction information, ensuring trustworthy data records.

One significant distinction between decentralized applications (dapps) and traditional applications is that dapps require a transaction for their operation, whereas traditional applications do not. For better understanding, here the architecture of dapps is explored (Takyar).

03.06 Architecture of DApp

As explained before, Dapps are located on the blockchain. Their function is similar to traditional app, however, its specific part which is smart contract is located on the blockchain. It enables users to interact with blockchain for their transaction to perfume the app. This type of interaction with smart contract happens through web, app, desktop, mobile, or any other software that has familiar user interface. The only difference is users need to connect their crypto wallet to dapp in order to work with it (Figure 13).

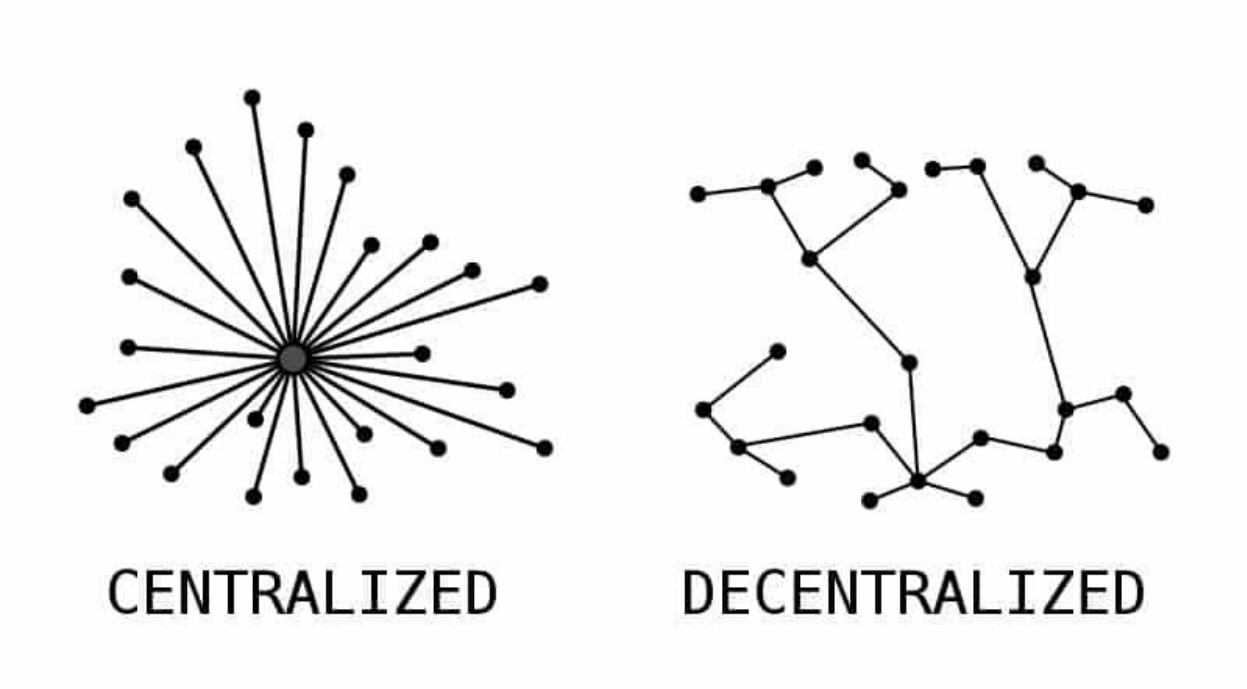

Figure 13: Centralized VS Distributed Ledger

For making a dapp that its function is more than just transaction, the centralized server is needed where the information of users keeps. Another factor that should be considered for creating dapps, is that if smart contract relies on some external data, decentralized oracle is needed. It acts like a node which must agree about the information that consider sending to smart contract. For creating

a dapp, technology stack should be chosen according to blockchain type, front end envisions (mobile/app), and feature of a dapp. “Tech stack is a combination of programming languages, frameworks, databases, servers, development tools and plugins, and other technology layers that make up any web or mobile application.” The standard tech stacks for a dapp developing in Ethereum is Truffle suite, Ganache, Programming language solidity, and development environment suite etc. In the table below, the different programs and software that can be used according to front and back end of the dapp will be explored (Table 5).

WEB2 AND WEB3 DEVELOPMENT TOOLS	FEATURES
JAVASCRIPT (REACT/VUE)	front-end development smart contracts testing
PYTHON, GO, RUST, C++	back-end coding business logic development
NODE.JS, SOLIDITY	Smart Contract Development
TRUFFLE	developing smart contracts with the Solidity programming language testing blockchain code
METAMASK	Ethereum wallet provides chain connectivity inside a browser
GANACHE	spin up a local blockchain in seconds with funded accounts cheap alternative to setting up a full-fledged testing environment
WEB3.JS OR ETHER.JS	connects the front-end portion of a dapp with a blockchain
EXPRESS.JS	off-chain back-end development
REMIX	browser-based development environment for writing blockchain code

Table 5: WEB2 and WEB 3 development tools and their features

A dapp requires both smart contracts and front ends, where a smart contract is a blockchain code executed when specific conditions are fulfilled, and front ends serve as a user interface to connect with smart contracts. Additionally, a back end is also necessary for managing the dapp. In essence, a dapp is a web application that interfaces with smart contracts through APIs and oracles.

Step 1: build a smart contract.

Decentralized logic of a dapp is implemented through smart contracts. To utilize smart contracts, one must choose a suitable blockchain, like Ethereum.

Step 2: Build a front end.

Dapps need a user interface like web / app environment where users can interact with it, so designing a front end plays main role in the business of a dapp.

Step 3: create centralized back end.

For managing and storing user data, the centralized server is needed.

STEP 4: TEST RIGOROUSLY

Like another app, it is necessary to test the app before running it in public.

STEP 5: DEPLOY AND MAINTAIN

And the final step is to deploy the dapp in the blockchain. It is like uploading an app in apple store and google play.

04. INTERIOR DESIGN

04.01 Introduction

The initial point regarding Interior design can be misconstrued as being the same as Interior decoration, when in fact they are distinct disciplines. An Interior designer is an individual who investigates how people interact with their surroundings to enhance their overall well-being and quality of life (Lyon, 2022). It is important that make it into consideration that interior design is part of architecture and environment design and today, many architectural companies have their own Interior design department which includes Architects, industrial designer, and graphic designer. The most popular projects in interior design field are residential, however, there are also nonresidential projects such as hotels, and commercial buildings (Savage & Friedmann, 2022). In the next section, the interior design workflow will be explored.

04.02 Interior design workflow

The process of interior design varies depending on the size of the project, but typically begins with a meeting between the designer and client. During this meeting, the client expresses their needs and desires while the designer offers potential solutions to help the client achieve their goals. This initial meeting is like an interview, and at the end, the client decides whether to move forward with the designer or not. Depending on the size of the company and project, the agreement between the client and designer can be a simple piece of paper or a legally binding contract that outlines the services and responsibilities of both parties throughout the project. This includes the project timeline, payment details, meeting schedules, and other related matters. Once the agreement is signed, the designer begins to explore the project and propose new ideas to the client. In the initial stage, the designer must accurately measure the project area (if it does not already exist) and propose an approximate budget based on the project requirements and the client's needs. However, this budget is not set in stone and may change as the design progresses (Savage & Friedmann, 2022).

Once the client approves the schedule and program proposed by the designer, the designer proceeds to create various design options based on the client's requirements. At this stage, the designer focuses on creating drawings and drafts to effectively communicate their ideas to all stakeholders, including the client. The designer's focus is on the aesthetics of the design, and the physical aspects of the project are not determined in detail. After developing their ideas, the designer prepares a presentation to present the design to the client. During this stage, the client provides feedback on the design, and the designer may need to adjust based on the client's needs. This process continues until both parties reach a mutual agreement on the design (Savage & Friedmann, 2022).

The subsequent stage is the final phase of the design process, where the designers finalize the drawings created in phase 2. Some of the drawings may be outsourced to subcontractors, such as mechanical engineers, who are responsible for proposing installations like pipes and MEP elements. This is because the potential conflict between MEP elements and the building's structure is crucial in building projects, including interior design. The designers aim to create detailed drawings that provide comprehensive information for different contractors to bid on the project (Savage & Friedmann, 2022).

Once the final drawings are completed, interior designers proceed to select and order furnishings, such as furniture and lighting. This process requires extensive knowledge of various products available in the market, which can be particularly challenging in large cities. In some cases, designers may even opt to design their own furniture. The method of ordering and payment varies among different interior design offices. Some designers prefer not to involve themselves in the product selection and purchasing process, while others take charge of the purchasing but provide invoices to clients for payment. The specific approach taken depends on the type of agreement that was reached between the designer and the client (Savage & Friedmann, 2022).

The final stage involves the construction phase, which also requires the designers' supervision. It is clear that managing large interior design projects requires careful attention from the beginning of the project all the way through construction (Savage & Friedmann, 2022).

04.03 Interior design Problems

In the realm of traditional interior design workflows, CAD software, such as AutoCAD, predominantly serves as the primary tool for creating drawings. In addition to drawings, various other software applications are utilized for visualization purposes. This dichotomy between drawings and visualization gives rise to challenges in error detection during the design phase, consequently leading to time-consuming processes in generating construction drawings. Furthermore, the final outcome often deviates from the original design. Another prominent concern pertains to the collaboration among different stakeholders involved in the project. These stakeholders encounter gaps during the various project phases. As previously elucidated, architects primarily engage with clients during the design phase, while other stakeholders, such as MEP (Mechanical, Electrical, and Plumbing) engineers, are required to be involved from the project's inception. Due to inefficient collaboration, an abundance of project files is generated, thereby fostering a propensity for errors during the construction phase (Hamid, Taib, Razak, & Embi, 2017).

In below, the main problems of Interior design workflow are listed:

1. Difference between Drawings and Visualization: The use of CAD software for drawings and separate software applications for visualization often results in a disconnect between the two. This disparity makes it difficult to identify errors during the design phase, leading to potential discrepancies between the intended design and the outcome.
2. Time-Consuming Construction Drawings: The process of creating construction drawings can be time-consuming in the traditional workflow. This is primarily due to the need for manual drafting and the incorporation of various software tools for different aspects of the design. As a result, the overall project timeline may be extended, leading to potential delays.
3. Design-Construction Discrepancies: Owing to the challenges in detecting errors and inconsistencies during the design phase, the final project may not align with the initial design intent. This discrepancy can arise due to misinterpretation, miscommunication, or limitations of the software tools used.
4. Inefficient Collaboration: The traditional workflow often involves multiple stakeholders, such as architects, interior designers, engineers, contractors, and clients. Effective

collaboration among these stakeholders can be hindered by gaps in communication, limited access to project files, and coordination issues. This can lead to misunderstandings, delays, and increased potential for errors in the construction phase.

5. Client-driven Changes: Clients place significant importance on achieving their ideal interior space and often seek modifications to align the design with their envisioned outcome. These requested changes can occur at various stages throughout the project. However, due to the disconnected nature of project phases in the traditional interior design workflow, implementing a single change can have ripple effects on other project components. Consequently, this leads to implications in terms of time and cost, as subsequent adjustments may be required to accommodate the client's evolving preferences (Infurnia, 2019).
6. Insufficient Transparency in Cost Estimation: Within the traditional interior design workflow, accurately estimating project costs presents a considerable challenge, primarily stemming from the disconnected nature of project stages. The lack of synchronization between these stages impedes the ability to establish a comprehensive and precise cost estimation from project initiation. Discrepancies between the estimated cost and the actual expenses incurred erode client trust in the interior design industry. Consequently, clients may seek to exert greater involvement in projects, thereby introducing potential issues concerning quality control and, in some cases, even the overall project cost (Infurnia, 2019).

04.04 Interior design Software

In this section, different Interior design software will be explored according to their workflow and features in order to understand that what are their advantages and disadvantages. There are different interior design software and in this section, try to select some of them according to their functionality and differences.

04.05.01 Sketch UP

Sketch Up is a software application renowned for its capacity to create both 2D and 3D models, offering a notably intuitive user interface. Its distinguishing feature lies in its push-and-pull functionality, whereby users can effortlessly shape objects by selecting and manipulating their respective faces. Beyond its capabilities in 2D drawing and 3D modeling, Sketch Up also encompasses a visualization component for rendering purposes. It is used in architecture, interior design, landscape design, and even video game development (Gavin, 2018).

In this part, the advantages and disadvantages of sketch up will be explored according to its capability for interior design and renovation projects.

1. User Interface: according to G2 website which is one of the famous websites for evaluation software, Sketch ups user interface is very high. Its work environment according to sketch up help center includes 7 sections that are:
    a. Title bar: It includes the name of the project with maximize, minimize and close icons.
    b. Menu Bar: It includes all the menu which includes all the commands. The menu includes File, Edit, View, Camera, Draw, Tools, Windows, and help.
    c. Getting Started toolbar: it includes basic tools and commands for 3D modelling, and it is located under the menu bar.
    d. Drawing area: It is an area with direction axes where the users can draw and model.
    e. Status bar: It includes two important sections that are tips for using the tools and measurement box.
    f. Default panels: it is in the right side of the program, and it includes tutorials, materials etc. (Figure 14) (SketchUp Help Center, s.f.)

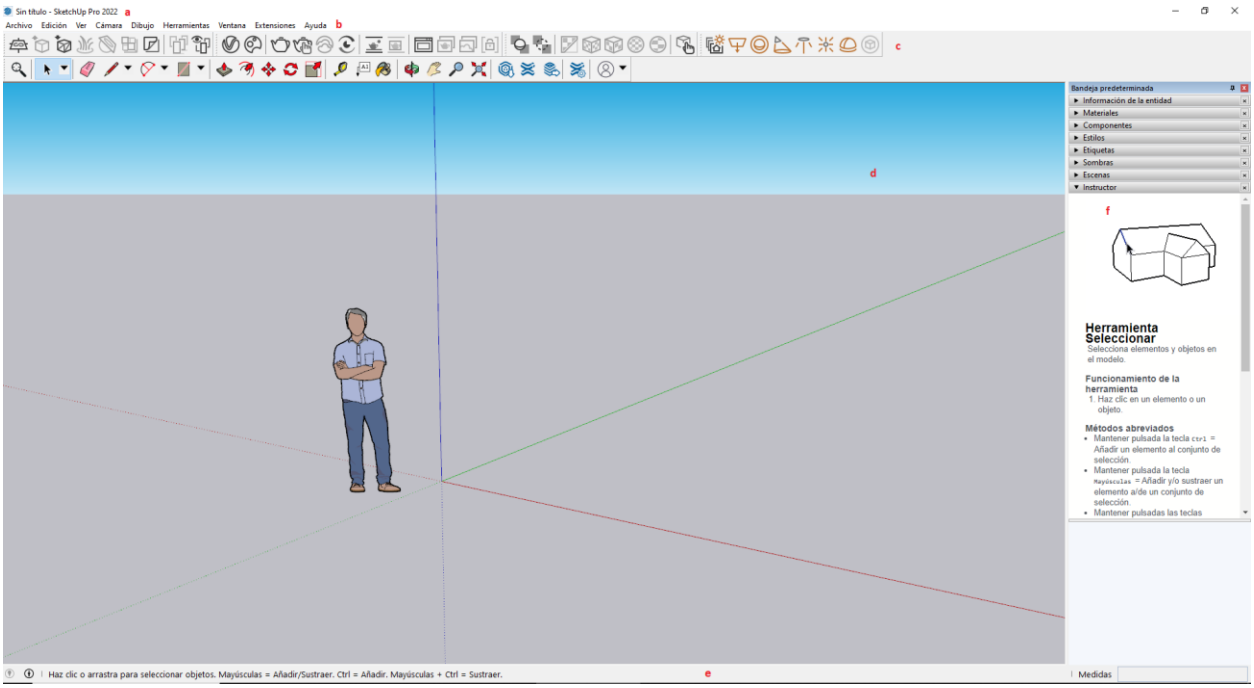

Figure 14: User Interface of SketchUp

2. Collaboration and sharing: Sketch up has the feature for collaboration between the team design, which allows them to work on the same model in the same time. It helps users to avoid do less mistakes in the projects as well as reducing the number of files which include different stages of the project. It also provides options for sharing models with others, including exporting files in various formats for viewing in other software or on the web.
3. Visualization and Rendering: it is the high feature of sketch up and according to G2 website, sketch up is leader in this section among other competitors (Figure 15).

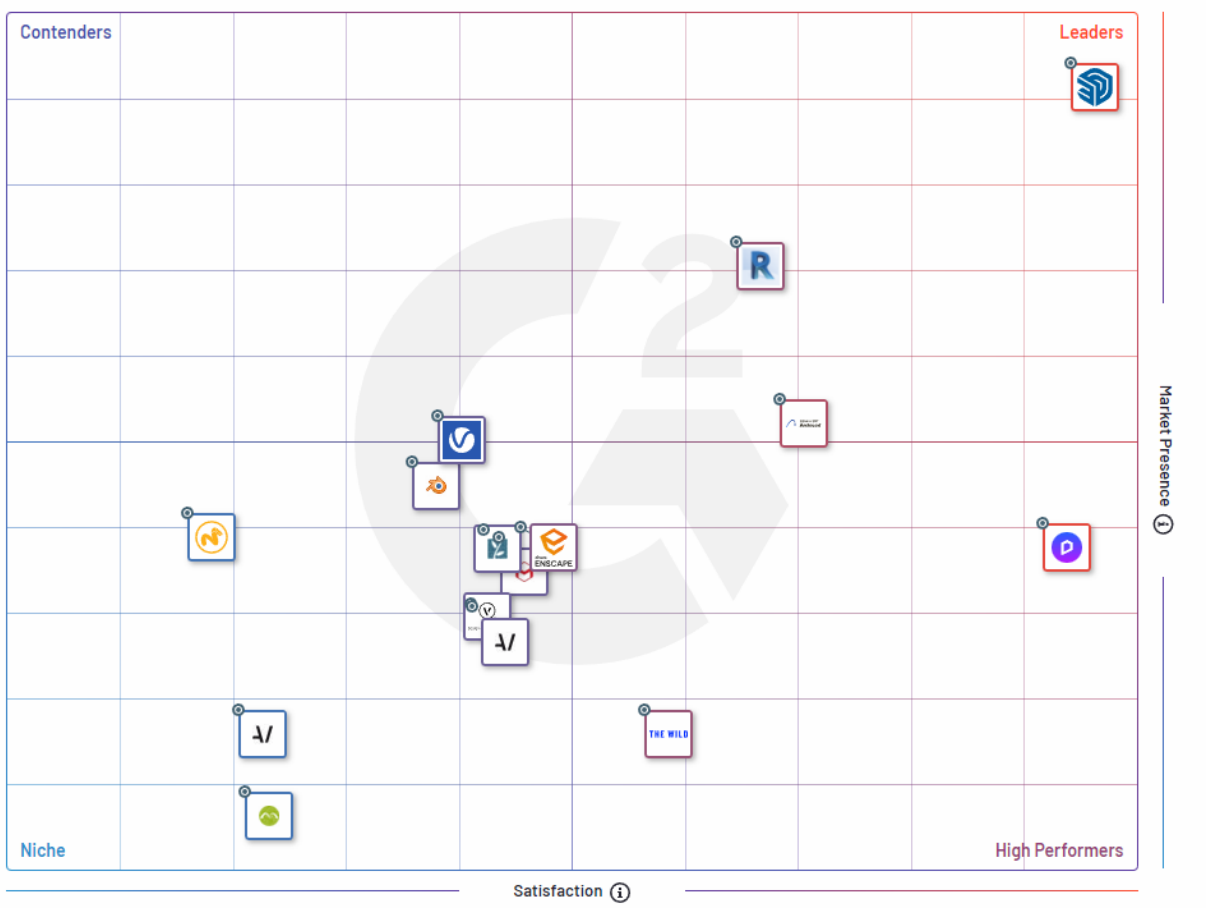

Figure 15: Visualization is the high feature of Sketchup in compare with other competitors (SkecthUp, 2023).

4. Interoperability: It is important that users can exchange their data with other software and sketch up provides different File formats for this purpose which also includes IFC files which is the common format file between different software specially in the BIM Workflow.
5. Not a BIM solution: As Sketch up is not a BIM tool, it doesn´t have many aspects in BIM workflow such as automatic documentations, information inside the model for using in different phase of the project (for example, evaluate cost of the project according to model), however, it tries to make benefits from cloud collaboration, interoperability and also direct connection with BIM tools such as ArchiCAD and Revit.

04.05.02 ArchiCAD

ArchiCAD is a sophisticated Building Information Modeling (BIM) tool specifically designed for architects, providing comprehensive support throughout the entire BIM workflow, encompassing conceptual design phases through to construction phases. This software offers a collaborative environment that enables architects to create detailed 3D models of their projects, enriched with relevant project information. Notably, ArchiCAD facilitates the extraction of pertinent information at each phase of the project's lifecycle.

One of the key features of ArchiCAD is its ability to automatically generate documentation directly linked to the main model. Consequently, any modifications made to the model have a ripple effect on all associated documentation within the project. This streamlines the documentation process and ensures consistency and accuracy across the board.

In addition to its prowess in 2D drawing and 3D modeling, ArchiCAD enables seamless collaboration with other project stakeholders. For instance, architects can easily collaborate with structural engineers for precise structural analysis. This collaborative capability enhances interdisciplinary coordination and promotes efficient communication and decision-making among project team members.

The versatile nature of ArchiCAD allows it to be employed across a wide range of disciplines. It finds extensive usage in architecture, interior design, landscape design, construction, and even facility management. This versatility underscores its value as a comprehensive BIM solution that caters to the diverse needs of professionals operating in various domains within the architecture, engineering, and construction (AEC) industry (Csikos, Graphisoft Community, 2022).

In this part, the advantages, and disadvantages of ArchiCAD will be explored according to its capability for interior design and renovation projects.

1. User interface: according to G2, User interface of ArchiCAD is user friendly, and its work environment includes 9 sections according to Graphisoft community:
    a. Menu Bar: It includes menus that are divided according to function and categories of commands.

b. Toolbar: Give Access directly to most common commands that are used in ArchiCAD, so users do not need to find them in a menu. It has feature of customization which users can add or remove commands from toolbar.
c. Info Box: It shows the current settings and characteristics of the selected object.
d. Tab Bar: It Works like web browser. It shows the plan view of the Project and different views can open in different tab.
e. Work area: it is in the middle as same as all other software for drawing and modelling.
f. Toolbox: according to modelling and documentation, this part is divided to four parts.
g. Pop-up Navigator: It is located at the right side which has divided to four sections according to process of the projects and users can navigate between different section of the Project by using this part.
h. Status Bar: it shows the status of current command or Project. It means when user select Wall, it shows that the user needs to select the start point and in somehow guide them to do a command.
i. Quick options Bar: It is on the bottom of the screen and includes the most common commands for managing model view such as layers, scale, etc. (Figure16) (Csikos, The Archicad Interface, 2021)

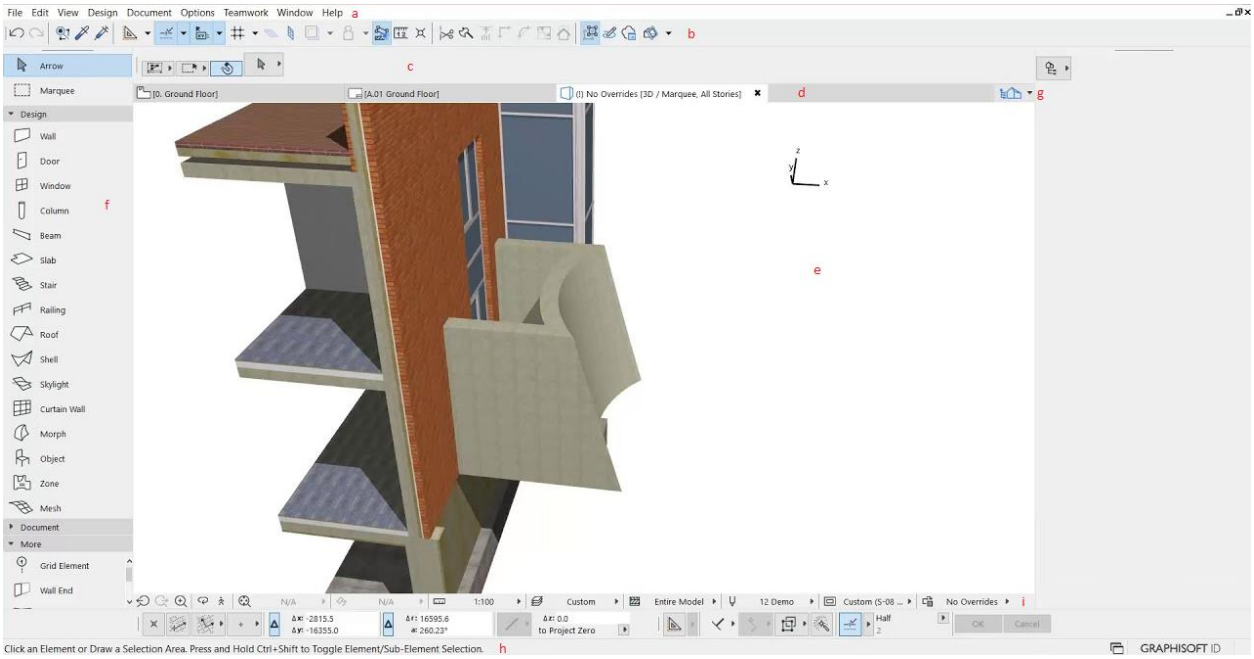

Figure 16: User Interface of ArchiCAD

2. Collaboration and sharing: ArchiCAD, a cutting-edge architectural design software, offers a remarkable feature set that includes robust collaboration capabilities and seamless integration with various software applications. This formal discourse aims to elucidate the exceptional benefits associated with ArchiCAD's collaboration functionalities and its ability to establish connections with diverse stakeholders and software platforms. To facilitate a comprehensive understanding, each feature will be examined individually, highlighting their distinctive advantages.
    a. Collaboration Capabilities: ArchiCAD's collaboration capabilities provide an indispensable avenue for effective communication and cooperation among diverse stakeholders involved in architectural projects. This feature enables seamless collaboration between architects, engineers, clients, contractors, and other relevant parties, fostering enhanced coordination and efficient workflows. The key advantages of Archicad's collaboration capabilities are:
        i. Streamlined Communication: ArchiCAD offers a centralized platform that facilitates real-time communication and information exchange between project stakeholders. This allows for prompt decision-making, reduced

communication gaps, and improved project understanding among team members.

ii. Concurrent Workflows: ArchiCAD enables multiple users to work simultaneously on the same project, eliminating the need for sequential processes and significantly reducing project timelines. This concurrent workflow feature enhances productivity and ensures efficient resource allocation.

iii. Version Control and Conflict Resolution: With ArchiCAD, version control becomes effortless, as it allows users to track and manage project revisions seamlessly. Additionally, the software incorporates conflict detection and resolution mechanisms, mitigating potential clashes and ensuring smooth collaboration among stakeholders.

b. Integration with Different Software: ArchiCAD's remarkable compatibility with various software applications is a notable attribute that expands its functionality and enhances project efficiency. By establishing connections with diverse software platforms, ArchiCAD enables seamless data exchange, streamlines workflows, and optimizes resource utilization. The key advantages of Archicad's software integration feature are:

i. Comprehensive Design Development: ArchiCAD's integration capabilities allow architects and designers to import and export files from a wide range of software applications, such as structural analysis tools, 3D modeling software, and rendering platforms. This enables a comprehensive design development process, promoting holistic project visualization and refinement.

ii. Data Consistency and Accuracy: Through seamless integration, ArchiCAD ensures data consistency and accuracy across multiple software applications. Changes made in one software are automatically synchronized with ArchiCAD, eliminating the need for manual data transfer, and reducing the risk of errors or discrepancies.

iii. Enhanced Workflow Efficiency: The integration of ArchiCAD with different software platforms promotes a streamlined workflow, as it facilitates the efficient transfer of data and project updates. This synergy

optimizes collaboration between various disciplines, enabling architects, engineers, and other stakeholders to work cohesively toward project goals.

c. BIMx: It provides a dedicated application that serves as a vital conduit for effective collaboration between design offices and construction sites. This feature enables constructors to effortlessly monitor the evolution of the design directly on-site, while facilitating prompt communication of any modifications or updates to the design team.

3. Visualization and Rendering: According to the Graphisoft Help Center, ArchiCAD utilizes the Cineware Engine, which is the rendering engine of Cinema 4D, for visualization purposes. However, ArchiCAD also offers various live connections with other software applications, such as Twin motion and Enscape, which are widely favored by users. Although ArchiCAD provides visualization and rendering capabilities, it is important to note that these may not be on par with the highest industry standards, which could be considered a potential disadvantage.
4. BIM solution: ArchiCAD, recognized as a prominent leader in the field of Building Information Modeling (BIM), occupies a pivotal position as one of the foremost BIM software solutions within the BIM workflow. With its purpose-built user interface and toolset, ArchiCAD is meticulously designed to align with the fundamental principles and requirements of the BIM methodology. Its unwavering focus on interoperability, open BIM solutions, and collaborative teamwork capabilities fortify its standing within the BIM industry.
5. Interior design objects and furniture: It includes a variety of objects and furniture from real manufacturers. It also enables us to create specific objects or import manufacturer's objects inside the software. It helps interior designers to make their design more real and the clients can easily decide about the furniture of their house.
6. Cost estimation: according to BIM feature, the software provides an environment where the users can list the elements according to their own criteria and provide precise cost estimation of the Project, which can help clients to manage their budgets, and even designers to design based on the Budget of the clients.

7. Centralized: One potential disadvantage of ArchiCAD is its centralized nature. As centralized software, ArchiCAD relies on a single master file that contains all project data and information. While this centralized approach offers certain advantages, it also presents some challenges and drawbacks, including:
    a. Potential Data Loss: If the centralized file becomes corrupted or damaged, there is a risk of losing all project data associated with that file.
    b. Reliance on Network Connectivity: ArchiCAD's centralized structure necessitates stable network connectivity for effective collaboration and access to project data. In situations where network connectivity is unstable or unavailable, users may experience difficulty accessing or updating project information. This dependency on network availability can pose challenges when working in remote locations or areas with unreliable internet connectivity.
    c. Scalability Challenges: As project sizes and complexity increase, the centralized nature of ArchiCAD can lead to performance issues. Large projects with extensive data and intricate designs may experience slower processing times and reduced performance, affecting overall productivity. This can necessitate additional hardware resources or optimization measures to maintain optimal performance.
    d. Untrust between different stakeholders: With all project data stored in a central file, concerns about data security and access control can arise. stakeholders may question the ownership and control of project data. In a centralized system, efficient and transparent communication channels become crucial to ensure that all stakeholders are adequately informed and involved in the decision-making process. Stakeholders may express concerns about the reliability and accuracy of the central file, as any errors or discrepancies within the file can have a cascading effect on the entire project.

04.05 Overview

Based on the identified features of BIM workflow and Blockchain, as well as the drawbacks associated with the traditional interior design workflow—namely, the lack of compatibility between the design and construction phases, imprecise cost estimation, inefficient collaboration among stakeholders, and time-consuming preparation of construction drawings—this research proposes the development of a software solution. The software, rooted in the principles of BIM workflow, aims to foster more efficient collaboration among stakeholders while offering precise cost estimation capabilities. Additionally, the software seeks to leverage blockchain technology to establish connections between suppliers, interior designers, and clients. This integration of blockchain features facilitates the implementation of smart contracts and seamless payment processing within the software. In the subsequent chapter, the proposed software will be comprehensively explored.

05. PROPOSAL

05.01 Introduction

The Arch Cloud Chain Dapp project is a decentralized software application designed to facilitate interior design and renovation projects using the BIM workflow and blockchain technology. Its primary objective is to provide an interactive and transparent platform for all stakeholders involved in the project, including designers, clients, and suppliers. The software runs on the blockchain and has its own token for payment purposes.

Through the Arch Cloud Chain Dapp, designers, clients, constructors, and suppliers can communicate with each other within the software to collaborate and agree on the requirements of the project. A smart contract is then created that outlines the terms of the agreement and cannot be altered after signing.

Once the smart contract is in place, designers can begin designing the project while clients have the ability to view the progress and offer feedback. Clients can also choose features of the project, such as materials, which are then incorporated into the design. A new smart contract is created for each feature chosen, and the supplier is notified to prepare the materials and deliver them to the construction site as specified in the agreement.

The use of blockchain technology ensures that the entire cycle of the interior design project is attached to a transparent and immutable database, which increases accountability and trust among all stakeholders involved. Additionally, the Arch Cloud Chain Dapp helps to improve the quality of the design while considering the precise budget needed for the project.

Overall, the Arch Cloud Chain Dapp project provides an innovative solution to the challenges of traditional interior design processes by leveraging blockchain technology to facilitate transparency, collaboration, and trust among all stakeholders involved.

05.02 Element of Design

The Proposal project comprises two primary components. The first component is a website that allows users to view the software's features and purchase products (Figure 17). The second component is a decentralized application (DApp) that enables users to manage their projects on the blockchain. This section aims to provide an explanation of each element of the project, while the subsequent section will delve into the software workflow.

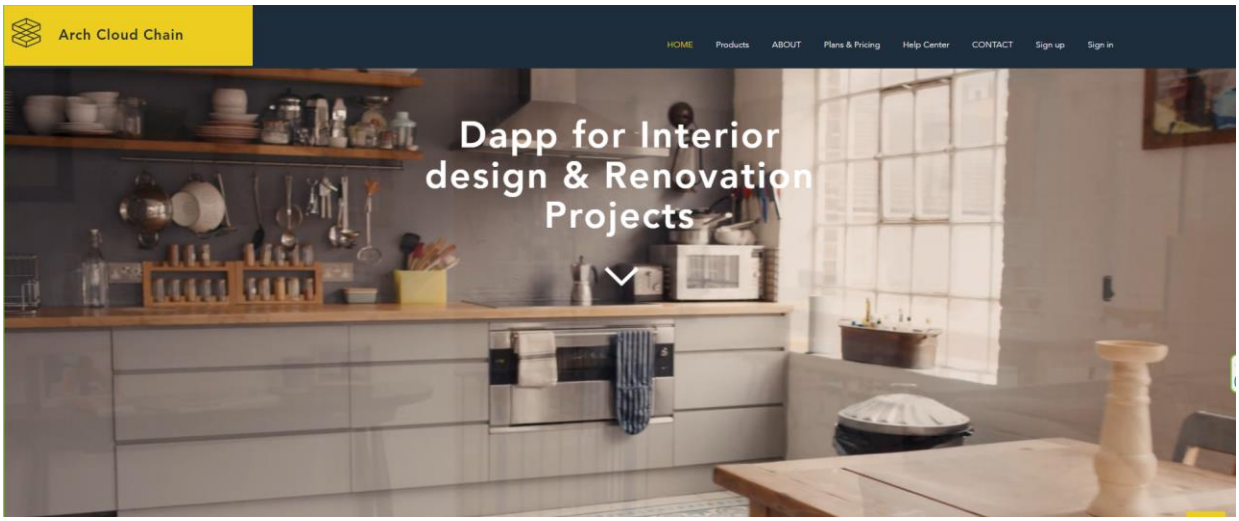

Figure 17: Arch Cloud Chain Website

The first section that users interact with is website where is divided into 7 sections that each section is explained below:

Products: According to potential users of the software, which is interior designer, architects, and suppliers, the products are divided into ACC Dapp, ACC Cloud, ACC materials library, and ACC token (Figure 18).

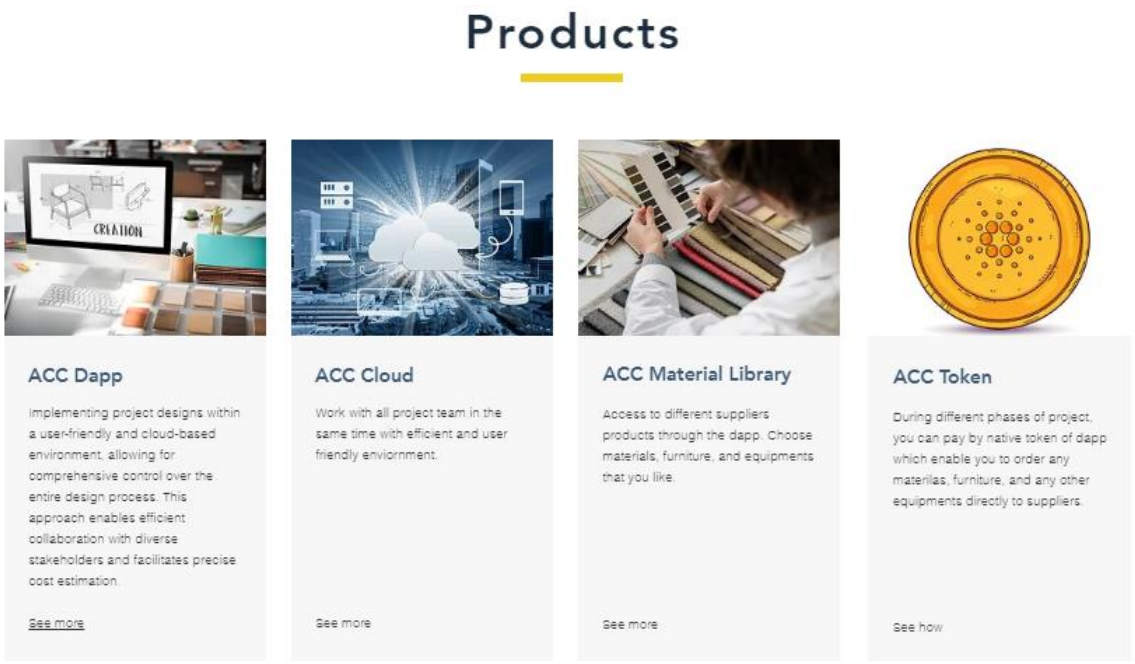

Figure 18: The project has four products that are: ACC Dapp, ACC Cloud, ACC Material Library, and ACC Token.

The main offering of the project is the ACC Dapp (Figure 19), a blockchain-based software that combines the functionalities of Interior design software with features from blockchain technology. The Dapp utilizes smart contracts and automatic payments using the project's native token, following the BIM ecosystem. Its user interface prioritizes user-friendliness and avoids the need for additional tools. One of its key features is the automated creation of 2D documents based on a 3D model. It also allows the addition of non-geographical information to the model for various purposes, such as cost estimation and tracking changes that affect all associated documents and information simultaneously. Collaboration with other stakeholders takes place in a cloud-based environment. The Dapp offers high-quality rendering through a powerful rendering engine and real-time rendering capabilities. Users can modify render settings, materials, and lighting parameters while the rendering process is ongoing. Another notable feature is its integration with multiple suppliers. By leveraging blockchain technology and the ACC native token, users can

easily place orders for preferred items during the project phase. Once the order is confirmed, prompt delivery of selected objects directly to the project site is facilitated, streamlining the procurement process. As wood is the primary material used in interior design, the Dapp enables users to effortlessly generate the necessary documents for CNC processing. These documents provide precise instructions for preparing the construction materials, ensuring efficient and accurate production, and contributing to the smooth progress of the construction project.

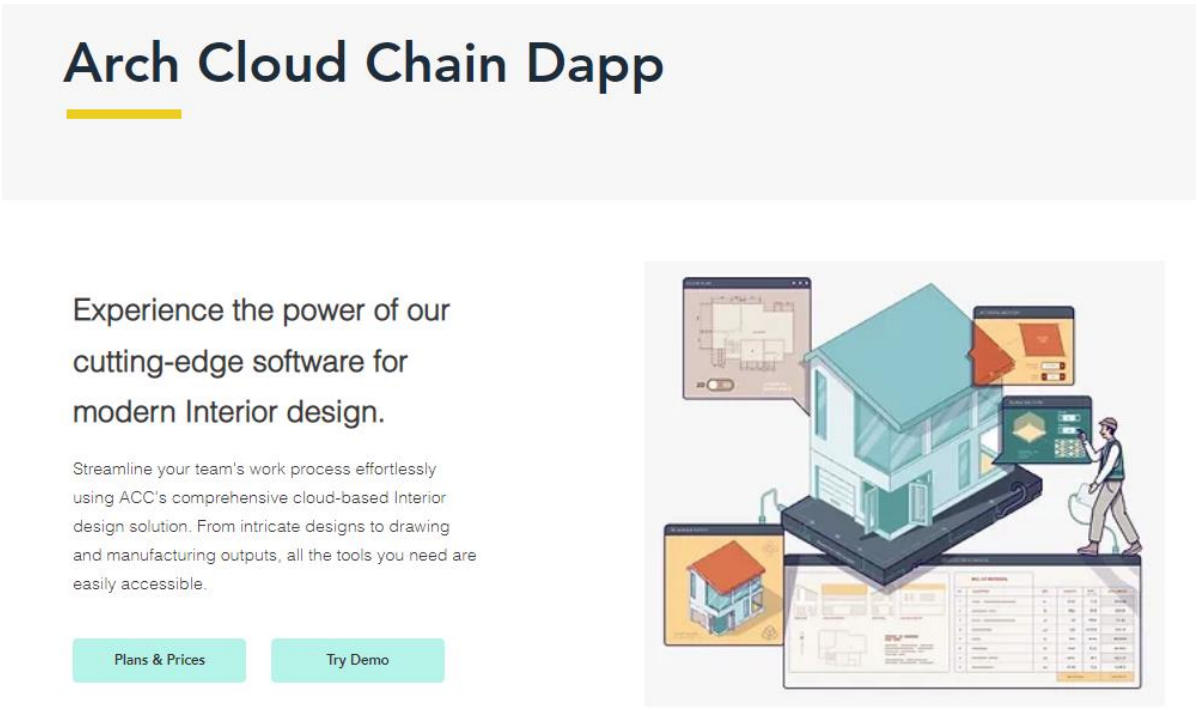

Figure 19: Arch Cloud Chain Dapp Plans & Prices

Another product of the project is Cloud (Figure 20), which provides a teamwork platform for users and enables them to work at the same time at the project from everywhere. The users can access the Cloud environment after purchasing the license. It has its own platform that users can manage their projects, define users, their roles, type of access for each role, and manage the project. By defining users and their roles, each user's responsibility is clear and according to their access and their work history, the changes are more easily traceable during the design process.

Figure 20: Arch Cloud Plans & Prices

Aligned with one of the project's objectives, which is to facilitate direct interactions between designers, clients, and suppliers through the software, a dedicated section called the "Material Library" has been established. This section encompasses an extensive collection of materials, products, and furniture sourced from various suppliers operating in the market. Designers and clients are granted the convenience of utilizing these materials directly within their models and can proceed to place orders through the utilization of smart contracts. Upon completion of the purchasing process, the smart contracts are transmitted to the construction site. Importantly, this entire procedure remains flexible and reversible, while concurrently ensuring complete traceability and transparency throughout the ordering process.

The final offering is the ACC token, which serves as the intrinsic token of the project. Built on the Ethereum network, it leverages the blockchain technology of Ethereum to facilitate payments and execute smart contracts, eliminating the need for intermediaries. Within this section, a comprehensive explanation of the token and its functionalities is provided. Furthermore, various exchanges are introduced to users, allowing them to acquire the ACC token for diverse purposes, including the purchase of products and the execution of smart contracts throughout the project lifecycle.

The Plan and Price section of the website is divided into three distinct plans (Figure 21). The initial plan, known as ACC Dapp, offers a license that covers a maximum of three individuals monthly. Users have the option to procure the license when they initiate a project. Additionally, supplementary user licenses are available for those who wish to incorporate more individuals into their project. Another plan offered is the ACC Cloud license, which possesses the same purchasing

requirements as the software license, albeit at a more affordable price. The final plan combines the features of the plans. Consequently, within a project, the plans and pricing have been established based on user requirements, ensuring users are afforded the flexibility to select the most suitable option to meet their individual needs.

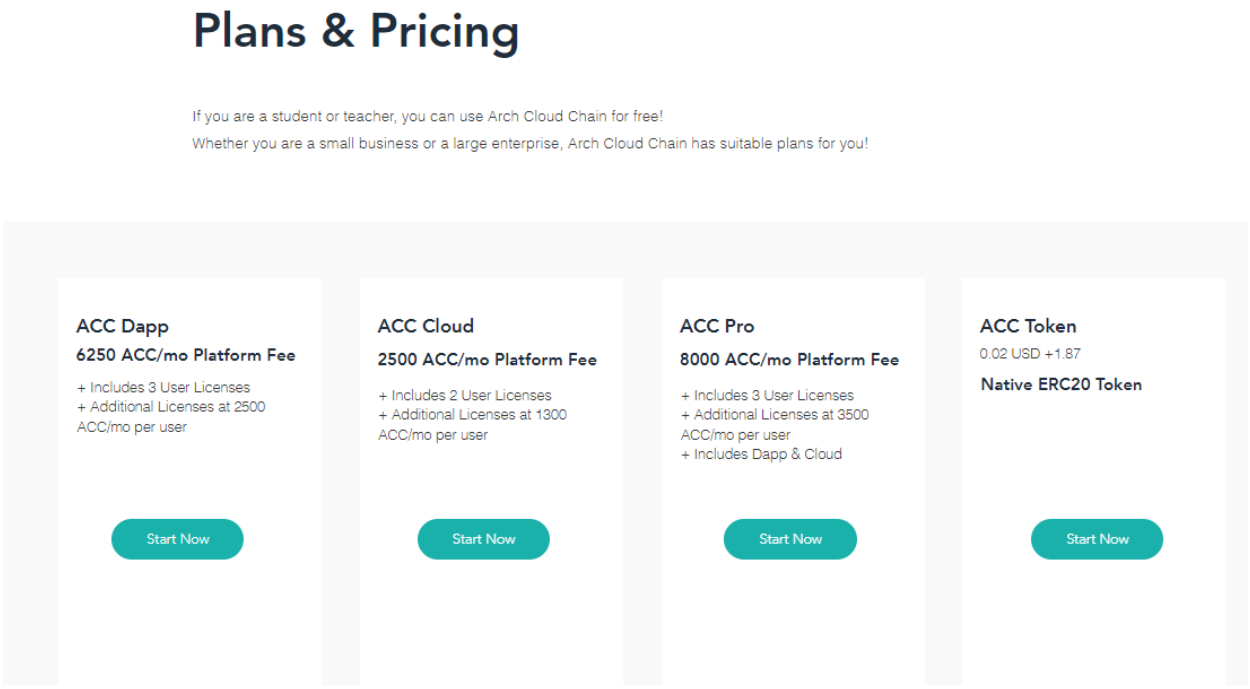

Figure 21: Plans & Pricing section of the website

Another section of the website is Help Center (Figure 22), where users can find useful information about software and its workflow. It includes YouTube channel, Guidebook, community where users can communicate with each other, and online courses.

Figure 22: Help Center which includes YouTube channel, Guidebook, ACC community and ACC course.

Other sections are very general and include contact information, about the service, and sign-in and sign-up.

Overall, users can learn about our services, try it for free as demo, purchase the product, and if they have problems with our services, can contact us. In the next section, the user interface of ACC software will be explored.

The second element of the project is decentralized app. It is designed based on BIM Workflow for Interior designer. Its user interface includes 7 sections that are: menu, quick toolbar, tab bar, toolbox, quick options, work environment, and Navigator (Figure 23).

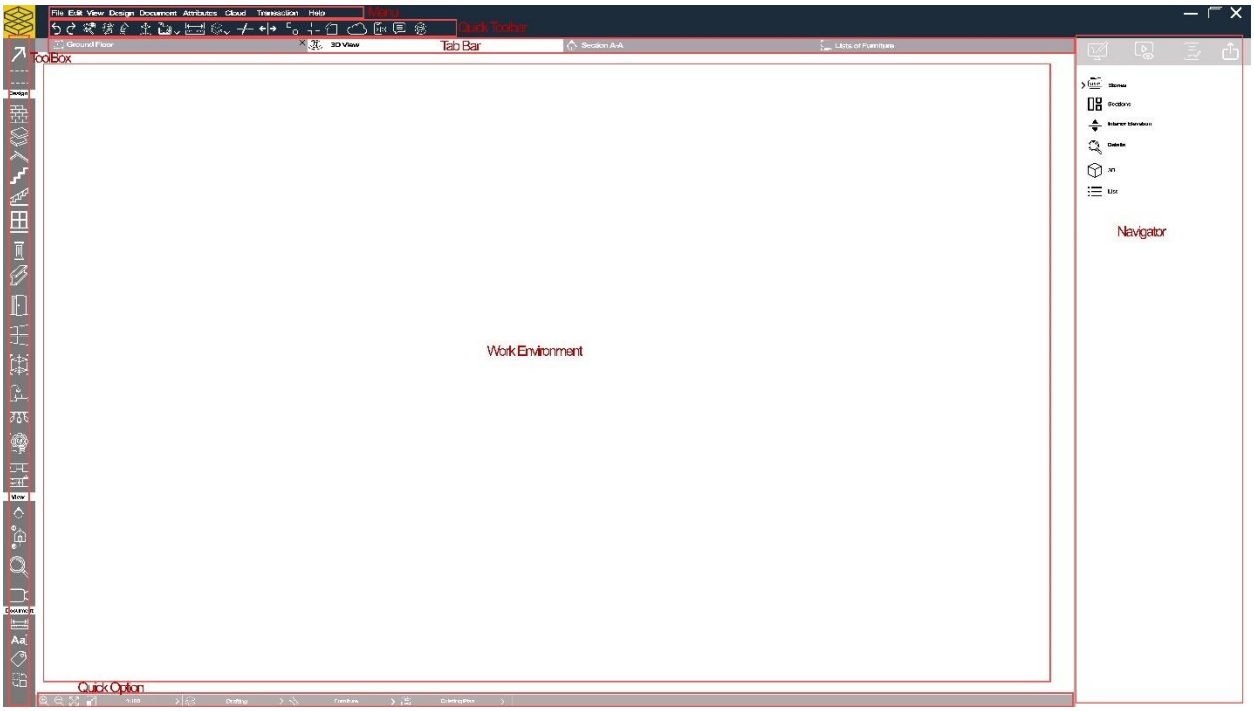

Figure 23: User Interface of ACC Dapp

The menu includes 9 sections that are divided according to the functions of the project. It includes:

- File: which includes the general commands like open, close, save, save as, export, and setting.
- Edit: includes commands that are related to edit function.
- View: It is related to setting the view of the project.
- Design: All the commands and tools for designing the project are included in this menu.
- Document: for documentation, users can find any related commands and tools in this menu.
- Attributes: It includes all attributes settings of the elements such as pen set, layer, building materials, composite, etc., and Users can also set their work environment in this menu.
- Cloud: all Teamwork commands and tools are available on this menu.
- Transactions: All tools that are related to payments are available here, such as buy ACC token, Transaction history, Payments, smart contracts, etc.
- Help: It includes different help guide documents.

The Quick toolbar (Figure 24) includes commands that are used frequently throughout the project. It includes:

Figure 24: Quick Toolbar

- Undo/Redo: Undo allows users to cancel or reverse the last action, or change that user made. Redo allows users to repeat or reapply the action or change that was previously undone by undo command.
- Find and select: It allows users to select the specific elements by defining specific categories (Figure 25).

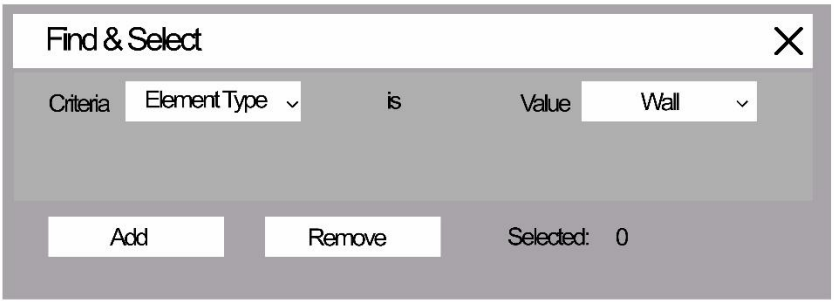

Figure 25: Find and Select

- Copy parameter: This command copies the properties of one element.
- Paste parameter: This command pastes the properties of the element that was copied.
- Plane: It shows the grid plane in the work environment. The users can activate or disactivate it by clicking on this button.
- Trace: It enables the display of an additional view that lies beneath the current view. For instance, when an interior designer creates a plan and scans it, they can import the scanned image into one view and use it as a reference to trace and model the plan.
- Measure: It is a useful tool for measuring.
- 3d Cut: It creates a section in the 3D view (Figure 26).

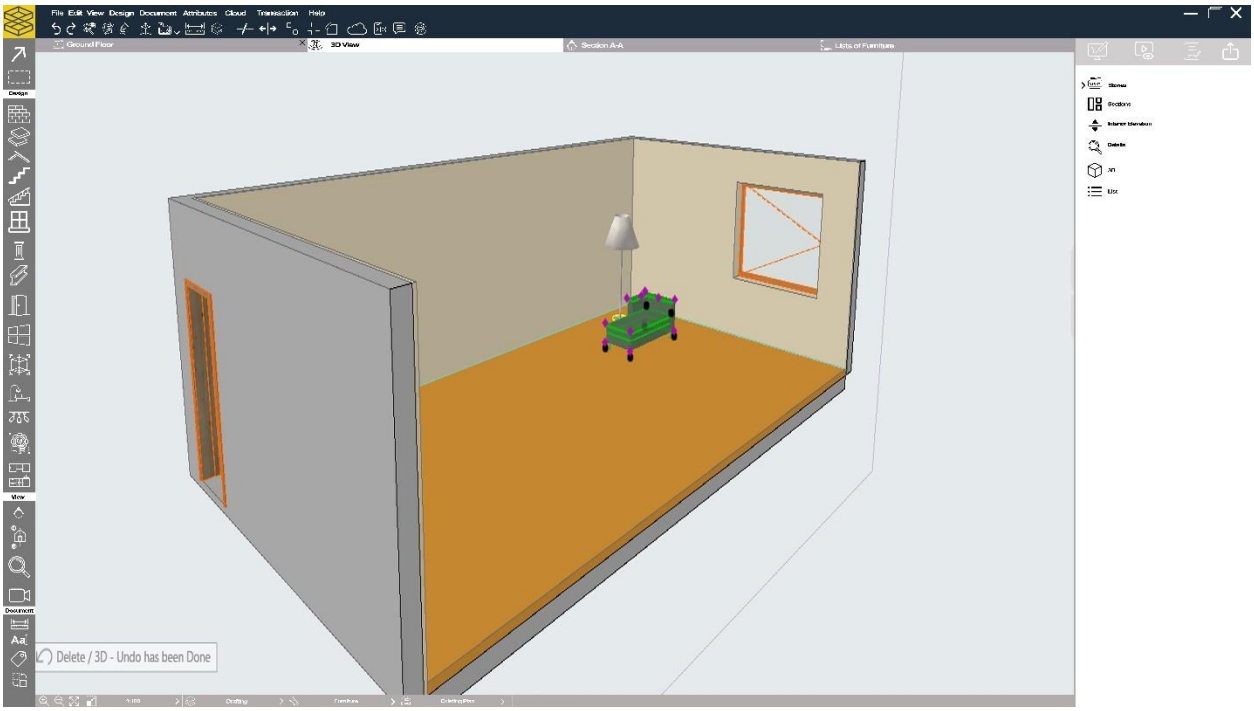

Figure 26: 3D Cut.

Trim: It is a command that cut the element and delete one segment of the element.

Split: It is a command that divides the elements into two segments.

Adjust: it is used for adjusting the selected elements according to reference point.

Intersect: intersect two elements with each other in their endpoints.

Fillet: It is like an intersect command.

Cloud: open the cloud manager.

Reserve element: it reserves element in the teamwork environment.

Message: open message window in the teamwork environment.

Change management: Open change management window, in which modifications and changes are stored.

Under the quick toolbar, it is the tab bar, that enables users to navigate to different views of the project.

On the right side of the software, there is a toolbox that is divided into three main sections that are: design, view, and document (Figure 27). Each section includes different tools according to their functions. The settings of the tools are mostly similar which includes Geometry and positioning, 2D documentation, 3D, and Nongraphic Info, however there are some differences according to their functions.

The design section includes tools that users need to design which includes wall, floor, roof, stair, railing, curtain wall, column, beam, door, window, free shape, object lighting, equipment tool, and cabinet.

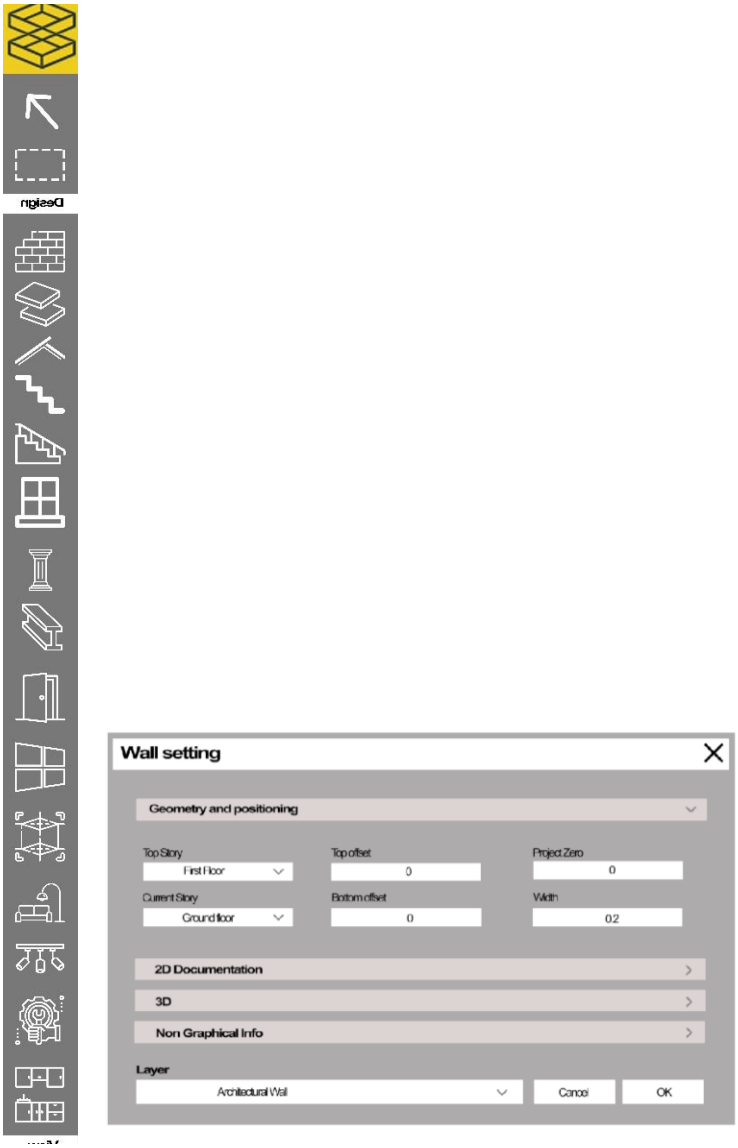

Figure 27: Tab Bar which includes different tools such as Wall.

The view section includes tools for setting different views of the project which includes Section, Interior elevation, detail, and camera.

The document sections include tools for documentation such as Dimension, Text, Label, and change.

The quick option which is in the bottom of the screen includes three main tools for the view which are scale, layer, and pen set. This section can be customized by users (Figure 28).

Figure 28: Quick options

The last section is named navigator which is designed according to workflow of the project (Figure 29). It includes four sections. The first section is Project design, which includes all the 2d drawings, 3d, sections, etc. In this section, all the models will be saved. The next section is View, which is set by users according to type of document. It is connected to the Project design section, and its aim is to categorize the documentation of the project by setting the view. The next section is documentation which users can design project sheet, and finally, they can set export of the project in the export section.

1. Project Design: The Project Design section serves as the foundation of the Navigator framework. It encompasses all the 2D drawings, 3D models, and sections related to the project. This section acts as a repository for storing and managing various design models. By centralizing the project design assets, users can easily locate and retrieve specific design elements throughout the project's lifecycle.

2. View: The View section in Navigator is designed to categorize project documentation based on user-defined views. Users can customize views according to the type of document they are working with. This section is closely linked to the Project Design section, allowing users to associate specific views with corresponding design elements. By organizing project documentation through views, users can streamline the retrieval of relevant information based on specific requirements.

3. Documentation: The Documentation section of Navigator provides users with tools to design project sheets and create comprehensive project documentation. This section allows users to generate reports, annotate designs, and add textual information to supplement the project's visual elements. By incorporating documentation capabilities within Navigator, users can effectively capture and communicate project details, enhancing collaboration and knowledge sharing among stakeholders.

4. Export: The Export section of Navigator enables users to generate project exports in various formats. This section provides options for exporting project documentation, such

as PDFs, image files, or specialized file formats required by other software applications. The Export section ensures that project information can be shared and distributed in a format that is compatible with external systems or for archival purposes.

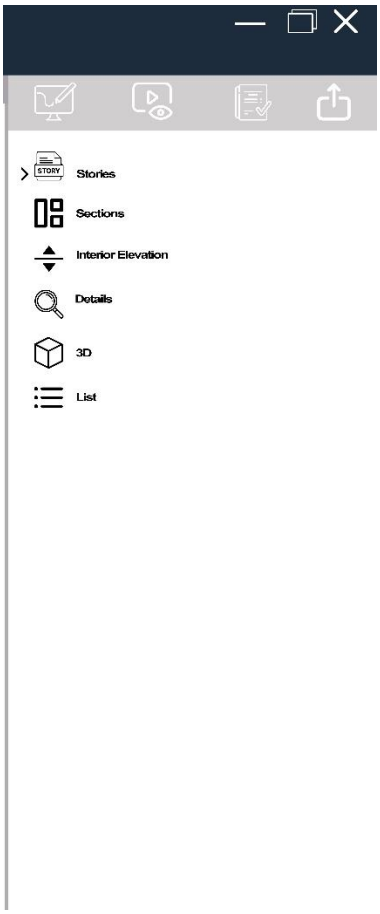

Figure 29: Navigator

05.03 Arch Cloud chain workflow

In this section, an elucidation of the project workflow shall be presented, delineated according to the three principal categories of users: interior designer, client, and suppliers.

The interior designer assumes a central role within the project workflow, acting as a focal point for the subsequent activities. Following the initial agreement between the designer and client, a series of meetings commence, wherein the designer diligently gathers essential information, encompassing the client's specific requirements. Subsequently, an accord is reached concerning the fundamental aspects of the project, including the data exchange process between the various stakeholders, the desired format and level of detail, as well as the stipulated timelines for information delivery. This pivotal phase is formally referred to as the Information Delivery Plan (IDP). The IDP plays a vital role in ensuring the precise dissemination of pertinent information at the appropriate junctures, thereby mitigating the likelihood of confusion and errors, while simultaneously enhancing collaboration and overall project efficiency.

Following the establishment of the Information Delivery Plan (IDP), the subsequent stage entails the formulation of an official contract between the interior designer and the client. This contractual agreement serves as a binding document that comprehensively outlines the respective tasks and responsibilities of both parties involved. It necessitates the endorsement of a smart contract, encompassing vital provisions such as design services, payment modalities, delivery schedules, formats of delivery, as well as delineating the specific tasks entrusted to the interior designer, among other pertinent aspects. The execution of this smart contract transpires automatically, and upon the mutual signatures of both parties, they are duly cognizant of its irrevocable nature (Figure 30).

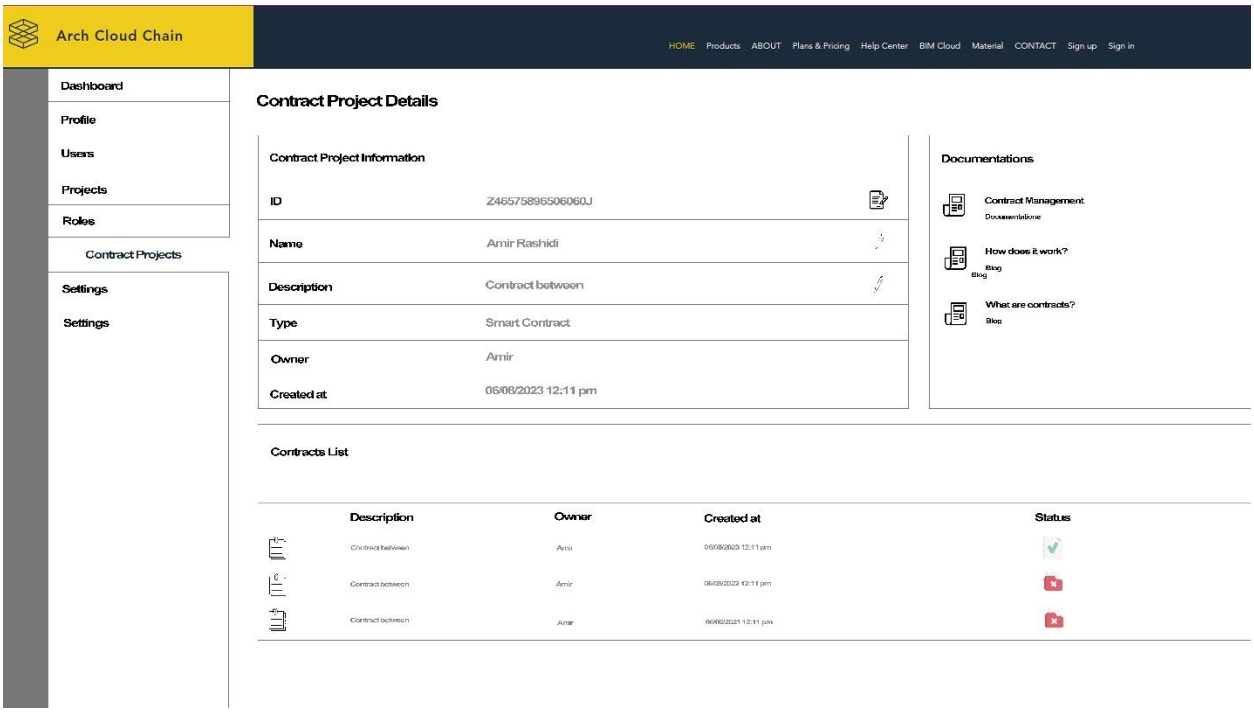

Figure 30: Sample of contract project platform

Upon the completion of the Information Requirement data definition, Information Delivery Plan formulation, and the signing of the smart contract, the interior designer proceeds to initiate the project. The initial step entails the comprehensive delineation of the project's scope, the identification of involved users, and the specification of their respective roles and responsibilities within the ARCH cloud platform. During this crucial phase, the designer is required to access the ARCH cloud by means of authentication, signifying their acceptance of the terms and conditions, and actively engaging with the platform's functionalities.

After the Designer defines the project, users, their roles and responsibilities, the project starts officially. Designers open the software and go to Cloud menu and connect to ARCH Cloud to access the project, which is on the blockchain. His access to the project is based on his role that was defined in the ARCH Cloud (Figure 31).

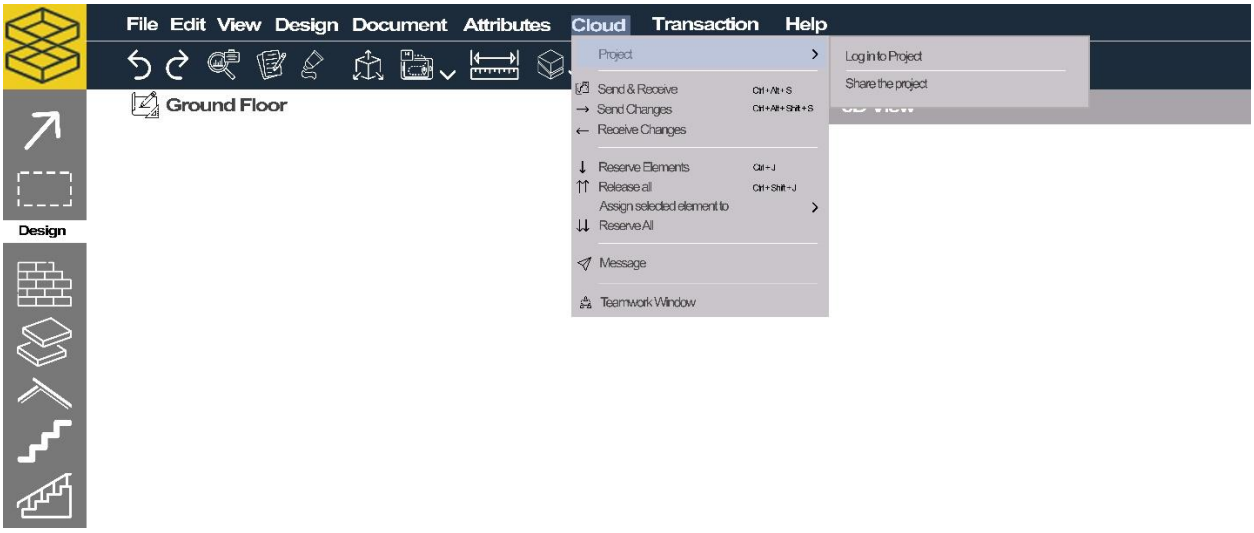

Figure 31: Connect to teamwork project.

After connecting to the project, the Designers start to design in the ACC software. During the design phase, designers enter whole the information of the project which includes graphical and non-graphical information into the model. Graphical information includes physical features of elements of the project such as wall, floor, roof, doors and windows, lighting, MEP elements, railing, stairs, any structural elements, furniture, and equipment. Non graphical information includes Materials, price, and other information that can be used for other parts of the project. During the process of designing, clients can connect to the project and supervise the project. They also can Make a comment to the design team and communicate with them through the software. Whole the communications will be saved which can be useful as a record. To do that, they need to open the teamwork window and click on the send new message button and select the users that want see the message, and then write the message, and also it is possible to attach the message to part of the model, and then send it. The designers can reply to messages and make an agreement about the changes that the client asks (Figure 32).

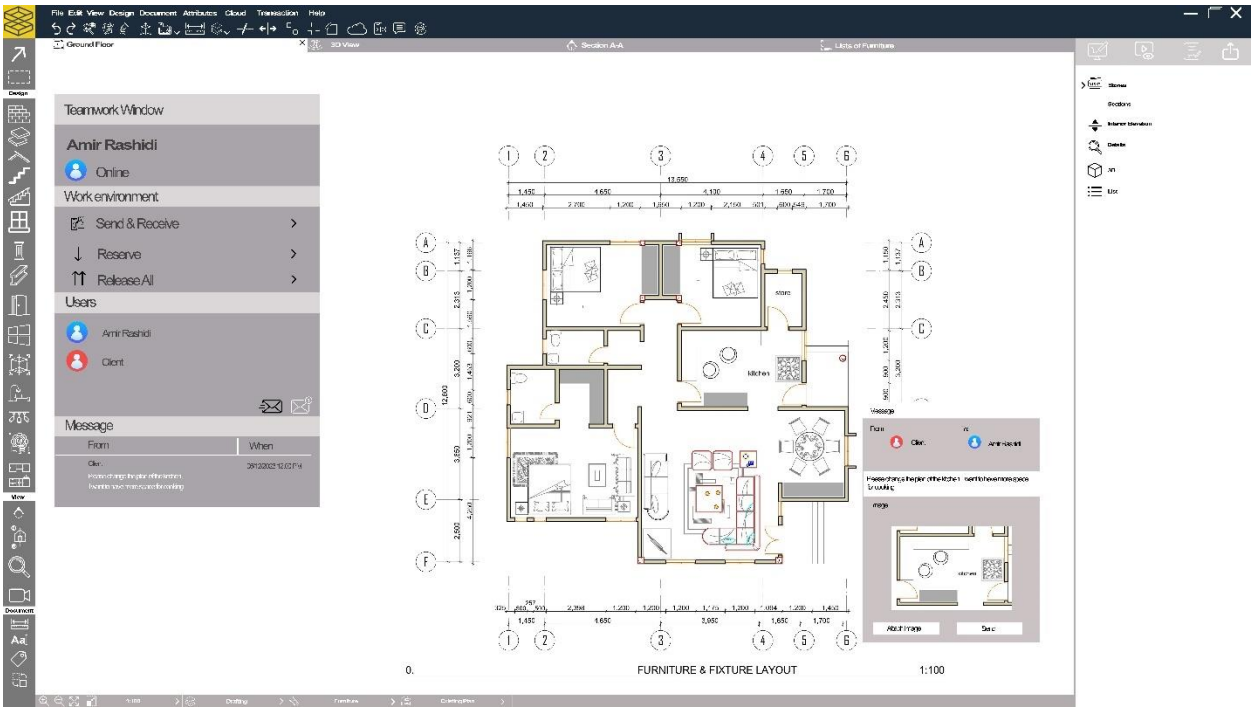

Figure 32: Communication between different stakeholders of the project.

Through the design phase, if each member of the project team wants to change the design element, need to reserve it first, and then edit it. This feature helps them not to interact with each other through the design process and know who did what (Figure 33).

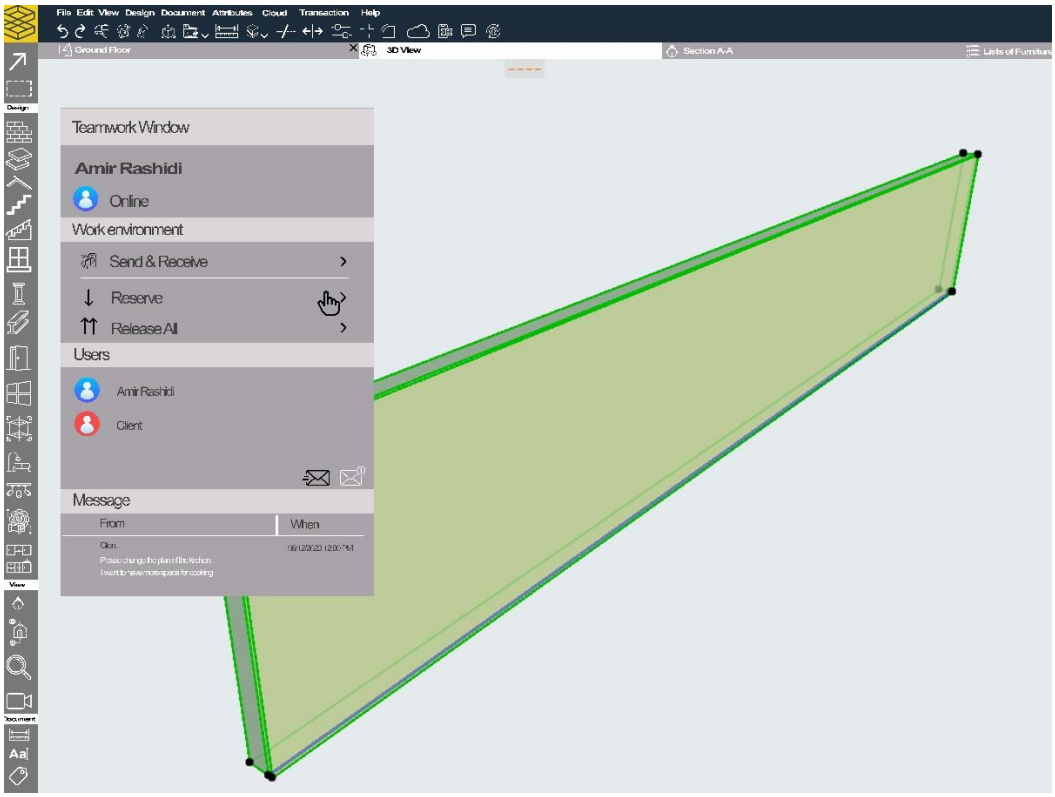

Figure 33: User needs to reserve the element in order to edit it.

During this phase, Designers and clients have many interactions through the teamwork environment, and after agreement about the design proposal, designers start to choose materials, furniture, equipment, and prepare cost of the project. In this phase, clients have main role and responsibilities because they need to approve the materials, and cost of the project, so during the choosing materials, and other elements, client need to communicate with design team members through teamwork environment, and check each element of the project, and approve them or propose alternative (Figure 24).

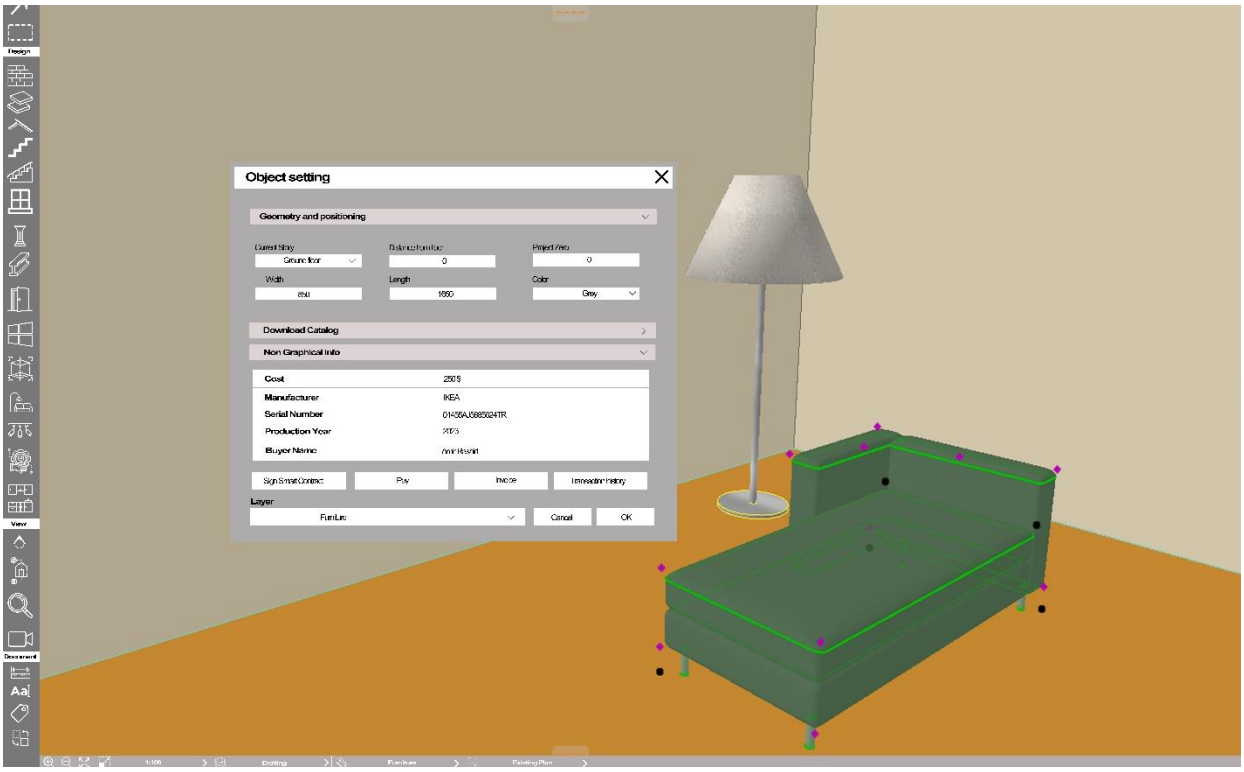

Figure 34: Client checks the furniture through the software and can also check its catalog and its price.

After the client approves them, the design team will estimate the cost of the project with the software which is extracted from the model, and information that they entered the model before (Figure 35). If the cost of the project is suitable and agreeable to the client, he needs to sign a smart contract for materials and equipment's that are needed for construction site (Figure 36) and pay them (Figure 37) through the software by its own native token (Figure 38). After transactions, the suppliers receive the smart contract improvements through their user panel which was explained in previous section, and they send the materials or equipment according to agreement and its proposed date.

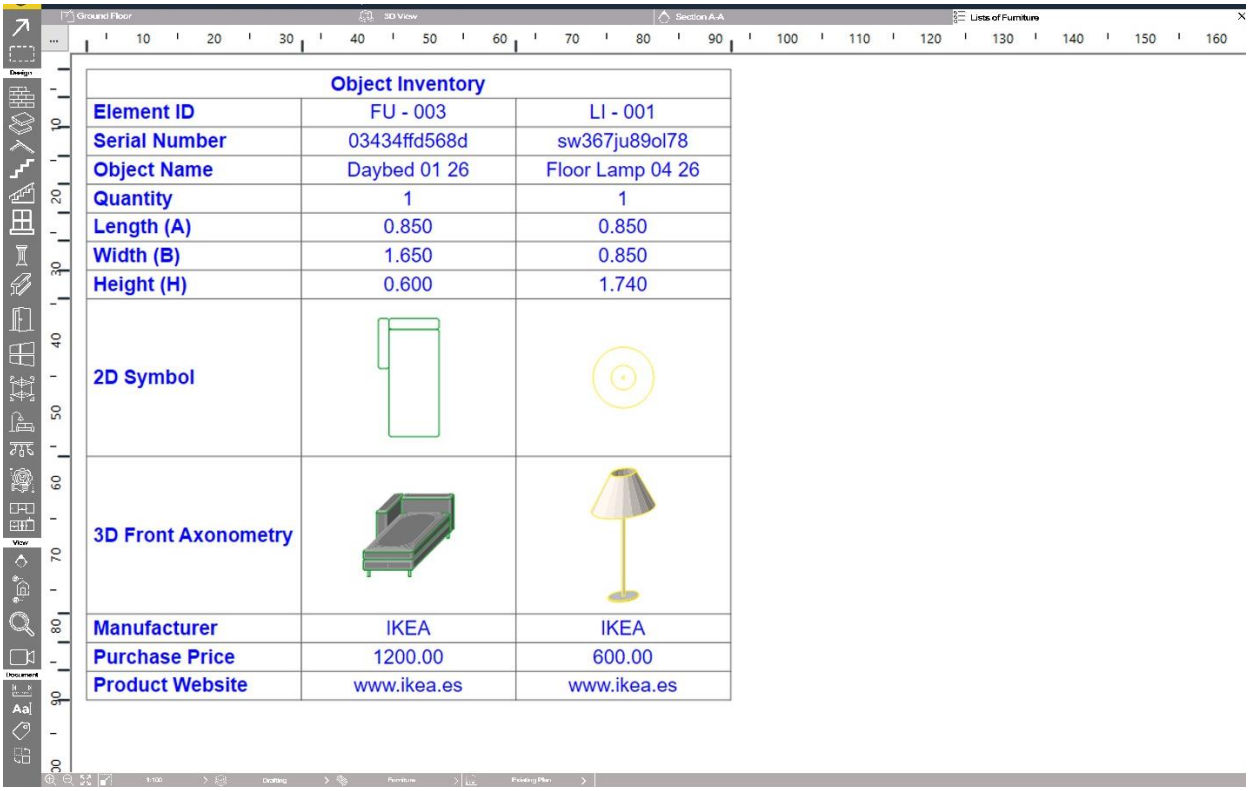

Figure 35: The list of the furniture of the project.

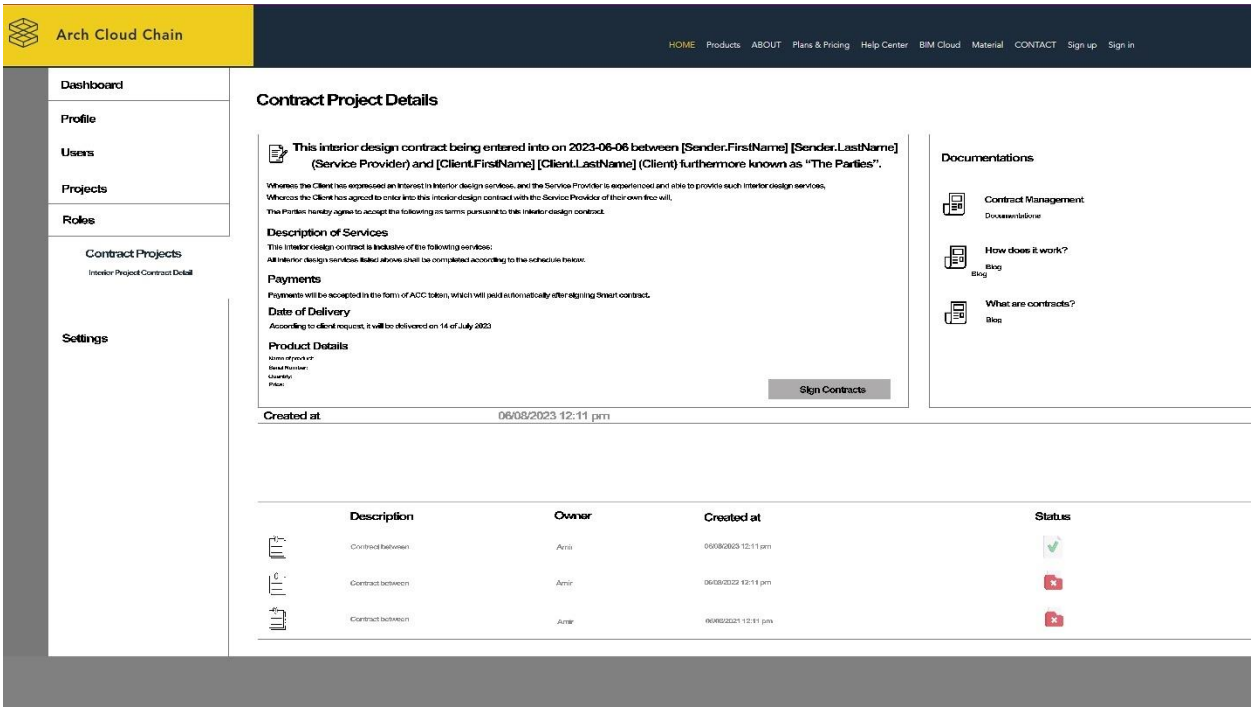

Figure 36: Client needs to sign a smart contract.

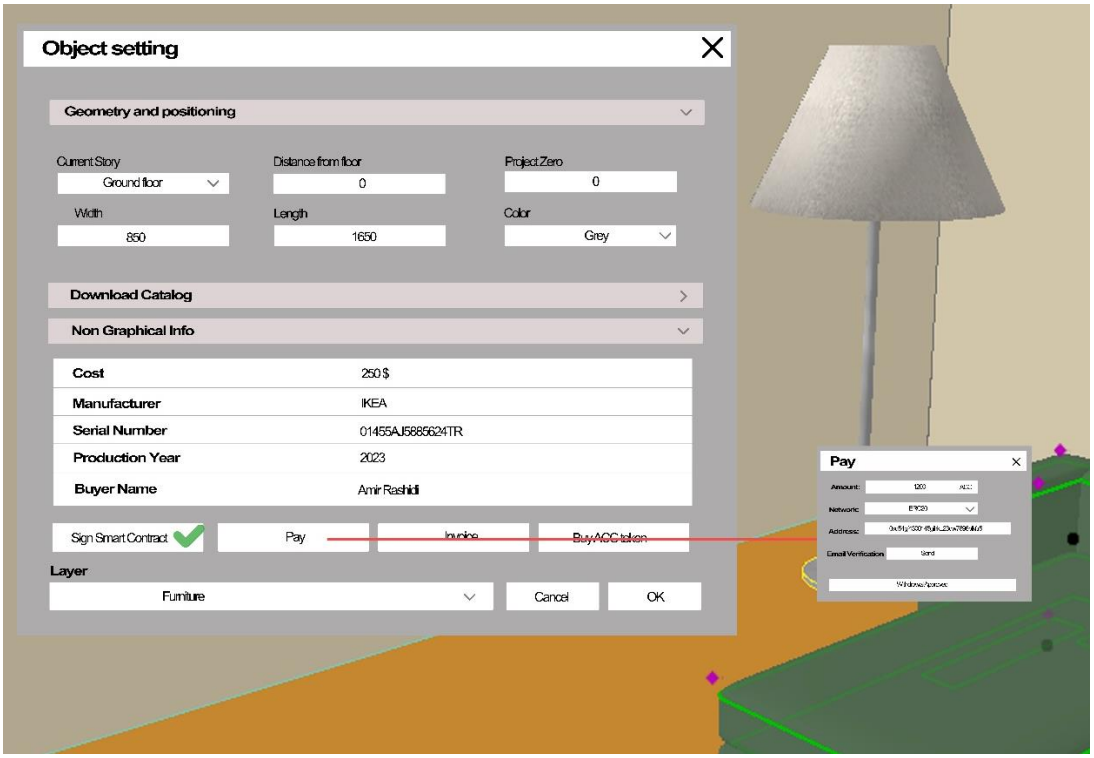

Figure 37: After signing smart contract, client needs to pay by ACC token.

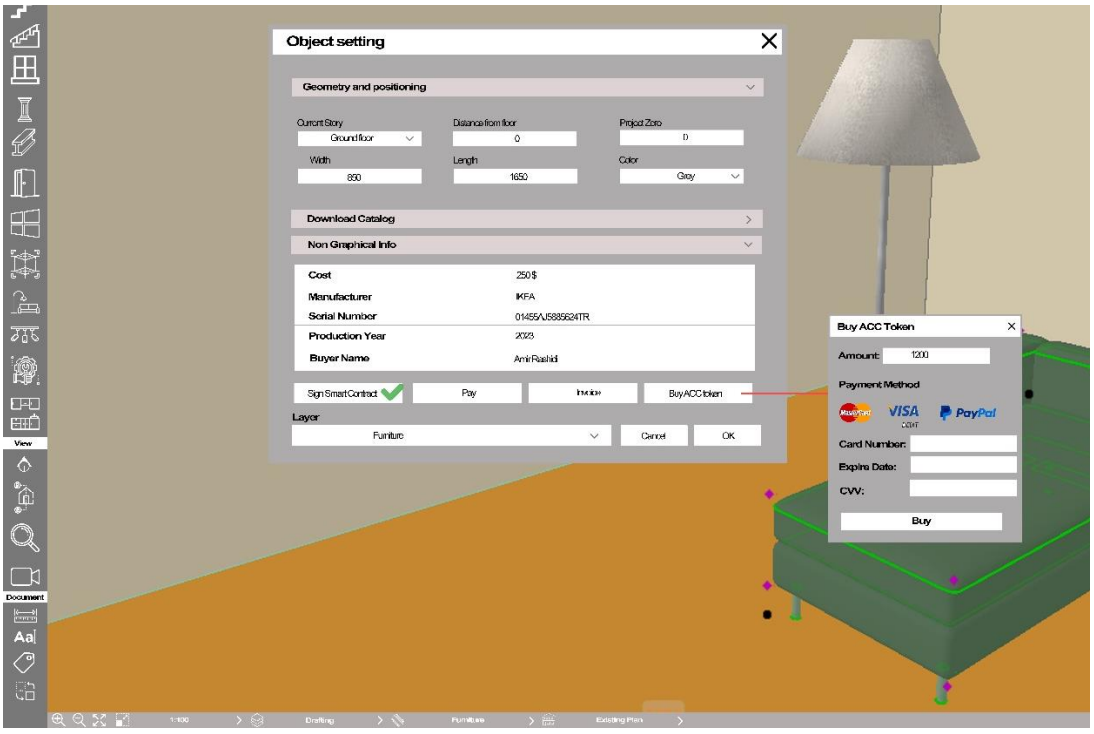

Figure 38: Client needs to buy ACC token to be able to buy the product.

05.04 Prototype Future plan

The ACC Dapp is a decentralized application designed to facilitate collaboration among interior designers, architects, contractors, suppliers, and educators. This section outlines the future development plan for the ACC Dapp prototype, aiming to enhance the system's functionalities and user experience. The plan encompasses three components, each focusing on specific aspects of the software's development and improvement (Figure 39).

Component 1: Advantages and Workflow Prototype

The first component of the development plan centers on the advantages of the ACC Dapp system and its workflows. In this stage, the initial prototype (prototype 1) is designed based on the requirements specified in the previous section. Once prototype 1 is completed, feedback is gathered from users, including interior designers, architects, contractors, suppliers, and educators. Their feedback provides valuable insights for improving the prototype and implementing new features.

Component 2: User Interaction and Bug Identification Prototype

The second component of the development plan aims to analyze user interactions with the software and identify any existing bugs or usability issues. Prototype 2 is specifically designed to study user interfaces and user behavior, helping to uncover software bugs and refine the user experience. Feedback obtained from this stage is crucial for improving the subsequent prototype (prototype 3) and addressing any usability concerns.

Component 3: Professional Workflow Simulation and Beta Version Development

The third component of the development plan involves simulating the software's workflow with professional users. This stage enables a comprehensive evaluation of the ACC Dapp's performance, usability, and workflow integration. Based on the insights gained from the professional workflow simulation, necessary improvements are incorporated into prototype 3. After this stage, the development process transitions to creating a Beta version of the software, which undergoes further refinement and testing.

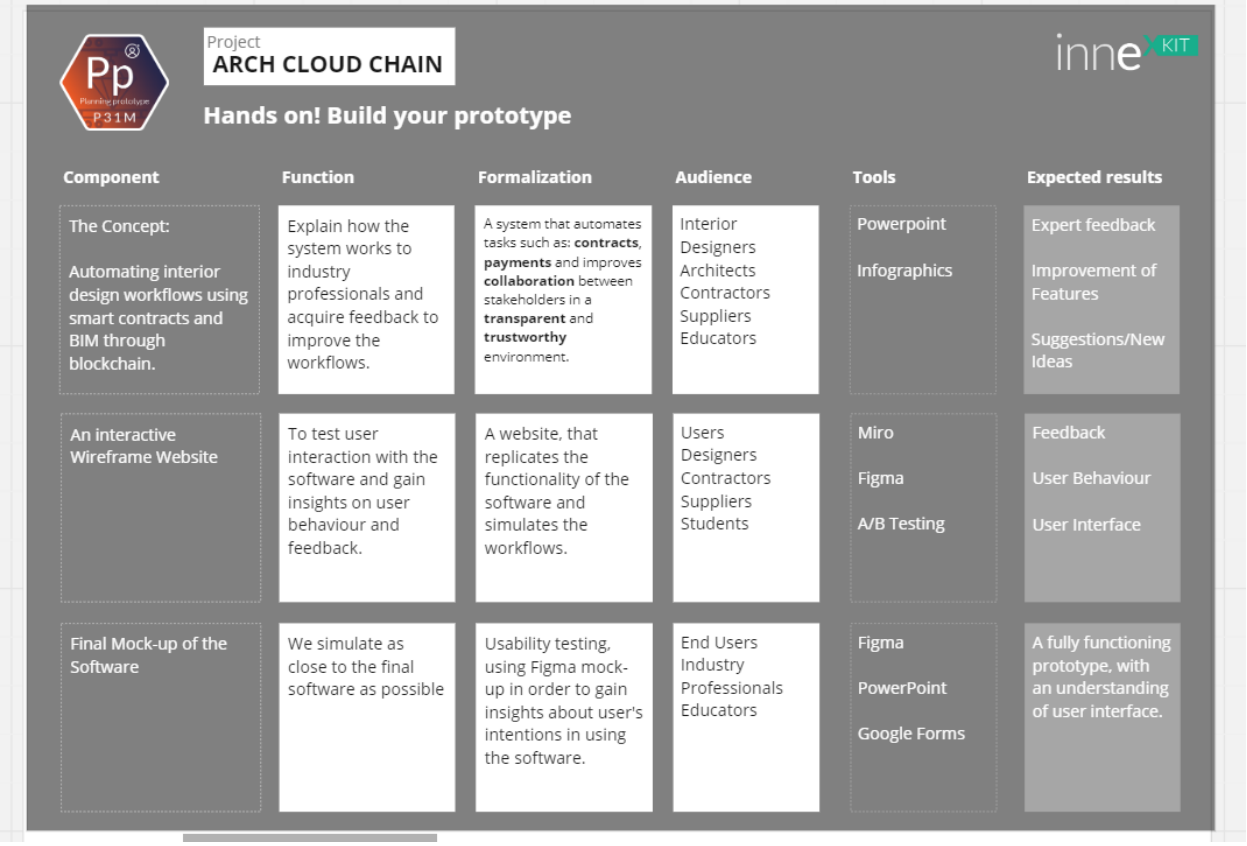

Figure 39: Prototype Future Plan.

05.05 Overview

The Arch Cloud Chain Dapp project is a decentralized software application that combines interior design and renovation with blockchain technology. It aims to create an interactive and transparent platform for designers, clients, and suppliers involved in interior design projects. The software operates on the blockchain and has its own token for payment purposes.

The project facilitates collaboration and agreement between designers, clients, constructors, and suppliers. It starts with the creation of a smart contract that outlines the project requirements and cannot be altered after signing. Designers can then begin designing the project while clients can view the progress and provide feedback.

By leveraging blockchain technology, the Arch Cloud Chain Dapp ensures transparency and accountability throughout the entire interior design project. It improves the quality of design while considering the project's budget. The project aims to overcome the challenges of traditional interior design processes by fostering transparency, collaboration, and trust among all stakeholders involved.

The Arch Cloud Chain Dapp project includes several components. The website serves as a platform for users to learn about the software's features and purchase products. The primary offering is the ACC Dapp, a blockchain-based software that combines interior design functionalities with blockchain features. It includes smart contracts, automatic payments using the native token, and a user-friendly interface. The software enables 2D document creation based on a 3D model, real-time rendering, collaboration in a cloud-based environment, integration with multiple suppliers, and generation of CNC processing instructions.

The project also includes the ACC Cloud, a teamwork platform that allows users to work together on projects from anywhere. The ACC materials library provides a wide range of materials, products, and furniture from various suppliers that can be directly used in the design process. The ACC token is the project's native token built on the Ethereum network, facilitating payments and executing smart contracts.

The project workflow is delineated according to the roles of interior designers, clients, and suppliers. The interior designer plays a central role in gathering client requirements and establishing an Information Delivery Plan (IDP). A smart contract is then executed to formalize

the contractual agreement. The interior designer initiates the project in the ACC software, entering graphical and non-graphical information. Clients can supervise the project, provide feedback, and communicate with the design team through the software.

Overall, the Arch Cloud Chain Dapp project offers an innovative solution to traditional interior design processes by utilizing blockchain technology to enhance transparency, collaboration, and trust among all stakeholders.

06. CONCLUSION

06.01Conclusion

In conclusion, Building Information Modeling (BIM) has significantly transformed the construction industry by providing a collaborative workflow that enables stakeholders to simulate and optimize building designs before construction. The features of BIM, such as 3D modeling, collaboration capabilities, data management, clash detection, simulation, asset management, cost estimation, and sustainability analysis, have revolutionized the way building projects are planned, executed, and maintained.

However, the implementation of BIM is not without challenges. The adoption of BIM workflows requires significant changes within companies, including the adoption of specific software and training of personnel. Cost, complexity, lack of standardization, resistance to change, and technical challenges pose obstacles to the widespread adoption of BIM, especially for small and medium-sized enterprises. Additionally, using BIM cloud services introduces challenges related to data security, compatibility with different software tools, and concerns regarding data ownership and control.

To address some of the limitations of traditional interior design processes, this research proposes the development of a software solution, the Arch Cloud Chain Dapp project, that combines interior design and renovation with blockchain technology. This project aims to enhance collaboration, transparency, and trust among interior designers, clients, constructors, and suppliers. By leveraging blockchain technology, the project establishes smart contracts, enables seamless payment processing, and ensures accountability throughout the entire interior design project.

The Arch Cloud Chain Dapp project includes various components such as the ACC Dapp, ACC Cloud, ACC materials library, and the ACC token. These components work together to provide a comprehensive platform for interior designers and other stakeholders to collaborate, create 2D documents based on 3D models, integrate with suppliers, and streamline the interior design process.

The intention of selecting Interior design in this project is that its scale is small, and the prototype can be tested with more detail, and the aim is after the implementation of this project, it is possible to expand it to other construction fields such as architectural, engineering, and construction

projects, especially the significant and vital projects such as hospital, hotel, and commercial buildings.

Overall, the Arch Cloud Chain Dapp project offers an innovative solution that combines BIM workflows with blockchain technology to overcome the challenges of traditional interior design processes. By fostering transparency, collaboration, and trust, this project aims to improve the efficiency and quality of interior design projects while considering budget constraints.

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07.02 Figures

07.03 Tables