Implementation of Blockchain Technology in the Construction Industry

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Abstract

In general, the construction industry has been pretty resistant to change. While most industries have gained in productivity over the years through implementation of new technologies and other factors, construction industry productivity has been on a steady decline since the 1960s. Even though there are a multitude of reasons for this, including more complex building types and a decline in the workforce, the major problem holding construction back are project management issues and alienation of project stakeholders in the construction process. Some improvements have been made to help with collaboration between parties, like BIM (building information modeling) and project management software like Procore and Plangrid, but there isn't one application that pools information to share data between parties.

This is where blockchain can make a difference and help solve the collaboration problem. Blockchain is a peer-to-peer, controlled, distributed transactional database used to record and store lists of transactions (called blocks) that are verified through cryptography. This paper explores the emergence of blockchain, highlights the progressive companies implementing this technology in construction, and analyzes the best practices and applications needed for blockchain to succeed in the construction industry.

Key Words: Blockchain, construction, collaboration, cryptocurrency, productivity, risk management, supply chain management

Introduction

The construction industry has existed in some fashion from the earliest civilizations. From pyramids in Egypt to major cathedrals in Europe to skyscrapers in Dubai, there have been distinct processes leading to built environments. While many things have changed, including project delivery methods and the use of new and more efficient materials, the construction process has retained some key elements like conception, preplanning, launch and execution, project performance and control, and the project close and handover to the client. In a system with many moving pieces and a lot of data being exchanged, it's easy for a project to get out of control. It's up to the skilled contractors to create a project that is timely, on budget and suitable for the client. With the growing complexity of buildings, new project delivery methods have entered the fold, including design-build and integrated project delivery, which most general contractors are using today. These project delivery methods are put in place to help all project stakeholders collaborate more effectively. Despite these efforts, construction productivity has stalled.

Construction Productivity

The construction industry is ready for a revolution. Since the 1960s, productivity has plunged by half and the industry has had lower productivity gains compared to manufacturing, which has "doubled over the same period" (Barbosa**).** There are myriad reasons for this productivity loss, including:

1. Regulation (applying for permits) has accounted for about an eighth of productivity since 1987
2. 63 percent of direct labor time is spent waiting on materials and equipment, according to the Construction Owners Association of America
3. No uniform design for each building, so contractors must start from scratch each time
4. For-profit industry drives up prices for the consumer (*Efficiency Eludes the Construction Industry, 2017)*

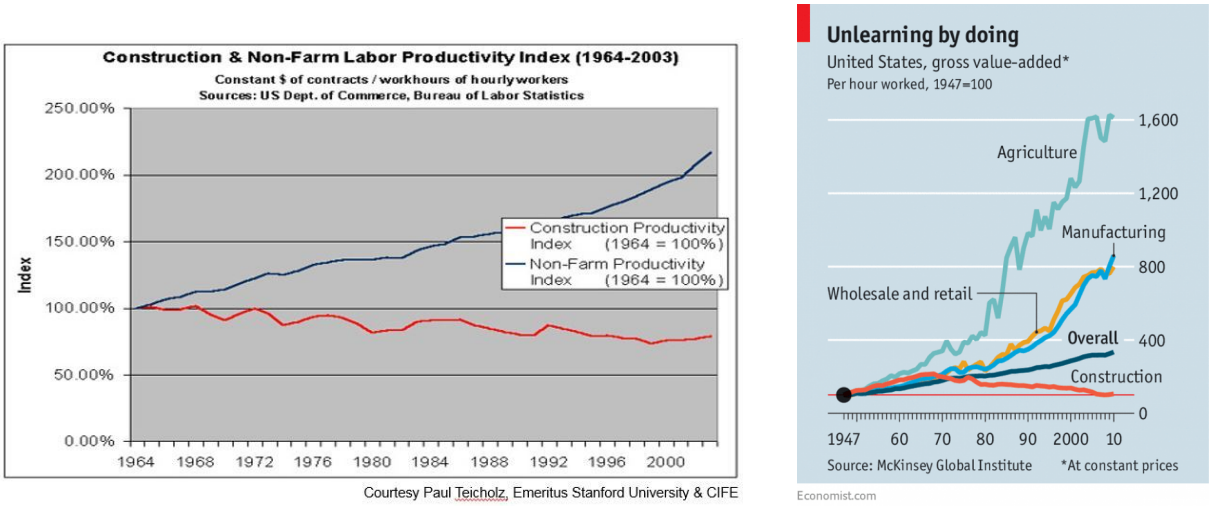


Figure 1: Declining Productivity of Construction Compared to Other Industries
Sources: Left: (Barbosa, 2017) Right: (The Economist, 2017)

While these are just some of the reasons why the construction industry has challenges, the vast majority of issues stem from two major areas: poor project management and ineffective collaboration between stakeholders in the construction process. According to the National Society of Professional Engineers in its article on construction productivity, the lack of consistent engagement between construction managers and project stakeholders has made project information flow inconsistent and chaotic. Contracts between parties are often cumbersome and litigious, so each party has as much legal insulation as possible to cover themselves **(**National Society of Professional Engineers, 2014**).** Contractual relationships usually require companies to put their individual performance before project performance, resulting in a system that is

inefficient. The National Institute of Building Sciences notes that “people and their effective engagement in project teams are the foundation of a project’s success.”

In order for collaboration and project management to improve, construction companies must embrace technology that fosters greater teamwork. According to data from the Institute of the World Economic Forum, successfully adopting technology can reduce costs by 20%, and updating the construction process could potentially result in a $1.6 trillion profit increase globally (Unearth Labs, n.d). Technologies like building information modeling (BIM) and project management software like Procore and PlanGrid allow for open collaboration. With the recent influx of tech-savvy workers rising through the ranks of the construction industry, there are new ideas for solving the collaboration problem. This momentum is leading to adopting novel methods and processes, including the use of technology called Blockchain.

What is Blockchain?

In response to the 2008 financial recession, a person or group of people known under the pseudonym Sataoshi Nakamoto, set out to create a digital currency that would 1) not be controlled by a central authority or middleman, like one of the big banks that caused the financial recession (Rosic, 2018), and 2) solve the double-spending problem plaguing many digital currencies. This digital currency, most famously known as Bitcoin, “requires all transactions, without exception, be included in a shared public transaction log known as a blockchain” and this mechanism makes sure that all parties spending bitcoins owns them and also prevents this double counting and other fraud” (Invesopedia, 2018). The blockchain is then built up overtime as more and more transactions are added to it, creating an immutable public ledger that can’t be “duplicated or falsified without other nodes of the network being aware” (Brickschain, n.d.). The records in the blockchain are secure since changing transaction records would require a majority share of the blockchain network’s computing power by obtaining a great amount of nodes; a feat that is virtually impossible.

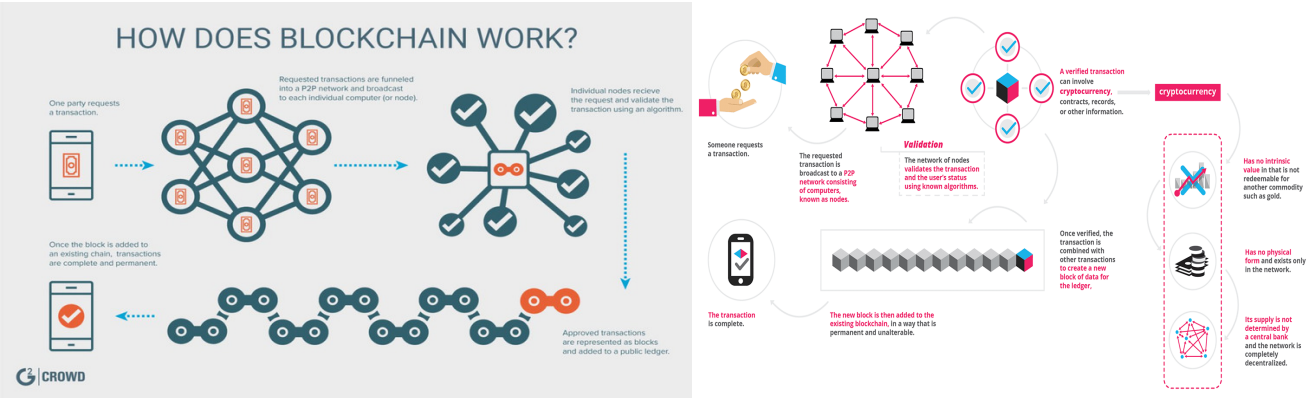


Figure 2: How Blockchain Works
Source: (Rosic,Ameer.et al., 2018)

In *The New Yorker* article "The Stuff Dreams Are Made of," Nick Paumgarten describes blockchain like this:

> "If you have ten dollars, you shouldn't be able to pay ten dollars for one thing, then spend the same ten for another. This requires some mechanism for keeping track of what you have, whom you gave it to, and how much they now have. And that was the blockchain.
>
> "Definitions of blockchain are as various as the metaphors—bingo, Google Docs, a giant room of transparent safes—that people use to try to illustrate them. Broadly speaking, a blockchain is an evolving record of all transactions that is maintained, simultaneously and in common, by every computer in the network of that blockchain, be it Ethereum, Bitcoin, or Monero. Think, as some have suggested, of a dusty leather-bound ledger in a Dickensian counting house, a record of every transaction relevant to that practice. Except that every accountant in London, and in Calcutta, has the same ledger, and when one adds a line to his own the addition appears in all of them. Once a transaction is affirmed, it will—theoretically, anyway—be in the ledger forever, unalterable and unerasable.
>
> "Historically, records have been stored in one place—a temple, a courthouse, a server—and kept by whoever presided. If you distrust central authority, or are queasy about Google, this won't do at all. With blockchains, the records, under a kind of cryptographic seal, are distributed to all and belong to no one. You can't revise them, because everyone is watching, and because the software will reject it if you try. There is no Undo button. Each block is essentially a bundle of transactions, with a tracking notation, represented in a bit of cryptographic code known as a "hash," of all the transactions in the past. Each new block in the chain contains all the information (or, really, via the hash, a secure reference to all the information) contained in the previous one, all the way back to the first one, the so-called genesis block." *(The New Yorker,* 2018)

Methodology

The methodology chosen for this study was primarily qualitative research gleaned from two construction software companies using blockchain technology. I also conducted quantitative research with an interview with a project manager from Gardner Builders to get their input on blockchain implementation. This information is relevant for those in the construction industry wanting their projects to be timely, on budget and suitable for the client. Integrating blockchain into their construction process could potentially facilitate these results.

The objectives of this research are as follows:

1) Expand the construction industry's knowledge of blockchain
2) Highlight companies using blockchain in their construction process
3) Provide an analysis of the benefits of blockchain technology

4) Understand the challenges of implementing blockchain technology

Intelliwave Technologies: SiteSense

Material management company Intelliwave Technologies created the material management software SiteSense, which maintains an activity feed for every construction resource and record document. It logs and categorizes every activity in sequence relating to the resource. Blockchain is used in conjunction with SiteSense to store these transactions securely and privately, allowing multiple shared stakeholders (or peers) to connect and sync the transactions**.**

Advantages of SiteSense Blockchain

The first advantage of blockchain is automation. SiteSense couples with sensors, Internet of things, and mobile technologies in order to automate and validate transactions. This helps reduce the amount of manual work involved in recording transactions while adding a stream of time-stamped and accurate information to the record book. This is used to validate manual entry and ensure mistakes or misrepresented information are identified and corrected.

The process is also very transparent. SiteSense uses a hierarchical, project-based authorization system in addition to role-based security in order to securely direct information to the correct project stakeholder. Stakeholders connecting to the blockchain would be able to view all transactions based upon their role on the project, ensuring the correct information is distributed to multiple shareholders.

Lastly, blockchain is a very integrated process. A project using a blockchain for transactions would allow all stakeholders' enterprise systems to have access to a shared ledger. A transaction log would ensure that all of these systems are automatically synchronized, in real-time, with accurate information (Intelliwave Technologies, 2017).

Brickschain

Brickschain is a company that digitizes buildings in the blockchain and chronicles the entire building process. Since "95% of building construction data currently gets lost in handover to the owner," according to Bassem Hamedy, founder of Brickschain, their process seamlessly integrates into workflows, systems and the building's supply chain to chronicle the entire building process and create a data repository (Bowcott, 2018). This enables companies using Brickschain to use all participants' data via simple application programming interface while using blockchain's immutable record of transactions that are searchable and discoverable, bringing to life data and information to project stakeholders. As a result, Brickschain provides cost savings and incredibly powerful risk management and risk mitigation tools.

Brickschain and a Minneapolis contractor, Gardner Builders, presented the first digital twin of the project documentation for the renovation and fitting-out of a new interior space for the Discover Strength exercise center. This documentation is secured and unchangeable or "immutable" (in blockchain parlance) because it exists on multiple databases that are all kept in sync (Sawyer, 2018). Collecting project data took a week by installing Brickschain's nodes to the project's Dropbox and Procore accounts, and the

system automatically scraped Industry Foundation Classes (IFC) data along with the submittal data about objects contained in the electronic files of the project's 2-D plans. According to Dave H. with Gardener Builders, Brickschain was installed late in the project cycle but the closeout of the project much faster than regular closeout methods the company used in the past.

This process could be beneficial for a project in its early stages as stakeholders could install nodes and capture all data going into the creation of a project from their own servers in real time. Brickschain could also solve disputes quickly as it shows all transactions and could pinpoint a mistake and, potentially, who made it. Creating and maintaining a digital twin using Brickschain costs approximately "10 cents a square foot" (Sawyer, 2018).

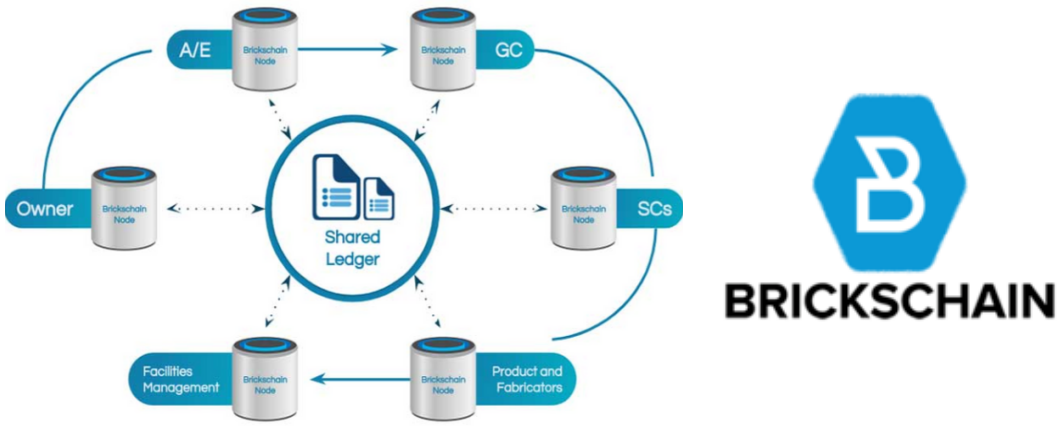


Figure 3: Brickschain's Distributed Ledger System

Benefits of Blockchain Technology

Construction projects that use blockchain technology have three major attributes. First, risk management is divided among all parties, since the distributed ledger technology of blockchain allows for everyone to have their own version, all stakeholders are informed when changes happen and can agree on the contents of the ledger. Secondly, asset and data provenance are more available than ever as the "loss and inaccessibility of critical data and equipment of a building" are all present in the immutable blockchain (Bowcott, 2018). Lastly, discovery and legal costs could be reduced since it is easy to find where mistakes are made.

Challenges to Implementation

While Blockchain is beginning to be implemented, there are a few challenges the technology faces before it can be adopted widely.

1) All parties in the construction process must be involved with blockchain and convinced that blockchain will be a useful tool for them. According to SiteSense,

   "Confidentiality and privacy is critically important in the relationship between architects, engineers, suppliers and owners. There are often complex contracts in place to protect the intellectual property (IP) of these organizations. Instituting an open record book of transactions is a challenge in this environment due to the IP. Each project's overall data management strategy needs to be established from the very beginning to account for types of transactions and the data structure of each block, respecting the privacy and confidentiality of every organization" (How Site Sense Uses Blockchain Tech, 2017).

2) Industry standards are pretty much non-existent regarding information systems for blockchain since this technology is so new. Currently, every project has its own standards. Just as the Construction Industry Institute has created industry standards, construction professionals can begin the process of developing Blockchain standards.

3) Because these standards are widespread across the construction industry, the industry's biggest challenges are the technological limitations that many construction companies have. Blockchain requires a simple IT infrastructure and servers but many construction companies are still transitioning to computer systems, making it difficult to transition to advanced technology. Construction companies will need to invest in new technology in order to keep up with the complexity that blockchain requires.

Conclusions and Future Research

Construction professionals who utilize blockchain from the inception of a project will be able to manage their data more efficiently and sustainably while also saving on data coordination, rework, legal claims, discovery costs, and downstream maintenance. A building on the blockchain is safer, more risk-managed, and data rich, allowing for seamless collaboration between all stakeholders in the construction process.

In terms of future research, quantitative research would provide a way to see how cost effective blockchain actually is for construction companies. Also, it would be important to see how smart contracts—a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract—and blockchain scaling are being implemented along with blockchain technology already in place

The construction industry has some serious challenges ahead, but with the help of new technologies, such as BIM, project management software, and blockchain, there could be an increase in productivity, reduction of costs, and more collaboration between all stakeholders in the construction industry. At this point in history where the world gets smaller everyday due to globalization, it is going to be important that we all get to the point of trusting each other, and blockchain might just be that glue that holds us together.

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