Issues Impacting Bitcoin and Blockchain Technologies

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Blockchain. Cryptocurrency. Bitcoin. These have become controversial topics. Some may roll their eyes. Others, their eyes turn to dollar signs. It is a fact that blockchain technology has become quite divisive in recent years, but at the time of its creation little was thought about Bitcoin. In 2009, a mysterious message was sent to a cryptographic mailing list by its anonymous creator, who goes by the name "Satoshi Nakamoto." His true identity remains unknown (Davis, 2011). The message contained a paper describing a "digital currency" that seeked to rectify the problems that led to the great recession in 2008.

Adoption started out slow. Starting out with a price of zero dollars, Bitcoin managed to climb to a price of around ten cents by 2010 (Edwards, 2024). It took until 2011 for it to reach the price of one dollar, and from there it would hover at around the ten dollar mark for a couple years. However, 2013 was the year Bitcoin would explode. It skyrocketed in price from a starting price of thirteen dollars, passing one hundred, two hundred and even surpassing a thousand dollars by the end of the year. From then, the growth of Bitcoin's value has been astronomical, currently sitting at a price of over seventy thousand dollars per Bitcoin.

While the rise of Bitcoin has been incredibly beneficial for those who decided to invest in Bitcoin, it has not accomplished its goal of completely transforming the economic landscape. Despite Bitcoin's failure to reach its creators aspirations, the massive shakeup caused by its incredible growth has caused many far reaching negative side effects. I guess you can't undercook an omelet without breaking some eggs, huh?

Crypto currency has been used in online black markets to anonymously buy and sell illicit goods like drugs or even child pornography (Scoular, 2021). The Bitcoin network requires massive amounts of electricity which contributes to massive amounts of carbon emissions that

pollute our planet (Stoll, 2018). Bitcoin miners require GPUs for their "mining rigs," which has caused a shortage and price inflation for home computers (Roach, 2023). The exchange of cryptocurrency is difficult to tax. Investors are shafted by scams, volatility and bad business practices. Many bad faith actors use blockchain tech as a get-quick rich scheme, like NFT-bros who push digital blockchain assets in an attempt to buy low and sell high (Sharma, 2023). The myriad of negativity spawned makes it seem like it might be time to move on; if we ditched blockchain we could be rid of all these problems and lose nothing of value.

Despite all these problems and scandals there may be something salvageable from under the rubble. There are promising technologies that may aid in the problems of blockchain, and add additional use beyond what most associate with blockchain. By performing a sociotechnical analysis, I intend to investigate possible use-cases and social challenges surrounding blockchain technologies. This analysis will shed light on the state of the technology, and help illuminate its future.

Background and Significance

Before we are able to know more about the social situation of blockchain and cryptocurrency based technology, we first must know what exactly a blockchain is. Put simply, a blockchain is a "decentralized data structure," meaning that it is a way of organizing and storing data. What makes it interesting is the "decentralized" aspect of the blockchain. Traditional data is stored in a "centralized" system, meaning that it is stored in a single dedicated server by a single entity.

Take a Gmail account for example. Your email inbox and the data contained within is being stored somewhere on a database maintained by Google. Google and only Google is

responsible for the preservation and delivery of your data. When you go to Gmail.com and pull up your inbox, a query is sent to the Gmail web server, which queries the Gmail database, which returns all of your emails. If one day, all of the Gmail databases suddenly blew up, your data would be lost forever!

The difference in a decentralized system is the lack of a dedicated third-party host. Instead of a single system being responsible for storing and updating the data, the load is shared by a number of "nodes" who all contribute to the system. A node can be any kind of computer. A node can be as small as a chromebook, or as large as a supercomputer. A strong decentralized system has a large number of nodes, for example as of April 2024, the Bitcoin network has over 17,000 nodes. (bitnodes.io) These nodes form a peer-to-peer network, a network that is only the users–no central server necessary!

An example of a decentralized system is the BitTorrent file-sharing network. It is mainly known for its use in media piracy, which is the illegal distribution of movies, music, video games and other forms of digital media. Since there is no singular entity to go after, enforcement becomes very hard despite the fact that pirated video in the United States getting over 200 billion views a year, and an estimated "$47.5 billion and $115.3 billion in reduced GDP each year." (McCarthy, 2019)

The Bitcoin network uses this decentralized structure in a similar manner to remain free from singular third-party control. The Bitcoin network stores and updates a "Blockchain." A blockchain is essentially just a list. In the case of Bitcoin, it is a list of transactions. Each transaction contains a sender, a receiver, and an amount of Bitcoin, along with the time and date of the transaction and the cryptographic signature of the sender. The transactions are grouped into sequential "blocks" thus forming a "block-chain."

When a block is added to the blockchain, this is called “minting.” Each block must have a “hash” value that is under a certain value, and also must contain the “hash” value of the previous block. How a hash value is calculated is extremely complicated, and making sure a block’s hash value is under a certain value can take massive computational effort. This process of finding a hash value is called “mining.” The fact that a block contains the hash of the previous block makes it so that if you want to change a block in the blockchain, it requires changing every subsequent block as well. This makes transactions in the blockchain so secure that, after just a few more blocks have been minted, they are effectively impossible to change.

It is up to network nodes to contribute these blocks to the chain. For a decentralized system to succeed, there must be an incentive for users to contribute to the upkeep of the system. Bitcoin gives its incentive in the form of a cryptocurrency reward. This reward is given to miners when they successfully find a valid hash value and complete the mining process. The verified block is then reported to the rest of the network, and the miner is rewarded in exchange.

The significance of blockchain and cryptocurrency is twofold. First is the obvious, the application of cryptocurrency in the global digital economy. But the second, less known reason is the existence of decentralized systems that live on the cryptocurrency powered blockchain. These systems are able to leverage the cryptographic nature of the blockchain to provide “programmable trust,” which is essentially, a guarantee of previously agreed upon information, as well as a cryptographic enforcement of actions based on those agreements (Mason, 2019). Of course, this only applies to actions that are within the domain of the decentralized system. As our world has become more global and interconnected, it has become increasingly difficult to enforce our laws and manage our systems. A decentralized system could take the burden off of

national authorities to enforce themselves, and provide ironclad enforcement of its own rules. There is potential to replace a "legal trust" with a cryptographic one.

Methodology

The main framework I will use to analyze collected data is the Social Construction of Technology (SCOT) framework (Bijker, 1987). This is a sociological framework that aims to investigate the creation of technology. My reasons for choosing this framework are as follows.

Firstly, it focuses on the framing of technological development as a social concept. Blockchain is a complex technology that exists within a complex society. The analysis of the technology cannot only focus on the technical aspects. The sociological approach of SCOT allows for the considered approach towards the problem that I think is necessary for a full inspection of the future of the technology.

Secondly, SCOT does not make a distinction between a successful technology and a failed one. It is equally suited to examining a technology regardless of its developmental state. Historically, there has been an idea that successful technologies are "correct" and unsuccessful ones are "incorrect," and the development of these correct technologies is somehow different from the incorrect ones. SCOT was created in part to refute this idea. This aspect of SCOT is critical towards examining blockchain technology. Blockchain sits at a critical point in its history, where it is unclear whether its next stage will be adoption or obsolescence. A SCOT analysis provides the impartial view from which we can fairly analyze.

Thirdly, SCOT has a focus on the stakeholders, problems, and possible solutions surrounding the technology in question, and defining the concepts, the relationships between them. Blockchain is a complex system with widespread possible uses, and many impacted parties. The concept of a technology meaning something different to different groups is called

"interpretive flexibility." These stakeholders and their problems have created much controversy about Blockchain, and SCOT provides a solid framework for finding a solution.

Fourthly, SCOT allows for a visual representation of the technology's sociotechnical network. It provides a framework for creating a diagram depicting the connections between the technology, its affected social groups, their problems, potential solutions, and technologies that arise from those solutions. This diagram provides a digestible visual aid to accompany the analysis.

I will collect data through literature review, overviewing what others have found about the technology. The focus will be on affected social groups, and compiled through the SCOT framework.

Literature Review / Discussion

Blockchain has dangerous, large-scale environmental effects, which means that it affects the entire human race as a social group. If you recall, peer-to-peer decentralized systems need an incentive. In the case of torrenting, that incentive was free video and a sort of pass-it-on honor system. In the case of Bitcoin, that reward was Bitcoin. And as Bitcoin got more and more valuable, that reward got more and more enticing. But as you also may recall, a single payout is rewarded on average once every ten minutes, regardless of how much computing power is being put towards minting blocks, since the "hash value" is dynamically adjusted to make sure this is the case.

This combination of facts led to an enormous amount of global computing power being put towards minting Bitcoin and other cryptocurrencies, and with that, an enormous amount of electricity. As of November 2018, it was estimated that the annual electricity consumption of

Bitcoin was 48.2 billion kilowatt hours, and with an estimated annual carbon emissions range from 21.5 to 53.6 millions of tonnes. This would mean that the electricity usage and resulting environmental impact is greater than that of the entire nation of Bolivia (Stoll, 2018). This massive amount of carbon emissions is from Bitcoin alone, with other cryptocurrencies contributing even further. A solution to this emissions problem would make a significant impact towards global environmental sustainability.

In addition to mass electricity usage, cryptocurrency mining also caused shortages for computer parts (Roach, 2023). The mass-produced computer part most suited for crypto mining is the Graphics Processing Unit (GPU), and a strategy for mining cryptocurrency that many used was to simply buy as many as possible and hook them up together into a "mining rig." This strategy was most effective if you were able to steal someone else's electricity to increase your profits. While dedicated mining machines could be more effective per dollar, this didn't stop miners from emptying the stock of every Microcenter, Newegg and Amazon warehouse in the world. While the shortage has died down, another mining craze is not an impossibility, and a change in the cryptocurrency system to avoid a repeat shortage would be a responsible choice.

An attempt at a solution of the problem of mining electricity computing consumption is an alternative minting process called "proof of stake." The previously mentioned mining process is what Bitcoin has and still uses, and is called "proof of work." Like proof of work, proof of stake also offers a cryptocurrency reward to those who validate blocks, however who gets to validate these blocks is chosen in a much different way. Instead of a "hash value" lottery, there is a "staking" system (Napoletano, 2023). Staking is when users put up some amount of cryptocurrency on the line. The more you stake, the more like the algorithm is to choose you to verify a block. If a user attempts to verify a block with fraudulent transactions, they lose all of

their staked currency, and cannot ever get it back. This creates a system where ownership of currency is encouraged over computing power. The need for mass electricity usage is seemingly eliminated; a verification can be done on a laptop. However, it is still not yet known if proof of stake is as secure as proof of work. Proof of work has a long track record of its strength, while proof of stake is relatively new.

In September of 2022, the Ethereum blockchain network switched completely from proof of work to proof of stake with the goal of a predicted 99% drop in electricity consumption. According to the Crypto Carbon Rating Institution, the switch caused an immediate 99.99% reduction in carbon footprint and electricity consumption! This extremely impressive result seemingly eliminates the electricity issue altogether (Ho, 2023). However, Ethereum electricity usage is on the rise, and there is much about proof of stake that we still do not yet know. Since the switch dropped the electricity usage, it has risen back over 300%. Despite this, the future of proof of stake is very promising. Building on top of a proof of stake system instead of a proof of work system will be of utmost importance if blockchain based systems are to be thoroughly used.

Another social group affected by Bitcoin are consumers. What I mean by consumers is the people who want to use Bitcoin or other cryptocurrencies for their original intended purpose: as currency. As Satoshi Nakamoto created Bitcoin to replace the current economic and financial systems, this idea has excited many, but there are many problems that stand in the way of realizing the idea, one of them being volatility. The wild swings of Bitcoin and other cryptocurrencies makes pricing impossible. How much should a car cost in Bitcoin? What if you put a car up for sale for 2 Bitcoin, and then the price of a Bitcoin plummets?

The volatility of Bitcoin stems from a “double instability.” That is, within the socioeconomic system of Bitcoin, there are two points that manifest price instability, and this

causes much greater volatility than in a traditional currency (Iwamura, 2019). Firstly, there is the issue of fixed supply. In a traditional market, when demand for a product increases, this drives an increase in producers, which in turn increases the supply. This increase in supply acts as a stabilization mechanism within the market. This varies significantly with Bitcoin, as increased demand does increase the amount of producers, but the fact that the system is coded to only produce a set amount of currency in a window of time (as Bitcoin "rewards" once every ten minutes) the increased number of producers does not increase supply.

The second point of instability is caused by the fact that miners are not incentivized to stop mining during a price drop. Miners may have sunk a large monetary investment into their mining equipment, and such even during a price drop when mining is not profitable, they continue to mine, expecting another price jump. If there were to be a mass exodus of miners from the network, blocks would no longer be validated, the system would cease to work, and Bitcoin price would fall to zero.

Iwamura and Matsumoto propose an alternative Improved Bitcoin (IBC) that attempts to remedy the volatility issue (Iwamura, 2019). The two major proposed changes are as follows. Firstly, IBC allows for the rate that new IBC is created to increase as the amount of miners increases. Secondly, there is a slow growth rate in the amount of IBC paid out over time. This intends to induce inflation which will incentivize miners to stop mining if IBC price decreases, since there is a long-term built in devaluation of the currency. The creators predict that these changes will allow for IBC to absorb the volatility and function as a dedicated currency. However, a cryptocurrency of this kind has never had a large-scale test, so it is unclear whether these changes would be effective in practice. Additionally, making the currency more viable as a

currency makes it less viable as a speculative investment, so the mass appeal of Bitcoin would be lost, and accruing a large enough mining pool would likely become more challenging.

Another attempt to address the volatility issue is “stablecoin.” And unlike IBC, stablecoin has actually been implemented. The idea behind stablecoin is simple. A cryptocurrency’s value is “pegged” to another currency. For example, as long as it is pegged, a single unit of the Tether stablecoin (USDT) will always be worth one dollar (Pierce, 2014). “Depegging” is what happens if a stablecoin falls below the value of its fiat counterpart. Depegging is catastrophic for a stablecoin, as users will lose trust and its value will drop to zero.

A stablecoin can be either pegged to a cryptocurrency or a fiat currency (Daly, 2023). A cryptocurrency pegged to another cryptocurrency is called an “algorithmic stablecoin.” It uses a variable exchange rate with its pegged cryptocurrency in an attempt to maintain a constant value. These stablecoins have a history of depegging. The first stablecoin, BitUSD was created in 2014 an algorithmic stablecoin, but lost its peg and collapsed in 2018. Algorithmic stablecoin is also responsible for one of the largest cryptocurrency financial blunders. The system consisted of a stablecoin called TerraUSD which was paired with a crypto called LUNA and pegged to the US dollar (Sandor, 2024). In May 2022, TerraUSD fell from its price of a dollar, becoming depegged, and LUNA fell from a price of 80$ down to a few cents. This caused tens of billions of dollars worth of financial losses of investors and users of TerraLUNA’s associated DeFi services. This catastrophe has given reason for distrust of algorithmic stablecoins.

The other variety of stablecoin, the fiat stablecoin, currently has a better reputation, but some are still uncertain. Fiat stablecoins function similarly to a bank. They carry a reserve of the pegged fiat currency, and exchange the cryptocurrency for the fiat currency at a static rate (Pierce, 2014). The aforementioned Tether is a fiat cryptocurrency that exchanges one USDT for

one US dollar. Tether is commonly used as an intermediary between cryptocurrencies. If you have some Ether and want to exchange for some Bitcoin, you can use decentralized exchanges to quickly convert to USDT and then to Ethereum.

Their lack of transparency makes investors anxious about the true value of fiat reserves. Tether, along with other fiat stablecoins, face questions about their reserves (Smith, 2024). Tether has a market capitalization of 95 billion dollars, so if there is a mass wave of people cashing out their USDT and Tether cannot pay them back, it would be a massive financial disaster. Tether is currently striving to improve transparency to improve investor and user trust, but time will tell if they will succeed.

Government law enforcement and regulatory agencies are another major social group involved with blockchain. Due to the novelty of the technology, government agencies are not on top of the new ways it can enable illegal activity, as well as the legality of many of the questionable crypto-based financial structures and assets that now exist.

Ransomware attacks are a major cyber-crime that their perpetrators use cryptocurrency to facilitate. A ransomware attack is when an attacker steals data or holds computer systems hostage and demands payment for the release of the computer system or data. The assumed untraceability of the payment using cryptocurrency makes cryptocurrency very popular for this sort of attack (Falk, 2021). For example, the infamous “WannaCry” ransomware attack that infected an estimated 300,000 computers, demanded a $300 dollar ransom paid via Bitcoin to release the infected computers (Graham, 2017).

Additionally, cryptocurrency can be used in illicit online markets. The Silk Road was an online dark-web black market that processed sales of over 9.5 million Bitcoin from 2010 to 2012. It was shut down when its creator was arrested in 2013 after a lengthy FBI investigation

(Ross, 2023). While the Silk Road used cryptocurrency, it was still a centralized system–a decentralized version is possible, and would prove much harder to dismantle. The identification and arrest of its creator would not be enough; it would require a truly global effort to eliminate (Krishman, 2020).

These legal issues are being met with an attempt to increase and improve crypto-currency based laws and regulations in order to prevent these kinds of illicit activities. A salient example of this is the Know Your Customer (KYC) protocol, which requires US-based cryptocurrency exchanges to require “robust customer identification programs.” This means customers must provide extensive evidence of their identity before they are allowed to participate in the exchange (Scoular, 2021). This means that US law enforcement is able to subpoena the exchange when an illicit transaction is identified and learn the identity of the owner of the account participating in said illicit transaction.

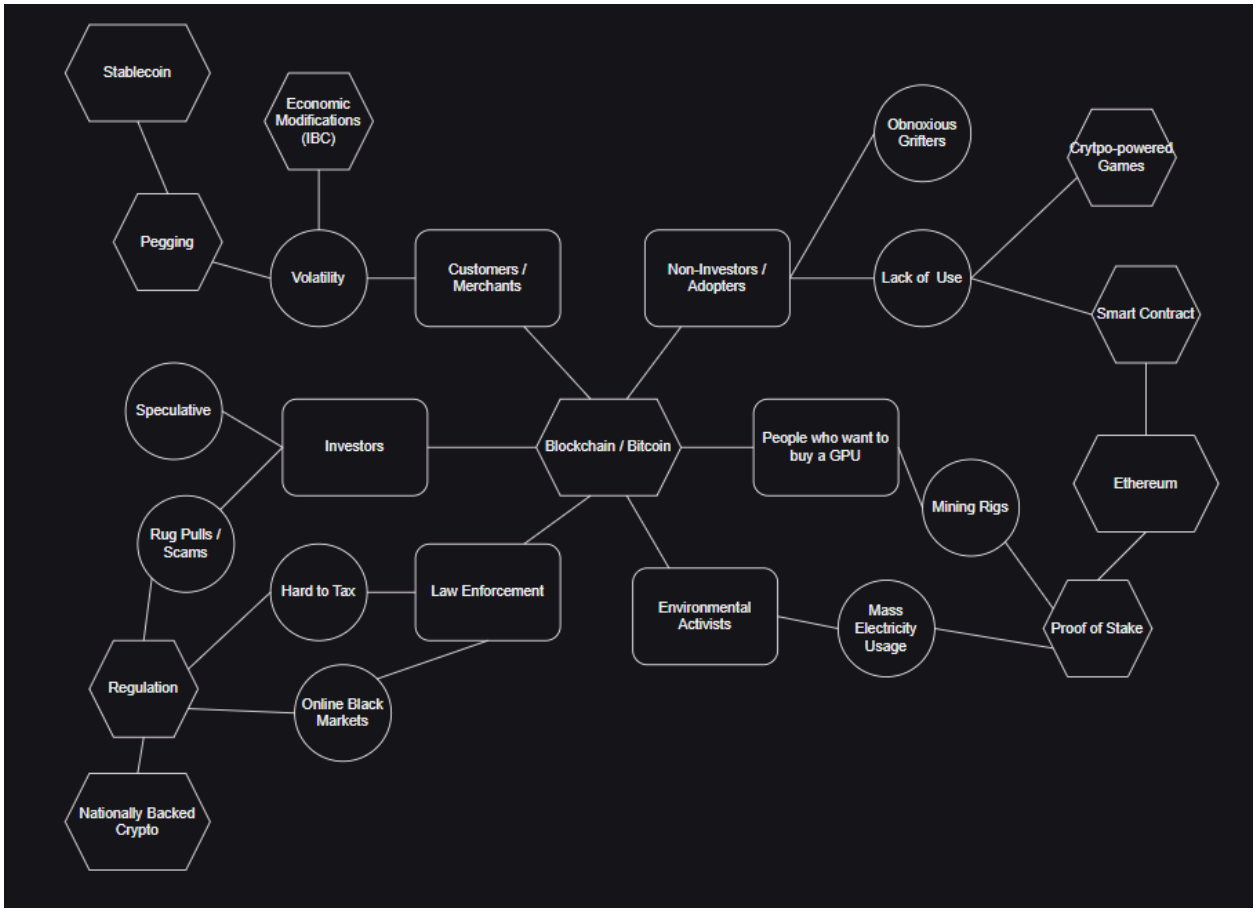

Figure 1

Relevant social groups, problems and solutions towards Blockchain using a SCOT diagram.

Conclusion

Blockchain and cryptocurrency are still changing and evolving. There is work being done on many fronts to try to remedy the many problems Bitcoin and its associated technologies have begun. Can these problems be solved? It seems likely. Proof of stake slashing crypto's carbon footprint eliminates a critical issue with the technology. Iterations of cryptocurrency may produce a safe and stable digital currency that is safe against massive price fluctuations. Steps towards a legal understanding and regulation of cryptocurrency as an asset may increase the favorability of adoption.

But even if these problems are fixed, I think what is more important is that there is a real reason for these currencies to be used over traditional fiat currencies. I think that that reason lies with decentralized programs. If these systems that live on the blockchain become realized and widespread, there will be a convincing reason for the existence of cryptocurrency. In this case, they would not even need to replace traditional currency to be useful. Their use derives from the systems they are used in.

Next steps in research would be towards these decentralized programs and systems that live on the blockchain. An investigation into the varied and many possible uses for these systems would allow us to determine the legitimacy of the blockchain. There is use in the space of real estate and legal contracts to keep track of property ownership. Shipping networks could keep track of the state of shipments and inventory. Web3 apps are underexplored and the uses are not fully understood. It may turn out that what we currently have is better, and blockchain integration into everything is a pipe dream. But the opposite may also be true, and I think it is worth the effort to find out.

References

STOLL, C., KLAASSEN, L., & GALLERSDÖRFER, U. (2018). The Carbon Footprint of Bitcoin. MIT Center for Energy and Environmental Policy Research. http://www.jstor.org/stable/resrep34616

Daly, L. (2023, December 1). *What Are Stablecoins?* The Motley Fool. https://www.fool.com/terms/s/stablecoins/#:~:text=The%20first%20stablecoin%20was%20BitUSD,)%2C%20launched%20later%20in%202014.

Davis, J. (2011, October 3). The Crypto-Currency. *The New Yorker*. https://www.newyorker.com/magazine/2011/10/10/the-crypto-currency

McCarthy, N. (2019, June 26). Pirated Video Gets Viewed Over 200 Billion Times a Year [Infographic]. *Forbes*. https://www.forbes.com/sites/niallmccarthy/2019/06/26/pirated-video-gets-viewed-over-200-billion-times-a-year-infographic/?sh=6d063d452bcf

Roach, J. (2023, December 20). The GPU Shortage Is Over, but It'S Still Wreaking Havoc. *Digital Trends*. https://www.digitaltrends.com/computing/gpu-shortage-screwed-everything-up/

Sandor, K. ., & Genç, E. (2024, April 14). The Fall of Terra: A Timeline of the Meteoric Rise and Crash of UST and LUNA. *Coindesk*. https://www.coindesk.com/learn/the-fall-of-terra-a-timeline-of-the-meteoric-rise-and-crash-of-ust-and-luna/

Smith, S. S. (2024, January 23). Why Questions About Tether's Reserve Assets Still Matter. *Forbes*. https://www.forbes.com/sites/digital-assets/2024/01/21/why-questions-about-tethers-reserve-assets-still-matter/?sh=6d0f808d52b6

Li, V. (2016). Bitcoin's Useful Backbone: Blockchain technology gains use in business, finance and contracts. ABA Journal, 102(3), 31–31. http://www.jstor.org/stable/24806927

Pierce, B. (2014) Tether: Fiat currencies on the Bitcoin blockchain. https://assets.ctfassets.net/vyse88cgwfbl/5UWgHMvz071t2Cq5yTw5vi/c9798ea8db99311bf90ebe0810938b01/TetherWhitePaper.pdf

Stackpole, T. (2023, January 10). What is web3?. Harvard Business Review. https://hbr.org/2022/05/what-is-web3

Ho, C. (2023, October 11). One Year After The Merge: Sustainability Of Ethereum's Proof-Of-Stake Is Uncertain. Forbes. https://www.forbes.com/sites/digital-assets/2023/10/11/one-year-after-the-merge-sustainability-of-ethereums-proof-of-stake-is-uncertain/

Iwamura, M., Kitamura, Y., Matsumoto, T., & Saito, K. (2019). CAN WE STABILIZE THE PRICE OF A CRYPTOCURRENCY?: UNDERSTANDING THE DESIGN OF BITCOIN AND ITS POTENTIAL TO COMPETE WITH CENTRAL BANK MONEY. Hitotsubashi Journal of Economics, 60(1), 41–60. http://www.jstor.org/stable/45124706

Mason, M., Spoke, M., & Centre for International Governance. (2019). Programmable Trust: A Practical Approach to Governance in the Digital Age. http://www.jstor.org/stable/resrep26129.17

Edwards, J. (2024, March 14). Bitcoin's Price History. Investopedia. https://www.investopedia.com/articles/forex/121815/bitcoins-price-history.asp

Napoletano, E. (2023, August 25). Proof of stake explained. Forbes Advisor. https://www.forbes.com/advisor/investing/cryptocurrency/proof-of-stake/

Sultan, O. (2019). Tackling Disinformation, Online Terrorism, and Cyber Risks into the 2020s. *The Cyber Defense Review*, *4*(1), 43–60. https://www.jstor.org/stable/26623066

Rosenberg, E., Spiro, J., & Dorshimer, S. (2020). *Financial Attacks on Democracy: The Role of Cryptocurrency in Election Interference*. Center for a New American Security. http://www.jstor.org/stable/resrep27458

Falk, R., & Brown, A.-L. (2021). Ransomware payments and regulating cryptocurrency. In *Exfiltrate, encrypt, extort: The global rise of ransomware and Australia's policy options*

(pp. 07–07). Australian Strategic Policy Institute. http://www.jstor.org/stable/resrep33991.8

Graham, C. (2017, May 13). NHS cyber attack: Everything you need to know about 'biggest ransomware' offensive in history. The Telegraph. https://www.telegraph.co.uk/news/2017/05/13/nhs-cyber-attack-everything-need-know-biggest-ransomware-offensive/

Krishnan, A. (2020). Blockchain Empowers Social Resistance and Terrorism Through Decentralized Autonomous Organizations. *Journal of Strategic Security*, *13*(1), 41–58. https://www.jstor.org/stable/26907412

Ross William Ulbricht's laptop. (2023, December 19). Federal Bureau of Investigation. https://www.fbi.gov/history/artifacts/ross-william-ulbrichts-laptop

Scoular, J. D. (2021). Cryptocurrency: Illicit Uses, Legislation, Regulation, and the Burden on Law Enforcement (Order No. 28720342). Available from ProQuest Dissertations & Theses Global. (2572554464). https://proxy1.library.virginia.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fdissertations-theses%2Fcryptocurrency-illicit-uses-legislation%2Fdocview%2F2572554464%2Fse-2%3Faccountid%3D14678

Bijker, W. E., Hughes, T. P., & Pinch, T. (1987). *The Social Construction of Technological Systems: New directions in the Sociology and History of Technology*. http://ci.nii.ac.jp/ncid/BA12006380

Sharma, T., Agarwal, R., & Shukla, S. K. (2023). Understanding Rug Pulls: An In-depth Behavioral analysis of fraudulent NFT creators. *ACM Transactions on the Web*, *18*(1), 1–39. https://doi.org/10.1145/3623376