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Disruptive Power of Blockchain on the Insurance Industry

Master's Thesis (30 ECTS)

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Disruptive Power of Blockchain on the Insurance Industry

Abstract:

The insurance industry has been a key component of the global economy by the amount of premiums it generates, the scale of its investment and more fundamentally, the essential social and economic role it plays in covering personal and business risk. Over the years, there have been a growing reform in this sector but despite some of these reforms, the insurance industry has remained much the same in its business model and operations. The sector has been dominated by intermediaries who play the key role of understanding and matching the need of the customer with specific tailored insurance product. A research conducted by PwC in a report titled "Insurance 2020: Turning change into opportunity" [1], takes into account STEEP (Social, Technology, Environmental, Economic and Political) drivers all points to the need of the insurance sector to evolve from the agency- based distribution model to an usage based business model.

This paper examines the blockchain technology and its disruptive power in the insurance sector by evaluating the current business process and model in the industry and how this technology can improve this model. This paper concludes by proposing a new process flow for the insurance industry placing emphasis on better values service to the customer using blockchain technology.

Blockchaini häiriv jõud kindlustusvaldkonnas

Kokkuvõte:

Kindlustus on olnud globaalse majanduse võtmekomponendiks oma lisatasude suuruse, investeerimismahtude ja ennekõike oma isikliku ja ääriiski katva sotsiaalse ja majandusliku rolli tõttu. Aastate jooksul on antud sektoris olnud püsiv reform, kuid sellele vaatamata on kindlustuse tööstusharu jäänud suuremalt jaolt samaks oma ärimudeli ja toimimise osas. Seda sektorit domineerivad vahendajad, kes mängivad võtmerolli kliendi vajaduste mõistmises ja viivad selle kokku kindlale sihtgrupile mõeldud kindlustustootega. PwC poolt tehtud uuring raportis „Kindlustus 2020: Muutuse pööramine võimaluseks" [1] võtab arvesse sotsiaalsed, tehnoloogilised, keskkondlikud, majanduslikud ja poliitilised faktorid ning viitab sellele, et kindlustuse sektoril on vajadus muutuda agentuuripõhisest jaotusmudelist kasutusepõhiseks ärimudeliks.

Antud uurimustöö uurib plokiahela tehnoloogiat ja selle häirivat mõju kindlustussektorile hinnates praegust äriprotsessi ja –mudelit ning seda, kuidas see tehnoloogia suudab antud mudeleid täiustada. Uurimustöö järeldusena pakutakse uut protsessi suunda kindlustuse tööstusharule rõhutades kliendile pakutavat parema väärtusega teenust, kus on kasutusel plokiahela tehnoloogia.

Võtmesõnad: plokiahela tehnoloogia, kindlustuse äriprotsess, jaotatud peaarvetehnoloogia

CERCS: P170 – Arvutiteadus, Numbriline Analüüs, Süsteemid, Kontroll

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1. Introduction

While many have predicted technologies such as big data, social media, cloud computing and artificial intelligence as the technology that would shape the next decade of business, Blockchain [2] stand out as the most disruptive [3] of all with disruptive processes in the various sectors of the global economy including the financial, health, insurance, manufacturing and food sectors amongst others. There have also been some skepticism about the true potential of blockchain [4]. This thesis is focused on explaining the distributed ledger technology and blockchain and to analyze how it truly it can be disruptive in the insurance industry. The focus would be to review the sub processes of the value chain, current business model and propose a new model (process flow) which would incorporate the implementation of blockchain.

1.1. Motivation and Scope

The world economic forum in 2016 ("These Are the Top 10 Emerging Technologies of 2016") considers blockchain as one of the top ten emerging technologies. It has already gained the full attention in the financial industry with investment interest from notable players like JP Morgan [5], Goldman Sachs, F-Prime Capital, and Thomson Reuters etc. [6] and a prediction that its market value would exceed $3.1 trillion by 2030 [7].

Despite these growing interest, there has been a diverse view from different global organization and government with most recent comment coming from the world bank president, Jim Yong Kim [8]who has hailed the technology but cast doubts about the true value of bitcoin price.

The head of the International Monetary Fund (IMF) also speaking during the IMF 2017 annual meeting in London, warned financial institutions on the potential disruptive nature of cryptocurrencies [9]owing to the lower cost of financial transaction and trust the technology provides. She had though voiced her support for blockchain and how it would promote trust in business transactions. While many believe this technology would revolutionize the technological and business world, some still hold fears as to how it would truly be implemented or maybe there could be some other technology to consider [10] and with known cases of hackers attack with the most recent being in 2016 were about $50 million worth of digital currency was stolen from the Decentralized Autonomous Organization (DAO) project, there are unanswered questions about the security of blockchain technology. Some have argued that the attack was a result of trying to re-centralize a decentralized technology, giving it a greater point of failure [11].

By 2020, Accenture strategy estimates that the use of modern technology could bring about a more disruptive model and create a digital platform for about 20% of the Property and Casualty Insurance market [12]. I aim to analyze the current value chain and process model (As - Is Process Model) of the insurance industry and propose a new process model which would integrate the blockchain technology. The greatest worry remains the ability of blockchain implementation to eliminate the middlemen like brokers and agents sooner or later from the business process model of the insurance industry. While there have been many previous literatures on what blockchain could do, there has been few or none addressing "what blockchain can do better and explain how this would affect the insurance business model and value chain". This would be the goal of this thesis.

1.2. Research Problem

Implementation of the blockchain technology has a long-term horizon and while the financial institutions seem to be taking the lead, there are already some use cases in the insurance companies. Blockchain is expected to find a lasting solution to some of the common problems [13] faced in the insurance sector including reducing operational cost, increasing efficiency and service delivery through technological innovations and growing the customer base through trust. The Major Research Question **MajorRQ**: "How could the Blockchain technology enable process innovation within the Insurance Industry?"

To answer this research, question the following sub-questions are defined:
1. ***SUB RQ1***: *What processes of the insurance industry can be innovated (enabled by blockchain technology)*
2. ***SUB RQ2***: *What are the blockchain use cases relevant for the Insurance Industry?*
3. ***SUB RQ3***: *What value could blockchain based innovation of processes within the insurance company deliver?*
4. ***SUB RQ4***: *What "innovation patterns" can be discerned?*
5. ***SUB RQ5***: *What are the possible limitation in the implementation of Blockchain technology?*

1.3   Summary of Contribution

The paper provides a systematic review and feasibility study of practical use cases in the implementation of blockchain technology in the Insurance industry, using guidelines for performing Systematic Literature Reviews in Software Engineering by Kitchenham as an oracle.

Currently, only consultant firms like McKinney, PwC, Deloitte, Cognizant etc. have proposed possible ways blockchain could disrupt the insurance market. There has been little or no publication that has conducted a detailed analysis and provided a new process model of the implementation of blockchain specifically for the insurance market. I aim to conduct a careful review of both products, services and value chain currently driving the insurance industry by first analyzing the current state, evaluate and identify areas in the value chain that could be disrupted by blockchain implementation and propose a new business model for the insurance industry which would be driven by blockchain technology and increase the organization efficiency including a better return on investment.

1.4   Structure

This paper is organized as follows. In Section 2, I would present the background and foundation of the thesis by explaining the insurance industry and gains made through the use information technology in driving service by taking a holistic look of how the industry has embraced technology and provide some insight to show that when an organization is innovative in their business, they get the full benefit of the underlying technology.

In section 3, I would carry out a literature review of the existing research, reports, prototypes etc. and used case while analyzing and evaluating the current "As-Is" business process model and then present the "To-Be" process model in Chapter 4 explaining the innovative processes blockchain would introduce. This would answer the research question. Chapter 5 would provide a conclusion and future for blockchain.

1.5   Related Work

Blockchain is still a relatively new technology and huge investment is being made yearly to fully explore its potential. Some well-defined areas of blockchain includes bitcoin [14], technological implementation of blockchain for the financial industry, security concerns etc. From the over 1000 papers hit during the search on Google scholar before 2016, only about 45 % covered the Distributed Ledger technology and explained in detail its implementation. Most related work before 2016 were skeptical as to its potential as there was little or no clarity about DLT at the time. Past comparison has been done between centralized databases and DLT. Leading related research had been championed by the Big three (McKinsey & Company, Boston Consulting Group and Bain & Company) with various yearly reports and whitepapers showing possibilities on the use cases and area were blockchain can be disruptive. The banking industry has been the focus area of such reports. The most promissory use case for the insurance industry was about smart contract for contract agreements and claims management.

2. Background

This chapter would provide us with a background of blockchain and the explain the Insurance business domain.

2.1 Blockchain Technology

Blockchain is an electronic ledger (either public or private) like a relational database that uses a global peer-to-peer network in providing an open platform in which transactions are recorded chronologically. In comparison to conventional databases, rules about a transaction (business logic) that are tied to the transaction itself, and not at the entire database level, or in the application can be set with interest in various industries with the financial industry leading the way. Other includes sectors like asset management, healthcare, insurance, different form of supply chain and logistics, housing and government. it allows a distributed transaction to be distributed thereby creating a chain of transactions where all parties trust the system. It is one of the most important technology to emerge and analyst belief this would change our world like the internet did two decades ago more importantly if there is a strong collaboration among players in the industry [15].

The human mind has been known to be so inquisitive and since the evolution of information technology up until the information age, we have seen numerous technological advancement. Most remarkable has been the transition from the mechanical age to the electrical and digital age. From the beginning of telecommunication, telegraph and telex messages enabling communication between computers to the floppy disk allowing for data storage and sharing among computers

[16] and then the internet, email, world wide web explosion and social media. The huge amount of information been generated and easily distributed amongst people gave rise to new technology in the area of computer processing power, data storage and networking. Technology is now moving in the direction of big data, artificial intelligence, predictive analysis, blockchain and facial recognition and organization are concerned about how to stay competitive and ahead in their industry. Analyst at Roubini ThoughtLab consulting have predicted in its recent report "Staying ahead of technology" that in 2020, most underlying technology including blockchain would rely on the SMAC (Social Media, Mobile , Data Analytics, and Cloud) stack [17] and forecast a positive growth rate for blockchain Distributed ledger technologies (DLTs). An estimated capital market spending in blockchain is projected to rise from $39 Million in 2014 to about $400 million in year 2019 [15] with disruptive potential beyond innovation in products, services, revenue streams and operating systems within existing industry frameworks but the economy and society.

Considering that innovation in technology is changing the industry [18], then understanding the opportunities and threat blockchain might bring to the insurance industry is very important.
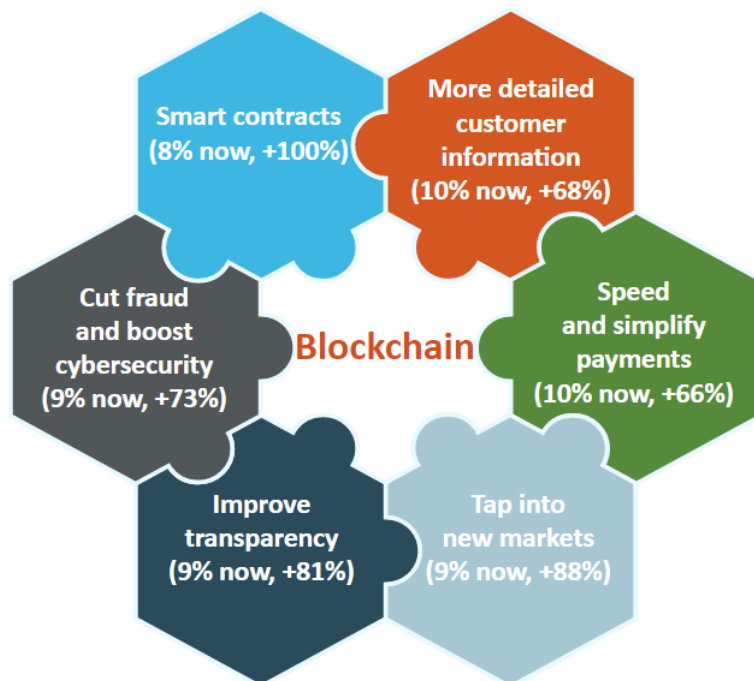

Figure 1 : Future of blockchain by 2020 *Photo credit : Roubini ThoughtLab: The path to Digital Leadership* [17]

Let us look at what blockchain entails.

Blockchain is a distributed ledger or decentralized database of various transactions constantly growing with each transaction grouped together and added in a linear and chronological order as a complete block. Through hashing, chain of blocks are entangled in a manner that prevents changes to one block [19]. Its core element of encryption, redundancy and immutable storage ensures records stored are accurate and secure. New blocks are constantly added in the same manner offering more equality and transparency through mining. Each block contains a hash pointer to the previous block, a timestamp and transaction date and allows anyone with access to view and take part while also having their own identical copy. Any changes in the ledger are likewise reflected in all copies thus a blockchain system allows entities to both transact securely using public key cryptography and keep every transaction is time stamped, verified and added in sequence which is made public [20]. Its immutability helps prevents double spending and the entry of corrupted data

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by malicious attack [21] and participants validate and authenticate online transactions via a public key infrastructure (PKI) encryption.

It was introduced in 2009 alongside Bitcoin [22], a cryptocurrency-based payment protocol [23] that establish a peer to peer technology through a distributed consensus mechanism thereby eliminating the need for trust in any third party or relying on a centralized authority. Instead, participants on the block have computers that serve as nodes within the network and these participants are rewarded when they process transactions using a consensus mechanism. It is best known as the operating system behind bitcoin enabling smart contracts and greater transparency through mass collaborators since data recorded in a given block, cannot be changed except by making changes to all previous block which requires a collective majority.

The blockchain technology has seen various evolution [24] from version 1.0 to currently version 4.0. Blockchain 1.0 saw the implementation of cryptocurrencies, while 2.0 was more focused on registration of smart contracts. Blockchain 3.0 brought about decentralized application which use both a decentralized storage and communication. Blockchain 4.0 currently proposes more alternative approach for implementing the technology in various industries. Solidity (contract-oriented programming language used in implementing smart contract), C++, JavaScript, Python are few of the common programming language used in blockchain. Distributed ledgers generally consist of three logical components: a network of nodes, shared ledger and consensus algorithm. The authority to execute transactions is controlled by public-private key cryptography.

A node is connected to some but not all nodes in the network (peer-to-peer - P2P) and transaction information is distributed across the entire network from one node to another. Nodes are identified by their IP address and communicates via Transmission Control Protocol (TCP)/Internet Protocol (IP) and User Datagram Protocol (UDP) with other nodes. Globally, distributed nodes are linked by a P2P communication network [25]. Every node has a copy of the ledger, but the shared ledger is update accordingly using a consensus algorithm. The algorithm uses a set of rules to ensure all nodes in the network can write data to the ledger while ensuring trust and consistency. There are two ways of consensus in which data can be written to the ledger which defines the type of ledger. We have either a permissionless distributed ledger or a permissioned distributed ledger. A permissionless distributed ledger is a public and open process thus allows anyone to contribute data to the ledger with each participant having an individual identical copy. Permissioned distributed ledger is private with one or more owners and the consensus of data added is approved by only trusted actors. Private, public, permission-less and permissioned blockchain are the main type/characteristics of blockchain [26] [27] [28].

In his recent book, "Blockchain Revolution" by Don Tapscott, the founder of the Blockchain Research Institute, he calls it the Trust Protocol owing to its unparalleled transparency and immutable nature.
There are over number 300,000 transactions per day (https://blockchain.info/charts) on various blockchain platforms with hundreds of applications using blockchain technology. In 2016, statistics showed that over 1.4 billion dollars [29] has already been invested by some financial giant in blockchain. This huge investment into bitcoin's underlying distributed ledger within the

last year demonstrates the impact and potential it is clearly having. Figure 2 below shows how transaction is recorded on blockchain based on the bitcoin protocol. Having a platform for a distributed consensus and anonymity of digital asset form the major strength of blockchain technology.

Its major capabilities includes being [30]

- Being Mutual -it is shared across various organization meaning everyone owns it equally.
- Being Distributed – it has a data structure spread across different location and user can keep their own copy. The blockchain is continuously replicated on at least one group of nodes in the network thereby preventing a single point of failure.
- Redundancy - These transactions are grouped together into blocks that contains various records. Once completed, it goes into the blockchain as a permanent database. A new block is created at the completion of a previous block.
- Data stored are immutable and does not require any central authority.
- Automation of various activities using smart contract.

Some of the disadvantages might include [31]:

- High power consumption in processing bitcoin transaction, (currently between 10 - 60 minutes)
- Mining process requires expensive hardware to guarantee a win.
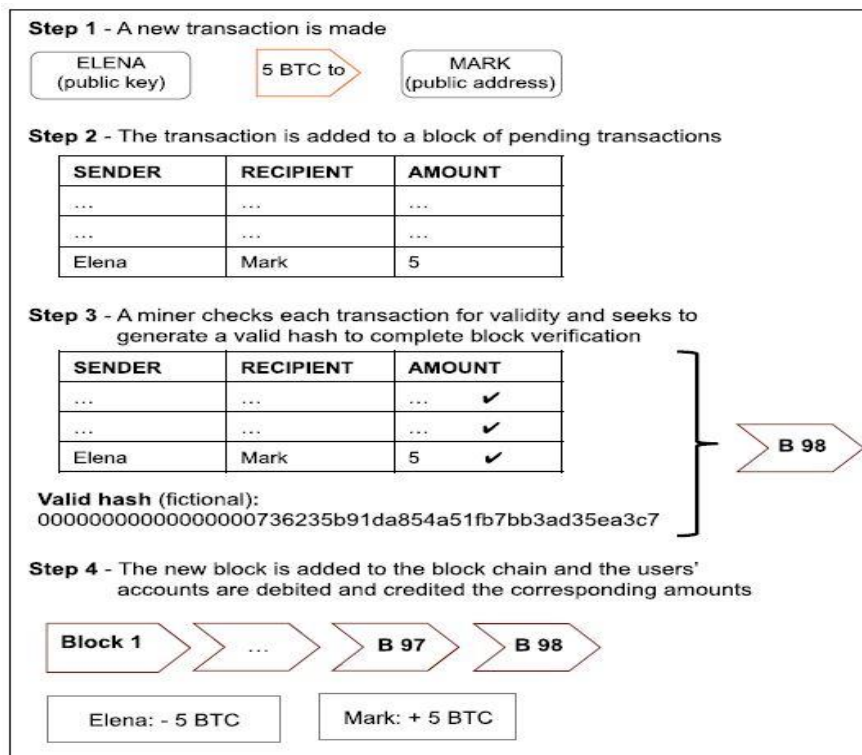- Data replication requires a lot of space

Figure 2. Sample transaction (simplified) with Bitcoin [32]

2.2 Insurance Business Domain

The insurance industry currently amount to a global insurance premium of about $4.55 trillion [33] as at 2015 amounting for about 6 percent of global GDP. According to statistics from the Organization for Economic Co-operation and Development [31], there has been a steady increase in total premium from $3,978,884 in 2006 to about $4,838,214 in 2015 amongst the OECD countries alone.

Insurance entails a risk transfer mechanism that involves a company taking a potential risk from a customer in form of a loss or damage caused by events beyond the control of the customer (insured party) and in return the customer pays a fee called premium. These premiums are then reinvested thereby generating better revenue return for the insurance company. There are majorly two types of insurance product: Life insurance and General insurance [34].

Life insurance involves providing a risk cover related to life in terms of death, partial or total disability and or terminal / critical illness of the policyholder called the insured. Such a cover comes as legal contract carefully written to also protect the insurance company in managing their own risk to ensure profitability and protect itself from undue claims payment and in cases of force majeure like war, riot, suicide, earthquake etc. we have two major classes of life insurance - permanent and temporary.

General insurance deals with other form of insurance not particularly related to life but more of valuables. It covers home, car, goods including other hazard such as fire. It is broken down into 6 major segments namely (1) Motor insurance, (2) Health insurance, (3) Combined, Comprehensive and Package policies, (4) Property insurance, (5) Pecuniary insurance and (6) Liability insurance.

There has also been new areas and risk such as cyber-attack, cover for a shared economy (Uber, Airbnb, Blablacars) etc. and adoption of more innovative business model is already being considered [35]. Over the years, some of the most notable technologies adopted to drive insurance business growth includes legacy application, mobile, web application and online insurance portals, 24 hours call centers etc. The need for innovation should enable organizations retain more customers, optimize pricing, increase profitability of services and the need to build trust with the customers. The figure below shows a research conducted by Accenture [36] which gives a breakdown of technological adoption by the insurance company starting with the use of mainframe computers [37] in the 1900s.
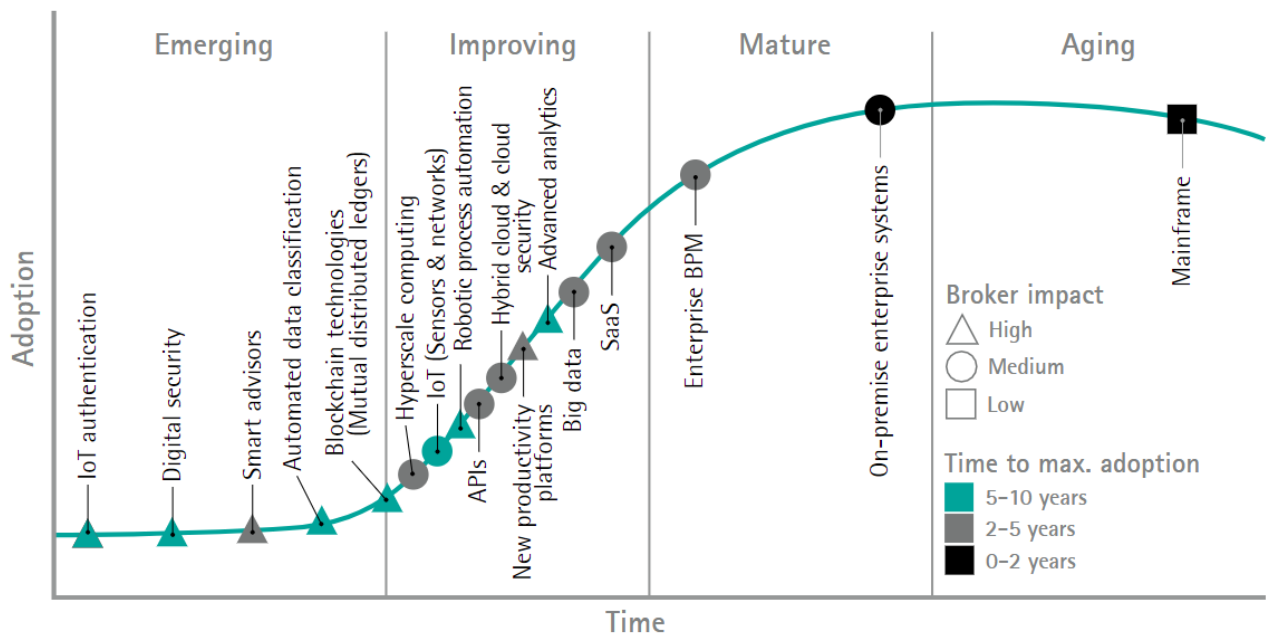
Figure 3: S-curve to commercial broker technologies showing technological adoption [36]

These innovative technologies like the use of big data, IoT, advanced sensors and new data sources, smart homes and property insurance, wearables and health and life insurance, mobile insurance etc. are already being used by various insurance companies.

With the help of technology, insurance companies can make better predictions of risk using predictive modelling to project more risky customers. In the past, insurance companies have only managed to have certain customers pay more premium based on their job and other estimated risk. E.g. an armed personnel or pilot is considered to be a risky job, but no detailed analysis is carried out as per their day to day activities. Aviva Insurance currently use a correlation between the purchase of life insurance policies and safer driving in its pricing for car insurance resulting in lower insurance quote. Other areas are in fraud detection, successful product marketing and improved customer experience [38].

The insurance branch of FinTech; Insurtech is also emerging as a possibility for more innovative product which would increase sales and foster more trust from the customers. An analysis by McKinsey shows most Insurtech are focused on the distribution channel of the insurance value chain [35] with over 17% in Property and Casualty. We now have even more innovative technologies like IoT devices used in healthcare apps that monitor people's daily lifestyle, telematics used in smart cars to provide pay-per -mile insurance and sensor devices used in homes e.g. temperature monitoring system like Google's Nest thermostats, ADT Pulse Services used for home security and remote home facilities control, thereby creating a huge data set for analysis and providing more personalized insurance product such as an adjustable mobile enabled motor insurance policy like "pay as you drive", home insurance based on risk prevention through smart home sensors etc.

Current technological innovation for the insurance industry has been around these six areas as shown below. One of the suggested possible tier of solutions that business can consider is combining blockchain with these other technologies [34] in providing innovative user product based on a usage model, better analysis of the customer behaviour pattern in detecting fraudulent

behaviors, use of advanced machine learning techniques such as deep learning in analyzing data stored on blockchain to help learn sophisticated risk patterns [39].
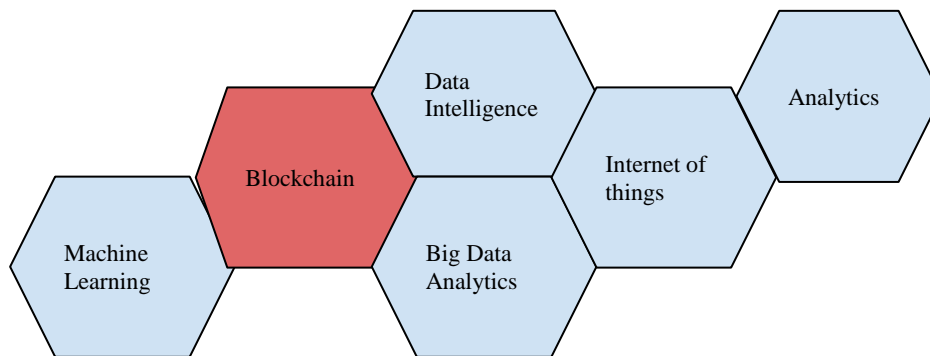

Figure 4: Innovative technology for the future [40]

Already some tech giants including google, are looking into ways of disrupting the industry with most recent being Amazon [41]. Organization such as banks and telecommunication companies are also providing some tailored insurance product and services such as the Zhong AN [42], china's first online insurance company that combines big data and artificial intelligence in providing insurance cover for thousands of her customers. Another example is MoneySupermarket, one of the leading UK aggregators that provides comparable insurance data to the customer in choosing an insurance cover to buy. According to the report by McKinsey " Digital disruption in insurance: cutting through the noise" [35], the top challenges facing the industry includes poor user engagement, legacy ICT systems, risk aversion and legacy cost structure.

Customers want more control over their insurance policies management. In view of this shifting consumer behaviour, some of the areas in continuous need of innovation includes product offering that's are more transparent, business process, models and organizational structure. The key is having an innovative value chain. In the past, there have been a limited interaction between the insurance company and their customers since most of the business is intermediated by brokers. The slow adoption to digitalization by most insurance companies have further weakened any possible bond and interaction between the insurers and insureds. In 2015 during the Digital Life Design conference in Munich, Christof Mascher, chief operating officer of Allianz had mentioned that [43]

"*How to get to a higher frequency of interaction with customers was always a big challenge for insurers. The digital age has brought us countless opportunities and frequent touch points. Now it is up to us to understand the devices and the customers' diverse ecosystems, so we can tailor our offer and reach out to them,*"

Nevertheless, some insurance companies are already reviewing their current value chain being inspired by this IT transformation. Companies that fails to act are most likely to have increasing

challenges with a decreasing returns and customer lifetime value. Adopting a new technology would require building new ICT systems, making changes to current business model, changing business culture and adapting the organization structure. These changes can enable new service offering and differentiate one insurance company from another. Focusing on one or more portion of the value chain can make an enormous difference. Insurance companies must focus on analyzing their customer's lifestyle from the huge data provided from sensors and devices because of the connections between the human daily lifestyle and processes with these devices to enable them deliver more innovative product and services.

The current value chain for most insurance companies is shown below moving from the product being offered to customer servicing and management. These sub-processes have faced numerous challenges [44] in the past including underwriting fraud, inaccuracy in analysis and risk cover due to lack of statistically correct data, claims fraud and poor claim settlements etc.

Figure 5: Insurance value chain. [15] [45]

Currently, the business process flow of this main activities like Customer Onboarding, underwriting process, claims handling and reinsurance process is explained and shown below.

2.2.1 Customer Onboarding Process (As- Is Process)

The current customer onboarding process for the insurance companies is a key requirement to completing the underwriting process. The current As-Is process flow requires customer providing KYC details which is then further validated by the insurance company using various manual process. In a case were the customer medical information is required, the insurance company would inform the customer to visit some hospitals and click to recapture medical information such as blood pressure, HIV status, eye test, body mass index (BMI) etc. Figure 6 below shows the typical process flow when registering a customer for a new business (NB), completing a policy endorsement (EN) or policy renewal (RN) which can occur monthly, quarterly, semi-annually or yearly. The repetitive process of completing customer KYC form at each stage of these types of transactions means increased operational cost and undue delay in KYC process. While industry leaders are faced with this challenge, there has been no real innovative solution to solve the problem.
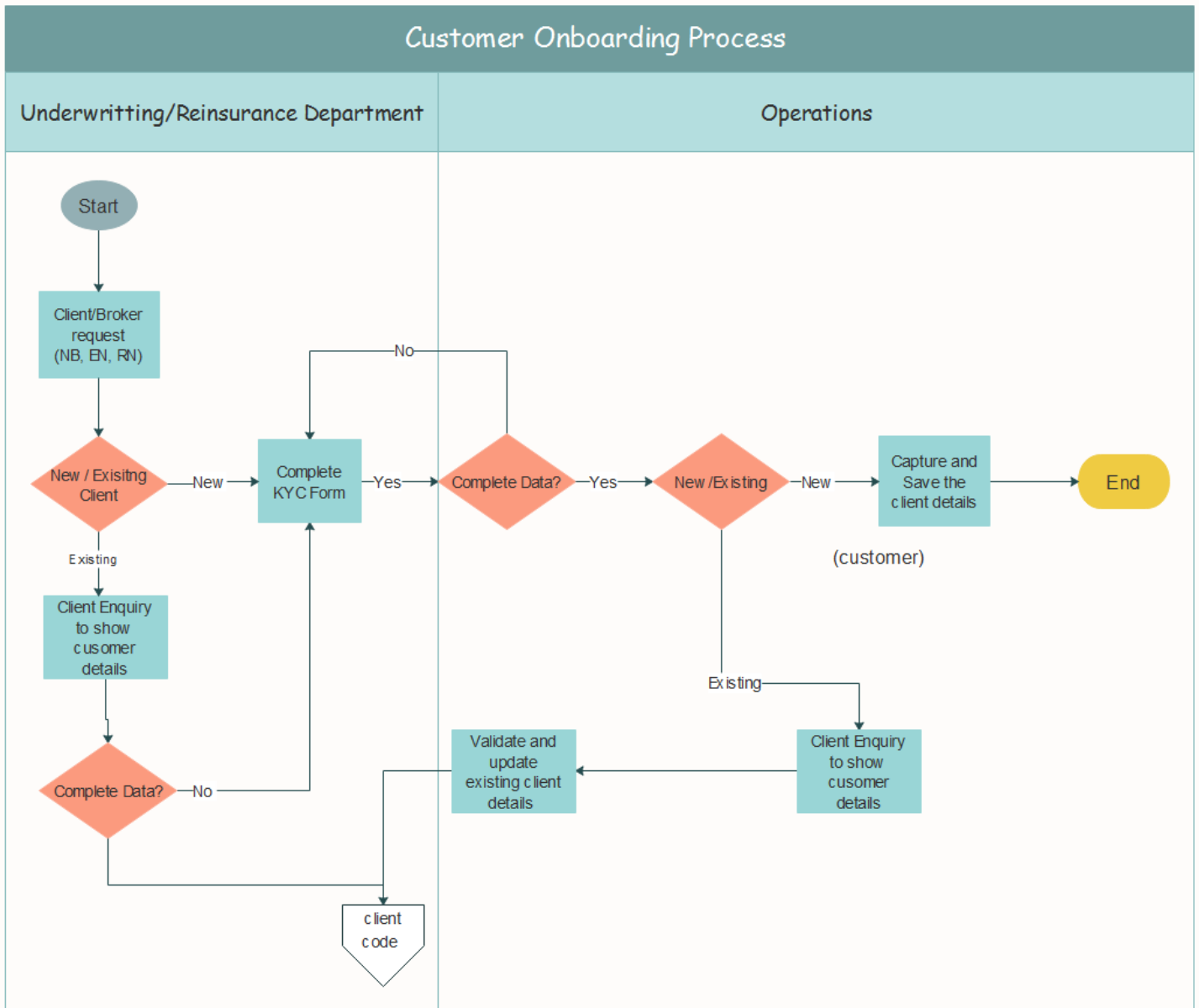
Figure 6: As – Is Process Mapping flow in the Customer Onboarding process

2.2.2 Underwriting Process (As- Is Process)

Policy underwriting typically takes an average of five days to 3 months for cases like aviation and marine insurance. There are different processes involving risk assessments, medical assessment etc. to ensure that the cost of insurance cover provided in proportionate to the risk being absolved by the insurance company. The process flow shown in Figure 7 indicates the need for accurate data from the customer to before a cover can be provided by the insurance company.

Underwriting Process 16

Underwritter	Client/broker	Operations
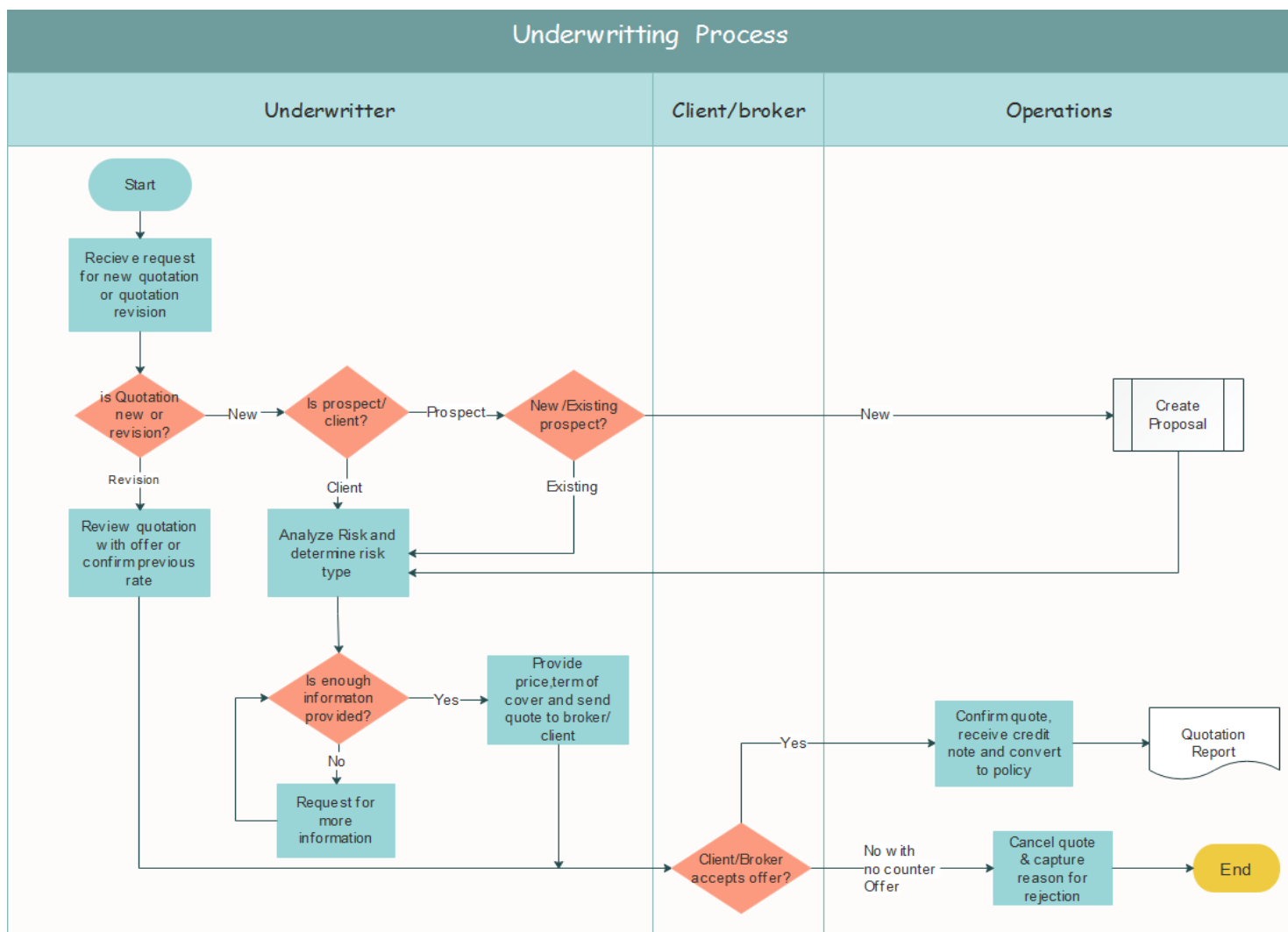
Figure 7: As – Is Process flow in completing a Policy Underwriting process.

2.2.3   Claims Process (As- Is Process)

Once a risk occurs, the claims unit swing into action to enable timely payment of the client. This process involves lots of investigation and due diligence to potentially identify fraudulent claims and ensure the organization is not paying more than expected. Both internal and external expertise are required including loss adjusters, surveyors and superintendent. A widespread problem of multiple claims request made by the insured is also one challenge the insurance industry face as there is little or no collaboration in sharing information amongst them. The process flow is shown below.
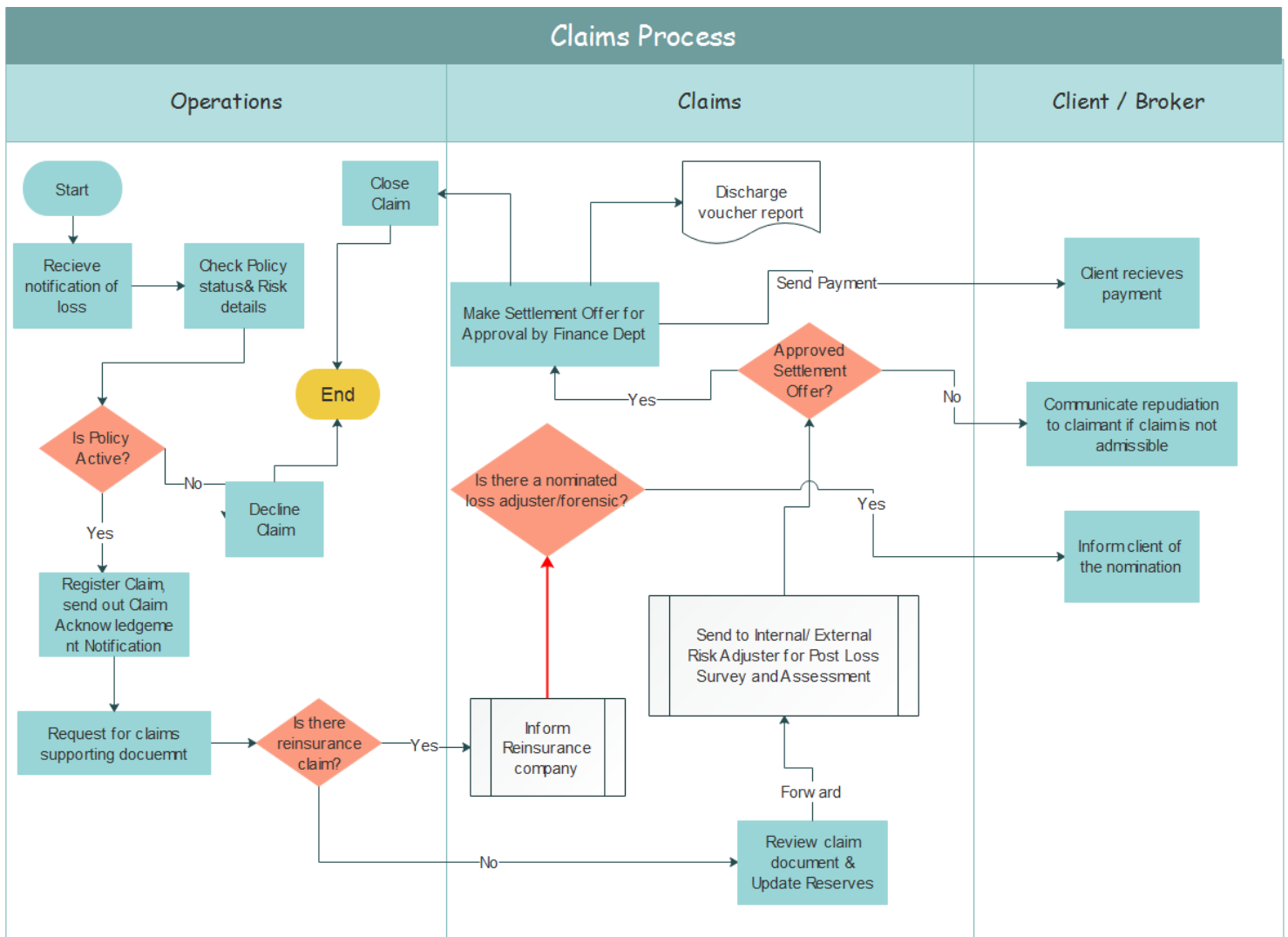
Figure 8: As – Is Process Flow Claims process.

2.2.4 Reinsurance Process (As- Is Process)

Various parties are involved during reinsurance process and payment. Huge risk amounting to billions of dollars cannot be covered by a single insurance company. In every country/ region, regulators set the capacity and level of risk each company can hold to help lower their risk and exposure level. This way risk can be spread globally involving reinsurance companies located across the globe.

As shown in Figure 9, currently insurance brokers are fully involved in the process and lots of adjustment and discussion takes place before payment is made.
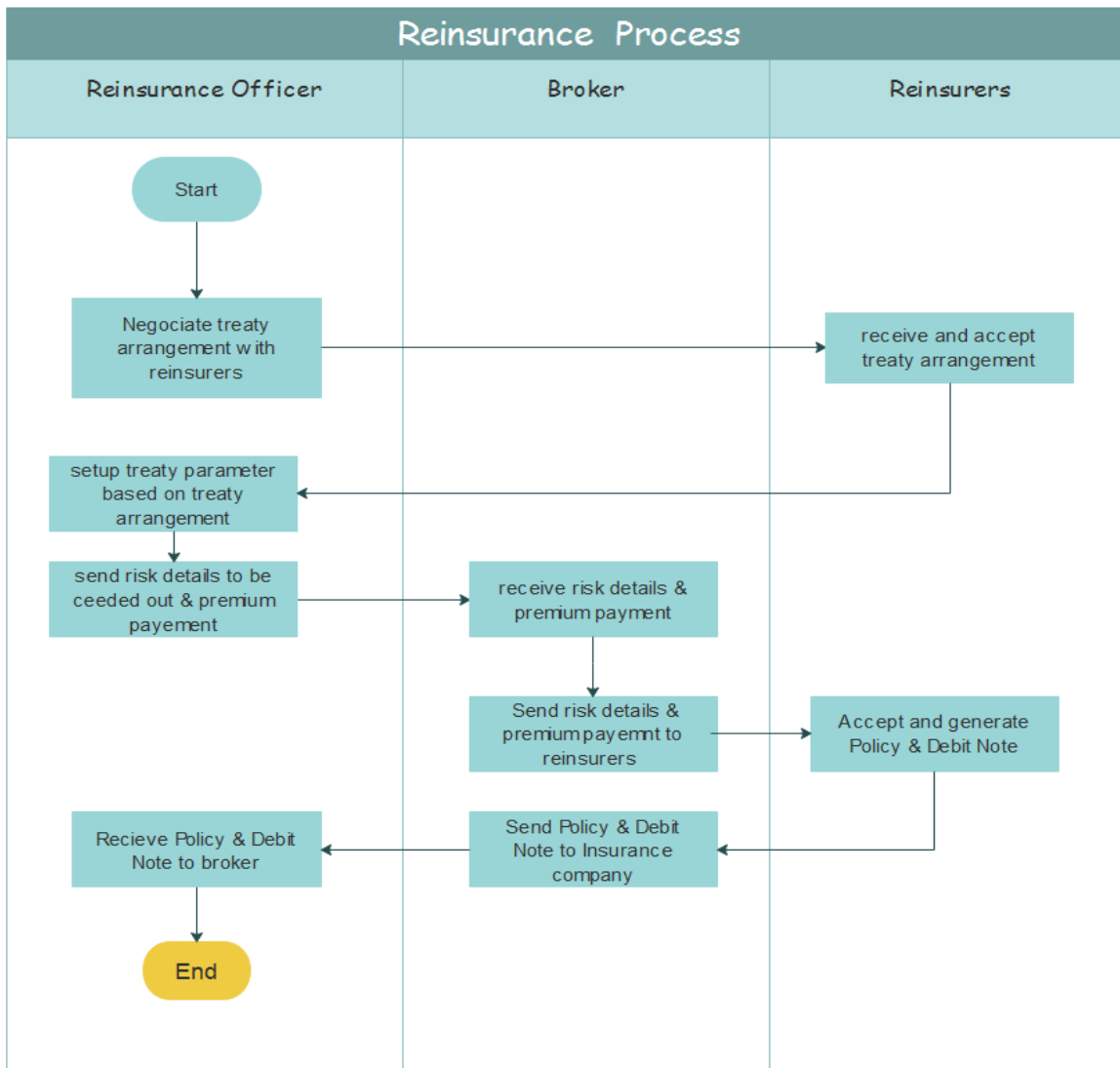
Figure 9: As – Is Process flow in Reinsurance process.

The goal of every insurance company would be to ensure increase revenue and reduction in operating cost Basically, profit for all insurance companies means (earned premium + investment income) – (incurred loss – underwriting expenses.). Insurance products are designed taking into considerations its profitability and how successful it can go through the value chain. Blockchain solution is expected to be cost effective and reduce operational cost generally on the long run including for the insurance industry when compared to centralized solution as it supports three downward sloping exponential cost curves [46]:

1. Moore's law (cost of processing digital information, i.e. speed, halves every 18 months);
2. Kryder's Law (cost of storing digital information, i.e. memory, halves every 12 months)
3. Nielsen's Law (cost of shipping digital information, i.e. bandwidth, halves every 24 months)

In the implementation of DLT, we would review in the next chapter the areas of the value chain that would be affected and what that means for the Industry by conducting a literature review.

3. Literature Review

The literature review would cover various related papers about blockchain technology and its applicable area in the Insurance Industry including the likely disruption in the value chain and business model of the industry. The methodology used in this research is the systematic literature review proposed by Kitchenham, which are designed for software engineering researchers [47] by analyzing the selected research papers.
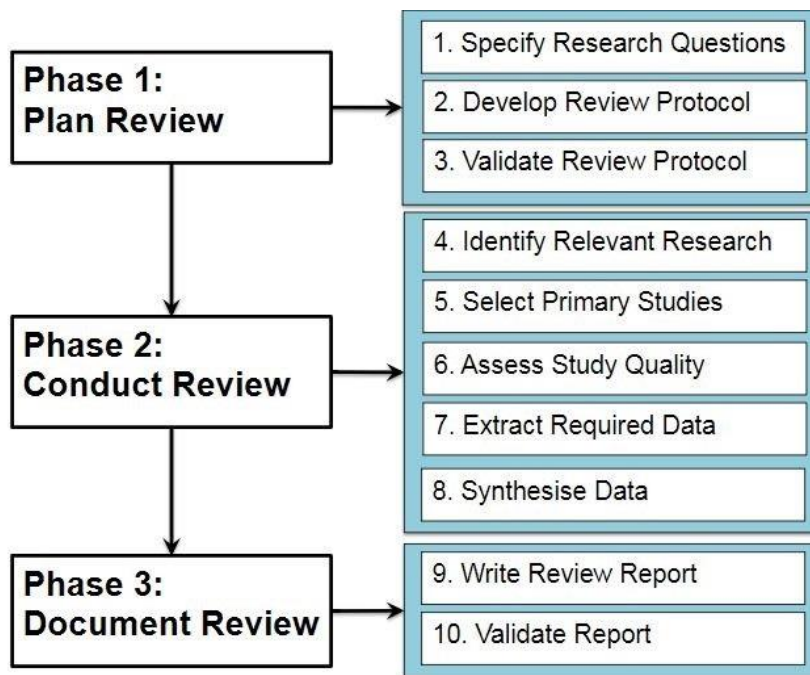
Figure 10. Kitchenham Systematic Literature Review [47]

3.1 Research Question

We would start by defining our research question and then going through the Kitchenham Systematic literature review accordingly.

In this section, we aim to answer the three of our sub-research question with the objective of explaining how truly thee blockchain technology can be effectively used in the Insurance Industry.

3.2 Review Protocol

While Blockchain is still relatively a new technology, the defined search strategy I used in getting relevant literature is discussed below.

3.2.1 Data sources and strategy for search

Initially when I started out, I used the main key search word: *("Blockchain" OR "Distributed Ledger technology") AND ("Insurance")* for the literature search. I then observed that the most efficient library to use would be Google Scholar as the result given also made references to the other various educational libraries including SpringerLink, IEExplore, ACM Digital library, Wiley Online Library and HeinOnline, CEEOL. Since blockchain is still a relatively new technology some other libraries did not have relevant papers as per the research question.

3.2.2 Study Selection Criteria

In making the study selection, we focused on blockchain, its application, use cases and disruptive potential in the insurance industry and ensured the research question was considered. The literature review considered papers from various libraries, business press papers, consultancy companies web reports. Using my key search word, the first data search in Google scholar gave me a total of 2,960 results. I further filtered the search from year 2016 forward and this reduced the total search result to 1,860. I had specified year 2016 because blockchain was still speculative at the time and I also discovered during my search that there was so much uncertainty and little technical knowledge about it [48] until after 2016 which saw a massive investment in blockchain startups and increased interest from various sectors with the banking industry taking the lead. The 1,860 was then filtered by Title and abstract and any paper with no information about insurance or the blockchain technology was not considered. Google scholar currently has a search limitation to allow showing only the first 1000 result. This means that with a "Results per page settings" of 20 in google scholar, only the first 50 pages was available which amounted to 1000 papers.

The following inclusion and exclusion criteria was used in the selection of the paper.

- Include only papers in English language.
- Include if type is journal, article, research paper or textbook
- Include if research paper publication has relevant insurance use cases.
- Include if the research further explains type of blockchain that is most suitable to the insurance industry.
- Exclude if the focus is not related to core insurance processes.
- Exclude if the business benefit is not stated and it's not accessible.
- Exclude if research is solely focused on bitcoin, cryptocurrency etc.
- Exclude if only the code implementation is contained in the research paper

In total, 1000 papers were reviewed. 35 papers were not in English, 120 papers were not accessible, and 460 papers were not related to insurance leaving only 385 number of papers. I then further excluded 317 papers with good abstract but repeated information or lacked content, leaving only 38 papers and 10 other online sources/blogs that met the criteria. This was the final number of papers used for the literature review.

Webpages were filtered by title and the following inclusion and exclusion criteria was used.

- Include if report was from a notable consultant firm.
- Include if report were available in pdf from 2016
- Exclude if report was not in English language.
- Exclude if the report was not related to the insurance industry

In total 10 of such reports were included from the web pages. Additional reports were added using 'pearl-growing technique' based on the initial 1000 papers earlier reviewed. This resulted in an additional 10 reports including some books excerpts bringing in total 20 other online sources.

3.2.3 Study Quality Assessment Checklists and Procedures

Amongst the final 385 papers left, a quality checklist was adopted to ensure the most relevant paper with a higher scoring was most considered during the review. All papers that meet at least 4 of the 6 inclusion and exclusion technique was given a score of 2 points. Paper that further explained in detail with at least one-use case got 2 points, 1 point if the paper provides a clearly stated findings with justified conclusion and 1 point was given to papers with more than 3 citations. All papers that had a score of 5 out of 6 were the most cited during the review. This amounts to about 38 papers. The remaining papers were mostly for extra reading and better elaboration.

3.2.4 Data Extraction Strategy

Each of the papers extracted was read one by one and the extraction sheet was updated accordingly. I had the following columns in my data extraction sheet to be able to extract all the required information needed for my review.

3.3 Review

The research paper being considered for our review report would include the 38 research papers and 20 online resource from various consulting firms and related blogs that discuss on blockchain.

According to the Gartner's 2016 hype cycle [49] for emerging technologies, there are three trends that organization must track to gain competitive advantage. They are transparently immersive experiences, the perceptual smart machine age, and the platform revolution. Mike J. Walker, research director at Gartner believes

"To thrive in the digital economy, enterprise architects must continue to work with their CIOs and business leaders to proactively discover emerging technologies that will enable transformational business models for competitive advantage, maximize value through reduction of operating costs, and overcome legal and regulatory hurdles"

This has been the focus of almost all industry including the insurance sector. Insurers today are developing new operating model in view of the continued adverse market conditions, evolving customer preferences and new players in the insurance underwriting industry. The digital age

requires speed and taking timely decision to stay competitive with the purpose of creating improved value for customers and better return on investment for the organization [35]. Technology has transformed how we do business and disrupted traditional business model. Organizations need to continually review their business process to ensure they stay relevant considering the constantly changing customer behaviour and competition from within the industry. The insurance business thrives based on trust. the trust to handle and pay the risk associated with the client's business. It is believed, the client would provide and disclose the required accurate data of their business in return for a timely payment and claims management. [50].

Our objective would be to review and research the insurance industry processes with blockchain and to answer our first three research question.

SUB RQ1: What processes of the insurance industry can be innovated (enabled by blockchain technology)

SUBR Q2: What are the blockchain use cases relevant for the Insurance Industry?

SUB RQ3: What value could blockchain based innovation of processes within the insurance company deliver?

A change in technology usually leads to changes in the business model of an organization [51] according to David J. Teece, the US-based organizational theorist and the Professor in Global Business. Such technology is expected to solve a lingering problem owing to the initial cost in the acquisition of that technology. Over the years, the insurance industry has adopted innovation in various area but some of the lingering problems remains such as operational cost, verification and process delays, unstructured data capturing in account and claims settlement including premium payments etc. For KYC /AML, currently we have duplicated process in data which has increases cost and causes delays likewise. Some other highlighted issues affecting the insurance companies includes [52] poor user engagement, lack of trust, risk aversion and delayed processing time. OECD report for 2017 highlights that one of the key factor for increased in premium and insurance cover in 2017 remains the customer's perception of insurance products (relevant for both life and non-life markets). Customer demands for excellent service and products has been on the increase with the Millennials generation (https://en.wikipedia.org/wiki/Millennials) were customer want more personalized service and are turning to innovative insurance products. Global customer experience [53] dropped nearly 4% in 2014. While these problem still exist, many argue that the absence of mutual trust and end - to- end transaction transparency between the insured and the insurance companies [36] would needs to improved and blockchain provides possible applicable area and use cases. Trusted parties play the role of validating, transacting and recording transaction details in the business value chain [54].

Trust is embedded through the verification process used by blockchain allowing transparent transitions to be shared in a transparent and immutable manner thereby reducing issue of fraud since blockchain provides a "digital fingerprint" [55] This is a key disruptive element of DLT and it signals the start of a new era in network technology with a trust layer, where peer-to-peer networks, cryptography, and hash technology combine to remove the need for a trusted third-party

intermediary [50]. Centralized transaction ledger and most legacy system are faced with issues such has forgery, ability to reverse transaction without history and omission of information [54] which can be addressed using blockchain.

The insurance industry is currently being threatened by a constant shift towards risk prevention as against risk cover, more availability of data and the continued investment in Insurtech startups [35]. Companies are looking for ways to retain customers and optimize profit [56]. Business automation is expected to reduce the cost of claims by over 30% [35] with growing investment in Insurtech companies. With over $1B in funding of Insurtech startups in the first half of 2016 [57], new models are expected to improve the visibility and communication between the insurance companies and their customer. This new models are expected to enable growth, increase effectiveness, and reduce cost by automating key processes [15]

The potential advantage of blockchain would be an increased transparency and accountability of transaction, reduced transaction cost with fairness and lack of favoritism in handling business transactions through the implementation of smart contract and the various underlying characteristics of blockchain including decentralized validation, robustness, data redundancy and immutable storage, encryption and transparency [15] [26] [58].

While still in its initial stage, there is a consensus that blockchain would make an impact in four major areas of the insurance value chain mainly in product development and delivery, underwriting process, payments, claims process and asset management with the ability to remove intermediaries from the value chain and give more power to the customer in areas like ownership and management of their personal data and identity management. A survey of about 526 insurance professionals carried out by Cognizant [59] shows that the percentage of insurance professionals believes that the most benefit from blockchain implementation would mean faster claim settlement (43%), reduce fraud (40%), improved record keeping (40%), streamlined processes (38%) and greater transparency (38%).
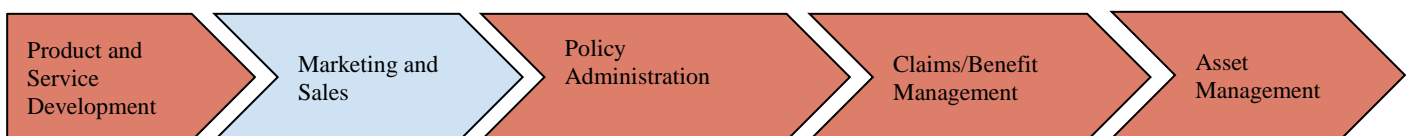
Figure 11: Insurance value chain indicating applicable area of blockchain

The insurance giants are already exploring ways on how it can be innovative to the industry. Aegon, Allianz, Munich Re, and Swiss Re, already set up a combined pilot project known as B3i to explore the nascent technology [35]. There is need for more collaboration amongst the many insurance and reinsurance companies to allow for the development of blockchain enabled products and adoption of a framework and type of blockchain to adopt. The world is changing with more emerging markets and products launched yearly. New risk such as cyber-attack which cost an average $11.7 million in 2017 [60] is one area insurance companies needs to position themselves in selling innovative products. The continued rise of a sharing economy is also another area of concern with more peer -to-peer insurance service with the likes of Uber and Airbnb that provide services that would require more customer customized insurance cover. Various factors are driving value and changes in the insurance industry namely [32] [35] [53] :

- Technological innovation and personalized service (customer ownership of their data) using big data in combination with technology like blockchain.
- Efficiency (cost savings) and effectiveness (higher returns) using predictive analysis.
- Connectivity with better exchange of information from anywhere and anytime using technology like IoT.
- Automated service, simplification and agility using technology that reduces complexity.

In the adoption of blockchain, some factors needs to be considered for the type of blockchain protocol to adopt [32]. Factors like the amount of decentralization required, time/cost constraints consideration to using blockchain over conventional databases [26], the key problem that wants to

be addressed, regulatory compliance (most recent being the General Data Protection Regulation" (GDPR) [28]. Most architectural choice adopted by currently available products favors security and data integrity [61] over scalability and flexibility which call for a need to standardize the technology and enable interoperability.

Currently, most legacy application being used in the insurance industry are centrally managed. For DDBMSs, data is logically centralized and managed as if all information are stored on the same machine allowing for CRUD transactions while blockchain uses a decentralized database management system which supports create and read function which makes it most suitable for recording critical information (e.g., insurance claim records). Its distributed architecture means no single point of failure and need for a centralized governance resulting in an autonomous, transparent, secure and tamper-free transactional database.

Our analyses would focus on the highlighted areas of the value chain above.
1. Product and Service Development
2. Policy Administration (including premium payment and collection)
3. Claims/ Benefit Management
4. Asset Management

3.3.1 Product and Service Development

The development of various insurance product has been focused in the past on solely covering the various risk, but analyst believe the current digital disruption in insurance would mean they would have to reinvent themselves. McKinsey [35] interviewed over 30 executive in 2017 and they all agree in this regard. Innovation in customer engagement, product development and management, risk underwriting, cover and reduction, delivery channels, process automation etc. are some of the process that would lead to new model in the insurance industry. The need to review organizational strategies more frequently as technology, consumer behaviour, and competitors evolve ever more rapidly. According to Klaus Schwab, chairman of the World Economic Forum,
"In the new world, it is not the big fish which eats the small fish, it's the fast fish which eats the slow fish."

Insurance companies would need a technology which when combined with other technologies like data analytics, machine learning, IoT etc. would allow for their relevance and competitiveness.

The interest in increasing sales services and effectively engaging the customer is of great importance. The need to develop innovative products like Index-based insurance (e.g. microinsurance) , risk cover for the increasing shared economy such as short-term home rental on platforms like Airbnb, Alterkeys and 9Flats.com and carpooling platforms uber, blablacars etc, peer-to peer insurance, on-demand insurance like pay-as-you-go [39] auto insurance whereby drivers are charged by the mileage driven and covering for new emerging risk such as cyber-attack.

The blockchain distributed ledger allows for storing both static and transaction records in multiple locations using a blockchain distributed database [54] thereby serving as data provenance for the storage of different kind of information. Valuable assets like diamonds can be uniquely identified and registered on the blockchain making their identification and tracking easier. Information about a physical or digital asset would hence provide information about the ownership and transaction details of such asset. Using blockchain, customers records, proof of ownership etc can be stored and linked to the customers digital wallet.

One of such example is the KYC-Chain (https://kyc-chain.com/) which allows customers to manage their digital identity securely. Other KYC related blockchain projects includes Tradle (https://tradle.io), IDChainZ built by Z/Yen in partnership with PwC using blockchain to record and provide personal information and document, E-Nome (https://enome.io/) [34] an Australian based private company that has developed a patent pending system based on blockchain technology and empowers consumers to take control of their medical history on their smartphone, with ultimate security and privacy, BanQu (http://www.banquapp.com/) which is focused more on the humanitarian space and developing countries, and are testing the BanQu digital identity in a number of projects including providing a digital identity to Syrian refugees in Amman [52]. The Australia's state-owned postal service [28] [34] [62] is already considering several blockchain applications also to stamp digital identity and expand further their core service of physical Identity. Mr. Ahmed Fahour, the chief executive said
"The future is going to be a digital identity so that when you say who you are, I can see who you are," adding that Blockchain had much wider applications than just financial services.

Thus, KYC enabled blockchain platforms allows customers grant access of their verified identity data only when necessary to other 3rd parties like doctors, insurance companies and other relevant organizations including compliance with government regulations like the recent European Union GDPR [28] which prevents the need for a repeated process for full identification and verification. This invariably speeds up and increase the efficiency in the onboarding process of a new customers. Such process can be integrated during policy underwriting thereby reducing operational cost [63] and processing time. Tradle (https://tradle.io/) [64] for example, aims to create a smartphone interface that can send documentation and verified identity to insurers instead of relying on paper-based communication. Since blockchain provides data immutability and there is no central ownership, both insurance companies and customers can trust the information. Most research including EY [56], a global leader in assurance and advisory services believes that this is one of the main disruptive nature of blockchain .This would be leveraged in the health sector

faced with numerous medical fraud, fake identities, tampered documents and also reduce claims. In the United State alone, federal prosecutors [65] had over 2,000 health-fraud probes open at the end of 2013 which is on a steady increase yearly and over $272 billion lost. The information of

the customers, their policies and claims (with a complete underlying transaction history) can be independently verified using blockchain. With the DLT, Insurance companies can perform better risk- assessments and underwriting of insurance policies. Also, contract agreement between the broker, the insured and claims agent can be stored on the blockchain making it accessible to everyone. Cognizant [59] and McKinsey [15] believes that the effective management of customers data using blockchain would invariably improve customer engagement and build more trust while also providing a greater degree of transparency and drive between $3bn and $5bn in industry cost savings through reduction in personnel and in AML regulatory penalties according to Gold Sachs [66]. This would further lead to new and innovative insurance product like for example InsureETH, which offers a peer-to-peer flight insurance policy using smart contracts and most applicable during flight delays and cancellation. Air passengers are guaranteed of automatic refund or some form of compensation during flight delays or cancellation hence building customers trust.

Currently, there are over 400 million people globally with no insurance cover according to the World health organization [67] as most people do not trust most insurance services [32] and are not convinced on the need to have an insurance cover. CNBC had reported in 2017, that the rate of U.S. adults without health insurance had jumped [68] in the first quarter of 2017 due to plans to repeal the Obamacare which was provided to moderate the cost of insurance through major changes to the individual insurance market with the adoption of the Individually purchased health insurance using a shared economy approach [21]. These various challenges have seen the emergence of different healthcare blockchain implementation in managing patient identity and health records for more transparency and fair pricing in the industry through data sharing using credible and verified content. Medicalchain (https://medicalchain.com/en/) is an implementation used to store medical records of patient and is already in partnership with the Groves Medical Group based in London, UK. Ariel Ekblaw and Asaf Azaria research [69] were able to demonstrate how the Medrec prototype (https://medrec.media.mit.edu) developed using blockchain can consolidate patient medical history across multiple providers and act as a distributed access and validation system using the blockchain to replace centralized intermediaries.

Also, PokitDok (https://pokitdok.com/) in partnership with Intel provides identity management to validate every partner in a transaction by checking medical practitioner credentials, tracking and reconciling errors or ambiguities in patient data, and verifying insurance claims thereby solving one major challenge facing the industry which is the ability to validate if a patient is eligible for health insurance or pharmacy benefits, be able to determine the cost, coverage limits and copays, and to be alerted about coverage limitations or restrictions. Prescription fraud [70] commonly referred to as Phantom prescription is also another area that is causing the health and life insurance sector huge cost and loses. In the United states, Florida is one of the most notorious states for prescription drug fraud with little regulation and control of pharmacy technicians. Susan Hayes [71], a pharmacy outcomes specialist affirms that the only way to solve this problem is for plan sponsors to take matters into their own hands and be able to monitor the system.

HealthChainRx (http://healthchainrx.pivot.design) and ScalaMed (https://www.scalamed.com/) are two blockchain implementation focused on solving this problem and allow easier management of drug prescriptions. Dr Tal Rapke [72] the founder of ScaleMed beliefs

"The next major advancement in medical record management will be transferring the control of patient data from healthcare organizations to the patient—placing the individual firmly in the center of their healthcare journey. The freeing up of patient data is a big leap forward for medicine, and blockchain technology is the vehicle that will make it possible."

Furthermore, the industry has continued to witness a growing number of uninsured persons and valuables with fraudulent insurance cover. In Nigeria, reports by the Nigerian Insurance Association says that over 12 million Nigerian motorists [73] carry fake insurance papers and avoid buying insurance out of the estimated 180 million people despite the benefits from motor insurance cover. A worrisome trend with several unsuccessful attempts initiated by the insurance companies to collaborate with law enforcement in bringing an end to fake insurance business in Nigeria. Many believe car insurance premiums are expensive. In the UK for example, most insurance company have attributed the high cost of car insurance to the rising cost of claims [74] inclusive of fraudulent claims thereby increasing the cost inclusive for honest motorist. In South Africa, an estimated 35% of 4 wheelers and 70% of 2 wheelers drivers are uninsured due to the huge cost of premium and lack of transparency in the insurance process [39]. Blockchain enabled processes and applications are expected to solve these challenges, reducing cost and building trust. An IBM Research in Australia demonstrates [39] using a prototype, how the implementation of a pay-as-you-go car insurance application on blockchain would ensure that all the data pertaining to the customer's actual trip and usage premium payment made are transparently recorded so that all parties involved in the insurance contract including the driver, the insurance company, and the financial institution were applicable are confident that the data is tamper-proof and traceable. In the motor industry for used cars, there is the global issue of Akerlof's Market for Lemons caused by the adverse selection problem were buyers and sellers have access to different information about the car thereby encouraging the purchase of vehicles with less value and invariably discrediting the industry. Past proposed solution such as hiring an external car expert to check the car, having a honest car dealers who can certify their cars from an external car audit agency, buyers using heuristic approaches to access the quality of their prospective purchase has not been an effective approach considering that the industry is a multilateral and global market etc.

With the use of blockchain, Denmark [21] is already looking for ways to solve the Lemons problem. The history of the cars, their previous owners and the lifecycle of the car can be captured using a blockchain based motor register with a higher transaction processing rate eliminating the need of a central authority (e.g. including the Digital Motor Register (DMR) managed by the government) by providing a platform that governs the transfer of ownership of used cars and inherently provides a reliable and complete record of vehicle history to the transacting parties like SKAT (the Danish Customs and Tax Administration), government agencies, and other third parties.

Blockchain would also be effective in solving the Title insurance cover cases when a home is sold to a buyer by a fraudulent seller who do not own the property originally [50]. The defect title case

in the US for example, were M Knoedler & Co of New York city was forced to close in 2011 after several court cases and FBI investigation showed massive fake painting that was sold for millions of dollars [75]. Various properties have bad title documentation or registration process in the US for example. This makes the process of title insurance search prone to lots of human errors. This manual effort in property title search increase the cost. Title insurance premium are priced by the insurance company based on the underwriting cost factors as opposed the actual risk. The Goldman Sachs Group [66] believes that premiums cost for title insurance runs between $1,000 and $1,800 on the average (representing a 0.4%-0.6% of the home value assuming a $275,000 property). With the implementation of blockchain, Bitfury for example (http://bitfury.com/) allows you to digitize your asset and makes easier transfer. Likewise, Epigraph (http://epigraph.io/about) a US company in Austin that is building a title registration solution for domestic and international organizations. This would disrupt the market and major leaders in title insurance in the US expected to be affected could include Fidelity National Financial (which holds 35% share of the title insurance market), First American (27% share), Old Republic (15% share), and Stewart Title (12%).

On demand home insurance service have also been implemented using a distributed ledger. This is one of the drivers for a shared economy encouraging more P2P insurance model were people in different geographical location can combine to form an insurance pool and platforms for providing insurance cover and improving accommodation booking, payments and validation of customer on the ledger. One example is the SafeShare Global, the British company that uses blockchain technology to confirm counterparty obligation. It is the first blockchain-based insurance solution for the sharing economy. It partnered with Vrumi, a UK based company that connects and allow homeowners share their home as office space to people who might wish to use it for work. SafeShare Global developed a fully integrated insurance product and now offers it to homeowners on Vrumi [75]. By using blockchain technology, SafeShare provides a product for counterparty agreement and obligation is maintained. Homeowners can get insurance cover for their houses while making it available to potential customers at an affordable price. The ability to track when the home is being used allows for insurance premium to be charge based on actual usage. This timestamp of such home is already being used by the Lloyd's of London in the providing a more customized insurance cover against the normal norm of just purchasing insurance on a yearly basics and the record of insured parties is maintained in the blockchain. Airbnb also acquired ChangeCoin (a micropayment infrastructure for the Internet that integrates payment processing with social media) in 2016, to help in the management of customer reputation and detail on its platform.

With a user base of more than 17 million in 2015, such a partnership would enable Airbnb to share its user profiles and credibility with other companies bringing about more synergy and value for both homeowners and users. If a home user's integrity and behavioral history can be validated over time of using an Airbnb home, such credibility can be shared in other shared economy platform like Uber for example and even for small P2P loan platforms. An estimated $3 - $9 billion [66] incremental revenue through 2020 is expected from this acquisition. Such experiment has also giving rise to new products were blockchain is combined with smart contracts and IoT devices in providing home insurance for smart homes [26], repairs of faulty cars and help automate the underwriting process etc. Already, Slock.it a German blockchain startup using IoT devices, provides the ability for Airbnb apartment rental to be automated were smart contract from Ethereum is used to unlock a rental home via a computer upon payment by the renter [34].

Also Dynamis [76] using blockchain provides a P2P unemployment insurance policies and severance coverage for small businesses in the case of layoffs or resignations powered by smart contracts. Using the social network like LinkedIn, the profile data of employees can be verified of their employment status. Teambrella (https://teambrella.com/) a Russia startup, also leverages on P2P concept and blockchain in providing insurance cover for group of friends who form teams. The teams pre-agree the insurance policy's terms and conditions including claim payments amount.

Blockchain would lead the way in Property and Casualty insurance (P&C) and P2P insurance contract which would disrupt the old business model in the insurance industry by eliminating or reducing the influence of the middle-men like brokers, claims administrators and loss adjusters in the business process of insurance underwriting and policy administration. The pilot project called Blockchain Insurance Industry Initiative (B3i) setup by five major European insurance and reinsurance companies to explore the implementation of the technology solution across the insurance value chain currently do not consider brokers in the value chain. Harald Rosenberger, the head of innovation at Munich Re and a B3i member believes collaboration [77] among the insurance company is key and it's needed for its success.

"Therefore, we see a huge benefit for the insurance industry in doing this together through B3i.

We would continue to see a rise in the exploration of blockchain in combination with innovative P2P concept that would push the boundaries of the current insurance model. Bernardo Nicoletti [64] strongly believes blockchain in combination with other technologies would bring about a rethinking of insurance value chain. Companies like Lemonade (https://www.lemonade.com/) already guarantees prompt claims payments with even less premium payment by customers using blockchain in combination with machine learning in its risk assessment. Bought by Many, (https://boughtbymany.com/about/) a company proving blockchain insurance products already has a unique product for pet and travel insurance and promises to improve prices, provide better cover and deliver exceptional customer experience.

3.3.2 Policy Administration (including premium payment and collection)

Policy administration involved various processes including processing of financial and non-financial transactions, premium collection and accounting and policy modifications (Policy cancellations, Policy withdrawals, Policy surrenders etc.). All insurance companies generates income by absorbing risk which is paid by the customer called the insured with larger premium payment coming from property and casualty coverage and sometimes in multi-currency settlement [59]. Most policies provide cover when payment has been made making premium collection susceptible to fraud and sometime too many paper works. The calculation of net premium, loss prevention and risk premium are current challenge in the industry over the years. There is the need to provide a seamless platform for premium collection and settlement with other parties like brokers and reinsurance companies in cases of a reinsurance business etc. Facultative reinsurance for example involves mostly ceding a huge one-off risk while treaty reinsurance includes a book

of risk that sometimes involves a longer form of relationship amongst the ceding participants. We also have the excess of loss reinsurance calculation process. All of these are complex process and overtimes the industry has tried different legacy system to address this with little success.

According to the Insurance Information Institute, in 2016, the total world gross premium was about 4.7 billion USD which was a 3.1% rise. One of the EU regulations for the insurance industry is the Solvency II regulation [78] [79], with the Pillar 3 requirement. It requires the full and transparent public and private disclosure including the providing the Regulatory Supervisory Report (RSR) by the insurance companies. The OECD [79] in its global insurance market trends report 2017, highlights this as one of the major challenges for insurance companies in Europe in 2016. By storing account and payment information on the blockchain, insurance companies can get better validation of counterparty information invariably reducing the false positive rate in transaction surveillance and help in fraud prevention and AML activities. One use case would be to streamline claims handling process and reconciliation with reinsurance companies. The risk each company can hold is regulated by relevant national and global bodies ensuring that they do not have more risk that it can bear. Excess risk is ceded out between to the reinsurance companies and involves the cedent, broker and reinsurer. In most cases, the excess risk is shared amongst various reinsurance companies ensuring more spread. Due to the level of risk and huge premium involved in such transaction, the agreements need to be carefully drafted, with real-time transparency and collaboration amongst all involved parties. When a claim occurs, all reinsurance companies are informed to enable timely claims payout. This process involves lots of complex regularization, calculations and reconciliation since huge capital is involved. Using a permissioned blockchain network [59] involving ceding insurer, broker, reinsurers and regulators etc. The losses and treaty arrangement for each insurance companies involved can be recorded making reconciliation of liabilities easier. The issue of claims leakage, conflicting interpretation of the contract etc. as a result of an insufficient reinsurance recovery process could be better managed using blockchain and can help save over $100,000 annually for the facultative reinsurance industry [80].

The Blem Information Management Ltd [81] in 2016, using the Z/Yen's Distributed Ledger implemented a system called XLRAS [2] for efficiently administering the complexities of excess of loss reinsurance. This system helps in the calculation and production of recoveries and reinstatements on complex reinsurance programs, particularly excess of loss making reinsurance process and payment reconciliation more effective and cutting down the initial high turnaround time previously experienced. Blockchain also solves the problem of double spending and malicious attack [82] by requiring miner on the blockchain nodes to solve a complex mathematical problem to verify every transaction. W. T. Tsai, R. Blower, Y. Zhu, and L. Yu in the 2016 IEEE Symposium on Service-Oriented System Engineering report [83] believes blockchain would enable both international, multi-entity and cross border payment applicable in different industry without the need for a bank. it would also pave the way for an alternative modes of insurance financing such as peer-to-peer lending. Ripple is one use case. It provides an interbank payment using blockchain in collaboration with R3 [84] in October 2016.

As companies grow, so also does their transaction volumes with more available information. Managing such financial data for multiple entities in separate datafile across multiple locations becomes extremely cumbersome. For example, in the case of a pay-as-you-go car insurance application, there would be a need to record premium payment made by the user for each trip

recorded in a transparent manner to encourage buying such product. By transparent keeping records on blockchain every party in the insurance contract including the driver, the insurance company, and the financial institution believes that the data are tamper-proof and traceable. These means the two core function that makes blockchain applicable would be record keeping and transaction settling [34]. The use of blockchain technology is expected to streamline the payment and claims handling process to reduce the risk of fraudulent claims.

3.3.3 Claims Management

Claims processing and management is one of the key business area for the insurance industry and the ability to promptly pay claim timely increases the reputation and trust by customers in purchasing insurance cover from such company. All claims processing undergoes three main process namely: submission of the claim by the insured, loss adjustment by the insurance company and other involved parties like the brokers and reinsurer and finally claims approval and payment. Fraudulent claims payment cost the insurance sector about $80 billion a year across all lines of insurance [85] which is roughly about 20% of the total claims payment annually. This is one key area all insurance companies are concerned globally with the Coalition Against Insurance Fraud body leading the way in reducing such fraudulent claims. As far back as 2004, the OECD [86] had proposed and adopted some set of guideline for insurance claim management amongst its member countries by providing practice for the entire claim lifecycle in relations to claims reporting, fraud detection and preventions etc. with the aim of improving the quality of claim management and the deterrence of claims fraud. Smart contract implementation on blockchain protocol is enforced once certain conditions are met providing a first notice of loss (FNOL) and automatic claims payout. This would enable a better claims management process by reducing human error and fraud cases significantly. A smart contract is a digitized contract that is stored on the blockchain which is executed based on encoded business logic defined and runs on the Ethereum platform. It is applicable in cases of multi-party agreement and interdependent transaction. With blockchain, through the provision of a decentralized repository, the issue of conflict of interest during claims payment would also be eliminated since prior to now, most insurance company are most likely to look for ways to pay less during claims payout. The OECD report for 2017 provides statistics of continued increase in insured premium globally for the insurance company and also noted the rising yearly claim which was about a 33.9% increase when compared to 2016 in Nicaragua for example. On top of this is also the huge cost spent by insurance companies in investigating all claim transaction before payout.

In the UK, the insurance fraud bureau was setup to tackle the issue of fraud and organized crime facing the general insurance industry. The popular "Crash for Cash" scam allowed drivers to fake an accident and made multiple claim from various insurance companies. This induced accidents cost the insurance industry in the UK about £400 million each year [87] including the popular whiplash claims caused as a result of sudden movement of the head or neck from a car accident.

To solve this problem, the Insurance Fraud Register (IFR) in the UK was launched in 2013 to provide a central repository of known fraudsters to combat the challenge. This was able to reduce reported cases of such fraudulent car insurance claims but would only work in the UK and nowhere else. It is also still being managed by a central authority. A shared blockchain would solve the problem better since its distributed and with no central authority thereby providing a truly global insurance marketplace with no central control or regulatory barriers. These claims can then be linked to customer's identity which is stored on the blockchain. Data from other sources

like a police theft report, medical assessment report etc. can also be used as oracle in updating the claims information and validation. Plex (Plex.ai), the Canadian startup is combining the Ethereum blockchain, machine learning and artificial intelligence to give insurance companies real-time, remote diagnostics on a car and its driver." There is also the case of subrogation in health and auto insurance claims which involves collaboration from two or more insurance companies in the claim recovery process. This recovery process sometimes in the US involves lawyers who are involved in protecting their client by investigating on individual cases where possibilities for subrogation and recoveries exist by reviewing and evaluating accident reports, individual claims, medical or other documents relating to funds paid out by an agency. The use of a shared ledger [59] would greatly enhance the work process by providing full visibility to all relevant personal of key information including accident report, vehicle information etc.

Currently, claims authentication is evaluated manually by loss assessors [31] which is elongating the claim turnaround time. By removing such intermediaries in the process using a decentralized real time claim processing, claims are validated and can be paid automatically. Claim management using smart contract would reduce complexity and cost of the process [2] [32], increase claims processing speed and reduce turnaround time from about 45 days to 6 months to about 3 to 4 days [59] since they are automated and automatically triggered with the occurrence of specific event. An oracle provides relevant information to enable the trigger of the smart contract once agreed condition are met. e.g. flight cancellation (InsurETH), the smart contract is executed, and applicable refund is made. Another example is the simplification of the death registration and claims process [88] were related parties like hospitals, insurance company, funeral home and finally policy beneficiaries are managed and notified in real time in case of a death of the insured using blockchain solution powered by smart contract. In a case of a dispute, blockchain application like Bitrated [44] can serves as a claims arbitrator. This way, insurance company would be able to pay claims almost instantly to the policy beneficiary [88].

In 2016 using blockchain smart contract, Allianz Risk Transfer AG (ART) and Nephila Capital Limited (Nephila) were able implement a system for transacting natural catastrophe swap [27]. The Catastrophe bond (Cat Bond) provides cover against natural catastrophe like hurricane, earthquakes etc. by allowing insurance companies sell this special risk to investors. Investors get return on the principal but would lose such amount should the catastrophe occur. In a case were such events occur, using smart contract, payment and settlements to the insurance company is automated removing the need for intermediaries. Presently, intermediaries play the role in verifying and authenticating the legitimacy of payments/transactions to and from the investors which takes longer processing time. Hans, Ronny, et al. [27] argues that with the combination of oracles and smart contract on blockchain, contractual agreement and settlement would be fully automated in the future including CAT Bonds [89] by replacing human intervention and manual process which is embedded in the entire risk transfer process and synchronized across all stakeholders creating an easier data sharing and pooling among concerned parties including reinsurance companies and brokers.

By combining emerging technologies [56] like blockchain, IoT, big data and analytics, machine learning and artificial intelligence, insurance organization would be able to mitigate risk. Risk avoidance and loss prevention measure are becoming increasingly important in insurance leading to more preventive insurance model. [32] rather than reactive ones. The development of autonomous vehicles and advanced driver assistance systems (ADAS) with IoT devices would

bring about a shift of liability from driver to car manufacturers and software vendors [35] and claim initiation process would be automated [90].

McKinsey strongly believes an extensive cooperation between insurers, manufacturers ,customers, and other parties will be needed to unlock Blockchain's full potential for claims management but concern about the irreversible nature of finalized smart contract [19] and how smart contract can handle various complex business rules and its scalability poses further question about its likely adoption. The need to implement standards and regulation that support the use of blockchain for business purposes will eventually lead to wider adoption and drive new business capabilities according to a Deloitte survey [77]. The emergence of smart contract auditing platforms likes Experfy (https://www.experfy.com/hire/smart-contract-audits) would also lead to more standard process in encoding business rules using smart contract. In 2016, 86% of total funding in blockchain was related to smart contract venture capital giving room for more future prospect for smart contract.

3.3.4   Asset Management

Managing the insurance portfolio requires various bookkeeping process such as updating policy cover details, conditions, payment patterns, reviewing anti money laundry policy and general risk analysis of already active insurance cover to help gain a competitive advantage. Being able to respond faster to emerging threats by taking advantage of new data sources and analysis places the organization above it pairs. Today, insurance managers are regularly examining their portfolio's performance to determine the actions that are required since insurance has become more complex and highly competitive. The use and combination of different technological tools likes predictive modelling, business intelligence and automation process are some of the leading techniques used already by global insurance leaders.

Driving such sustained effort to remain competitive rely heavily of organization business process and current underlying technology in use. With the implementation and adoption of DLT/blockchain, fingerprint of digital assets, exchange of such assets and the transaction history is safely stored on the blockchain which is immutable, transparent and auditable [91] and would facilitate the growth of the collaborative/'sharing economy' [92]. This would enable asset tracking and ownership transfer verification [93].
Notable example is in properties management, car ownership and sales etc. With the use of smart contract, blockchain encoded property can become a smart property [94]. Swaincoin for example, the well-crafted artwork which was only 121 available globally was available for purchase and transfer using blockchain. (http://swancoin.tumblr.com/). Benedikt Notheisen, Jacob Benjamin Cholewa and Arun Prasad Shanmugam [21] were able to propose a working prototype platform that governs the transfer of ownership of used cars with a complete transaction history accessible to all involved parties including the government which invariably address the Lemons problem earlier mentioned.

Blockchain can help insurance companies in the area of fraud prevention through anti money laundry (AML) compliance procedures. Many of the research papers [27] [66] [58][93] believes that by using a distributed database as against a central database, the digital identity of customers,

account and payment information can be stored on the blockchain allowing both insurance companies, healthcare provider, financial institutions etc. easily validate financial transactions and reduce various known industry challenges. Goldman Sachs research believes that though blockchain technology might not by itself solve the problem [66] and huge cost in AML processes incurred by organization, it would enable some significant cost reduction.

The implementation of a blockchain enabled system would give rise to new product development like P2P insurance, usage-based insurance cover, build customers trust in the system, reduce payment and business process reconciliation, reduce fraudulent claims, too many subjective decisions and operational cost and encourage better collaboration in the industry.

In summary the blockchain technology would affect major value chain for the insurance areas. Most research believes that to unlock the ability of blockchain, a strong collaboration amongst the insurance companies across the value chain is required since it generates a maximum value when used at scale across the industry though some 55% of the over 526 insurance expert interviewed [59] said that working with industry partners and their competitors is still one of the top barriers to adoption. Such collaboration would mean both insurance companies and other stakeholders like agents/brokers would change their data management processes. World Insurance report 2017 by Capgemini [76] in collaboration with Efma also approves of that digital collaboration would redefine the insurance domain. I believe Government regulations and standards like the ISO/TC 307 [63] [95] [93] with 35 participating member countries already is a step in the right direction that would encourage easier adoption and consideration by the insurance companies. IEEE also is promoting [61] the DLT standard by forming the blockchain interest group to coordinate and disseminate information on the activities of blockchain. The UK, Australian and Danish Government are few examples were the government is looking at possibilities of blockchain and its possible use case. There has also been recent approvals from the US congress [96] for distributed ledger technology.

Insurance executives would need to align their organization to understanding this technology by identifying functional areas and possible use case while taking part in collaborative project like the B3i. This way they are not be left behind when finally, blockchain takes full shape in the insurance industry. Cognizant Consulting [59] reported that already 44% of the insurance executives interview have already identified such functional areas and business processes that could be impacted.

3.4 Result

During the Systematic literature review, I have been able to identify the main processes of the insurance industry that can be innovated. They include Product and Service development, Policy Administration, Claims management and Asset Management. Most of the research papers believe identity management and the use of smart contract in claims management would be the most disruptive application of blockchain in the insurance industry. Over 30% of insurance customers have had a bad insurance experience and were likely to switch to another provider according to Accenture [98] when 7,875 insurance policy holders were surveyed from 14 countries in 2014. All this would change using a more open and immutable record storage platform like the DLT. Also, the ability to transfer assets or make payment to the insured once certain conditions are meet would build trust with the customer and eliminate or reduce the influence of intermediaries would determine the insurance market leaders for the future. Already, survey shows that 56% of insurance firms know the importance of blockchains but almost 57% [25] still do not know how to respond or implement on the advantage that blockchain offers [27]. Further regulation and standardization like the ISO/TC 307 would generate more interest in blockchain in the industry. Support from government like Australia, Denmark, UK, Georgia and now the US (i.e. US Federal Trade Commission (FTC), U.S. Securities and Exchange Commission (SEC), Commodities and Futures Trading Commission (CFTC) [99]) would also build more interest with more use cases.

Innovative product development using the blockchain technology has been pioneered by the Insurtech startups. AXA, MetLife, and Aviva have all launched labs in Singapore with great support for the Insurtech industry in counties like Australia and the UK also. A greater percentage has though been focused on enabling the insurance value chain which means insurance companies can better collaborate. Raconteur research [40] indicated that in the UK, 46% of the insurance companies are already working with Insurtech startups to explore innovative technology such as blockchain.

One of such partnership like the B3i is a wonderful opportunity for the insurance companies to collaborate fully and evaluate how blockchain can enable their business processes. By direct or venture investment, insurance companies can invest in these Insurtech startups and infuse this into their current business model and processes.

Table 1 below provides a summary of the different blockchain prototypes and implementation focused on insurance mentioned in the research papers used for the literature review. A greater percentage had more use cases for the underwriting and Policy servicing process.

Business Process	Product and Service Development	Underwriting & Policy Administration	Payment and collection	Claims/ Benefit Management	Risk capital & Asset Management
Potential use case	Customer identity management, Risk analysis	Improving underwriting pricing and customer experience, Identity management, usage-based insurance or micro-insurances, Title Insurance, Car Insurance	Payment infrastructure	Information about insured goods to prevent fraud	Available information for re-insurers or other related parties
Potential use case with Blockchain and Smart Contract	P2P insurance, Micro Insurance product,	Use of smart contract in premium calculation, event-based insurance	Automated payment, immutable transaction audit trail record, cross-border remittance.	Automate claims triggering and handling with smart contracts,	Easy account reconciliation, Payout amount
Key Benefit of Blockchain	Reduced administration cost, operations cost and increase customer trust	Personalized insurance offer based on usage, reduction of dependency on 3rd party, cover identity management, medical records and health insurance cover, property and car insurance	Efficient payment process	Eliminate fraudulent claims, Easy monitoring of potential claims event, Transparent and faster claims arbitration process	Reduced administration cost Open process between related parties
Examples	Dynamics [97], Everledger [15] [64] [98], ShoCard, Tradle [64] [15] [35], ChainThat, BlockStack [66], Onename [66], IDchainZ [2]	Dynamics [97], Safeshare [64] [99], ChainThat, InsurETH [31] [27] [15] [35], Bitfury [66] [55], Epigraph [66], Teambrella [53], Lemonade [18] [35], Friendsurance [64], Proof of Existence [98], Augur [44],IBM ADEPT:IoT system [44] [98], Slock.it [34], Genecoin [32], OpenID Connect [32], SAP Ariba [55], Lenderbot [55], Codex 1 [101]	Ripple [2] [66] [59] [84] [19] [92], Ethereum [92] and Smart Contract, XLRAS [83], InterChainZ [54], BitGO [56]	Ethereum and smart Contract [92], Edgelogic, Teambrella, Blockverify [98] [35] [15], Bitrated [44]	AllianZ Risk Transfer, Blem IMS, Factom [2]

Table 1: Blockchain use cases for Insurance. (Table structure adopted from McKinsey & Company [15] and Capgemini Analysis) [44]

The implementation of blockchain would support new products and services underwriting including microinsurance, peer-to-peer insurance and on-demand insurance. McKinsey [35] believes almost £200 million invested annually on identity fraud by insurance companies would be saved, there would be improved risk profiling and the exchange of information during underwriting including with co-insurance or brokers would be more efficient, prone to less error and require less paper work. Blockchain would provide a data provenance of verifiable claims record. Hence, claim settlement process cost to the insurance would also be streamlined and reduce between 15 to 20% total expenses of the process [40].

While its upside is significant, so also the various challenges and risk it poses. Insurance expert have some transaction risk concern since they are unable to reverse transaction on the blockchain. Security risk are also of concern like the "51% attack" [58] [83] [102] were one node in the system has a mining capacity of more than 50%. [103], loss of private key (digital identity), the history of past money laundering (e.g. Silk Road dark market) and previous system hacking. There are also scalability issues like forking problem, number of transaction that can be handled per second (The theoretical maximum transaction speed for Bitcoin is 7 transactions per second due to the 1-megabyte block size limitation in the current protocol [58]) and longer turnaround time for block synchronization and how it would be able to handle large transactions. Also, a decentralized infrastructure would initially increase cost in terms of monitoring in the short term.

In summary of all the papers reviewed, the table below shows the distribution of how many paper focused on a specific process of the value chain.

Process	Product and Service development	Policy Administration (including premium payment and collection)	Claims Management	Asset Management
Tally	6	17	10	5

Table 2 : Summary of area of focus amongst paper reviewed

4. Implementation of Blockchain and Analysis of the New business process flow

In this chapter, we would focus on the implementation of blockchain by specifically looking at each of the processes in the value chain highlighted in chapter 3. Already in chapter 2, we provided the current As -Is process flow. Our focus would be to propose a new To – Be process flow that incorporates blockchain.

Michael Mainelli and Chiara von Gunten [32] believes that in order for insurance companies to kickstart and adopt blockchain implementation these 3 steps below must be considered:

1. First, is the need to experiment the technology using a private blockchain.
2. Use of different protocols and economic structure during experimentation.
3. Conducting details risk analysis of how existing legacy system would integrate with blockchain with focus on both current and future product offering of the organization.

This view is also supported by Accenture (https://insuranceblog.accenture.com/seizing-the-blockchain-opportunity) with the need to prioritize for a proof of concept. KPMG [104] highlights some key questions to ask which provides a clear assessment of how blockchain can address an organizational need. Questions about data, process, counterparties, technology, performance/ security, industry, business case and regulations.

Organization are exploring a variety of use cases and how specifically it can generate business value for their organization as Cognizant [59] believes the adoption of blockchain is mostly strategic rather than technical. The bigger concern is about communicating the business value of blockchain first rather than addressing technical issue. A greater percentage of expert see the most benefit in the implementation of blockchain in faster claims payment and reduced fraud cases with 41% of insurance executives approving of an open blockchain while 36% believes in permissioned blockchain [59].

We would further analyze which type of blockchain would be most suitable for the insurance industry in this chapter. Let us first consider from chapter 3, the current areas of the value chain being affected by blockchain and how our new process flow would look like.

4.1   Review of the Business Process with blockchain

The 4-business process we would be discussing, and reviewing are

1. Client Onboarding
2. Underwriting process
3. Claims
4. Reinsurance process

4.1.1   Customer Onboarding Process (To- Be Process)

With the use of blockchain, the customer would only need to update their KYC details on a blockchain platform and approve access to specific data needed by the insurance company using the customer's wallet address. This way, the customer's identity is stored on the distributed ledger which is encrypted and safe. The customer has full control of what to share and all historical changes are immutable likewise hence making the customer identity data accurate, trustworthy and reliable. As shown in Figure 12 below, all internal redundancy and repetitive process in capturing the customers details is reduced or eliminated using the blockchain.

Digital identity projects in countries like Estonia, Norway, Netherlands and now the UK are already reality. The UK's Gov.UK Verify platform requires 4 levels of assurance in the identification and verification process. This is exactly what the blockchain platform would provide, giving the insurance company just enough information at every stage of the customers transaction to complete that process. The amount of information needed during a customer change of surname endorsement would be completely different from that needed during a death claim transaction. Bain & Company "Prescription for cutting costs research" showed that a 5% increase in client retention result in more than 25% increase in profit. Proving a more efficient and robust customer onboarding process using a blockchain platform would provide a seamless process for the insurance industry to grow in customer base. Allowing the customer to determine [105] what data to share would be a balanced thought since insurance company would need more data in the future to propose rewards likes premium reduction etc. based on customer medical history for example.
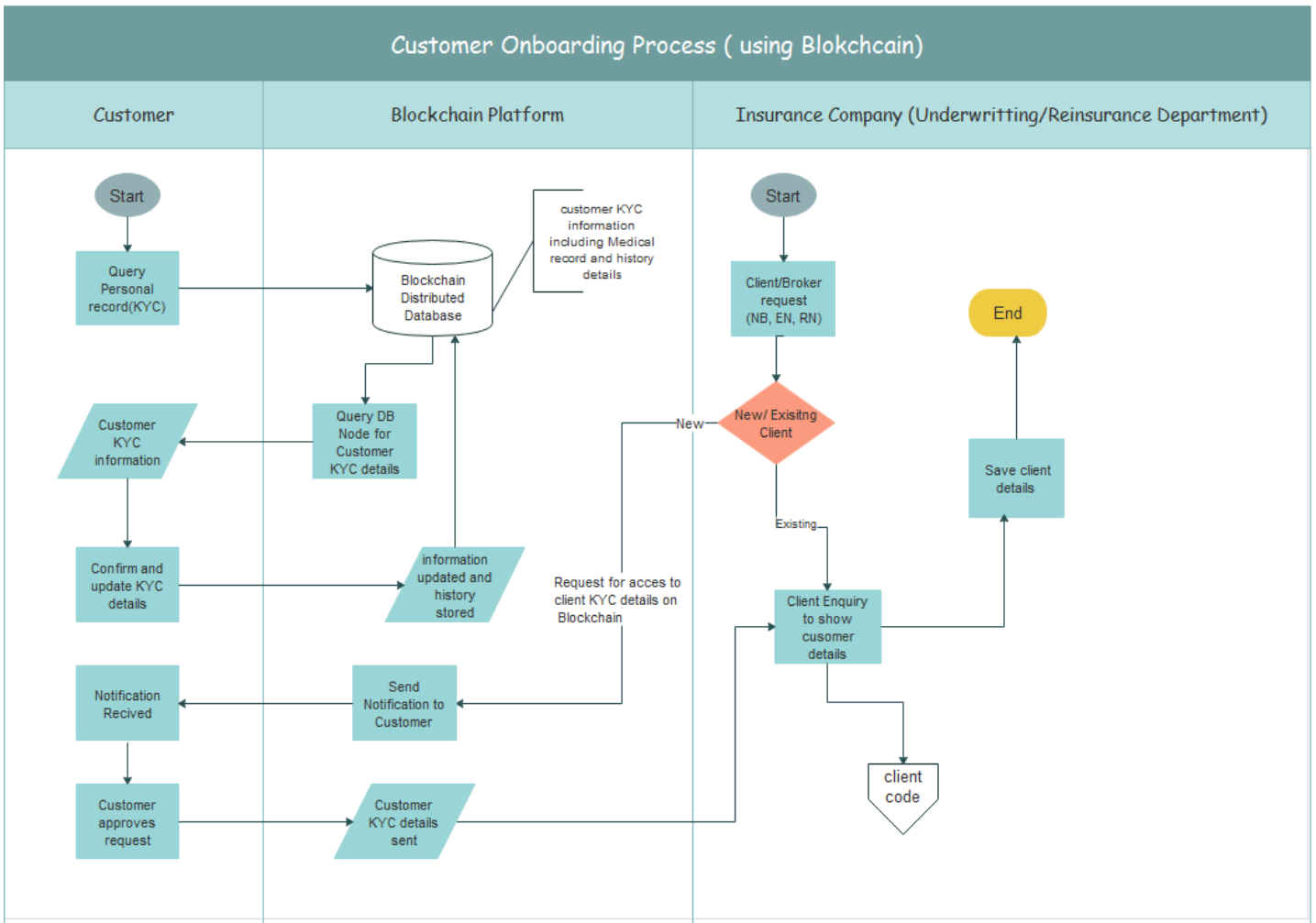
Figure 12: Customer Onboarding process for the Insurance Industry using Blockchain. (To - Be Process)

Also, the growing global concern of money laundering can be better managed. In the American insurance industry, a vast number of persons are using insurance product to hide money from federal taxation agencies because of poor KYC or AML process. Edmund Tribue, from NTT DATA Services' Risk & Regulatory [106] dealing with AML and KYC requires two simple things – "tools and expertise". DLT has enormous potential to be such tool for the insurance market.

4.1.2   Underwriting Process (To -Be Process)

Underwriting process is core operation to providing an insurance cover. This process is supervised by insurance specialist including actuaries, surveyors, superintendents etc. As in seen in Figure 7 in chapter 2, most of the underwriting process currently involves lots of paper work and in most cases, this takes an average of about 5 - 10days to get a policy underwriting process completed.

With the redefined process flow shown below in Figure 13, an estimated period of 2 days to complete an underwriting process including complex process involved in marine insurance, aviation, Oil & Gas etc. Already EY had built a supply-chain platform in late 2017 using

blockchain that connect client's exposure data to brokers and insurers thereby automating placement activities and effective premium collection in marine insurance using smart contract.

Such collaboration with industry giant like Maersk, Ms Amlin, Willis Towers Watson, Microsoft etc. shows how truly blockchain would be innovative and disruptive in the industry. By providing this shipping data in real time, the complexity of the underwriting process is reduced and there is more accuracy in term of premium pricing.
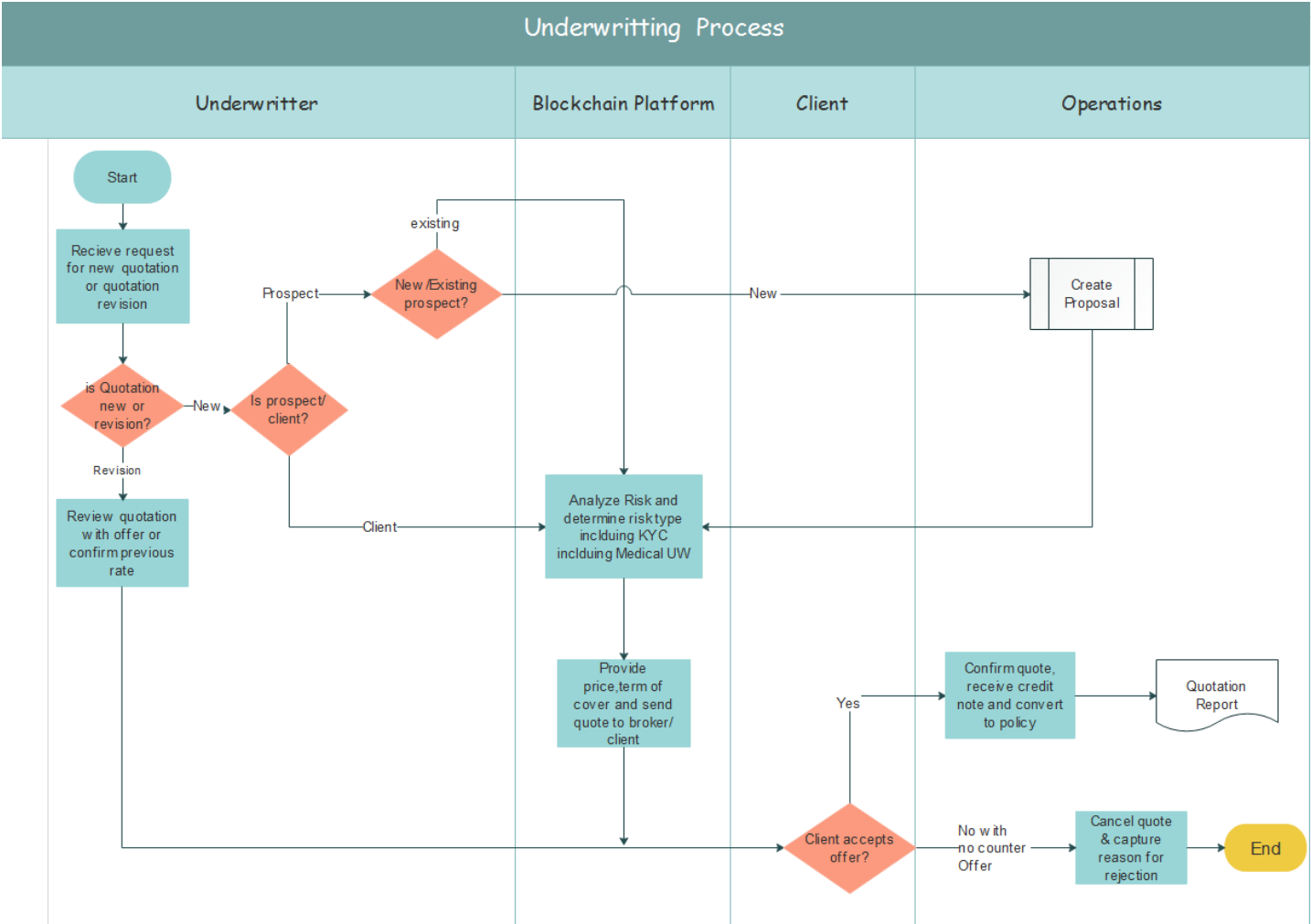

Figure 13: Policy Underwriting using Blockchain. (To - Be Process)

IBM, AIG and Standard Chartered were able to deliver a multinational insurance policy powered by blockchain using smart contract and a secured ledger [59] in 2017. This has created a new level of trust and introduced more transparency in the underwriting process allowing for multiple policy placement in different counties using multiple currencies. This demonstrates clearly the ability of blockchain to automate premium payment and improving customers experience.
In aviation, insurance companies require full disclosure of the risk details and loss ratio for the aircraft before initiating a policy quotation in view of the huge claims amount. Currently, there are fragmented data source and getting a complete information for the aircraft is quite time taking. Blockchain DLT can be used to store this information thereby reducing the turnaround time further in completing an underwriting process.

Policy servicing like renewals and endorsements can be automated with smart contract were oracles like government databases can provide relevant information to completing this process. For example, a newly married person or a dead employee are information which can be gotten from a central government database and used to process a change of name or death claim payout to beneficiary respectively. This means for insurance brokers to remain relevant, they would have to rethink and start acting as risk innovators instead of administrator since more and more task would now be automated using smart contract with a project 20% drop in revenue by 2020 [12].

4.1.3 Claims Process (To -Be Process)

The combination of IoT devices and the use of smart contract on blockchain implementation would allow for connected cars and smart homes to provide in real-time more accurate data for analysis and automatic claims payments. These smart devices would serve as oracles and be able to communicate and update smart contract providing information in real time such as brake pressure, airbag status, tire pressure etc. Insurance companies would be able to compensate for a safer driving habits as it would reduce claims payout thereby evolving from providing insurance cover to becoming valued partners that help their customers monitor, mitigate and avoid risk. Lemonade Blockchain inspired App already allow you to file for claims in less than 5 minutes and approval done within 3seconds. The company is promising more innovative ideas for the future. It has applied for operation licenses in all 50 states in the US and projected to be available to about 90% of US consumers.

With bigdata and smart contract, the key role played by Loss adjusters and marine superintendents during claim would be automated or reduced. Blockchain would also provide an irrefutable claims history of transaction which is vital in Aviation business for example. A PwC report in 2016 says 48% of insures fear that over 20% of their business would soon be lost to innovative startups like Lemonade. Therefore, collaboration and integration of a blockchain enabled claims processing would be key to eliminating fraudulent claims and staying more competitive. The Institutes RiskBlock Alliance [107] with already 18 members was formed in 2017 to explore how blockchain can be used for risk management and to reduce transaction cost for the insurance industry, speed up data sharing amongst customers and all relevant industry stakeholders etc. It is already driving the development of DLT for the insurance industry in subrogation and first notice of Loss. Indicative projection from Accenture are that processing cost could reduce up to 80%, average handling time by 40% and 50% increase in FTE productivity for some transaction.

In Fig 14, we can see that with the implementation of blockchain, a greater percentage of the process flow would rely on oracle data sources and less on human. We already discussed in chapter 3, the use of blockchain smart contract technology for transacting a natural catastrophe swap implementation by Allianz demonstrating how transaction processing and settlement can be effective. This shift in process means policyholders would need to be careful and understand the full terms and condition of the policy purchased [105] since less human effort would be involved during payout. In a case were wrong policy condition was provided, there would be a need to have a process to correct and make needed adjustments.
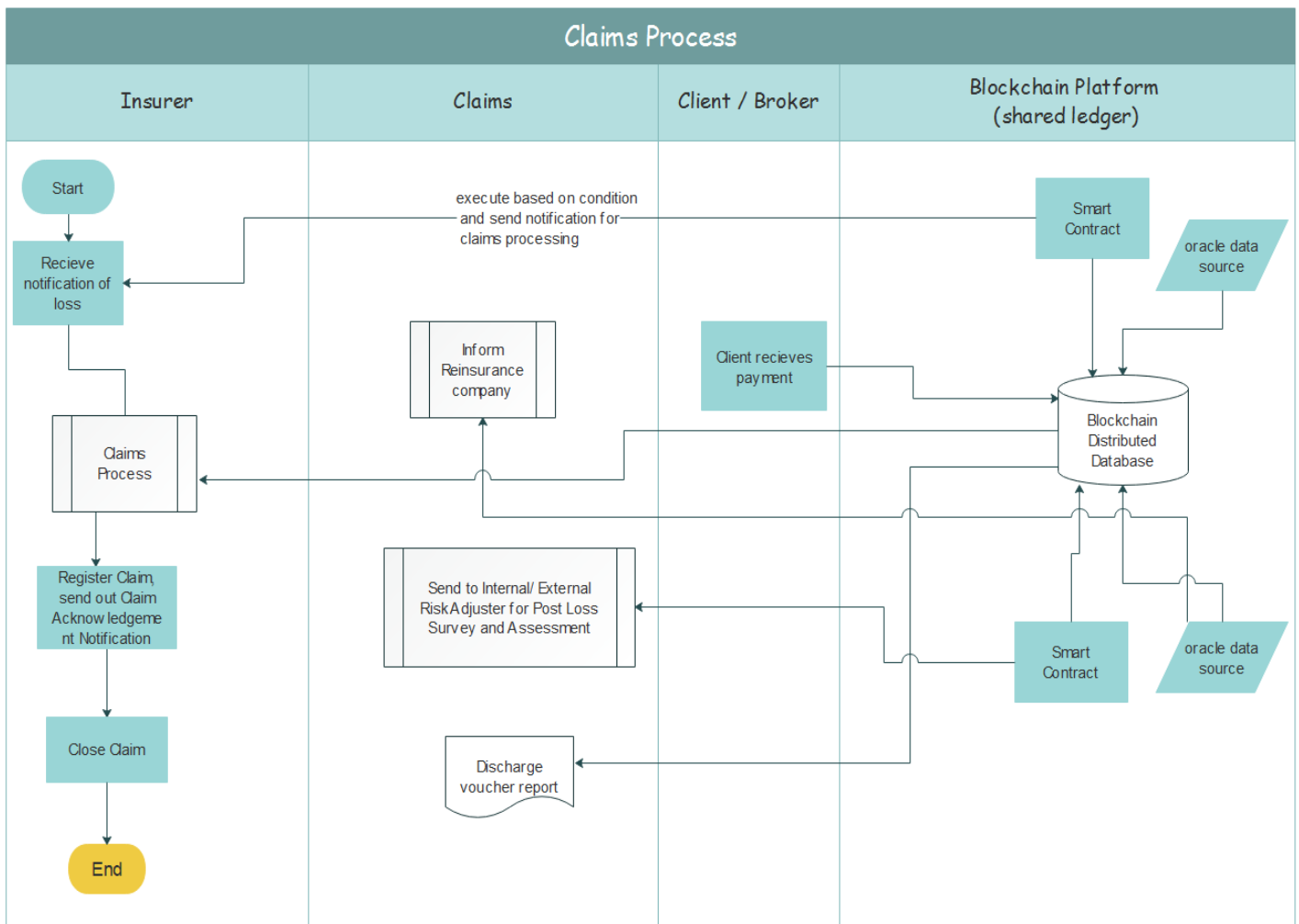
Figure 14: Claims Processing. (To - Be Process)

4.1.4   Reinsurance Process (To -Be Process)

Information sharing amongst all relevant parties involved in a reinsurance transaction has in the past been of much burden. Since all parties involves in the risk sharing using different systems, there are cases of wrong interpretation of contract terms or undue delays from third party like the broker. With blockchain, this process can be done in real time thereby reducing transaction cost that arise for both the insurance and reinsurers in placing and managing a reinsurance contract. This would also fast track apportion payment when there is a claim. Once negotiations are completed, digital copies can be signed and can be accessible to all including regulators. Smart contract then ensures payment and reconciliation is seamless when a claim occurs. In Figure 15, all parties involved are able view the apportionment and agreement signed. Since reinsurance involves huge risk and premium payment, a permissioned blockchain would be most suitable for information sharing.
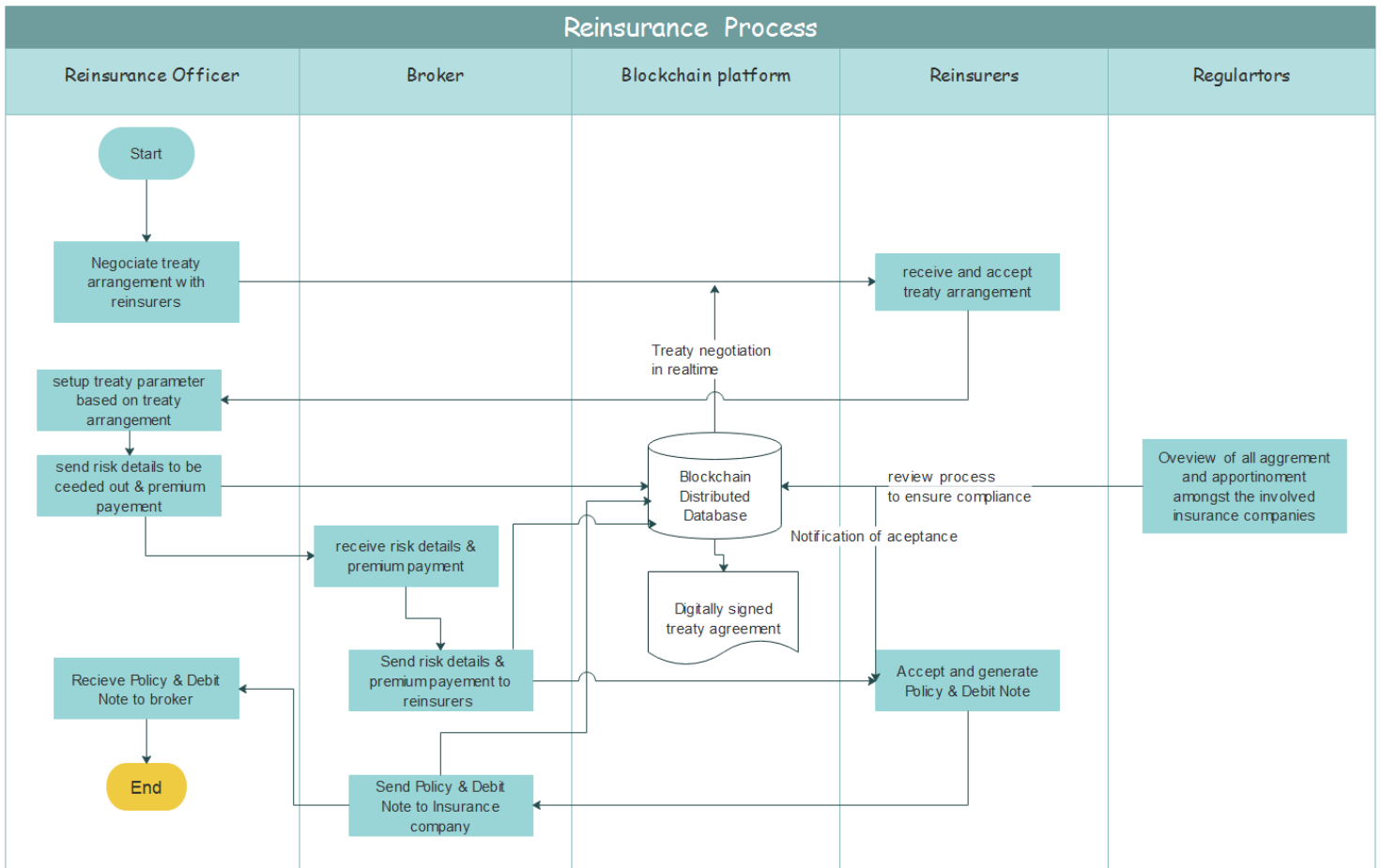
Figure 15: Reinsurance process using Blockchain. (To - Be Process)

4.2   Business Factors for Insurance Consideration for Blockchain Adoption

Many insurance company are focused on private/ permissioned blockchain [27] [28] [55] since it allow only a selected group of participants which can be identified. By leveraging on the advantages of its database architecture, organization can get a better performance with specific ledger architecture when compared to public blockchains and since it allows for customization of organizational specific requirements like automating contract agreement between relevant parties using smart contract etc. then organization can maintain better control. It also allows for greater transaction throughputs and support decentralized market exchange with lower transaction cost and most use cases discussed in chapter 3 were considered or implemented on a permissioned blockchain.

Organizations are concerned about [59] possible business use case, business requirements such as scalability, speed, privacy, security, risk exposure level, efficiency of transactions, reduced operational risk, etc. in the consideration of a specific platform to adopt. Permissioned blockchain are more suitable for data protection regulation compliance including the EU's GDPR [28] [93] since it has the ability to restrict participants involved in the consensus mechanism on its network. As concerning payment, there would also be the consideration of exposure to currency exchange fluctuation for transaction payment.

The successful introduction and implementation of the distributed ledger technology would introduce key resources like smart contract which would replace Agents and brokers shown in Figure 16 in most of the underwriting and claims processes. It would also help deliver on the value proposition and ensure transparency and full visibility to the customer. In the next section we consider the challenges in blockchain adoption and compare current and future process changes.

The Insurance Business Model Canvas (As – Is Model)

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
• consumers • Investors • Brokers • Reinsurance companies	• Providing Insurance • customer Marketing and sales • Product development	• corporate and Personal Insurance • Brand status • convenience and different frequency of payment • accessibility • Prompt claims payment and Trust	• 24 hours customer service • Sales Agents	• Mass Market • Business to Business (B2B) • corporate client
	Key Resources • Human Resources and experts • Agents and Brokers • • Legacy ICT systems		*Channels* • Social Media • Sales Agents and Brokers • Digital channels e.g. web solution, mobile Apps etc. • Local event	

Cost Structure	Revenue Streams
• Co-Insurance premium • Marketing • Claims payment • Operational and underwriting expenses • brokerage fee and handling	• Premium Payment for Insurance cover • Premium Investment returns • Investor Income

Figure 16: Current As-Is Insurance Business Model

4.3   Challenges in the adoption of Blockchain

Every technology comes with varying form of challenges in its adoption. Most analyst believes that one of the major concern in the adoption of blockchain is in terms of security. There is a higher risk since current blockchain platform are public. There would be need for permissions and access management, rule setting, network dependency and monitoring, validation and fraud detection, patch management, membership management, encryption and identity management and business continuity planning. Some expert also wants to see how well blockchain can integrate with legacy systems to reduce total cost of its implementation.

Igor Kabashkin [103] beliefs since organizations have various complex business rules and regulatory obligation to be taken into consideration, then the big question would be how organization can introduce blockchain and propose the need for a blockchain access layer.

Some discussed concern for the adoption of blockchain adoption in the insurance industry includes during the literature review includes:
1. Security vulnerabilities
2. Data privacy
3. Lack of skilled personnel

4. Regulatory uncertainty - improve technical standard would create a "tipping point" for widespread adoption.
5. Scalability – computing power

Despite this concerns, EY [108] advise for insurance companies to get prepared by educating their workforce, starting small and be able to seize relevant opportunities. Allianz Group Chief Digital Officer, Solmaz Altin believes "In our journey to become more digital, Blockchain promises to help us create more transparent, more convenient and faster services for our customers"

4.4 Summary / Discussion

In comparison of traditional current process and implementation of blockchain, we see notable difference in cost, simplicity of process, required number of manual processes etc. in Table 3.

Process	Current As – Is Process	Process Implementation using Blockchain
Customer Onboarding process	Central management of client's data in multiple systems. KYC onboarding process is repetitive for each business transaction and independently managed by each insurance company. Data duplication and manual process. Average time for customer onboarding is about 5 days.	Full ownership and control of customers identity by client including medical data [63] [69] KYC process is seamless and take less than 5 minutes. KYC details can also be shared across multiple insurance companies. Improved documentation process and history.
Policy Underwriting (U/W)	Brokers play key role in the U/W process and negotiation of agreed premium. Little or no relationship between the insured and insurance company. Proof of Insurance process requires paperwork and can take a minimum of 1day to complete.	Proof of Insurance can be done using smart contract. Support for real time communication with other stakeholders.
Claims Processing	Claims validation process takes a long time and relies completely on human judgement. Multiple systems used in processing claims in a case of a co-insurance business. Market characterized by too many fraudulent claims transaction and multiple claims request on a single policy.	All involved parties in real time can transact and complete the claims transaction Cost saving in faster payment reconciliation. Ability to reduce and defect fraudulent claims using the DLT to store claims history.
Reinsurance Process	Most of the reinsurance process is controlled by the lead underwriter leading to administrative delays. Lack of an integrated system for automatic information distribution to reinsurer and relevant parties.	Smart contract encoded rules is used for automation and control of the reinsurance process flow. Easy transfer of information amongst all participating stakeholders including regulators. Estimated cost saving of about $100 million annually in Facultative reinsurance.[109]

Table 3: Comparison of the current processes with future outcome using Blockchain technology.

To answer our last two research question below,

1. **SUB RQ4**: *What "innovation patterns" can be discerned?*
2. **SUB RQ5**: *What are the possible limitation in the implementation of Blockchain technology?*

We have been able to demonstrate from the To-Be process flow map, the innovative patterns which blockchain would introduce in the industry. These includes increase trust, reduce fraud in the industry, automate the sub processes of the value chain and support the customer's quest for full control of their identity data. It would also lead to new risk and emergence of new market and product [101] in the industry like P2P insurance, Index based insurance . Historical information for storage and analysis in combination with other technologies would mean the insurance industry would need to start driving revenue not by being a risk

4.5   Threat to Validity

Threat to Validity here refers to the degree with which correct inference and interpretation was made from my research result.

To begin with, I used the Kitchenham Systematic Literature Review in conducting my literature review. This was chosen since the concept of evidence-based software engineering (EBSE) recommends Kitchenham Systematic Literature Review for aggregating evidence.
In total, I analyzed 1000 literatures by using Google scholar. Google scholar only shows a maximum 1000 result. My main key search word was *("Blockchain" OR "Distributed Ledger technology") AND ("Insurance")*
My choice of using google scholar as the main source to search for the literature was that blockchain was still relatively new and it made reference to the other various educational libraries including SpringerLink, IEExplore, ACM Digital library, Wiley Online Library and HeinOnline, CEEOL.

To avoid selection biases, I ensured I checked all 1000 papers during my search one after the other. The number not available for download using the university license and those not in English language were automatically excepted. The selection criteria used was majorly those that covered blockchain as it relates to insurance with relevant use cases. Also, papers relating to the security risk, challenges of adoption of blockchain and articles from industry and world leaders in the insurance industry were included. Available papers were from the globe were leading insurance market exist including the US market, Europe, Asia, Africa and Australia.

This means the final set of papers selected gave a holistic approach to the topic and ensured the research question was well discussed in detail. Also, all the steps used in producing the selection result is well explained and documented in chapter 3 of the thesis.

The process can be repeated by following the defined steps in chapter 3. The research objective was well stated in chapter 3. My aim was to be able to propose a new process flow for the main value chain for the insurance industry. Understanding the market dynamics for insurance globally was put into consideration. A data extraction sheet was used with the following column headers:

1. Name of paper
2. Author(s)
3. Year of publication
4. type of paper
5. number of citation of paper
6. Processes to be changed by the paper
7. Prototype implemented / conceptual / WIP
8. Applicable use case
9. Quality Assessments
10. Stated Value
11. Who would gain this?
12. How would they gain this?
13. Limitations / challenges
14. Highlight mentioned in the paper

The link to the sheet is available online

https://docs.google.com/spreadsheets/d/1DFh1T4xam4xAA3yPKMy2q09YiFF68y8JBRprMVIIam4/edit?usp=sharing

Since blockchain was relatively a recent technology, to ensure clarity and preciseness in my research, my search result was limited to papers from year 2016 only as I noticed papers from past years were more focused on bitcoin and cryptocurrency only. Also, the subject was still in it early stage with too many wrong hypothesis and contradictions.

Yearly report and papers from more than 10 industry leaders and consultancy firms (e.g. McKinney, PwC, Deloitte, Cognizant, PwC, Deloitte, Capgemini, Accenture etc.) driving on the adoption and implementation of blockchain was included as additional materials in this thesis.

One limitation I would mention would be that blockchain implementation is yet to provide implementation statistics ad Metrics. Metrics like cycle time in completing a large-scale transaction, measure of possible penetration test of a blockchain application to confirm its encryption and security. I expect such information would be public in the coming years with more use cases either fully tested or already gone live in the industry.

5. Conclusion

The digital revolution is already here. Technology is powering businesses and opening new channels and risk for the global economy. The future for blockchain in the insurance industry though still in the development stage, would scale and improve the current value chain and business model. As at the time of writing, we have already seen the few possibilities of blockchain in terms of lowering operational cost and automating redundant process. Amongst the top 12 fastest advanced growing technologies to be used in 2020, blockchain showed the highest growth rate of 110% [17]. Blockchain have evolved beyond just bitcoin or cryptocurrencies into a trusted ledger for handling different transactions.

Permission blockchain network would provide users visibility and reduce counterparty risk making the claim process as transparent as possible. The possible elimination of better still improved service delivery from the middle men (e.g. brokers) remains a big and growing concern to the adoption of blockchain. The lack of support from government and supporting framework including the slow curve in the adoption of a new technology are few of the challenges it would have to overcome in the coming years. The huge initial cost in blockchain also highlights why currently more interest seems to be coming from the financial sector. Most of the uses cases have been tested on small scale transactions. Insurance transactions are mostly huge and can cut across different continents with different time zone and currency. Using a consensus-based validation and continuous replication of data means more hardware requirements and increasing computational power. Also, current values shows a limitation [110] of 15 transactions per processed (tps) on Ethereum blockchain when compared to visa payment network of 2,000 transaction per seconds though permissioned /private blockchain have shown better result in lab test like IOTA [101] launched in 2016 to handle larger transactions. This gives a glimpse of hope that blockchains in the future would greatly be improved to handle large scale transactions.

The push for an active collaboration and strategic partnership [35] amongst the industry players would create the need for more use cases and PoW thereby providing the tipping point for more knowledge sharing. IBM [91] suggests that any sector that involves multiple parties and the need for accurate record of date and time of each transaction, would be most suitable for blockchain. This means blockchain would most likely have an impact in the insurance sector though some statics still shows the lack of willingness to collaborate [59]. The lack of industry expertise is a grey area for consideration. Setting up smart contract, configuration, deployment and monitoring this platform requires highly skilled personnel. Wider adoption would hence lead to more expertise. Experfy [93] for example is already proving a solution to enable you audit your smart contract. BlockBench [61] on the other hand provides a means of comparison for different private blockchain platforms and enables deeper understanding of different system design choices.

Known security and operational concerns [83] [102] [103] like digital identity theft, Chain death spiral (CDS), 51% Attack etc. must also be addressed and the provision of an operating standard. The inaugural meeting of ISO TC 307 [96] blockchain and electronic distributed ledger technologies in 2017 with 35 participating members and 12 observing members is a welcome

development since the leading challenge to its adoption is the lack of industry standard [82][111] [93]. Guidelines from [87] international organization like OECD are also possible consideration.

The architecture of blockchain [94] and how data is stored [39] also raises concern about data manipulation, data control and privacy. Furthermore, many government regulations do not support national data to be distributed in different location around the world. Already the UK government have proposed plans to regulate the crypto technologies and might extend this to distributed ledger technology also. Blockchain stores data which is immutable and new regulations likes the GDPR [28] requirements which requires customer's right for erasure of data would be of conflict. There are suggestions of handling some transaction off-the chain [39] and the adoption of permissioned ledgers. This type of ledger has a control group of users but with no incentives, mining incentive would have to be figured out .

The need for automations of business process and the fusion of trust and openness in all insurance transaction gives room for blockchain to make a big impact [40]. In addition, blockchain implementation would lead to a cultural changes in business approach and operations [59]. Don Tapscott expects to see some form of leadership by managers and CEO's to enable this drive. Already Insurtech startups are driving the market. PwC [1] predicts a 30% of the new emerging market will move into the developed world to become global insurer.

This thesis has been able to show that indeed blockchain can be used in the insurance industry for process innovation. The objective was to explain the current insurance model and how blockchain can bring support and enable innovation in the value chain of the industry invariable giving rise to a new business model (To – Be) with more innovative sub -process. The theoretical proposition and suggestion made would be a starting point for future research. Hence, we have answered our Major Research Question (RQ).

In conclusion, the world insurance report for 2017 clearly proves the changing customers behaviour and preference for insurance. It believes insurers must invest in the right technology to stay relevant for the future and have a comprehensive Insurtech strategy for stronger collaboration and partnership.

Future research would need to focus on testing some metrics by experimenting blockchain on a large-scale transaction. The B3i group would be expected to provide such drive and statics from their project involving the top tier insurance companies.

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Data extraction sheet for all the materials used for literature review can be downloaded here https://docs.google.com/spreadsheets/d/1DFh1T4xam4xAA3yPKMy2q09YiFF68y8JBRprMVIIam4/edit?usp=sharing

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Appendix

I. Abbreviation and Glossary

- Peer-to-Peer (P2P)
- Decentralized Autonomous Organization (DAO)
- Proof-of-Work (POW)
- Proof of Stake (PoS)
- Proof -of-Concept (PoC)
- Decentralized apps (DApps),
- Timestamp: The time a transaction is requested
- Distributed Ledger Technology (DLT)
- Property and Casualty insurance (P&C)
- Mutual Distributed Ledgers (MDLs)
- Know Your Customer (KYC)
- Anti-Money Laundering (AML)
- Distributed Database Management System (DDBMS)
- Create, Read, Update and Delete (CRUD)
- General Data Protection Regulation (GDPR)
- Machine-to-Machine (M2M)
- Blockchain Insurance Industry Initiative (B3i)
- General Data Protection Regulation (GDPR)
- The Organization for Economic Co-operation and Development (OECD)
- Autonomous Decentralized Peer-to-Peer Telemetry (ADEPT)

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