Final Report Submission for CCS Project (Term IV)

Submitted to

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Indian Institute of Management, Bangalore

For

Contemporary Concerns Study in

Post Graduate Diploma in Management Program 2016 – 18

Title of the CCS

Emergence and the impact of Blockchain Technology

Name of the Guide

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Submission Date

27 August 2017

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Acknowledgement

We would like to express our sincere gratitude to Professor Chetan Subramanian for his invaluable guidance in steering this paper in the right direction. His enthusiasm and support throughout the last four months were instrumental in our learning and getting this paper completed in good stead.

Objective of the CCS

The key objective of this paper is two-fold. The first is to synthesize a clear understanding of the Blockchain technology from both a technical and business perspective. Once we gain clarity into the concepts behind Blockchain, we will look at cryptocurrencies, especially Bitcoin, that is essentially a network on the Blockchain. We will address some of the key allegations against bitcoin such as “Bitcoin is essentially deflationary currency” and “Bitcoin standard is the next Gold standard”

Key takeaways from the paper

1. A clear understanding and appreciation of Blockchain technology.
2. Comparison of a Credit card transaction with Blockchain transaction
3. Introduction to Bitcoins, their similarity with Gold Standard
4. Popular misconceptions about Bitcoins and our critique of those arguments.

Introduction

Advancements in Information Technology have always had an idealistic, utopian spin to them. Some of the most important innovations in the history were sought by hard core technologists who single-mindedly focused on bringing about a revolutionary change to the status quo in the society. They primarily achieved this by reducing inefficiencies, cutting down the middle man, decentralizing power and giving everyone a voice. Telephones, Televisions, Personal Computers, the Internet, Mobile Phones – each one of these inventions fell into the broader themes of "decentralization", "redistribution of power" and/or "giving a voice for all" among others. So, it isn't all that surprising that early developments in Blockchain and Bitcoin revolve around similar utopian ideals.

Blockchain Technology

WHAT IS A BLOCKCHAIN?

A Blockchain is a vastly distributed, global, open, shared ledger or database that run on millions of devices, recording all transactions happening between any two parties. It does this efficiently and in a verifiable manner, essentially acting as a secure storage for not just information, but anything of value. [i]In simple terms, a Blockchain is a decentralized network for *value* exchange much like the internet of 90's which acted as a decentralized network for information exchange. The blockchain is considered to be a foundational technology that no single organization owns or controls. In this paper, we will try to understand more about the technology and the impact some of its derivatives, namely cryptocurrencies, have on the macro economy.

Before further breaking down the definition for Blockchain, it helps to put the technology in the context of some of the other well-known technologies of today.

	Organizationally Centralized	Organizationally Decentralized
Database Centralized	PayPal, Paytm	Blockchain
Database Decentralized	MS Excel, Photoshop.	Email

Figure 1 Categories of various technologies

"Organizationally Centralized" systems are software systems that are controlled by a single organization. "Database Centralized" systems are ones where the data is stored in a centralized database rather than multiple different databases. [ii]

The 3 quadrants in the red are examples we can recognize:

- PayPal/Paytm are examples of a single organization controlling the software system through a centralized database that is owned by them. By extension, all the internet banking services provided by existing commercial banks also fall under this category. These are cases of one large organization owning and controlling both software and the database all by themselves.
- MS Excel as a software is owned by Microsoft. But individuals using that application each store and control a separate copy of excel database on their computers.
- E-mail is an example of a "protocol" or a "standard" that is not owned by any one organization. And also, each individual user maintains separate databases of their emails.
- The blockchain is a first of its kind innovation where the technology is Organizationally Decentralized and also the system is logically centralized for everyone's access.

This explains a major part of the definition of Blockchain we saw earlier – "A Blockchain is a global centralized, shared ledger or database that run on millions of devices, recording all transactions happening between any two parties". The next part of the definition is that it is also a vastly distributed, open and shared ledger. Before we look at how Blockchain achieves this, it is critical to understand why we need such a system in the first place when all our existing platforms such as Paytm or onlineSBI seem to work just fine.

WHY DO WE NEED BLOCKCHAIN?

To fully appreciate the technology and its capabilities, it is important to understand why it is needed in the first place. And for that, we need to look at the inefficiencies and risks present in the existing systems.

Inefficiencies in the present-day systems are due to one major factor – presence of too many intermediaries. Consider a credit card payment system for example. There are at least 3 intermediaries who eat up a share of the price we pay for products. Let's look at this in more detail.

COMPARING CREDIT CARD TRANSACTIONS WITH BLOCKCHAIN TRANSACTIONS:

As seen in the diagram below, a single credit card transaction involves all of the following players - the credit card owner, his/her card-issuing bank (say HSBC), the credit card network provider (say Visa), the merchant bank that supports the vendor (say Citibank) and lastly the vendor himself (say the grocery store owner).

For illustration purposes, let's assume a transaction where a credit card owner pays $100.00 to a merchant for goods purchased, the merchant bank discounts 2% of the net transaction, leaving

only $98.00 for the merchant. The $2.00 discount is split among the intermediaries as fees – with issuer bank taking $1.70, credit card network taking $0.10 and merchant bank taking $0.20. [iii]

Clearly, in the absence of intermediaries, goods and services would be much cheaper and transactions could ideally be processed much more efficiently. To understand the situation better, we need to understand why these intermediaries exist and what value do they add to the transaction to deserve their $2 fee.

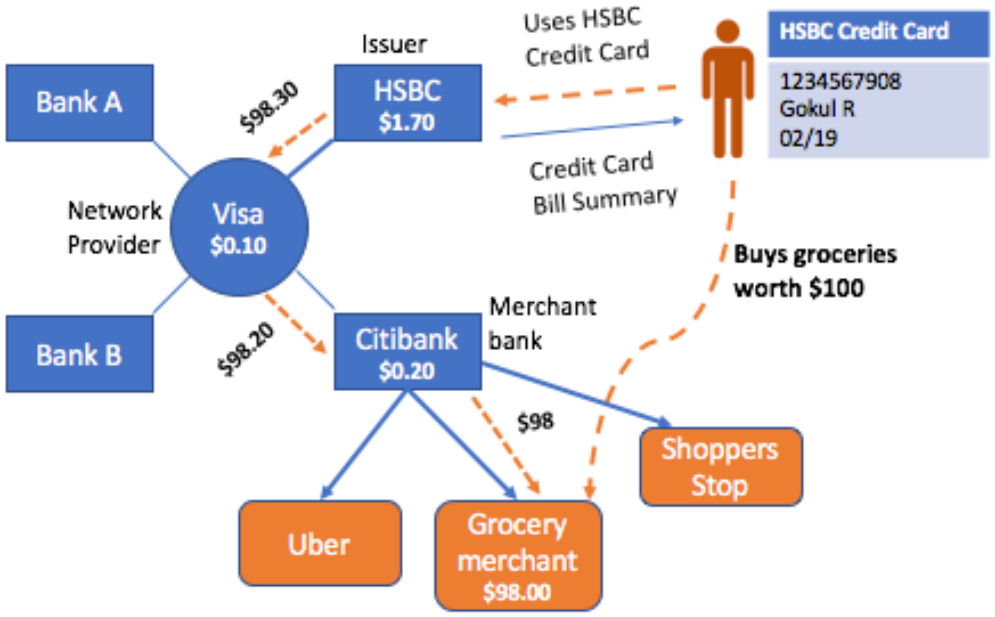

Figure 2 Flow of credit card transactions

ROLES OF INTERMEDIARIES

At a broad level, every intermediary, irrespective of their nature or the industry, provides the following benefits. They

- Establish Trust
- Verify Identities
- Process and Reconcile transactions
- Provide security & Prevent fraud
- Keep records of ownership

These are critical jobs that need to be performed and cannot be neglected. And for that, the intermediaries collect a fair fee ($2 in the case of a credit card transaction as above). However,

as the number of middle-men doing these jobs increases, the cost of per unit transaction goes up as well. That is the inefficiency that Blockchain is well suited to address.

Having seen the important roles performed by intermediaries, let's look in detail the issues associated with these intermediaries as in today's system.

Problems with Intermediaries

Intermediaries today are largely centralized systems (as seen in the 2x2 matrix in the above section). This means that they are immensely vulnerable to attacks and failures. Centralized systems, by design, have a single point of failure. This presents tremendous opportunities for malicious players to stage large scale attacks.

For instance, many flights in the airline industry load their auto-pilot software from a vendor's centralized database. This means a hacker only has to break into one system to launch a large-scale attack on multiple flights at the same time. Historically, we have also seen many examples of bad players breaking into bank accounts of hundreds of thousands of users threatening to steal or compromise anonymity.

All of the above and the fact that intermediaries typically have high transaction costs presents Blockchain a ripe opportunity to make a difference. A blockchain's distributed network means that a hacker must not just hack into one system to stage an attack but he must do it across the network before anything even remotely goes wrong.

How Blockchain establishes Trust?

By being Organizationally Decentralized - Database Centralized, Blockchain commoditizes trust. [iv] Every time there is a need to validate a specific transaction, "miners" enter a "mathematical race" to validate the transaction and add it to the Blockchain.

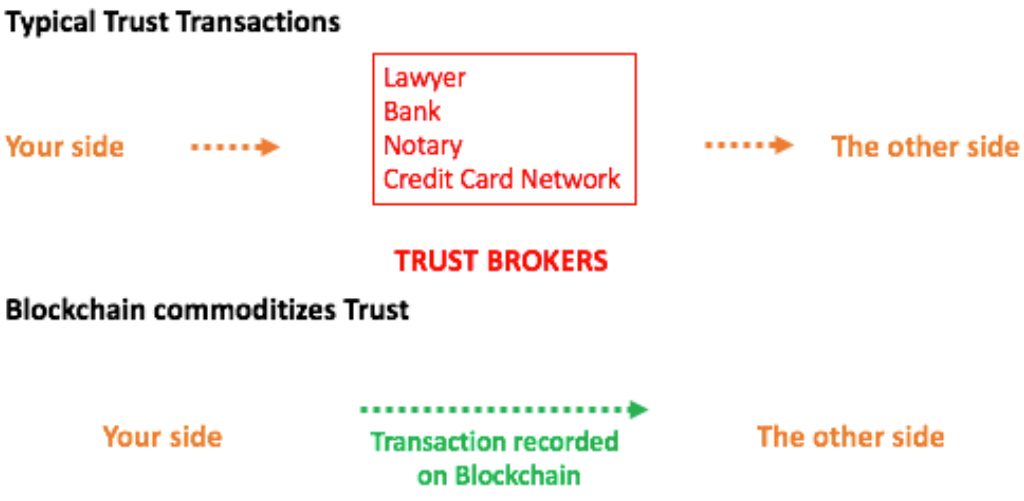

Figure 3 Establishing trust in Blockchain

Validation of a transaction here refers to verifying the following functions:

- The transaction was indeed initiated by the sender to the receiver
- The person spending the currency for the goods bought indeed has the requisite account balance to pay the merchant for the goods
- The spender doesn't indulge in any sort of double-spending
- No one has hacked into the spender's account and transferred the currency to themselves

The mathematical race not only verifies all of the above conditions but it also implicitly ensures transactions are securely done. Thus, the need for a central party to validate is eliminated and trust is commoditized in the Blockchain network. Once the transaction is validated and added to the Blockchain, a new Bitcoin gets mined and is added to the miner's wallet as a reward for validating. This, interestingly, is the only way how a new Bitcoin currency can enter the system.

If and when Blockchain reaches its full potential, we can expect the technology to disrupt several industries such as banking, law, music, airlines etc. where there is immense potential to disrupt traditional trust brokers and improve security.

A QUICK ASIDE ON BITCOINS AND MINING

Miners are hobbyists and tech hackers present all over the world validating Blockchain transactions by solving the mathematical problem released in the Bitcoin network. The release of a new Bitcoin is their financial reward/incentive to put in the necessary computational effort to validate the transaction. This release of new Bitcoin is also considered to be the "transaction fee" in the Blockchain world and it is expected to be lower than the transaction fees of present-day mechanisms.

Mining (validating) a "block" in the network started with a reward of 50 Bitcoins in 2009 (worth in excess of USD $214,000 today) and this reward is designed to get halved every 4 years. Today (from 2016), after 2 halving, the reward for successfully mining a single block is 12.5 Bitcoins.[v] The system is also designed such that 6 blocks of transactions are validated and added to the network every hour

HOW FAR ARE WE FROM SEEING THE TRUE POTENTIAL OF BLOCKCHAIN?

Before we look at the economic aspects of Bitcoin, a final note on the future of Blockchain. Since Blockchain is a foundational technology, very much in the same line of other foundational technologies such as PCs, the Internet, Smart Phones etc., we expect it to go through certain a similar evolution curve.[vi]

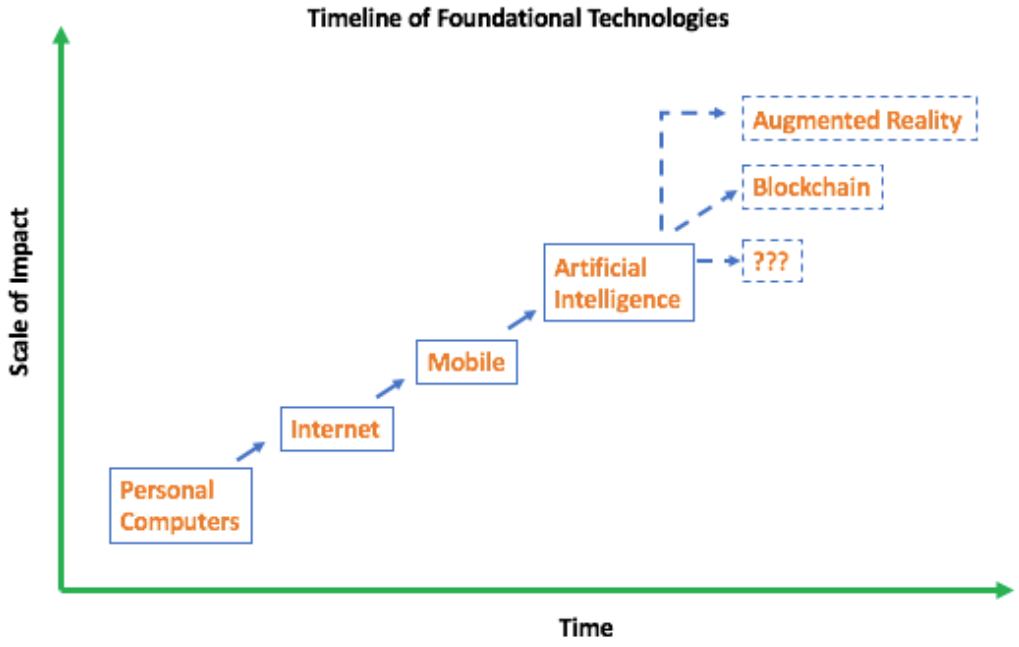

Figure 4 Timeline of Foundational Technologies

As mentioned in Dr. Lakhani's paper "The Truth About Blockchain", adoption of foundational technologies occurs in four phases in the order mentioned in the diagram below.

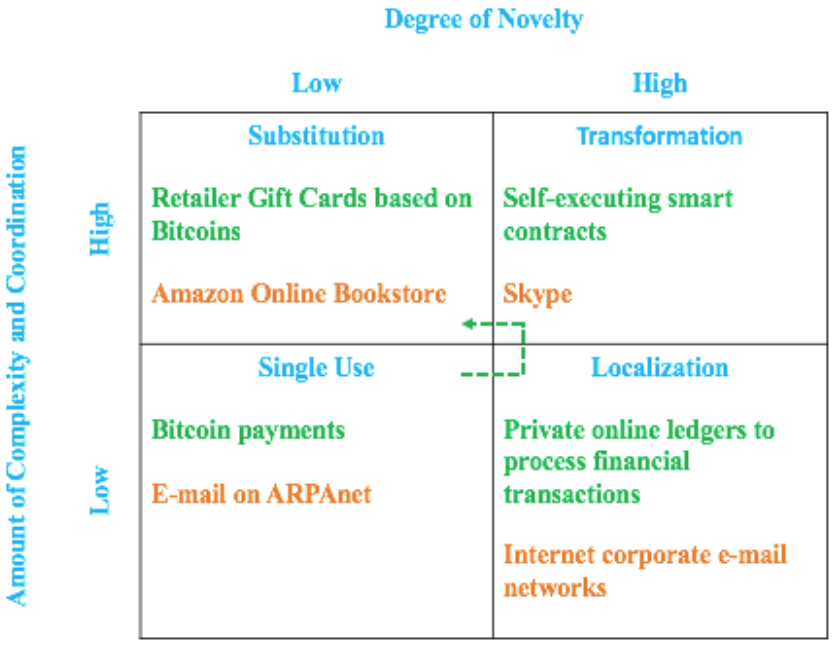

Figure 5 Adoption of fundamental technologies

Starting with "Single Use", they evolve all the way through to "Substitution" phase. Examples mentioned in green are how we can imagine Blockchain evolving with it already being in **Localization** phase as of today. Examples in orange color are equivalent of how internet evolved during its early days. [vii]

Today, we already see many firms in the Banking, Shipping, Music and Healthcare industry having a version of their own Blockchain to record internal transactions, keep track of ownership of goods, track digital copies of their music or patient records. While the true blockchain-led transformation of business and government is still many years away, there is huge potential for disruption in many of these industries when it does happen.

Bitcoin

Bitcoin is by far the most popular *cryptocurrency* in the Blockchain world. Cryptocurrencies are digital currencies that use cryptographic algorithms to moderate and verify the generation and circulation of a unit of currency. Other popular cryptocurrencies that are in circulation today are Ethereum (ETC) and Litecoin (LTC).

Blockchain and Bitcoins are often misconstrued to be synonyms. It is important to note that cryptocurrencies such as Bitcoins are essentially a "*network*" on the Blockchain. To give an analogy - just as Facebook is a *social network* on the *internet* or Paytm is a *payment network* on the *internet* - Bitcoin is a *cryptocurrency network* on the *Blockchain*.

In the following sections, we will look at the nuances of how this currency works.

Bitcoin Supply

Bitcoins are programmatically scheduled to release at a certain rate. By design, only 21 million Bitcoins are programmed to ever exist and the last Bitcoin is scheduled to be mined by the year 2140. Below is a basic math on how BTC supply works:

We already know from the previous sections that a new Bitcoin can come into the system only when a miner adds a block of the transaction to the Bitcoin blockchain. We also know that the reward for mining a block gets halved every 4 years and every hour 6 new blocks are mined and added to the Blockchain. [viii]

To calculate the number of blocks that will be validated per 4-year cycle:
6 blocks per hour * 24 hours per day * 365 days per year * 4 years per cycle
= 210,240 (roughly 210,000 blocks)

Sum all the Bitcoin rewards starting from the year 2009, halving every 4 years:
50 + 25 + 12.5 + 6.25 + … = 100 (with 50 bitcoins reward starting in 2009)

Multiplying the above 2 values:
210,000 * 100 = 21 million

How does the halving of reward affect the price of Bitcoin?

In a perfect market, the USD/BTC price would simply double each time the reward of mining is reduced by half. This is mainly because the cost of mining a block in the blockchain hardly reduces and without a doubling of price, miners instantly see their revenue drop to half. The logical expectation is that any pricing effect from the halving has most likely already happened due to the market anticipating it. [ix] This is also another probable reason why there is a huge price surge for Bitcoins every time there is a halving of reward.

Technical aspects of mining

So far in this report, we looked at Blockchain and Bitcoins from a business point of view. In this section, we will look at how mining for a bitcoin in the blockchain network happens at a technical level.

Every time a transaction happens, say Eve paid Bob 5 BTCs for a pizza, the transaction message is broadcasted to the entire network and is added to a pool of pending transactions that need to be validated and added (a.k.a. mined) to the shared ledger (a.k.a. Blockchain).

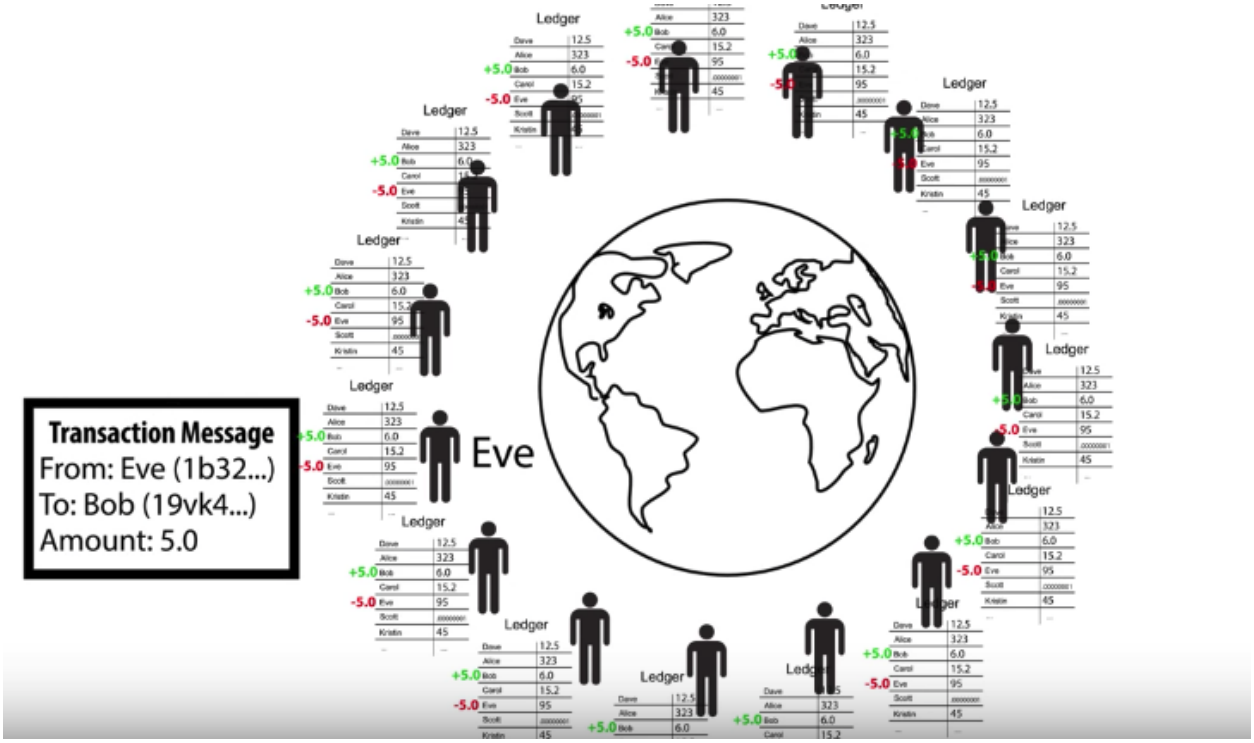

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Figure 6 Blockchain- digital ledger

Each transaction employs a digital signature that ensures that the transaction was indeed initiated by Eve and not a hacker. Digital signatures are a cryptographic hash (non-readable array of text) of Eve's private key (a unique identifier of an account or a person in cryptography world)

and the transaction message (which contains information such as Eve's and Bob's anonymized account number, the transaction value etc.). Each signature is unique to that transaction and can't be copied and reused.

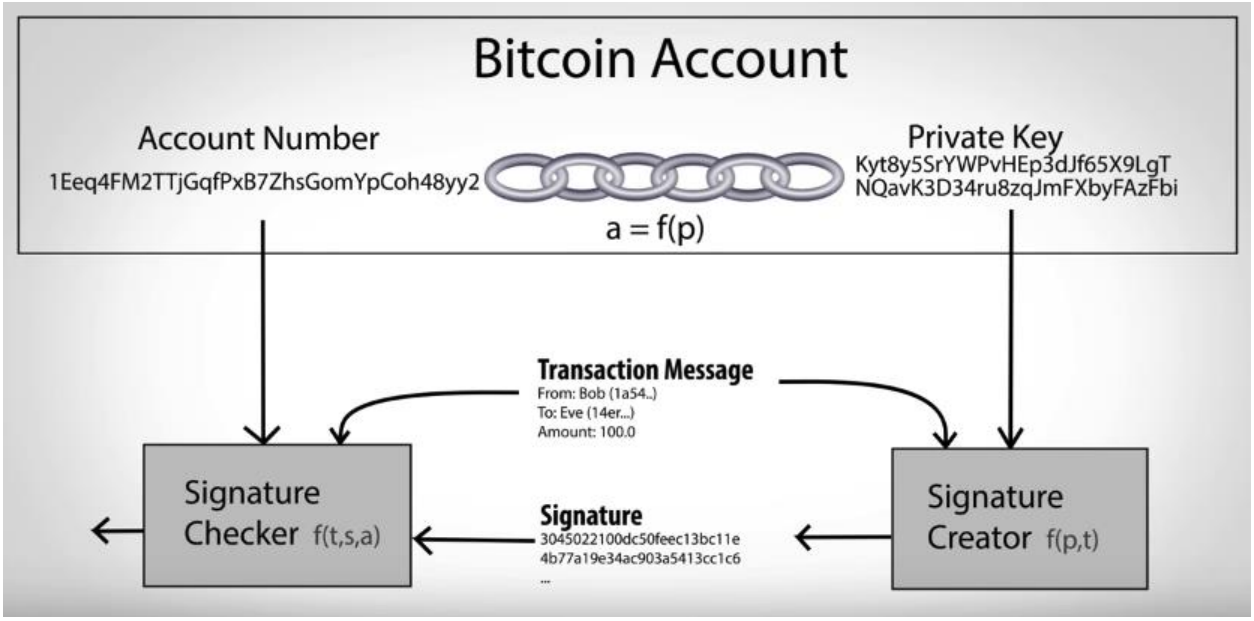

Figure 7 Secure transactions using private key

Once a transaction is added to the pending pool of unverified transactions, it is picked by a miner who has the computing resource to validate it.

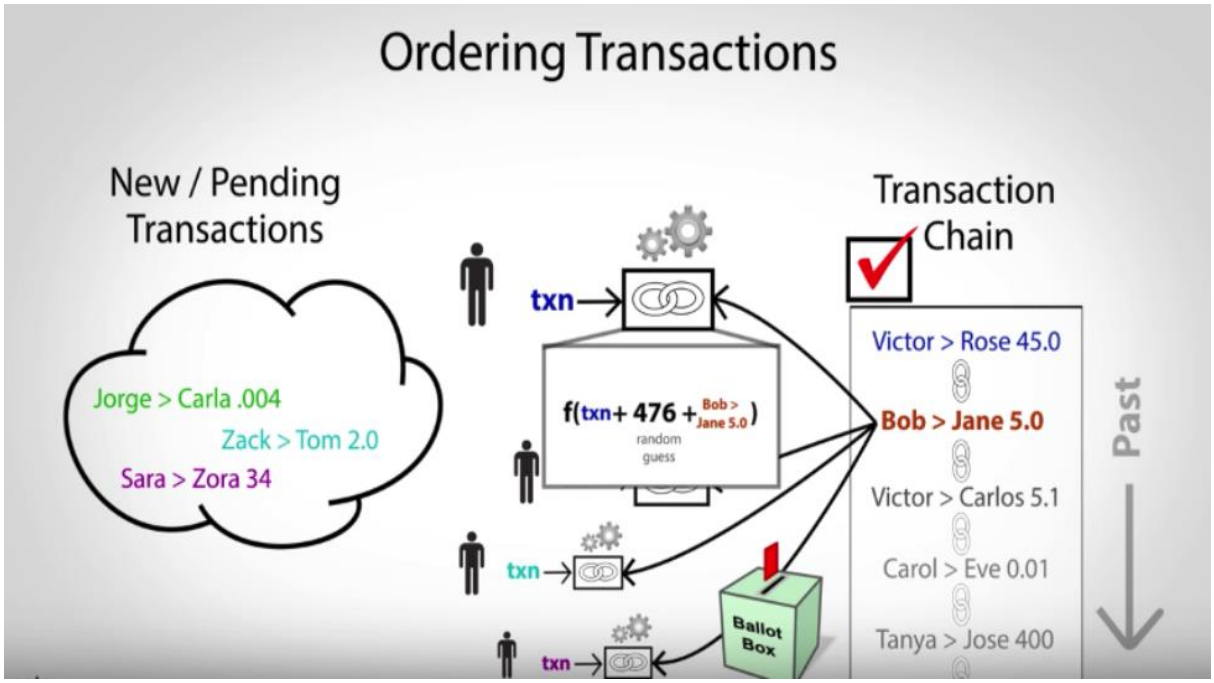

Figure 8 Order of transactions in Blockchain

Mining is a process where a math problem in the form of a special cryptographic function is attempted to solve. This function takes three things as its input – the transaction to be validated, the previous transaction in the blockchain after which the new one will be added and a randomly guessed number. The random number arrives after guesswork and the process of guessing is repeated until the mathematical problem is solved. [xi]

For brevity's sake, we will not get into details of the cryptographic function, the output, the versioning concepts or how voting for multiple versions of a Blockchain happens. Each one of these steps is critical to the process of mining and they warrant sufficient detailing of technicalities to cover each of them comprehensively. For now, it suffices to say that the mining process as described above helps ensure that transactions are validated, ordered and added into the blockchain in a way that is probabilistically extremely tough for hackers to manipulate.

Innovations in Cryptocurrencies: Initial Coin Offering (ICOs)

One of the key innovations with the emergence of cryptocurrencies is using them as a means to bootstrap companies. With the successful emergence of new currencies such as Ethereum, many startups have begun to raise capital in the order of tens of millions of dollars by offering new cryptocurrencies (or tokens as they are called in this context). This process is called Initial Coin Offerings (ICO) mimicking the other popular way to raise capital - IPO. Each newly issued "token" represents a stake in the company that issued it (much like stocks). Many investors in the US have started funneling ethers (ETC) to exchange them for new tokens that represent a stake in a company. How the process of ICO works and complexities that are associated with them could mandate a separate research topic in itself. So, we will not cover them in detail in this paper.

Advantages of Bitcoin[xii]

In this section, we look at some of the advantages of Bitcoins over the current modes of payment, such as credit cards.

- **Freedom of Payment** – Bitcoin transactions can be done at anytime from anywhere in the world. Users needn't be concerned about bank holidays.
- **No Transaction fee** – Currently, there is no transaction fee for bitcoins. This gives Bitcoins an advantage over credit cards. Another major advantage of Bitcoin transactions is that it allows merchants to easily convert Bitcoins to fiat currency and get it deposited in their bank accounts. These services are offered at a much higher fee with credit cards.
- **Low Risk for merchants** - Bitcoins prevent merchants from losses caused because of fraudulent transactions. Merchants can safely sell their products in new markets where other modes of payment aren't available, thus expanding their reach to larger markets.
- **Secure and transparent**- Unlike other payment methods, sellers cannot add unnoticed charges in Bitcoin transactions. Since Bitcoin is built on a secure medium like Blockchain, users can protect their money with encryption and backup.

Also, all the transactions are available on the Blockchain for anyone's perusal. They can be easily verified in real-time. This makes Bitcoin transactions neutral and transparent.

Disadvantages of Bitcoin

- **Low acceptance** – Although Bitcoin acceptance has been growing rapidly over years, the currency is still in the process of maturing. Businesses are still skeptical of adopting Bitcoins as a medium of exchange. Features and tools are being added to make it more secure and appealing to the users.
- **Price Volatility** – Business activities and market trends can significantly affect the price of Bitcoins, and this affects the small number of businesses using Bitcoins currently. However, price volatility will go down once more Bitcoins are mined and the technology matures.

Bitcoin Standard Vs Gold Standard

We have tried to explore the similarities and dissimilarities between Bitcoin standard and Gold standard.

SIMILARITIES

1. Scarcity

Both Gold and Bitcoins are available in scarcity in this world. There are limited reserves of Gold, and not more than 21 million bitcoins can be mined in this world.

2. Uncontrolled Supply

Another similarity between Bitcoins and Gold is that the supply of neither is controlled by the central bank. The supply of bitcoins depends on the algorithm that governs how many new Bitcoins will be distributed to "miners", whereas invention of techniques to extract gold changes the world stock of Gold.

3. Monetary Policy- Lender of last resort

Under a fiat monetary system, the central bank can create reserves in commercial banks when they are running short of notes or deposits. The central bank doesn't need to hold Gold or Bitcoin equal in value to the amount of reserves it credits to the commercial bank since the transaction is in the form of fiduciary currency. [xiii]

However, the central bank did act as lender of last resort during Gold standard when it issued fiduciary currencies against the amount of Gold in case of shortage in commercial banks. Banks can, thus, act as lenders of last resort even under the Bitcoin standard.
But, there is only a limit up to which central bank can issue fiduciary currency under the Gold or Bitcoin standard, i.e. until Gold or bitcoins are available. This limits the central bank's ability to act as a lender of last resort.

DISSIMILARITIES

1. Monetary Policy- Interest rate policy

Under the Gold standard, arbitrage was possible. Central banks of different countries could set different rates. A central bank raised or lowered interest rates in its country to keep the domestic economy under control. Ideally, one would assume that wherever rate of return is higher, Gold would flow to that country, and this would eventually limit the differences in interest rate among countries. However, Gold arbitrage was costly, and that gave some leeway to central banks to set different interest rates.

However, under the Bitcoin standard, it won't be possible for countries to make use of interest rate policy to control the domestic economy since the cost of arbitrage is zero. Central banks of different countries won't be able to set different interest rates, and thus, the exchange rates for all currencies would be one-to-one.

2. Divisibility

Unlike Gold, Bitcoins are infinitely divisible. At present, the smallest unit of Bitcoin is called Satoshi, which is 1/100,000,000 of a Bitcoin. In future, if more units of currency are needed, Bitcoins can be further broken down into smaller units.

Misconceptions about Bitcoins

Currently, there are a lot of misconceptions and myths about Bitcoins, resulting in lower trust of a common user in the virtual currency. In this section, we will see some of the most common criticisms against Bitcoins as a medium of exchange and some of the ways these criticisms or risks can be mitigated.[xiv]

1) Scarcity leading to deflation

Money scarcity has always been a concern for economists since traditionally it is believed that insufficient increase in money supply will result in deflation. Deflation will lead to increase in prices of goods and services, thus, encouraging people to hoard their money with the hope that prices will reduce in the future. This results in a decrease in the overall demand and translates into a further reduction in company profits, lower employee wages, and unemployment. This way the vicious cycle continues. [xv]

Gold has always been a scarce resource. Supply of Bitcoins is also capped at 21 million. Many economists believe that this will lead to a deflationary economy.

#Answer: Why Bitcoin protagonists are not worried about limited supply?

At present, over 2/3rd of 21 million Bitcoins have been mined, and the rest are expected to be minted by 2140. However, the supply of Bitcoins can go on for years. As mentioned earlier, Bitcoins are infinitely divisible. If at a point in future, a Satoshi, the smallest unit of Bitcoins, becomes highly valuable and cannot be used as an effective medium of exchange in the market, it can be further broken down into 10 mini-Satoshis.

Also, calling Bitcoin a 'deflationary currency' won't be accurate. Bitcoin as a currency is intended to inflate in its early years. Starting with zero in 2009, the Bitcoin economy has constantly risen over years. It is expected to eventually become stable in the coming years.

However, the supply of Bitcoins can become scarce in one scenario- when a user loses his/her BTC wallet. The Bitcoins will still remain in the Blockchain, but in a dormant state, since there is no way to find the private key(s) in order to gain access to those Bitcoins. With fewer Bitcoins in the system, demand will increase causing an increase in the price.

2) Artificial demand leading to deflation

According to antagonists of Bitcoins, the knowledge that supply of bitcoins is limited plays a major role in its soaring demand. The high demand of Bitcoins leads to its high price, which reduces the price of everything else in terms of Bitcoins, thus leading to deflation.

#Answer: Why Bitcoin protagonists are not worried?

Bitcoins are like other assets; their demand depends on the public perception of the system. Once all the Bitcoins are mined, the demand for Bitcoins will also go down.

As far as price volatility of Bitcoins is concerned, fortunately, the main benefit of Bitcoin as a medium of exchange between two parties is not affected by its price volatility. It is possible for a consumer to convert Bitcoins to local currency instantly, thus benefiting from the advantages of Bitcoins and not being affected by price fluctuations. Because of such solutions, Bitcoins as a currency is expected to mature to a level where price volatility will become limited.

3) Money-supply "shocks" could set off systemic collapse

Shocks causing loss of faith in Bitcoin exchanges could result in withdrawal of Bitcoins in panic, thus leading to a decline in the volume of Bitcoins floating in the market. One such shock was the crash of Mt Gox in 2014, one of the biggest Bitcoin exchange. Users hoarding Bitcoins could seriously damage Bitcoin's status as a medium of exchange.

#Answer: How Bitcoin protagonists see this issue?

Similar crashes are common in the capital markets sector as well. Several markets across the world face panic attacks, causing investors to hoard money rather than trade in the market. Also, such issues are extremely rare. Mt Gox incident occurred because of an individual exchange's technical oversight. With technological advancement, the frequency of such issues will decrease.[xvi]

Conclusion

Blockchain truly has the potential to become the next big thing in technology space and when it matures, much like what internet did in the 1990s, it can disrupt several industries at scale. As we have seen, firms across several industries have already started adopting and piloting a few internal services on Blockchain. So, how fast the technology gains mass adoption is now a function of how rapidly innovative applications can be built on top of Blockchain.

Cryptocurrencies such as Bitcoin, on the other hand, although popular, may take some time to be adopted as a primary medium of exchange, replacing fiat currencies. We have already seen how Bitcoin standard is seen in comparison to the Gold standard, without some of the disadvantages of the latter. To become the future currency of the world, it needs to get the nod of governments and policy makers. It also needs to make itself technologically much safer to vulnerable attacks. These are as much a problem of public perception as they are about the economic soundness. In the truly exciting times ahead, we only have to wait and watch how Bitcoins and Blockchain play out and where they live up to their potential and promises.

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