INNOVATION DOCUMENT

of

The Impact DAO Cooperative

(hereinafter "**LVC**")

A) THE INVENTORS BELONGING TO THE LVC HEREBY DESCRIBE THE INVENTION AS FOLLOWS:

The Internet of Impact is an innovation of Web3 and data protocols that is implemented through a decentralised infrastructure of blockchain networks, with related software products and know-how, that enable developers to build applications used to access services for coordinating, financing and verifying investments and projects relevant to sustainable human development, human security, ecological regeneration and clean energy transition.

The ixo Technical White Paper (version 3.0) published in December 2017, and the Internet of Impact White Paper published in May 2021, together describe the basis for the innovation and are included as Annexes to this Innovation Document.

The Proof of Concept for the Internet of Impact idea has been established through reference implementations that have included:

- A 2-year market deployment and capacity-building program for the Hong Kong Social Sector implemented by the Impact Data Consortium Chain (IDCC) with funding support from the Hong government Social Innovation and Entrepreneurship Fund.
- A one-year pilot implementation of the Chimple Alphabond for primary education in India, in partnership with the UBS Bank Emerging Technologies team and UBS Optimus Foundation. This was the culmination of a 4-year research and development program with UBS Bank and the UBS Optimus Foundation.

B) THE FOLLOWING INNOVATION IS INTENDED

Open Protocols: We will develop open protocols that enhance interoperability between blockchain networks, operating systems, data formats, and services. This will facilitate the exchange of data and value across networks and platforms, enabling developers to build and deliver more useful and robust applications and services for the Internet of Impact.

Crypto-economy: We will create innovations for growing the tokenized impact economy, such as crypto-economic mechanisms for outcomes-based digital finance and verification. We will develop and host a cross-chain decentralised Impacts Exchange platform that provides a venue for trading impact assets. This will include innovative features such as AI-assisted smart matching and portfolio management.

Business models: We will innovate decentralised and tokenized business models for outcomes-based digital financing and verification relevant to sustainable human development, human security, energy transition and ecological regeneration.

Market mechanisms: We will develop innovative market mechanisms that offer more sustainable and scalable market access to products and services delivered through the Internet of Impact.

Marketing and growth: We will innovate communication strategies and campaigns for growing awareness and understanding of the Internet of Impact, that will lead to increased adoption by developers and users.

Ecosystem Platform: We will build and host an ecosystem platform for coordinating and financing the contributions by members of the Impact DAO Cooperative to achieve these ambitious innovation goals. This will include a Launchpad marketplace and support program to accelerate the path to market for platform developers building on the Internet of Impact.

C) The individual steps in the development from the invention to the innovation are set out in supplements to this Document. These supplements must be numbered, dated and attached to this Document.

Vaduz, 14 February 2023

The Inventors:

Dr Shaun Conway

As Chairman and duly authorised to represent ixo.world AG

The Internet of Impact

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This white paper describes the purpose and design of an Internet of Impact. We explain how this blockchain-based Internet will become an essential digital infrastructure for Sustainable Decentralised Finance (Sustainable DeFi) and Impact Data. To finance and verify the changes that are urgently needed in the social, environmental and economic state of the world, and to mitigate impacts of the climate crisis.

Summary

ixo is leading the development of an Internet of Impact. This essential digital infrastructure is formed by interconnecting globally and locally distributed blockchain networks that implement the ixo protocol. Through which Sustainable Decentralised Finance (Sustainable DeFi) and Impact Verification applications can be built and deployed at Internet scale.

This new Internet overcomes the limitations of legacy Web 2.0 Internets, by being stateful, graph-based, programmable and trustworthy. It is also verifiably carbon-neutral.

The ixo protocol defines a new open standard for producing verifiable claims about changes in the state of the world. Which are the basis for impact creators to mint non-fungible (NFT) Impact Tokens.

The ixo protocol applies the latest decentralised web (W3C) standards for linked-data (JSON-LD), decentralised identifiers (DIDs) and verifiable credentials (VCs). We have created the Interchain Standard for next-generation non-fungible tokens (NFTs) and verifiable metadata.

Sustainable Decentralised Finance (Sustainable DeFi) and Impact Verification applications built on the Internet of Impact have the potential to fundamentally change the state of the world. By transforming how we finance, implement, measure, value and create markets for sustainable impact. Which is relevant to all forms of capital flowing into social, environmental and economic development, as well as Climate Finance and Carbon markets.

Community currencies implemented through the Internet of Impact can drive outcomes towards local social, economic and development goals, in ways that are inclusive, locally governed, low-risk and sustainable. With great potential to innovate new use-cases, new forms of economic production, new types of incentive schemes, new investment mechanisms, and new economic models for community sustainability and local resilience.

Internet of Impact networks will give people everywhere access to the trustworthy information and financial tools they need, to invest and spend their money in more sustainable ways, and to hold public finance accountable. As mandated by the *UN Task Force on Digital Finance for the Sustainable Development Goals*.

Impact Tokens are units of value created through the Internet of Impact. Each Impact Token represents a real-world outcome state that people care about, are willing to invest in, work towards, or spend their money on. Impact tokens will become the new standard for measuring, verifying, reporting and valuing impacts through marketplace mechanisms.

Tokenizing verified outcome states through the ixo protocol transforms traditional certificate-based outcome representations, such as Carbon Emission Reduction Certificates, Education Certificates, Immunization Certificates, Biodiversity Certificates, or any other certified outcome state, into tradable and investible digital assets. Which are backed by data assets and verification proofs, with embedded executable rights.

Programmable Capital applications can be built using the crypto-economic mechanisms and Impact Graph provided by the Internet of Impact. Alphabonds are are the world's first cybernetic Sustainable DeFi mechanism for results-based financing of outcome

states, and to produce Impact Tokens, with risk-adjusted token bonding.

Alphabonds adaptively bond real-world state changes to blockchain state-changes, through trusted information-feedback loops, which algorithmically update a bond's share token prices and supply, in response to real-world risk signals, which can be derived from any trusted oracle data source.

Alphabonds have been engineered and scientifically validated to deliver *Impact Alpha* – above market average – financial returns and sustainable impact results.

The Alphabond design also offers a novel internal prediction market mechanism for deriving risk signals directly from the convictions of bond token-holders over time. Which transforms stakeholders into a collective intelligence oracle and puts people in the loop of development financing processes.

This versatile crypto-economic primitive can be configured into a diverse range of sustainable DeFi applications, including tokenized Impact Bonds, Green Bonds, Use of Proceeds Bonds, Insurance Bonds, Innovation Bonds, Governance Bonds, and Community Currency Bonds.

The Internet of Impact Hub is a global network of proof-of-stake ixo protocol blockchain validator nodes, operated by leading development agencies and impact market-makers. This interconnects autonomous Impact Zone networks using the Inter-Blockchain Communication Protocol (IBC), which connects through to the Cosmos Hub and Internet of Blockchains, with bridges into other networks, such as Ethereum and Bitcoin.

Prediction Oracles are a new type of service delivery mechanism for processing and enriching impact claims. Data-driven specialised services perform event-driven tasks, such as verifying claims, prescribing and personalising interventions, predicting outcomes, detecting threats and preventing risks.

Prediction Oracles integrate external data sources, such as satellite imagery and IoT devices, to transform claims into digital credential certificates, such as Renewable Energy Certificates.

At the application layer, ixo provides new tools, market access and data for both legacy and AI-augmented verification services to improve the performance and reach of their proofing and prediction methods. Offering investors and project implementers everywhere more affordable and better access to specialised expertise, intelligent decision-support and trustworthy impact verification.

"**A digital immune system for humanity**" describes the bio-mimetic design of the Internet of Impact. Which enables us to locally sense and respond to sustainability threats or opportunities, with mechanisms to coordinate, signal and amplify interventions. Building innate intelligence and enduring memory to replicate what works, evolve, and respond more effectively in future.

The tokenized impact economy built on the Internet of Impact has potential to grow rapidly through marketplaces that are already worth trillions of dollars.

1 Sustainable Digital Finance

The Internet of Impact provides the infrastructure for the next generation of sustainable digital finance.

1.1 DeFi

Decentralised Finance (DeFi) has successfully demonstrated that traditional financial instruments can be reinvented and deployed at Internet scale for anyone to use, replicate and rapidly evolve.

Tokenized assets worth billions of dollars are now staked in or flowing through DeFi protocols.

1.2 Sustainable DeFi

Sustainable DeFi further advances the concept of DeFi, by embedding DeFi mechanisms, together with claims verification, into a stateful, graph-based, programmable and trustworthy blockchain infrastructure.

A key differentiator, in comparison with most DeFi applications to-date, is that Sustainable DeFi crypto-economic mechanisms are deterministically driven by extrinsic real-world state changes.

This is an extremely powerful concept, because what happens in the real-world is what matters.

Sustainable DeFi responds to changes in the state of the world by autonomously triggering events — such as price changes, or payment transactions, which change the state of a blockchain.

An even more powerful idea, which leads from this, is that changes in the state of a blockchain can bring about changes in the state of the real world.

Human behaviours are substantially influenced by blockchain state-changes when:

- People receive the financial incentive of being paid for results.
- The current state of progress towards shared goals is both visible and accountable to all stakeholders.
- Trust is elevated by making claims verifiable, with independently verified data as evidence.

Sustainable DeFi can therefore better align people's incentives to work together, invest their money into outcomes they collectively care about, pool available resources, and coordinate their actions to achieve the future-state outcomes in which they all have a stake.

For example, an immunization campaign can trigger an Outcome Payment to investors and implementers, when the campaign has successfully achieved a target population coverage threshold.

Sustainable DeFi requires trustworthy interfaces between the real-world and blockchain state-machines, which are bound to a series of state-changes over time, recorded in an ordered, directed acyclic graph. With reliable signalling mechanisms and economic stakes, bonded to reality.

The Internet of Impact provides the mechanisms, services, data and economic platform with which to

build the next generation of sustainable digital finance ecosystems.

1.3 Community Currencies

Tokenized community currencies are rapidly emerging as an essential mechanism for building localised socio-economic resilience, autonomous community organisation and sustainable socio-economic growth.

A leading example is the pioneering work of Grassroots Economics in East Africa where, in partnership with Red Cross, Community Inclusion Currencies have demonstrated an efficient and scalable way of implementing cash transfers to communities in need.

Fractional fiat reserves, in the form of stable fiat tokens, can be used to issue multiples of local currency to increase the money supply and means of exchange within local economies. The power of this mechanism was clearly demonstrated in the context of communities hit by the economic crisis resulting from the Covid pandemic in 2020 [2].

Token bonding curves provide an automated mechanism for managing the treasury of community currencies in a decentralized and sovereign way. These mechanisms allow for the currency supply to grow - or contract - in response to real economic growth, in a way that is sustainable and non-inflationary. Demonstrating a compelling alternative to blunt instruments, such as Stimulus Cheques, for cash-transfer programs.

These mechanisms are also highly suited to Universal Basic Impact applications, which are gaining traction in many different economic contexts - including government-sponsored social welfare programs in developed countries.

Whilst local currencies can be issued using standard DeFi mechanisms, embedding these mechanisms in the Internet of Impact graph creates potential for greater economic transformation and social change, towards outcomes-focused growth. Allowing for innovative forms of incentives, governance and self-determinism, with inclusive community participation.

The results of community currency transactions and systems can be measured using verifiable Impact Claims.

Impact Tokens can be produced to represent the various forms of value being generated within a community, to finance economic activities, and to trade commodities as digital assets.

The Internet of Impact connects community currencies by linking automated market-maker reserves, for local economies to trade with each other, into regional economies or within global digital marketplaces for products, services and capital.

Alphabonds can be instantiated to direct Outcome Payments into the community currency reserves, to make all currency-holders richer when shared development goals are achieved. Thereby creating incentives for community-wide coordinated action and promoting local solutions to local problems.

1.4 Potential of Sustainable DeFi

Sustainable DeFi enables capital to be continuously programmed to achieve future outcome states in capital-efficient, deterministic, risk-adjusting ways, at a decentralised level.

It is conceivable that Sustainable DeFi, implemented at Internet scale, could fundamentally change how capital markets operate. By providing more efficient and accountable financing mechanisms, with trusted data, local feedback loops and economic incentives, to optimise both the financial results and impacts of creating and using financial capital in more sustainable ways.

The crypto-economic mechanisms powering community currencies, combined with the configurable state-space of the Internet of Impact Graph, holds great potential for socio-economic innovation that could lead to entirely new models of sustainable economy and social transformation.

Sustainable DeFi could become a critical enabler for proven interventions to rapidly scale, through decentralised replication.

Sustainable DeFi will make it feasible for social, environmental, economic and climate impacts of any type to be systematically programmed into any financial transaction, business process, or other human activity.

Sustainable DeFi applies to all economic sectors, industries, geographies and socio-economic contexts.

2 People's Money

Enabling people to earn, invest and spend their money in ways that improve the current and future states of the world, is a profound paradigm-shift.

The August 2020 *People's Money* report of the UN Task Force on Digital Finance for the Sustainable Development Goals [1] identifies that:

"Historic opportunity, combined with unprecedented crisis, provides a unique moment and imperative to act in harnessing digitisation to accelerate financing of the Sustainable Development Goals (SDGs)".

The report warns that *"Failure to act would be a wasted opportunity and risks finance diverging from the needs of citizens for inclusive sustainable development".*

People's Money makes specific calls to action, defines the moral imperative for building citizen-centric financial systems, demonstrates a broad political mandate, and identifies specific catalytic opportunities to immediately start making progress, by building sustainable digital financing ecosystems. *People's Money* is a framework for:

"Triggering broader systemic changes by driving innovation, disrupting stagnant markets, undermining rent-taking, increasing accountability, and encouraging governance innovations"

by:

1. Channelling domestic savings into development financing.
2. Enhancing financing for small and medium-sized businesses (SMEs).
3. Digitizing public financing and making public budgets and contracts transparent.
4. Embedding SDGs into the decisions made in financial and capital markets.
5. Shaping consumption decisions through improved information and choice architecture.

These catalytic opportunities:

"cover much of global finance, from the vast pools flowing through global financial and capital markets, to public finance that makes up a major part of the global economy, to the aggregated potential of citizens' savings and consumer spending, and the lifeblood financing for the employment and income-generating world of SMEs".

We believe Sustainable DeFi with impact verification is a fundamental technological breakthrough for people's money to finance a sustainable future.

Providing composable financial lego and accountability systems for building citizen-centric sustainable local economies.

3 Impact Tokens

Impact Tokens are the units of value which can be created through the Internet of Impact.

Each Impact Token represents a Verified Outcome State, in the form of a non-fungible token (NFT), which is backed by impact data assets and verification proofs, with embedded executable rights.

3.1 Verified Outcome States

An Outcome State is a representation of the cumulative claims about what has changed in the state of the world, at a point in time.

To deliver Sustainable DeFi solutions, we need to innovate how Outcome States are used to drive digital transactions and information-flows.

The ixo protocol defines an open standard and methods for tokenizing Outcome States, using Verifiable Claims which have been independently verified.

The legitimacy of an Outcome State is established by verifying that claims about this state are true and by demonstrating a positive correlation between prior state-changes, with the observed outcome state.

Factual truth and positive correlation are both probabilistic statements, which can be statistically predicated and cryptographically verified.

State representations are recorded as Verifiable Claims. Which must provide sufficient good-quality data as evidence, to be verified with cryptographic proofs and then represented as non-fungible tokens.

Impact Tokens have intrinsic value which is directly related to the value people place on outcome states relevant to their real-world contexts.

Impact Tokens could replace all tradable analogue instruments, such as

- *Verified Emission Reduction Certificates* for Carbon Credits,
- *Renewable Energy Certificates* for clean energy outcomes,
- *Qualification certificates* for educational outcomes,
- *Biodiversity certificates* for nature outcomes,
- *Immunisation certificates* for health outcomes.
- Or any other verified outcome states that people care about, are willing to invest in, work towards, or spend their money on.

Impact Tokens can be built into any financial transaction, capital allocation, government expenditure, business process, or consumer product. The economic space for Impact Tokens is therefore large.

Impact Tokens can be bought or sold, swapped, invested in, collateralised, or used in tradable financial derivatives, such as warrants, options and futures contracts.

We anticipate that Impact Tokens have the potential to become the tokenized commodities of sustainable finance markets.

3.2 Data Assets

Impact Tokens produced through the ixo protocol are data-rich. And can be further enriched by the insights and value added by Prediction Oracle services.

Impact Tokens, together with their linked data assets, may therefore also be seen as data commodities. Which can be sold, traded, rented, or licensed through new data marketplaces, such as Ocean Protocol.

The potential societal and commercial value that can be extracted from abundant, accessible, consented, high-quality Impact Data is extraordinary.

Especially considering that lack of data is the most-cited impediment to deploying capital for impact [3].

3.3 Accorded Rights

Depending on the class of Impact Tokens, this may accord rights to the token controllers/owners, including executable rights for invoking services – such as the right to mint derivative fungible tokens and sell fractional shares in the Impact Token.

4 Programmable Capital

The Internet of Impact is used to program capital and other resources into producing sustainable outcome states in the real world.

Alphabonds are the world's first cybernetic Sustainable DeFi mechanism which is built into the Internet of Impact. Alphabonds dynamically adjust the blockchain state in response to real-world risk signals.

Developers can use the Alphabond mechanism to build novel applications for a wide range of use-cases, such as:

- Impact Bonds that return outcome payments.
- Innovation Bonds that return a share of IP rights or future revenues.
- Insurance Bonds that make event-based payouts.
- Equity Bonds that convert to discounted share distributions.
- Collateralised Debt Bonds that return loan repayments with interest.
- Or any other conceivable Sustainable DeFi application that adapts to external state-change signals.

The ixo Bonds Module also provides a library of generic fixed parametric bonding curves that can be used for other applications, such as Community Currencies which are issued against a fractional reserve.

This class of Sustainable DeFi applications therefore has far-reaching potential to be used for implementing more sustainable solutions in finance and investment, insurance, equity and debt financing, commodity trading and supply chains.

A computer-aided design (cadCAD) tool enables Alphabond implementers to simulate, calibrate and test new classes of Alphabonds for novel use-cases.

4.1 Token Bonding Curves

DeFi protocols use token bonding curve mechanisms as automated market-makers and for continuous financing processes. However, these DeFi mechanisms have generally been static, with fixed *a-priori* assumptions about the interaction between the crypto-economic mechanism and external systems.

With most token bonding curve mechanisms to-date, changes in the state of external systems cannot modify the bonding curve configuration during live execution. This may result in pricing and supply anomalies, such as tokens being mis-allocated on both buy-side and sell-side, with losses in risk correlation.

DeFi systems implemented in the unpredictable real-world, or with complex economic mechanisms, have inter-dependencies that produce non-linear, compounding risk. Which can lead to the systemic collapse of non-adaptive financing mechanisms.

These constraints are addressed by Alphabonds.

4.2 Risk-adjusted Bonding

Alphabonds have been engineered to internalise and control investment risks, to make investing in outcomes safer, more efficient and scalable through replication [4].

Figure 1: *Alpha Signal over time*

The mechanism implements a novel class of parametric token bonding curves, which adapt the bonding curve algorithm in response to external state changes.

This enables dynamic, risk-adjusted pricing of shares in a bond's liquidity reserve and in the distributions of future returns. By algorithmically re-calibrating the current-state costs and risks of capital allocations, against the probability of success.

The mathematical proofs, engineering designs and simulations for validating this mechanism are detailed in a System Specification, developed in collaboration with BlockScience [5].

4.3 Alpha Risk Signal

Information about the observed state of the real-world is fed into the Alphabond as an Alpha Risk signal. *Alpha* predicts the probability (ranging from 0 to 100 percent) that an investment will succeed to deliver an expected future-state payout. For instance, Impact Bonds pay an Outcome Payment back to the bond investors when an outcome state target is reached.

As the value of Alpha changes over time, this adjusts the shape of the bonding curve through a coefficient that modifies the algorithmic price of the token, in relation to its current reserve. If the probability of success decreases, the bond retains a higher reserve ratio to protect investors.

Figure 1 demonstrates how Alpha inputs over time update prior probabilities, to adjust the bonding curve algorithm.

An Alpha signal could, in principle, be derived from any credible source of information which has predictive value — including AI oracles, IoT devices and prediction markets.

4.4 Internal prediction market

When data is unavailable – for instance, in novel project implementations, the ixo blockchain SDK provides a Risk-prediction module for implementing an internal prediction market mechanism.

The risk-adjusted bonding and internal risk-prediction mechanisms are tightly coupled in the Alphabond system, as depicted in Figure 2.

Figure 2: *The Composite Alphabond Mechanism*

The technical design of these composable mechanisms has been subject to extensive engineering research, mathematical validation and cadCAD simulation testing [5].

The ixo blockchain Risk-prediction module may also be used as an alternative, or supplement, to obtaining Alpha predictions from external Oracles.

The Internal Prediction Market mechanism offers bond token-holders the option of taking positions in Success or Failure pools, based on their private beliefs of the Risk Alpha.

The pay-out mechanism is designed to drive outcomes biased towards success.

But this also provides a fractional hedging mechanism, in case of failure.

An agent may attest both positively and negatively with subsequent actions, reflecting changes in their conviction about a project's chances of success.

Agents may choose to participate in only the bonding curve, or the bonding curve and internal prediction market.

Unallocated tokens minted through the bonding curve can be burned back to the curve to reclaim the collateral. But when tokens are attested towards the success or failure options pool, they cannot be unattested, withdrawn or re-cast.

4.5 Outcomes-based Financing

Alphabonds could overcome many of the operational impediments to issuing conventional bonded capital instruments, such as:

- The need to form all capital commitments upfront.
- Technical constraints to quantifying project risks *ex-ante*.
- Achieving investor consensus on the risk premium.
- Restricted participation options, due to fixed entry or exit points.

Risk-transfers to investors in traditional results-based financing mechanisms produce a bias towards funding lower-risk endeavors. Which diminishes project innovation and limits capital allocations to a subset of interventions that are implemented in carefully controlled contexts.

Traditional outcomes-based financing mechanisms will therefore not produce the scale and pace of changes in the state of the world that are needed to achieve the SDGs by 2030, or to significantly impact on the race against climate change and ecological degradation.

Alphabonds have the advantage that capital does not have to be formed in advance. Investors can choose to enter and exit at the bond price ranges that satisfy their risk-return preference – depending on how this has been configured.

Alphabonds allow for either a pre-specified or adaptive risk tolerance level to be incorporated into each bond instantiated, to fit the risk preferences of a representative class of investor.

In cases where an underlying investment fails to perform to the investor's expectations, they have the option to exit through the Alphabond – if there is sufficient liquidity, or by selling their bond share tokens through a secondary market.

The ixo blockchain SDK Bonds Module includes a Uniswap-style AMM for trading token-pairs.

4.6 Pricing Signals

Alphabonds provide real-time pricing signals which reflect both the performance of an underlying investment and investor sentiment.

Pricing signals can have a powerful influence on both investment and project implementation decisions. Providing an information-feedback loop that can direct the investment towards achieving successful outcomes, by adapting to the complex, dynamically changing state of real-world contexts.

4.7 Scaling through replication

By programmatically automating and decentralising the processes of forming, allocating and verifying the impacts of capital investments, Alphabonds locally control risks, so they can be scaled through replication.

As an example, the ixo Foundation is demonstrating with a leading traditional investment institution how a large, costly, "too big to fail" Impact Bond for primary education in India can be replaced by unitised portfolios of Alphabonds.

Each Alphabond instance limits the financial and operational risks to an autonomously controlled DeFi investment within a local context. Informing investors, implementers and other stakeholders with real-time data. Whilst benefiting from local governance, local knowledge, local ingenuity, local resources, and meaningful local stakeholder participation.

5 Prediction Oracles

ixo Prediction Oracles are a new class of blockchain services for the Internet of Impact.

Blockchain oracles commit information about the state of the world into blockchain smart contracts and stateful databases. Typically, blockchain oracles are un-opinionated and their purppose is to securely communicate factual information into the relying mechanism, from trusted data sources. These signals can be programmed to change the blockchain-state in ways that are predictable and deterministic.

The ability to drive state-changes based on real-world observations goes well beyond the capabilities of established blockchain oracle systems.

In contrast, Prediction Oracle services are opinionated about claims which make assertions about the state of the world.

Service providers implementing Prediction Oracles use their domain-specific expertise and established rubrics to evaluate each claim and apply statistical methods, together with cryptographic verification, to infer the probability that each claim is both factually true and positively correlated with the claim subject.

Prediction Oracles produce verified data assets, in the form of W3C standard Verifiable Credentials. Which may be further enriched with reference data and information from other sources, adding the value of expert opinion and specialised computation.

5.1 P-functions

Prediction Oracle services can offer a wide range of data-driven Precision functions (P-Functions), giving investors and project implementers access to intelligent systems and human expertise for:

- Proofing claims.
- Personalising services.
- Planning.
- Prescribing interventions.
- Predicting Outcomes.
- Programming transactions.
- Preventing risks.
- Protecting against threats.

5.2 Data Science

Prediction Oracles open up the powerful intersection between AI/data-science and blockchain technologies. Continuously improving their performance by using data for machine learning and intelligent analytics. For example, in Alphabonds, this feedback loop is calibrated by the binary success or failure outcome state of each bond.

As volumes of verified claims data increase, this machine-readable, semantically standardised data can be shared and pooled across projects, for Prediction Oracle service-providers to gain system-wide insights, gather human intelligence, and use machine-learning, to optimise their prediction capabilities and to build new types of oracle services.

The need for Prediction Oracle training data-sets for federated learning should drive the creation of decentralised impact data marketplaces. Potentially providing additional revenue to investors and project owners.

Data assets are tokenized and traded through the Internet of Impact as NFTs, with executable data access and usage rights which are mediated through a delegatable access-control mechanism, using Authorization Capabilities (zCaps). These data tokens can be rented, sold or exchanged through decentralised peer-to-peer marketplaces.

5.3 Oracle marketplaces

Delivering both Legacy and AI Prediction Oracles through the Internet of Impact should make these services more widely accessible and affordable to impact project implementers and investors everywhere. Legacy services provided by evaluators, auditors and certification agencies can now be technology-enabled.

The Internet of Impact Hub provides a network through which Impact Relayers connect project implementers and investors with Prediction Oracle services.

Prediction Oracles are remunerated through the ixo claims processing mechanism, with service fees automatically processed, accounted for and distributed by a programmable ixo-Blockchain SDK Payments Module.

We anticipate the emergence of a competitive marketplace for trusted oracle service-providers, with expertise in their respective domains.

A share of oracle fees is distributed to the originating Impact Relayer and to the Impact Hub treasury, to maintain and grow the network.

he historical performance levels of Prediction Oracle services can be transparently assessed using transaction analytics.

Tooling, such as Jupyter Notebook integrations, will be made available for any data-driven service to build their own Prediction Oracles.

A Prediction Oracle Launchpad, implemented on the Internet of Impact Hub, will provide a funding and skills marketplace for researching, developing and distributing Prediction Oracle services.

6 The ixo Protocol

The ixo Protocol defines a new open standard for making verifiable claims about changes in the state of the world and to represent the resulting outcomes as non-fungible Impact Tokens.

This is a generic and versatile protocol that can be used to process claims relating to any real-world subject or observation. It enables any imaginable non-fungible resource – whether physical or conceptual, to be tokenized as a uniquely identified, verifiable, digital asset. Backed by high-definition data [6] and verification proofs, with embedded rights.

Figure 3: *The ixo Protocol Life-cycle*

As an example of this versatility, the protocol could be used to evaluate and verify identity claims, to issue KYC Verifiable Credentials, which may be linked as resources to non-fungible, non-transferable, Membership Tokens.

We believe this protocol is the fundamental enabler of Sustainable DeFi, which must be embed financial mechanisms in stateful graphs of information, with verifiable evidence of real world state-changes and outcome states.

As Outcome States typically result from interdependent processes in the complex real-world, so claims about the observable changes in the state of the world must be linked across chains of causality.

Which requires claims to be connected through linked-data graphs, with edges that describe the relationships between identified organizations, agents, investments, verification mechanisms, data sources and indicator frameworks.

6.1 Inter-operable Open Standards

The ixo Protocol builds on core new decentralised, semantic web standards from the W3C, for Linked-data (JSON-LD), Decentralised Identifiers (DIDs), and Verifiable Credentials (VCs), which further extends into a family of related specifications – including Authorization Capabilities (zCaps) which provide decentralised, delegatable control over the processes and services for issuing and verifying claims, minting Impact Tokens and executing the rights accorded to token-holders.

To mint Impact Tokens, the ixo protocol implements the Interchain Identifier (IID) specification for next-generation NFTs and Verifiable Metadata.

ixo has been a leading contributor to the development and adoption of these various standards, since 2015.

These inter-operable standards make available to application developers all the tooling and integrations which have been built for DIDs – such as wallets, confidential data stores, and credential exchange mechanisms.

The ixo protocol directly addresses the challenge that legacy financial and impact measurement and management methodologies were never yet designed to be interoperable and are difficult to standardise.

6.2 Protocol Life-cycle

The ixo protocol defines the steps and methods for making and verifying Impact Claims and then tokenizing Verified Outcome States, as illustrated conceptually in Figure 3.

1. Observations about the state of the world are identified, using decentralised identifiers (DIDs) for the subject and classified for semantic context, using linked-data schemas.
2. Verifiable Claims are issued and cryptographically signed by identified, authenticated agents. This is typically done using client applications, such as mobile apps, to capture the claim data at the implementation edge of the real-world processes which are creating and observing change.
3. These claims, together with their evidence, are evaluated by independent Verification Agents, using standardised rubrics and statistical methods to form opinions whether each claim can be approved, to issue Verification Proofs.
4. Collections of verifiable claims over time, together with their verification proofs and additional information – such as the verifiable credentials of a project implementer, are combined to issue a

Verifiable Credential for an Outcome State. Which includes a graph of the claims, proofs and credentials.

5. Impact Tokens are minted with this graph of data assets as Linked Resources, which can be retrieved by authorised users from a specified service endpoint – such as ixo Cellnode confidential data stores, in a permissioned way, using Authorization Capabilities (zCaps).

The configurability of this protocol, together with the flexibility of decentralised, delegatable Authorization Capabilities (zCaps), enables complex business rules and workflows to be implemented through the Internet of Impact, in fully decentralized, controlled and secure ways.

7 ixo Blockchain SDK

The ixo blockchain SDK offers modular components for configuring and deploying sovereign network zones of the Internet of Impact.

Engineered using the Tendermint consensus engine, Cosmos SDK framework, Inter-blockchain Communication, and related tooling [7].

This benefits from the diversity of novel innovations and technology advancements which are being made within this vibrant ecosystem of researchers, engineers, entrepreneurs and users.

7.1 Modular architecture

In addition to core Cosmos SDK modules, such as Staking and Governance, the ixo SDK includes modules which have been purpose-built to implement the ixo Protocol. Including: Decentralised Identity, Alphabonds, Risk-prediction, Payments, Claims Processing and Interchain Standard NFTs. This SDK can be extended by developers adding or modifying modules, with almost limitless configuration possibilities.

7.2 The Impact Graph

At the data layer, ixo protocol blockchains hold system-level state in the directed acyclic and linked-data graphs which together form *The Impact Graph*.

The Impact Graph records metadata about the state of the world in stateful, ordered, navigable, privacy-preserving, distributed registries of agents, claims, organisations, projects, oracles, investments and outcome states.

The data architecture of this graph increases the resolution of information about impact, by encoding each data object as a node, with a decentralised identifier. The relationships – edges, between nodes are encoded with linked-data contexts, which increases the dimensionality of the data.

This allows changes in the state of the world to be compared over time and attributed to causal chains, with linked evidence.

By design, humans are included in this graph as addressable and authenticated entities – using self-sovereign identifiers. Which puts people in the loop as agents making transactions and interacting with the cyber-physical mechanisms of the blockchain – such as Alphabonds, to produce state transitions through their actions. This should enable new forms of citizen-centric sustainable finance, organisation, action and governance.

Linked-data allows us to establish a common global ontology, using semantic schemas. Which extends to the ontology of measures – such as standardised sustainable development indicator frameworks.

Which makes the rubric for impact measurement and reporting interoperable and comparable across previously silo'd systems.

Higher degrees of resolution, with stateful structured data, should enhance the quality of intelligence gathered and shared through Internet of Impact networks.

The graph also serves as a configuration space for encoding future system-level target states for outcomes-based financing. For instance Alphabond Sustainable DeFi applications can incentivise stakeholders towards achieving desired future state outcomes, such as net-zero targets for carbon emission reductions [8].

Over time, the Impact Graph will grow our collective intelligence to empower more precise service matching, resource allocation, data-sharing digital asset exchanges.

7.3 The power of graphs

Considering how graphs have powered the growth of the Web 2.0 Internet giants, such as Google's Knowledge Graph, Facebook's Social Graph and Amazon's Trust Graph, we see the opportunity for the decentralised Impact Graph to power the creation and rapid growth of new digital marketplaces for products and services directed toward financing, delivering and verifying sustainable impact.

8 Internet of Impact Networks

The Internet of Impact infrastructure is delivered through networks of Level-1 Cosmos blockchain nodes implementing the ixo protocol, and interconnected by IBC Relayers through the Inter-Blockchain Communication Protocol (IBC), with a Hub and Zones topology.

These networks are anti-fragile and can be made incorruptible, when fully decentralised, with governance and economics distributed amongst all stakeholders. This is particularly important for producing and reporting impacts in contexts where there are strong political, social or commercial forces at play which are resistant to changing the state of the world.

8.1 The Internet of Impact Hub

The Internet of Impact Hub provides the first global network of provably carbon-neutral ixo Protocol blockchain nodes, which forms the backbone routing infrastructure for this Internet.

The Hub is globally distributed and will initially be operated by up to 150 leading organisations who serve as network validators and Impact Market Relayers.

The Hub inter-connects sovereign Internet of Impact Zone networks, through to the broader universe of blockchains, using the Inter-Blockchain Communication Protocol (IBC), with bridges into Ethereum and other networks.

Applications from other Cosmos blockchains, or even other ecosystems, such as oracles from Chainlink, carbon registries from the Regen Network, data marketplaces from Ocean Protocol, or decentralised machine learning from Fetch.ai, will become available to users of the Internet of Impact.

User from other networks can also use the services of the Internet of Impact, which potentially brings the ecosystem of sustainability focused products, services and markets into any blockchain application on any network.

8.2 Impact Market Relayers

Nodes of the Hub are hosted by a network of Impact Market Relayers, who are well-recognised sustainability and impact-focused market-making organisations across all geographic regions. Representing a wide range of market sectors and stakeholders.

Impact Market Relayers provide both online and physical channels into their regional or sector-specific marketplaces. Market Relayers may also offer marketing and technical support, to connect Internet of Impact users to agents, applications, services, data, financial capital and digital asset exchange venues.

This should enable all market participants to operate, transact and invest more effectively in the Impact Economy and to create new markets for impact.

8.3 Internet of Impact Zones

Impact Zones are autonomous networks ixo protocol blockchains, which may be deployed locally or globally, configured with application-specific security, privacy, governance and economic models.

The first Impact Zone is the Hong Kong Impact Data Consortium, which is providing a platform for growing, financing and strengthening the social sector, through a consortium funded by the Hong Kong government Social Innovation and Entrepreneurship Fund.

8.4 Carbon-neutral networks

A token slashing mechanism for offsetting the carbon costs of Internet of Impact networks will be built into the Proof-of-Stake security mechanism of the ixo protocol blockchain.

Network Validators who operate nodes will be required to make claims about their carbon emissions, which will be independently verified.

Nodes which don't use renewable energy sources, or do not voluntarily offset their carbon emissions, will be penalised by having a proportion of their staking deposits periodically slashed, to be automatically traded for Carbon Impact Tokens that offset the emissions.

The Internet of Impact Hub will implement this mechanism with real-time transparent and verifiable monitoring of the network's carbon balance.

9 The Internet of Impact Applications Stack

The open-source Internet of Impact applications stack includes mobile, web and IoT client interfaces for performing claims submissions, evaluations, issuing Verifiable Credentials and financing outcome states. Claims data is processed and stored in stateful, decentralised confidential data stores. Prediction Oracles provide their services through standard APIs, with tooling such as Jupyter Notebooks and software integrations to third-party information sources.

Reference software applications developed by the ixo open-source community demonstrate what can be built on the open architecture and standards offered by the Internet of Impact.

Developers are free to reconfigure or build on these open-source implementations, or to innovate entirely new software solutions and integrations.

10 The IXO Token

IXO is the first staking token of the Internet of Impact. This enables token-holders to self-stake or lease their IXO Tokens through a delegation mechanism for Proof-of-Stake Bonding. Which gives stakeholders the right to perform work and receive shares of fee distributions for their contributions, from Impact Market Relayers.

IXO tokens staked in service contracts give users access to message processing (gas), claim submissions, oracle services, data hosting, submission of governance proposals, listing projects, digital asset and credential issuance, identity verification, membership registration, subscriptions, dispute-resolution, rental of digital assets, or any other services which are built on the Internet of Impact and utilise the Hub.

Token-holders may choose to stake IXO as collateral, to provide liquidity for loan mechanisms, supply tokens into Automated Market-Maker Liquidity Reserves, provide performance guarantees, curate registries, or participate in Alphabond Risk-prediction pools.

Holding minimum stakes of IXO Tokens, together with digital membership credentials, may offer Stakeholders additional benefits, such as value-added services and discounts offered by Impact Market Relayers, Impact Zone networks and – in future, other non-ixo networks.

Governance staking gives Stakeholders the right to submit and vote on various types of proposals. Depending on the type of voting procedure implemented, the quantity of IXO tokens held by a Stakeholder may be used in weighting the results. Governance Bond applications – using the ixo Alphabond DeFi mechanism, may pay out yields in IXO tokens.

11 Tokenized Impact Economy

We envisage a future in which Impact Tokens will represent the state of the world for all the outcomes that people or organisations care about and value.

Tokenizing the non-fungible social, environmental and economic outcomes — such as carbon emission reductions, children's education, or population immunisation, will add new and renewable forms of capital to the economy.

Tokenized outcome states can be paid for, sold and traded in both traditional capital markets, as well as the fast-growing digital asset marketplaces.

This provides a core building-block for innovating how we program capital for sustainable finance and impact investing , using Sustainable decentralised finance (DeFi) mechanisms such as Alphabonds.

It is conceivable that the Tokenized Impact Economy will become the mainstream economy. As capital markets shift towards financing sustainable outcomes and are compelled to demonstrate the impacts of capital allocations. Impacts will have to be explicitly identified, proven and valued in social, environmental and economic terms.

Tokenization of impact is directly relevant to how the world will finance and track progress towards achievement of the Sustainable Development Goals and climate impact mitigation over this decade, to 2030.

12 Digital Immune System

The Internet of Impact design is based on the biomimetic principles of natural immune systems.

It enables decentralised, autonomous localised sensing of social, environmental, economic and climate threats or opportunities.

With response mechanisms for coordinating, targeting and amplifying both localised and systemic actions.

In the process this builds innate intelligence, latent memory and preparedness, to speed up and replicate future responses.

Using tokens like antibodies to carry information and potentiate, aggregate, neutralise, or catalyse changes in the state of the world.

This is the Digital Immune System for Humanity.

13 Conclusion

The Internet of Impact is a much-needed global public good. It provides an open, standards-based digital infrastructure that is built on the latest open-source, inclusive blockchain and sovereign data technologies. Which are easy to customise, evolve and deploy at Internet scale.

Financial and data applications built on the Internet of Impact could profoundly transform how the world finances, implements, measures, values, and creates markets for impact.

Offering an unprecedented opportunity to imagine and create a citizen-centric new world economy. Which can generate prosperity now, by giving people the information and tools to earn, spend and invest their money in ways that will lead to a more sustainable future.

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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. However, all recent analyses confirm growing trends in capital flowing 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 2 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[4] revealed that millennials are leading the sustainable investing charge, with 86% believing that their investment decisions can make an impact. In this paper, we refer to all investments 4 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.

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.**

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[3] https://www.newamerica.org/bretton-woods-ii/
[4] https://www.morganstanley.com/ideas/sustainable-socially-responsible-investing-millennials-drive-growth

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The 17 Global Goals for Sustainable Development (ixo brand rendition)

Count what matters. Value what counts.

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.

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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.

The problem is that valuable 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 audits[5]. 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.

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

[5] The Kellogg Foundation as cited in Bloomquist, J. 2003. Impact Evaluation of Social Programs: A Policy Perspective. Revised Draft. World Bank, Washington, DC
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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, as described by Simon De la Rouviere. Our partnerships and collaborations with these and other pioneers 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

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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 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 economy and grow the 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 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 so on. 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 an Impact Token can be exchanged for another.

For instance, an Impact Token representing a Carbon Credit can be exchanged for a Health Impact Token.

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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.

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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

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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.

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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.

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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.

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.

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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 decisionmaking. 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.

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How ixo works in practice

Anyone can set up an Impact Exchange[8]

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.

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 uses 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 set up 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 build on the ixo-OS 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

[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.

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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 control[9].

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.

[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.

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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.

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.

8. If the project is processing a Qualifying impact claim type, a new IXO Token is generated as a Protocol reward that is sent to the project sponsor. (A small percentage of each IXO that is generated as a token reward is paid to the ixo Foundation, to fund its ongoing operations).

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

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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 a national Early Childhood Development Social Franchise network, SmartStart, which aims to empower 100,000 young people in disadvantaged communities to start businesses as daycare and afterschool providers.

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 Financing Impact Bond that is 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.

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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, is 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. 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.

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

```
{
"id": "http://ixo.foundation/schema/", "type": ["impact claim Set"], “templateID” :
"01454600a18666a9f08f2f99a79ce8734e5b6f353a91", "contractID" :
"0134b4b59c3acfeb9afd9398c88b2f6f003cbf29b553" "indicator": {
"type": "Indicator", "brand": "IRIS", "code": "PI9468" }, "issued": "2016-02-
08T16:02:20Z", claims: [ { "@context": [
"http://schema.org/", “http://ixo.foundation/schema/”, ], "id":
"did:method:424342341218764655" "type": ["Location", "Time"], "issuer":
"did:method:464562546245625", //devices did "issued": "2016-02-08T16:02:20Z",
"claim": { "geo": {
"location": {
"latitude": "12.01156874", "longitude": "-175.57177874" }, "timestamp": "2016-02-
08T16:02:20Z" } "signature": {
"type": "RsaSignature2016", "created": "2016-02-08T16:02:20Z", "creator":
"did:method:8uQhQMGzWxP1vw5P3W9H1j#key/1", "signatureValue":
"IOmA4R7TfhkYTYW8...CBMq2/gi25s=" } }, {
"@context": [
"http://schema.org/", “http://ixo.foundation/schema/”, ], "id":
"did:method:4645621218764655" "type": ["Location", "Time"], "issuer":
"did:method:464562121245625", //service agents did "issued": "2016-02-
08T16:02:20Z", "claim": {
"serviceCenterID": "did:method:637463264" //did of the service center
"productsUsed": [],
  "reason": "Water provided", "result": {
"type": "Rating", "ratingValue": "79" }, }, "signature": {
"type": "RsaSignature2016", "created": "2016-02-08T16:02:20Z", "creator":
"did:method:8uQhQMGzWxR8vw5P3UWH1j#key/1", "signatureValue":
"IOmA4R7TfhkYTYW8...CBMq2/gi25s=" } } ]
```


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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 to be proven, as all projects and related claims are 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).

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2. Decentralized Impact Exchanges

The DIX data model

The DIX smart contract system codifies what impact claims 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 data Project

Payment transactions

DIX Smart Contracts can be specified to record payments for services that include the services delivered by Service Agents and Evaluation Agents. Each payment is specified by the type of payment (e.g. 10 Currency[10]), 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 being 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.

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- 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.

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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) attestations 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. The economic value of Impact Tokens increases as these credits are exchanged between impact investors, or purchased through public funding mechanisms, such as government grants. Impact Tokens can be exchanged through secondary markets and used to implement innovative development financing mechanisms, such as Social and Development Impact Bonds, or impact bounties. 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 a service 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.

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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.

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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 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.
- **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.

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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 and 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.

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E. The IXO Network Token

IXO is a multi-purpose ERC20[11] utility token that enables token-holders to transact within the ixo network. Token holders have a vested interest to increase the utility of the network and to grow the value of the ixo ecosystem, as they will both directly and indirectly benefit.

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.

Network node hosts receive transaction fees from users of the ixo Network as compensation for the infrastructure

[11] https://github.com/ethereum/eips/issues/2

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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 and 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 users[12]. 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.

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

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

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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 ecosystem[13]. 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.

How value flows using IXO Tokens

The only distribution of value that takes place to directly benefit the ixo Network, is the automated payout of transaction fee revenues to network node hosts, which is mediated by Ethereum smart contracts. This compensates the hosts for the infrastructure costs they incur and provides a small incentive to offer this hosting service. Hosting fees are derived from the network transaction fees paid by the users of the network services. These fees are sent to and 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.

Users of the ixo network can purchase IXO Tokens through application interfaces, to immediately pay

[13] "Kyle Samani, Author at Multicoin Capital." https://multicoin.capital/author/kylesamani/. Accessed 19 Dec. 2017.

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network transaction fees when they access the network. Users may alternatively choose to pre-purchase IXO Tokens on the open market and to hold onto these tokens until a future time, or to exchange IXO tokens for other forms of value, outside the ixo Network (which is beyond the control of the ixo Foundation).

Beyond the initial generation and distribution of IXO tokens, users acquire their tokens from the market, via independent exchanges and not directly from the network or the Foundation. The Network does not hold stocks of Tokens. Pricing of the tokens at the transaction interface is linked to the market price of tokens.

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.

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.

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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 provider 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.

Using ixo, anyone will have the tools to participate and the power to make positive changes.

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