

The impact of Hyperledger Fabric on the time it takes to complete the conveyancing process in Ireland.

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The Impact of Hyperledger Fabric on the time it takes to complete a conveyancing process in Ireland.

Using Discrete Event Simulation to determine the impact of Hyperledger Fabric on the time it takes to complete the conveyancing process.

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Abstract

The current conveyancing process in Ireland is not utilising technology in the same way many other processes are. The current system is reliant on traditional methods of communication and file storage. This is resulting in a process that is not efficient. The modern consumer is tech savvy and has access to a lot of information through their smartphones. However, in the case of the conveyancing process they are largely left in the dark. The traditional methods of file transfers such as post and couriers are required due to security and government regulations. These methods add valuable time to a process that already seems slow to the consumer. The addition of blockchain would create a unified platform where all actors of a conveyancing process would be able to have almost instant access to view and transfer the necessary files within the process. The aim of this paper is to simulate the time for the current process and replace the traditional file transfer methods with what a blockchain solution could provide. The paper does not intend to evaluate the time efficiency of having access to documentation. This research attempts to evaluate if blockchain is an appropriate solution to the conveyancing problem and what Hyperledger Fabric could provide. The research estimates using simulation, that the application of a blockchain network for the transfer of documents in the conveyancing process would result in an 18 day or 42% reduction in the time it takes to complete a conveyancing process in Ireland. These figures could be further reduced after this research, once the overall impact of access to documentation through blockchain can be measured.

1 Introduction

Following on from the Ethereum network being created in 2015, where applications could be built on top of a Blockchain network to allow the currency to be exchanged in more innovative ways (Buterin, 2013). The global audience began to see how applications built on blockchain platforms could be used to execute various tasks, they began to wonder if it could be used in their industry. At its core blockchain is used to decentralise power and enforce trust among peers and in order to do so it had to be open to anyone to join. IBM has described the top five benefits of blockchain as transparency, security, traceability, efficiency and lower costs¹. A permissioned blockchain network is created by allowing copies of the ledger in multiple servers, but only certain members can access that information. The two organisations at the forefront of this enterprise-level blockchain innovation were Hyperledger and R3. Hyperledger has created a suite of products that aim to cover all areas that permissioned blockchains may

¹ IBM, 2018. Top five blockchain benefits transforming your industry [WWW Document]. Blockchain Pulse: IBM Blockchain Blog. URL <https://www.ibm.com/blogs/blockchain/2018/02/top-five-blockchain-benefits-transforming-your-industry/> (accessed 4.5.19).

apply to. While R3's Corda is aimed particularly at dealing with financial institutions. Both organisations are being developed by consortiums of industry-leading companies.

Motivation ~ One of the industries which this technology can rapidly transform is the legal profession and more specifically the conveyancing process. Conveyancing is known as "*the process of moving the legal ownership of property or land from one person to another*"². This process within Ireland deals with lots of documents such as title deeds and many other documents containing sensitive information. While many industries within Ireland have adopted strategies to transfer such documents to a digital format, the conveyancing process has been slow to catch up, due to a lack of suitable technological solutions available. The current conveyancing process is highly fragmented with many different agencies and actors holding different pieces of information. In order to complete conveyancing, a solicitor must gather the relative information which can sometimes require long delays due to the processing and communicating requests for information. On the bases that solicitors are dealing with sensitive documents, it is often required that they are sent by post or courier which is currently inefficient in comparison with technologic solutions such as emails. However, traditional server storage methods are not trusted enough to digitalise the process.

Objective ~ The objective of this research is to evaluate, using academic resource, the ability for Hyperledger Fabric to be used as a blockchain solution for the conveyancing process. The paper will then simulate the application of this solution and compare it to the current process in place.

The paper will consist of the following sections: the related work section aims to evaluate Fabric's ability to serve the various areas of the conveyancing process. Then related research methodologies are discussed. The steps as chosen in the research methodology are then broken down in the design section. The evaluation section will show how using the technology will impact on the time it takes for the conveyancing process to be completed. Finally, the evaluation and conclusion will describe the results of the research and what that could mean to the industry and process moving forward.

2 Related Work

2.1 Is Blockchain Necessary?

An online article on hacker Noon explains the difference between a traditional database vs blockchain³. Tabora discusses a developing technology that would be able to merge the strengths of both traditional and blockchain networks which later became known as permissioned blockchains. Early in the development of permissioned blockchains, one paper looked at blockchains ability to store records (Lemieux, 2016). The Lemieux used a 2012 ISO standard (ISO, 2012) to evaluate the use case. They call upon a case study undertaken in Honduras, where the government called upon an American blockchain company to develop a land registry system. The journal did not lead one to believe that blockchain was ready to be adopted for the storage of land titles. Some more recent studies by both academics and governments have tested and proven that blockchain can, in fact, serve as a database for storing

² CONVEYANCING | meaning in the Cambridge English Dictionary [WWW Document], n.d. URL <https://dictionary.cambridge.org/dictionary/english/conveyancing> (accessed 7.29.19).

³ Tabora, V., 2018. Databases and Blockchains, The Difference Is In Their Purpose And Design [WWW Document]. Hacker Noon. URL <https://hackernoon.com/databases-and-blockchains-the-difference-is-in-their-purpose-and-design-56ba6335778b> (accessed 4.5.19).

digital records. A list of these numerous projects and proofs of works were compiled in a 2019 journal article (Bennett, Pickering and Sargent, 2019). The registration of land is not only applicable to the western world, one recent study looks at the current state of land registry in India and blockchain’s ability to rectify its faults (Thakur *et al.*, 2019). However, one must be conscious that although many proofs of concept and research have been conducted on the storage of land information or exchange of property on blockchain, they are not including the most time consuming and important aspect, which is the conveyancing process.

Returning to the question at hand, a key recent study on evaluating the need for blockchain was simply titled “*Do you need a blockchain?*” (Wüst and Gervais, 2018). Wüst and Gervais compared the 3 types of database structures available at the time of writing which were traditional, permissionless blockchain and permissioned blockchain. It was established that in order to decide on what is needed one must ask, are the parties involved mistrusting of one another and unable to agree upon a single party to save and manage the information needed (Wüst and Gervais, 2018)? When comparing this to the conveyancing process, it could be assumed that parties involved are not trusting of one another as they are employed by different people, be it either the vendor or purchaser. The journal article provides a table (Figure 1) to visualise the various aspects of each database type.

	Permissionless Blockchain	Permissioned Blockchain	Central Database
Throughput	Low	High	Very High
Latency	Slow	Medium	Fast
Number of readers	High	High	High
Number of writers	High	Low	High
Number of untrusted writers	High	Low	0
Consensus mechanism	Mainly PoW, some PoS	BFT protocols (e.g. PBFT [5])	None
Centrally managed	No	Yes	Yes

Figure 1 (Wüst and Gervais, 2018, p. 48)

From the various studies on storing legal documents, to the sale of property on blockchain application such as propy.com, one can see that blockchain can store sensitive documents and exchange them over a network. When looking at the conveyancing process in Ireland, one could find that for each conveyancing process there is a minimum of 6 parties involved in every process from the vendor, vendor solicitor, purchaser, purchaser solicitor, Revenue Commissioner and the property registration authority (Stephenson *et al.*, 2016). The inclusion of financial institutions is optional to both sides of the sale. The process as mapped out would look like (Figure 2).

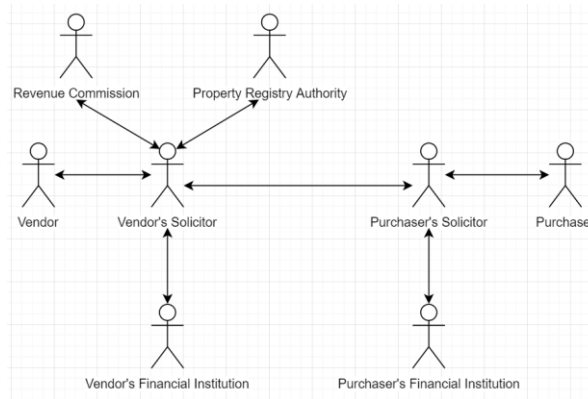


Figure 2 Current Conveyancing Process

2.2 Hyperledger Fabric

2.2.1 Why use it?

Hyperledger Fabric (Fabric) is a division of the Hyperledger project which is under the umbrella of the Linux Foundation. The aim of the project was to create a modular blockchain network where the state is commonly shared among all members of the network⁴. Ethereum works on a singular consensus mechanism which is currently a proof of work (PoW) and was originally built with one goal in mind. Hyperledger was built with only a permissioned enterprise-level network in mind. One journal article went about comparing the 3-primary permissioned blockchain networks (Figure 3).

No.	Property	Ethereum	Hyperledger Fabric	Corda
1	Platform type	Generic blockchain platform	Modular blockchain platform	For financial industry
2	Governance	Ethereum developers	Linux foundation	R3
3	Mode of operation	permissionless, public or private	permissioned, private	permissioned, private
4	Consensus	1.Mining based on proof-of-work (PoW) 2.Ledger level	1.Broad understanding of consensus that allows multiple approaches 2.Transaction level	1.Specific understanding of consensus(i.e., notary nodes) 2.Transaction level
5	Currency	Ether	None	None
6	Contract language used	Solidity	Go, Java	Kotlin, Java
7	Data Storage	Swarm	CouchDB, LevelDB	—
8	Access to data	1. All (Public Network) 2.Authorized (Private Network)	Authorized (Private Network)	Only to relevant parties.

Figure 3 (Saraf and Sabadra, 2018, p. 6)

One of the networks is Corda. Corda has traditionally been associated with being “*designed specifically for financial applications*” (Ciatto *et al.*, 2019, p. 85). It was used to test a similar conveyancing application in the United Kingdom (UK) in association with the land Registry⁵. Since there are no fully operational concepts, one would be wise to use the technology with the greatest ability to adapt. Fabric is ideal for the processes that store private documents and that require a high level of security (Saraf and Sabadra, 2018).

⁴ Hyperledger, 2017. Why Hyperledger Fabric? — hyperledger-fabricdocs master documentation [WWW Document]. URL <https://hyperledger-fabric.readthedocs.io/en/v1.0.5/whyfabric.html> (accessed 4.9.19).

⁵ R3, 2019. R3 Marketplace [WWW Document]. Instant property network. URL <https://marketplace.r3.com> (accessed 7.31.19).

2.2.2 Fabric vs. The Conveyancing Process

In order to demonstrate how Fabric could be used in relation to the conveyancing process, this research will address the following areas: Network, Efficiency, Security and Development.

2.2.2.1 Network

As Fabric is an enterprise-level permissioned blockchain, it could provide a decentralised architecture. The permissioned aspect means that each actor's level of access can be edited or removed depending on which information they need to have access to⁶. The replication of the ledger across multiple servers is to reduce the chance of incorrect information being stored and increase the immutability of correct information. One 2018 paper (Androulaki *et al.*, 2018) outlines the whole structure of the Fabric network, as described above. It also states that all peers will have to host a copy of the ledger, the official Fabric documentation describes this as not being true; presumably, this feature was introduced in an update between publishing and now⁶.

As seen in the previous diagram showing the current conveyancing process, there are many actors all of which have and need a different level of access and ability to either read or write within the process. The proposed blockchain network would ensure a unified platform for communication between all actors of the conveyancing process, which could be represented as in (Figure 4).

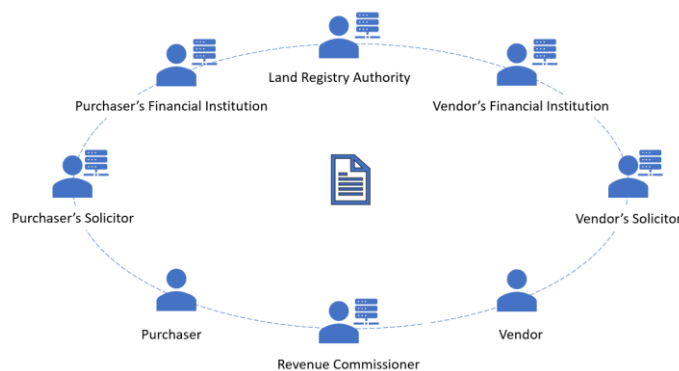


Figure 4 Proposed Blockchain Solution.

2.2.2.2 Efficiency

For the use of blockchain consensus is used to set the minimum requirement to be agreed upon before a transaction can be added to a ledger. Within Fabric the most common consensus mechanism used is Practical Byzantine Fault Tolerance (PBFT). This process of checking for agreement among members is broken down into 3 steps, “*pre-prepare, prepare, and commit*” (Castro and Liskov, 2002, p. 407). The PBFT works on the basis that a transaction needs to be approved by 66.66% of members with authorising powers in order to be committed. This can be represented as an equation $\frac{N-1}{3}$ (Hao *et al.*, 2018). The 2018 journal article included a visual aid to this equation where node number 3 is a potential faulty actor.

⁶ Hyperledger, 2019. Blockchain network — hyperledger-fabricdocs master documentation [WWW Document]. URL <https://hyperledger-fabric.readthedocs.io/en/release-1.4/network/network.html> (accessed 7.31.19).

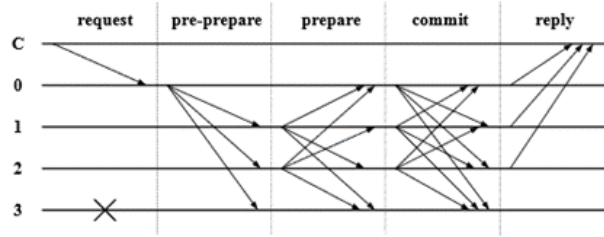


Figure 5 (Hao *et al.*, 2018, p. 281)

While some other blockchain applications can provide quicker transaction speeds due to quicker consensus mechanisms, they are unable to change consensus or use different language to suit user needs like in Fabric (Sankar, Sindhu and Sethumadhavan, 2017). In comparison to Ethereum blockchain solutions, one journal shows Fabric has a far better transaction per second (TPS) rate than Ethereum (Hao *et al.*, 2018).

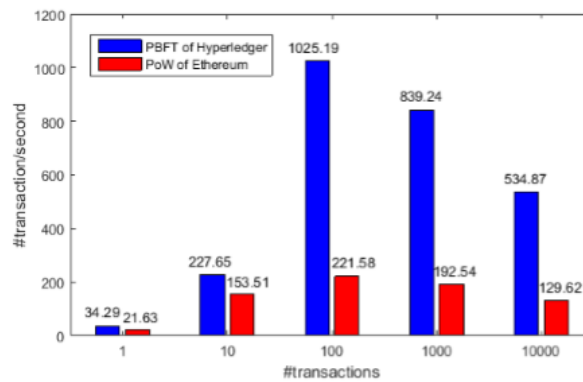


Figure 6 (Hao *et al.*, 2018, p. 284)

While Fabric is being shown to create a great speed of transactions it also has a reduced latency with different levels of throughput (Pongnumkul, Siripanpornchana and Thajchayapong, 2017). Hao *et al.*'s (2018) study on TPS has already become out of date with a more recent journal article citing that it was able to reduce the latency and increase transactions per second by a factor of 7 to nearly 20,000 TPS (Gorenflo *et al.*, 2019) where opt p-iii is their optimization methods.

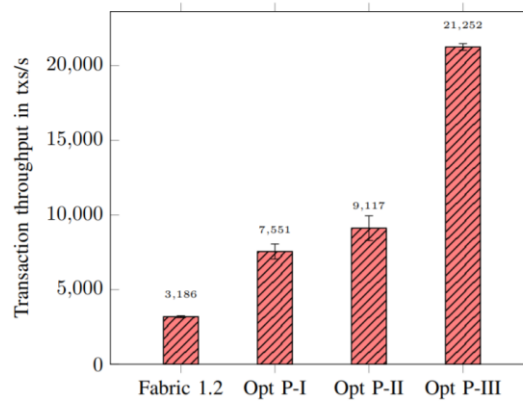


Figure 7 (Gorenflo *et al.*, 2019, p. 459)

Where the conveyancing process would be concerned with this information is in the knowledge that Fabric would have the ability to keep up with the volume of transactions that may take place at any one time in the day. The difference in transaction volumes between (Hao

et al., 2018) and (Gorenflo *et al.*, 2019), shows the rapid pace of innovation happening with this technology.

2.2.2.3 Security

Benhamouda, Halevi and Halevi (2018) attempted to create a function to allow the transfer of private data on Fabric. Eventually a similar function was added in order to meet this appropriate level of security need for GDPR, Fabric introduced the concept of a side database from its v1.2 onwards. The ability to communicate privately with another member within a network is part of the private data collection. As seen in previously in (Figure 2) different actors need to send different information to specific people but also need to stay within the network.

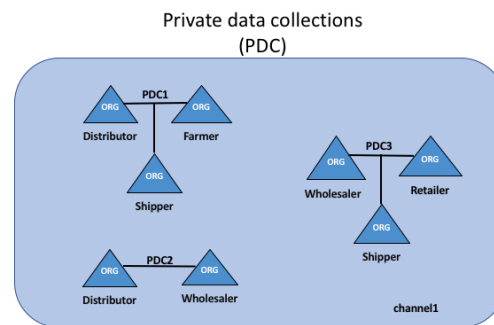


Figure 8 Private Data Collections ⁷

The conveyancing process could use PDC's to develop different lines of communication under a singular network. This would allow for the exchange of sensitive information throughout the application without losing the benefits of being transparent and immutable. The use of encryption prior to sending information using methods such as AES could then be decrypted only by those who have the appropriate key, thereby reducing the chance of a man in the middle attack (Benhamouda, Halevi and Halevi, 2018).

2.2.2.4 Development

Open-source software has been associated with more innovate ideas while also having fewer errors and quicker fixes (Paulson, Succi and Eberlein, 2004). The journal established that the overall development of open source and inhouse project are similar, however, the fewer errors and quicker solutions are more beneficial. To summarise, if an individual company decides to reduce its update schedule due to the financial difficulty the organisation using that technology will suffer. Whereas an open-source project will keep evolving with new challenges, as once someone encounters a problem, they are more likely to try to fix it than not (Paulson *et al.*, 2004).

For the conveyancing process, this information is positive as there is a steady flow of updates. If Ireland was to encounter with a regulatory change or other, that affected the conveyancing process a 3rd party developer could supply the code to bring the system in line with those changes. This will ensure that the system to not become stagnant in an age of increased regulatory and technological innovation.

⁷ Private data — hyperledger-fabricdocs master documentation [WWW Document], n.d. URL <https://hyperledger-fabric.readthedocs.io/en/release-1.4/private-data/private-data.html> (accessed 3.9.19).

2.3 Instant Property Network

As previously mentioned, a trial was run in the UK using an alternative technology provider called the Instant Property Network. The trial network involved 40 companies in 20 different countries, all of which had some exposure within the current UK conveyancing process (Reynolds *et al.*, 2019). While there are some key differences between how the conveyancing process in Ireland is operated when compared to the UK, the report produced from the trial had some interesting insights that deserve to be evaluated. Similar to the Irish process, the problem within the UK system is the “*fact that processes have never been optimised at the level of the marketplace*” (Reynolds *et al.*, 2019,p. 6). The UK system is primarily a paper-based documentation with most transfers being either by post or email. The customer journey is said to be “*Slow, Complex and inefficient*” (Reynolds *et al.*, 2019,p. 6). The report makes special notice to one of the few successful attempts to create a digital conveyancing process, which is the PEXA system that was implemented in Australia. The report states that while initial adoption was high there was increasingly negative view on the centralised monopoly that the platform now has. While the trial was being run which involved 200 professionals, a survey was conducted on their experience. It was commonly viewed that both vendors and purchasers want to reduce the time it takes to complete the sale and to have improved visibility to the end to end process. An important figure from the survey was that “*93% of the respondents believed that IPN, in time, could enable the average transaction time to be reduced from 3 months to approximately one week*” (Reynolds *et al.*, 2019,p. 17). From this information alone, one could conclude there is an appropriate case to further investigate the application of a blockchain network to the conveyancing process in Ireland.

3 Research Methodology

3.1 Market Research

Like the IPN described above the conveyancing process in Ireland is inefficient. To be efficient is to “*functioning or producing effectively and with the least waste of effort; competent*”⁸. When stating the benefits of their network as more efficacy, IPN referenced to the amount of time it took to complete the transactions as a key point for its implementation (Reynolds *et al.*, 2019). As time is a continuous variable one must first establish the time it takes to complete a conveyancing process and then compares it to the time it takes to complete a conveyancing process while using a blockchain network. As the current time, it takes to complete a conveyancing process is private data known only to each solicitor within the transaction one must conduct some market research to gather the necessary information. It is important to evaluate the objectives of market research in order to establish the appropriate method of gathering it. Hart (1987) attempts to establish a guide to the use of different surveying techniques and objectives. Hart states that the most common form of market research is conducted using surveys, as they provide:

- A way of receiving either quantitatively or qualitative research.
- Large scope for information and population.
- Survey data meets the requirements of academic research (Hart, 1987).

It also mentions the various downfalls associated to survey data which are:

⁸ Efficient definition and meaning | Collins English Dictionary [WWW Document], 2019. URL https://www.collinsdictionary.com/dictionary/english/efficient_1 (accessed 8.2.19).

- Ability for the respondent to provide desired data.
- The ability of respondents to prove data, not educated in the field.
- Respondents may give the answers they think the researcher wants to get (Hart, 1987).

As the objective of this research is to evaluate blockchains impact on time. While qualitative analysis is better at establishing the nuances of human perception, qualitative data is better suited for numerical evaluation (Amaratunga et al., 2002). Some later studies have evaluated the use of online surveys and one has concluded that online surveys have many advantages of traditional mailing such as:

- Low financial costs, short response cycle
- Controlled samples and data entry
- Storage times are reduced (Ilieva, Baron and Healey, 2002).

While there are not any distinct methodologies for the analysis of survey data like that of regular data analysis, where one would follow the likes of KDD or CRISP-DM. However, it is common practice to evaluate the data sets before moving onto analysis as, “*Missing data are a prevalent problem in many social and economic studies*” (Kenett and Salini, 2012, p. 17).

From the guidance of the above academic studies, this research paper has decided it is appropriate to conduct an online survey. Only qualified solicitors were invited to partake. Qualitative data was required from all questions, with a mandatory response in place for all questions to reduce empty responses.

3.2 Data Analysis

Discrete-Event Simulation (DES) was originally introduced as a way of measuring systems through time. It builds upon the original idea of Monte Carlo’s (MC) methods but is specified to help evaluate a current process flow (Brailsford, Churilov and Dangerfield, 2014). While MC is a well-established way of conducting analysis using random numbers, its application is used for areas such as nuclear physics, chemistry, biology and medicine (Hammersley and Handscomb, 2013). While MC does include the realm of operational research (OR) it is not specifically designed for it. OR is the process of using quantitative mathematics steps to define a decision-making process. It is used to evaluate the current process in order to gain insight or improve efficiency⁹. DES is primarily aimed at OR and thus is a better choice for this research. DES was first introduced in the late ’50s by Jay Forrester. Forrester believed that structure and feedback was an integral part of a system, while also arguing that if system feedback is understood and managed it will result in a highly efficient system (Brailsford *et al.*, 2014). The use of DES can be seen across many industries and research papers; like evaluating procedures for a boat terminal in order to identify bottlenecks, OR and resources (Legato and Mazza, 2001). Understanding the effects of different manufacturing styles on assembly lines (Detty and Yingling, 2000). The choice of using DES for this study was supported by another study conducted, where DES was used to model the current operations of an emergency department. In doing so the researchers were able to reduce the estimated waiting time by more than 20% (Komashie and Mousavi, 2005). Using DES, Komashie and Mousavi were able to evaluate the key performance indicators as well as simulating process changes with varying resources, while also performing an investment free trial of allocating resources to various areas. To do so in real life would have been very costly

⁹ BusinessDictionary, 2019. What is operations research (OR)? definition and meaning [WWW Document]. BusinessDictionary.com. URL <http://www.businessdictionary.com/definition/operations-research-OR.html> (accessed 8.6.19).

and time-consuming. This study was a key indicator for the use of DES as it was one of the few that specifically addressed time as the variable which it was attempting to reduce.

As stated in section 3.1 there are general guidelines and reasoning behind picking different elements and methods of market research. This research required a well-defined methodology for conducting DES. From the research there were two primary standards bodies that had released documents. Firstly, was IEEE (2010), where they introduced standards for modelling and simulations. Secondly was the International Nursing Association for Clinical Simulation and Learning, (INACSL Standards Committee, 2016). The INACSL Standards Committee's standards were aimed at creating a method of analysis after encountering many simulations being run on the hospital environments. While reading Komashie and Mousavi (2005), one would see that they adopted a Verification, Validation and Testing (VV&T), method. This method could also be followed for this research; however, it is vague. More recent standards have placed a higher emphasis on the methodology and pre-processing required. A frequent journal article cited as a good source of information for a simulation methodology is Banks (1999). Commonly cited by simulation journals, it breaks the method into 12 steps with no fancy acronym to help remember it. More recent studies like Skoogh and Johansson (2008) were published. The process is down into 13 steps in an aim to "*secure quality and increase rapidity in DES projects*" (Skoogh and Johansson, 2008, p. 1727). However, they are primarily looking at the pre-processing of data for DES. This research should be acknowledged in relation to the stages of Banks' (1999). More recent research on DES and simulations was conducted by Law (2008), that presents a 7-step process to designing and building simulation models. However, the steps require multiple interactions with a subject-matter expert. The steps have been developed from an in-house or consulting perspective, where they would have far greater access to the data needed. This research chose to follow Banks' (1999) methodology as seen in the Design Specification section, as it was the most appropriate for the problem at hand.

4 Design Specification

4.1 Problem Formulation

The problem was seen first-hand by the author of this research, while involved with the conveyancing process of their family home. The author then began to investigate the conveyancing process to further understand why the current process was inefficient. Building on top of various article that put a spotlight on the problem such as the 2015 article by the Irish times¹⁰. Where a survey conducted by the Institute of Professional Auctioneer and Valuers (IPAV) showed that almost 70% of respondents aligned delays in the conveyancing process to "*an unwillingness by solicitors to do business via email or telephone, preferring instead to use the traditional method of letter writing*"¹⁰. In 2008 a report was published by the Law Society of Ireland (2008) documenting the potential set up and reasoning behind an electronic conveyancing system. This platform known as eConveyancing has since not come to fruition. This acknowledgment by the national press and the attempt of the national law society to build an alternative platform were evidence enough to progress.

¹⁰ McMahan, A., 2015. Move to electronic transactions part of radical overhaul of conveyancing [WWW Document]. The Irish Times. URL <https://www.irishtimes.com/news/crime-and-law/move-to-electronic-transactions-part-of-radical-overhaul-of-conveyancing-1.2147509> (accessed 8.8.19).

4.2 Setting of Objectives and Overall Project Plan

The objective as stated in the research subtitle is to evaluate, Using Discrete Event Simulation to determine the impact of Hyperledger Fabric on the time it takes to complete the conveyancing process. As previously stated, the variable of time was chosen as it is currently the only way in which the process can currently be quantified. Alternative ways of quantifying could be found but they would require an exact replica network to be built and used. Building such a network is far outside of the scope of this research. Once time was established as the variable for analysis, this research looked at different ways of modelling this, such as Monte Carlo and DES.

4.3 Model Conceptualisation

From the information of Stephenson *et al.* (2016) and the Law Society of Ireland (2008) this research was able to create a model of how the current conveyancing process looks. Banks (1999) describes this stage as evaluating the real work system. The model was built and can be seen in (Figure 2). From the appropriate material this research was able to deduct that there is a minimum of 6 actors involved in a conveyancing process with a minimum of 12 documents being sent per conveyancing. The way in which documents were sent varied for each step and each solicitor. The conveyancing process was originally broken into 21 steps. However, these were too detailed and did not reflect the larger stages of a conveyancing process. After consulting with a solicitor, the process was narrowed down to 9 steps, which is of similar value to the 10 steps proposed by the Law Society of Ireland (2008).

4.4 Data Collection

In this section Banks (1999) proposes that the data requirements should be given to the client. For this research there were no clients driving the evaluation of the current process. Thus, the available data was not readily available. As each conveyancing process has two solicitors involved and there are 10,972 registers solicitors as of (Analysis, 2019). This means that the data about each side of the conveyancing process is highly fragmented between solicitors. With no centralised database to consult or access, market research was used to collect the data. A survey was conducted to gather information from solicitors on the time it takes to complete the 9 stages of the conveyancing process and the percentage of methods of communication used.

4.5 Model Translation

In this section, the research is supposed to translate their conceptual model into a model for statistical analysis. For the sake of this research the conveyancing process was broken down into 9 steps. At different stages between these steps' documents are sent a minimum of 12 times. The amount of times each form of document transfer is used was surveyed and the transfer times of each form were taken from alternative sources, such as An Post's website ¹¹. The survey asked for the mean amount of days, minimum amount of days and maximum amount of days it took to perform each step. The maximum and minimum were used to evaluate a uniform distribution and the mean days were used to get the normal distribution. A pseudo code of the method used to simulate the process is:

- Create a running total.
- Run a loop from 1 to 57,003 (57,003 = Number of properties sold in 2018)

¹¹ <http://www.strata3.com>, S.-, 2019. Post & Parcels [WWW Document]. URL <https://www.anpost.com/Post-Parcels> (accessed 8.8.19).

- Take a random time variable from the survey data for step 1.
- Add that number to the running total.
- Take a random variable from the survey date for step 2.
- Add that number to the running total.
- Repeat for all 9 steps.
- Then, run a loop from 1 to 12.
 - Each loop randomly selects a method of communication as based off the probability of each method, which is taken from the survey date for question 10.
 - Add time for each method to the running total on each loop.
- Save the running total to the process vector at position of the loop
- Evaluate process vector containing 57,003 simulations.

4.6 Verified?

Each stage builds upon the last to develop an overall goal for the research. At this stage the code is written and continuously evaluated to make sure it is correct and relevant to the objectives. This would be a similar process to an agile software methodology. Once the code has been written, the analyst should then assess the whole body of work to make sure it meets the requirements as set out in the previous stages. The code was written using the foundation of Monte Carlo methods while incorporating the discrete event element of DES.

4.7 Validated?

This section requires the analyst to compare the results of their simulation of current process and ensure it is an “*accurate representation of the real system*” (Banks, 1999, p. 13). Banks (1999) makes note of the fact that validation is not always possible but that there are alternative ways of doing so. For the sake of this research there was no method of validation as the current process was not openly documented in order to establish the timeline of historical conveyancing processes. However, this research was able to find information for an estimated time for a conveyancing process. From a law firms’ website, it was stated, “*As a rule of thumb, the process of completing the sale and purchase of a standard suburban house should be complete in six weeks from the signing of the contract by the purchaser*”¹². This results in an estimated time of 42 days. Due to the lack of accurate information on the current process and the fact that only estimates being made available, for the sake of this research the figure of 42 days will be taken as the benchmark. It must be noted that, this is purely a benchmark and represents the opinion of only one solicitor’s office. Access to more data on exact completion times was not possible.

4.8 Experimental Design

This section involves establishing the number of times a simulation should be run. For this research, the number used was the total number of properties sold in 2018 as the number of times to run. The simulation should give an understanding of an average yearly processing

¹² Why does my Conveyancing take so long? [WWW Document], 2015. . McGarr Solicitors - Dublin Solicitors Ireland. URL <https://www.mcgarrsolicitors.ie/2015/10/17/why-does-my-conveyance-take-so-long/> (accessed 8.8.19).

amount. As of the end of 2018 there were 57,003 properties sold in Ireland¹³. Thus, each model was run for that amount of iterations.

4.9 Production Runs and Analysis.

This stage is used to better understand the performance of a simulation. For this research the models were run 57,003 times. Each time the model was run the result is saved to a vector. The vector containing the results of each simulation is then analysed for each process. These subsequent tests are then compared to one another.

4.10 More Runs?

Based on the results of the initial simulations the analyst must then establish if more runs are needed. If the results do not align to what was expected or what was the objective of the simulation additional scenarios or runs may be needed.

4.11 Documentation and Reporting

Banks (1999) The documentation of all steps that were taken during the simulation process. For the sake of this research that includes the research paper and the configuration manual. This step is to aid the update or rerun of a simulation to allow for further work or different situations to be implemented in the future. These documents should allow for the client to clearly review the simulation undertaken and ensure that it was evaluated under the correct conditions and reasons.

4.12 Implementation

Banks (1999) makes note that this final section is aimed at conveying the results of the simulation in an appropriate manner. He enforces the fact that the person producing the simulation should merely present the findings as they are and not for any alternative motive. In following the previous steps and implementing this unbiased opinion Banks (1999) states that there is a likelihood for adoption.

5 Implementation

For this research project all the various steps were followed in accordance with the design research methodology and design. How these steps were then implemented to run the simulations are as follows:

- The survey was administered to qualified solicitors.
- The results were transferred to an excel file.
- A copy of that file is created within R studio pointing to a new data frame.
- The data frame was evaluated, and the necessary pre-processing was done.
- One survey response was removed due to missing data, complete-case analysis (Kenett and Salini, 2012).
- The questions were then separated to be analysed individually.
- Each question was then assigned to a step in the process.
- The model was run and evaluated in R.

¹³ Propertypriceregister.ie. (2019). Residential Property Price Register. [online] Available at: <https://www.propertypriceregister.ie/website/npsra/pprweb.nsf/PPRDownloads?OpenForm&File=PPR-2018.csv&County=ALL&Year=2018&Month=ALL> [Accessed 18 Jul. 2019].

6 Evaluation

The models were built after following the Banks (1999) methodology and all relevant steps were followed before building the model. 4 models were built in this research;

- firstly, a model of the current process using random normal distribution of averages for each step.
- Secondly, a model was built of the new process using random normal distribution of steps using the averages provided.
- Thirdly, a model of the current process using a uniform distribution of the min-max ranges provided.
- Finally, a model of the proposed new process was built and random numbers using a uniformed distribution were taken from the range data provided.

The total length of the process is evaluated, as to evaluate the times of individuals steps is inappropriate. This is because many stages of the process are conducted by various actors in the process and the survey was purely a solicitor's observations of these step as they are central to the operation but could not comment on what might be slowing down other parties.

6.1 Experiment 1

After running the model 57,003 time in order to replicate the amount of property sales in one year.

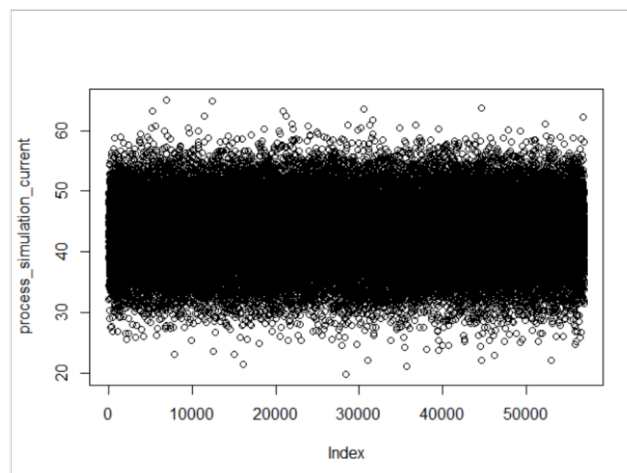


Figure 9 Simulation of Current Process

After running for the specified amount of time the simulation returned a simulation scatter like that in (Figure 9 Simulation of Current Process. The mean of these observation results in an average process time of 43.0560 days per process. As stated before, a solicitor estimated that the process should take around 6 weeks or 42 days.

6.2 Experiment 2

This model was run using the same step parameters for step 1-9 however for step 10 the percentage chance of using a form of communication was swapped out for a variable of 0.00005 which is an approximate number for how long it will take for a block of transactions to be committed to in Fabric 1.2v (Gorenflo et al., 2019). This figure represents a block being committed within 0.5 seconds. As the purpose of implementing a blockchain solution is the secure storage and transfer of documentation between all actors of the conveyancing process. Once this new document transfer method was implemented into the current process, results such as that in (Figure 10 Proposed New Process.

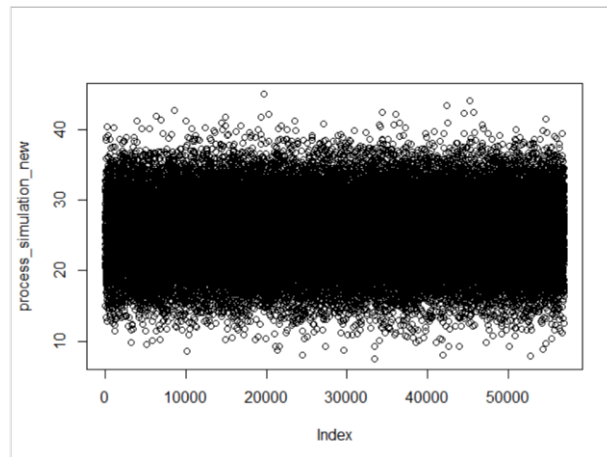


Figure 10 Proposed New Process

While the above figure may look like the previous process. However, if we look at the mean value of this process, we get *25.33155*. This number represents a total time of 3.5 weeks, which is a similar number to that of which the IPN’s blockchain solution proposed.

6.3 Experiment 3

In order to cover all areas of the process, the model was also run using a uniform distribution. The random selection of days at each stage was selected using the minimum and maximum ranges provided in the survey. This was then implemented into the model and run for the same amount of times. This process resulted in a mean simulation process of *775.5056* days per sale, this was due to highest maximum times for individual steps as presented by some respondents.

6.4 Experiment 4

As conducted in experiment 2 the new transfer times for document were introduced into the process and the model was run in the same uniformed distribution as before. After processing was complete it resulted in a mean value of *758.2046*. Again, these high numbers are based on an observation of the extreme minimum and maximum cases ever observed by the respondents.

6.5 Discussion

As seen above, Experiment 1 and Experiment 2 were closely aligned to the results experienced by that of a solicitor and a blockchain conveyancing process hosted in the UK. In changing the various forms of communication to a unified method which would be enabled by the implementation of a blockchain network such as Hyperledger Fabric. The conveyancing process could be reduced by *18 days or 42%* which is solely based on replacing the transfer method. Additionally, even under the extreme scenarios like that in Experiment 3 and Experiment 4 the conveyancing process could be reduced by 18 days. While the model was built and run using the basic methods of Monte Carlo simulation it was also ran using a DES package in R called Simmer. Simmer allows for various stages of a simulation to be set the resources to each step to be update and edited. The simulation run using this Simmer was inconclusive.

The result line ends around the 25 mark which is like experiment 2. However, due to a limited amount of time available the amount of exposure to the package and limited understanding of how to use it, this research was unable to run the other experiment through

the package. This research was also unable to properly evaluate these results other than by eye. These should be regarded as supporting and not informative.

There were various limitations to the experiments that were run:

- There were 7 respondents to the survey and 1 response was disregarded due to missing data.
- This level of respondent does not represent statistical significance that the proposed new process is quicker. It is only a demonstration of what could be presented.
- Many respondents replied to survey in a 7-day working week format as opposed to a 5-day working week requested. The information has then been presented as 7 days even though the industry is based on a 5-day working week.
- The survey data was conducted using assumed qualified solicitors. While solicitors are the key actors involved in the process, they are not the only actors.
- The survey contained question of their observation of other actor's process times. Thus, this information may be an incorrect view of a process that could be reliant upon other processes.
- In Ireland it takes a minimum of 3 years after a primary law degree, to become a qualified solicitor¹⁴. Thus, the knowledge associate with the conveyancing process is vast. The author of this research is not a qualified solicitor. Therefore, there is the possibility that stages of the conveyancing process have been misinterpreted by the author.

In relation to previous studies conducted on the Irish conveyancing process this is a unique way of evaluating the process and a unique solution to rectify the current inefficiencies. The results of Experiment 1 & 2 provide similar feedback to the report and study conducted by IPN on the UK conveyancing process, which would support the use of the simulations. However, the IPN study was inclusive of all actors involved in the process and was a joint venture of many actors within the process as opposed to this research conducted by a single person. The experiment builds upon the theoretical application of blockchain to the process and the support those findings with the results from the various experiments albeit with their limitations.

7 Conclusion and Future Work

In the final section of a journal on simulations the Ingalls' (2011) presents a section titled "*WHAT HAVE WE LEARNED?*". Like the research on a fast food line conducted by Ingalls (2011), this research has evaluated a real-world process and provide a solution to improve efficiency which in this case was time.

Ingalls (2011) sets the first section as the more complex the system the longer the modelling process will take. This is the same for this research. The conveyancing process in Ireland is very complex and requires several actors involvement with various layers and levels of communication. To appropriately map out the whole process would take the involvement of some actors from the process and would take a significant amount of time. As seen in the eConveyancing which was first proposed more than 10 years ago.

Secondly, Ingalls (2011) proposes that the person analysing the simulation must have a good understanding of the process and statistics. This research was conducted under the best possible resources available to this research. The research maximised the time and information

¹⁴ Lawsociety.ie. (2019). *How To Become A Solicitor / Become A Lawyer*. [online] Available at: <https://www.lawsociety.ie/Public/Become-a-Solicitor/#qualification> [Accessed 9 Aug. 2019].

available to conduct a valid representation of what a blockchain solution could provide to the conveyancing process in Ireland.

Thirdly, as Ingalls (2011) put it the simulation process are designed by the analyst and not the system. Thus, an in-depth knowledge of the process is required. This knowledge should be communication to various parties to present a true representation of the current process. Due to the limited time and access to the various actors and information involved in the process, this research was conducted in coordination with the research methodology to assure the best results for the information gathered.

In conclusion, the research evaluated the current problem, researched the various solutions available and then provided a solution in the form of Hyperledger Fabric. The research then simulated the current process to the best of its ability. It ran simulation for the tradition process and for the introduction of a blockchain network. One solution of the experiments run resulted in a 42% reduction in the time it takes for the conveyancing process in Ireland to be completed. Resulting in greater efficiency for solicitors, auctioneers, land registry authority and Revenue Commissioner. While also increasing transparency and reducing the process time for Irish consumers.

The results of this research are not conclusive due to the various limitations of the research. It only addresses the time elements associated with transfer of documentation. It does not attempt to quantify the additional benefits that could be achieved from aspects such as transparency, security, traceability, efficiency and lower costs¹⁵. However, this research does highlight the current inefficiency with the current conveyancing process in Ireland, while also providing a theoretical solution. This research should be used to as the foundation behind further studies in the area. The next steps to this research would be to build a full network work structure with the input of the many actors involved in the process. This sample network would then be used to provide information for a more detailed and accurate simulation of the current and proposed new process. Only then could one understand the true impact of Hyperledger Fabric on the time it takes to complete a conveyancing process.

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¹⁵ IBM, 2018. Top five blockchain benefits transforming your industry [WWW Document]. Blockchain Pulse: IBM Blockchain Blog. URL <https://www.ibm.com/blogs/blockchain/2018/02/top-five-blockchain-benefits-transforming-your-industry/> (accessed 4.5.19).

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