Integrating Ethereum with Autodesk Forge

Executive Summary

Blockchain integration with BIM Design software can improve design coordination processes

For this case study, a demonstrator solution was developed to integrate Autodesk Forge **(Autodesk Forge, 2019)** with the Ethereum Blockchain **(Ethereum Foundation, 2018)**. The solution successfully demonstrated that comments made against a 3D model in a web browser could be recorded and timestamped as transactions on the Ethereum blockchain. The same approach could be extended to integrate the Ethereum blockchain into other commonly used design software, for example AutoCAD, Revit, and Bentley Building Suite. Using the blockchain as a single-source-of-truth ledger, recording changes made by different design software could help to resolve some of the design coordination issues and disputes commonly found in construction projects.

Project Participants

Foreword

The Construction Blockchain Consortium (CBC) supports knowledge transfer, arranges commercial and academic presentation, assesses and tests commercial services and technology, conducts research, and drives policy, regulation and understanding of the radical consequences of technology and services. Where required we also develop proprietary technology and services for the consortium members; using both outside contractors, and leveraging PhD and Masters students. You can find more about the CBC value proposition and strategy by reading our [open letter].

Abel Maciel, EngD
Director,
Construction Blockchain Consortium

Contributors

Author

Stephen Smith

Stephen Smith is a technology consultant with the Built Environment sector with 22 years of experience working on complex infrastructure projects. He is the founder of Blocks and Mortar, a technology development consultancy helping the Construction industry to adopt digital transformation with a focus on Digital Ledger Technologies and Digital Twin.

Stephen brings extensive experience in Information Management, Innovation Implementation and Building Information Modelling from working on a number of world class international projects including Crossrail, High Speed 1, Cingular 3G Wireless (USA), Zayed Port (Abu Dhabi) and Tengiz (Kazakhstan). He is an active member of the Digital Construction workstream of the Construction Blockchain Consortium (CBC).

Autodesk Forge Developers

Jamie Lopez, Petr Broz

Design Computation Developers

Abel Maciel, Pranamya Jain

1. Business Case Definition

There is no central ledger of changes for cross-platform federated BIM models, leading to poor project coordination

Design work for the majority of construction projects is typically contracted to multiple responsible design companies. The design will usually be contracted based on completion phases [e.g. RIBA Plan of Works **(RIBA, 2013)**] and by discipline (e.g. Structural, Mechanical, Electrical etc.). These designs are often undertaken using different design software. Coordination is required at defined stages to ensure each individual design integrates with its adjacent systems. If an issue arises once construction has commenced that is identified as being caused by poor design coordination (e.g. structural designer not providing sufficient access for a mechanical system), it is time consuming and expensive to investigate liability. The investigation requires opening and reviewing multiple individual design models and trying to assess when design changes were implemented and approved. If design coordination models have been generated it is still a time consuming and difficult task to try to establish the time sequence of changes made.

2. Application Challenge

Cross-platform BIM interoperability can be further improved via a common immutable ledge

Provenance and Interoperability in BIM workflows have always presented a major challenge. The complexity and large number of specialisms in the sector has led to the creation of many niche software solutions. The technological legacy of the digital tools also contribute to the industry fragmentation and loss of project information. This case study examines the integration of Collaborative BIM, running on the Autodesk Forge platform, and smart computational contracts running on the Ethereum blockchain, as a bridging mechanism applicable to various BIM and specialist software for digital construction management.

3. Solution Proposition

Ethereum blockchain was used as it is the leading Smart Contracts solution and had existing code libraries that could be integrated with Autodesk Forge

The blockchain is a public time-stamped ledger of transactions that cannot be altered once the record has been verified. If the design software being used by each responsible company is integrated with the blockchain then every change to a model file would be recorded and time stamped on a central ledger. This central ledger can then be quickly reviewed to identify what model changes were made, by whom and when; helping to identify liability for design-based constructability issues and to avoid associated project delays.
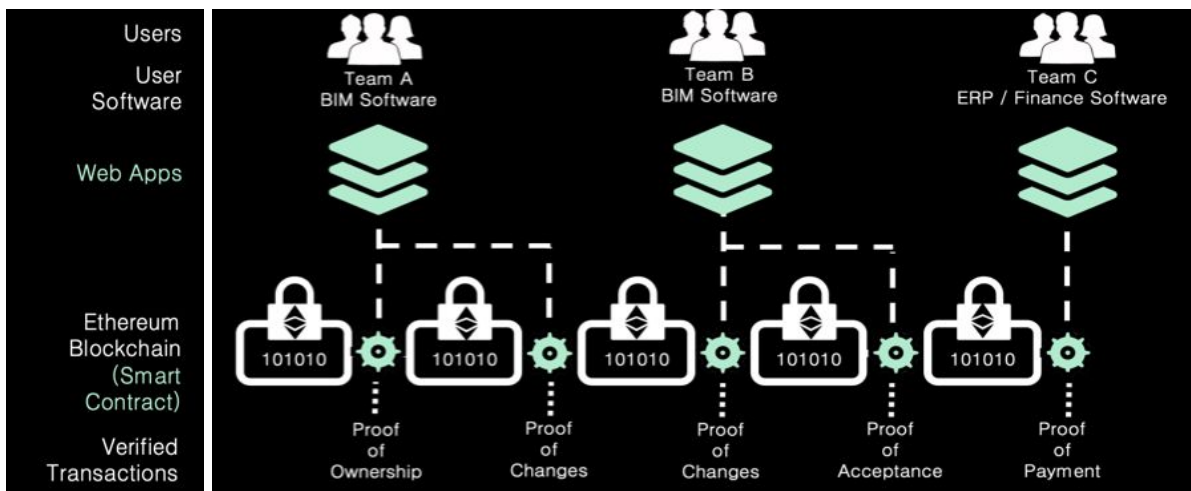
Figure 1 - Solution Architecture Overview

For our solution we chose to integrate the public Ethereum blockchain (test network) with Autodesk Forge. The Forge platform provides cloud-based developer tools including a 3D model viewer. See Solution Screenshots below for more details on the solution functionality.

In summary, the solution enabled design comments to be recorded against 3D design model objects within a Forge web application. These comments could then be reviewed and closed-out by another user who logged in separately to the same web application. Both the original comment and close-out response comments were recorded as transactions on the Ethereum blockchain. This was achieved by using the Metamask Ethereum web wallet **(MetaMask, 2019)** which integrates with the web browser. The Metamask wallet called a Smart Contract which in turn recorded the comments as timestamped transactions onto the Ethereum blockchain. A user dashboard was developed which retrieved the timestamped transactions so users could easily see the status of their open and closed comments.

We integrated the Ethereum blockchain into our web application using open source JavaScript libraries **(Web3, 2020)** provided by the Ethereum community.
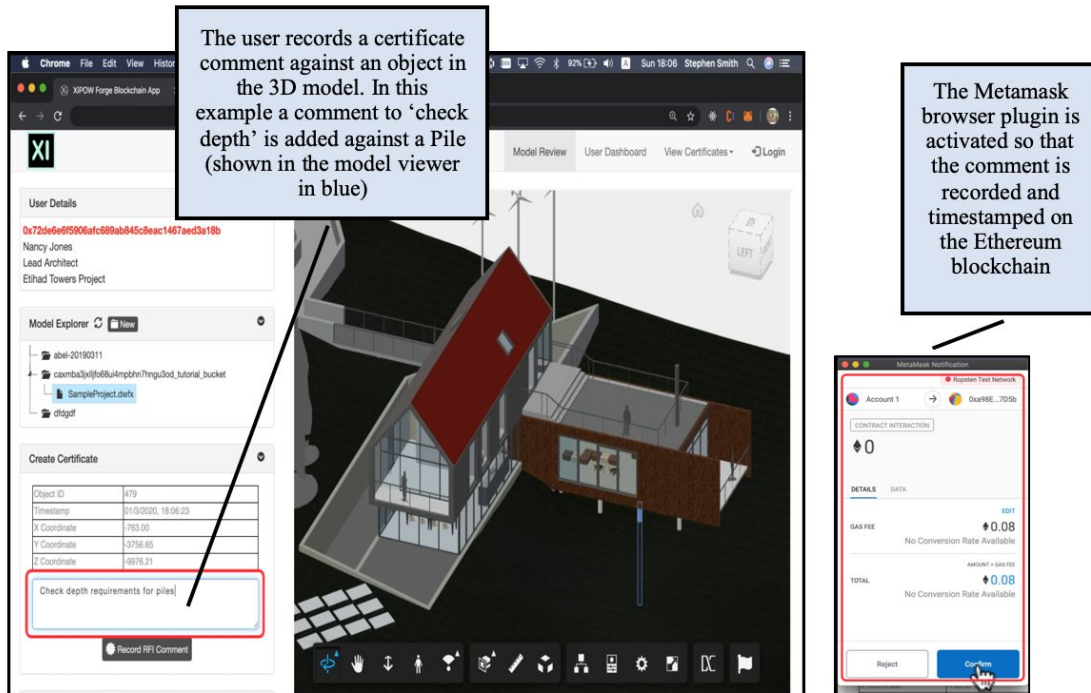

Figure 2 - Solution recording certificate comments on Ethereum blockchain
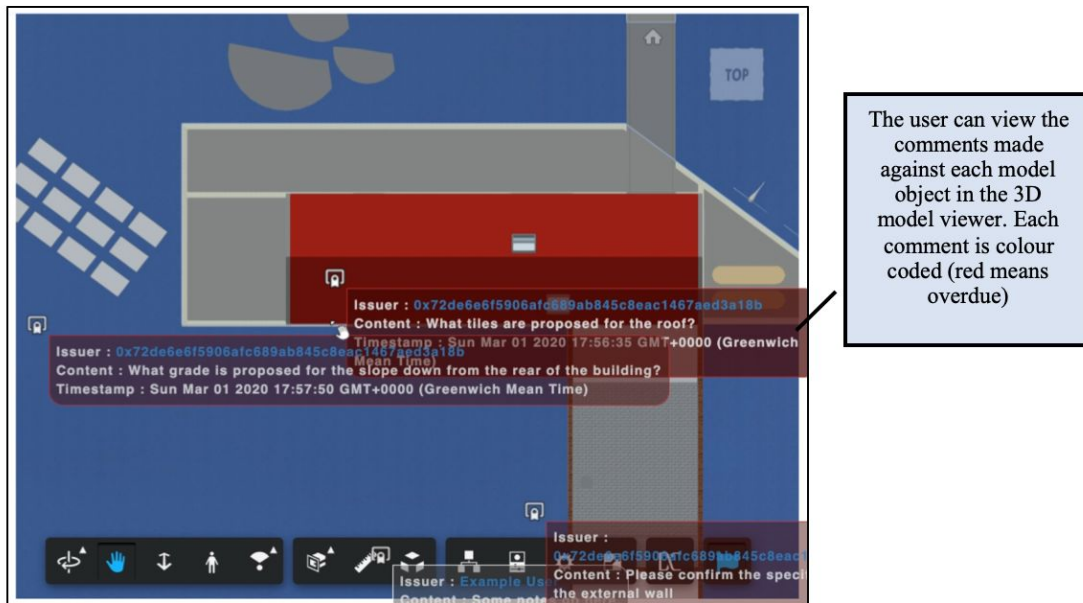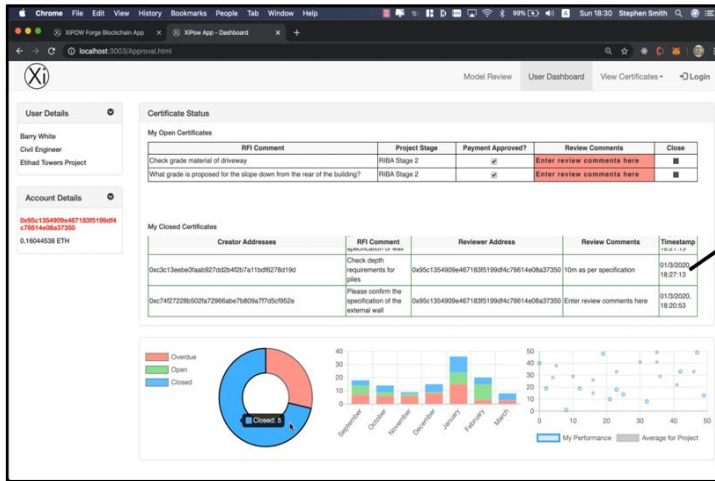

Figure 3 - Solution showing certificate comments from Ethereum blockchain in 3D model viewer

Each user has a dashboard showing the status of the comments assigned to them for close-out. Here the user has provided a Review Comment against the 'check depth of pile' comment raised above

As before the Metamask browser plugin is activated so that the comment is recorded and timestamped on the Ethereum Blockchain (not shown)

Figure 4 - Solution showing certificate comments from Ethereum blockchain in User Dashboard
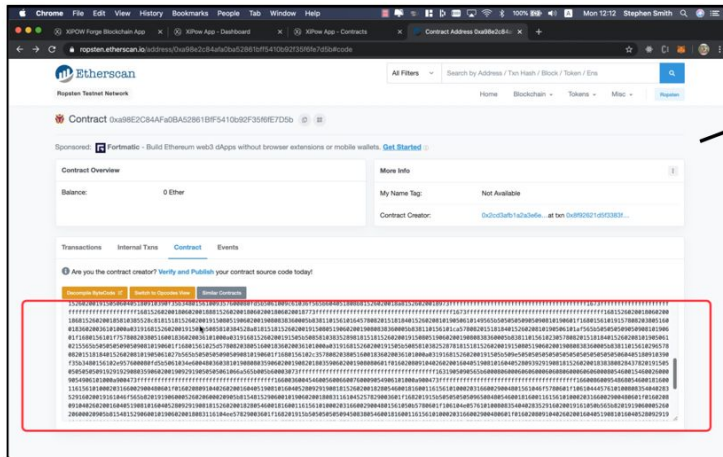
The Ethereum Smart Contract which records the original comment and corresponding close-out comment on the Ethereum blockchain is shown here (Encrypted)

Figure 5 - Solution showing Ethereum Smart Contract via Etherscan blockchain explorer
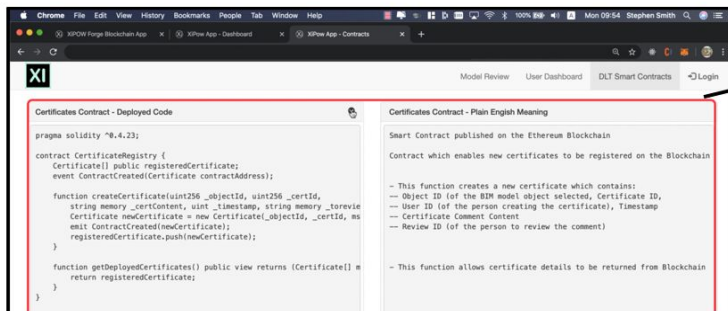
Within the Forge Web App the Smart Contract code can be viewed in both code and plain English formats

Figure 6 - Solution showing Ethereum Smart Contract within web application

4. Analysis & Outcomes

We successfully demonstrated that changes to a 3D model could be recorded to the Ethereum blockchain as transactions. These transactions recorded who made the change, the details of the change and the time the change was made. In our solution the transactions recorded both comments made to a model object and then the subsequent response close-out comments. We also successfully demonstrated that the transactions recorded on the blockchain could be retrieved into the web application and presented clearly in a user dashboard.

5. Considerations

In our solution we chose to integrate with Autodesk Forge because it provided a set of pre-built tools to enable us to build our demonstrator quickly. This has successfully shown how the blockchain can be integrated in design software. To build this into a solution that would fully solve the problem set out in this case study, we would need to create blockchain integrations with commonly used design software (e.g. AutoCAD, Revit, Bentley Building Suite). If all of the project participants used software that was integrated into the same blockchain and called the same Smart Contracts, then all of the design changes would be recorded on one immutable timestamped ledger. This would help to identify liability for design-based constructability issues. Having all of the cross-design software design information in one central ledger would also be useful for other purposes, such as assessing project-wide design progress.

We chose to develop this solution with JavaScript web3 API libraries because JavaScript is extensively used. The code developed for this case study could be reused to integrate the Ethereum blockchain directly into other design software (both Autodesk **(Autodesk Forge, 2019)** and Bentley **(Bentley, 2019)** have JavaScript APIs available for their products).

Ethereum was selected as it is the most advanced and well supported Smart Contracts blockchain available. However, there are fees associated with recording transactions onto the live Ethereum blockchain. Paying these small fees may be acceptable to users for recording certain important information but will probably not be viable for this use case where we record all design changes (note that this would quickly grow to millions of transactions for larger projects). Other fee-less technologies such as IOTA **(Sønstebø, 2017)** could be considered as an alternative.

References

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