Blockchain Technology: A new development paradigm? Implications for finance, corruption and voter fraud.

By Dr. James Mulli
European Business University of Luxembourg

Blockchain fundamentals and challenges of understanding

Blockchain technology is not an easy concept to grasp. Essentially, Blockchain technology is difficult due to the “simple” fact that its complexity is what makes it unique. It is essentially the largest consensus algorithm on the planet and it is at work right now. However, this complexity does not understate the urgency of being able to understand how Blockchain can fundamentally alter the political, social and economic landscape. This paper will survey the social and economic implications of Blockchain technology on finance, fraud and social corruption, while providing proof of concept real use cases being enforced today.

Let us begin this understanding with a fundamental understanding of why this new technology has attracted so much attention. Beyond the speculative “gold rush” of Bitcoin, the true story lies not in Bitcoin, but in the underlying Blockchain technology and its potential to change how transactions such as voting, finance and recordkeeping are conducted. But first some rudimentary questions and insights are in order.

Rudimentary understanding

How is it that we have come to accept voting results, financial transactions, bills of lading, letters of credit and others that are scripted on paper to be valid? How is it that we have come to embrace the validity of elections, financial statements in the form of a balance sheet or an income statement or a cash flow statement presented to us by financial and election auditors? When we look at our bank statements and all types of audit reports, we are faithful to the record keeping method that has been presented to us, in that it reflects the value of what we hold in trust being in the hands of multiple parties and intermediaries. The failing of the aforementioned multiple intermediaries is the fundamental problem faced by developing and developed countries. When check, balances and enforcement are weak or lacking, a new trust protocol called Blockchain has quickly come to the fore and presented new applications for trust. As alluded earlier the technology is not easy to grasp, but we must not be dissuaded by this fact, but find reason to understand due to its importance.

What is the Blockchain?

A simple explanation to the very complex computing is that the Blockchain is an electronic ledger. In financial accounting a ledger is a document that records transactions through a system of credits and debits. These are transactions, which are audited in order for them to verify and match all inflows and outflows. In Blockchain voting, the process is similar, however, each transaction is unique and identifiable through a hashed encryption code with 64 characters. A hash being a function that maps data of any size into a fixed size. But let’s take a step back and remember that each time a document is sent over the internet, the transmission is only a copy. Therefore, what the blockchain effectively does is allow only one original version of any transmission to be sent by the assignment of hashed encryption code for its unique identification. Without getting too technical, the encryption code is called a Secure Hash Algorithm (SHA), something similar to your password but much longer. Essentially the SHA256 Hash is one of several cryptographic hash functions that are used as your signature, one public and the other private. The cryptographic hash algorithm generates an almost-unique, fixed size 256-bit (32-byte) hash. Because of the mathematical challenge the security of SHA256 is almost impossible to crack with 36^64 possible values equaling log2(36^64)≈330log2(36^64)≈330 bit key strength.

Now take that one step forward again and consider a document being monitored or continuously audited in a ledger of information. This ledger is in a group file called the Blockchain. The auditing is done not by a centralized authority but through a distributed network of independent individuals spread globally using encryption technology that is virtually impossible to crack and not only decentralized but as mentioned, distributed. The security of the system is immutable, meaning it cannot be changed, and in essence, also serves as the underpinning of cryptocurrencies. When it comes to the excitement over Bitcoin, essentially the cryptocurrency offers an unparalleled efficient means of transferring money over the internet and is controlled by a decentralized network with a transparent set of rules, thus presenting an alternative to central bank-controlled fiat money. The solving of what has been referred to as the Byzantine Generals Problem, became the mathematical equivalent of a landing on the moon.

A brief History

Also referred to as achieving Byzantine Fault Tolerance, this proved to be one of the most difficult challenges addressed by blockchain technology. Byzantine Fault Tolerance means that two nodes (computers) can communicate safely across the internet or network, knowing that they are displaying the same data at the same time[1]. This is quite complex and contrary to popular belief, Satoshi Nakamoto wasn't the first person to solve the Byzantine fault tolerance dilemma. What he presented in his paper Bitcoin: A Peer-to-Peer Electronic Cash System is one widely used application that has successfully applied the Byzantine general's dilemma.

The first practical solution was represented by Miguel Castro and Barbara Liskov in 1999 with the Practical Byzantine Fault Tolerance [2] (PBFT) algorithm. Miguel Castro hailed from Microsoft Research and Barbara Liskov from MIT Laboratory for Computer Science. The Agreement Problem another name for the PBFT was noted as a fundamental Problem in Distributed computing system. This was essentially, to achieve overall system reliability in the presence of a number of faulty processes. In this, processes were to agree on some data value (called a Decision) that is needed during computation. Interactive consistency, source congruency, error avalanche, Byzantine agreement problem, Byzantine generals' problem, and Byzantine failure all refer to the same challenge and are a condition of a computer systems, particularly distributed computing systems, where components may fail and there is imperfect information on whether a component has failed. The term takes its name from an allegory, the "Byzantine Generals' Problem", developed to describe this condition, where actors must agree on a concerted strategy to avoid catastrophic system failure, but some of the actors are unreliable.

This process was formalized by Robert Shostak, who dubbed it the *interactive consistency* problem. This work was done in 1978 in the context of the NASA-sponsored

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[1] *Kirrmann, Hubert (n.d.). "Fault Tolerant Computing in Industrial Automation"). Switzerland: ABB Research Center. p. 94. Archived from the original on 2014-03-26. Retrieved 2015-03-02.*

[2] Castro, Miguel & Liskov, Barbara. (1999). Practical Byzantine Fault Tolerance. OSDI.

SIFT project in the Computer Science Lab at SRI International. [3] SIFT (for Software Implemented Fault Tolerance), and was the brain child of John Wensley, who based it on the idea of using multiple general-purpose computers that would communicate through pairwise messaging in order to reach a consensus, even if some of the computers were faulty.[4]

Together with Leslie Lamport who wrote the seminal paper, *Reaching Agreement in the Presence of Faults* [5] the authors were awarded the 2005 Edsger W. Dijkstra Prize for this paper.

To make the interactive consistency problem easier to understand, Lamport devised the colorful allegory.

The Generals Problem

A group of army generals formulate a plan for attacking a city. In its original version, the story cast the generals as commanders of the Albanian army. The name was changed, eventually settling on "Byzantine", at the suggestion of Jack Goldberg to future-proof any potential offense giving. This formulation of the problem, together with some additional results, were presented by the same authors in their 1982 paper, "The Byzantine Generals Problem".[6]

In its simplest form, the generals must decide only whether to attack or retreat. Some generals may prefer to attack, while others prefer to retreat. The important thing is that every general agrees on a common decision, for a halfhearted attack by a few generals would become a rout and would be worse than either a coordinated attack or a coordinated retreat.

The problem is complicated by the presence of treacherous generals who may not only cast a vote for a suboptimal strategy, they may do so selectively. For instance, if nine generals are voting, four of whom support attacking while four others are in favor of retreat, the ninth general may send a vote of retreat to those generals in favor of retreat, and a vote of attack to the rest. Those who received a retreat vote from the ninth general will retreat, while the rest will attack (which may not go well for the attackers). The problem is complicated further by the generals being physically separated and having to send their votes via messengers who may fail to deliver votes or may forge false votes.

I n the paper *Reaching Agreement in the Presence of Faults,* the authors were pivotal to Blockchains emergence, and the rest is history.

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[3] "SIFT: design and analysis of a fault-tolerant computer for aircraft control". *Microelectronics Reliability*. **19** (3): 190. 1979.

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[5] Pease, Marshall & Shostak, Robert & Lamport, Leslie. (1980). Reaching Agreement in the Presence of Faults.. J. ACM. 27. 228-234.

[6] Lamport, Leslie & Shostak, R. & Pease, M.. (1982). The Byzantine general problem. ACM Trans. Programm. Lang. Syst.. 4. 382-401.

The application of Blockchain is multifold as some of the following real-world cases illustrate:

Real use cases: Blockchain voting

A survey conducted by IBM and the Economic Intelligence Unit have shown that government interest in blockchain is increasing[7]:

- 9 in 10 government organizations plan to invest in blockchain for use in financial transaction management, asset management, contract management and regulatory compliance by 2018[8]
- 7 in 10 government executives predict blockchain will significantly disrupt the area of contract management[9]
- 14 percent of government organizations expect to have Blockchains in production and at scale in 2017[10]

Real use cases: Georgia – Blockchain Land Registry

The government of Georgia has started using blockchain to register land titles and validate property-related government transactions.

Real use cases: UK – Blockchain-as-a-service, Welfare payments

Blockchain-as-a-service has been made available for purchase through the UK government's Digital Marketplace.

In 2016, the Department for Work and Pensions began a trial to use blockchain technology. Claimants can use a mobile app to receive and spend benefit payments, and with their consent, transactions are recorded on a distributed ledger to support their financial management. UK government's chief scientific adviser Sir Mark Walport has highlighted in a report how blockchain can help in areas such as reducing benefit fraud, protecting critical infrastructure and registering assets.

Real use cases: Estonia – Blockchain identity management, e-voting, electronic health records

Estonia is considered to be a leading nation in the adoption of blockchain technology. Estonia citizens and e-residents are issued a cryptographically secure digital ID card powered by blockchain infrastructure on the backend, allowing access to various public services. On a blockchain platform, citizens can verify the integrity of the records held on them in government databases and control who has access to them. Earlier this year, Nasdaq

[7] https://public.dhe.ibm.com/common/ssi/ecm/gb/en/gbe03801usen/GBE03801USEN.PDF
[8] Ibid, Page 2
[9] Ibid, Page 2
[10] Ibid, Page 2

successfully completed a trial in Estonia that will enable company shareholders to use a blockchain voting system.

Estonia is also adopting blockchain technology to secure the country's 1 million health records. Every update and access to healthcare records is registered on the blockchain, preventing medical fraud and making it impossible for hackers to hide their trail. It also provides real-time alerts to attacks, enabling the government to respond to incidents immediately before large-scale damages occur.

Real use cases: Singapore – Blockchain interbank payments

The Monetary Authority of Singapore (MAS) has successfully completed a proof-of-concept pilot to explore the use of blockchain for interbank payments.

Real use cases: Dubai – Global Blockchain Council

Dubai has set up the Global Blockchain Council to explore current and future blockchain applications. The council currently consists of 47 members from both the public and private sector and launched seven blockchain proofs-of-concept trails, covering health records, diamond trade, title transfer, business registration, digital wills, tourism engagement and shipping.

The Crown Prince of Dubai has also announced a strategic plan that would see all government documents secured on a blockchain by 2020. The Dubai government estimates that the blockchain strategy has the potential to save 25.1 million hours of economic productivity each year.

Real use cases: Delaware, USA – Smart blockchain contracts, public archives

In 2016, Delaware became the first US state to embrace distributed ledger technology.

What is the trust protocol?

In all of the aforementioned cases, Blockchain has been implemented due to failings or efficiency in the role of multiple intermediaries. Therefore, checks, balances and enforcement were weak or non-existent and Blockchain presented new applications for trust. Trust in society is the bedrock of all transactions. Without trust, intermediaries, who act as custodians, would not exist. Let us begin by continuing our understanding with a reliance on historical perspective. How is it that we have come to accept financial transactions, bills of lading, letters of credit and others that are scripted on paper to be valid? How is it that we have come to embrace the validity of financial statements in the form of a balance sheet or an income statement or a cash flow statement presented to us by auditors? When we look at our bank statements and audit reports, we are faithful to the record keeping method that has been presented to us, in that it reflects the value of what we hold in trust being in the hands of multiple parties and intermediaries.

The historical origins of centralized trust

If we were to wind back the clock and gaze through the historical lens into what we claim to be early systems of trust between individuals and their transactions, we can find what led to a trust acceptance by society. Among others, it was a trust-based accounting system in Hammurabi's Babylon, in the form of accounting ledgers that established this very trust that became the bedrock of civilization. Included is the double entry system of bookkeeping established by Luca Bartolomeo de Pacioli in the late 1400's in Europe, which went on to improve upon new ways of structuring the economy in which the value of these systems has proved themselves beyond question today to the corporate financial world. This is not to say of course that these systems do not have their flaws, nor is it a statement that these systems are not manipulated today. However, it is a statement that trust is the underpinning of our financial and social system. Let us not fail to mention early trust systems established in other ancient kingdoms like China in the Western Zhou Dynasty that predate the aforementioned and reached a peak of sophistication as early as 1100 – 771 B.C.,[11] the Egypt Civilization during 1000-3000 B.C. and its use of trust systems and early Islam Accounting Systems dating 652 A.D. which also established the same underpinning for commerce.

In the face of history, another new form of bookkeeping might seem like a dull achievement. However, when we consider the monumental instances of theft involving tampered records such as Enron and Worldcom or Wellsfargo with fake accounts or consider Lehman Brothers and repo105 being all endorsed by its auditor, Ernst & Young, perhaps another trust protocol is needed. With Lehmen Brothers, faith in a centralized system triggered the biggest financial crisis in the year 2008 with banks in the US and Europe also having misreported their positions.

While the trust order and centralization of transactions are being redefined into our modern norms of interpretation, the focus however is mostly on the fanfare associated with cryptocurrencies. As stated before, the real promise of Blockchain technology is not in the financial speculation that is rampant in the crypto currency markets. The true promise of this technology is in achieving what Thomas L. Friedman unwittingly meant when he said, "The World is Flat". If indeed we have a level playing field, whereby Blockchain technology is equally at everybody's disposal, then in this equation, the prospects for all laggards in development must be redefined. For example, over two billion people are locked out of essential services such banking because of the latter being unable to ascertain identities and

[11] Maxwell Aiken and Wei Lu
The Accounting Historians Journal
Vol. 20, No. 2 (December 1993), pp. 163-186

assets. These bottom billion in the developing countries of the world have new hopes when trust becomes decentralized.

Development paradigms, infrastructure, brief colonial history, neo colonialism

Let us apply our understanding of technology to the early underpinning of Walter W, Rostow and his 5 stages of economic development, 1) traditional society, 2) preconditions to take-off, 3) take-off, 4) drive to maturity and 5) age of high mass consumption. Essentially, all technology enables a leap-frog or at the very least an acceleration effect within these stages. Traditional society therefore may indeed bypass the preconditions and witness a takeoff. Do nation states need landline telephones or do mobile telephones suffice? Do small businesses need a bank in order to conduct financial transactions or does mobile banking suffice? This discussion can be extended to other social, economic and political forums.

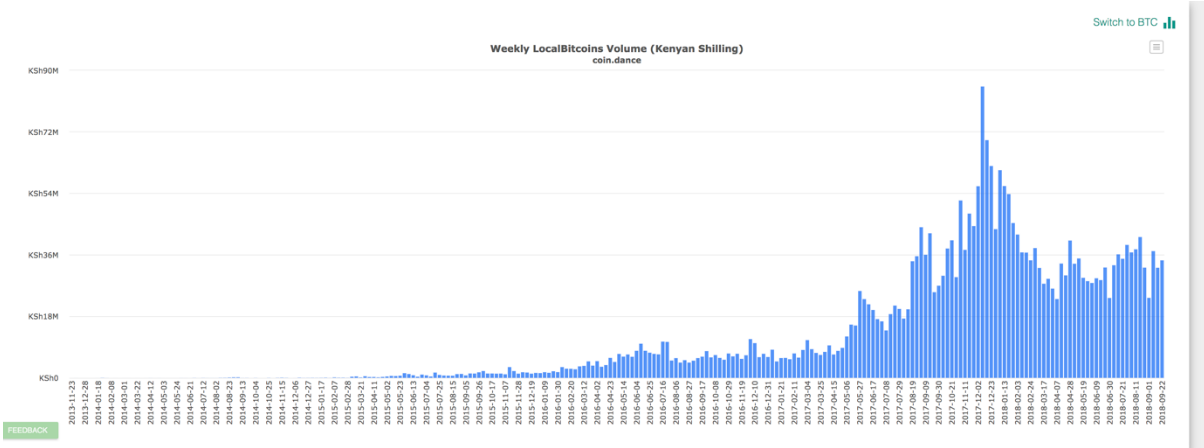
The Harrod- Domar theory of saving and productivity of capital as well as discussions of warranted growth, actual growth and natural rate of growth all need to be revisited to allow for a discussion on labor intensive and capital-intensive productivity. How does Blockchain fit in the Ricardian Growth Model? Is comparative advantage a reality in a borderless system of trade where location is not the rule? In this very respect Euro-centricity is a non-item and perhaps as antiquated as Malthusian theory in the context of population, land and the debunking role of technology.

At the heart of this discussion on the penetration of technology, it is without a doubt that infrastructure challenges are self-evident not in the lack of sea bed fiber optic cables and satellite dishes, but inward penetration and proliferation. Although Mobile technology penetration has emerged like a beacon of light, penetration lags behind. These failings have perhaps ironically also been the root cause for the aforementioned emergence of a well-established mobile banking culture in East Africa. Without landlines mobile technology leapt forward and reframed our understanding of how mobile telecommunication, that is more pervasive than in more developed countries can propel banking and thereby economic growth. So, what does Blockchain promise in term of adoption for early adaptors? If mobile technology was a leapfrog into mobile banking and financial empowerment, can Blockchain prove to be the spring-board effect for a redefinition of political, social and economic development paradigms?

Financial real-world use cases and application in Africa

If technology lives up to its speed, by the time this paper is read the data and facts on Africa will have moved forward very fast. At the time of writing Cross-border volume via one exchange - localbitcoin.com, in Kenya, topped over KES 80 Million per week on December 2nd 2017 with an average of KES 1.728 billion per year. This figure is a far cry from Kenya's mobile commercial transactions being valued at KES 1.1 trillion in 2017 and growing by 53 percent quarter on quarter[12].

[12] https://www.capitalfm.co.ke/business/2018/04/kenyas-mobile-commerce-transactions-value-hit-sh1-1trillion/



[13]

With alternatives to the banking system, Localbitcoins.com, localethereum.com, Bitpesa, and new and upcoming competitors such as ripple and IBM, show us that the development paradigms are shifting.

In the world of finance, Blockchain technology will find its path of least resistance, due to the very nature of the incentives inherent. Therefore, Blockchain technology can be used in assisting developing economies in many areas to facilitate transactions. Furthermore, the one area that will find a positive outcome in this disruption is that which most perturbs development efforts, financial corruption. Although it may not completely succeed in eliminate the draining effects of corruption, it can markedly reduce its encroachment. Initiatives the organization blockchan.ge of New York University's Governance Lab closely examining the social benefits of the new technology.

When it comes to public resources and their misappropriation, the use and application of Blockchain transactions creates the transparency and traceability of each and every transaction transactions. In a best use case example, the public projects in the Ukraine are moving towards making a blockchain-integrated government system beginning with procurement. In a move to tackle corruption and to improve efficiency and transparency, Ukrainian Minister of Finance, Alexander Danilyuk, announced a plan to ensure that all public service management in the sector is blockchain-based[14].

Through and Auction based trade system, the Ministry plans to sell government property and become, the first country in the world that uses the blockchain in selling state assets: to sell them transparently at the highest price and to make sure that there's no place for corruption. ***"We would like Ukraine to be the first country in the world that use the blockchain in selling state assets: to sell them transparently at the highest price and to make sure that there's no place for corruption. And I believe that the blockchain offers such opportunities. That's why I'm actively supporting the project Auction 3.0, which is done in partnership with Georgian Innovations and Development Foundation",*** the Minister explained. It will be wrong to assume that corruption is unique to developing countries alone or that it has declined on average. The prevalence of corruption can be well attributed to a

[13] https://coin.dance/volume/localbitcoins/KES

[14] http://forklog.net/ukrainian-government-to-use-the-blockchain-auction-for-selling-its-assets/

few factors, but most importantly the lack of effective monitoring and weak accounting information system.

When we consider cryptocurrency, the clear advantages that it has over (Mo) printed paper and minted coins, beyond the costs, is the mere fact that it eliminates multiple intermediaries and allows for digital identity to be established, as previously explained, through a private and public key, rendering all transactions immutable and traceable to the user of the private key. This level of transparency is unparalleled and harkens a new age of trust. Corruption will therefore be severely challenged once anonymity is removed and with the immutability of the data, tracing and enforcing the laws against corruption become less of a challenge.

Voter fraud and the Blockchain

Voter apathy, electoral fraud and institutional failures are the bane to any democratic form of government. As an example, the voting process in Kenya has taken a technological leap forward but may still be subject to manipulation. It is the intention of the Kenyan and all Electoral Commissions to drastically reduce of voter apathy, and in the case of Kenya, this is very feasible by leveraging the over 81%[15] mobile penetration. With a complimentary, not wholesale replacement of current systems, implementation of a trust protocol to enable Blockchain voting can reach 90% of the voter registered population of Kenya.

A ballot that is cryptographically represented within the blockchain has dramatically altered the costs-benefit analysis of disruption. Contrary to the trend, this particular technology not only dramatically cuts costs, but also increases voter turnout through convenience as this can be conducted on a mobile phone, ensures the integrity of the vote and empowers the voter to track and monitor their vote.

Because a blockchain is a distributed ledger of transactions is shown above, the information it records isn't stored once in a single system but many times across many independent nodes of the distributed network. This distribution of authentication therefore allows for an immutable and tamper-proof process. Once a vote has been secured and linked with aforementioned hashing algorithms and stored across thousands, millions, or perhaps one day billions of nodes, modifying it is theoretically impossible and would require a huge amount of resources and computation power that no single party could effectively bring together.

Historically, when a new technology is introduced to the general population, there is not only anxiety, but also a disruption to the norm. In addition, the increased costs of adoption are generally borne by early adopter seeking to leverage the change. These fears were evident with the concerns raised by the media when Internet banking was first introduced more than two decades ago. Internet banking is now a gold standard in Kenya

[15] http://data.worldbank.org/indicator/IT.CEL.SETS.P2

with mobile transactions accounting for close to 44% of GDP of $63.4Billion[16]. The cost efficiency of internet banking and Blockchain voting is the common denominator.

Blockchain technology and the use of the protocol can therefore be leveraged to bring an effective closure to electoral fraud and protect voter credentials through the creation of a secure end-to-end voting platform that not only offers convenience of use through, for example mobile applications, but also essentially ensures unparalleled transparent auditing through the aforementioned networked ledgers. Voters would eliminate the casting of votes in centralized locations; thereby reducing the 3.7 trillion Shillings costs associated with these centers for the 2017 elections used for the purchase of equipment and mobilization of personnel.

In addition, the convenience of this virtual vote mechanism when applied to a mobile platform would effectively raise participation rates with the unique quality of real-time viewing. Participation would be further augmented when the underlying Blockchains auditability features underpin the faith and trust in the results.

Present day elections are amenable to influence where Voters can possibly be intimidated to vote against their will. In many instances, the trustworthiness of the election process is itself uncertain. In such a situation, we need an election process that is fair, convenient transparent, and inexpensive. Blockchain technology provides a possibility to attain a highly dependable and certifiable election process.

Challenges of the Blockchain

Any system has its shortcomings and the Blockchain is no exception. However, the cost-benefit analysis dispels this uncertainty.

Technology poses problems since not all users are familiar or comfortable with its application. However, the blockchain technology can be implemented on the back-end for security and transparency purposes while maintaining simplicity and ease of use on the front-end for users. In addition, while the blockchain itself is may be very secure, the private keys and passcodes that ensure the security of user accounts (or wallets) can become a point of compromise if they are lost or if they fall into the hands of fraudulent users. This degree of fraud in the cost-benefit analysis is acceptable.

The last pressing argument for the consideration of Blockchain voting trials is that, with generational change, it is only a matter of time before internet voting and other application are made available as an option for all electors and users, simply as a response to public demand.

[16] https://qz.com/873525/safaricoms-m-pesa-has-kenyas-government-worried-what-happens-in-the-event-of-a-crash/

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