



White Paper



**Where Blockchain Technology
and the World's Data Intersect**

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Abstract

The need for maintaining individual data integrity and security is as important as ever in the 21st century. Even while more centralized infrastructure solutions for cloud storage present some advantages with respect to these ends, XRoad believes that blockchain technology presents a decentralized and more democratized alternative where data integrity and security are achieved with self-verifying and self-executing smart contracts. Smart contracts, among other benefits, remove the need to rely on large enterprises, and position individual Internet users to maintain the digital cloud storage themselves, for the benefit of themselves and others.

Moreover, there is the need to sustainably and securely be able to interact with the world's "unstructured repository" of data so that products and services can be effectively provided, particularly in the rapidly-expanding decentralized world.

With XRoad Decentralized Storage, XRoad Locker and Oracle solutions, XRoad empowers individual Internet users (whom we refer to as X-roaders) to leverage blockchain technology for user-friendly access, protection and control over their data (rights). Moreover, user activity powers essential XRoad Oracle that smart contracts rely on to effectively and safely interact with off-chain environment data in the decentralized world.

Mission

XRoad aims to provide individual Internet users with the decentralized infrastructure needed to serve as the intersection between blockchain technology and the world's data.

We pursue this with XRoad Oracle, Decentralized storage and Locker for user-powered interoperability between the off-chain world and smart contracts, as well as for individual data self-sovereignty.

Market Status

There is an ever-growing demand for digital data storage worldwide, with projected growth for end-user spending in 2021 to exceed 300 billion USD.¹ Moreover, the top cloud providers in the world, AWS, Azure and Google Cloud, account for 58% of total cloud spending and thus represent, collectively, a heavily centralized global infrastructure for cloud storage, for both individuals and organizations alike. In the prevalent centralized cloud storage market, value capture and innovation are controlled mostly by the three largest enterprises in the sector.²

Many of the largest companies in the world rely on their ability to leverage individual user data for insights, revenues, favorable company valuation and more. Social media juggernaut Facebook generated four petabytes of data every day in 2020 and is currently valued at just over 932 billion USD.³ The dominant companies simultaneously fail both securing user data and electing to not share data-powered revenues with its users, due to its core value proposition of free social network services being indelibly tied to leveraging user data.⁴

Moreover, data breaches happen nearly every day all over the world. With the ever-increasing development of applications with authentication requiring sensitive identity information, and growing centralized data storage in data centers as well as the exponentially-increasing need for individual data storage itself, centralized data management infrastructure has become a highly-risky endeavor. However, because of the need for data management, breaches have become a phenomenon we have seemingly grown to accept as a global society.

Human beings collectively generate 500 million tweets, 294 billion emails, 4 million gigabytes of Facebook data, 65 billion WhatsApp messages and 720,000 hours of

1 “Gartner Forecasts Worldwide Public Cloud End-User Spending to Grow 18% in 2021”

<https://www.gartner.com/en/newsroom/press-releases/2020-11-17-gartner-forecasts-worldwide-public-cloud-end-user-spending-to-grow-18-percent-in-2021>

2 “Canalys: Global cloud services market reaches US\$42 billion in Q1 2021”

<https://www.canalys.com/newsroom/global-cloud-market-Q121>

3 “Wild and Interesting Facebook Statistics and Facts (2021)”

<https://kinsta.com/blog/facebook-statistics/>

4 “Understanding Facebook’s Business Model”

<https://about.fb.com/news/2019/01/understanding-facesbooks-business-model/>

new content added to YouTube each day. Moreover, 100 new hyperscale data centers are built every two years.⁵

It is not surprising that data has been deemed “the new oil.”⁶ Many of the applications, devices, digital services, websites and more that we use regularly actively leverage individual user data in real-time, or store the data in data centers per the needs of enterprises. These data centers are tasked with maintaining enterprise-grade security, uptime and beyond.

Blockchain technology can be described as database architecture where data is stored in blocks. These blocks, being chained together most often in deterministic fashion, present an alternative to the current data infrastructure, most notably by serving as a distributed ledger that decentralizes the way in which data is stored, verified and secured.

When new data is collected and stored by a block up to its capacity, this block is then added, or chained, to the previous block. It is this chronological approach to adding blocks that enhances the ability for one to “trust” the blockchain database, among other features.

One may consider the LAN parties popularized in the 1990s in seeking to understand the role that blockchain networks have the potential to play. These LAN parties entailed friends gathering together to create a micro-network for the purposes of playing games such as Starcraft or Warcraft. By connecting their individual computers to each other, LAN party members would create a “closed network” of sorts, whereby anyone outside of the network was unable to participate.

Whereas the main objective of LAN parties was to bring together individuals to play a game, blockchain technology bring people together to collect information together, most notably to serve as a secure ledger for transactions, in a decentralized and trustless manner. Whereby no single entity has ultimate control and many participants are able to contribute and capture value from the network.

5 “The world’s data explained: how much we’re producing and where it’s all stored”

<https://www.weforum.org/agenda/2021/05/world-data-produced-stored-global-gb-tb-zb/>

6 “The world’s most valuable resource is no longer oil, but data”

<https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data>

At the heart of this process are smart contracts.

What are Smart Contracts?

Smart contracts can be described as computer code run on a blockchain network tasked with facilitating secure value exchange, carrying out an agreed upon operation or both. They are essentially composed of “IF” and “THEN” functions that enable the contract to know that if X happens, Y is to automatically be carried out. Whether a collection of friends or large organizations, establishing trust when engaging with other parties within a network is challenging and risky.

Smart contracts help to solidify the trustless usefulness of blockchain technology.

This is perhaps why the global smart contracts market is projected to surpass 340 million USD by 2026, from 106.7 million USD in 2019, at a compound annual growth rate of 18.1% during the forecast period 2021-2026.⁷ Yet, there are limitations to smart contracts, for in order to provide sustainable value to society, the need to interact with and incorporate real-time, verifiable and authenticated data is frequently required. It could be argued that the limitations to smart contracts are due in large part to the very nature of their value proposition: they are programmed to be unchanging in a world changing constantly.

Whether in the centralized or decentralized world, the need to leverage data remains, as well as the question of how this is achieved.

What are Blockchain Oracles?

Blockchain oracles serve as bridges between smart contracts and the unstructured world where data is continuously being created, updated and organized. Because a smart contract is only able to access data existing within the confines of its network, a blockchain oracle plays a critical role as a facilitator in the transformation of non-

⁷ “Global Smart Contracts Market”

<https://www.marketresearchfuture.com/reports/smart-contracts-market-4588>

deterministic data found in the everyday world into deterministic data a smart contract requires.

It is important also to note that a blockchain oracle is not actually the data itself, but instead serves as the external data source layer that conducts the required authentication, verification and query needs of the network, or more specifically, a smart contract.

A blockchain oracle, furthermore, can facilitate the transference of data both into as well as outside of the blockchain network, depending on network needs.

Let's consider an example:

Bob and John enter into a bet on which team will win an upcoming baseball game. Bob picks the Yankees. John picks the Red Sox. They place a bet via a smart contract, with both of them placing the equivalent of 1 ETH into the smart contract. The Yankees and Red Sox play the game, with the Yankees being the winner.

The smart contract, independently, has no way of knowing who won the game.

In this instance, the smart contract needs a reliable method for receiving information, *or data*, as to who won the game, so that it can determine whether Bob or John is the winner of the bet, so that ultimately it can release the total funds (2 ETH) to the winner.

In this case, data regarding the baseball game can be fed *into* the smart contract. If there were a need to keep an anonymous record of these types of bets off-chain in a database, then the smart contract could feed data containing the bet results through the oracle and into a database where the results could be stored and accessed efficiently.

Like real-time price information to “smart” device health insights, and temperature readings done by sensors to accessing, as opposed to replacing, legacy systems, the tasks a smart contract can be designed to carry out become far-reaching with the addition of a blockchain oracle to the system architecture.

Without blockchain oracles, smart contracts can be thought of as black boxes, or silos, particularly with respect to processes that go beyond settlement needs, which is the essential operation undertaken by the Bitcoin network.

The increased use cases for blockchain oracles has been in parallel with the increase in smart contract usage, as in the case of parametric insurance. For example, claims are paid out based on a clearly-defined event and at a clearly-defined amount. While parametric insurance as a concept has been around since the 1990s, the technology is catching up to the needs of an increasingly uncertain world.⁸

Growth of Blockchain Oracles

As real-world problem-solving is pursued through the usage of smart contracts, the growth of blockchain oracles has followed. Particularly with respect to the importance of well-designed *decentralized* blockchain oracles that provide the benefits of connecting smart contracts with the unstructured world. This is essential in preventing harmful actors with a central point of attack within the network. An individual's data self-sovereignty, therefore, can be at similar risk as it is within a centralized data management infrastructure.

At the heart of blockchain technology ethos is decentralization, particularly with respect to public blockchains. A centralized oracle essentially neutralizes the benefits of a decentralized blockchain network, and potentially endangers network participants. This can be understood when one considers the nature of how *flash loan attacks* are achieved within Decentralized Finance (DeFi) protocols. Malicious actors can leverage centralized price oracles sourced from a single Decentralized Exchange (DEX) if they have a large amount of capital to expose.⁹ So, it is vital in seeking to leverage blockchain oracles that the philosophy of decentralization is not

⁸ "How Blockchain Smart Contracts Are Reinventing the Insurance Industry"
<https://www.nasdaq.com/articles/how-blockchain-smart-contracts-are-reinventing-the-insurance-industry-2021-01-29>

⁹ "Flash Loans Aren't the Problem, Centralized Price Oracles Are"
<https://www.coindesk.com/flash-loans-centralized-price-oracles>

forgotten, especially as their usefulness expands to the areas of finance, supply chain, prediction markets, and beyond.

It is no coincidence that the growth in DeFi has coincided with the growth of high-quality decentralized oracles.¹⁰ As blockchain technology becomes more integrated into traditional and legacy systems, or as they play a significant role in the replacement of these systems altogether, blockchain oracles will be in higher demand in order to ensure optimal blockchain and smart contract performance as well as reliability.

Moreover, the need for decentralized approaches to oracles designed to be effective in the world of blockchain technology, where data is constantly needed for the effective execution and usefulness of smart contracts, is also revealed with respect to data storage.

Effective data storage is essential to effective data usage, and decentralization is critical to embrace if one is committed to empowering and protecting individuals' data rights.

What is Decentralized Storage and Why is it Important?

Decentralized storage, much like a decentralized oracle, is increasingly relied upon within blockchain ecosystems to safely, efficiently and equitably facilitate the distribution of operations to the various nodes that constitute any given network. These processes and protocols also reward nodes commensurate with their contributions, guided by the incentivization policy established within the network.

Within a centralized data storage solution, all of an entities' data is housed within a single data center. But, more commonly desired today by organizations are multi-data center strategies with the hope of essentially ensuring business continuity.¹¹

10 "Making Sense of Price Oracles in DeFi"

<https://hackernoon.com/making-sense-of-price-oracles-in-defi-e42c3ziv>

11 "Top Three Business Continuity Factors for Data Centers"

<https://avtech.com/articles/9245/top-three-business-continuity-factors-data-centers/>

Perhaps the most important development with respect to the evolution of data management strategies is the rapid onset of (multi) cloud data storage. In rapid fashion, multi-cloud environments are becoming the norm for enterprises with needs that involve the development of hyperscale infrastructure, due to the advantages these types of environments offer with respect to cost-effective resource management, data portability, data backup & replication, and more.¹²

Even before considering the unique benefits blockchain-based decentralized storage solutions can provide individuals and enterprises, it is worth noting here explicitly that organizations have been pursuing more decentralized data management solutions before blockchain technology began to gain traction as a viable alternative. Decentralized storage, therefore, has been embraced as a concept by the industry, given that a more decentralized data management infrastructure theoretically improves uptimes, security and more.

It's clear that few want to put all of their data management eggs into the same basket, and rarely is it a wise choice given the uncertainties.¹³ This is especially because of the varied nature of the management required or desired for optimal data management.

With a multi-cloud data management strategy, for example, an organization can leverage public clouds for the sake of affordability while also leveraging a private cloud which houses sensitive consumer information, and as well relying on on-premises data management for artificial intelligence or machine learning activities.¹⁴ The flexibility that a multi-cloud data management strategy offers can quickly evolve from nice-to-have to compulsory.

Environmental context represents an important factor as well. A report published by Deloitte on the impact of COVID-19 on data centers, particularly in the Middle East, revealed that companies are migrating their infrastructures to cloud solutions at rapid

12 "Finding the right balance in multi-cloud data management"

<https://www.cio.com/article/3533461/finding-the-right-balance-in-multi-cloud-data-management.html>

13 "Multicloud Benefits: 9 Reasons to Use Multicloud"

<https://www.datamation.com/cloud/multicloud-benefits-9-reasons-to-use-multicloud/>

14 "The Future of the Datacenter is Multicloud" <https://www.nutanix.com/blog/future-datacenter-multicloud>

pace; as well as that the COVID-19 pandemic enabled many to learn that workers can indeed be productive while working remotely, but that also, company business continuity plans are “not what they thought they were.”¹⁵ The questions these organizations and to an increasing extent, individuals whose data are stored must continue to ask is this:

What if X happens?

Google Photos alone holds more than 4 trillion photos and videos with 28 billion new photos and videos being added every week.¹⁶ Large enterprises like Google dominate the industry, but they are often suspected of cooperating with the authorities and giving them access to private data. It can be easily accomplished because users’ files are not encrypted, are stored in one place and as well they are vulnerable to myriad manipulations.

Even governments can restrict access to certain content for political purposes, as was done by Turkish officials in 2017, when Wikipedia received a ban. China has also banned globally-popular social media, cloud storage and video platforms, only to replace them with native analogs.¹⁷ These examples highlight the issues that persist with respect to user data, particularly in the areas of censorship, control and even mismanagement.

Your Data

The average individual creates 1.7 MB of data every second. Most people do not know how much of their data is being tracked. Senior fellow at Wharton Customer Analytics and Drexel University marketing professor Elea Feit sheds light on the reality that “most companies are collecting data these days on all the interactions, on

15 “COVID-19 implications for data centers (PDF)”

https://www2.deloitte.com/content/dam/Deloitte/xe/Documents/About-Deloitte/mepovdocuments/mepov33/covid-19-implications-for-data-centers_mepov33.pdf

16 “Google Photos is ending free unlimited storage in 2021 — so what are your options?”

<https://thenextweb.com/news/google-photos-is-ending-free-unlimited-storage-in-2021-so-what-re-your-options>

17 “How Can Blockchain Improve Data Storage?”

<https://cointelegraph.com/news/how-can-blockchain-improve-data-storage>

all the places that they interact with customers in the normal course of doing business.”¹⁸ Whether a retailer keeping track of email opened, or a site keeping track of links clicked, there are very few action points within an internet user’s experience where data is not being collected. As the importance of effective data leveraging increases with respect to improving the bottom line in (online) business, especially in times of uncertainty,¹⁹ the appeal of an organization to either supplement or center its business model on the selling of data to 3rd parties will persist. Furthermore, advertisers leveraging data for ad targeting is now standard practice, with individual data creators’ share of revenues being non-existent.

What’s more, there is the issue of companies sharing access to data, as in the case of PayPal, where a user’s name, address, phone number, date of birth, IP address and more is shared with hundreds of entities worldwide.²⁰ To further highlight this phenomenon, we can look to Facebook again, where the average user on the Facebook platform makes the company \$7 per month.²¹

The traditional methods for architecting the verification, management and leveraging of data, while limited to centralized and multi-cloud data management where private enterprises retain a stronghold on the value generated from the operations, are ripe for disruption. Decentralized storage presents a formidable alternative, where individual users’ data rights are well-protected within a network that rewards a distributed collection of nodes to secure, govern and power a new road for data self-sovereignty.

18 “Your Data Is Shared and Sold...What’s Being Done About It?”

<https://knowledge.wharton.upenn.edu/article/data-shared-sold-whats-done/>

19 “LEVERAGING DATA: A PROVEN STRATEGY IN UNCERTAIN TIMES”

<https://www.machinemetrics.com/blog/leveraging-data-proven-strategy-uncertain-times>

20 “List of Third Parties (other than PayPal Customers) with Whom Personal Information May be Shared” <https://www.paypal.com/ie/webapps/mpp/ua/third-parties-list>

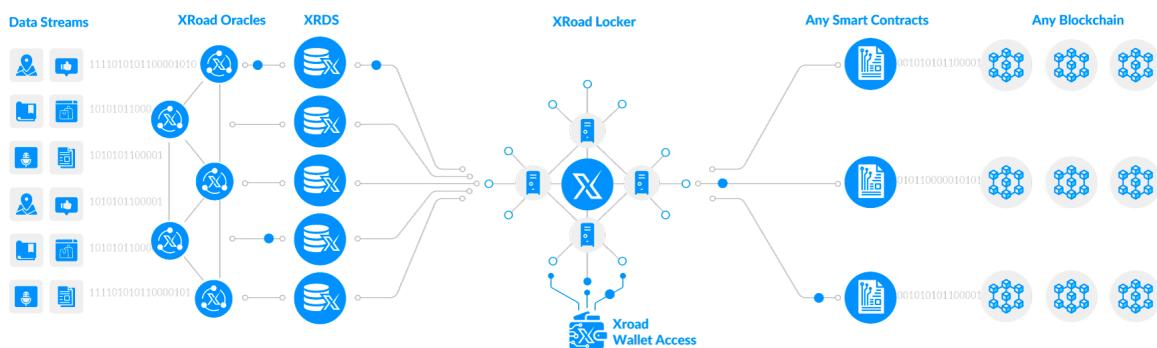
21 “What if Google shared its profits off your data with you?”

<https://www.androidauthority.com/google-data-sharing-1002538/>

XRoad Project

As blockchain and smart contracts technologies gain acceptance and as these technologies are more integrated into the current global IT infrastructure, the demand for bringing off-chain environment data into on-chain environments will only grow. As more and more people come online and continue producing massive amounts of personal data, the demand for storage and user control over their data will only grow.

The XRoad Project suite of solutions is at the intersection of these two demand paths.

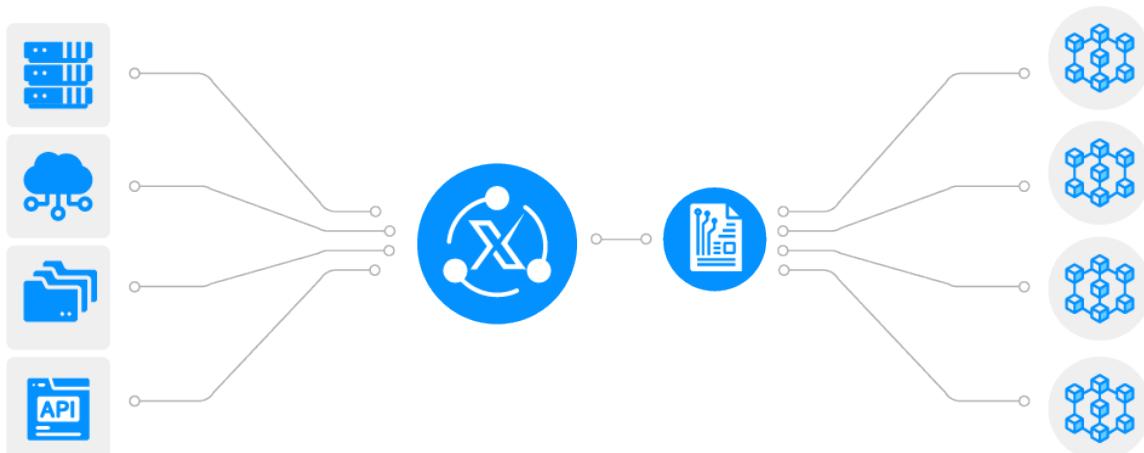


XRoad Oracle

Within the rapidly-evolving decentralized world of blockchain technology, smart contracts are executable, tamper-proof applications where no entity is able to make changes to the code or hinder the execution of the contract. This is in stark contrast to the more traditional contracts which are susceptible to the changing motivations of a centralized body with power and accessibility to make contract alterations.

A smart contract offers the assurance of execution based on the parameters set when the smart contract is initialized. Thus, trust may be established between multiple parties without the need to place trust in any of the individual parties. This assurance is achieved via the self-verifying and self-executing functionality of a smart contract, with the actualization and administration of the smart contract being, in effect, trustless.

We find here, then, a novel trust model, but one severely limited by a lack of connectivity to the real world, due to the inability of a smart contract to directly acquire essential data via more traditional routes such as data feeds and APIs. This is due in large part to the consensus mechanism of a smart contract. The XRoad Oracles are the solution for this problem.



Whatever the data source, if it is Web-based, the XRoad Oracles effectively and efficiently bridge the connectivity gap, providing the ability for interaction with online sources of information and the ultimate transference of this information to the

blockchain. From websites to databases and beyond, the XRoad Oracles serve as the essential data feed for the decentralized world. Moreover, XRoad Oracle carries out the ever-important task of verifying and authenticating data, and enables the smart contract to efficiently execute its logic.

The information supplied by the XRoad Oracles can be easily delivered to smart contracts, and in real-time. Some of the most common information-wrangling uses for these types of oracles include for asset price, exchange rate, and weather temperature information required by a smart contract within a blockchain network.

 XRoad (XRI) Price \$ 265.72	 Bitcoin (BTC) Price \$ 39,470.00	 Ethereum (ETH) Price \$ 2,465.05
 Tether (USDT) Price \$ 1.00	 Binance Coin (BNB) Price \$ 362.33	 Cardano (ADA) Price \$ 1.54
 Dogecoin (DOGE) Price \$ 0.314311	 XRP (XRP) Price \$ 0.862148	 Polkadot (DOT) Price \$ 24.02

Furthermore, when pursuing blockchain network architecture development, there is often the question of whether data is best stored “on-chain” or “off-chain”. XRoad blockchain oracles allow for increased flexibility when integrating with a blockchain network, where both on-chain and off-chain data can be readily accessible, without becoming burdensome to the blockchain network itself to enable the stable and accurate transmission of data, in real-time, according to the needs of a network.

XRoad Oracle Data Stream

The XRoad project seeks to initially specialize in personal data to build an ecosystem around individual ownership and control (further explained in sections below). However, as the platform expands and grows, the XRoad Oracles will provide users with additional capabilities to feed various types of data via the oracles. Users have the ability to unlock data streams for sports data, foreign

exchange currency data, securities real-time information, IoT data, supply chain data and beyond.

Whether the need is for stock market prices, sensors that keep track of insurance-related data points (i.e., data from hurricane indicators) or ERP systems, the XRoad Oracle data streams are next-generation tools well-equipped to meet the data needs of our users. By prioritizing diverse data needs during the design and development of the XRoad Oracle, XRoad users are uniquely positioned to quickly leverage worldwide data onto decentralized systems.

XRoad Decentralized Storage

XRoad decentralized storage offers a peer-to-peer (P2P) storage infrastructure so as to achieve the security and authenticity of data while enabling constant availability of the same data to support accuracy and stability as well as to reward stakers of XRI.

Current Decentralized Storage

BitTorrent is a highly established P2P file sharing protocol on which files are shared based on the number of seeders (users who store the data and have made it available to others). Availability of any given file depends on the number of seeders within the BitTorrent decentralized storage ecosystem. The more seeders, the quicker the access to the data. With few or no seeders, however, access to the data can be effectively severed often permanently.

In the case of InterPlanetary File System (IPFS), one finds a protocol and P2P data storage network whereby there is no need for a central location for data, and instead it presents a disruptive approach to Internet architecture altogether.

Unlike BitTorrent, IPFS supports file versioning and the storage of file change history. A single file with a given hash may be updated at any time, eliminating the need for multiple versions of the same file with different hashes. But just as is in the case with BitTorrent, files with few or no seeders are liable to go dormant and become unavailable in perpetuity.

Another more well-known solution is Filecoin, which was created by the creators of IPFS and indeed built on top of IPFS technology with the goal of addressing the problem of dormant files. The Filecoin founding team saw only two solutions for this:

1. The incentivization of nodes (essentially rewarding users for hosting data)
2. Proactive distribution of files to make sure there are a sufficient number of duplicates available within the network

In fact, in 2017, the world witnessed the benefits of distributed solutions. In April 2017, the Turkish government blocked access to Wikipedia's centralized servers, holding the belief that Wikipedia was a "threat to national security." However, once a

copy of the entire Wikipedia site was put onto IPFS, it became impossible for the Turkish government to block access to its content. This was due in large part to the decentralized storage infrastructure of IPFS. Moreover, since IPFS supports version control, the IPFS-based copy of Wikipedia maintained its up-to-date status. An occurrence such as this in Tukey reveals the value of decentralized storage, but the IPFS solution still possesses a number of limitations, the first being the lack of special treatment for private data.

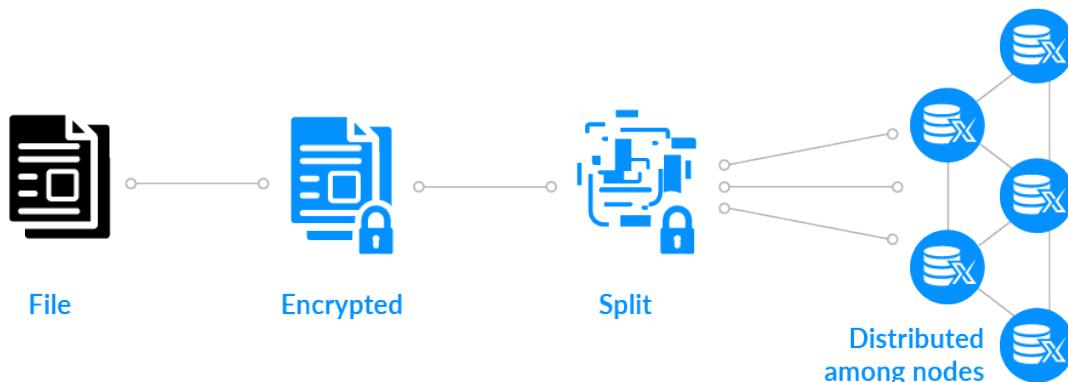
As an individual data creator, the question still looms with IPFS' solution: *How can we preserve data while also securing it according to the privacy needs of data owners?* This is the key area where decentralized storage alternatives fall short, and where XRoad seeks to differentiate in the eyes of users. XRoad seeks to provide nodes within a network with rewards for helping the distribution of decentralized data. As well for the proactive distribution of data as storage demands increase.

XRDS: XRoad Decentralized Storage

Our approach with XRoad decentralized storage ("XRDS") is to combine data encryption and decentralized data storage where all stored data is encrypted. In the event that data is obtained without permissions, the encrypted data will be 1 part of a data set, leaving the individual with an encrypted piece of a puzzle.

The users' data will be processed and stored as follows:

1. First, data is encrypted
2. Then, it is divided into multiple pieces
3. Next, the encrypted data pieces are stored on decentralized nodes



XRoad's blockchain-based decentralized storage is the convergence between multi-cloud decentralized data management philosophy with individual data self-sovereignty. XRDS provides effective solutions to problems which centralized storage solutions are unequipped to match. A decentralized approach to data management powered by blockchain technology empowers individuals around the world to participate in the ongoing operation to store, secure, verify and authenticate individual data, in a manner that multi-cloud storage solutions are incapable of enabling.

Within XRDS, data is distributed throughout an entire network, thus making the network highly difficult to be attacked or censored. Additionally, the efficient usage of storage space within a borderless and distributed network yields significant cost reductions at a time when data storage costs are either becoming exorbitant or, alternatively, difficult to understand.²²

With respect to the highly-critical need to backup data, XRDS enables multiple copies of data to be securely stored on various nodes within a network. This is so that individuals and/or enterprises enjoy uptime and assurance not achievable with centralized storage, and oftentimes too complex to architect with multi-cloud storage.

22 "Complex pricing hinders enterprise assessment of AWS, Google and Microsoft cloud IoT hubs"
<https://www.computerweekly.com/news/252442494/Complex-pricing-hinders-enterprise-assessment-of-AWS-Google-and-Microsoft-cloud-IoT-hubs>

In addition to a more efficient method for data storage, XRDS is rooted into blockchain technology and offers the capability of data encryption with the usage of private keys, whereby creators and owners of data themselves are able to retain ownership.

Furthermore, files within the XRDS solution are broken down into multiple pieces and spread across multiple nodes. This leads to a virtually impossible task for a single node to access a file in its entirety. The importance of decentralization largely centers on its ability to surpass the functionality of centralized data management solutions, while placing individual data self-sovereignty and distributed network participation at the core. Additionally, XRDS also positions the individual data creator to capture the most value from the decentralized storage solution, and so it turns the centralized data management revenue model on its head.

XRoad Locker

Whereas XRoad Oracle serves as the decentralized road for transmitting off-chain data from its environment into the on-chain world of blockchain technology, XRoad Locker is the decentralized personal data storage space for individuals.

Rewarding individuals for simply storing data within a network does not account for the true value of one's data. As previously mentioned, the massive amount of data created by individuals goes largely, if not completely uncompensated for. Normally, none of the direct or indirect revenues generated from an individual's data is shared with the individual.

XRoad Locker provides benefits to the owners of data. An ever-evolving and adaptable decentralized data management infrastructure, XRoad Locker presents individuals with a user-friendly dashboard and the ability to easily customize their Locker according to their needs. Individuals are easily able to select the monetary value placed on certain aspects of their data, which they can customize within XRoad Locker.

Control Your Data

XRoad Locker is designed with the core belief in user-controlled data. We are committed to the adherence of one simple principle:

Users own their data and decide how data is used.

With XRoad Locker, the users is in truly complete control, this includes control over:

- What information of theirs is registered
- Which service providers have access to the data
- What data to disclose to specific service providers
- The value of the disclosed data to the specific service provider

XRoad Locker facilitates a simple authentication processes for users to gain access from anywhere, and keep track of their data control choices from anywhere. What's more, individuals can easily keep track of the data revenues they have obtained as a result of allowing service providers to gain certain aspects of their data. By keeping flexibility and customization on top of mind, XRoad Locker will be well-positioned to cater to the needs of users.

Consider the example of John, a 32-year-old Programmer living in San Francisco, CA:

John uses his cell phone more than 9 hours per day,²³ including work-related hours. He decides that he wants to monetize his data by viewing advertisements. However, he would only like to view ads in which he has a high interest. He configures his profile as a male living in California for advertisement viewing purposes. However, for other service providers in which he has a high interest, he constructs a different profile. For example, with respect to the data he needs to provide to a travel agency, he provides his next travel plans.

For each confirmed interaction between a consumer and advertiser, the advertiser pays the XRoad platform. The platform will distribute a majority of the advertisement fees to the consumer, while leaving a small portion of the fees to be allocated to the operational costs of the XRoad platform. This way, the XRoad platform is self-sustaining. As more and more value is exchanged between stakeholders, the more the XRoad platform will be able to expand (and scale) its suite of services in various sectors.

XRoad Locker Additional Storage

Within the XRoad Locker network, the optional feature of additional storage will be available to users interested in expanding their Locker. These storage capabilities will be constructed with specialized data storage needs in mind. As an example, let us consider gamers:

23 "How much time on average do you spend on your phone on a daily basis?"

<https://www.statista.com/statistics/1224510/time-spent-per-day-on-smartphone-us/>

If their gaming platform of choice is one of XRoad's partners, the users will have the option to store game results in the Locker. The type of data stored would be game titles, best scores, total playtime and so forth, enabling users to maintain an organized understanding of the data they are creating on the Internet, and thus enabling them to better understand how to leverage their data. The individual users' rights to the control and sharing of their data would continue with these Specialized Data Lockers.

Ultimately, the XRoad platform provides solutions to three important problems:

1. Ensuring privacy and user control with respect to their data
2. Providing incentives for the sharing and storage of individual users' data
3. Replacing centralized design philosophy with decentralized design philosophy

XRoad NFT

An NFT is a token minted exclusively for an item (or items) such as a contract, image, video, software, other data, or even real-world assets, with one exclusive owner verified on the blockchain. A NFT is recognized on the blockchain as an ad-hoc, once-off token, thus the term “non-fungible token.” The NFT is not fungible, in that it cannot be replaced or exchanged for another token. It is essentially a token tied to a digital item which can only be owned by a single individual, with a decisive record of ownership written immutably to the blockchain and easily verified. Once ownership is written to the blockchain’s immutable ledger, it can only be traded if the owner agrees to sell it via a smart contract.

NFTs are essentially the digital equivalent of a real-world deed, confirming ownership of assets, only they carry a multitude of advantages over paper deeds, starting with the fact that they are almost impossible to be altered. NFTs represent ownership of digital assets stored on a decentralized network such as IPFS or Filecoin, or even real-world items. Once a NFT is minted, the initial data associated with it is rendered extremely difficult to be changed without a conflict with its hash value stored. It is possible to mint a single NFT, or multiple copies of the same NFT.

XRoad NFT allows users to mint ownership of the XRoad storage data, whether for the purpose of selling to a buyer with royalty options on down sells, or simply as permanent confirmation of ownership.

Uniquely to XRoad, users may mint NFTs representing digital assets which are stored on XRDS. Upon minting, users irreversibly and exclusively link the NFT directly to the digital assets within the XRoad ecosystem. Users can furthermore connect their NFTs to XRoad Locker allowing them to control the sales and rentals, and revenues generated through their NFTs.

XRoad NFT is mutually exclusive; once a NFT is minted representing digital assets, the digital assets may not be associated with another NFT. The support for versionable data is useful for assets such as software which require occasional updates. In the case of multiple copies of a single NFT representing the same digital

asset, no duplication is required. The single copy of the digital asset is simply associated with multiple owners on the network.

XRoad Tokenomics

The XRoad token, XRI, is used throughout the XRoad platform. Without usage of XRI, access to the XRoad platform is not possible. Whether a user is interested in contributing to the XRoad platform's operation or benefitting from its services, XRI is critical to the sustainability and success of the platform.

XRoad Oracles



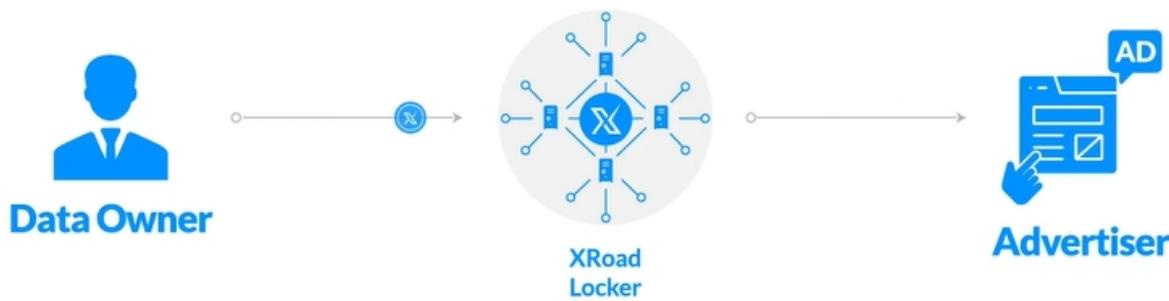
XRoad Oracle node operators must stake a certain amount of XRI in order to run an XRoad Oracle. Requiring operators to stake XRI initiates a model that prevents malicious actions by the operators. In the event an operator is found to provide low quality data on a constant basis, or is found to intentionally provide inaccurate data, the operator will lose the staked XRI. On the other hand, XRoad Oracle operators receive XRI when processing correct data, maintaining, and operating their nodes. The XRI rewards to the operators come from services that connect to XRoad Oracle in order to process their smart contract or services.

XRDS



When users connect to XRDS, and operate storage nodes that help with the decentralized storage needs of the platform, they receive the XRI rewards. XRDS will set levels of storage operators, with the more storage and uptime operators being a higher level, thereby receiving a larger amount of the XRI rewards for their storage and operation. For those who want to access XRDS to leverage the decentralized storage services of the platform, they will need XRI to do so. A percentage of fees paid in XRI goes to those operators helping to effectively run XRDS.

XRoad Lockers



Advertisers looking to target specific demographics or types of people for their products and services will need to purchase their traffic using the XRI token. When users view or interact with the ads, XRI in the advertisers smart contract for ad allocation, automatically deducts XRI from the smart contract. The viewer receives the majority of the XRI as reward for viewing or interacting with the ad, and a portion of the XRI goes to the XRoad platform for operations and growth.

The XRoad tokenomics approach seeks to stay true to the core tenet of decentralization and individual data self-sovereignty, by creating an ecosystem whereby XRI incentivizes data creators to build the roads making up data management infrastructure.

Summary

XRoad seeks to connect, extract and store individuals users' personal data for the purposes of enabling them to collectively manage and monetize at the discretion of individual data owners, by leveraging decentralization as a design philosophy.

The evolution of data management needs across the globe make decentralized oracle and storage solutions essential to protecting the data liberty of individual Internet users. Particularly when considering the growing multi-cloud data management needs being pursued by organizations, and the high costs and complex pricing structures for cloud services. Perhaps mostly, the constant need for leveraging data that exists today which yields to the need for better security. There is a clear demand for solutions to these issues as discussed in this paper. XRoad enters the market with solutions to the issues.

XRoad seeks to develop a self-supporting ecosystem built with the blockchain technology, and most importantly smart contracts where trustless, decentralized and customizable data management repositions individual data creators as true owners of their data. The core offerings of XRoad Oracle, Decentralized Storage and Locker are essential components to the data self-sovereignty of Internet users. The XRoad token powers XRoad and rewards XRoad users, while contributing to the development of a more equitable and efficient global data management infrastructure.

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Risks

Adherence to All Legal and Regulatory Standards

The purchase of any tokens involves a high degree of risk, including but not limited to the risks described below. Before purchasing X Road Initiative Ltd. (henceforth "Project") Tokens "XRI", it is recommended that each participant carefully weigh all the information and risks detailed in this White Paper, and, specifically, the following risk factors.

Dependence on Computer Infrastructure

Project's dependence on functioning software applications, computer hardware and the Internet implies that Project can offer no assurances that a system failure would not adversely affect the use of your Project Tokens. Despite Project's implementation of all of our expert and reasonable network security measures, our processing center servers are to some measure still vulnerable to computer viruses, physical or electronic break-ins or other disruptions of a similar nature. Computer viruses, break-ins or other disruptions caused by third parties may result in interruption, delay or suspension of services, which would limit the use of Project Tokens.

Smart Contract Limitations

Smart contract technology is still in its early stages of development, and its application is of experimental nature. This may carry significant operational, technological, regulatory, reputational and financial risks.

Regulatory Risks

The blockchain technology, including but not limited to the issue of tokens, may be a new concept in some jurisdiction, which may then apply existing regulations or introduce new regulations regarding blockchain technology-based applications, and such regulations may conflict with the current Project Token Smart Contract setup and Project Token concept. This may result in substantial modifications of Project Token Smart Contract, including but not limited to its termination and the loss of Project Tokens as well as a suspension or termination of all Project Token functions.

Taxes

Token holders may be required to pay taxes associated with transactions involving Project Tokens. It is the sole responsibility of the token holder to comply with the tax laws of the relevant jurisdiction and pay all required taxes.

Force Majeure

Project's performance may be interrupted, suspended or delayed due to force majeure circumstances. For the purposes of this White Paper, force majeure shall

mean extraordinary events and circumstances which could not be prevented by Project or its management and shall include: acts of nature, wars, armed conflicts, mass civil disorders, industrial actions, epidemics, lockouts, slowdowns, prolonged shortage or other failures of energy supplies or communication service, acts of municipal, state or federal governmental agencies, other circumstances beyond Project's control.

Disclosure of Information

Personal information received from Project Token holders, the information about the number of tokens owned, the wallet addresses used, and any other relevant information may be disclosed to law enforcement, government officials, and other third parties when Project is required to disclose such information by law, subpoena, or court order. Project shall at no time be held responsible for such information disclosure.

Governing Law and Jurisdiction

Governing law and court of jurisdiction of the conditions above ("Terms") comply with the laws and regulations of Pohnpei and shall be interpreted and executed under the laws of Pohnpei. Disputes arising between parties concerning these Terms, their subject, or effectivity shall be resolved in the courts of Pohnpei.

Value of Project Token

Once purchased, the value of Project Token may significantly fluctuate due to various reasons. Project does not guarantee any specific value of Project Token over any specific period of time. Project shall not be held responsible for any change in the value of Project Token. Assumptions with respect to the foregoing involve, among other things, judgments about the future economic, competitive and market conditions and business decisions, most of which are beyond the control of the Project team and therefore difficult or impossible to accurately predict.

Please note that the Project and/or Project Token may be subject to risks not foreseen by its team at this time.