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# BIMChain for Site 4.0

## Executive summary

The construction industry is currently experiencing a profound transformation, and Building Information Modelling (BIM) stands as a prime illustration of this evolution. Indeed, BIM integrates all essential data for project planning, design, construction, and operation, distinguishing itself from traditional CAD by employing parametric modeling.

Despite BIM's advancements in the design phase, the construction process still grapples with challenges such as delays and cost overruns stemming from inefficient information management. The BIMChain for Site 4.0 project represents a groundbreaking solution, fusing BIM and blockchain technologies to revolutionize communication, transparency and management methods. This innovative approach aims to automate and comprehensively monitor construction activities in real-time, curbing errors, rework, and expenditures. Stakeholders, including engineers, architects, managers, subcontractors, and suppliers, benefit from tailored communication channels.

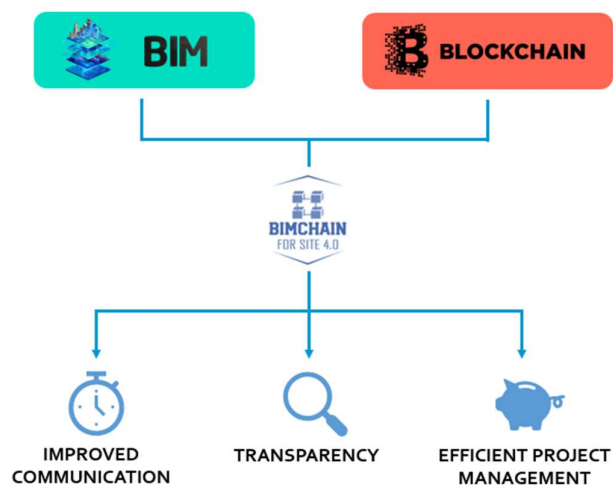
The project's open and modular platform architecture allows flexibility in selecting components, including the blockchain platform. In the prototype, Polygon was chosen for its security and cost-effectiveness. The client application, a React-based web app, ensures accessibility from any internet-enabled device, facilitating a seamless experience both on construction sites and in technical offices.

Integrating BIM data into the web app relies on Revit and the Industry Foundation Class (IFC) format, simplifying information access for stakeholders. A specialized identification code set, aligned with the Italian standard UNI 8290, links elements in Revit models to construction tasks, aiding project organization and Gantt chart creation.

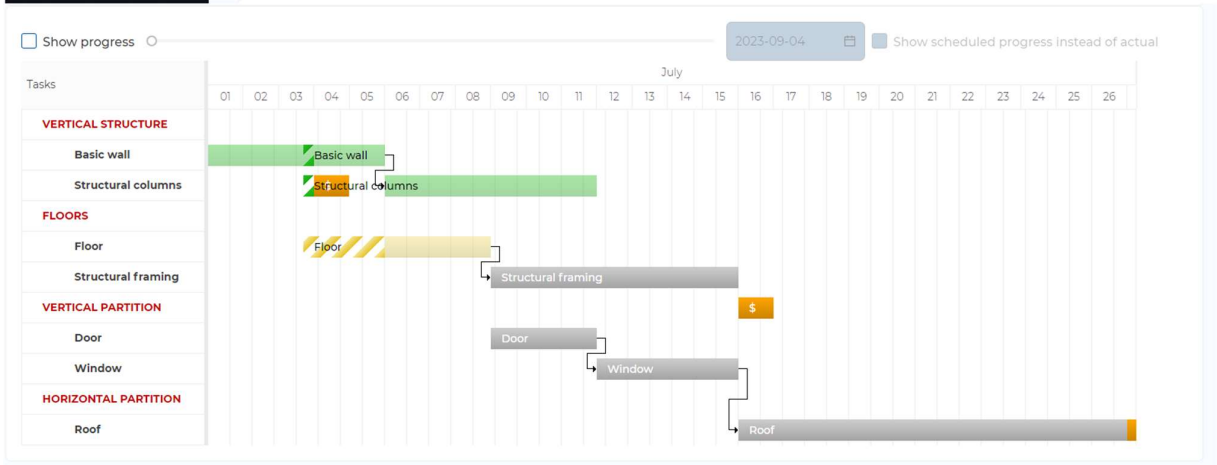
The Gantt Chart Generator Tool streamlines project planning by offering an Excel-based template for creating Gantt charts. This tool streamlines timelines, integrates Revit model data, and tracks progress. Project indicators, such as the Schedule Index, help monitor performance, while the platform records all updates in a secure blockchain ledger.

## Key Words

AEC industry, Blockchain, project management, BIM



Infographic of our mission.



### Task List

Code	Name	Status	Delay	Actions	Start	End
4.2_1.2.1.1	Basic wall	Completed			14/07/23	18/07/23
4.2_1.2.1.2	Structural columns	Completed			19/07/23	24/07/23
4.3_1.2.2.1	Floor	In progress	4 days early	<input checked="" type="checkbox"/> Complete	19/07/23	21/07/23
4.3_1.2.2.2	Structural framing	In progress	7 days early	<input checked="" type="checkbox"/> Complete	22/07/23	28/07/23
4.4_2.1.2.1	Door	Not Started		<input type="button" value="Start"/>	22/07/23	24/07/23
4.4_2.1.2.2	Window	Not Started		<input type="button" value="Start"/>	25/07/23	28/07/23
4.5_2.4.1.1	Roof	Not Started		<input type="button" value="Start"/>	29/07/23	08/08/23

Features of the webapp: 3D perspective of a construction project, allowing users to highlight in-progress objects. It also provides a Gantt chart view of the project and a task list for efficient project management.

**Project description  
written by the  
Principal Academic  
Tutor**

The research project proposes possible solutions to the issues of the construction industry that suffers a lack of standardization in the processes of management and maintenance of the existing building stock, especially in the phases of progress of works in the construction sites that are not resilient to the digital transition that is ongoing in modern society.

It foresees the development of an application able to manage in real-time the progress of works on a construction site. The application will have to guarantee the upload of data related to the progress of the planned activities. Through the development of graphical interfaces - that ensure collaboration between the users present on site and the design office of the company - an update of the project will be guaranteed starting from the production, transport, and assembly of components with a significant reduction of errors.

The main expected results of the project focus on:

- The analysis of typical construction supply chain information flows to define threats and turn them into opportunities;
- The adoption of a collaborative approach between the various users involved in the management and maintenance of the real estate;
- The digitalization of the construction sector by transforming the current BIM model into a contractual, verifiable, qualified, and therefore valuable digital asset by leveraging Blockchain technology;
- The development of a collaborative digital platform to optimize the data management flow of a contract from knowledge of the state of the art, to design, to mass production and to the construction site.

The solution will be aimed at collaboration between designers, construction managers and operators in the construction industry, in compliance with safety and company Environmental Health and Safety (EHS) rules.

**Team description by  
skill**

With a diverse array of expertise, the BIMChain for Site 4.0 team effectively merged their individual contributions into a cohesive project development strategy:

**Aurora Bosia** and **Alessia Musicco** spearheaded project management and strategy, capitalizing on their understanding of Architecture and Management Engineering, respectively. Both of them worked on the project's GANTT and its implementation. In particular, Alessia Musicco's role involved coordinating team efforts, ensuring alignment with project goals, and managing the overall progress.

**Chiara Pappagallo's** background in Structural Engineering proved essential in tackling the technical intricacies of integrating structural data. Her expertise in this area informed decisions related to project design and execution.

**Marco Porro**, as a Computer Engineering specialist, took charge of the software development aspects of the project, including the creation of the web application and its integration with blockchain technology. His technical proficiency played a pivotal role in constructing the core of the platform architecture.

**Pourya Safari's** Building Engineering background contributed insights into building systems and construction processes, offering valuable perspectives on how to optimize communication and efficiency within the construction context.

**Silvia Taddei's** dual expertise in Building Engineering-Architecture was instrumental in bridging the gap between architectural design and engineering requirements. She played a key role in translating design data into the digital platform.

The collaborative nature of the team extended to the design of the user interface. Alessia, Aurora, and Chiara collaboratively ensured that the application design aligned with user needs, emphasizing ease of use and transparent access to information. The integration of BIM and blockchain involved careful orchestration of tools and processes. Marco's software development efforts dovetailed with Silvia and Pourya's work in BIM tool integration and the development of specific codes to introduce data into the project model.

## **Goal**

BIMChain for Site 4.0 project aims to revolutionize the construction industry by integrating Building Information Modelling (BIM) and blockchain technology. The primary objective is to create an automated and comprehensive solution that enables real-time monitoring of construction activities, reducing communication errors, rework, and cost overruns. This initiative aims to optimize construction project management involving a wide range of stakeholders, including engineers, architects, managers, subcontractors, and suppliers.

The objective is to create a platform that collects data from various sources and securely stores it on the blockchain, providing a clear and reliable view of project progress, with potential benefits in legal contexts as well. Overall, the BIMChain for Site 4.0 project embodies the innovation and collaboration necessary to shape the future of the construction industry.

## **Understanding the problem**

The Architecture, Engineering, and Construction (AEC) industry stands as one of the world's largest sectors, yet it has long grappled with under-digitization, renowned for its resistance to change and slow adoption of digital innovations. Despite the emergence of revolutionary technologies like BIM and virtual reality, manual processes persist in dominating the industry, leading to a staggering 30 percent productivity gap as revealed by the McKinsey Global Institute [1].

The advent of the COVID-19 pandemic acted as a catalyst for change, forcing even the most traditional businesses to transition online. For the construction industry, 2020 provided an opportune moment to embark on digitalization. As social distancing and remote work became imperative, construction firms had no choice but to increase their adoption of technology. Virtual inspections, contact tracing solutions, remote project status tracking, and the development of plans to enable social distancing for workers became essential tools during the pandemic [2].

Embracing digital transformation has bestowed significant advantages upon companies in terms of enhanced efficiency, cost savings, and improved collaboration. However, there is still much ground to cover in keeping pace with the ongoing wave of digitalization. Notably, construction project management and supply chain management face numerous challenges, including payment discrepancies, transparency issues, and inadequate collaboration for seamless information sharing.

In the quest for transformative technological solutions, blockchain technology has emerged as a frontrunner with the potential to revolutionize various industries [3]. Though still in its early stages, the application of blockchain in the construction industry shows immense promise. Construction projects often grapple with errors, delays, and accidents at different stages and varying degrees. Blockchain's inherent accountability features can pave the way for greater efficiency, transparency, and accountability for all project participants, addressing critical areas of concern in the construction realm.

## Exploring the opportunities

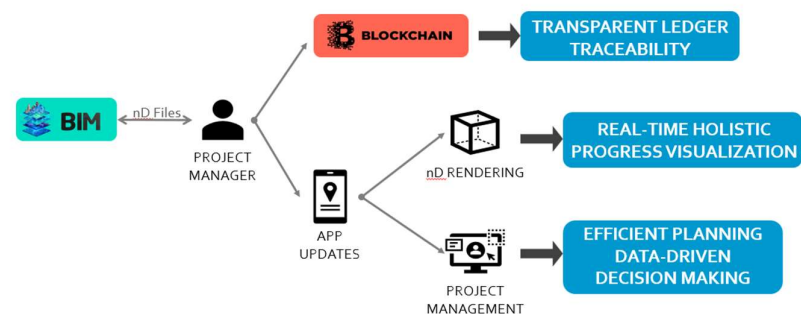
The contemporary discourse in the construction industry is marked by an increasing interest in blockchain technology, driven by numerous studies that delve into its potential and implications [4]. This is especially pertinent in the context of the industry's transition to the 4<sup>th</sup> generation (CI4.0), where increased automation, digitalization, and methodologies like BIM and the Digital Twin (DT) concept are shaping the landscape. However, within these promising advancements, a significant gap becomes evident: the absence of a dependable communication and information exchange system. Thus, [4] states that blockchain, with its attributes of security, transparency, and decentralized governance, surfaces as a prospective cornerstone for the systematic extraction and seamless exchange of these various types of information, although it is largely theoretical along with analyzing other literature.

The joint use of BIM and Blockchain offers three significant benefits. Firstly, it engenders a unified register coupled with a collaborative environment where each participant's responsibilities and obligations are distinctly delineated, obliterating misunderstandings. Secondly, it affords the capacity to preserve and trace intellectual property linked to information, by safeguarding against unauthorized use. Finally, it empowers the automation of delivery phases, thereby expediting project completion, enabling earlier utilization of the finished building, and accelerating the return on investment.

## Generating a solution

To cater to the diverse needs of stakeholders in the construction process, the project adopts an open and modular architecture. Better communication is achieved by consolidating all project data in one place through BIM. Revit, a BIM tool, is employed to integrate building data into the web application. From Revit, the models are extracted in the Industry Foundation Class (IFC) format, ensuring interoperability with the web app. Moreover, our open-source approach using Blockchain Technology (BTC) further enhances accessibility, as anyone can access all the data without the need to create accounts or navigate through complex access procedures. It also ensures transparency, since all data modifications are tracked and cannot be changed. Another fixture of the web app is a 4D viewport that provides real-time visibility into the progress of individual project components. This dynamic view enables stakeholders to track the construction timeline and identify any potential bottlenecks or delays, facilitating proactive project management. Thanks to the creation of an open-source and distributed repository of all project data is possible to calculate KPIs of the construction projects. This repository, securely stored on the blockchain, ensures that data integrity is maintained, making our KPI calculations reliable and transparent. This level of accuracy empowers project managers to make data-driven decisions and optimize project performance effectively.

Infographic of the webapp.



In terms of project management within the web app, a comprehensive list of building activities is crucial. A specialized identification code set is formulated based on the Italian standard UNI 8290, linking elements in Revit models to corresponding construction tasks. This system enables the organization of project Gantt charts and the establishment of a dictionary for the introduction of various elements into the web app. Dynamo, a graphical programming interface integrated into the Revit environment, is utilized to assign standard work breakdown structure (WBS) codes to each element within the design model.

The outputs of the Revit environment include elements categories and codes sheets for the adjustment of the activity Gantt Chart and an IFC file. While the IFC file is directly uploaded as input into the web app, model categories, and codes are inputted into a Gantt Chart Generator Tool. This tool, designed as a user-friendly Excel template, streamlines construction project planning. It simplifies Gantt chart creation, automatically computing project timelines based on input data, including Revit model extraction data, start dates, durations, predecessor activities, and payment requirements. The integration of this tool with the web app ensures accessibility and collaboration without the need for external software dependencies.

Having a detailed timetable is essential for effective progress control. The web app incorporates project indicators, including the Schedule Index, which tracks deviations between the Planned Schedule and the Actual Schedule as the project progresses. This allows for the identification of delays or overruns, with the Schedule Variance (SV) indicating project performance relative to the schedule. Additional indexes, such as Cost Variance (CV) and Resource Variance (RV), can be integrated into the Gantt Chart generator to assess project costs and resource utilization.

The core innovation of the project lies in its use of blockchain technology. All available information from IFC and Excel files is securely stored on the blockchain, creating a transparent and tamper-resistant ledger of on-site activities. This facilitates real-time monitoring, data collection, and trust-building with stakeholders. In legal contexts, it provides a certified account of events.

In summary, the BIMChain for Site 4.0 project leverages an open and modular architecture, Polygon blockchain technology, Revit for BIM integration, and a Gantt Chart Generator Tool to create an innovative web application. This application not only streamlines construction project management but also ensures transparency, security, and efficiency through blockchain integration. It represents a significant step toward reshaping the construction industry by embracing cutting-edge technology and collaboration.

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