THE BLOCKCHAIN ETHICAL DESIGN FRAMEWORK

BY CARA LAPOINTE AND LARA FISHBANE

beeck center social impact + innovation

GEORGETOWN UNIVERSITY

Acknowledgments

The Beeck Center for Social Impact + Innovation, launched in 2014 through generous support from Alberto and Olga María Beeck, is an experiential think tank at Georgetown University working to shift the marketplace to deliver social impact at scale. We incubate new ideas, promote innovative approaches, and train leaders and practitioners to become brokers of outcomes. We leverage the power of data, technology, innovative finance, and our networks to improve people's lives. And we share Georgetown's commitment to the common good, bringing a lens of equity and inclusion to all we do. The Blockchain Ethical Design Framework was developed with support from The Rockefeller Foundation. The Framework builds upon the Beeck Center's work in data for social good and outcomes-focused solutions.

For more than one hundred years, The Rockefeller Foundation has brought people together around the globe to try to solve the world's most challenging problems and promote the well-being of humanity. Today, in a world capable of so much, it is unacceptable that there are still so many with so little. That's why The Rockefeller Foundation fights to secure the fundamentals of human well-being—health, food, energy, jobs—so they're within reach for everyone, everywhere in the world. Their approach is grounded in what they've seen work over more than a century: It's inspired by science, rigorous about data, brings together and empowers others, and is focused on real results that improve people's lives. We thank The Rockefeller Foundation for its financial support of this project.

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Introduction

There are dramatic predictions about the potential of blockchain to "revolutionize" everything from worldwide financial markets and the distribution of humanitarian assistance to the very way that we outright recognize human identity for billions of people around the globe. Some dismiss these claims as excessive technology hype by citing flaws in the technology or robustness of incumbent solutions and infrastructure. The reality will likely fall somewhere between these two extremes across multiple sectors. Where initial applications of blockchain were focused on the financial industry, current applications have rapidly expanded to 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 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 for establishing identities for individuals without identification papers, improving access to finance and banking services for underserved populations, and distributing 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 take on building these types of solutions, the social effects of blockchain can 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 and social impact organizations. 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 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 on people's lives.

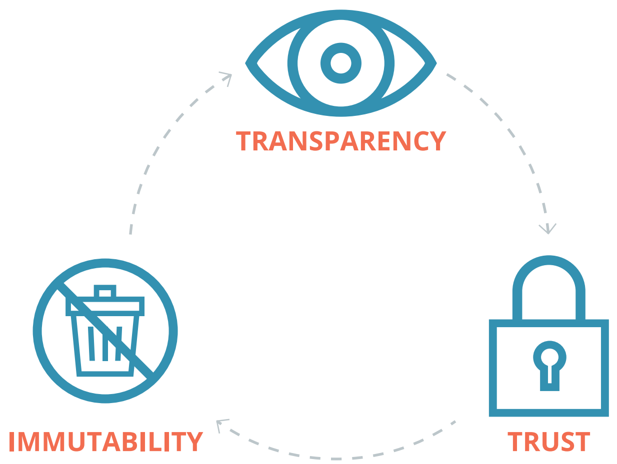
This white paper addresses why intentionality of design matters, identifies the key questions that should be asked, and provides a framework to approach use of blockchain, especially as it relates to social impact. It examines the key attributes of blockchain, its broad applicability as well as its particular potential for social impact, and the challenges in fully realizing that potential. 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 Beeck Center for Social Innovation + Impact at Georgetown University, with support from The Rockefeller Foundation, is pleased to introduce the **Blockchain Ethical Design Framework** as a tool to integrate values and ethics into the blockchain technology design and implementation process.

What is Blockchain?

Blockchain is a term that refers to a particular class of digital distributed ledger technologies that share records of sequenced information or transactions simultaneously in an immutable and secure manner across a network. Blockchain does not require a central trust authority to verify information or authenticate transactions; rather, trust is built into the governance rules with pre-written code defining 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 represent either the transfer of a digital asset of value, 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 and time-stamped record of a series of transactions.

> This unique combination of attributes—**transparency, trust,** and **immutability** of transactions—makes blockchain technology appealing in its application for social impact.



The technology's flexibility and extensibility to apply it in countless ways for solving long-standing problems are driving technologists, innovators, and blockchain evangelists across the globe. However, blockchain is not 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 versus 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 designated private audiences. Furthermore, for blockchain development, open source blockchain platforms are available as well as proprietary or custom options. These are just some of the many choices that give blockchain its flexibility and extensibility.

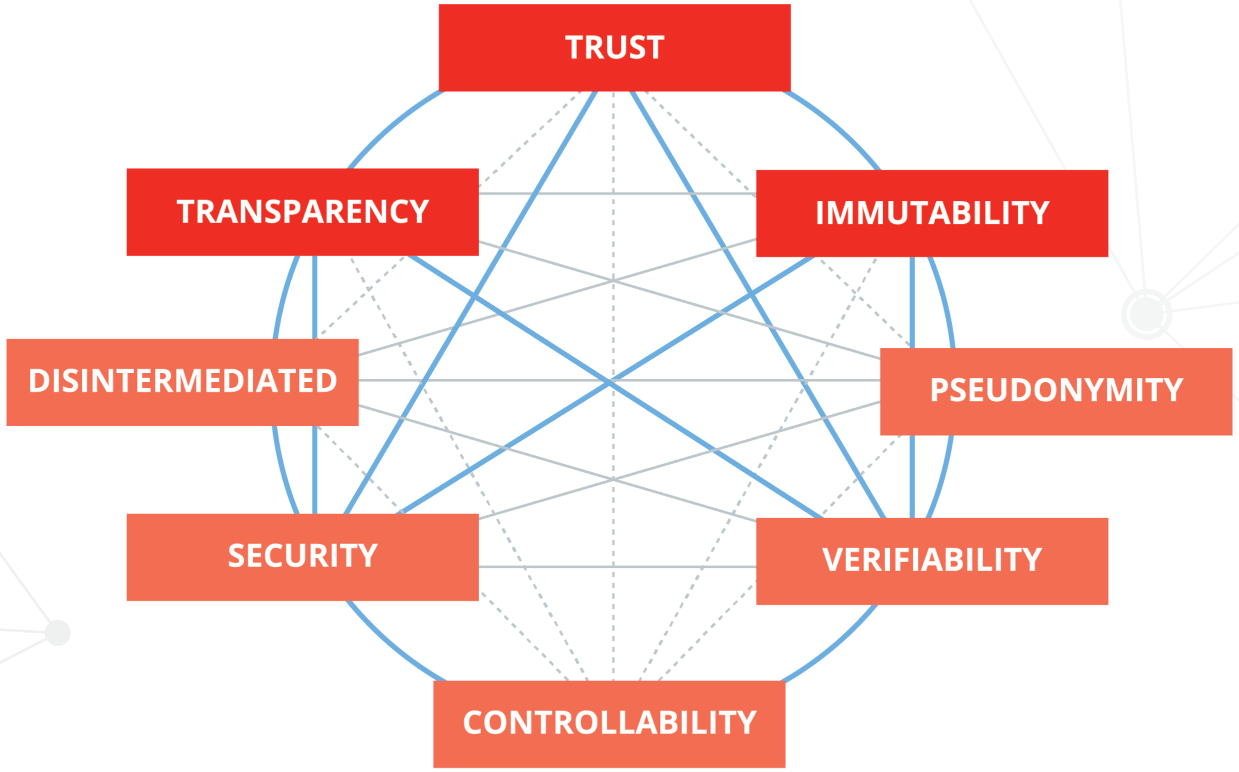
> Depending how it is designed and implemented, blockchain can produce a wide range of consequences for people.

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 which vary in their relative dominance based on design and implementation. All of these key features should be considered as 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 key potential attributes, including pseudonymity, verifiability, controllability, security, and a disintermediated structure, are not unique to blockchain but are also important for understanding the potential and challenges of the technology. In practice, these attributes are interconnected and their relative strengths will be 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 create potentially significant consequences on people's lives.



Transparency

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

Trust

Strict governance rules, cryptography, and immutability of 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 the possibility of 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, as well as reduce the risk of 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, 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 that 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 a public-private partnership named ID2020 to supply digital identities to people living without officially recognized identities in order to provide those individuals with economic, political, and social opportunity.[1] Another example is a recently launched blockchain 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.[2]

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.[3]
The Sovrin Trust Framework is an effort to create a robust governance structure that allows, among other things, for a person to exert positive control over any personal digital identifiers on the blockchain. That person would have control over sharing 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 nonconflict diamonds.[4] 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.[5]

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.[6] 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.[7] 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.[8]

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.[9] Data is 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.[10]

One specific way that 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.[11] One example is smart contracts for peer-to-peer lending or sharing networks. Entrepreneurs such as Lendoit[12] and ETHLend[13] are leveraging smart contracts for direct, peer-to-peer lending programs. Brooklyn Microgrid, an energy-sharing micro power grid, uses smart contracts to create direct energy market exchanges where people can buy and sell energy with other members of their community.[14]

Within the realm of digital identity, asset tracking, and enterprise efficiency, blockchain has a diverse range of particular social good applications. Some representative examples include:

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 for creating digital registries and online government services, which includes securing over 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 records by scattering data throughout a distributed blockchain ledger, thus reducing vulnerabilities compared with data that is 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 Peruvian economist Hernando de Soto has teamed with Bitfury and the Republic of Georgia to design and pilot a blockchain titling system to improve security, allow for real-time audits, and reduce 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 the barriers to voting.[19] From March to May 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, iRespond is leveraging its blockchain digital identity systems to help prevent forced labor in offshore fisheries.[22] The U.S. Department of State is also working with Coca-Cola and other private partners to create blockchain-based secure registries for workers to help prevent forced labor worldwide.[23]

Improving Medical Research and Healthcare

Blockchains are being piloted to improve medical research and health care. 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 solely on one desired feature without understanding and accounting for the interaction of all the attributes of blockchain. In the design process, to optimize the desired attributes of blockchain for a given application, there will always be trade-offs, which will result in functionally different blockchain systems.

> Small design choices can have resounding ethical consequences for people and communities.

Similar to 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 can also 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 exploitative 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 has also 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 the control of certain entities over information and personal data. These human consequences could be the result of intentional action, but they could also be created unintentionally through blockchain technologies designed with positive motivations.

The following examples represent some of the many potential consequences of the trade-offs 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, particular technical design issues such as private key systems and encryption algorithms are presented 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 of 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 the 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 in the initial land title data in a blockchain. Additionally, the falsification of 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 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 life span. 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 on 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 forge transactions.[27i]

Environmental Impacts

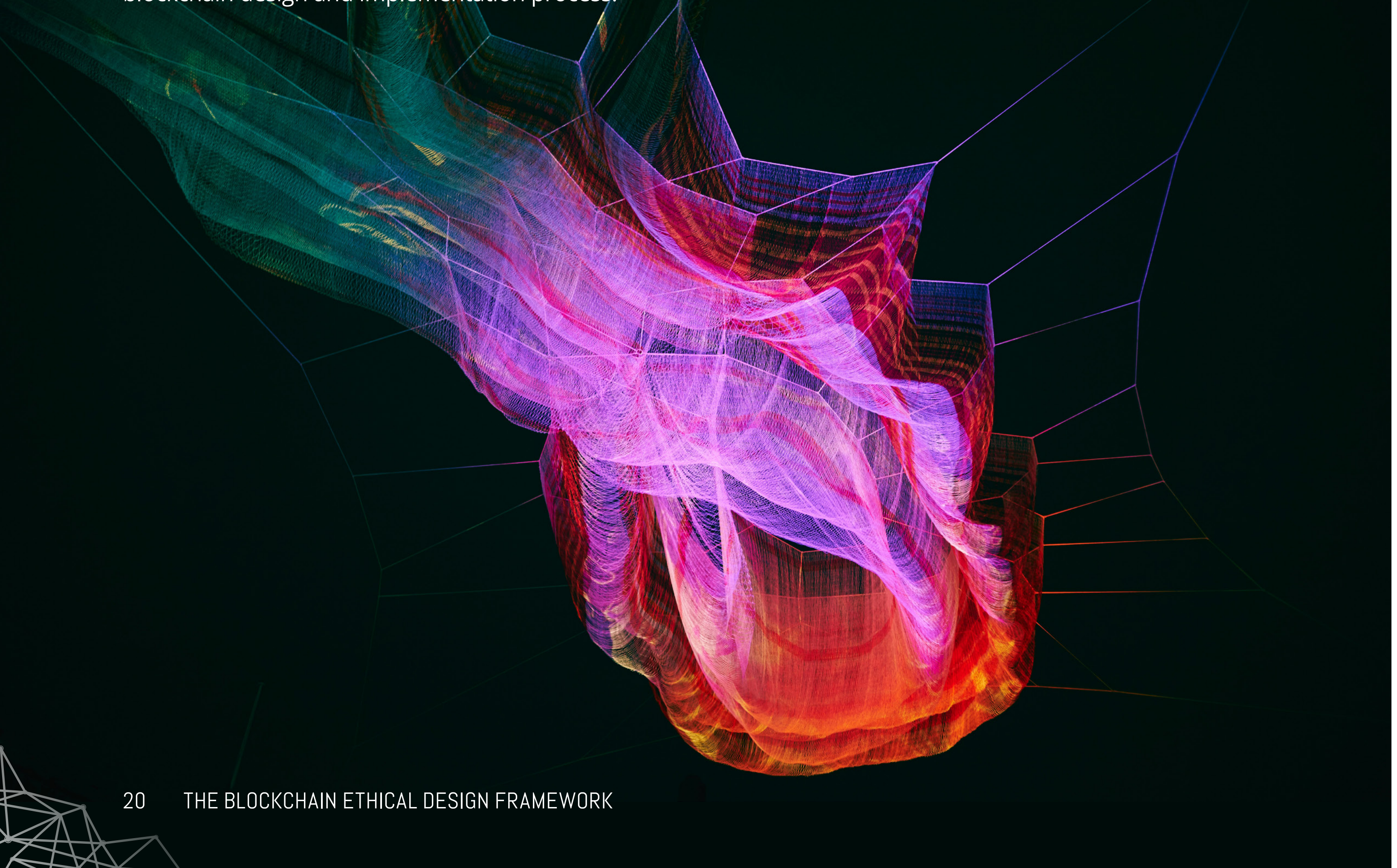
In the absence of a trusted central authority, bitcoin-based blockchain applications allow entities worldwide to transact safely and securely, yet they consume significant environmental energy. Bitcoin authenticates transactions on its distributed network using a network consensus rule, or a consensus 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 in which 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 use by an average American home for 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 for 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 to 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.



Introducing 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 is a tool for creating an intentional design that incorporates key ethical questions for the development and use of blockchain.

The overarching goals of the Framework are to (1) give decision makers an outcome-focused and user-centric tool to assess the context-specific consequences and ethical implications of their blockchain design choices; and (2) to enable them to use this understanding to make the appropriate values-based design choices to achieve better social outcomes. For the purposes of this Framework, "decision maker" 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 of the critical stakeholders throughout the process from problem definition through execution.** The stakeholders will come from a diverse range of communities, fields, and organizations that are involved in all aspects of the relevant ecosystem.

To develop this Framework, the Beeck Center worked with more than one hundred experts across academia, government, and the private and nonprofit sectors. The contributors represent more than ninety 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 regarding desired outcome and approach to achieving that 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. This involves asking critical questions in each of the key ethical consideration issue areas and how particular design choices in each area will affect the desired outcome and the 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 that this process of intentional design from the outset and iterative reassessment will ensure that blockchain continues to achieve the desired social impact while predicting and preventing unintended consequences to the maximum extent possible.

The Approach

The first phase of the Framework is to establish intentionality of design through a conventional design process with an enhanced 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 if blockchain is an appropriate technology choice

These steps represent a conventional design approach enhanced by targeted additions to explicitly identify the desired outcome; the ethical approach and values that will guide the design process; and to understand all of 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 trade-offs 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 ensuring 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 the ethical intentionality as a guiding star to help navigate the inevitable design trade-offs.

However, before moving on to design of a blockchain, it is critical to assess whether blockchain is the best, or even a viable, application for the desired outcome given the context. For example, the cost of implementing a blockchain system may not provide a reasonable return on investment, especially if legacy or incumbent systems exist to address the situation. Therefore, after setting the outcomes, identifying the approach, assessing the ecosystem, and determining the guiding design philosophy, the Framework helps users assess whether blockchain technology is appropriate. If it is, then it is time to proceed to the next phase of the Framework to assess the root ethical considerations of the design.

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.

Identity

Significant ethical considerations surround what constitutes “identity” and 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. 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, moving with the individual, to prove identity or credentials.

Verification and Authentication

How inputs are verified and then authenticated is critical in an open ledger system. 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, such as 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?

Access

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

Data Ownership

There are important questions about who owns the data, who exercises control over the data, where and how the data is stored, and how adjustments are made to incorrect information. 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, among other things, people to exert positive control over their personal digital identity information.

Security

Data can be scattered throughout a distributed infrastructure, thus reducing the vulnerabilities compared with data that is aggregated and stored in one location. 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, there are ethical challenges here as well. Blockchain security uses encryption algorithms and the use of 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 increasingly used to secure private information such as health records. What would happen if someone lost her digital key to control her assets or medical information?

> The Framework uses an iterative assessment and design process in which each of the root issue areas are considered to understand their effects.

Since the attributes of blockchain are interconnected in a complex web, the designer needs to go through all of the issue areas iteratively several times. This is sometimes referred to as a "design spiral," and it 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 perspective of the user, the dynamics of the community, 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 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, context changes over time. The choices made in the initial implementation of blockchain technology may lose relevance or create unintended consequences for people as the context changes. Therefore, this Framework is iterative by nature. The questions in the Framework should be periodically revisited at key transition points in the life cycle of a project to ensure that the blockchain continues to provide the social impact for which it was designed.

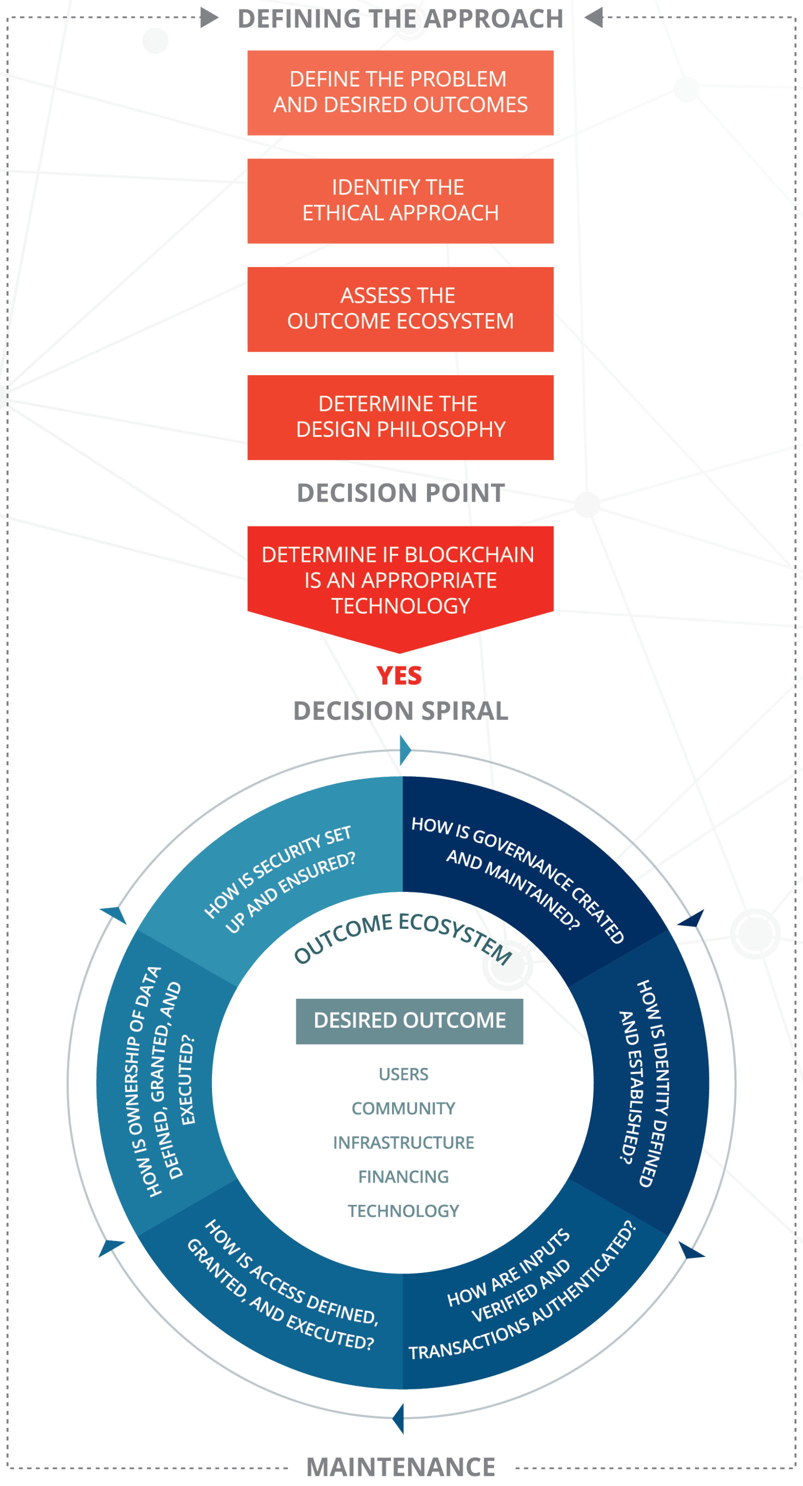
Conclusions for Social Impact Organizations and Policymakers

The promise of blockchain to 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 efficiency, security, and verifiability in the way that social impact organizations operate, access to services is delivered, data is 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.**

As blockchain solutions are built and deployed, the **Blockchain Ethical Design Framework** provides a way to ensure that social value is protected. It is a tool for practitioners to drive ethical intentionality into the design of blockchain technology. The diverse group of experts convened to inform this work need to continue to be at the forefront of efforts to bring ethics to action. As such, the Beeck Center is working with standards organizations and practitioners to integrate this Framework within broader initiatives addressing digital inclusion and the ethical implementations of data and technology. From practitioners to policymakers, we all share the responsibility to continue the conversation and demand intentional ethical approaches in the design and application of data and technology for social good. To meet the potential that blockchain has for social impact, we hope that a deliberative and iterative approach to the technology as proposed by this Framework will contribute to efforts to create an informed design process that will have scalable impact.

Appendix A:
The Blockchain Ethical Design Framework

The Blockchain Ethical Design Framework has three phases, each consisting of multiple steps. The first phase is defining the approach to creating social impact, and it involves the initial work of understanding the desired outcome and explicitly defining an approach with which to achieve this outcome. The second phase is the design and implementation of the blockchain through a design spiral approach that reveals the impacts of design choices on the desired outcome and on the people affected by the design. The final phase of the Framework is the maintenance stage, in which the steps from the first two phases are periodically revisited throughout the life cycle of a blockchain project to ensure that the technology is still achieving its desired impact.



Phase 1:
Defining the Approach to Creating Social Impact

The first phase of the Blockchain Ethical Design Framework is to define the approach to creating social impact. From the beginning of the first phase, critical stakeholders need to be involved in a collaborative process to maximize the robustness of the overall impact. These stakeholders will come from a diverse range of communities, fields, and organizations that are involved in all aspects of the relevant ecosystem.

At the beginning of a blockchain design, it is critical to explicitly identify the desired social good outcome of the project in order to provide clear direction throughout the design process. Furthermore, there are many different types of ethical approaches that could be prioritized above all others while designing a blockchain to achieve the desired outcome. For instance, prioritizing the minimization of harm to participants is a very different ethical goal from maximizing participation, which, in turn, is very different from ensuring equitable access to a service.

To achieve a desired outcome in accordance with a designated ethical approach, it is important to develop a design philosophy that will guide all of the specific design decisions. This design philosophy is a set of guiding principles that are informed by both the chosen ethical approach and the assessment of the ecosystem. For example, if the ethical approach is to provide equitable access to financial services across a community and the assessment reveals significant power and access disparities in that community, the design philosophy could be that every design decision needs to work to minimize the access disparities in the community.

After assessing the ecosystem, a decision maker may conclude that an alternate data ledger technology would be more appropriate for the context, or that blockchain is not an appropriate technology because an immutable record would be harmful in the given context. A decision maker should proceed with the Framework at this point only if blockchain is still seen as a viable technology option for the desired outcome.

This phase involves the initial work of understanding the desired outcome and explicitly defining an approach with which to achieve this goal through a series of five discrete process steps:

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

Therefore, the Framework begins with identifying the desired outcome of the project to ensure that it benefits the end user in a meaningful way. Using this desired outcome as a guiding principle, the Framework explains how to conduct an initial assessment of the project's ecosystem. This ecosystem assessment is important to understanding the full context of the desired outcome and how the elements of that context interact to affect the outcome.

The results of the ecosystem assessment will then be used in conjunction with the appropriate ethical approach to determine the guiding design principles of the project. These principles will serve as the ethical backbone of the project. They will provide the standards to which the project will be held and against which the design choices will be measured. However, before moving onto the design spiral, it is important to reevaluate and decide if blockchain is an appropriate technology choice for the project. If blockchain is determined to be an appropriate technology choice, users will enter the second phase of the Framework represented by the design spiral, which addresses blockchain-specific questions.

DEFINING THE APPROACH

DEFINE THE PROBLEM AND DESIRED OUTCOMES

IDENTIFY THE ETHICAL APPROACH

ASSESS THE OUTCOME ECOSYSTEM

DETERMINE THE DESIGN PHILOSOPHY

Step 1:
Define 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 decision makers behind the technology are responsible for delivering an outcome that benefits the end users of the tool. By making the outcome and the user central to the design process, the Framework holds decision makers 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; identify the desired outcome to solve that problem; and 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 in the interest of reaching 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.

Step 2:
Identify 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 decision-making 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 benefit for and minimizing harm to the users. A different path might prioritize the overall societal benefit of the blockchain project even if that creates the risk of harm to 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.

The second step of the Framework is to identify the ethical approaches that will guide the decision-making of 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 decision makers to explicitly identify, understand, and remain consistent with their ethical approaches. Using the chosen ethical approaches during the ecosystem assessment enables the identification of the key principles and values for the project. These key principles and values create the design philosophy that will guide the navigation of design and implementation trade-offs throughout the project so as to ultimately arrive at the desired outcome.

Step 3:
Assess the 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, 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.

Using the desired outcome and the chosen ethical approach as inputs, the ecosystem assessment will guide the development of a project's principles and values; provide an understanding of how the goals of the project map to the ecosystem components; inform the answers to key design questions; and act as a framework to evaluate the design decisions within. However, ecosystems are not static; they are fluid and will continue to change and evolve throughout the life cycle of the project. It is particularly important to understand not only natural changes to the ecosystem, but also how the design and implementation of a blockchain solution may hasten or spur these processes. Therefore, just as the assessment should be periodically revisited to inform and evaluate key design choices, it should also be updated and reconsidered as the project progresses.

[1]The field of applied ethics provides tools for determining how one ought to act in everyday private and public settings. The field of applied ethics typically recognizes five basic approaches to ethical decision-making, each of which offers a slightly different idea of how to think about right and wrong. These approaches are commonly known as (1) the Utilitarian Approach, (2) the Rights Approach, (3) the Fairness or Justice Approach, (4) the Common Good Approach, and (5) the Virtue Approach. The Utilitarian Approach suggests that an ethical action provides the most good and the least harm, while the Rights Approach suggests that an ethical action respects the fundamental moral rights of everyone. The Fairness or Justice Approach focuses on ensuring that everyone is treated equally without favoritism or discrimination, while the Common Good Approach promotes the idea that an ethical action is one that benefits the welfare of all people. The Virtue Approach assumes that there are common virtues to which society should aspire and that ethical actions focus on developing these moral virtues.

ECOSYSTEM COMPONENTS

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 as well as their potential evolution in possible future contexts.

SAMPLE INITIAL ASSESSMENT QUESTIONS:

- Who are the users?
  - What are important key attributes of the users?
    - How digitally literate are the users?
    - How context literate are the users?
  - Why are these the end users of the desired outcome?
- What are the needs/goals of the users?
  - How might these change over time?
- What are the vulnerabilities of the users?
  - How might these change over time?
- What are risks to the users?
  - How might these change over time?

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 the community members whether or not they are direct blockchain end users. Developing this understanding may require collaboration from 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.

SAMPLE INITIAL ASSESSMENT QUESTIONS:

- What are the relevant boundaries of the community?
  - Physical boundaries?
  - Social boundaries?
  - Cultural boundaries?
  - Economic boundaries?
  - Do these boundaries conflict with each other?
- What are the important relationships in the community?
  - Who nominally holds power within the community?
  - Who effectively holds power within the community?
  - How is the distribution of power established?
  - Are there marginalized or vulnerable community members?
    - Are there internal threats to certain members of the community?
  - Are these relationships formalized or informal?
- What is the relationship of the community with external actors?
  - What external organizations have relationships within the community?
    - Is the relationship with all community members or a particular subset?
  - Are there external threats to members of the community?
- What are community-level needs/goals?
  - How might these change in the future?
- What are community-level vulnerabilities?
  - How might these change in the future?
- What are community-level risks?
  - How might these change in the future? (Consider the evolution of technology, climate change, changes in power)

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 potentially be leveraged to achieve the desired outcome, but 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.

SAMPLE INITIAL ASSESSMENT QUESTIONS:

- How, if at all, does the current infrastructure reach the outcome?
  - Where in the process is improvement occurring? (Time saving, cost saving)
    - Could this improvement be replicated through a new blockchain system?
    - If not, how can the opportunity costs of remaining with the old system be balanced?
- What policies, legal and regulatory frameworks, informal systems, cultural and social systems, and other processes are in place that might affect the desired outcome?
  - Which elements of the infrastructure could be leveraged in the blockchain solution?
  - Which factors or dynamics may disrupt or prevent the execution of the solution?
- What data currently exists?
  - Who owns the data?
  - How accurate is the data?
    - Is there universal or adequate acceptance of its accuracy?
  - How precise is the data?
  - How comprehensive is the data?
  - How is it stored?

Financing

The financial incentives driving the implementation of a blockchain tool will influence every stage of the project life cycle. 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.

SAMPLE INITIAL ASSESSMENT QUESTIONS:

- What are the financial incentives of the entity building a blockchain?
- How would the blockchain be financed at each stage in the process?
- Who would benefit financially from the implementation of a blockchain?
  - How would they benefit?
- What are the financial incentives to keep the current system in place?
  - Who would be harmed financially from the implementation of a new blockchain?
- Is the funding model for the blockchain sustainable?
- Are there financial hurdles that would drive design decisions?
  - Would the resulting design decisions increase or decrease user utility?
  - Would the resulting design decisions increase or decrease user risk?

Technology

Analogous to the financial component, technology will also significantly affect the implementation of a blockchain tool. It will influence every stage of the project life cycle. Therefore, understanding the technology landscape is necessary. A decision maker 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 sufficiently more desirable in reaching that goal. If no technology solution exists, the decision maker must determine if 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 potentially 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.

SAMPLE INITIAL ASSESSMENT QUESTIONS:

- Are there existing technologies that would attain the outcome?
  - How might blockchain technologies be better in achieving the design outcome?
- What technologies are in place or what new technologies would have to be developed to interact with the blockchain technology?
  - What types of technology could be leveraged in the blockchain solution?
  - What technology or lack thereof disrupts or prevents the execution of the solution?
- What technology currently exists?
  - Who owns the technology?
  - How effective is the technology in achieving the outcome?
  - How would the technology have to interact with a new blockchain tool?
  - Is there a risk of obsolescence with existing or interconnected technologies?
- What are the incentives to keep technologies in place?
  - Who would be harmed from the implementation of new blockchain technologies?
  - Who would benefit from the implementation of new blockchain technologies?

Step 4:
Determine 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 there is verification on the blockchain of 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 as a result of 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 trade-offs, especially when values and guiding principles are in 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 provides all users equal access. The design philosophy is important because it creates a sound foundation for the entire design process.

Step 5:
Determine if Blockchain is an Appropriate Technology

Blockchain is not always the best option for achieving a desired social or environmental outcome, so the fifth step of the Framework is to decide whether blockchain is a viable technology option.

Once a desired outcome and an ethical approach have been determined, an ecosystem assessment has been conducted, and a design philosophy has been defined, a decision maker must determine whether blockchain is a viable and appropriate 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 better align with the design philosophy.

Blockchain applications exist along a broad design spectrum; there are many specific design options that could dramatically shift the resulting technology functionality. Therefore, it is critical to understand blockchain technology and the breadth of options associated with it, as well as to determine if it might be an appropriate technology choice. This Framework is not a definitive guide to determining whether blockchain is the best technology for a project; rather, it encourages decision makers to compare it against the best alternatives and make a choice given all viable options.

The tool below provides a starting point for understanding if blockchain might be the right technology option for addressing a particular social/environmental challenge. This blockchain viability checklist is different from other valuable tools, such as those presented by Morgen E. Peck and Gideon Greenspan, in that it is not prescriptive.[31] However, this tool offers more 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. Instead, it helps determine the viability of blockchain as an option.

DEFINING THE APPROACH

- DEFINE THE PROBLEM AND DESIRED OUTCOMES
- IDENTIFY THE ETHICAL APPROACH
- ASSESS THE OUTCOME ECOSYSTEM
- DETERMINE THE DESIGN PHILOSOPHY

DECISION POINT

- DETERMINE IF BLOCKCHAIN IS AN APPROPRIATE TECHNOLOGY

YES

Is Blockchain a Viable Technology Option?

Procedure: The following activity is meant to provide an estimate of whether blockchain might be an appropriate technology choice for a particular situation. Check each box for which the answer to the corresponding question is "Yes," and tally the total below.

	QUESTIONS	YES	
	Does the solution require a database?	☐	
PARTICIPANTS	Will there be multiple writers inputting/updating information?	☐	
PARTICIPANTS	Is there a lack of trust among participants?	☐	*
PARTICIPANTS	Is there a lack of trusted intermediary?	☐	*
RULES	Can a consistent set of rules help achieve the outcome?	☐	
RULES	Will the governing rules be consistent over time?	☐	*
DATA	Is transparency of the transactions an important feature?	☐	**
DATA	Is an immutable, auditable record of transactions important?	☐	
DATA	Are transactions dependent or interrelated?	☐	
	Can a distributed infrastructure reduce the risk of censorship or attack?	☐	

LESS LIKELY — MORE LIKELY

0/10 … 10/10

* Consider a permissions blockchain
** Consider a public ledger

If decision makers determine that blockchain may be an appropriate technology choice, they should move into Phase 2 of the Framework to determine ecosystem-appropriate design choices.

Phase 2:
Designing and Implementing the Blockchain

The second phase of the Framework is an iterative assessment and design process that considers the root ethical issue areas to understand their effects. Every design decision is considered in light of how it will affect or be affected by the elements of the ecosystem: users, community, infrastructure, financing, and technology. Since the design choices themselves have effects on one another, the designer needs to go through the loop several times until the design decisions converge. This is sometimes referred to as a "design spiral," and it helps achieve an effective design with a complex technology.

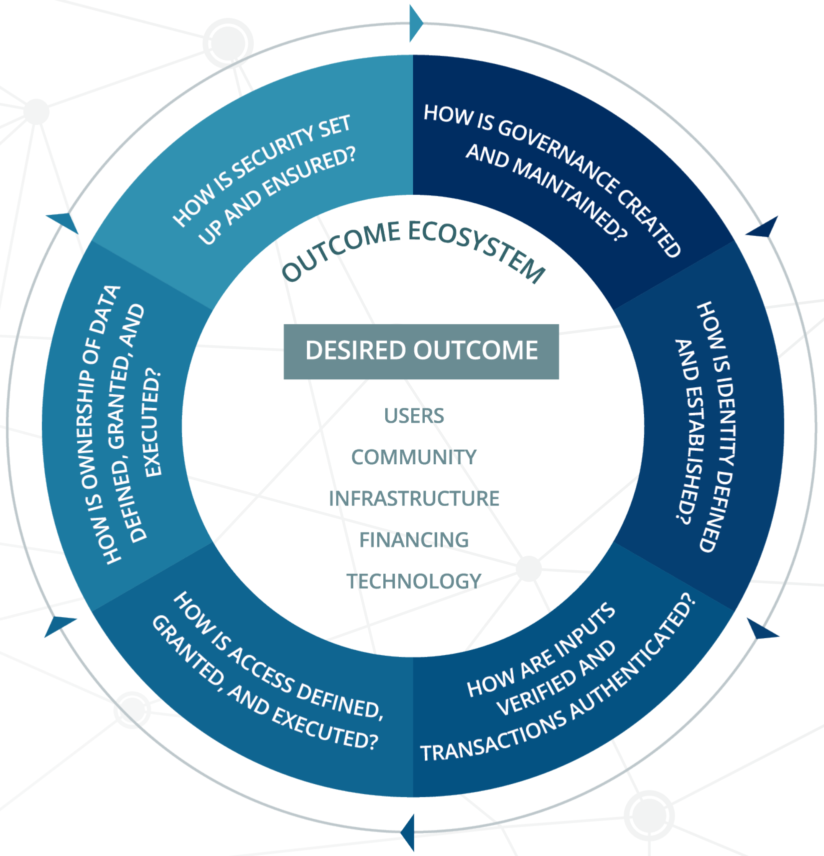
Design choices such as ledger, platform, consensus protocol, and so forth will have dramatically different impacts on the desired outcome and on the users and other stakeholders. Therefore, each of the ecosystem assessment components is mapped to each of the six root issue areas. This assessment mapping will inform the key design decisions with respect to all of the ecosystem components, including the perspective of the user, the dynamics of the community, the role of existing infrastructure and processes, the incentives created by the financing, and how this all fits within larger technology choices.

The complex interrelationships among the ecosystem components require that decision makers make multiple complete rotations around the design spiral during the initial design phase before the blockchain design converges. This design spiral will be revisited throughout the life of a project to ensure that the blockchain is still achieving the desired outcome in accordance with the design philosophy.

Research and conversations with expert stakeholders have identified hundreds of questions related to different ethical concerns in blockchain applications. To better understand and structure these questions, six root issues for ethical considerations were determined: governance, identity, verification and authentication, access, data ownership, and security. These areas span the breadth of questions and concerns raised. Though there is some overlap and the categories are not entirely distinct, we have found them to be a useful taxonomy for delving into design. These areas are defined by six overarching questions:

- 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?

DECISION SPIRAL



Governance

Overarching question:

How is governance created and maintained?

Definition:

Governance refers to the rules and regulations of the blockchain. 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.

Key design considerations include:

- Determining who the stakeholders are, their roles, and how their roles are established
- Establishing the processes, rules, and regulations of governance (both technical and otherwise)
- Creating pathways for these rules and roles to change over time
- Having a plan for closing out or continuing the system if key stakeholders leave

Key assessment considerations include:

- The stakeholders who need to be included to bring about the solution
    - Note: these stakeholders may be different depending on the guiding principles of the project. For example, a project that values equity might want community members who represent marginalized voices, while a project that values anti-fraud and -corruption may require legal representation.
- The roles and relationships of stakeholders
- The ways in which the technology may formalize currently informal processes
- How changes in governance and governing processes will affect users

	WHO	WHAT	HOW
DESIGN	Who are the stakeholders and what would be their roles? Who would set up the governance? Who would decide on changes to the governance?	What would be the technical rules that govern the system? What would be the capabilities of nodes and other stakeholders in the system?	How would stakeholders interact and communicate? How would the system continue or close out if key stakeholders were to exit? How would people be incentivized to participate in the transaction authentication process?
ASSESSMENT	Who are the stakeholders needed to provide the service? Who are the stakeholders needed to provide the tools end users need to access the service?	What are the technical capabilities of the potential stakeholders? Do the stakeholders trust one another?	By what processes do stakeholders currently interact or communicate? Are users dependent on the service? (Will they continue to need it after a stakeholder exits?)
EVALUATE	How does this group of stakeholders affect the power balance? Do any of the governing figures pose a threat to users?	Are some stakeholders made more powerful by the system? Does the system hold stakeholders accountable? Are other mechanisms needed to do so?	What happens if there are disagreements among stakeholders? What incentives or processes ensure productive collaboration?

Identity

Overarching question:

How is identity defined and established?

Definition:

Identity in this context refers to the collection of identifiers needed to adequately affirm that end users are who they claim to be. The underlying premise is that a particular set or number of identifiers is necessary for users to access certain services.

Key design considerations include:

- Understanding who is granted identity in this context
- Understanding level of identity required for the solution
  - Note: a transactional identity can be considered as a limited-purpose identity that grants a person single-use or limited access to a certain service. A foundational identity, on the other hand, serves as a fully functioning identity that can be used for many purposes over time.
- Determining which identifiers will be used to constitute this entity
- Preventing exposure of personally identifiable information on a blockchain
  - This may require never putting personally identifiable information directly on a blockchain

Key assessment considerations include:

- Understanding which identifiers are available and formally accepted within the community
- Understanding which identifiers put users or the community at risk

	LEVEL OF IDENTITY	WHICH IDENTIFIERS?
DESIGN	Foundational or transactional? What components of identity would be necessary in a transactional context?	Which identifiers would establish that (1) the identity claimed is real and unique and (2) the identity rightfully belongs to the user claiming it? Is there a set of minimally viable identifiers that could be used?
ASSESSMENT	What level of identity do service providers need to provide the service? What identity systems are in place that can be leveraged?	Which identifiers are currently used to establish that people are who they claim? In what ways are end users vulnerable? • Which identifiers expose this vulnerability? • Which identifiers should not be collected? Which components of a user's identity need to be legitimized? How can technology be used to establish identity? (What biometric options are available?)
EVALUATE	Is it useful to have an identity system that outlasts the specific outcome of the project?	Do any of these identifiers put end users at risk? • Could identifiers be aggregated and correlated in a potentially dangerous way? • Are certain groups in the community more vulnerable to risk? How might these needs and risks change over time? Do these identifiers work in emergency situations?

Verification and Authentication

Overarching question:

How are inputs verified and transactions authenticated?

Definition:

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 and authentication include questions such as who completes the verification and authentication, and the methods by which they are done.

Key design considerations include:

- Determining how and by whom verification will be done for the initial entry, or "zero state," follow-on data input, and how transactions between users are authenticated
  - This includes setting up both information-vetting processes and technical structures that prevent invalid entries
- Ensuring that the established process can be trusted by all stakeholders
- Understand any social impact of consensus protocol algorithms

Key assessment considerations include:

- Understanding current barriers to verification, including disputes over information
- Knowing who currently verifies and authenticates information, the current processes, and potential issues
- Understanding the availability and quality of zero-state data

	WHO	HOW
DESIGN	Who would verify the veracity of input data? Who would authenticate transactions on the blockchain?	How would verification be done? • For the zero state? • For follow-on data input? How would transaction authentication be done? • What consensus protocols are used? What would ensure that all relevant stakeholders trust the verification and authentication processes?
ASSESSMENT	Who are the trusted members of the community? Who has vested interests in falsely verifying or authenticating information?	What are current disputes over the zero state? Are there any current authentication processes? Where do the tensions exist in the authentication process?
EVALUATE	How will this group of stakeholders affect the power balance?	Will users have a method of checking or disputing authentication?

Access

Overarching question:

How is access defined, granted, and executed?

Definition:

Access refers to any stakeholder's ability to use the system. Access includes both physical access, such as read and write permissions on the blockchain, and more intangible questions around digital literacy.

Key design considerations include:

- Who has write permissions
- Who has read permissions
- How these permissions are established
- The level of access that users are granted

Key assessment considerations include:

- Understanding which stakeholders currently have access to information, which need it to execute the service, and which would benefit from having it
- Users' familiarity with and access to different digital technologies
- Financial incentives for certain groups to have or to not have access
- Understanding if there are conflicts of interest in who might have access to the data

	WHO	WHAT	HOW
DESIGN	Who would determine who has access to the blockchain? Who would have access to write information? Who would have access to view or read information?	What technology would be needed to access the system? What understanding of the system would be needed to use it effectively?	How would users get access to their own information?
ASSESSMENT	Which stakeholders need to have access to which pieces of information? Who, external to the system, should have access? What are the financial incentives for any group to have access?	What level of digital literacy do end users have? What technologies do end users have access to? Are there different levels of digital literacy among members of the community? Are there different levels of technological access?	What information do users currently have access to? What information would it be useful for them to have access to?
EVALUATE	Are there any stakeholders who might misuse the access? Do any stakeholders profit from an opaque structure? Do the financial incentives create a conflict of interest?	How can the user interface be set up in such a way that it is accessible to all participants? Do the technological choices prevent certain users from using the system? • How can this be made more equitable?	If users have access to their information, do they know how to use it most effectively?

Data Ownership

Overarching question:

How is ownership of data defined, granted, and executed?

Definition:

Data ownership refers to exercise of control over data. It addresses questions such as who owns the data, who exercises control over the data, where and how the data is stored, and how incorrect information is adjusted.

Key design considerations include:

- Determining who owns data, both in name and in practice
- Understanding how stakeholders can use and benefit from owning the data
- Deciding if data will be stored on the blockchain or externally
  - Considering decentralized data storage options
- Creating a process for users to flag and fix incorrect information

Key assessment considerations include:

- Understanding how data is currently being stored and whether that repository could be leveraged
- Identifying who currently owns data and how they are able to use it
- Understanding if users would benefit from having ownership of their own data and what data ownership would effectively mean

	WHO	WHAT	HOW
DESIGN	Who would have nominal ownership of data? Who would have physical control of data?	What effective control over data would different stakeholders have? Who would benefit? Where would data be stored? Would it be on the blockchain or linked to from an external source?	How would end users exert ownership over their data, if they were to have it? How would end users know if there were incorrect information on the blockchain? How would end users have the incorrect information fixed?
ASSESSMENT	Who has nominal ownership of the data? Who has physical control of the data? Would users benefit from having more control of their own data?	How is data being used? Are stakeholders profiting from the data?	Can users currently exert ownership over their data? Are there processes for fixing incorrect information?
EVALUATE	What happens if the people who own the data use it nefariously? Does owning the data mean that it can be sold? Does owning the data mean that stakeholders can leave with it?	Will stakeholders profit from the data? Can stakeholders use the data nefariously?	Are the information correction processes accessible? Is the information correction process overly burdensome to users?

Security

Overarching question:

How is security set up and ensured?

Definition:

Security refers to the protection of 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.

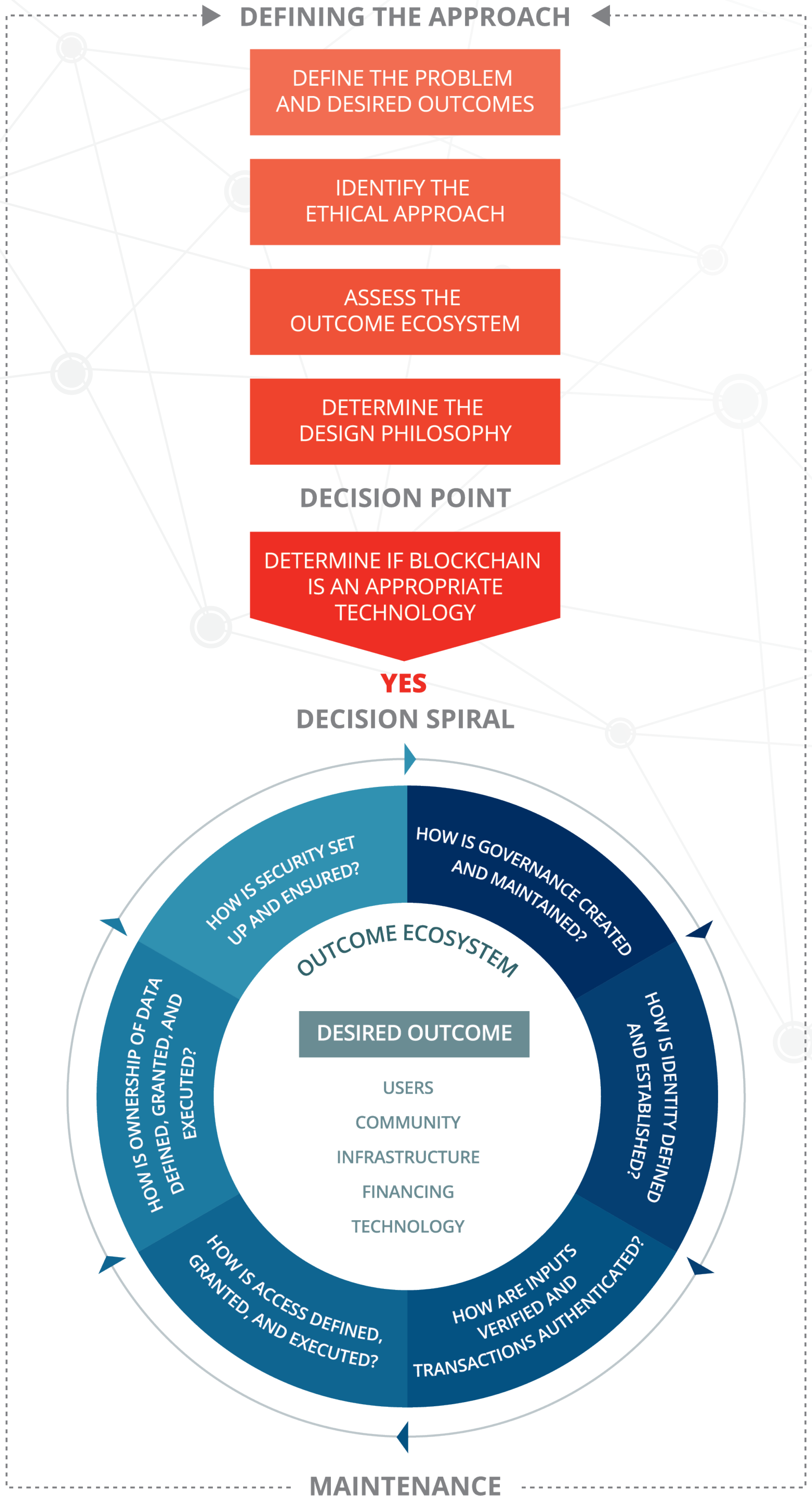
Key design considerations include:

- Determining who establishes security as well as who is responsible for breaches of it
- Ensuring that vulnerable data is adequately protected against current and future threats
- Deciding how different pieces of information will be protected
- Creating a system for safe and effective access to private keys

Key assessment considerations include:

- Knowing users' understanding of potential cyber threats as well as their capacity to protect themselves from them
- Being aware of what security threats the community faces and how they may change over time

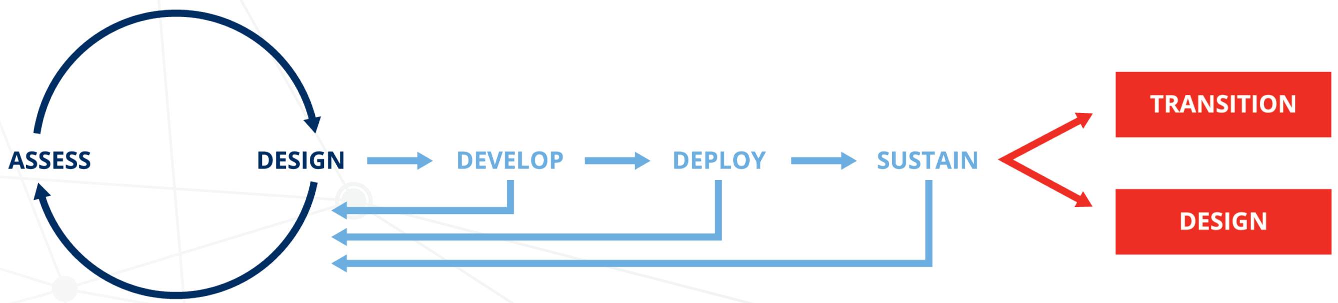
	WHO	HOW: SYSTEM LEVEL	HOW: INDIVIDUAL LEVEL
DESIGN	Who would set up, maintain, and update security? Who would be responsible for potential breaches?	How would you ensure that vulnerable data was protected as cryptographic and hacking technologies evolve? How could peripheral connections to a blockchain be vulnerable to security threats? Would different information be protected in different ways?	How would you ensure that individuals were aware of and could protect themselves against potential security threats? How would you ensure that users maintain effective and safe access to private keys?
ASSESSMENT	Who understands the technology and the evolution of it well enough to create adequate security?	What are security risks faced by the community as a whole? Where are the peripheral connections to the blockchain that could be put in jeopardy? What information is the most vulnerable?	Do users have experience protecting themselves against security threats?
EVALUATE	How do you ensure that the chosen stakeholders are incentivized to adequately protect the system?	Does the system remain secure as technologies, politics, and other social factors change?	Does the system make users more susceptible to security risks? Can they adequately protect themselves? Is the key system accessible to users without compromising security?



Phase 3:
Maintaining the Blockchain Across its Lifecycle

The initial assessment and design spiral process accomplished in Phase 2 of the Framework sets the stage for creating positive social impact with blockchain technology. However, context changes over time. The choices made in the initial implementation of blockchain technology may lose relevance or create unintended consequences for people as the context changes. Therefore, the Framework is iterative by nature. Phase 3 of the Framework includes periodically revisiting the earlier phases across the life cycle of a project.

A notional project life cycle is shown in the following diagram. It starts with an iterative assessment and technology design process, then moves into technology development and deployment. After a technology has been deployed, it will be sustained until it reaches an end of its life cycle, where it is either transitioned to a new technology or redesigned.



Thus far, the Framework has focused on the iterative design spiral in the initial project design phase, but it is critical that the design philosophy be maintained and implemented throughout the project. In Phase 1, decision makers answered the five entry questions. In Phase 2, they worked iteratively through the design spiral multiple times to fully understand the complex interrelationships among the various assessment elements and design choices.

After development and deployment of the product, the first two phases should be periodically revisited and evaluated at key review points throughout the project life. This maintenance pattern is necessary to account for the evolution of the desired outcome, the ecosystem, and the technology throughout the project. This repeated, rigorous evaluation ensures that ethical considerations are taken into account and that the project aligns with its design philosophy throughout the design, development, deployment, implementation, sustainment, and evolution of the project.

Appendix B:
Relationship of the Blockchain Ethical Design Framework to Existing Resources

Several institutions working at the intersection of technology and social good have released standards, guidelines, and other research designed to promote best practices in the areas of digital data, information and communication technologies, sustainable development, and humanitarian assistance. The Blockchain Ethical Design Framework should be used in conjunction with several of these publications, some of which are briefly described in the table below:

PUBLICATION	DESCRIPTION
Principles for Digital Development[32]	Created in consultation with international aid donors and implementers, this "living" document provides practitioners with nine guidelines to help apply digital technology to development programs.
World Bank Principles on Identification for Sustainable Development: Toward the Digital Age[33]	Published by the World Bank and endorsed by a large set of donors, this set of ten principles aims to mitigate the risks and maximize the benefits of creating legal identification systems for sustainable development.
Draft National Institute of Standards and Technology Interagency Report (NISTIR) 8202: Blockchain Technology Overview[34]	This draft publication provides a high-level technical overview of blockchain technology. It discusses blockchain's application for electronic currency as well as broader uses. The document looks at different categories and approaches for blockchain platforms.
National Institute of Standards and Technology (NIST) Digital Identity Guidelines[35]	To promote the U.S. economy and public welfare, this set of guidelines defines the technical requirements for digital identity services for U.S. federal agencies.
The Sphere Project Humanitarian Charter and Minimum Standards in Humanitarian Action[36]	The Sphere Project was initiated in 1997 by a group of humanitarian nongovernmental organizations (NGOs) and the International Red Cross and Red Crescent Movement to improve the quality of their actions during disaster response and to be held accountable for them. Implemented through a Humanitarian Charter and Minimum Standards in Humanitarian Action, Sphere's philosophy is based on two core beliefs: that those affected by disaster or conflict have a right to life with dignity and, therefore, a right to assistance; and that all possible steps should be taken to alleviate human suffering arising from disaster or conflict.

PUBLICATION	DESCRIPTION
The Signal Code: A Human Rights Approach to Information During Crisis[37]	Developed by the Harvard Humanitarian Initiative, the Signal Code identifies five rights relating to humanitarian information activities and lays the groundwork for the development of ethical obligations and minimum technical standards for future humanitarian information activities before, during, and after humanitarian crises.
Think Brief: Building Data Responsibility into Humanitarian Action[38]	This report from the UN Office for the Coordination of Humanitarian Affairs identifies the critical issues that can emerge as data is integrated into humanitarian operations and proposes a framework for using data responsibly.
A Path to Social Licence: Guidelines for Trusted Data Use[39]	Developed for companies, NGOs, and government agencies in New Zealand, but applicable to many others, this document provides eight key questions that lead to improved citizen trust and comfort in the collection and use of personal data. It also lays out ways to engage with citizens to ensure their understanding of how their data is used.

Alongside these important standards and guidelines, the development of this Framework was informed by several papers and ongoing efforts on blockchain for social good, some of which are described in the table below:

PUBLICATION OR EFFORT	DESCRIPTION
Center for Global Development Policy Paper on Blockchain and Economic Development: Hype vs. Reality[40]	This paper assesses blockchain's real potential in the context of development. It focuses on identifying questions that development practitioners should be asking technologists, and challenges that innovators must address for the technology to meet its potential.
GovLab Blockchange[41]	Blockchange is an initiative by GovLab to examine whether and how blockchain technologies can be used for social change.
Primer on Blockchain: How to Assess the Relevance of Distributed Ledger Technology to International Development[42]	Developed by the U.S. Agency for International Development (USAID), the primer provides a tool for international development practitioners to assess when distributed ledger technologies may be an appropriate technology choice.
Blockchain for Social Impact: Moving beyond the Hype[43]	The Center for Social Innovation at the Stanford Graduate School of Business conducted an analysis of the social impact blockchain efforts of nearly two hundred organizations, initiatives, and projects.
Blockchain beyond the Hype: A Practical Framework for Business Leaders[44]	The World Economic Forum developed this tool to assist business leaders in assessing whether blockchain is an appropriate and helpful tool for their business needs.

The Blockchain Ethical Design Framework Contributors

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Blockchain Trust Accelerator
Booz Allen Hamilton
BrightHive
CARE USA
Center for Democracy and Technology
Center for Global Development
ConsenSys
Digital Sisters/Sistas
Defense Innovation Unit Experimental
DocuSign
Embassy of Italy in the United States
Ember
Empowerment Capital
Evernym
Fathom5
FinClusive Capital
FinTech4Good
Fordham University Graduate School of Social Service
Fordham University Institute of International Humanitarian Affairs
FrontlineSMS
Gavi, the Vaccine Alliance
George Mason University Schar School of Policy and Government
Georgetown Institute for Technology Law and Policy
Georgetown University Law Center Center on Privacy and Technology
Georgetown University Law Center Institute for Technology Law and Policy
Georgetown University McDonough School of Business
Georgetown University Baker Center for Leadership and Governance
Georgetown University Center for Financial Markets and Policy
Georgetown University Ethics Lab
Georgetown University Information Services
Georgetown University Kennedy Institute of Ethics
Georgetown University Law Center
Georgetown University McCourt School of Public Policy
Georgetown University Communication Culture and Technology Program
Global Innovation Management Institute
Giveth
Global Alliance for Humanitarian Innovation
Google
The GovLab
Hyperledger
ID2020
Identity Woman
Institute of Electrical and Electronics Engineers Standards Association
International Finance Corporation
Internet Identity Workshop
iRespond
Kora
The Linux Foundation
Lux Capital
Massachusetts Institute of Technology Sociotechnical Systems Research Center
Mastercard
MicroSave
Microsoft Philanthropies
Milken Institute
MonetaGo
New America
New York University Center for European and Mediterranean Studies
Omidyar Network
One World Identity
Oxfam America
Santa Clara University Markkula Center for Applied Ethics
Save the Children
Harvard Humanitarian Initiative Signal Program on Human Security and Technology
Sovrin Foundation
Stanford University Center on Philanthropy and Civil Society
Stanford University Digital Civil Society Lab
Stanford University Philosophy Department
Stranger Labs Inc.
TechNotch Solutions
Think.iT
Third Sector Capital Partners Inc.
U.S. Agency for International Development Center for Digital Development
U.S. Agency for International Development Global Development Lab
U.S. Department of Homeland Security Homeland Security Advanced Research Projects Agency
U.S. Department of State Secretary's Office of Global Partnerships
U.S. General Services Administration Emerging Citizen Technology Office
United Nations Development Programme Alternative Finance Lab
United Nations Office of Information and Communications Technology
University of Toronto Rotman School of Management
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