

The ixo Protocol White Paper

(Draft 3.0 for Technical Review)

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This version of the ixo Protocol White Paper is intended for technical review and not for public dissemination. Please direct all comments, feedback and enquiries to shaun@ixo.foundation

8 December 2017

A. Opportunities for Impact

“As impact investing has grown into a worldwide practice, the ability to measure and demonstrate the impact of portfolios, individual investments, and impact organizations has become increasingly vital”.

[Measuring Impact, Working Group of the G8 Social Impact Investment Taskforce \(2014\)](#)

The growing Impact Economy

The **Impact Economy** is [valued at trillions of dollars annually](#)¹. The problem is there is no good data to back up this claim. But all recent analyses confirm the growing trends in capital flows towards addressing the world’s greatest social, environmental and economic sustainability challenges. These challenges are increasingly seen as opportunities to open up new markets and to generate new forms of economy - for instance, based on renewable energy using sustainable, exponential technologies.

Investment portfolios with higher environmental, social and governance (ESG) ratings have shown to [outperform other investments](#)². For the allocators of large, long-term capital, including sovereign wealth and government pension funds, the question is not whether they can afford to invest responsibly, but rather if they can afford not to?³ Ordinary people also want to make a difference. A [2017 survey by Morgan Stanley](#) revealed that millennials are leading the sustainable investing charge, with 86% believing that their investment decisions can make an impact.⁴ In this paper, we refer to all investments and funding that have sustainability and social considerations, as **Impact Investments**.

We will explain why the Impact Economy needs a new data-driven operating system. This is the ixo Protocol. We invite everyone to directly get involved, or to support this critical mission, which has a looming deadline.

The Global Goals provide a framework for the Impact Economy. The due date is 2030.

Impact is the measurable change that we want to see in society, for the environment and within the economy. The UN’s 17 [Sustainable Development Goals](#) provide a guiding framework for the types of impacts that will create the future we want. This incorporates the 2015 [Paris Agreement](#) for responding to climate change.

¹ "Make it your business: Engaging with the Sustainable Development"

https://www.pwc.com/gx/en/sustainability/SDG/SDG%20Research_FINAL.pdf. Accessed 7 Dec. 2017.

²<https://www.forbes.com/sites/moneyshow/2017/08/16/socially-responsible-investing-earn-better-returns-from-good-companies/#46773e28623d>

³ <https://www.newamerica.org/bretton-woods-ii/>

⁴<https://www.morganstanley.com/ideas/sustainable-socially-responsible-investing-millennials-drive-growth>

The Global Goals are about ending poverty, protecting the planet and ensuring prosperity for all, by the year 2030. These goals are relevant at all levels of society, in all countries.

The 17 Global Goals for Sustainable Development



Achieving the Global Goals would create a world that is comprehensively sustainable, socially fair, environmentally secure, economically prosperous, inclusive, and more predictable. This will improve people’s lives, for instance through better education, good health and wellbeing, affordable energy, decent work, innovation and economic growth. It will increase resilience to global threats, such as climate change, and reduce systemic risks - including for business and investors.

Most profoundly, this will reshape our economy and create new economic opportunities. Pursuing this path has immense potential to generate profits, grow capital, mitigate business risks, create resilience and promote human prosperity. We could be building an economy of abundance. Consider every investment that is made with some consideration for impacts on society, the environment or sustainable economic growth, is an impact investment. Each impact investment grows the Impact Economy.

Impact Data fuels the Impact Economy

All impact investments need verified impact data, to prove that value has been delivered, to get evidence for results and to improve how impacts are achieved. Verified impact data should also increase accountability and reduce inequalities and injustices by ensuring that the right goods and services are delivered to the right beneficiaries.

The Impact Economy is primarily driven by economic exchanges of financial capital for impact data. **Impact Investors pay for impact data.** Higher-quality, verified impact data should therefore be more valuable.

In many cases, impact data exchanges also yield rich information that can be used for other purposes, such as business intelligence, impact results management and investment analytics. The secondary marketplace for big impact datasets provides largely untapped opportunities.

But verified impact data is scarce

Until now, it has not been technically or economically feasible to produce, measure and value impact-related data at scale, in ways that are cost-effective and useful.

Legacy data gets locked in silos of proprietary indexed databases, with little to no compatibility, interoperability, or ways of avoiding aggregation errors, such as double-counting.

The fidelity of data has been a pervasive problem. It was hard to prove that datasets had not been tampered with, corrupted, or originated from untrustworthy sources.

However, with [Verifiable Claims](#), it is now feasible to collect, transport and store data resources in high-fidelity formats. Data can be cryptographically hashed and digitally signed at the point of collection or issuance. This cryptographically verifiable data can be proven not to have been tampered with and the signatures of the claim issuer can be authenticated. This adds trust assurance and data provenance.

We now also have the technological means to resolve impact-related data to globally unique digital identifiers, rooted in the distributed public key infrastructures of blockchains. The [Decentralized Identifier \(DID\) specification](#) developed by the [Rebooting the Web of Trust](#) community (in which we participate) is becoming a [W3C web standard](#). This enables the creation of high-resolution datasets, tagged with globally unique identifiers that can be cryptographically authenticated.

Evaluation of impact-related data has been a costly process. At least 5-7% of development funding is typically spent on independent evaluations and audits⁵. Evaluations of more complex results-based financing mechanisms, such as [Social and Development Impact Bonds](#), can cost up to 30% of the fund value.⁶ This excludes the ongoing costs of data collection, administration, storage and security. In the voluntary carbon credit market, transaction costs can be even higher - it takes on average of more than 2 years for a project to become certified and start generating carbon credits.⁷ Skilled evaluators are trusted intermediaries that are in short supply and their evaluation methods are not easily scaled.

⁵ The Kellogg Foundation as cited in Bloomquist, J. 2003. Impact Evaluation of Social Programs: A Policy Perspective. Revised Draft. World Bank, Washington, DC

⁶ Interview with Sonja Giese, Executive Director of Innovation Edge

⁷ Forest Trends Ecosystem Marketplace http://www.forest-trends.org/documents/files/doc_5591.pdf#

The marketplace for Impact Data is still highly inefficient, fragmented, centralized and operates with entrenched information asymmetries. Coordination costs are high and there have been few real economic incentives for market incumbents to change how they operate.

Recognizing these challenges, The UN Secretary-General in 2015 called for a [Data Revolution for Sustainable Development](#).

This is a compelling market opportunity

We believe that it is now feasible to grow a fast-scaling, decentralized marketplace in which verified impact data is produced and traded through networks, using information infrastructures such as the [Ethereum](#) blockchain application platform.

With high-performance computing and Machine Learning becoming pervasive, software-augmented evaluation mechanisms will become commonplace. New algorithmic evaluation agents can be implemented using consensus-based validation mechanisms that include economic incentives. Software oracles can bring together multiple sources of truth from different data sources, to perform intelligent evaluations that will yield powerful new insights.

Verified impact data will become abundant. We are developing the mechanisms to share data-sets through software-mediated governance mechanisms, using the [Ocean Protocol](#). Data resources will become locatable across any data store, using content-addressing, based on the [Interplanetary Linked Data](#) (IPLD) specification. The quality of these datasets will improve through the economic incentives and coordination capabilities of [curation markets](#). Our partnerships and collaborations with the pioneers of these and future initiatives will produce even more exciting possibilities, as this space evolves. Within the next 10 years, we believe scarcity of verified impact data should no longer be a problem. But we need to ensure that this abundance provides the best possible quality of high-definition impact-related data, accessible through a big (impact) data commons for the world, to optimize how impacts are achieved.

Impact Tokens are a new form of capital in the Impact Economy

Consider that Capital is a statistical measure of something of we value in the economy that can be counted in stocks and flows and traded for other forms of capital. Carbon Credits and Bitcoin are two recently-invented new forms of capital.

[Cryptographic tokens](#) are a core innovation of Blockchain technology. A token represents the digital record of an asset within a [blockchain ledger](#). The record is controlled by the holder of a cryptographic key that was used to sign a transaction that created this record. This provides a way for control (or ownership) over a token to be passed on to new owners, through transactions. The transaction history

provides a record of the provenance of the token. Token records can also hold valuable information about the assets they represent.

Previously, it was almost impossible to count what matters for sustainability and value what counts, in ways that could easily be traded for capital. Without having reliable measures of how impact investments improve capital productivity and resilience to capital risks, these kinds of investments have been undervalued and not grown to their potential.

Impact Tokens will now enable us to statistically measure, value and trade as capital all the proof of impact we consider valuable for sustainability and human well-being. Impact Tokens provide a new form of capital for the Impact Economy. Increasing the supply and tradable value of Impact Tokens will add enormous value to the existing real economy and grow the emerging impact economy.

Impact Tokens can be configured to represent a wide range of valuable underlying asset classes, such as de-polluted water, drought resilience, immunized children, carbon sinks, and so on. Each Impact Token is derived from a statistical measure of verified impact data, using a measurement standard that is relevant to each specific type of impact and a method for recording Proof of Impact. The stocks and flows of Impact Tokens are recorded in a distributed global public ledger, which enables accounting for the Tokens and prevents double-counting or double-spending problems.

Impact Tokens can be traded between willing sellers and willing buyers, using standard blockchain transactions. Impact investors purchase Impact Tokens as evidence for funding the delivery of goods and services, or putting in place infrastructure and mechanisms to increase sustainability or resilience. The exchange value of any specific Impact Token is determined by the market, influenced by factors such as: the stakeholders who were involved in the projects that generated the tokens, value pre-invested and who the investors were, reputation of the service agents, perceived quality of the impact delivered, and other criteria. Statistical algorithms can be used to normalize diverse Impact Tokens to a comparable common unit of value, by which tokens can be quantified.

Impact Tokens are generated using a prescribed specification, in much the same way that tokens prescribing to the ERC20 specification on the Ethereum Network form a system of tokens that are interoperable. Using the specification described in this paper, Impact Tokens can be generated by anyone using the ixo Protocol. One form of Impact Token can be exchanged for another. For instance, an Impact Token representing a Carbon Credit can be exchanged for a Health Impact Token. This is relevant for implementing the Paris Agreement on Climate Change that includes a mechanism for linking trading systems and enabling [international transfer of mitigation outcomes](#) (ITMOs).

As this system of Impact Tokens gains acceptance and becomes widely adopted, Impact Tokens should become tradable with other crypto-tokens, including Ether or ERC20 tokens. The [Bancor Protocol](#), for instance, could simplify trading of diverse baskets of Impact Tokens, by representing multiple units of tokens as a single derivative token.

B. A New Operating System for the Impact Economy

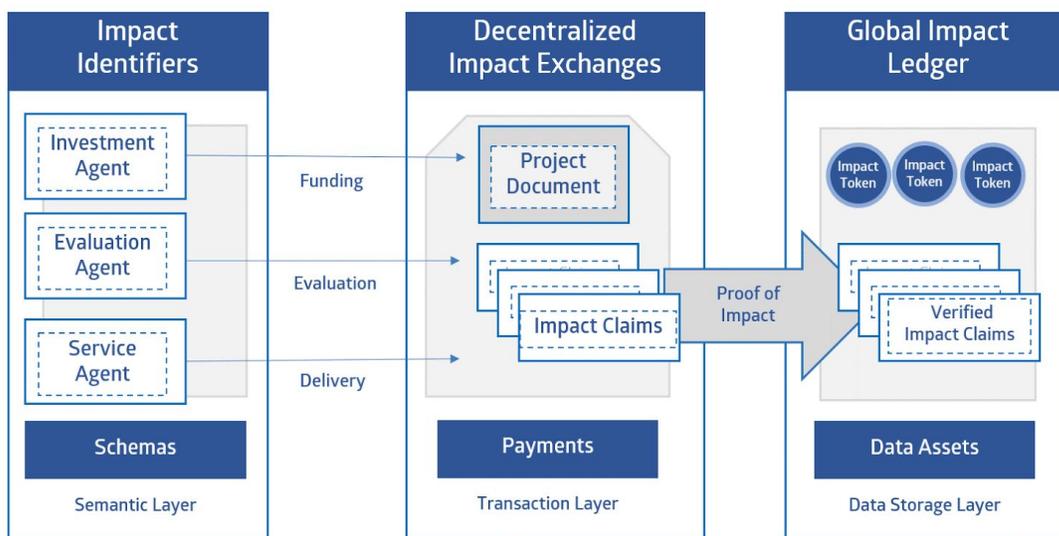
The ixo Protocol

ixo is a new operating system for the Impact Economy. This is built using blockchain technologies, Web3 standards and a decentralized impact evaluation protocol. ixo is built on open standards, with reusable design elements. Many diverse sustainable development applications can be built using the generic capabilities of the operating system. There are no significant barriers to participation.

ixo enables anyone to collect, measure, evaluate, value and trade verified impact data, with Proof of Impact. The users of the protocol include:

- **Investment Agent** institutions, financing instruments, or individuals who contribute the economic value to resource impacts. This accommodates all kinds of innovative financing mechanisms, such as crowd-funding, [liquid pledging](#) and impact bonds.
- **Service Agent** organizations, independent individuals, or devices that deliver goods and services to achieve impact. For instance, a vending machine that dispenses mosquito bed-nets to protect people from Malaria.
- **Evaluation Agent** organizations, individuals, or software algorithms that process impact claims to evaluate whether these qualify as Proof of Impact.

Components of the ixo Operating System



The ixo Protocol has three main components, depicted in the diagram above:

1. Impact Identifiers

Impact Identifiers provide the semantic abstraction layer on which the data evaluation protocol operates. Agents who deliver, evaluate and fund impacts are identified using decentralized identifiers and digital identity credentials.

Open schemas define the data models for recording impact claims, using standardized data ontologies and indicator definitions. Impact projects are identified using machine-readable project specification document formats. Each type of impact has an identified, reusable data model that includes standard indicators linking to identified measurement frameworks. Impact proofs identify standard parameters that are formulated as signed attestations. Impact Tokens are a system of measures that include standardized parameters, for instance, to identify Impact Tokens that represent Carbon Credits.

2. Decentralized Impact Exchanges

Decentralized Impact Exchanges (DIX) function as the transaction layer of the operating system. Impact exchanges are used to coordinate and incentivize investors, service agents and evaluation services to come together to work on specific impact projects that will deliver pre-defined results.

- A DIX functions like a multi-sig escrow contract between these participants.
- Each DIX is a system of smart contracts that executes in a virtual machine – for instance on the Ethereum Public Network.
- A DIX is independently set up and directly controlled by a project sponsor who does not have to rely on any central authorities or intermediaries.
- The project sponsor configures a project document that defines which impact claim schemas will be used, who is authorized to participate (based on identifiers, credentials and capabilities), as well as the value transfers that will be made between the participants.
- Cryptocurrency payments and other digital asset transfers between peers are processed through the DIX smart contracts. Payments can alternatively be made using conventional payment mechanisms, with a record of these transactions reconciled in the DIX.
- Transaction fees are paid to the hosts of a network of computing nodes who operate the ixo Protocol as a service. At a minimum, this covers the Ethereum Network Gas fees, computation costs of evaluating the impact claims through the DIX and the storage costs for the resultant crypto-asset Impact Tokens and metadata that are permanently recorded in the Global Impact Ledger.

3. The Global Impact Ledger

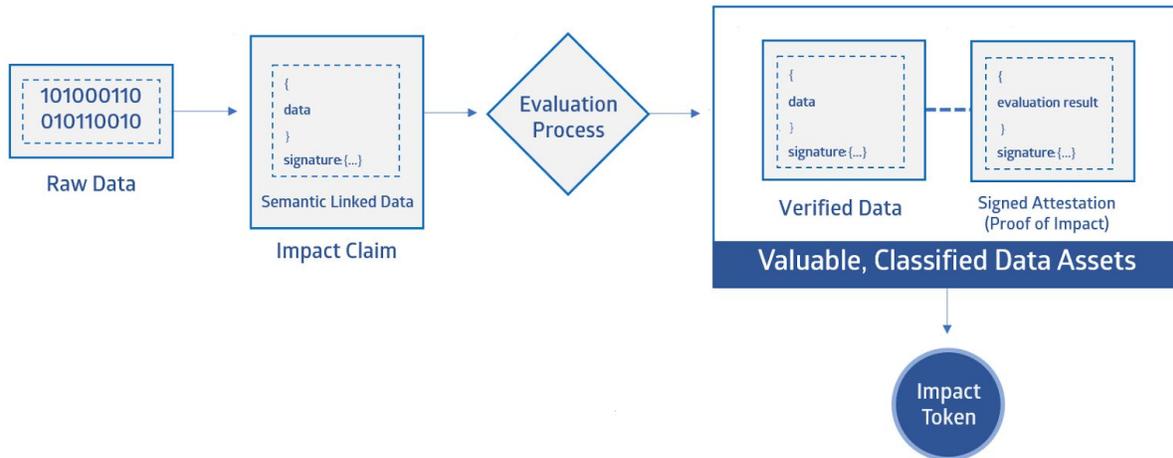
The Global Impact Ledger is the decentralized data storage layer for the ixo protocol. This also provides data processing capabilities for claims to be evaluated.

- Service agents submit impact claims to be validated and evaluated. Claims Validation takes place through a consensus mechanism between ixo Nodes. This rejects duplicated or fraudulent claims.
- The ledger governs access to all claims data. It permits authorized evaluation agents to use the data for evaluating the claims that are associated with a specific impact exchange. Once an evaluator verifies a claim, they issue a signed attestation as a Proof of Impact that records the result of the evaluation, together with other useful information.
- Verified impact claims and the associated Proof of Impact are recorded as digital assets in the ledger, in the form of cryptographic Impact Tokens. These transactions include claims metadata that enables anyone to query the ledger, analyze or visualize the impacts. This is great for accountability and transparency. For instance, impact dashboards can be constructed to view types of impacts at any level – from global to local, and from different stakeholder perspectives.
- The Global Impact Ledger functions as a virtual index to all the verified impact claims data processed using the ixo Protocol. This provides a growing ocean of big impact data for the world that can be shared and used for all kinds of valuable applications. The actual impact claim data is stored off-node under the control of the data owner. This can be configured for any type of data storage service – including on-premise, decentralized (e.g. using [IPFS](#) or [IPDB](#)), or in various cloud configurations.
- Data flowing through the Global Impact Ledger provides real-time information feedback loops to optimize how investments are made, how impacts are management and how claims are evaluated.
- Many innovative financing and performance accounting applications can be built on the shared data layer of the Global Impact Ledger.

How impacts are evaluated

Impact claims are evaluated using standard protocols that verify the data, with proofs. Impact claims combined with proofs are the valuable, classified data assets that get recorded in the Global Impact Ledger as Impact Tokens.

The generic process for evaluating an impact claim



When an impact claim is submitted to the ixo Network, the claims data is stored within a specified database and the metadata relating to this (which includes the content address of this data) is recorded in a cache on the Global Impact Ledger. Evaluation agents receive an authorization token, to access the data for the evaluation process.

Evaluations typically also incorporate data from external sources. Ideally, both positive and negative data should be sourced and evaluated, to reduce statistical biases.

The evaluation processes should yield information about why, where, when, how and how much impact occurred. It should be possible to identify who delivered, received, witnessed, measured, evaluated and funded an impact. This is important for accountability and to prove attribution.

Evaluators verify claims by producing signed attestations, which we refer to as Proof of Impact. In these attestations the evaluation agent claims to have followed a defined evaluation method to reach an opinion on how to classify the claim – for instance, true or false, or probabilistically.

All the proofs issued by evaluators are in themselves cryptographically verifiable. These proofs record details of the evaluation, including the evaluator’s identifier (DID), evaluation method (hash of the algorithm used), evaluation result, evaluation qualifiers, and so on. Each Proof is stored in the Global Impact Ledger, appended to the impact claim. This mechanism allows for multiple evaluations to be made against a single impact claim in a way that avoids double-counting.

Many types of evaluation agents can use the protocol

Evaluation Agents can be human agents using software tools, humans augmented by software agents, or fully automated software agents. There is enormous scope to increase the efficiency of evaluation processes through automation.

Evaluation activities are coordinated and incentivized through decentralized impact exchanges. In many cases - at least to begin with, Impact Evaluators will be existing professional service providers who now have a powerful set of new data collection and analytic tools for monitoring and evaluation, with higher quality data to evaluate. The Decentralized Impact Exchange mechanism makes it feasible for evaluation agents to participate in an open marketplace, where their reputation counts. Having a public record of all the claims an evaluation service has processed provides an indication of the experience of an evaluation agent, which will be useful for scaling virtual evaluation services. Impact Investors will gain access to a growing decentralized network of Evaluation Agents.

Evaluation processes will become more automated and intelligent

Routine evaluation processes will increasingly be carried out by software agents that combine trusted external data sources with claims data, to perform sophisticated evaluations. There will be an increasing role for AI-assisted claims analysis and intelligent decision-making. Evaluations will become more effective using information feedback loops and externally referenced data.

The ixo Foundation will promote open-source development of Impact Oracles and evaluation algorithms.

Disputed evaluations can be resolved

Dispute resolution will be managed through a mechanism that is defined in the project documentation and is standard to any contractual agreement, with nominated arbitrators and jurisdictions as standard dispute resolution clauses. Future options could possibly include reputation-based distributed arbitrator networks as a choice of arbitrator in dispute resolution clauses that are executed by smart contracts.

How ixo works in practice

Anyone can set up an Impact Exchange⁸

The ixo Protocol is agnostic as to who initiates and sponsors a project. This could be a Service Agent, Evaluation Agent, Investment Agent, or any other third-party. There are many use-cases that require each of these sponsorship scenarios. The main prerequisite is that all the entities must at least be identified with their own universal decentralized identifier (DID) and have the necessary credentials.

⁸ Project templates will be available from a public repository. These can also be repurposed for new projects. It should become possible to automate most steps in setting up a new project, so this will not require specialized skills.

As the protocol is fully decentralized, the relationships between these parties can be many-to-many. One or more Investment Agents can finance a project; one or more service agents can submit impact claims; and one or more evaluation agents can verify claims.

Beneficiaries are also identified within impact claims, which enables user-centric collation of their records and improved continuity of benefits across services. This also implements the Decentralized Identifier specification that can be configured in ways that are privacy-preserving.

These roles are also interchangeable. For instance, a Service Agent could choose to setup and fund their own project, in the Investment Agent role, to generate Impact Tokens that they can subsequently use to recruit new investors by demonstrating the impacts they are already delivering.

ixo can be used by almost all types of existing projects, services or interventions that run today on legacy systems or that are not digitally capturing impact data.

Participants are identified and authorized as agents

To participate in a project, entities must authenticate their identifiers and demonstrate that they have required capabilities, such as qualification credentials, that are specified in the project's DIX authorization smart contract. For instance, the project might specify that service agents must have the credential of being a qualified health professional with a certificate to practice in a specific jurisdiction. This capability will require a verifiable digital identity claim that has been issued by a recognized credentialing authority. This is why the protocol is rooted in a decentralized identity network. It is a powerful feature of ixo that all claims resolve to authenticated identities, with provable credentials.

Applications built on the ixo Protocol generally include the feature for users to register their decentralized identifiers and to establish their credentials, or to link their existing identity assets.

Data gets identified using impact claim schemas

Impact-related data is captured in the form of verifiable impact claims. This uses standardized, semantic linked-data models, with authenticated identifiers. Claims are cryptographically secured and signed by the issuer. Typically, impact claims are compiled on devices at the point and time of impact delivery. For instance, this can be done by service providers using a mobile application, or by an IoT device.

This process produces valuable digital assets that have a number of compelling characteristics:

- The data is normalized and semantically defined, using Linked-Data graphs to standardize all data points to the context of open schemas. This ensures interoperability – even across legacy systems that have proprietary data ontologies.
- The data is high-quality as this is issued as a Verifiable Claim that is compiled at the service interface, with machine validation and automated oracle inputs.

- The data can be trusted, with a high level of assurance, as this is verified by independent evaluation agents using statistically calibrated tools and evaluation methods.
- The data is privacy-preserving, as pairwise decentralized identifiers are used in a way that cannot be correlated to an entity without their permission. Only proofs about a claim are publicly displayed. The claim attribute data is never stored publicly 'on-chain', in the Global Impact Ledger.
- The data assets are well-governed as the access and usage rights are encoded within a public ledger, which makes Proofs of Impact accessible, immutable, persistent and tradable.
- High-resolution Impact Data is particularly valuable for big data analytics for which there are many compelling use-cases. High-fidelity Impact Data is valuable as the basis for funding and investing in impacts. It makes possible a system of fungible Impact Tokens, which is a new form of capital.
- The data is real-time, as a record of each claim submission is ledgered immediately.

Decentralized Impact Exchanges are configured as projects

A Decentralized Impact Exchange sets up an offer to deliver, fund and evaluate the impacts of a project or intervention. The size of the project, type of impact, number of participants, value and duration are all configurable. Each DIX is a unique project that initiates its own system of blockchain Smart Contracts. A project sponsor initiates the impact exchange for their project and retains full control⁹.

The main function of the DIX is to coordinate and incentivize participants in a project to achieve expected impacts through funding, delivering and evaluating the creation of Verified Impact Data and Proofs of Impact that can be cryptographically verified. This outputs Verified Impact Data (with Proof of Impact) and Impact Tokens for the project. The DIX coordinates the relationships and value exchanges between project participants.

Step-by-step

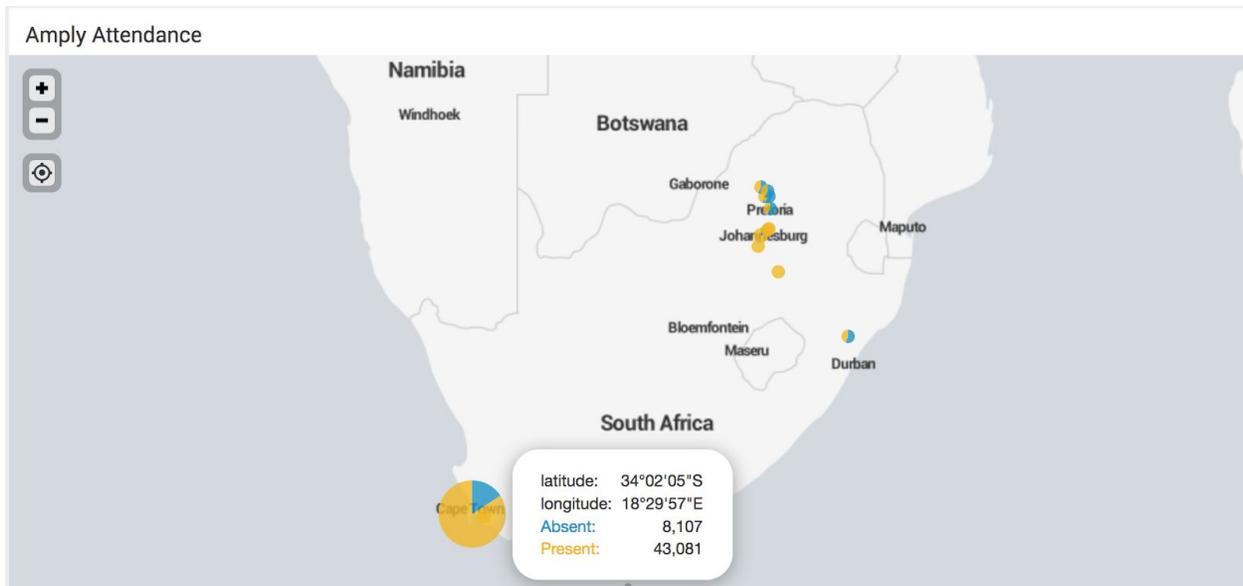
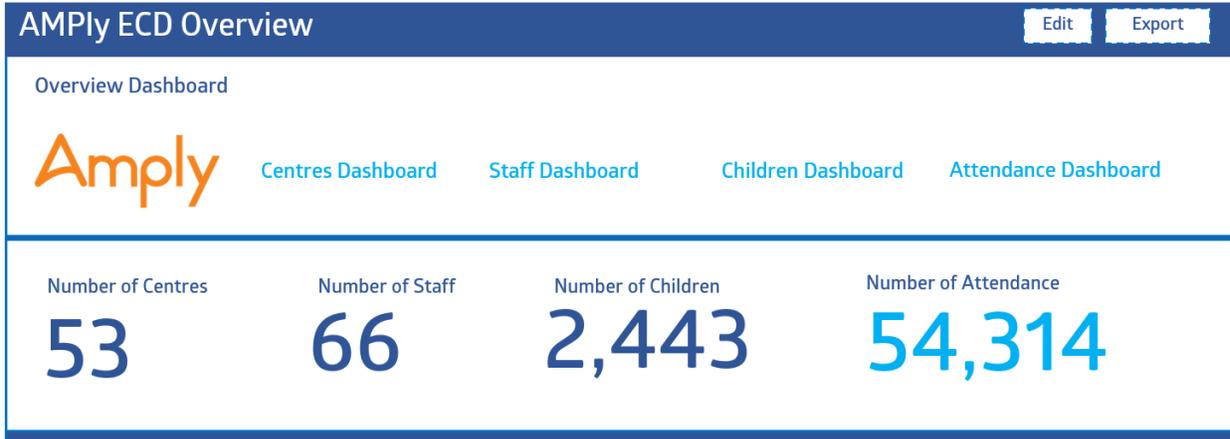
1. A project sponsor sets up a Decentralized Impact Exchange. The sponsor is typically an Investment Agent, but in some contexts this could be the Evaluation Agent, or Service Agent. Using the ixo Portal, the project sponsor specifies the details for a new Impact Project. They define the project description, participants - including any capabilities the participants must demonstrate, and the impact claims schemas to be used.

⁹ Neither the IXO Foundation, nor any custodian hosting a node of the IXO Network has any direct control over a DIX, nor liability for the counter-parties who choose to participate in the DIX. Participants get to freely choose who they trust and which intermediaries (if any) they want to include within a project.

2. To initiate the DIX that will run this project, the sponsor submits a deposit of IXO tokens from their IXO Wallet, to the project's DIX address.
3. Service Agents connect with the project using a mobile application supplied by an application developer for this specific use-case. They accept the terms of the project and download the project impact claims schemas. They will use the application to record delivery of their service, digitally sign and submit their impact claims. Signed claims are messaged to a node on the ixo Network.
4. An Evaluation Agent connects with the DIX and accepts the specific terms of the project. Using Agent Software to evaluate the claims that have been submitted, the agent verifies the claim if the evaluation criteria have been successfully met. The agent produces a signed Proof of Impact for the claim. A defined number of IXO tokens will be allocated to them for each claim they process, as payment from the project sponsor.
5. The Verified Impact Claim, with its Proof of Impact, is submitted to a destination data store and an Impact Token with metadata relevant to this impact gets created through a transaction in the Global Impact Ledger.
6. The Service Agent is paid by the Investment Agent for the successful impact claim. This payment can be made off-chain, using an acceptable payment method, or peer-to-peer, through the DIX. Proof of Payment is submitted to the DIX and this triggers a transfer ownership of the Impact Token to the project sponsor, who now controls access to the related data assets.
7. A small fixed value transaction fee in IXO is automatically paid to the ixo network.

ixo is already being implemented for Early Childhood Development impacts

In South Africa, the government-subsidized early childhood development program is transitioning from paper-based service attendance claims processing, to a fully automated digital claims management platform, based on the ixo Protocol. The UNICEF Innovation Fund and Innovation Edge (backed by Omidyar Network and UBS Optimus Foundation) have provided seed investments to develop and test this application of ixo in this context, through a project called Amply. Educators log each child's attendance using a mobile device, to generate impact claims. An evaluation agent software algorithm ('Attendance Bot') verifies each attendance, with a signed attestation, and an Impact Token is created. Pre-school centers redeem these Impact Tokens for subsidies from the government. This application has helped teachers upgrade their previously paper-based administration.



Since November 2016, we have recorded nearly 55,000 attendance records across 53 schools and are preparing to scale this service to more than a million beneficiaries during 2018.

AmPLY is now also being deployed through the first government-issued Social Impact Bond for Early Childhood Development, which is funding networks of community agents support to children in poor households.

Further ixo use-case examples

A range of reference use-cases are being developed with partners of the ixo Foundation, to demonstrate the applicability of the protocol across various sustainable development goal areas and to provide working open-source code that can be further built on by other developers.

ixo will be used to collect impact claims data that produce Impact Tokens for:

- Improving educational outcomes for girls in India, through a Development Impact Bonds investment mechanism that is being set up by the [UBS Optimus Foundation](#).
- Demonstrating how clean-burning cookstoves can generate tradable Carbon Credits and Health Impact Tokens, certified by the [Gold Standard](#).
- Delivering household-level child support services in South Africa, funded through an innovative Social Impact Bond, underwritten by the government social development agency.

Visit the [ixo website](#) for further information and to view the growing list of initiatives building on the ixo Protocol.

C. Technical Design

In this section we take a deeper look at some of the key technical details of how the ixo Protocol operates.

1. Impact Identifiers

Data semantics

The ixo Protocol standardizes the way in which detailed event-driven information is recorded about what impacts have occurred, to who, when, where, why and how, together with indicators of success. This is based on open-standard schemas, Linked-Data structures (JSON-LD), cryptographic proofs and algorithmic verification mechanisms. Security data, such as the geolocation and a device fingerprint can be captured together with each claim to provide a first level of claim validation.

Claim schemas

Impact claims schema templates are serialized and version-controlled, using the [IPLD specification](#). An example schema is illustrated in the box.

Each claim includes the identifier of the organization that published the schema, with cryptographic proofs of the Schema's authenticity. When stored in a decentralized public database, such as the [Interplanetary Database \(IPDB\)](#), these become persistent data resources that can be referenced far into the future.

Impact claim schema templates can be configured for literally any type of sustainable development Impact. Ideally, standard impact claim templates will be issued by reputable standards-setting agencies, such as specialized UN agencies. [Token Curated Registries](#) can be implemented to elevate the reputational trust and consensus to support the use of these schemas.

Linked-Data schemas for Verifiable Impact Claims will transform the standards for gathering service delivery data that have been developed over many years, into high-quality, trusted and interoperable data resources. This will result in a higher level of standardization and interoperability across services and also between services (for instance, education and health).

Data normalization is a big deal in the Development Sector, as this will unlock the value and uses of data within a broader ecosystem.

JSON-LD code example of a generic impact claim data model

```

{
  "id": "http://ixo.foundation/schema/",
  "type": ["impact claim Set"],
  "templateID" : "01454600a18666a9f08f2f99a79ce8734e5b6f353a91",
  "contractID" : "0134b4b59c3acfeb9afd9398c88b2f6f003cbf29b553"
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        "http://ixo.foundation/schema/"
      ],
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      "type": ["Location", "Time"],
      "issuer": "did:method:464562546245625", //devices did
      "issued": "2016-02-08T16:02:20Z",
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      }
    },
    {
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        "http://ixo.foundation/schema/"
      ],
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      "type": ["Location", "Time"],
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        "result": {
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          "ratingValue": "79"
        },
      },
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        "signatureValue": "I0mA4R7TfhkYTYW8...CBMq2/gi25s="
      }
    }
  ]
}

```

Digital identifiers

The use of Decentralized Identifiers is a powerful and unique feature of the ixo Protocol. This is based on a new international Web3 standard for decentralized digital identity (the [DID Specification](#)). This describes a standard for recording universally unique digital identifiers on distributed ledgers, with cryptographic authentication using key signatures. These identifiers can be associated with provable credentials, using the [Verifiable Claims](#) specification.

Each participant in an Impact Exchange project - including Service Agents, Investment Agents, Evaluation Agents and beneficiaries - is identified as an entity, using a Digital Identifier. Entities can refer to natural persons, organizations, software agents or devices. For instance, an Evaluation Agent could be an identified software agent that functions as a Smart Oracle, checking submitted claims data against external data references and performing algorithmic calculations, to arrive at a conclusion that verifies the claim. These identifiers resolve back to verifiable identity credentials, such as a proof of skills qualification, that can be used to determine the eligibility of the entity to exchange their claim for funding.

The use of cryptographic digital identifiers is a game-changer because this enables:

- Accountability for every entity involved in funding, delivering and evaluating impact claims.
- Attribution by all projects and related claims being linked to identifiable agents.
- Authenticity through cryptographic authentication and digital signatures.
- Authorization based on capabilities, which can include the requirement for specific credentials to be demonstrated.

The ixo protocol is agnostic to which identity service is used to record and authenticate Digital Identifiers (e.g. on the [Sovrin Identity Network](#), or using [uPort](#) on the Ethereum blockchain), as long as this complies with the standard DID Specification. However, to achieve high standards of personal privacy and data protection, the use of derivative pairwise identifiers and cryptographic proofs of identity credentials is preferred.

Personal Data will be stored and access controlled by the data subject, using open-standard methods that are currently under development through the [Decentralized Identity Foundation](#) (in which the ixo Foundation participates).

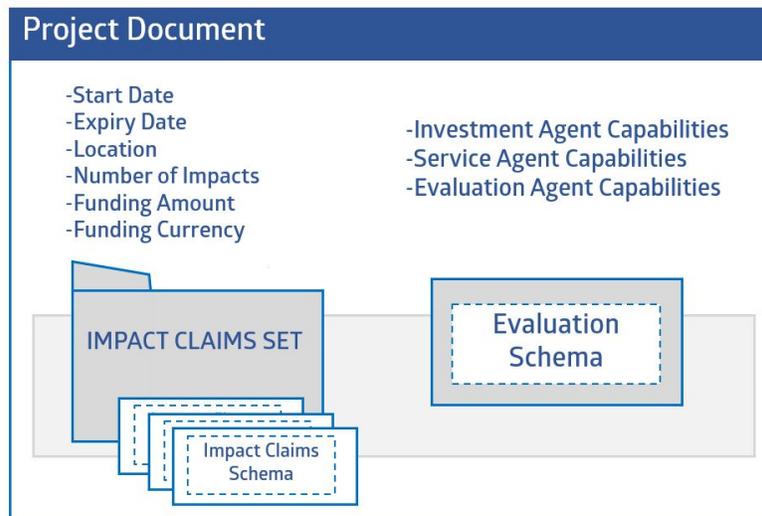
2. Decentralized Impact Exchanges

The DIX data model

The DIX smart contract system codifies the impact claims that will be evaluated, which entities are eligible to submit, evaluate and finance the impact exchange; the mechanisms and terms for payment; links to the legal terms; validity period and other conditions. These parameters are semantically defined within a JSON document that is contextualized to open schema definitions, using the Linked-Data specification.

The conceptual structure of a project definition document is shown in the Project Template diagram. The manifest of each project sets out the terms under which the DIX will operate, such as the duration. This also defines who is eligible to participate in the project. Participation is restricted to specific Investment Agent, Service Agent and Evaluation Agent capabilities. To transact with the DIX Smart Contract system, these agents must be able to cryptographically authenticate that they have the required [Object Capabilities](#) - for instance, they must be able to sign the transaction with the valid cryptographic private key associated with their identifier.

The structure of a Project Document



Payment transactions

DIX Smart Contracts can be specified to record payments for services that include the services delivered by Service Agents and Evaluation Agents¹⁰. Each payment is specified by the type of payment (e.g. Currency), method of payment (e.g. out-of-band or crypto-transaction), terms of payment (e.g. Bounty or fee-for-service) and condition of payment (e.g. minimum number of claims to be submitted or due-date). Any project sponsor, or external parties, can further incentivize participation in a project, by adding a bounty, performance bonus or simple reward to a DIX. This powerful capability that can be used to configure decentralized impact bonds and other innovative mechanisms for results-based financing.

To begin with, ixo could be used more as a coordination and accounting mechanism, with only a fraction of the evaluator fees transacted through the DIX, to incentivize evaluation agents to use the Protocol. However, over time we see the full payment for evaluation services being transacted peer-to-peer through the DIX – especially when these evaluations are conducted by software agents.

The DIX can be configured to require any combination of evaluation agents to sign the transaction. Criteria for participation can be restricted to specific evaluation agents identifiers or identity credentials (authenticated against verifiable claims of identity). For Evaluation Agents that call external services to retrieve oracle data or services through decentralized applications, or using web APIs, the flow of value using IXO tokens should allow for increased automation in payment processing. This should become a powerful driver for growing an open Impact marketplace.

Network architecture

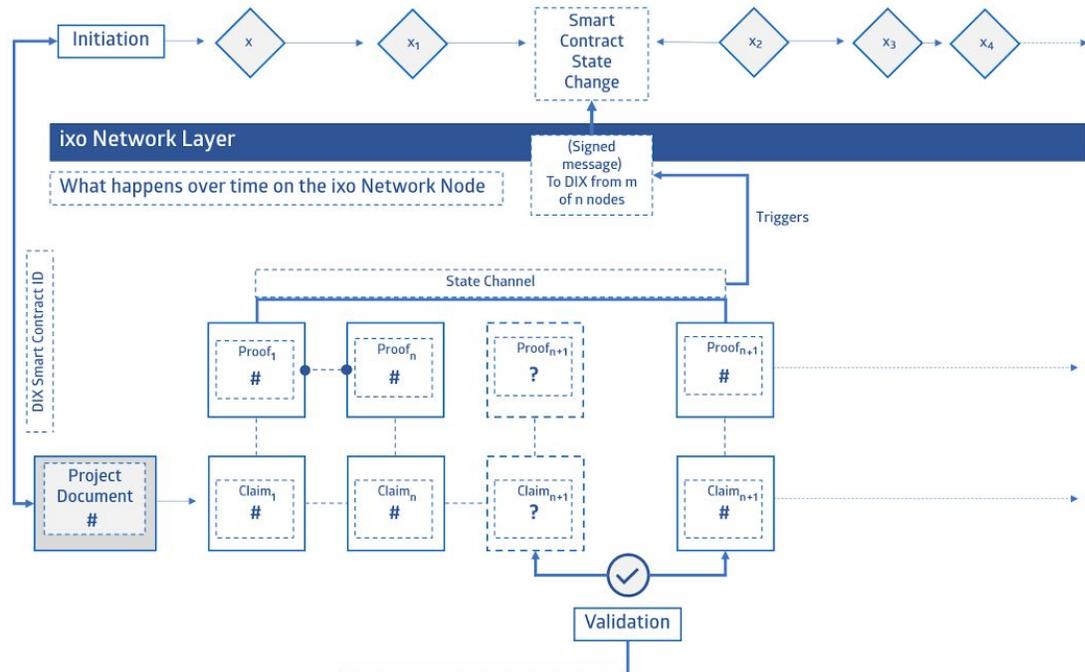
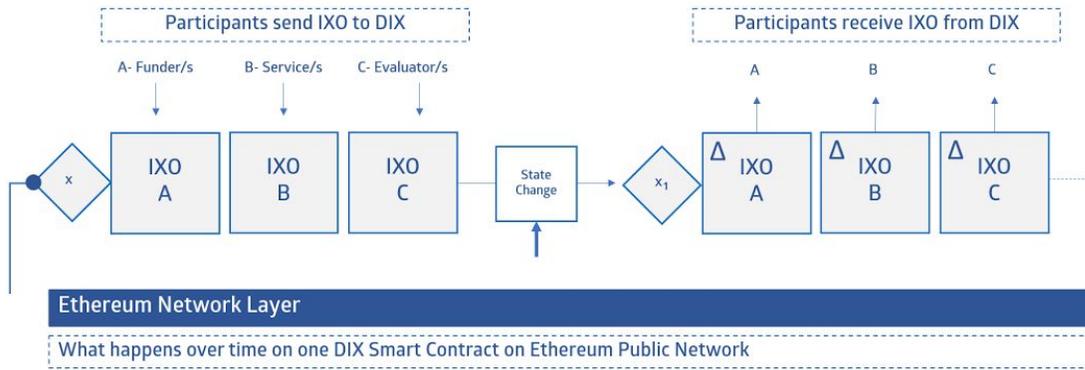
The ixo Operating System diagram illustrates how DIX smart contracts on the Ethereum Network interact with the ixo Network.

- Each DIX is associated with a corresponding Blockchain database record for the project. This provides data caching across independent nodes and manages permissioned access to the data for the purpose of evaluation and verification.
- The [Merkle Root](#) of this Blockchain is derived from the Project Document. The Project Document defines the parameters for the project and sets the rules for the DIX smart contract. At registration, the DIX is pegged to a corresponding Project Blockchain.
- As each impact claim is submitted to the ixo Network, this is validated by a set of nodes before the record is inserted into the transaction log. This cryptographically signed transaction log of validated claims serves as a State Channel.

¹⁰ These are entirely Peer-to-peer transactions and at no times do the IXO Network Hosts nor the IXO Foundation directly hold any deposits, take any liability or provide guarantees for the payments being made.

- At periodic intervals, or after a prescribed number of transactions, the ixo Nodes send signed messages to the DIX smart contract. This produces a state change in the DIX, once a threshold number of signatures has been reached. The state change updates the numbers of IXO Tokens that are allocated to each of the participants in the DIX. In this way, participants receive payments for their services.

ixo Operating System



- | Registration | Validation | Processing | Storage of Proofs |
|--|--|---|---|
| <input checked="" type="checkbox"/> Transaction ID | <input checked="" type="checkbox"/> Verify Checksum and Signatures | <input checked="" type="checkbox"/> Classify | <input checked="" type="checkbox"/> Content Address |
| <input checked="" type="checkbox"/> DIX pegged | <input checked="" type="checkbox"/> Authentic Identifiers | <input checked="" type="checkbox"/> Compare | <input checked="" type="checkbox"/> Metadata |
| <input checked="" type="checkbox"/> Merkle Root Hash | <input checked="" type="checkbox"/> Data Structure & Completeness | <input checked="" type="checkbox"/> Calculate | <input type="checkbox"/> other |
| <input type="checkbox"/> other | <input checked="" type="checkbox"/> Security | <input checked="" type="checkbox"/> Reference | |
| | <input checked="" type="checkbox"/> No Disputes | <input checked="" type="checkbox"/> Score | |
| | <input type="checkbox"/> other | <input checked="" type="checkbox"/> Poll | |
| | | <input type="checkbox"/> other | |

3. The Global Impact Ledger

The Global Impact Ledger receives impact claims and validates these before writing a claim transaction that includes metadata about the claim and a pointer to the address where the claim data is stored. The ledger communicates state changes in the claim record to the DIX.

Verified Impact Data and Proofs are tokenized and recorded as digital assets.

When impact claims are verified, valuable digital assets are created. Evaluation proofs (Proof of Impact) are signed attestations that add further value to the claims. Verified claims and their associated proofs are digital assets. Tokenization converts the rights to these assets into a digital token on a Blockchain. We call these Impact Tokens.

There can be many types of Impact Tokens - for Social Development, for Carbon Credits, for clean water, and so on. Impact Tokens can be traded as a crypto-assets and exchanged for fiat, or similar impact assets. For instance, Health Credits can be traded for Carbon Credits. The value derived from each impact claim is recorded the Global Impact Ledger. This allows for impact claims to be tracked as these pass through an impact value chain. For instance, a project that increases the use of clean burning cookstoves to reduce carbon emissions and prevent pollution-related respiratory complications, can claim both climate impacts and health impacts, without the problem of double-counting.

Impact tokens tell the story of a positive impact that has been delivered. Each token is associated with the verified data that proves the credibility of the impact, in an accountable and transparent way. Impact Tokens are measured, compared and reported in a universally standardized format. Each Impact Token links its impact claim data to a standardized impact indicator.

Impact Tokens reference a set of verified impact claims, with their Proof of Impact signed attestations. These are recorded together with other classifying metadata that makes the records searchable. Impact Tokens may be exchanged between impact investors, or purchased through public funding mechanisms, such as government grants, or used to implement innovative development financing mechanisms, such as [Social and Development Impact Bonds](#), or impact bounties. Impact Tokens may also be exchanged through open markets, in the way that carbon credits are currently traded. As such, Impact Tokens not only provide valuable Impact Data for funder reporting but, in effect, function as the coupon of a Social Impact Bond or return on a social investment, even when there is no formal scheme to pay returns on an impact project.

Recording Verifiable Impact Claims in this way provides a permanent public record of the impact that occurred and the provenance of the associated Impact Data, together with proof of its ownership and associated rights of use. The metadata in a claim record provides insightful information that can be

openly monitored and used for data analytics. It also points to the underlying data source with data governance mechanisms for sharing this data.

Impact claims data can be stored in any compatible database system

To store impact claims data, users of the network can either make use of the decentralized data storage services of the ixo network, which offers a permissioned big data distributed database that includes blockchain characteristics, such as decentralized control, immutability and a transactional method for transferring digital assets.

Alternatively, users can choose their own database architectures and services (such as [Filecoin](#), [IPDB](#), [AWS](#)), which can be centralized or decentralized, public or permissioned. This will allow for configurations to suit the type, location, size, security, privacy and other specific requirements of a service.

D. The ixo Network

The ixo operating system runs on a globally decentralized network of computation and data storage nodes. This eliminates dependence on central services and intermediaries. The network infrastructure is collectively owned and governed by independent node hosts. Organizations are incentivized to host the network infrastructure and keep the operating system running because they are regular users, or provide services to connected networks of users.

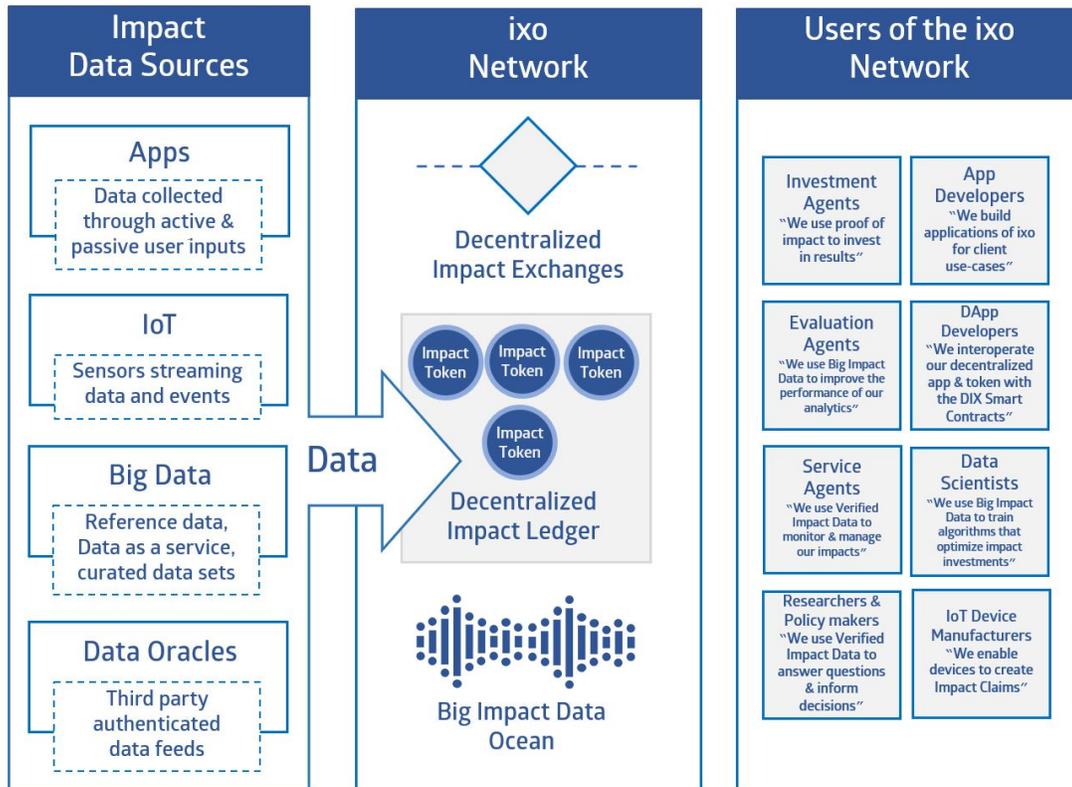
Use of this network infrastructure, the shared data layer and other network resources is restricted to holders of a native cryptographic payment token - the IXO Network Token. This token is used to pay transaction fees to the Network nodes for processing impact claims and to perpetually store Impact Tokens and related metadata. The design and functionalities of this token mechanism are described in section D.

The network supports an ecosystem

The potential ecosystem that can be enabled by the ixo operating system is expansive. ixo provides some of the decentralized marketplace mechanisms for these ecosystem players to find each other and work together using a common set of open standards. An analogy is the ecosystem that has developed around the Ethereum Network.

Participation in this ecosystem will be coordinated and incentivized by the IXO network Token. The token mechanism enables otherwise competing initiatives and incumbent infrastructures to join efforts, by using a common standard to exchange value within this ecosystem.

The ixo ecosystem



The diagram illustrates how some of the participants in this ecosystem collaborate to build and operate the shared network infrastructure and data layer. This will promote network effects that generate economies of scale more quickly.

- Software developers, evaluation experts and other technical contributors will be incentivized and coordinated to build open-source reference software implementations, using open standards to evolve the operating system and to create related IP that will increase the utility of the network. They can also create proprietary applications that run on the operating system and use the shared data layer.
- Networks of institutions that commission and/or fund impacts will be coordinated and incentivized to host and use the ixo network.
- Decentralized networks of service providers and funders will be coordinated and incentivized to deliver impacts using applications that are built on the ixo Protocol.

Participants in this ecosystem will also be able to explore their own paths, as the network matures. Providers of applications that run on the core operating system will be free to implement their own business models as application developers, evaluation agents, service providers, and other ecosystem participants.

Project sponsors drive use of the network

The value of the ixo ecosystem and what this contributes to the Impact Economy will primarily be driven by project sponsors using the operating system and services of the ixo Network to fund, deliver and evaluate impacts. These are the customers of the network.

Potential project sponsors include (but are not limited to) stakeholders within the following broad interest groupings:

- **Private impact investors** who structure Impact Bonds as results-based financing mechanisms that use private financing to pay upfront for development programs and receive investment returns once pre-agreed project outcomes have been achieved. (See the case study of an education impact bond in Annex b).
- **Bilateral, multilateral or private Donors** who are interested in increasing transparency and accountability for funding development aid and humanitarian relief projects.
- **Government agencies** or municipalities that wish to track government spending, for instance to improve a city's municipal bond ratings or to link municipal bond payments to certain milestones.
- **Project financiers**, such as Development Finance Institutions that require financial accounting, linked to performance accounting, to release tranches of funding when verified project milestones are reached.
- **Certification and Standards-generating bodies** who, for instance, certify climate-change projects and issue Carbon Credits. (See the case study of Cook-stoves in Annex A).
- **Corporations** that need to demonstrate their socio-economic contributions for triple bottom line reporting, to qualify for ESG investing schemes, or to reduce business risks by measuring how impact investments contribute to corporate risk mitigation.
- **Civic organizations and private individuals** who create projects that they care about, with bounties or pledges for achieving a common objective.
- **Long-term asset allocators** such as pension funds, insurance companies, or endowments that must measure long-term portfolio tail risk and volatility and need to quantify how sustainable development investments reduce those long-term risks.
- **Service-delivery networks** including for-profit, or non-profit organizations that deliver goods and services relevant to sustainable development, who want to track and report on their impacts

and use verified impact data to improve the performance of their services and attract more funding and contracts.

- **Evaluation agencies** who want to become more competitive and perform better in their evaluation service delivery.

The ecosystem taps into a growing *ocean* of impact-related data

The idea of a shared big data commons for sustainable development is not new. However, to achieve this, data contributors, data curators and data users must all be coordinated and incentivized to participate. This requires a multi-sided decentralized marketplace. Effective data governance needs to also be put in place. Storing, processing and using personally identifiable information within this commons must comply with data protection and privacy regulations (such as the [EU GDPR](#)). Jurisdictional limitations must be managed – for instance, some governments don't permit citizen data to be transmitted or stored outside a country.

The ixo Foundation is building the Global Impact Ledger using the [Ocean Protocol](#). The ixo Protocol and Ocean Protocol will be fully interoperable. This will enable participants in the ixo ecosystem to tap into a growing ocean of impact-related data. Impact-related data is stored wherever the data owner chooses and they retain full rights of access and control over how their data gets used. Using the Global Impact Ledger as an index to this data, with fine-grained rights management, will enable sharing of impact datasets for different uses. This data layer will become an increasingly valuable resource within the ecosystem.

The ixo protocol interoperates with a universe of Decentralized applications (Dapps)

ixo uses open standards and operating principles that enable service-delivery applications to become more interoperable and incentivized to cooperate. The ixo Protocol is extensible through third-party modules and Decentralized Applications interacting with the ixo smart contracts. DApps built on top of the Protocol can access standard data analytics tools, or create their own analytics and charge transaction fees on business intelligence and other proprietary products. For example, Impact Evaluators may compete for business to validate impact claims by developing their own DApps, utilizing their own analytics platforms and setting fees accordingly.

E. The IXO Network Token

IXO is a multi-purpose ERC20¹¹ utility token that enables token-holders to transact within the ixo network.

Token utility

The utility of the IXO token is derived from a multitude of functions within the ixo network.

Using IXO to process transactions

Access to the ixo network services is charged on a transaction fee basis. Fee structures for various types of transactions will be set by the ixo network node hosts (using the decentralized governance voting and consensus mechanism that is described later).

Network services include:

- Decentralized Impact Exchanges, as a service (with unlimited use of impact claim schemas and related IP).
- Processing of impact claims, including claim validation, evaluation and verification.
- Use of evaluation and oracle services, provided by third-parties.
- Creation of Impact Tokens and ledgering exchanges of these tokens.
- Perpetual data storage of claims metadata within the Global Impact Ledger.
- Curation and exchange of verified big impact data, using the Ocean Protocol (through interoperability with the Ocean Token).
- Secure peer-to-peer messaging and data exchanges between network participants.
- API access to curated data feeds and web services from third-party providers.
- Licenses to use core software applications, including reference code for mobile applications and hardware devices.
- Interoperability with decentralized applications, such as dispute-resolution services, from within the DApp ecosystem. This includes interoperability with other protocol and application tokens.
- A decentralized marketplace for buying and selling impact-related evaluation services, software tools, legal-ware, algorithms and data.

¹¹ <https://github.com/ethereum/eips/issues/20>

Network node hosts receive transaction fees from users of the ixo Network as compensation for the infrastructure costs they incur and this provides a small incentive for organizations to offer this hosting service. Hosting payments are automatically distributed from a multi-sig smart contract wallet on the public Ethereum Network that requires a threshold proportion of node hosts to make any changes to the automated pay-out mechanism.

Transactions can only be paid using the IXO native token. This will enable frictionless transacting across geographic territories and between applications that use the ixo Protocol. It also provides a more price-stable medium of exchange that is not affected by unpredictable fluctuations in other general-purpose currencies, such as Bitcoin and Ether, which are subject to excessive market speculation.

Users of the ixo network can purchase IXO Tokens through application interfaces, to immediately pay network transaction fees when they access the network. The Network does not hold stocks of Tokens. Pricing of the tokens at the transaction interface is linked to the market price of tokens.

Using IXO for staking

As a decentralized protocol in which participants have a lot at stake, ixo implements crypto-economic mechanisms to protect the network and its users¹². Whilst this comes at the cost of locking up value in the network, the benefits of increased security and trust make it economically much less costly to defend the network, than to protect the interests of all participants. It also enables consensus to be achieved across the network, without the need for trusted intermediaries or central interventions.

Network node hosts stake long-term security deposits to assure the integrity, performance and security of the network. Host organizations risk losing their deposits if they compromise the consensus mechanisms or expected service levels of the network. Execution of this Proof-of-Stake (PoS) mechanism will be automated using smart contracts. The required numbers of IXO tokens to be deposited and value of penalties will be set through the decentralized governance mechanism that is described below. Edge-cases that are not covered by the automated PoS mechanism will be deferred to a decentralized arbitration network. The ixo Foundation will have no direct control over this adjudication process, or the execution of the PoS smart contracts.

Project Sponsors stake a deposit within each Decentralized Impact Exchange when they set up a project. This covers the transaction fees to the Network, with the value based on the number of transactions the DIX is configured to execute over its lifespan. Any residual deposit left at the end of the project lifespan gets automatically returned to the project sponsor, if there are no disputes raised against the project by participating investment agents, evaluation agents, or service agents.

¹² "The Meaning of Decentralization – Vitalik Buterin – Medium." 6 Feb. 2017, <https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274>.

Evaluation agents stake performance deposits if required by a project's sponsor, to guarantee their service levels. Performance metrics could include the speed and quality of processing evaluations, and number of disputed evaluation results.

The community uses staking to curate impact claims registries for sustainable development impacts they want to have prioritized. This provides a decentralized curation marketplace mechanism that operates on top of the core ixo protocol.

Decentralized governance of the network is achieved by staking linked to a voting mechanism in which the proportional number of votes is strengthened by the size of stake (with built-in veto mechanisms to prevent over-representation and gaming by entities that have bigger interests).

Dispute arbitration is facilitated by staking deposits in escrow contracts that are controlled by validators in arbitration networks.

Tokens that are lost through these staking and penalty mechanisms will be automatically burned (taken out of circulation).

Staking also has the effect of increasing the long-term non-speculative value of the network, which grows as more people become vested in the network and its ecosystem¹³. Total IXO token supply staked at any point in time will therefore become a proxy measure of how well the network achieving its intended purpose.

Using IXO for peer-to-peer payments

While paying transaction fees will be required in IXO tokens, users can optionally choose to use IXO Tokens as a medium of exchange (or any other currencies) to pay for the services of Evaluation Agents. In many cases these services will be software agents that process impact data, using the ixo Protocol.

Service payments are peer-to-peer transactions that take place through decentralized impact exchange smart contracts on the public Ethereum network. These transactions do not take place directly through the ixo network. The ixo network therefore does not hold any funds or deposits on behalf of users. Transaction fees are not refundable and the network has no liability for making service payments, which will be made clear in the ixo network Terms and Conditions.

Legal liabilities

Users of ixo Network establish their own legal agreements as transacting counterparties, which includes terms and conditions for payments and the legal dispute-resolution mechanisms that might apply. Users must meet their own compliance requirements and obligations within their jurisdiction, including for fraud prevention and anti-money laundering.

¹³ "Kyle Samani, Author at Multicoins Capital." <https://multicoins.capital/author/kylesamani/>. Accessed 19 Dec. 2017.

The ixo Network hosts and ixo Foundation have no liability for transactions between users, do not exercise direct control or influence over any financial deposits that users submit to the Decentralized Impact Exchanges and provide no guarantees of financial returns or refunds. The staking mechanisms are coded into self-executing smart contracts that use the security of the Ethereum network. The ixo Foundation is not a custodian of the deposits and has no means of controlling or seizing these deposits as assets. The Terms & Conditions of using the ixo Network services make participants liable for their own deposits in case of loss, theft or hacking.

Conclusion

Verified Impact data should inform, drive and help govern how investments are made for goods and services to be delivered in ways that promote sustainable development. Investors and service-providers need good-quality, trusted data to prioritize how resources are used and to know what works. Trusted data should also increase accountability, reduce inequalities and injustice and ensure that the right goods and services are delivered to the right beneficiaries.

The Global Impact Ledger provides a shared big impact data commons for the world. Through advances in AI and data analytics, this data will provide deeper insights and drive smarter decisions that will optimize sustainable development and increase the chances of meeting the Global Goals, by 2030.

A decentralized marketplace for investing in and delivering sustainable development impacts will drive the growth of the impact economy. Anyone will have the tools to participate and the power to make positive changes.

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