EXPEDITING THE DEMOCRATIZATION OF BLOCKCHAIN TECHNOLOGY

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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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AN EVALUATION OF THE OBSTACLES HINDERING THE SPREAD OF BLOCKCHAIN TECHNOLOGY AND THE DEVELOPMENT OF AN ACCESSIBLE MACHINE LEARNING PLATFORM

The purpose of technological advancement is to liberate humanity so that "people are no longer relegated to being robots," allowing them to focus less on repetitive tasks and more on creative ones (Shukla, 2019). However, the benefits of technological advancement can only be maximized through equitable democratization, and new technology is not always desired or accessible by all social groups. Both issues, opposition and inaccessibility, hinder the democratization of new technology. Two such emerging technologies are blockchain and machine learning (ML).

Blockchain is a means of storing and accessing data in a decentralized, distributed virtual ledger (Iredale, 2020). Its unique qualities, including decentralization and cryptographic security, make it suitable for solving a multitude of problems, such as cross-border payments (Smith, 2022). However, blockchain remains a controversial topic, with many opponents criticizing its usefulness and adverse consequences. Thus, the research question explored in this paper is: "How do critics of blockchain technology oppose mass adoption?". The purpose of the STS thesis is to investigate these conflicting viewpoints on blockchain, analyze the ways in which different social groups influence each other's viewpoints, and offer solutions that address opposition and expedite blockchain democratization. Achieving this purpose is of particular personal interest because many software engineering opportunities currently revolve around blockchain; doing so will allow for an ethical decision to be made regarding whether and how to use blockchain technology in practice. Though other reasons for impeded democratization certainly exist, opposition was chosen because analyzing opposition allows for understanding the

viewpoints of various social groups, which would lead to a compelling STS issue analysis paper. Three categories of opposition were selected: usefulness, consequences, and top-down push. This is because most criticisms, from background research, can fall into these categories, and focusing on three categories allows for a deep dive into each of them.

ML is the usage of machines to recognize patterns in data and produce a desired output without a predefined set of steps to follow. It is often used in applications that are difficult to address through traditional programming and are better addressed through practice and repetition, such as self-driving cars, image recognition, and natural language processing. Unlike blockchain, the spread of ML is mainly blocked due to inaccessibility rather than opposition. To use ML requires developers to have a text-based coding background (Rao, 2020); yet, less than 0.5 percent of the world's population knows how to code (Prenda, 2016). The technical research project, TensorSnap, aims to remedy this problem by providing a block-coding interface to machine learning. This interface, developed under the guidance of Assistant Professor N. Rich Nguyen and alongside student Harsh Padhye, allows non-programmers to learn about and perform a myriad of ML tasks, including regression, classification, and generative tasks.

This paper will begin with a brief overview of the history and current state of blockchain, followed by a summary of the major points given in its support. After that, the major reasons for blockchain opposition will be systematically explored. This will be done through the creation of an Actor Network model in accordance with Actor Network Theory (ANT) as proposed by Callon, Latour, and Law. Such a model will also allow for the relationships among the various social groups impacted by blockchain to be explored, which will yield insight into the ways in which different social groups influence each other's viewpoints on blockchain.

Therefore, the overarching goal of both the technical and sociotechnical project is to understand the effects of new technologies on different social groups and expedite the democratization of new technologies in a way that equally benefits all. Coupling these two projects allows for the systematic analysis of obstacles to mainstream adoption, which, in turn, affords the ability to generate and implement qualities of equitable engineering.

"BLOCKEDCHAIN": WHY CRITICS OPPOSE THE MASS ADOPTION OF BLOCKCHAIN TECHNOLOGY

INTRODUCTION TO BLOCKCHAIN OPPOSITION

One of the fastest growing fields in technology over the past ten years is blockchain, a means of storing and accessing data in a decentralized, distributed virtual ledger (Iredale, 2020). This ledger records all digital transactions in a permanent "chain" of data "blocks," which are cryptographically secure, viewable by anyone, and not controlled by a single centralized authority. Due to the decentralized nature of blockchain, anyone with a computer can download and run the software that maintains the network and ledger for a particular cryptocurrency, a digital coin or token that leverages blockchain and facilitates a network of exchange.

Since the advent of Bitcoin in 2008, many cryptocurrency projects have emerged that use such a ledger and cover a myriad of use cases. Bitcoin, for instance, is used primarily as a means of exchange and a store of value, granting it the nickname "digital gold" (Reiff, 2022). Ethereum, on the other hand, powers countless decentralized applications (dApps), which are run on the computers of network participants (or "miners"), who are rewarded with Ethereum.

The global cryptocurrency market capitalization is approaching $2.6 trillion, which is greater than the market capitalization of Microsoft, Apple, Google, Amazon, and silver, but less

than that of gold (Roberston, 2021). As a result, many compare the cryptocurrency boom to the dotcom boom of the 1990s. During that time, many newly-founded internet companies quickly attained very high valuations, primarily due to the hype around the “next big thing” and the accompanying fear-of-missing-out. However, after the “bubble” burst, only a few internet companies remained to dominate the industry. Today, many investors and economists foresee a similar pattern playing out with cryptocurrencies.

Proponents have likened the potential impact of blockchain to that of the internet, citing freedom, security, privacy, and constant up-time as the major driving forces for its adoption in numerous fields (Higginson et al., 2018). Such fields include cross-border banking, identity verification, supply chain monitoring, and provable ownership (Daley, 2021).

However, such growth is not without opposition. Researchers have attributed COVID-19 vaccine hesitancy to "lack of confidence in the need for vaccines" and "aversion to the risk of side effects" (Shen et al., 2021, p. 4005). Similarly, blockchain critics question its practicality and perceive it as risky and dangerous. Opponents emphasize slow transaction speeds, the potential for destructive hacks, high energy demands, and regulatory risks as obstacles to widespread adoption (Iredale, 2021).

Thus, concerns over practical usage and potentially harmful side-effects make blockchain technology a controversial topic. On the other hand, strict resource and knowledge requirements make machine learning not equally accessible to all. Learning and addressing reasons for opposition and increasing accessibility can expedite the democratization of both blockchain and machine learning, thereby bringing their potential benefits to more individuals at a quicker rate.

This STS research paper will proceed as an issue analysis. By exploring the various viewpoints around blockchain using ANT, the particular obstacles blocking mainstream adoption

will be discerned. Afterwards, these obstacles will be addressed, resulting in suggestions for future equitable engineering.

THE CASE FOR BLOCKCHAIN

The primary quality that makes blockchain revolutionary compared to the status-quo is decentralization. For instance, using blockchain for financial purposes allows users to directly transact with each other without the fees and overhead associated with a third-party intermediary, such as a bank or credit union (Smith, 2022). This is analogous to using cash in the physical world to make a purchase, since doing so does not require interfacing with a centralized authority. Furthermore, currently, the vast majority of websites and applications are hosted by a small number of large cloud providers, such as Amazon Web Services and Google Cloud Platform (Vincent, 2019). Using blockchain for this purpose allows for decentralization, which decreases reliance on these cloud providers and lowers the possibility of having one's website or application taken down.

Another critical quality of blockchain is cryptography, the study of techniques for secure communication (Sahu, 2021). Such techniques include public-private key encryption, which ensures that a given message can only be decrypted by its sender or intended recipient, and hashing, a virtually irreversible operation on a message that obfuscates its contents and is used to verify the authenticity of a user. For example, such techniques are used in cryptocurrency "wallets" to ensure that only their owners can access and control their funds while simultaneously allowing all users to view public transactions and send cryptocurrency to each other. Thus, although all data on a blockchain is publicly accessible, certain data can only be decrypted by authorized users, thereby affording privacy, security, and transparency.

Because of these characteristics, many traditional financial and nonfinancial services are being re-engineered using blockchain. For example, escrow accounts can be created using dApps to ensure that two parties meet the criteria for a transaction before that transaction occurs (Smartlink, 2022). Moreover, decentralized exchanges (DEXs) allow users to lend cryptocurrencies to each other for a certain amount of time at a predetermined interest rate (Daley, 2021). In addition, Filecoin allows users to pay each other to store files on their computers for a certain amount of time (Phillips & Hussey, 2021). Because of the inherent transparency of blockchain, all code for such services is publicly available, allowing users to audit such code before interacting with it using their cryptocurrency.

Proponents of blockchain include The Blockchain Advocacy Coalition (BAC), Fedex, and the Enterprise Ethereum Alliance (EEA). BAC "is committed to educating legislators and regulators about blockchain technology" (2018, para. 1). The CIO of Fedex, Rob Carter, emphasizes the significance in making shipping data - including certificates of origin and commodity-specific licenses - transparent on a blockchain-enabled public ledger (Mearian, 2019). The EEA claims Ethereum can revolutionize the telecommunications roaming system by reducing authentication delays when switching between providers, improving security, and reducing infrastructure costs (Fromm, 2019).

CONCERNS OVER BLOCKCHAIN USEFULNESS

One major point of contention is the slow transaction speeds associated with many blockchain projects. For example, the Bitcoin network can now process only 5 transactions per second, while Visa's network can handle 1,700 per second (Griffin, 2020). In response to this concern, researchers are developing a "parallel proof of work" system, which allows multiple

different “miners” to handle blockchain transactions cooperatively instead of having a random individual “miner” handle a given transaction (Shahriar Hazari & Mahmoud, 2020).

Similarly, opponents claim that high transaction fees will deter usage of certain cryptocurrencies, such as Bitcoin (Salvo, 2021). These fees are necessary to incentivize miners to maintain the networks, but they can fluctuate and rise at times of congestion. However, proponents argue that even with high transaction fees, cryptocurrencies offer a more secure and trustworthy alternative to currencies in fragile nations (van den Berg, 2018). According to van den Berg, “modern fragility combines dysfunctional governance with often high levels of technological adoption” (p. 2). This trend is exemplified by Somalia’s longlasting civil war producing high mobile phone coverage and relatively low telecommunication costs. Thus, cryptocurrencies are expected to follow this trend.

A major concern raised by the International Monetary Fund (IMF) is that the value of crypto assets is “too volatile” and “unrelated to the real economy” (Adrian & Weeks-Brown, 2021, Cryptoassets as legal tender? section, para. 3). Jerome Powell, Chair of the cryptocurrency-opposing Federal Reserve, similarly believes that the volatility of crypto assets “undermines their ability to store value” (Al Jazeera, 2021, para. 2).

THE HARMFUL CONSEQUENCES OF BLOCKCHAIN

Environmental Concerns

Maintaining a blockchain network is highly energy intensive (Küfeoğlu & Özkuran, 2019). This is exemplified by the fact that, in 2017, when it hit peak power consumption, Bitcoin mining consumed power equivalent to the installed electrical capacity of Finland (16 GW).

This high energy cost is due to the fact that cryptocurrency mining often requires large computational resources (Bada et al., 2021). In a proof-of-work (PoW) cryptocurrency system, such as Bitcoin, miners compete with one another by randomly guessing numbers until they find one that produces a hash with a particular, globally-recognized quality. The first miner that successfully does so earns the reward and fees associated with the data block currently being mined into the network. Thus, miners are incentivized to use the fastest hardware for their mining operations, which require a large amount of electricity to power.

In response, proponents such as the International Youths Organization for Peace and Sustainability (IYOPS) point out that the traditional banking system currently consumes 139,000 GWH per year to run servers, ATMs, and physical branches (Eugenia, 2021). Furthermore, they argue that scaling up cryptocurrency usage would not result in significant energy cost increases, as the current cryptocurrency infrastructure is already sufficient to maintain global cryptocurrency networks.

Moreover, other cryptocurrency consensus mechanisms, such as proof-of-stake (PoS), require less computational resources than PoW (Bada et al., 2021). PoS works by giving miners holding more cryptocurrency a higher chance of being chosen to do the work necessary to mine the current data block and earn the associated reward and fees. However, this gives rise to another criticism: those holding more cryptocurrency are likely to earn even more and gain more control over the network.

The Potential for Criminal Activity

Janet Yellen, Secretary of the Treasury, warns of criminals using cryptocurrencies for illicit financing, money laundering, and black-market activity (Lennon, 2021). Although blockchain affords transparency and the ability to trace cryptocurrency transactions between

accounts, it is difficult to discern the particular owners of such accounts, which complicates matters involving tax evasion and other criminal activity. Moreover, because transacting with cryptocurrency is analogous to transacting with cash (Smith, 2022), digital black-market users can use Bitcoin and other cryptocurrencies to bypass any intermediaries, such as banks or governments.

Many also believe that the existence of non-fungible tokens (NFTs), or unique, nonreproducible assets stored on the blockchain, gives rise to more money-laundering (Cassady, 2022). This is because, increasingly, NFTs are being sold for large sums of money; in the first three months of 2021, the NFT market generated $1.5 billion, with numerous individual NFTs being sold for hundreds of thousands of dollars. Many critics believe that the only possible explanation for such high valuations is criminals attempting to disguise their illicit gains as the proceeds from an NFT sale.

THE TOP-DOWN PUSH FOR CRYPTOCURRENCIES

Proponents point to El Salvador's recent Bitcoin Law, which gave Bitcoin the status of legal tender, as a sign of blockchain's increasing adoption and ability to combat inflation (Hanke, 2021). However, the Cato Institute compares the Bitcoin Law, which made Bitcoin both legal tender and forced tender, to Article 175 of the Soviet Union's civil code and other forced-tender laws, which are common during military occupations. Hanke points out that Nayib Bukele, President of El Salvador, has a history of totalitarian activity - firing the attorney general who initiated investigations into corruption in Bukele's government, replacing five judges who attempted to apply the rule of law upon Bukele, and more. Hanke claims that enacting the Bitcoin Law is just another action to add to this list, since it would allow Bukele to more easily

facilitate money-laundering and corruption without immediate punishment from the Financial Action Task Force (FATF).

Similarly, critics view the usage of celebrities to promote the spread of blockchain as disingenuous and desperate. Examples of such instances include Tom Brady and Gisele Bündchen promoting FTX, a cryptocurrency exchange, Kim Kardashain promoting Ethereum Max, a cryptocurrency that dropped 98% in value following her promotion, and Matt Damon promoting Crypto.com, a cryptocurrency exchange (Rosen, 2022). Though none of these celebrities are particularly qualified to discuss the potential of cryptocurrencies, they are paid large sums of money to use their influence to convince consumers of the potential of cryptocurrencies. Moreover, they rarely offer legitimate points about the utility of blockchain, relying more on emotional pleas such as "fortune favors the brave."

In contrast to the claim that blockchain fosters corruption, Yang et al. offer increased election integrity as a benefit of blockchain; by providing encrypted, unmodifiable vote counts on a public ledger, election results can be made indisputable and verifiable (Yang et al., 2020).

ENGINEERING BLOCKCHAIN SOLUTIONS THAT MINIMIZE HARM AND MAXIMIZE ACCESSIBILITY AND UTILITY

Applying ANT to the obstacles blocking mainstream adoption of blockchain can assist in visualizing, understanding, and addressing such obstacles. Doing so yields Figure 1, an Actor Network model of the social groups and concerns involved in blockchain democratization.

Figure 1: Actor Network Theory Analyzing the Opportunities and Spread of Blockchain Technology: This diagram illustrates the various social groups that have a stake in the democratization of blockchain technology, including potential beneficiaries, along with obstacles that hinder its spread (Stein, 2022).

As seen in Figure 1, the media plays a major role in connecting the various social groups together. By selectively reporting on news concerning blockchain, the media is able to decide which news becomes common knowledge, thereby influencing viewpoints on blockchain. For instance, by relaying environmental concerns and the potential for criminal activity to blockchain consumers without offering examples of the benefits of blockchain, the media is able to increase the likelihood that consumers avoid blockchain for ethical reasons. Such reasons include having a duty to not patronize criminal activity or environmental damage, which relates to duty ethics.

Another conclusion that can be drawn from the application of ANT is that governments, through regulation, can impact every other social group, either directly or indirectly. For instance, if governments ban intensive cryptocurrency mining, some blockchain critics could approve of the motion and become advocates of cleaner blockchain technology, while miners could become more likely to adjust their mining configurations or cryptocurrency of choice to continue to generate income.

Having defined the major relationships among and concerns of the social groups impacted by blockchain technology, solutions that address these concerns and leverage these relationships can now be constructed. The methods for doing so are outlined in Figure 2.

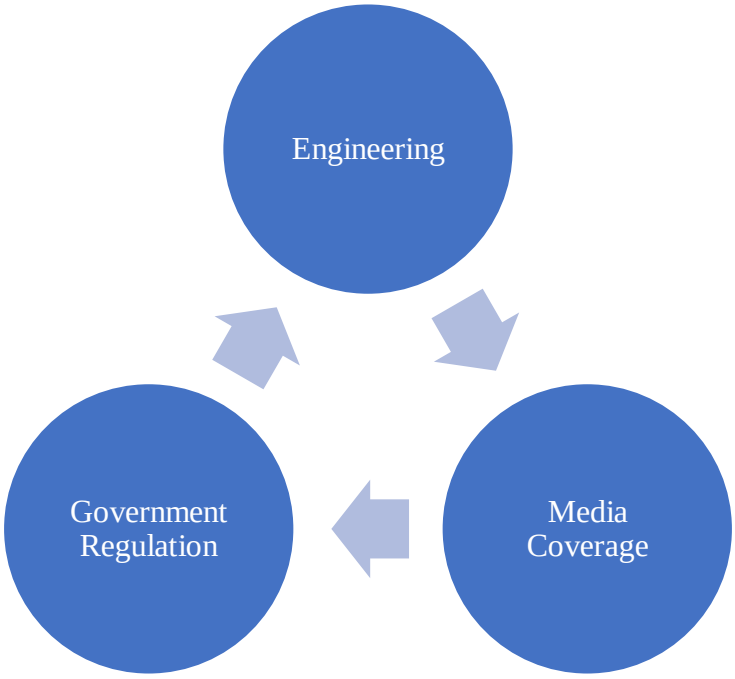

Figure 2: Blockchain Development Cycle: This flowchart depicts the major stages involved in developing and improving blockchain technology. Each stage is associated with a particular social group and influences the social group that follows it (Stein, 2022).

As illustrated in Figure 2, once blockchain engineering has occurred, such as in the form of a new cryptocurrency, the media begins covering it. Depending on the nature of this coverage, governments may begin creating regulations: if the coverage is negative, governments may restrict usage; if coverage is positive, governments may encourage usage, potentially leading by example, as in the case of El Salvador. These regulations or incentives can influence engineers to develop alternative blockchain applications that address the concerns raised by consumers, echoed by the media, and enforced by the government.

To combat destructive environmental effects, cryptocurrencies that use consensus mechanisms other than PoW can be further developed and given more media attention (Daly, 2022). Although PoS, mentioned earlier, is the most popular alternative to PoW, other consensus mechanisms are being developed that further improve energy efficiency. For instance, delegated

proof-of-stake (DPoS) involves having other nodes on the network elect the next block miner, thereby reducing the need for computationally-expensive randomization operations (Bada et al., 2021). Another mechanism – proof-of-elapsed-time (PoET) – streamlines miner selection by using a timer-based system to select the next miner, thereby giving each node an opportunity to be a miner and removing the need for energy-intensive competition. However, such a system would only work with a relatively small number of nodes on the network; otherwise, nodes may need to wait long periods of time before receiving rewards for mining, which can disincentivize them from remaining on the network.

To combat slow transaction times, cryptocurrencies designed for fast transactions, such as Stellar Lumens, can be promoted to those who require quick transactions (Williams, 2021). However, such cryptocurrencies may be less decentralized and secure than more established cryptocurrencies such as Bitcoin. In the case of Stellar Lumens, high transaction speeds are achieved through the use of mini-networks scattered throughout the globe. Though this expedites mining, as only several mini-networks are needed to validate a given transaction, it also makes it easier to fool the network into validating an illegitimate transaction, thereby decreasing security. Thus, prospective cryptocurrency users should be aware of such tradeoffs.

To combat market volatility, new cryptocurrencies that tie their value to that of less volatile real-world assets, such as gold or treasury bonds, can be developed and promoted. For instance, one Tether Gold token represents one troy fine ounce of gold; thus, it is less prone to price fluctuations than cryptocurrencies that are not backed by real-world assets (Quiroz-Gutierrez, 2022). Similarly, tokenized equity – cryptocurrencies backed by company stock – are only as volatile as their underlying assets on the stock market.

To combat the usage of blockchain for criminal activity, government regulations can be imposed. Although it is difficult to ban cryptocurrencies due to their decentralized nature, traditional infiltration techniques used to combat black-market activity can be used in cryptocurrency black-markets, such as using undercover agents to pose as buyers or sellers (Sin, 2019). However, new techniques could also be engineered, such as automated "bots" that track cryptocurrency transactions and flag suspicious activity, including splitting a large sum into thousands of smaller transactions or receiving many transactions for an unknown reason.

FUTURE IMPLICATIONS FOR PROMOTING THE EQUITABLE SPREAD OF TECHNOLOGY

Through the analysis of the views of different social groups on blockchain, an understanding of the major concerns of blockchain critics has been achieved. These include concerns about the practicality of blockchain; as evidence, critics cite slow transaction speeds, high transaction fees, and high market volatility. They also stress the possible adverse consequences of blockchain, emphasizing high environmental cost and the increased potential for criminal activity. Finally, many view the top-down push for cryptocurrencies as totalitarian and disingenuous.

However, combatting such concerns involves more than simply engineering new blockchain solutions. The power that the media, celebrities, and the government hold in promoting technology is substantial, and ensuring that this power is used to promote the most useful and least harmful cryptocurrencies is critical in democratizing blockchain. The media and celebrities should promote cryptocurrencies that will be more environmentally sustainable, have lower fees, have quicker transaction times, and address other concerns raised by blockchain critics. The government should impose regulations on volatile, get-rich-quick cryptocurrencies,

should offer incentives for environmentally sustainable cryptocurrencies, and should engineer and deploy modern solutions for detecting and stopping criminal activity using blockchain.

This analysis also has major implications on the technical project. By being mindful of usefulness- and consequence-related concerns, TensorSnap can be engineered to more quickly, effectively, and safely bring ML to those who do not know how to code. For instance, allowing TensorSnap to run in an internet browser minimizes its environmental footprint and the barrier to entry, and allowing users to perform any task that can be performed using text-based machine learning increases its usefulness. Moreover, a curriculum that provides training in machine learning to non-programmers using TensorSnap as an educational tool can be developed; such a curriculum could be promoted using the media and celebrities, which can expedite the democratization of ML.

Future research can expand upon this thesis by including different social groups in its ANT analysis, such as blockchain engineers and bank employees. Additional research could also be conducted on government-issued cryptocurrencies, which have begun to gain traction, and whether they address the concerns raised by blockchain critics. Moreover, tools other than engineering, media, and the government can be considered when designing solutions that address blockchain controversy. Finally, case studies can be conducted that compare blockchain to other technologies that required multiple iterations and improvements before widespread adoption was experienced and the benefits of technological advancement were maximized.

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