QUALITY ASSURANCE FRAMEWORK FOR NEW PROPERTY DEVELOPMENT: A DECENTRALIZED BLOCKCHAIN SOLUTION FOR THE SMART CITIES OF THE FUTURE

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ABSTRACT
BY 2050, 70 PERCENT OF THE WORLD POPULATION WILL BE LIVING IN URBAN ENVIRONMENTS. ALL THIS HAS STARTED WITH THE UNPRECEDENTED URBAN GROWTH IN THE LAST FEW DECADES. REGARDLESS OF WHETHER A COUNTRY HAS A SHRINKING POPULATION, CITIES ARE STILL GROWING AND THRIVING. IN 2017 THE EU HAS SEEN ITS BEST YEAR IN NEW PROPERTY DEVELOPMENT SINCE THE DIP OF 2010 AFTER THE GLOBAL ECONOMIC CRISIS IN MEMBERS RANGING FROM THE UK TO ROMANIA. HOWEVER, THE PROBLEM OF BUILDING QUALITY HAS STARTED EMERGING. IN MARCH 2017, A SURVEY CONDUCTED BY YOUGOV FOR THE HOUSING CHARITY SHELTER FOUND THAT 51% OF HOMEOWNERS OF NEW BUILDS IN ENGLAND HAVE EXPERIENCED MAJOR FAULTS, IN ROMANIA, ANNUALLY THERE ARE HUNDREDS OF COMPLAINTS ABOUT ABUSES IN CONSTRUCTION BUT THE MEASURES BEING TAKEN ARE TOO FEW WHEN COMPARED TO THE NUMBER OF NEW PROJECTS. THIS PAPER PROPOSES A QUALITY ASSURANCE FRAMEWORK BASED ON BLOCKCHAIN TECHNOLOGY WHICH WILL ALLOW A MORE TRANSPARENT HOUSING DEVELOPMENT MARKET WITH MORE ACCOUNTABILITY AND OPPORTUNITY FOR LESS ESTABLISHED COMPANIES TO COMPETE.

KEYWORDS: URBAN GROWTH, PROPERTY DEVELOPMENT, BUILDING QUALITY, QUALITY ASSURANCE, BLOCKCHAIN

INTRODUCTION

According to the United Nations' World Urbanization Prospects: The 2007 Revision, by 2050, 70 percent of the world population will be living in urban environments. All this has started with the unprecedented urban growth in the last few decades. For the first time, in 2008, the number of people living in cities (400 over 1 million and 19 over 10 million) was equal to those in rural environments. Taking this trend into consideration and a need for

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sustainable growth, a demand for greater efficiency in the administration of cities is a natural emergence. For this to happen, the use of information and communication technologies is a must. In recent years the concept of the Smart City has come out to merge the ideas and technologies that will lead to the cities of the future. By using information and communication technologies, Smart Cities will be able to more efficiently run their infrastructure and public services with a smaller environmental footprint and enable the people living within them to interact at a more base level with both authorities and the city itself. One of the outcomes and, in part, driving forces of the shift in population distribution is a growing real estate market in cities around the world[5]. The real estate industry has a positive outlook on the major markets despite many political and economic uncertainties clouding Europe's future. Today, factors such as quality of life, forward-thinking municipal authorities, physical and social infrastructure, diversity, and sustainability are an intrinsic part of the equation. Regardless of whether a country has a shrinking population, cities are still growing and thriving[6]. In 2017 the EU has seen its best year in new property development since the dip of 2010 after the global economic crisis[7] in members ranging from the UK to Romania. However, the problem of building quality has started emerging. In March 2017 a survey conducted by YouGov for the housing charity Shelter found that 51% of homeowners of new builds in England have experienced major faults including issues with construction, unfinished fittings and problems with utilities[8]. In Romania, annually there are hundreds of complaints about abuses in construction but the measures being taken are too few when compared to the number of new projects. In a paper titled Emerging Trends in Real Estate: Europe 2017, PWC revealed that the industry is starting to look beyond traditional solutions, perhaps having realised it does not hold all of the solutions. For real estate to thrive in an uncertain and fast-changing world its leaders will have to make bold disruptive decisions[9]. This paper proposes a quality assurance framework based on blockchain technology which will allow a more transparent housing development market with more accountability and opportunity for less established companies to compete.

KNOWN ISSUES IN QUALITY

Although the root of the problems might be different, the issues that arise for new homeowners are common among the the two markets studied, UK and Romania. Some of the problems reported are weak mortar, faulty drainage or unfinished fittings which turns buying new homes into a problematic endeavour. Experts report that the rush to build homes in Britain's housing shortage and the dominance of large building firms which use a variety of

[5] "World Urbanization Prospects - Population ...." Accessed July 30, 2017. https://esa.un.org/unpd/wup/

[6] "Emerging Trends in Real Estate: Europe 2017 - PwC." Accessed July 30, 2017. https://www.pwc.com/gx/en/industries/financial-services/asset-management/emerging-trends-real-estate/europe-2017.html

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[8] "Why are Britain's new homes built so badly? | Money | The Guardian." Accessed July 30, 2017. https://www.theguardian.com/money/2017/mar/11/why-are-britains-new-homes-built-so-badly; "Research Report: Survey of Private Landlords - Shelter England." Accessed July 30, 2017. https://england.shelter.org.uk/professional_resources/policy_and_research/policy_library/policy_library_folder/research_report_survey_of_private_landlords;
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[9] "Emerging Trends in Real Estate: Europe 2017 - PwC." Accessed July 30, 2017. https://www.pwc.com/gx/en/industries/financial-services/asset-management/emerging-trends-real-estate/europe-2017.html

subcontractors are, in part, to blame for poor execution[10]. In the UK, there is no single licensing body that issue licences for builder to practice, they can however sign up to a body like the NHBC or the Federation of Master Builders but on a voluntary basis. All homes need to be signed off by the local authority building control to ensure that each key stage meets building regulation standards. Organisations such as NHBC can provide approved inspectors to do these checks. NHBC says in about half of the homes where it provides warranty, building control is carried out by another body, usually the local authority. Questions have been raised over NHBC's independence after it emerged that the organisation pays millions of pounds to housebuilders every year.[11] In Romania, problems arise not from lack of regulations but corruption and lack of compliance with the issued building permits. Although many complaints have been issued in regard to new homes there hasn't been significant response from authorities. To date, no new apartment block has been demolished even if it was illegally constructed or had not been in compliance with construction regulations. From 2013 to 2014 alone the ISC (State Inspectorate for Construction) has put a halt to 641 construction sites due to problems but only at the request of the owners that have already bought property from the developer. After the devastating earthquake of 1977 when dozens of buildings collapsed in Bucharest authorities changed building standards and imposed very strict guidelines to avoid further problems that might arise from seismic activity. These standards are still in place today but in the 40 years since, the constant alteration of laws regarding accountability, the political changes and the centralized non transparent issuance of permits has created loopholes that have been exploited to the detriment of safety and quality.Be it in Romania or UK, the main issue that affects new home buyers comes down to a lack of transparency in the building process of the properties.

PROPOSED QUALITY ASSURANCE FRAMEWORK

A. Blockchain Technology

A blockchain is a distributed database that is used to maintain a continuously growing list of records, called blocks[12]. Each block contains a timestamp and a link to a previous block[13]. A blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for validating new blocks. By design, blockchains are inherently resistant to modification of the data. Once recorded, the data in any given block cannot be altered retroactively without the alteration of all subsequent blocks and a collusion of the network majority. Functionally, a blockchain can serve as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way. The ledger itself can also be programmed to trigger transactions automatically."[14] Blockchains are secure by design and are an example of a distributed computing system with high Byzantine fault tolerance. Decentralized consensus has therefore been achieved with a blockchain[15].

[10] "Fixing our broken housing market - GOV.UK." Accessed July 30, 2017. https://www.gov.uk/government/publications/fixing-our-broken-housing-market

[11] Why are Britain's new homes built so badly? | Money | The Guardian."
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[14] Iansiti, Marco, and Karim R. Lakhani. "*The Truth About Blockchain*." Harvard Business Review 95, no. 1 (2017): 118-127

[15] Raval, Siraj. *Decentralized Applications: Harnessing Bitcoin's Blockchain Technology*. " O'Reilly Media, Inc.", 2016

This makes blockchains potentially suitable for the recording of events, medical records,[16] and other records management activities, such as identity management,[17] transaction processing, and documenting provenance. The first blockchain was conceptualised by Satoshi Nakamoto in 2008 and implemented the following year as a core component of the digital currency bitcoin, where it serves as the public ledger for all transactions[18]. Blockchains in some sense can be considered as automatically notarised ledgers. They alleviate the need for a trust service provider and are predicted to result in less capital being tied up in disputes. Blockchains have the potential to reduce systemic risk and financial fraud. They automate processes that were previously time-consuming and done manually, such as the incorporation of businesses[19].

B. **Smart Contracts**

Blockchain-based smart contracts are contracts that can be partially or fully executed or enforced without human interaction.[20] One of the main objectives of a smart contract is automated escrow. The IMF believes blockchains could reduce moral hazards and optimize the use of contracts in general. Due to the lack of widespread use their legal status is unclear[21]. Some blockchain implementations could enable the coding of contracts that will execute when specified conditions are met. A blockchain smart contract would be enabled by extensible programming instructions that define and execute an agreement[22].

C. **Quality assurance framework**

i. Digital Twining of Property on Blockchain

The concept of creating a decentralized quality assurance framework leverages Ethereum technology created as an evolution of the Bitcoin platform which only made use of one of the many possible applications of the Blockchain technology (peer-to-peer transfer of funds). Ethereum is a platform based on the Blockchain technology used for developing decentralized applications. It has a few benefits over Bitcoin such as the feature of coding Smart Contracts and the Ethereum Virtual Machine. Smart Contracts are a digitized version of a traditional contract. They are computer programs which run on the Blockchain database and can be programmed to self-execute when the conditions written in their source code are met. Smart Contracts are trusted by the users as once programmed, the terms of the contract cannot be changed thus making the contract immutable[23]. As such, we can consider the quality rating of a property as a smart contract with conditions as legal constraints, construction material quality, qualifications of the builders, etc. In essence, a digital twin of the property is created which has the advantage of not being prone to failures such as power

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[16] Yuan, Ben, Wendy Lin, and Colin McDonnell. "*Blockchains and electronic health records*." Mcdonnell. mit. edu

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[21] He, Dong, Karl Friedrich Habermeier, Ross B. Leckow, Vikram Haksar, Yasmin Almeida, Mikari Kashima, Nadim Kyriakos-Saad et al. *Virtual Currencies and Beyond: Initial Considerations*. No. 16/3. International Monetary Fund, 2016

[22] Swan, Melanie. *Blockchain: Blueprint for a new economy*. " O'Reilly Media, Inc.", 2015

[23] "Smart Contracts: Separating Ethereum from Bitcoin - Cointelegraph." Accessed July 30, 2017. https://cointelegraph.com/news/smart-contracts-separating-ethereum-from-bitcoin

cuts, node failures, tampering, there is no risk of misplacing or losing the information as the contract is saved on a distributed ledger. What this means is that each device connected to the network has a copy of the contract and the data stays on the network forever. Since the terms of the contract cannot be changed, the users are at a lesser risk of being cheated. Smart contracts are free from all kinds of human intervention. Although the underlying base technology exists and is constantly being developed, a user friendly application and interface has to be developed for the specific creation of smart contracts in this particular use case.

ii. Legal Requirements as Contract Conditions

To address the issues that arise from not withholding the requirements set by authorised legal entities upon issuance of building permits these can be integrated into the digital twin's smart contract as conditional barriers to the rating system. The advantages of this approach are an increased transparency for all stakeholders as well as an automated system for validating all conditions set forth by the authorities. However, implementing such a system has to have political support as it requires adoption by the city government which in turn would need a legal basis for recognising authority of the automated smart contract. Furthermore, for legal requirement validation, digital signatures would have to be adopted and used by all parties interacting with the smart contract. Although not in this particular use case, implementation of a similar project on blockchain technology has gone through a pilot program in Sweden by the Mapping, Cadastre and Land Registration Authority in collaboration with Landshypotek Bank, SBAB, Telia, ChromaWay and Kairos Future to study and test the possibilities of using blockchains as a technical solution for real estate transactions and the mortgage deed processes. It is the second stage of the program, the first having ended successfully in June 2016. As outlined in their 2017 report, among other considerations, further lobbying, investigation and innovative solutions to allow for a digital process with digital signatures is a key element to secure the realization of the value of the project. Furthermore, the operation of a blockchain is a joint responsibility. The appropriate governance and incentives for operation has to be set up. The ambition is to make the solution open source to a large extent. Still, ownership of the software and hardware, and a framework for potential external partners for cloud solutions, storage, network etc. has to be outlined. There are many possibilities to develop new solutions and services with the use of the data and platform developed. Conditions for this has to be discussed, and the process for decision on changes investigated[24].

iii. Conditional Use of Suppliers, Materials, Expertise

As previously mentioned, another consideration for home buyers is the quality of materials used as well as the expertise of the builders, especially in markets where there aren't strict legal requirements for formal qualifications. For example, training of builders in Germany takes three years, where the 'master craftsman' status is a formal licence to trade, which is not the case in the UK, hence the proliferation in the UK of 'builders' who do not have formal qualifications[25]. By digitising the builder's licenses, they can be integrated into the smart contract thereby contributing to the final quality rating of the property. In the case where formal education is more relaxed or absent, builders can still use a digital signature as proof of the quality of their work which would be backed up by their past reputation in work done transparently through smart contracts on the distributed ledger. Suppliers can also

[24] "The Land Registry in the blockchain - testbed - ChromaWay." Accessed July 30, 2017. https://chromaway.com/papers/Blockchain_Landregistry_Report_2017.pdf

[25] "Why are Britain's new homes built so badly? | Money | The Guardian."
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adhere to this framework and create a feedback loop where the quality of the end product influences their reputation and vice versa.

CONCLUSION

This paper proposes a blockchain - smart contract based quality assurance framework to reduce or eliminate issues that have affected new home buyers as a result of rapid property evolution in markets where population redistribution and growth have created a need for new real estate development. The advantages of this technology over a centralized database provided by a third-party trust service provider are, by its nature, improved reliability, increased transparency from city authorities, contractors, builders and suppliers as well as resistance to tampering, an immutable history of the digital twin of the property and in the end more trust in the market as a whole. Hence, the integration of a distributed network based on smart contracts running on blockchain technology into the framework of a smart city would alleviate some of the friction brought by rapid development and create growth from value assurance. Further works have to be done to study the potential viability of the proposed system from a logistical point of view as well as political acceptance. However, creating a digital twin of a property has potential application in other aspects of the life cycle of the asset that might bring value in other aspects of managing a smart city.

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