THE BLOCKCHAIN ETHICAL DESIGN FRAMEWORK

CARA LAPOINTE AND LARA FISHBANE

Dramatic predictions have been made about the potential of Blockchain to revolutionize everything for billions of people around the globe, from worldwide financial markets and the distribution of humanitarian assistance to the very way we recognize human identity. Some dismiss these claims as excessive technology hype by citing flaws in the technology or the robustness of incumbent solutions and infrastructure. The reality will likely fall somewhere between these two extremes across multiple sectors. Whereas initial applications of Blockchain were focused on the financial industry, current applications address a wide array of sectors, with major implications for social impact. This paper aims to demonstrate the capacity of Blockchain to create scalable social impact and to identify the elements that need to be addressed to mitigate challenges in its application.

We are at a moment when technology is enabling society to experiment with new solutions and business models. Ubiquity and global reach, increased capabilities, and affordability have made technology a critical tool for solving problems, making this an exciting time to think about achieving greater social impact. We now can address issues for underserved or marginalized people in ways that were previously unimaginable. Blockchain is a technology that holds real promise for dealing with key inefficiencies and transforming operations in the social sector, and for improving lives. Because of its immutability and decentralization, Blockchain has the potential to create transparency, provide distributed verification, and build trust across multiple systems. For instance, Blockchain applications could provide the means to establish identities for individuals without identification papers, improve access to finance and banking services for underserved populations, and distribute aid to refugees in a more transparent and efficient manner. Similarly, national and subnational governments are putting land registry information onto Blockchains to create greater transparency and avoid corruption and manipulation by third parties. From increasing access to capital to tracking health and education data across multiple generations to improving voter records and voting systems, Blockchain has countless potential applications for social impact.

As developers begin to build these types of solutions, the social effects of Blockchain could be powerful and lasting. With the potential for such a powerful impact, the design, application, and approach to the development and implementation of Blockchain technologies have long-term implications for society and individuals. This paper outlines why intentionality of design, which is important with any technology, is particularly crucial with Blockchain and offers a framework to guide policymakers, social impact organizations, and other decisionmakers. As social media, cryptocurrencies, and algorithms have shown, technology is not neutral. Values are embedded in the code. How the problem is defined and by whom, who is building the solution, how it gets programmed and implemented, who has access, and what rules are created have consequences, in both intentional and unintentional ways. In the applications and implementation of Blockchain, it is critical to understand that seemingly innocuous design choices have resounding ethical implications for people's lives.

This paper addresses why intentionality of design matters, identifies the key questions that should be asked, and provides a framework to approach the use of Blockchain, especially as it relates to social impact. It examines the key attributes of Blockchain, both its broad applicability and its particular potential for social impact, and the challenges in fully realizing that potential. Social-impact organizations and decisionmakers have

ABOUT THE AUTHORS

Cara LaPointe is a Senior Fellow at Georgetown University within the Beeck Center for Social Impact + Innovation, where she works at the intersection of technology, policy, leadership, and ethics. Over the last two decades, LaPointe has held a diverse range of technical, acquisition, research, and operational roles, including at the White House, the United Nations, and the United States Navy. LaPointe is a patented engineer and a White House Fellow, and she holds degrees from the United States Naval Academy, the University of Oxford, the Woods Hole Oceanographic Institution, and the Massachusetts Institute of Technology.

Lara Fishbane is a Research Assistant at the Brookings Institution within the Metropolitan Policy Program. Fishbane is a graduate of Georgetown University, where she studied economics and English and researched issues related to poverty, labor, and education policy. Previously, she worked at the nonprofit 826DC, where she taught in inner-city schools in Washington, D.C., and explored the relationship between writing and education reform. Fishbane has served as a reporter at Forbes, Kiplinger, and the Georgetown Voice, with a focus on financing higher education and innovation in classrooms.

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http://beeckcenter.georgetown.edu/Blockchain-ethical-design-framework-social-impact/.

an obligation to understand the ethical approaches used in designing Blockchain technology, especially how they affect marginalized and vulnerable populations. Launched in June 2018 at the Beeck Center for Social Innovation + Impact at Georgetown University, with support from The Rockefeller Foundation, the Blockchain Ethical Design Framework is a tool for integrating values and ethical intentionality into the design and implementation of Blockchain technology.[1.]

WHAT IS BLOCKCHAIN?

Blockchain refers to a particular class of digital distributed ledger technologies that share records of sequenced information or transactions simultaneously across a network in an immutable and secure manner. Blockchain does not require a central trust authority to verify information or authenticate transactions; rather, trust is built into the governance rules that include pre-written code that defines how actors can behave in the system. Each transaction between network actors is strictly verified using computer algorithms against the governance rules. The accepted transactions are then grouped into secure "blocks" of information and linked sequentially in a virtual "chain." While this paper focuses on Blockchain, much of the discussion is more broadly applicable across distributed ledger technologies.

Transactions on a Blockchain could be either the transfer of a digital asset, such as a cryptocurrency token, or a way to link information to a particular profile, such as associating a university degree with a digital identity. Every transaction in a Blockchain has a unique identity that is linked to a single entity who can exercise control over the information or asset from that transaction. Once a transaction is recorded on the Blockchain, it is effectively irremovable and unchangeable. The result is an immutable timestamped record of a series of transactions.

This unique combination of attributes—transparency, trust, and immutable transactions—makes Blockchain technology appealing in its application for social impact. The technology's flexibility and extensibility to apply it in countless ways to solve longstanding problems are driving technologists, innovators, and Blockchain evangelists across the globe. However, Blockchain is in fact neither a single technology nor a monolithic entity.

There are myriad design and implementation choices that create functionally distinct Blockchain systems. One of the most significant Blockchain distinctions is between permissionless and permissioned systems. In permissionless versions, anyone can participate in creating the blocks for a Blockchain; permissioned applications allow only authorized entities to do so. Similarly, some Blockchain ledgers are publicly viewable, whereas others can be seen only by a designated audience. Furthermore, open-source Blockchain platforms are available for Blockchain development, as are proprietary or custom options. These are just some of the many choices that give Blockchain its flexibility and extensibility.

Depending how it is designed and implemented, Blockchain can have a wide range of consequences for people. Furthermore, a Blockchain is always one component or layer of a larger system in which people and technology interact to create an overall outcome. Hence, making intentional, ethical decisions in Blockchain design and implementation into an overall system is crucial to ensuring the technology's potential for transformative change.

THE KEY ATTRIBUTES OF BLOCKCHAIN

Blockchain has a spectrum of key attributes that are highly interdependent and that vary in their relative dominance, based on design and implementation. All of these key features should be considered potential attributes, since their exact realization depends on the detailed design of a particular Blockchain system. As mentioned above, the combination of transparency, trust, and immutability is unique to Blockchain. Other potential key attributes, including pseudonymity, verifiability, controllability, security, and a disintermediated structure, are not unique to Blockchain but are important for understanding the potential and challenges of the technology. In practice, these attributes are interconnected and their relative strengths are determined by the design and implementation. Decisions about how to optimize combinations of these attributes in a Blockchain will determine the impact of its application and have potentially significant consequences for people's lives.

Transparency

Identical copies of the entire record of transactions are available to all participants of a Blockchain at all times. This is often referred to as a distributed ledger. The ledger provides transparency of transactions to anyone with access. In some cases, these ledgers are available to anyone.

Trust

Strict governance rules, cryptography, and immutable transactions work together to provide strong security for individuals interacting directly on a distributed network without a central trusted authority.

Immutability

Immutable transactions recorded on a Blockchain cannot be changed or removed. To change a transaction on the Blockchain, a new transaction needs to be added to reverse the effects of the original. In immutable ledgers, there is no way to "expunge" the record of a transaction.

Pseudonymity

Using public and private key systems, participants have a public-facing digital "address" that is not publicly associated to them but over which they exercise unique control. This provides pseudonymity through encryption that creates effective anonymity for participants.

Verifiability

Transactions on a Blockchain are immediately auditable in real time. As an immutable and sequenced digital ledger, a Blockchain allows the complete record of transactions to be directly verified.

Controllability

The tracking of individual assets uniquely on a Blockchain allows an individual to exercise effective and exclusive control over data or digital assets. Furthermore, transactions on a Blockchain allow the secure transfer of control between individuals over the network.

Security

The use of encryption algorithms combined with the disaggregation of data across a distributed network of nodes (i.e., computers) provides security against attempts to destroy or change the record of transactions.

Disintermediation

Using direct transactions, Blockchain technology can streamline processes by cutting out unnecessary intermediaries and process steps, and reduce the risk of

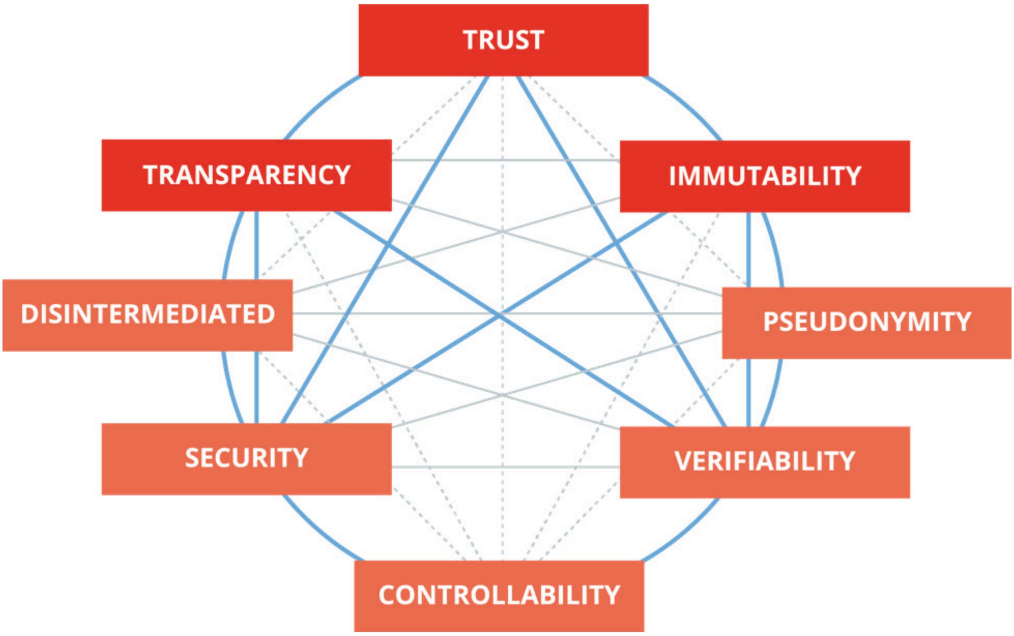

Figure 1. The Key Attributes of Blockchain

errors that usually come with extra transactions in a system.

THE SOCIAL IMPACT POTENTIAL OF BLOCKCHAIN

Blockchain's potential for social impact spans a wide spectrum. The technology has the ability to disrupt different types of institutions and social systems across the globe. The crypto-economic functions of Blockchain are creating microeconomies and incentive systems that are bypassing traditional institutions to meet the specialized needs of diverse populations. Blockchain can also be used as a tool to create transformative shifts in control over information, which is a critical and valuable resource in an increasingly digital society. Blockchain can be a tool for democracy by creating immutable records of information that cannot be altered, censored, or suppressed by authoritarian regimes. Blockchain also can transfer effective control over personal data back to individuals, thereby allowing them to restore their privacy and to exercise power over the monetization of their own data.

While the potential transformative power of Blockchain is vast, much of this transformation will be achieved through the proliferation of practical applications of the technology. The possibilities of Blockchain are already being explored across a wide spectrum of social impact initiatives, organizations, and applications. Below are some broad categories in which Blockchain has demonstrated promise.

Digital Identity

One of the most important things Blockchain can do is create a digital identity. The immutability and verifiability of

Blockchain systems enable the establishment of permanent and portable digital identities. These identities are linked to a unique individual and can be used in a variety of contexts to prove identity or credentials. This capability provides extensive social-good benefits. One example is the effort by ID2020, a public-private partnership, to supply digital identities to people living without officially recognized identities in order to give them access to economic, political, and social opportunities.[2.] Another example is a Blockchain recently launched in New York City by the organization Blockchain for Change that creates a digital identity system to connect homeless individuals with efficient access to services and programs.[3.]

Digital identities also raise important questions about privacy and control of data. The Sovrin Foundation is leveraging Blockchain technology to return control over digital identity to the individual.[4.] The Sovrin Trust Framework is an effort to create a robust governance structure that, among other things, allows a person to exert positive control over any personal digital identifiers on the Blockchain. That person would have control over the sharing of his or her identifiers in a way that preserves anonymity so that individual identifiers could not be linked to one another, thus preventing data brokers from aggregating that information, as is currently done via the Internet.

Asset Tracking

Blockchain has significant potential for supply chain management and tracking assets. For example, De Beers is piloting a diamond-tracking Blockchain to ensure the traceability of diamonds to help industry professionals and consumers distinguish between conflict and non-conflict diamonds.[5.] In another example, IBM is working with several big food retailers to prevent fraud by verifiably tracking the provenance of food and to increase food safety by efficiently facilitating rapid responses to recalls of contaminated food.[6.]

Blockchain technology can also help governments, aid agencies, and individual donors to transparently track financial resources, such as humanitarian or disaster assistance funds, from the point of origin to the point of application.[7.] For example, the platform Giveth provides a tool to create Decentralized Altruistic Communities, which transparently track donor funds for individual projects, such as funding electricity for schools in South Africa.[8.] In another example, AID:Tech has created a Blockchain system to transparently track digital entitlements from aid organizations. Using mobile phones and plastic vouchers, users can create digital identities that are then linked to spendable assets in a Blockchain. The aid organization has transparency on every voucher being spent and on the full distribution chain.[9.]

Enterprise Efficiency

Blockchain offers tremendous potential for its ability to aggregate, verify, and transact with multiple data sources. Many governments and businesses are considering applying Blockchains to manage internal transactions. A recent report from Accenture says Blockchain's transformational potential lies in its power to create efficient data-sharing and reconciliation processes within an enterprise.[10.] Data are the backbone of most business operations, and current methods for multiple parties to leverage data often include laborious and inefficient transactions and back-and-forth communications. By comparison, Blockchain allows multiple parties to efficiently and transparently collaborate with data in a way that is immediately verifiable.[11.]

One specific way organizations create better data-sharing and greater transparency is through contracts. Blockchain has great potential for creating outcomes through "smart contracts," in which computers automatically execute an action once conditions are met. These contracts increase the speed and accountability of managing transactions. Outcomes-based contracts do not have to be executed on a Blockchain, but putting them on an immutable Blockchain provides irreversible security guarantees that make it harder for users to violate the contracts.[12] One example is smart contracts for peer-to-peer lending or sharing networks. Entrepreneurs such as Lendoit and ETHLend are leveraging smart contracts for direct, peer-to-peer lending programs.[13] Brooklyn Microgrid, an energy-sharing micropower grid, uses smart contracts to create direct energy market exchanges where people can buy and sell energy with other members of their community.[14]

EXPLORING SOCIAL-GOOD APPLICATIONS OF BLOCKCHAIN

Within the realm of digital identity, asset tracking, and enterprise efficiency, Blockchain has a diverse range of particular social-good applications. Below are some of the many representative examples.

Expanding Access to Services

Blockchain can increase inclusivity by allowing people who do not have formal identity credentials or credit histories to build a secure digital identity, thus reducing risks for lenders. For example, BanQu's economic-identity Blockchain aggregates personal identifiers, such as financial transaction histories, property records, trust networks, and education records, so that people can develop a portable and vetted personal history that gives them access to formal services.[15]

Protecting Vital Records

Governments and other entities across the globe are exploring Blockchain applications for vital-record protection. Estonia is one of the world's leading governments in the adoption of e-governance technologies to create digital registries and online government services, which includes securing more than one million public health records with a form of Blockchain technology. The records themselves are kept in a traditional database and, to enhance the security of private information, the Blockchain logs every time those records are accessed or altered.[16] In addition to providing auditable records, Blockchain protects those records by scattering data throughout a distributed Blockchain ledger, thus reducing vulnerability more than is possible with data that are aggregated and stored in one location.

Recording Public Transactions

Blockchain-based land registries are being piloted in countries around the world. Nonprofit foundations such as Landesa and the Cadasta Foundation are testing Blockchain applications to record property titles and transfers.[17] In another example, the Bitfury Group and the Republic of Georgia have designed and piloted a Blockchain titling system to improve security, allow for real-time audits, and reduce the transaction costs of registering land property titles in Georgia.[18]

Enabling Secure Mobile Voting

Blockchain-based technologies are being explored to provide secure mobile voting. Companies such as Voatz are leveraging the attributes of Blockchain to provide end-to-end verifiable voting on an accessible platform that reduces barriers to voting.[19] In 2018, West Virginia piloted a mobile voting solution for deployed military personnel that securely records votes directly onto a Blockchain-based system developed by Voatz.[20.]

Preventing Human Trafficking

Governments and organizations are looking at the promise of Blockchain to combat and prevent human trafficking. The United Nations has partnered with the World Identity Network to launch a pilot project in Moldova of a Blockchain-based digital identity system for undocumented children.[21.] In a similar effort, the nonprofit organization iRespond is leveraging its Blockchain digital identity systems to help prevent forced labor in offshore fisheries.[22.] The U.S. Department of State is joining with Coca-Cola and other private partners to create Blockchain-based secure worker registries to help prevent forced labor worldwide.[23.]

Improving Medical Research and Healthcare

Blockchains are being piloted to improve medical research and healthcare. A prototype for electronic health records and medical research data called MedRec was developed through a collaboration between the Massachusetts Institute of Technology Media Lab and the Beth Israel Deaconess Medical Center.[24.] Using MedRec, control and responsibility over medical records are shifted from institutions back to the patients, who are ultimately in control of where those records can travel.[25.] In another example, iRespond has created a Blockchain digital identity system to anonymize patient records, thus reducing barriers to HIV testing and collecting more accurate data for HIV clinical trials. It has implemented this system in various projects with academic partners, such as its partnership with the University of Washington in Kenya and a separate partnership with Johns Hopkins University in Thailand.[26.]

BLOCKCHAIN DESIGN CONSEQUENCES

What makes Blockchain so relevant is also its greatest challenge: the interdependence of its attributes. It is impossible to focus on one desired feature without understanding and accounting for the interaction of all the attributes of Blockchain. There always will be tradeoffs in the design process in order to optimize the desired attributes of Blockchain for a given application, which will result in functionally different Blockchain systems. Small design and implementation choices can have resounding ethical consequences for people and communities.

Like the potential positive social impacts of Blockchain, the ethical consequences of this technology can be just as diverse and wide ranging. Whereas Blockchain can be an instrument of democracy, it also can be used by governments or other entities to exert and consolidate power over people and information. Whereas crypto-economic systems can increase financial inclusion and create innovative microeconomies, these structures could also create exploitive systems with perverse incentives or undermine existing payment and monetary systems that have the virtue of being understood and accepted within formal financial markets. The effective anonymity of cryptocurrencies also has been used for criminal activity. Whereas Blockchain has the ability to restore personal control over data, it could also have the effect of consolidating and codifying certain entities' control over information and personal data. These human consequences could be the result of intentional action, but also they could be created unintentionally through Blockchain technologies designed with positive motivations.

The following examples represent some of the many potential consequences of the tradeoffs made in Blockchain design. These examples are meant to be representative, not comprehensive; they illustrate the breadth of the challenges and potential consequences that arise from the practical applications of Blockchain design and implementation. At one end of the impact spectrum, Blockchain technologies could create or exacerbate severe power inequities in communities, or they could consolidate power over individuals and information by entities that design and implement the technology to their own advantage. At the other end of the impact spectrum, we present particular technical design issues such as private key systems and encryption algorithms to show that even these seemingly innocuous design details can significantly affect people.

Codifying Negative Social Impacts

One potential consequence for end users of Blockchain technology is the codification and exacerbation of existing negative social dynamics. Blockchain could be used as a tool to consolidate control over people or entities or to create secret agreements that circumvent laws and regulations. For example, a Blockchain used to provide access to financial services through verification that relies on members of a community to collectively verify a person's creditworthiness has vastly different effects on an end user from a Blockchain that relies on a person's history of financial transactions, property ownership, and education record. The first example runs the risk of codifying biases within the community, while the latter runs the risk of codifying the status quo. Without intentional design, a Blockchain could run the risk of exacerbating disparities.

The Risks of Transparent or Immutable Personal Information

Transparency of personally identifiable information could put someone at risk of exploitation, while transparency of ethnic or religious background, sexual orientation, or other identifiers could put a person at risk for persecution. Immutability of information on a Blockchain removes the ability to be forgotten. Should a political refugee, witness to a crime, or survivor of domestic abuse have the right to anonymity or to create a new identity? Even if someone legally changed her name, she would be unable to disassociate her biometrics from the old digital identity in the Blockchain. Is there a minimally viable set of identifiers that should be used to create a digital identity in order to help mitigate these effects? For example, if the purpose of a Blockchain is to enable short-term access to services or resources, such as post-disaster assistance, is it even necessary to include any personally identifiable information as part of the digital identity, or would a transactional username suffice?

The "Zero State" Challenge

Beyond personal identity, many Blockchain efforts are designed to create secure, immutable, and immediately auditable provenance records for physical items. However, what happens if the veracity of those items' provenance initially entered into the Blockchain comes into question? This is referred to as the "zero state problem," and it is a major issue for Blockchain-based provenance records for physical objects that predate the Blockchain. Consider land registry systems and efforts by entire countries to transition to Blockchain for land title recording and transfer. Some of the world's population lives on land without having clear title, which could lead to significant uncertainty about the initial land title data in a Blockchain. Additionally, the falsification of a land title is already a problem in some places, so false land title data recorded in an immutable

Blockchain could exacerbate the effects on disenfranchised owners.

Reliance on Private Keys

In a Blockchain, security and control over a digital asset are established with encryption algorithms and public-private key pairs, which include a publicly known "address" and a private digital key that can unlock the mailbox at that address. The advantage is that individual users do not need to remember passwords or link their personal information, such as email addresses or telephone numbers, to collections of stored information. However, users do need their private keys to access the system. If there is no way to retrieve a lost private key, the negative effects could be considerable. Consider a Blockchain-based system to record property titles. An individual would need his private digital key to access control over his property and sell it to someone else. What if he loses his private key? Is there any way to reset or retrieve his private key? If not, does that mean he has lost control over his property? If Blockchains are hosting control over assets, especially valuable assets, it is important to incorporate a way to retrieve an individual's private key.

The Limited Lifespan of Encryption

Blockchain relies heavily on encryption, and encryption has an effective lifespan. As computational techniques and computer power continue to evolve at a rapid pace, so, too, must encryption algorithms stay ahead of the technology to break through encryption. If immutable and distributed information on a Blockchain is encrypted with outdated algorithms, that information may become vulnerable to exposure. This can have significant consequences for people's lives if the exposure of personal information leaves vulnerable populations open to exploitation. Blockchains built for long-term applications, such as land registries, must also consider the possible effects of quantum computing to amplify this threat through its projected ability to break through any non-quantum-proof digital signatures used on Blockchains and to forge transactions.[27.]

Environmental Impacts

In the absence of a trusted central authority, Bitcoin-based Blockchain applications allow entities worldwide to transact safely and securely, yet they consume significant environmental energy. Bitcoin authenticates transactions on its distributed network using a network consensus rule or a consensus protocol called Proof of Work, which uses brute force trial-and-error methods to guess trillions of possible solutions to a cryptographic puzzle. The electrical energy consumption required to accomplish this has become an increasing area of concern, as leveraging Blockchain for social good with a Proof of Work consensus protocol could risk harming the environment. In June 2015, the electrical consumption estimated for a single Bitcoin transaction was equivalent to the energy used by an average American home in 1.57 days. By December 2017, the increasing value of Bitcoin had driven so much competition into this space that the electrical consumption for a Bitcoin transaction had jumped to 8.45 days of average use by an American home.[28.] Alternate ways to create consensus on a Blockchain are being designed to address the environmental challenge.[29.]

THE IMPORTANCE OF INTENTIONAL DESIGN

In a traditional design and build context of digital technology, there is an opportunity to modify code and to test and fix design flaws even after the technology has launched. For instance, an application can change how to manage an identity by modifying code and releasing a new version. It's not that simple with Blockchain. Once built, it is much more complicated to change course, and any information already in a Blockchain is immutable and distributed. This drives the need for intentionality in design to identify what attributes need to be prioritized at the expense of others in the design process.

Even before deciding whether Blockchain is the right technology to use, social impact organizations need to clearly identify the problems they want to address and the associated outcomes they want to achieve, establish the appropriate ethical approach and guiding values, and understand the available technology choices. This is particularly important in Blockchain, in which the rules governing the human interactions with the technology are determined from the earliest stages of design and can be exceedingly difficult to change once the technology is implemented.

As with all technology implementation, organizations are managing the costs, schedule, and performance requirements. Therefore, ethical design and social-impact goals must be incorporated into the project requirements from the start. Blockchain development is no exception. As a result of these challenges, we designed the Blockchain Ethical Design Framework as a practical tool to integrate intentional ethical design into the Blockchain design and implementation process.

BUILDING BETTER TECHNOLOGY WITH THE BLOCKCHAIN ETHICAL DESIGN FRAMEWORK

Social-impact organizations and policymakers have an obligation to understand the ethical approaches used in designing Blockchain technology, especially how they affect marginalized and vulnerable populations. The Blockchain Ethical Design Framework was launched in June 2018 as a tool to create an intentional design that incorporates key ethical questions for the development and use of Blockchain. A summary of the Framework is presented in this paper.

The overarching goals of the Framework are to (1) give decisionmakers an outcome-focused and user-centric tool to assess the context-specific consequences and ethical implications of their Blockchain design and implementation choices; and (2) to enable decisionmakers to use this understanding to make the appropriate values-based choices to achieve better social outcomes. For the purposes of this Framework, "decisionmaker" is considered to be anyone who is influencing a social-impact solution that may involve the design and implementation of a Blockchain. Furthermore, the Framework should be used in a collaborative way that actively involves all critical stakeholders throughout the process, from problem definition through execution. The stakeholders will come from the diverse communities, fields, and organizations that are involved in all aspects of the relevant ecosystem.

To develop this Framework, the authors worked with more than one hundred experts across academia, government, and the private and nonprofit sectors. The contributors represent more than 90 organizations with expertise in a diverse range of fields, such as digital identity, information privacy, ethics, governance, law, technological innovation and development, international development, humanitarian assistance, cybersecurity, artificial intelligence, information technology management, and their intersections. Collaboration with this diverse community of experts revealed important ethical questions, concerns, and considerations in the implementation of

Blockchain technology for social impact. Ultimately, these ethical considerations traced broadly to six root issues: governance, identity, access, verification and authentication, ownership of data, and security. Together, these factors create the foundation for the development of the Framework.

The Framework incorporates three main elements. The first is to establish the foundational definitions for the desired outcome and explicitly defining an approach with which to achieve this outcome. This includes an assessment of whether Blockchain is an appropriate technology for the desired outcome. The second element is using the Framework to design the Blockchain through a design spiral approach that reveals the impact of design choices on the desired outcome and on the people affected by the design. This involves asking critical questions in each of the key areas of ethical consideration and understanding how particular design choices in each area will affect the desired outcome and participants. The final element is to iterate and revisit the Framework to reassess the key questions at transition points in a Blockchain's life cycle. We believe this process of designing intentionally from the outset and following with iterative reassessments will ensure that Blockchain continues to achieve the desired social impact while predicting and preventing unintended consequences to the maximum extent possible.

Establishing the Approach

The first phase of the Framework is to establish intentionality of design through a conventional design process with a strong focus on ethical intentionality. The steps of this process are:

- Define the problem being addressed and the desired outcomes
- Explicitly identify the ethical approach
- Assess the ecosystem of the desired outcome
- Determine the guiding design philosophy
- Determine whether Blockchain is an appropriate technology choice

These steps represent a conventional design approach enhanced by targeted additions to explicitly identify the desired outcome; by an ethical approach and values that will guide the design process; and by understanding the contextual elements that can affect the desired outcome. These contextual elements include the users of the Blockchain, their community, the financing mechanisms driving the project, the existing infrastructure, and the existing and potential technologies affecting the outcome.

The design process will require making tradeoffs between the attributes that were described earlier in the paper. Explicitly identifying the outcomes and the ethical approach will guide Blockchain design choices. For example, in an aid-distribution Blockchain, the ethical approach may be to ensure that all members of a community have equal access to aid. If the community has significant power disparities among its members, the guiding design philosophy would be to prioritize design choices that minimize disparities in aid distribution. Addressing these questions at the outset of the design process provides ethical intentionality that offers a guiding star to help navigate the inevitable design tradeoffs.

Defining the Problem and the Desired Outcomes

The Framework is guided by an outcome- and user-focused approach to driving social impact. Blockchain technology holds immense potential for social-impact applications, but it is still just a technology. Ultimately, the decisionmakers behind the technology are responsible for delivering an outcome that benefits the end users. By making the outcome and the user central to the design process, the Framework holds decisionmakers accountable to their goals, and to the users.

The first step of the Framework is to clearly define the problem, including addressing any inherent bias; to identify the desired outcome to solve that problem; and to create a system that supports the realization of that result. This means ensuring that every aspect of the design, including the choice of technology, is made in the interest of achieving the outcome. However, it is also essential that the outcome be evaluated through the user's perspective and address user needs through the lens of an ethical approach.

Identifying the Ethical Approach

Making ethical design decisions involves identifying an appropriate ethical approach and understanding the resulting principles and values that underpin a project. Ethical design and decisionmaking can follow many possible ethical paradigms and approaches, such as one created by researchers at the Georgetown University Kennedy Institute of Ethics and the Fred Hutchinson Cancer Research Center, and others created by the Santa Clara University Markkula Center for Applied Ethics.[30.] The approach could focus on maximizing the benefits for the users and minimizing harm. A different path might prioritize the overall societal benefit of the Blockchain project, even if that risks harming some individual users. One ethical approach could be to create a system that treats all users equally, while another could focus on ensuring the welfare of all users by tailoring the system to function differently for individual segments of the user population. Each of these represents a valid yet slightly different ethical approach, and in practice a combination of these approaches will generally be used.[31.]

The second step of the Framework is to identify the ethical approaches that will guide decisionmaking on your project. This Framework does not presuppose the choice of any particular combination of ethical approaches. However, these approaches can lead to very different outcomes for users and communities, so it is important for decisionmakers to explicitly identify, understand, and remain consistent with their ethical approaches. Using the chosen ethical approaches during the ecosystem assessment enables identification of the project's key principles and values. These key principles and values create the design philosophy that will guide the navigation of design and implementation tradeoffs throughout the project so as to ultimately arrive at the desired outcome.

Assessing the Outcome Ecosystem

Conducting a contextual or ecosystem assessment for the desired outcome is critical, since outcomes do not exist in a vacuum. Rather, they are driven by an ecosystem of factors: the user, the community, existing infrastructure, financing, and technology options. Therefore, the third step of the Framework is to conduct an ecosystem assessment to thoroughly understand and acknowledge the roles that each of these core components plays in contributing to an outcome. The roles of these components are often connected via a web of complex interactions, and these roles may vary throughout the project timeline. Knowing the context for an outcome is the only way to effectively achieve the desired outcome. The five major components of the ecosystem outcome are users, community, infrastructure, financing, and technology.

Users

At the outset of the ecosystem assessment, the end users of a Blockchain tool must be explicitly identified and the ecosystem must be understood from their perspective. Understanding this end-user perspective often involves in-depth conversations and research, along with an inclusive design process to fully understand who the end users are, what their needs might be, what their vulnerabilities might be, and any risks they might face. These needs, vulnerabilities, and risks should be evaluated in the present state, and how they might evolve in future contexts.

Community

In addition to identifying the individual end users of the Blockchain, it is also important to identify and understand their community. This involves understanding the borders of the community or communities, as well as the dynamics within and between them. When considering a community, it is important to pay attention to what dynamics and systemic forces are at play, as well as the roles and relationships of all of community members, whether or not they are direct Blockchain end users. Developing this understanding may require collaboration with community members to identify, for example, who could provide a good or service that is integral to the desired outcome, who could provide the identity necessary to access that good or service, and who in the community could authenticate the validity of the identity claims.

Infrastructure

To achieve a new desired outcome, it is important to understand the infrastructure that binds members of the community together. This infrastructure could include legal and regulatory frameworks, public policies, informal rules or systems, and data and other assets. These structures could be leveraged to achieve the desired outcome but they may also create friction or barriers to the implementation of Blockchain tools. The potential for these structures to create friction could occur at any stage of the project, from design, to development, to deployment, to implementation, to sustainment, to the potential termination or transition of Blockchain tools.

Financing

The financial incentives driving the implementation of a Blockchain tool will influence every stage of the project lifecycle. Therefore, it is critical to understand how a Blockchain would be financed, who would benefit financially from its implementation, who would be hurt financially from its implementation, and how financial hurdles might alter key design choices.

Technology

Analogous to the financial component, technology will also significantly affect the implementation of a Blockchain tool and will influence every stage of the project lifecycle. Therefore, understanding the technology landscape is necessary. A decisionmaker must know if and what legacy technology systems exist that achieve or influence the desired outcome. If existing technologies can achieve the desired outcome, it is critical to understand if and how Blockchain would be a more desirable choice for reaching that goal. If no technology solution exists, the decisionmaker must determine whether a Blockchain technology would be viable. Either way, one must understand what other technology systems exist or have to be created that will interact with the Blockchain system and whether these systems create hurdles that might alter key Blockchain design choices. Again, these are existing technologies that could be leveraged to achieve the desired outcome, but they may also create friction or barriers to the implementation of Blockchain tools. These frictions or barriers could emerge anywhere along the project timeline.

Determining the Design Philosophy

The fourth step of the Framework is to determine the project design philosophy by defining the values and guiding principles underpinning a project. The design philosophy could include ideals such as equity, fairness, transparency, the right to individual privacy, and the right to own property. Whereas the ethical approach provides a framework for considering how standards are set, the values outline the project's priorities. For example, protecting user privacy would be an important guiding principle that aligns with the ethical approach of minimizing harm to users. In digital identity use cases, no sensitive private information would be put on the Blockchain directly. The Blockchain could link to the information, or the Blockchain could use zero knowledge proofs in which the Blockchain verifies the existence of an identifier, such as a social security number, but the social security number itself is not on the Blockchain. This is one example of how the ethical approach and values are considered together to constitute the design philosophy.

The guiding principles and values are determined by assessing the ecosystem of the desired outcome within the context of the chosen ethical approach. By understanding how the ecosystem components interact to create an outcome and the resulting ethical implications, a decision-maker can identify the guiding principles and values that will have a contextual impact and create the foundation of the entire design process. This will help the implementer navigate inevitable design and implementation tradeoffs, especially when values and guiding principles conflict. For example, there may be a conflict between equity and fairness in a Blockchain that provides user access to services in a context with severe inequalities. Valuing equity in outcome in this example may lead to optimizing the Blockchain to provide priority access for the most vulnerable users, while prioritizing fairness in the design philosophy may result in a Blockchain that gives all users equal access. The design philosophy is important because it creates a sound foundation for the entire design process.

DECISION POINT: IS BLOCKCHAIN AN APPROPRIATE TECHNOLOGY CHOICE?

Blockchain is not always the best option for achieving a desired social or environmental outcome, so there is a decision point in the Framework to determine whether Blockchain is a viable technology option. If there are no alternative choices, Blockchain may be appropriate if it is viable in the given context. If an alternative technology exists that could achieve the desired outcome, Blockchain may still be a suitable option if it offers efficiency or other desirable attributes over incumbent solutions that are better aligned with the design philosophy.

The tool below provides a starting point for understanding whether Blockchain might be the right technology option for addressing a particular social/environmental challenge. This tool offers flexibility in deciding whether to use a Blockchain. It raises key considerations that should be taken into account but does not prescribe based on them. It instead helps determine the viability of Blockchain as an option. If Blockchain is a viable option, then it is time to proceed to the next phase of the Framework to assess the root ethical considerations of the design.

Figure 2. Decision Tool to assess Whether Blockchain Is an Appropriate Technology Choice

Ethical Design and Implementation

Once Blockchain is selected as an appropriate technology, the Framework moves iteratively through a detailed analysis of six root issues for ethical consideration: governance, identity, verification and authentication, access, ownership of data, and security. At each stage, guiding questions identify the effects of the design choices on the end users and communities:

- How is governance created and maintained?
- How is identity defined and established?
- How are inputs verified and transactions authenticated?
- How is access defined, granted, and executed?
- How is ownership of data defined,

granted, and executed?

- How is security set up and ensured?

Governance

Governance refers to the establishment and maintenance of the rules that govern the entire Blockchain system. A fundamental characteristic of Blockchain technology is having a rigid set of rules by which all transactions within the system are governed. In the social sector, it is critical to ensure that a sound human governance structure is driving the technology. Governance includes questions such as who sets up the rules, who maintains the system, how the rules are executed, and how a Blockchain system would be closed out. The established governance structure should also be responsible for ensuring adherence to the guiding principles and design philosophy of the project.

Identity

Significant ethical considerations surround what constitutes "identity," to whom identity is granted in a given Blockchain, and how identity information is used, accessed, and protected. Multiple pieces of identifying information collectively create a digital identity and that identity can be used to affirm adequately that end users are who they claim to be. Blockchains can be used to establish limited or transactional digital identities for accessing information or services. Blockchain systems can also be used to establish portable, foundational digital identities—in other words, identities that are permanently linked to a unique individual and can be used in a variety of contexts to prove identity or credentials, and that move with the individual.

Verification and Authentication

How inputs are verified and then authenticated is critical in an open ledger system. Verification refers to ensuring the veracity of information being entered onto a Blockchain, and authentication refers to validating and accepting transactions on a Blockchain. Verification of information put onto a Blockchain presents a range of challenges. For digital assets such as cryptocurrencies or digital photographs, the verification process is closely related to the transaction authentication process to determine if the entity initiating a transaction has control over that asset. When linking a nondigital asset like a person or an object to a Blockchain, verification becomes more complicated because it introduces human interaction and, therefore, various political, legal, and ethical obstacles. For instance, how can someone's claim of land ownership be verified? Verification and authentication include questions such as who completes the verification and authentication, and the methods by which this is done.

Access

The definition, granting, and execution of access are critical to any person's ability to use and interact with a Blockchain system. Moreover, the scope of access to individuals' personal information on a Blockchain may have serious consequences for those individuals if that information is exploited. Beyond the specifics of accessing a Blockchain to view or write to the ledger, access includes more intangible questions around digital literacy and the effective ability to access the system.

Data Ownership

Data ownership refers to multiple facets of controlling data. There are important questions about who owns the data, who exercises control over the data, where and how the data are stored, and how incorrect information is adjusted. A compelling characteristic of Blockchain is its ability to give users the power to exercise functional control over data. For example, the Sovrin Foundation is building a self-sovereign identity trust framework that creates a robust governance structure that allows people, among other things, to exert positive control over their personal

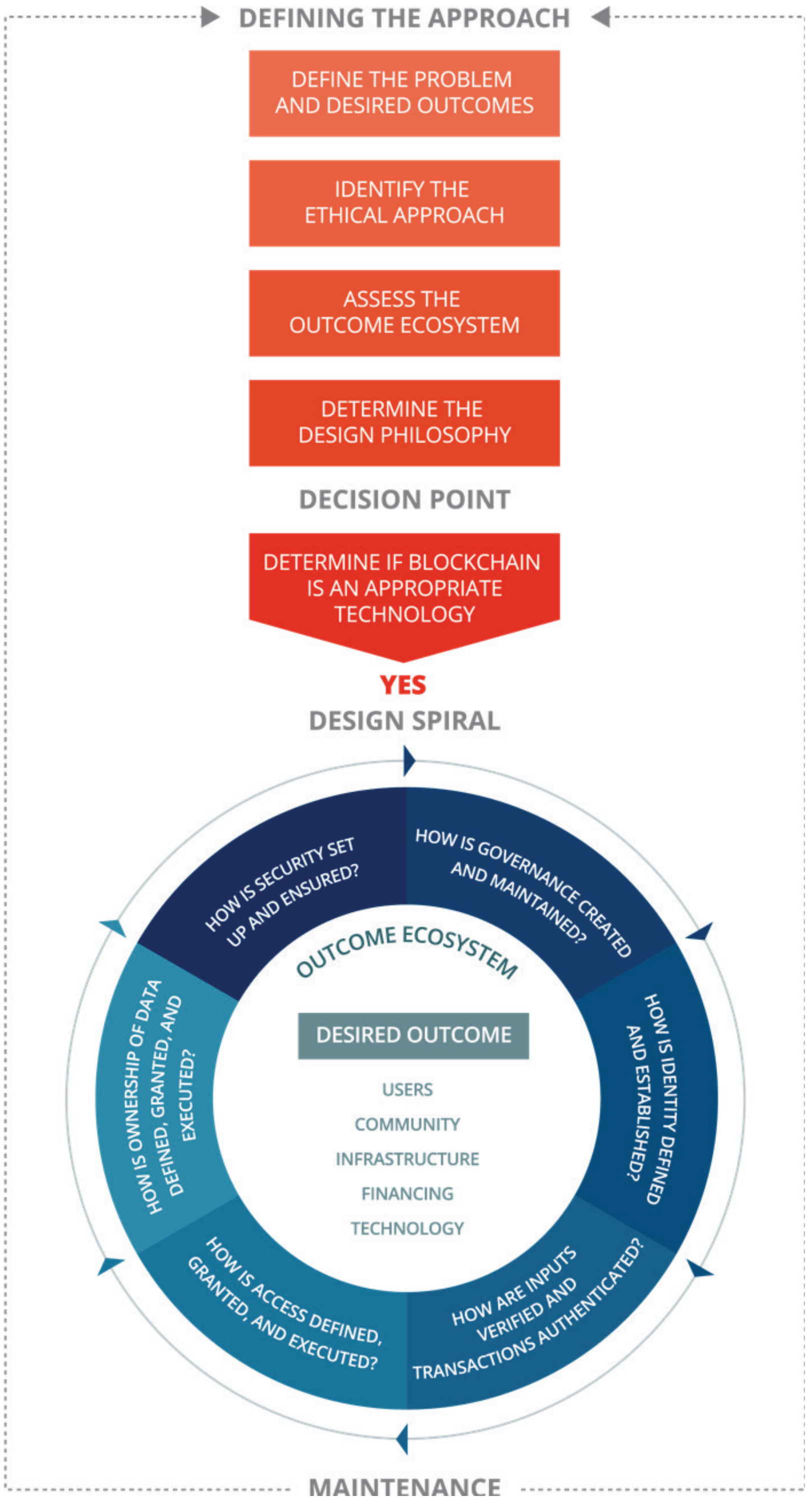

Figure 3. The Blockchain Ethical Design Framework

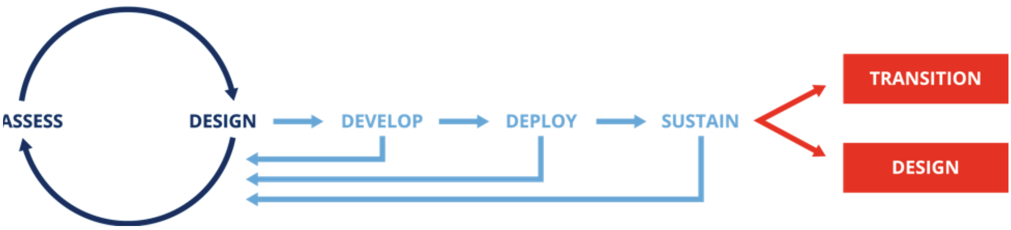

Figure 4. Maintaining the Blockchain

digital identity information.

Security

Security refers to protecting information from potential threats. At an individual level, this refers to a user's understanding of potential risks as well as private key management. At the system level, this refers to potential vulnerabilities within and at the periphery of the system. Data can be scattered throughout a distributed infrastructure, thus making them less vulnerable than data that are aggregated and stored in one location. Individual users do not need to remember passwords or link personal information such as email addresses or telephone numbers to stored information. However, there are ethical challenges here as well. Blockchain security uses encryption algorithms and public/private key pairs that are like a publicly known "address," and a private digital key to essentially unlock the mailbox at that address. Blockchain technologies have been used increasingly to secure private information such as health records. What would happen if someone lost her digital key to control her assets or medical information?

Building the Framework

The Framework uses an iterative assessment and design process in which each of the root issues is considered in order to understand its effects. Since the attributes of Blockchain are interconnected in a complex web, the designer needs to go through all of the issue areas several times. Sometimes referred to as a design spiral, this helps achieve an effective design with a complex technology.

Design choices such as ledger, platform, consensus protocol, and so forth will have dramatically different impacts on the desired outcome and on the users and other stakeholders. Each root issue area is considered in light of the user's perspective, the community dynamics, the role of existing infrastructure and processes, the incentives created by the financing, and how this all fits within larger technology choices. Throughout this iterative assessment and design process, the ethical approach and design philosophy are used to guide the design choices in order to maximize the desired social impact of the Blockchain technology.

Applying an intentional ethical design methodology to the initial implementation of a Blockchain project sets the stage for creating positive social impact. However, contexts change over time and the choices made in the initial implementation of Blockchain technology may lose its relevance or create unintended consequences for the people as the context changes. Therefore, this Framework is iterative by nature. The questions in the Framework should be revisited periodically at key transition points in the lifecycle of a project to ensure that the

Blockchain continues to provide the social impact for which it was designed.

CONCLUSION

The promise that Blockchain will have an impact on millions of people is real. Its key attributes of transparency, trust, and immutability have the potential to improve lives across the globe. By increasing the efficiency, security, and verifiability of the way social-impact organizations operate and how access to services is delivered, data are stored and controlled, and assets are tracked, Blockchain's potential can literally change the world. However, the realization of this potential to improve lives requires an ethical approach that recognizes the relationship between design and human outcomes. From practitioners to policymakers, as Blockchain solutions are built and deployed, we will all share the responsibility to demand intentional ethical approaches in the design and implementation of Blockchain technology to create more positive social impact. The Blockchain Ethical Design Framework provides a methodology that ensures that social value is protected.

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