# Beyond Token Issuance

## How Interoperability and Real-World Data Unlock the True Value of Tokenized Assets

**Chainlink**

WITH CONTRIBUTIONS FROM

BCG   21shares   PAXOS   BACKED

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# Executive Summary

Digital assets present both a significant opportunity and a formidable challenge for asset managers and wealth management advisors. On the one hand, there is increasing demand from clients for exposure to digital assets, which are perceived as a new asset class offering exposure to novel technologies and new types of financial services via tokenization. On the other hand, many traditional asset managers are grappling with a knowledge gap in this domain, especially when it comes to evaluating the security and risks of the underlying infrastructure and interacting with these digital assets.

Tokenized assets, a subclass of digital assets, are blockchain-based digital tokens that represent physical or traditional financial assets. This approach to asset digitization offers opportunities for enhanced liquidity, transparency, risk management, and compliance. Yet, the complexity and novelty of these assets also pose challenges, particularly in evaluating the security and risk associated with them.

As a result, many asset managers find themselves unable to construct or offer comprehensive digital asset investment products involving tokenized assets. With clients increasingly seeking exposure to tokenized assets, asset managers who are unable to securely incorporate these assets into their product offerings risk falling behind their competitors.

This report provides asset managers with critical industry insights into:

- **The tokenized asset landscape**, including an exploration of their benefits, a taxonomy for better classification and understanding, an outline of the tokenization process, and case studies that demonstrate the potential of this evolving asset class.

- **The risks of tokenized assets**, providing perspective and guidance around identifying and navigating the risks associated with the technology underpinning tokenized assets, including critical security and programmability considerations.

- **Chainlink as an infrastructure and risk filter for tokenized assets**, featuring a highly secure and fully featured technology platform that enables financial institutions to develop customized, flexible, compliant, and future-proof blockchain applications and tokenized assets.

By gaining a better understanding of the technological complexities of the tokenized asset sector and adopting Chainlink's risk management infrastructure into their tokenized asset strategy, asset managers are empowered to make more informed decisions in their asset development and selection process. This strategic approach not only prepares them to effectively meet the current demand but also positions them to better capitalize on the forthcoming market opportunities in tokenized assets.

# The Market Opportunity

Blockchains were initially conceived as a parallel financial system to challenge the traditional status quo, but over time, digital assets began mirroring the traditional financial system, and the traditional finance sector started to fully realize the advantages of the technology. Consequently, blockchains are evolving from a competing model to an integral component of the existing financial ecosystem, and traditional assets and blockchain-based digital assets are converging into a single global financial ecosystem. This convergence is the inevitable byproduct of continued digitization, with blockchains and other forms of distributed ledger technology (DLT) offering superior backend infrastructure for storing, transacting, and building financial services for digital assets.

The tokenization opportunity is sizable, as it has the potential to encompass virtually any financial asset. Northern Trust and HSBC estimate that 5-10% of all assets will be digital by 2030. A report from 21.co and a joint study by BCG and ADDX project the market for tokenized assets to reach $10 trillion and $16 trillion, respectively, by 2030.

As of March 2024, the total value of tokenized assets on public ledgers is ~$147 billion according to data from DeFiLlama, Coin Metrics, and The Block, with fiat-pegged stablecoins making up over 97% of this market according to 21.co. The sector is poised for considerable growth, with an expanding array of assets being tokenized and a variety of markets and industries integrating tokenized assets into new and existing workflows.
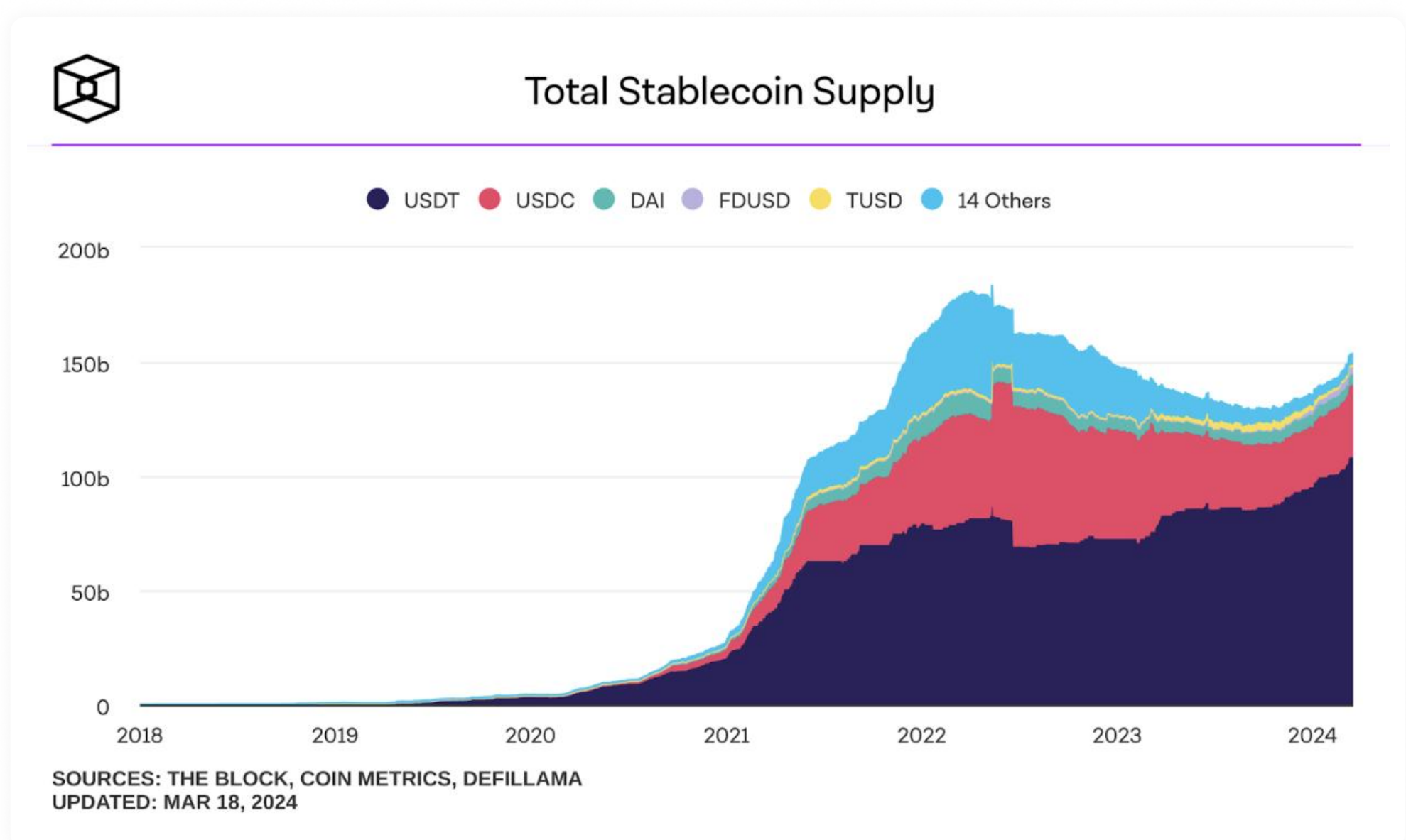


While the value of tokenized assets on private ledgers is more difficult to estimate, institutional interest in tokenization is growing. According to a survey conducted by BNY Mellon and Celent, 97% of institutional investors agree that "tokenization will revolutionize asset management". BlackRock CEO Larry Fink described the approval of 11 spot Bitcoin ETFs as "step one in the technological revolution in the financial markets. Step two is going to be the tokenization of every financial asset." Furthermore, DTCC Executive Director Stephen Prosperi explained in a DTCC blog how the collaboration between DTCC and Chainlink "opens the door to a multitude of use cases that could redefine how the financial industry operates."

This growth is not confined to financial markets either—a range of other industries are adopting tokenized assets, signaling an even larger tectonic shift in the global economy towards tokenization. The WEF estimates that $867 trillion of value is ready to be disrupted by tokenization, with use cases not limited solely to financial assets. One example is Vodafone's Digital Asset Broker (DAB), which demonstrated a proof of concept in 2023 with Sumitomo Corporation, Chainlink Labs, and InnoWave centered around tokenizing trade documents to help address longstanding challenges in the $30+ trillion global trade ecosystem.



> *"We see a growing appeal of tokenized assets among institutional investors and their clients. This presents a substantial market opportunity for the traditional asset management sector, as a significant amount of capital is ready to be enhanced by the tokenization market. The time has come for asset managers to start actively engaging with this expanding industry."*

**Kaj Burchardi, Managing Director, Global Lead of Emerging Technology Team, BCG Platinion**

# The Benefits of Asset Tokenization

To appreciate the tokenization megatrend, it's important to first understand the biggest benefits gained from asset tokenization.

### Real-Time Settlement

Blockchains enable the execution and settlement of trades to occur simultaneously, allowing for delivery vs. payment (DvP) settlement, continuous 24/7 trading, and instant access to global pools of liquidity. Smart contracts can be used to automatically execute transactions based on predefined criteria. This enables financial institutions to program complex rulesets directly into tokenized assets, further helping reduce settlement times and frictions.

Unlike traditional settings, where settlement might take T+2 days and counterparty risk exists throughout the process, blockchains facilitate near-instant transaction execution and settlement, paving the way for T+0 settlement in financial markets. Sweden's central bank experimented with an e-krona that could offer real-time settlement for payments.

This transformation to intraday settlement not only makes markets more available and efficient, but the transition to decentralized financial market infrastructure (dFMI)—such as blockchains, smart contracts, and oracle networks—for tracking asset ownership, executing trades, and facilitating settlement can introduce cost savings and performance enhancements.

### Golden Record

Using blockchains as an immutable, shared source of truth regarding tokenized asset ownership can make a number of administrative processes more efficient, including buybacks, profit distribution, distribution of net asset values, corporate actions, shareholder voting, and coupon payments. Ultimately, this can lead to more transparency and the elimination of reconciliation processes, as there are fewer intermediaries and a single, reliable, tamper-proof source of truth is shared between a diverse set of counterparties.

### Global Liquidity

By introducing a universal standard for execution and settlement through blockchains, tokenization can unlock vast liquidity and capital efficiency gains, increase the velocity of capital, and create global, instantly accessible pools of liquidity. Most notably, tokenization can bring liquidity to historically illiquid assets due to them being inaccessible to a broader market. With these assets represented as digital onchain tokens, they not only become more accessible but can also be incorporated more efficiently into the processes of financial institutions.

Another key benefit of tokenizing assets is the enablement of fractional ownership around high-ticket items, which effectively lowers the barrier to entry and broadens the potential investor base. In traditional settings, dividing an asset like real estate into smaller, tradable portions is impractical—but tokenization makes it feasible to own and trade small fractions of such assets at near-zero marginal cost.

## Composability

Tokenization opens up the creation of entirely new financial markets and instruments since assets that have been historically siloed across disconnected environments can exist within a standardized settlement layer of blockchains. With a common settlement layer, tokenized assets can be seamlessly incorporated into a wide variety of onchain smart contract-based financial services, which offer functionality such as lending and borrowing, asset swaps, fractionalization, and staking. These capabilities can be easily programmed into onchain applications, enhancing capital efficiency and broadening asset utility.

Decentralized finance (DeFi) has already scratched the surface of this composability potential, leading to entirely new financial primitives such as flash loans—a concept not feasible in traditional finance.

## Broad Scope

While tokenization offers the most immediate benefits to the finance industry and major enterprises, anything possessing monetary value or information can be tokenized, such as a piece of art, intellectual property, or even a skilled worker's time. This is why asset tokenization is often considered the greatest potential use case for blockchains, with its total addressable market in the hundreds of trillions, since it encompasses nearly all economic activity.
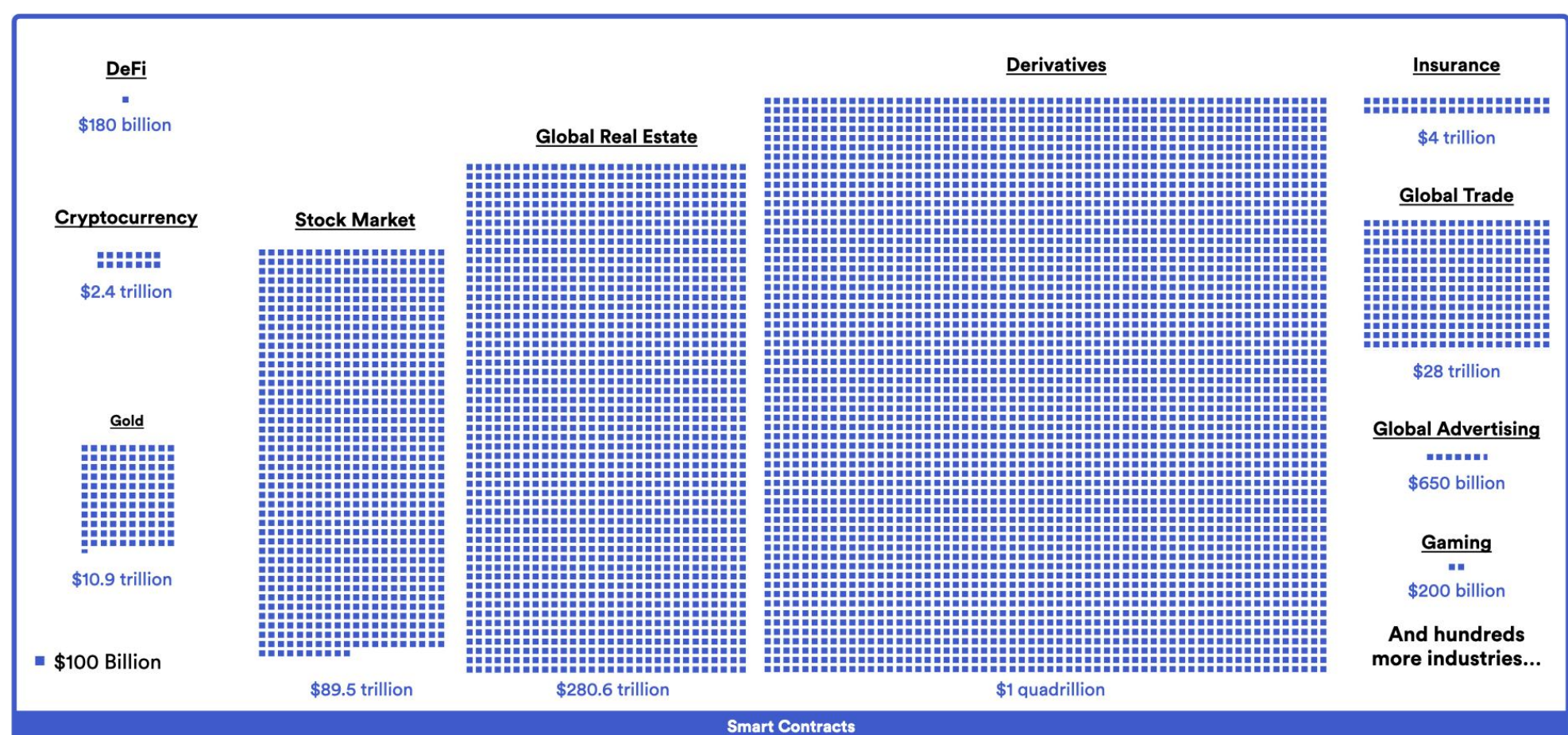


Tokenization ultimately expands the boundaries of the investable universe. As tokenization extends beyond conventional financial assets, it can increase the diversity of asset portfolios and greatly broaden the variety of collateral (e.g., non-cash assets) that can be used in financial markets.

Private equity and bonds are likely to be some of the first markets to be tokenized onchain. But as the benefits of tokenization are proven in these markets, even larger markets can be tokenized, with the upper bounds of tokenization encompassing essentially anything of value.
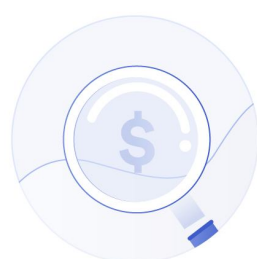
# The Benefits of Tokenized Assets
# for Asset Managers

With the advantages of tokenization understood, let's look at the specific benefits tokenization provides to asset managers.
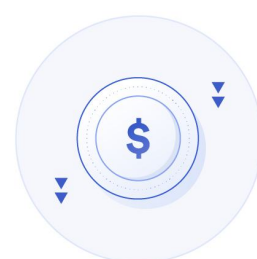
- **Unlocking dormant capital:** Tokenization can unlock higher returns for both asset managers and their clients by enabling them to tap into previously inaccessible markets or asset classes and access global, liquid, 24/7 markets. This expansion can attract more capital for asset managers and lead to higher revenues. The tokenization of traditional assets can also increase yields by allowing asset managers to put dormant capital to work through borrowing and lending activities, automated market making, or other low-risk, value-providing activities.

- **Greater availability of assets:** Tokenization broadens the types of assets available to investors, enabling asset managers to diversify client portfolios into asset classes that were previously inaccessible or challenging to enter. The growing demand for such diversified portfolios is already evident in the growth of the alternative investments sector and the burgeoning interest in digital assets like Bitcoin.

- **Novel revenue models:** Integrating tokenized assets into their portfolio offers asset managers potentially new sources of revenue due to the unique opportunities unlocked. For example, asset managers can earn yield from DeFi protocols or through staking assets on behalf of clients, such as in Ethereum's proof-of-stake mechanism.

- **Unified client portfolios:** Asset managers can capture more AUM by becoming the sole provider for their clients' investment needs, incorporating both traditional financial assets and digital assets into a single offering. This consolidation increases client retention and satisfaction because it eliminates the need for a client to manage their traditional assets with one firm while seeking out digital asset investments elsewhere.

- **Differentiated service offerings:** Asset managers can leverage tokenization to provide novel and bespoke financial products for their clients, such as fractionalized assets, and tokenized fund shares, and unique financial products such as self-repaying loans or DeFi yield.

- **Improved risk management:** Tokenization allows for more granular and automated risk assessment and management since the entire ownership history of the asset is available onchain. Furthermore, smart contracts can reduce counterparty risk in financial transactions. Improved risk management ultimately drives better decision-making and understanding, which can lead to better management of client funds.

- **Automation of back-office processes:** Tokenization simplifies and automates many back-office processes, such as settlement, compliance, and record-keeping. This efficiency not only saves time but also significantly reduces operational costs for asset managers since they have to employ fewer intermediaries.
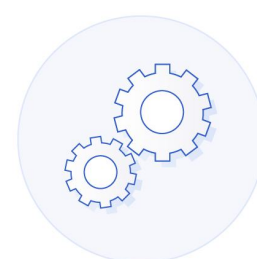
| Enhanced Liquidity | Better Asset Availability | Lower Costs | New Services |

## Understanding Tokens as a Fundamental Primitive

While the benefits of tokenization are numerous, the potential of tokenization extends far beyond issuing a token onchain. Consider the following parallel: Tokens are a fundamental primitive of onchain finance just as a web page is a fundamental primitive of the Internet. Initially, early web pages existed to bring existing analog content online, like newspapers or radio broadcasts. Over time, the concept of a web page has evolved via the introduction of more and more advanced programmability. Web pages can now host dynamic content, social networks, and games, spawning entirely new forms of media.
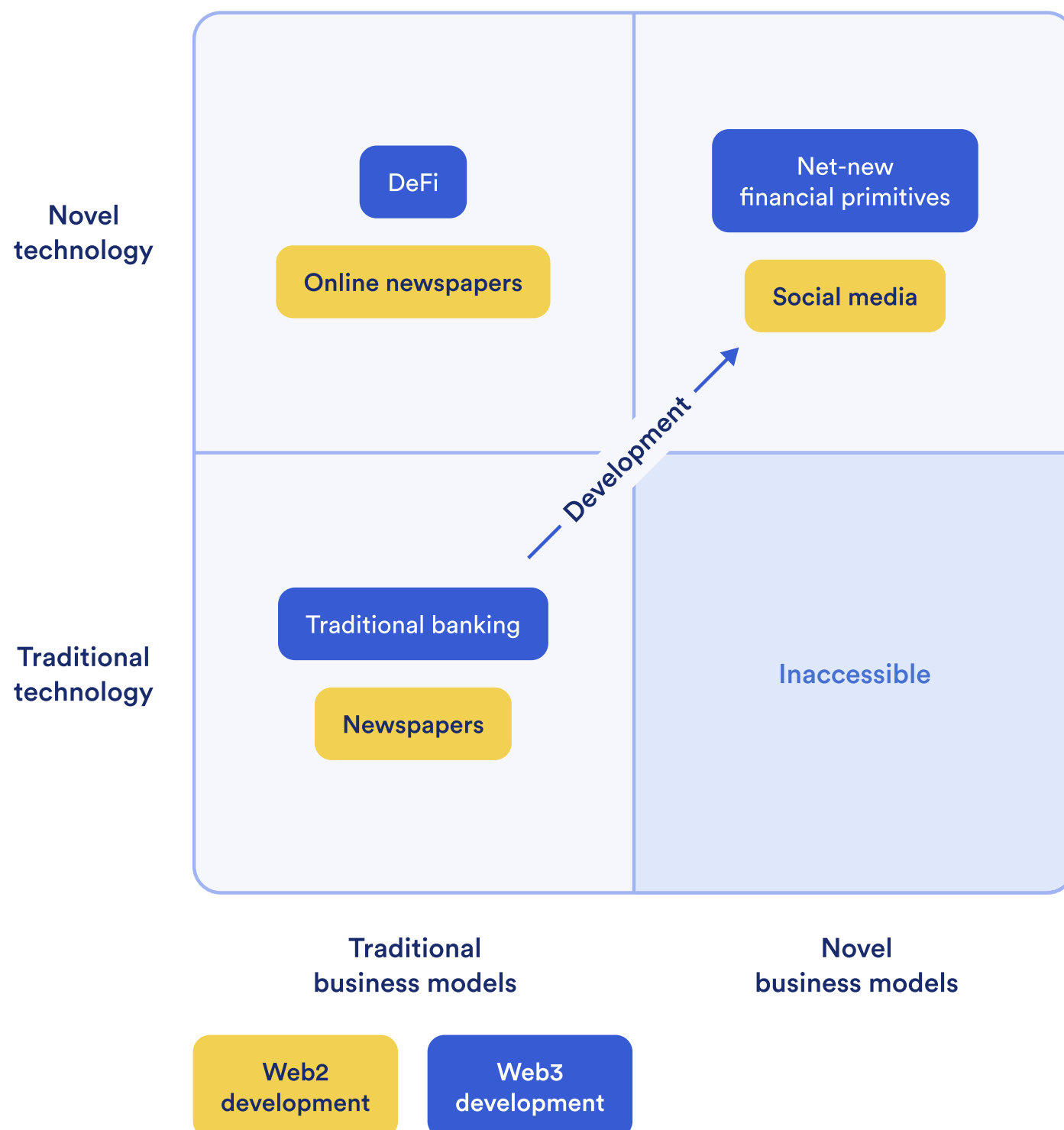


DeFi found initial product-market fit by introducing programmability to interactions with tokens, spawning decentralized lending markets, perpetual derivatives products, and stablecoins. However, this is an initial step in a much larger transition of the global financial system onchain, centered around digitizing assets as tokens and programming financial and social services via smart contracts for how those assets are issued, earned, serviced, governed, tracked, and exchanged.

Adding programmability requires additional infrastructure beyond what blockchains provide, most notably oracle networks. This is because blockchains inherently cannot pull in data from or push data out to any external system, making them isolated networks akin to a computer with no Internet connection. Bridging the connection between onchain environments and the outside world requires an additional piece of infrastructure—an oracle.

## A Quick Primer on Oracles

Oracles are infrastructure between blockchain networks and external systems that facilitate communication between onchain applications and any offchain system. Integrating offchain data inputs within a smart contract greatly expands its functionality but also adds security concerns—particularly because the oracle data is used to automate some function of the smart contract, whether it's providing an exchange rate for a trade or determining if a payout should be rewarded on a parametric insurance claim. If an entity can tamper with the data input or the data isn't delivered in a secure and timely manner, the application's functionality and security are greatly hindered.
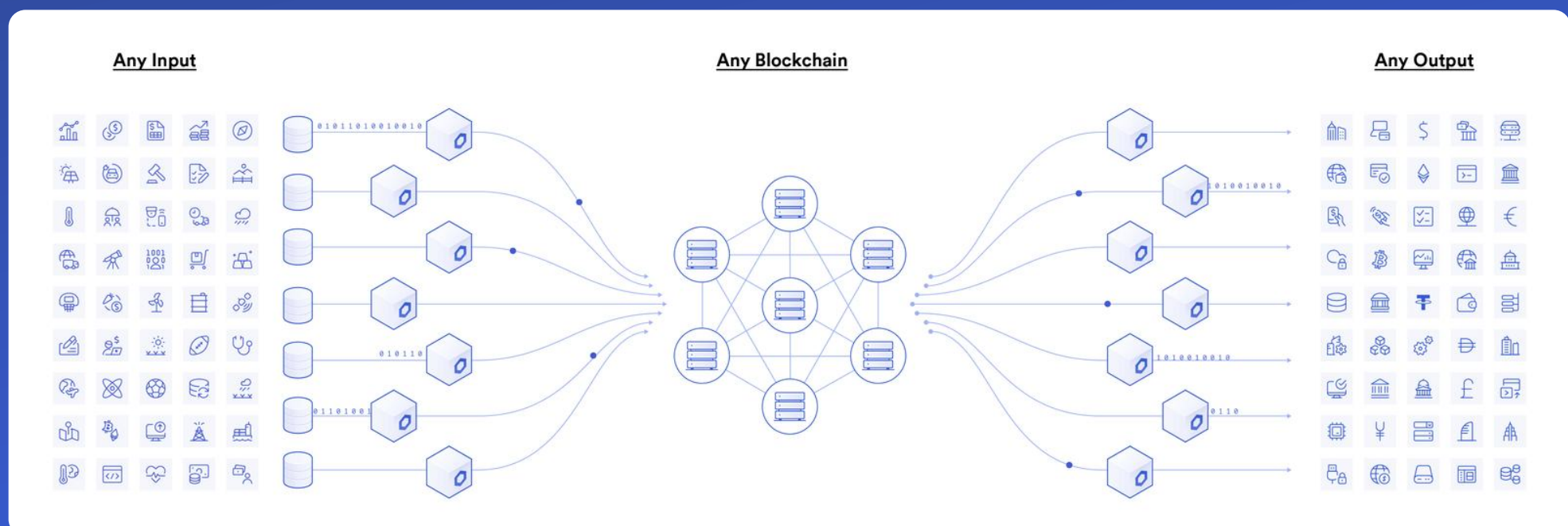


Chainlink solved the oracle problem by launching decentralized oracle networks (DONs) that enable smart contracts to securely connect with external data, computing, and systems. Chainlink DONs use a decentralized network of nodes to perform a service for smart contracts, such as relaying data between a blockchain and external API or delivering a fair market asset price onchain that's aggregated from multiple high-quality sources. Since its initial launch in 2019, Chainlink has demonstrated a proven track record of maintaining the highest standard of security and reliability in the digital asset industry, even during periods of extreme market volatility.

> *"Tokenization offers asset managers significant opportunities, but its broader adoption has been historically constrained by the lack of high-quality infrastructure capable of addressing the technological challenges associated with integrating the technology with traditional capital markets. To confidently engage with this growing market, asset managers need robust risk management infrastructure through which they can securely integrate tokenized assets into their portfolio. Chainlink is setting a new standard for bringing utility, security, and transparency to tokenized assets, supporting asset managers looking to future-proof their strategy for the growing tokenization market."*

**21shares**       Eliézer Ndinga, VP, Head of Strategy and BD, Digital Assets, 21Shares
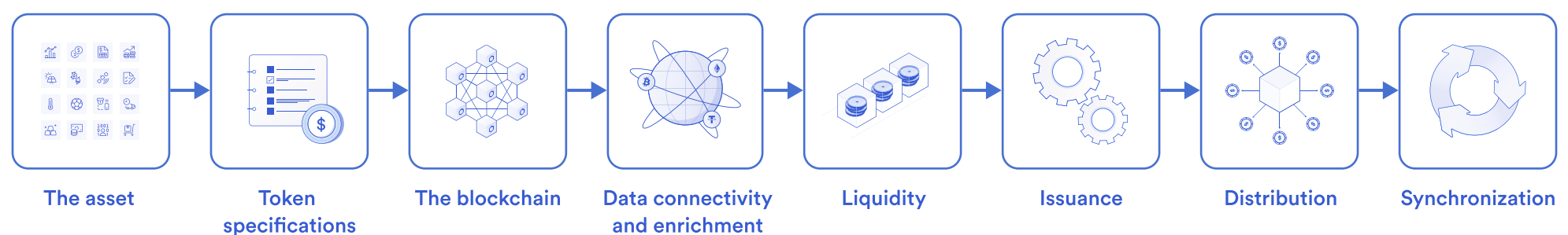
# An Overview of Tokenized Assets

## Taxonomy of Tokenized Assets

Before looking at how to enable programmability, let's look at the current digital asset landscape.

- **Traditional assets** are issued and traded within the traditional financial system.

- **Tokenized assets** are blockchain-based digital tokens that represent physical and traditional financial assets, such as cash, bank deposits, commodities, equities, bonds, and more. Through tokenization, a digital representation of the underlying asset is created, enabling onchain management of the asset's ownership rights. This report is focused on the opportunities presented by this asset class.

- **Onchain assets** are fully represented in onchain environments, such as Bitcoin's native asset BTC or Ethereum's native asset ETH.

## Asset Tokenization Process

The asset tokenization process broadly involves the following steps.



| The asset | Token specifications | The blockchain | Data connectivity and enrichment | Liquidity | Issuance | Distribution | Synchronization |

- **The asset:** Determine the asset to be tokenized onchain.

- **Token specifications:** Select the type of token (fungible or non-fungible), the token standard to be used (like ERC-20 or ERC-721), and other fundamental aspects of the token.

- **The blockchain:** Choose the public or private blockchain network on which to issue the token(s). Consider the benefits and tradeoffs of each blockchain.

- **Data connectivity and enrichment:** Establish offchain connections the tokenized asset needs to facilitate secure and reliable markets for itself. For example, tokenized assets may need access to proof of reserve data to prove collateralization, exchange rates to ensure fair market-to-market valuations, identity verification services to manage compliance checks, and more.

- **Liquidity:** Make the token cross-chain interoperable so counterparties on other blockchain networks can interact with it.

- **Issuance:** Deploy the smart contracts on the chosen network, mint the tokens, and make them available for usage.

- **Distribution:** Ensure distribution of the token to a wide range of individuals and institutions to help open up a larger market for the asset and, in turn, the opportunity for greater liquidity.

- **Synchronization:** Once tokenized assets are in the market and begin to move across chains as a natural part of their lifecycle, it is essential that the data that allows the asset to operate correctly—such as price, NAV, identity data, proof of reserves, and more—stays synchronized and up-to-date, no matter what chain the asset travels to. This is essential to maintaining a unified golden record across blockchains.

# Existing Types of Tokenized Assets

## Stablecoins

Fiat-backed stablecoins are the first and, so far, most successful implementation of tokenized assets. Stablecoins represent a superior form of the underlying fiat currency: digitally native, programmable, composable, and offering immediate settlement.

Many of the largest stablecoins in the market—such as Circle's USDC and PayPal USD, the stablecoin from PayPal, issued by Paxos—are predominantly backed by cash and short-term US Treasuries, offering a reliable backing that increases user confidence in the stablecoin's stability and redeemability. However, some "USD-collateralized" stablecoins, such as Tether (USDT), are backed by a variety of other assets, such as cash equivalents (like US treasuries), secured loans, precious metals, bitcoin, and corporate bonds. In this way, the structure of some of the largest stablecoins bears resemblance to both tokenized money market funds and e-money issuers, although stablecoins don't typically offer native yield to their users.

As of March 2024, the onchain supply of stablecoins amounts to approximately $146 billion (including various other types of stablecoins, in addition to those which are fiat-backed). At the same time, more than 50 million onchain addresses are currently holding or have previously held a tokenized asset on the Ethereum blockchain, with 99%+ of these assets being fiat-collateralized stablecoins. Despite these figures being substantial within the blockchain industry, they have much larger potential for use in retail and capital markets. Not only could they be used as a form of retail payment, but they could also be used to represent the cash leg for transactions involving other tokenized assets, making atomic delivery vs. payment workflows possible, since both the cash and security are tokenized.

## Funds

With onchain ecosystems emerging for both payment-focused and yield-generating tokenized assets, asset managers can create tokenized funds that are launched, accessed, and managed entirely onchain—all they need is a secure blockchain interoperability protocol to connect to and across tokenized asset ecosystems.

Tokenized funds unlock several further benefits for asset managers, including:

- Faster and more efficient record-keeping
- Digitally enabled back-office processes
- Cost-efficient fund administration
- Automated processes for distribution or corporate actions
- The ability to use fund tokens as collateral
- Personalization of investor portfolios

Arta TechFin, a premier Hong Kong-based financial institution, is an example of an institution using Chainlink to help bring next-generation features and transparency to its fund tokens.

> *"Arta is developing cross-chain-enabled regulated fund tokens supported by Chainlink Proof of Reserve and Cross-Chain Interoperability Protocol (CCIP) with the aim of bringing a seamless investing experience to global Web3 users. We see overwhelming demand from Web3 users, traditional investors, and regulators for secure, socially responsible, and fully onchain investment products."*
>
> **Eddie Lau, Co-CEO of Arta TechFin**

## Debt

Debt instruments, such as corporate bonds and government securities, are another financial asset being tokenized onchain. For example, Siemens issued an onchain digital bond in 2023. Tokenized debt issuers can leverage smart contracts to automate many aspects of the debt lifecycle, from issuance to settlement, interest payments, and maturity. Automation reduces operational complexity and cost, while blockchains ensure the immutable recording of ownership and transactions.

Tokenized debt can also be fractionalized so investors are able to purchase smaller portions of debt securities than otherwise would be possible in traditional markets. This fractionalization enables a broader investor base to participate in markets previously only accessible to institutional or accredited investors.

## Commodities

Tokenization extends to commodities, transforming physical goods like gold, silver, oil, or agricultural products into digital tokens that represent ownership or a claim on the underlying asset. The integration of real-time data feeds with tokenized commodities ensures transparency and traceability—crucial for verifying the authenticity and provenance of these assets.

Commodities traditionally suffer from issues related to divisibility and accessibility. Tokenization addresses these challenges by enabling fractional ownership, making it feasible for a wider investor base to gain exposure to the asset class without the need for physical storage or handling.

Furthermore, tokenized commodities can be traded onchain, providing 24/7 market access and reduced friction associated with buying, selling, and transferring ownership. This market efficiency benefits both investors and asset managers seeking to diversify their portfolios and producers looking for more stable pricing mechanisms and access to global markets.

Redeemable for one fine troy ounce of gold and supported by Chainlink Price Feeds, Pax Gold (PAXG) tokens by Paxos are an example of precious metals being tokenized and represented onchain, with an outstanding supply of ~$400 million as of March 2024.

## Real Estate

The real estate market is one of the largest markets in the world. Compared to other assets, real estate is highly illiquid and involves many intermediaries, with transactions taking weeks to close.

Tokenization is set to enhance real-estate transactions by optimizing processes, removing unnecessary third parties, and lowering the barriers to entry. When assets become easier to transact, there can be an increase in liquidity, better price discovery, and a reduction in transaction costs. This accessibility unlock can help asset managers incorporate this asset class into their offering for clients, helping them attract a larger investor base and increase their AUM.

RealT is a real-estate tokenization platform that supports fractionalization and enables users to trade tokenized real estate.



**Fractional Ownership**

10%  10%  10%  10%  10%  10%  10%  10%  10%  10%
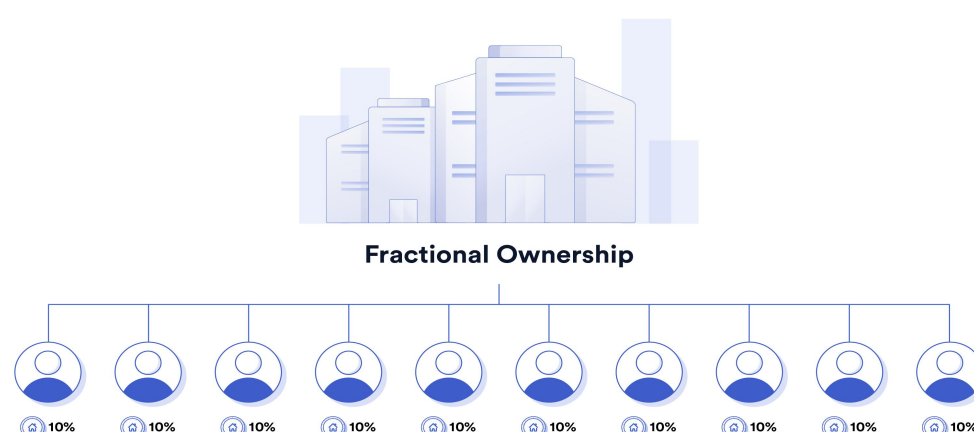
## Carbon Credits

The climate finance market has grown rapidly over the past decade, attracting a high level of interest from corporations, banks, and governments. However, climate finance has been historically held back by inefficiencies and illiquidity.

The primary challenge with carbon markets lies in a lack of liquidity—the market is highly fragmented, often with limited trading activity spread across inaccessible and illiquid assets. If these fragmented markets are consolidated through a unified carbon credit standard, with global trading enabled through onchain environments, carbon markets could see significant improvement in liquidity and impact.

In a 2022 report, BIS Innovation Hub, in collaboration with the Hong Kong Monetary Authority and UN Climate Change Global Innovation Hub, explored smart contract-based carbon credits attached to green bonds.

### CASE STUDY: ANZ and Chainlink CCIP Successfully Demonstrate Purchase of Nature-Based Tokenized Assets Using Stablecoins

Australia and New Zealand Banking Group Limited, a leading Australian bank with $1+ trillion in AUM, successfully demonstrated how ANZ customers could use CCIP to securely transfer ANZ-issued stablecoins across blockchains to purchase nature-based assets—showcasing a cross-currency, cross-chain purchase of tokenized assets.

Lee Ross, ANZ's technology domain lead, stated, "We're excited to drive financial innovation at ANZ by providing our clients with seamless access to tokenized assets through an easy-to-use platform. Chainlink CCIP played a key role in abstracting away the blockchain complexity of moving tokenized assets across different chains and ensuring atomic cross-chain DvP."
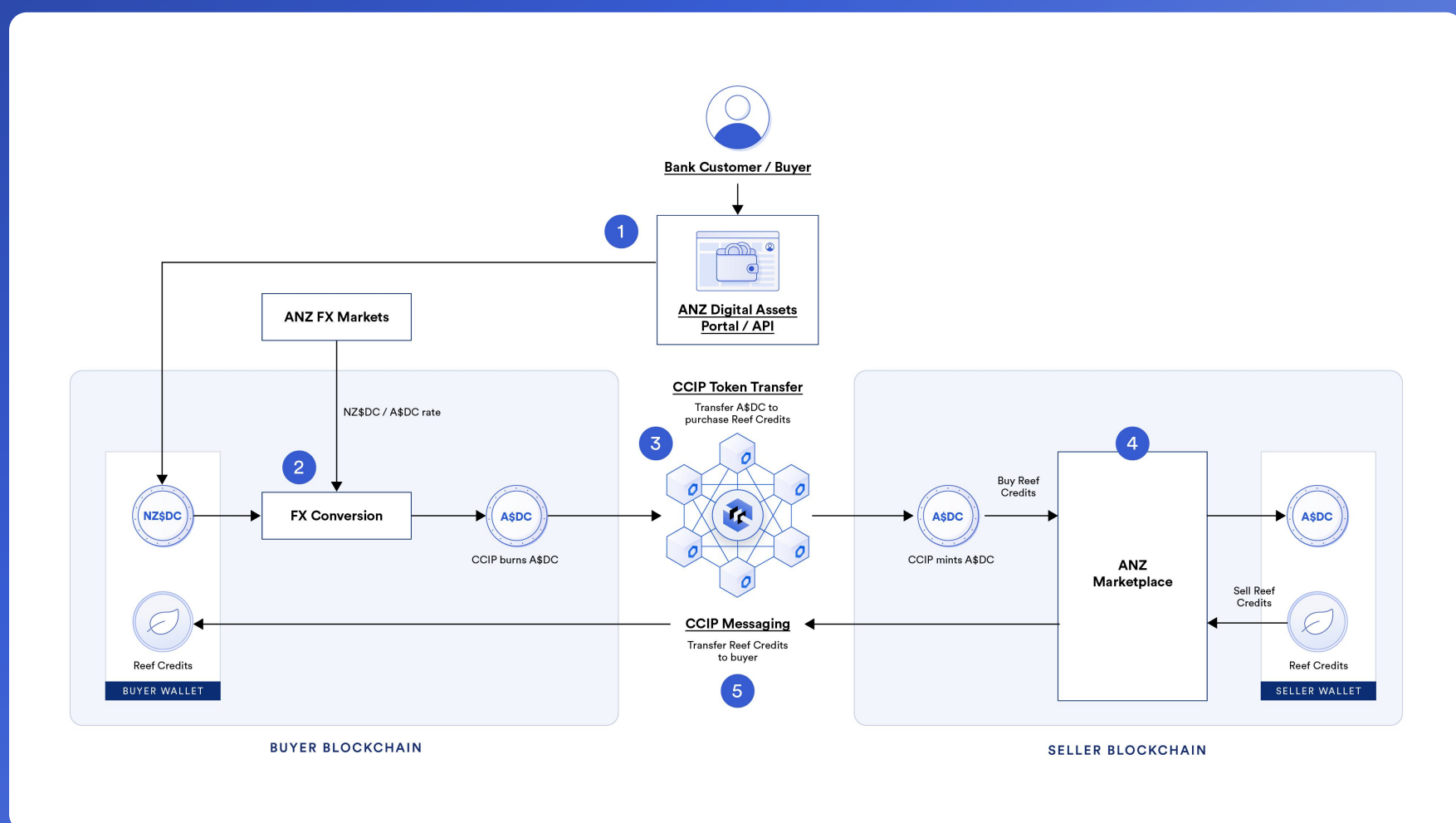
## Artwork and Collectibles

Tokenization also impacts the art and collectibles market and the music industry, enabling the digital representation of ownership for music, artworks, collectibles, and artifacts, typically through the creation of non-fungible tokens (NFTs). This shift not only democratizes access to these assets but also introduces a level of liquidity previously unseen in the traditionally illiquid art and collectibles market.

For artists and collectors, tokenization offers new ways to certify authenticity, provenance, and ownership without the need for physical verification or a complex web of intermediaries. Fractional ownership of art and collectibles enables consumers to purchase a fraction of high-value collectible items and artists to participate in resale royalties. For example, an artist or a band can issue an NFT of their new album, which collectors can purchase to receive a portion of royalties or access special perks.

## The Evolution of Popular Music Formats



| Vinyl | Cassette Tape | CD | MP3 | Streaming | NFT |
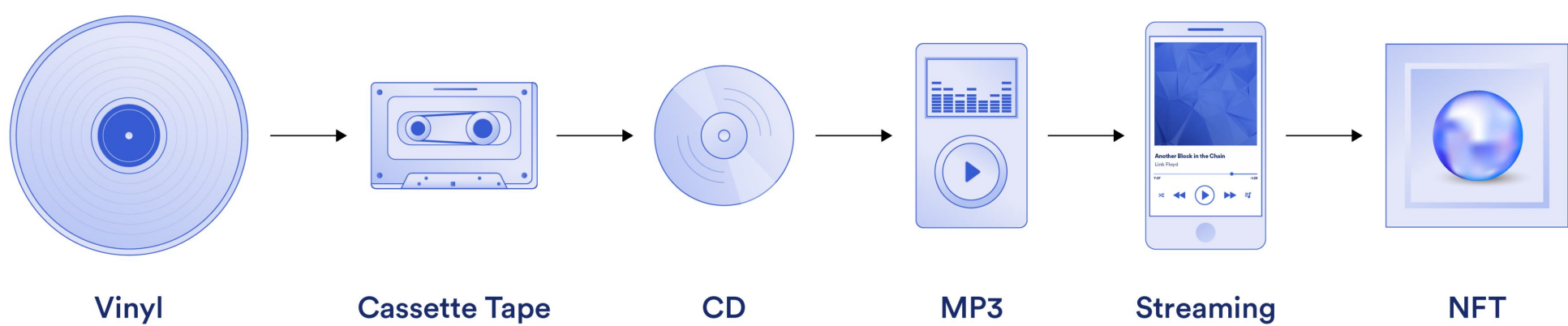
Chainlink

# Chainlink: Essential Infrastructure for the Tokenized Asset Economy

Tokenized assets present numerous benefits for asset managers and traditional financial institutions. However, simply issuing tokens onchain or purchasing tokenized assets is not as straightforward as it may seem—there are several challenges that must be understood, particularly as it relates to building and evaluating the security of tokenized asset infrastructure. Overcoming these challenges will require institutions to be able to satisfy compliance requirements, set up robust risk management frameworks, and establish high security standards while remaining future-proof to inevitable changes in the blockchain and DLT landscape.

It's important to understand that once a tokenized asset is issued onchain, it requires a variety of additional services if it is to achieve a high level of programmability and a robust secondary market, such as:

- **Connection to high-quality offchain data**, which provides information about the state of the asset or information needed to facilitate a transaction, such as market pricing, reference data, KYC/AML data, and identity data.

- **Access to a reliable proof of reserves mechanism** that helps protect users from malicious or accidental over-issuance attacks and manage various risks such as market value, liquidity, duration, and liability.

- **Secure cross-chain interoperability** so the token has access to users and liquidity across both public and private blockchains.

- **Synchronization with existing systems**, so that once the tokenized assets are in the market and have begun to move across chains as a natural part of their lifecycle, the data that allows the asset to operate correctly—such as price, NAV, identity data, proof of reserves, and more—stays synchronized and up-to-date, no matter what chain the asset travels to.
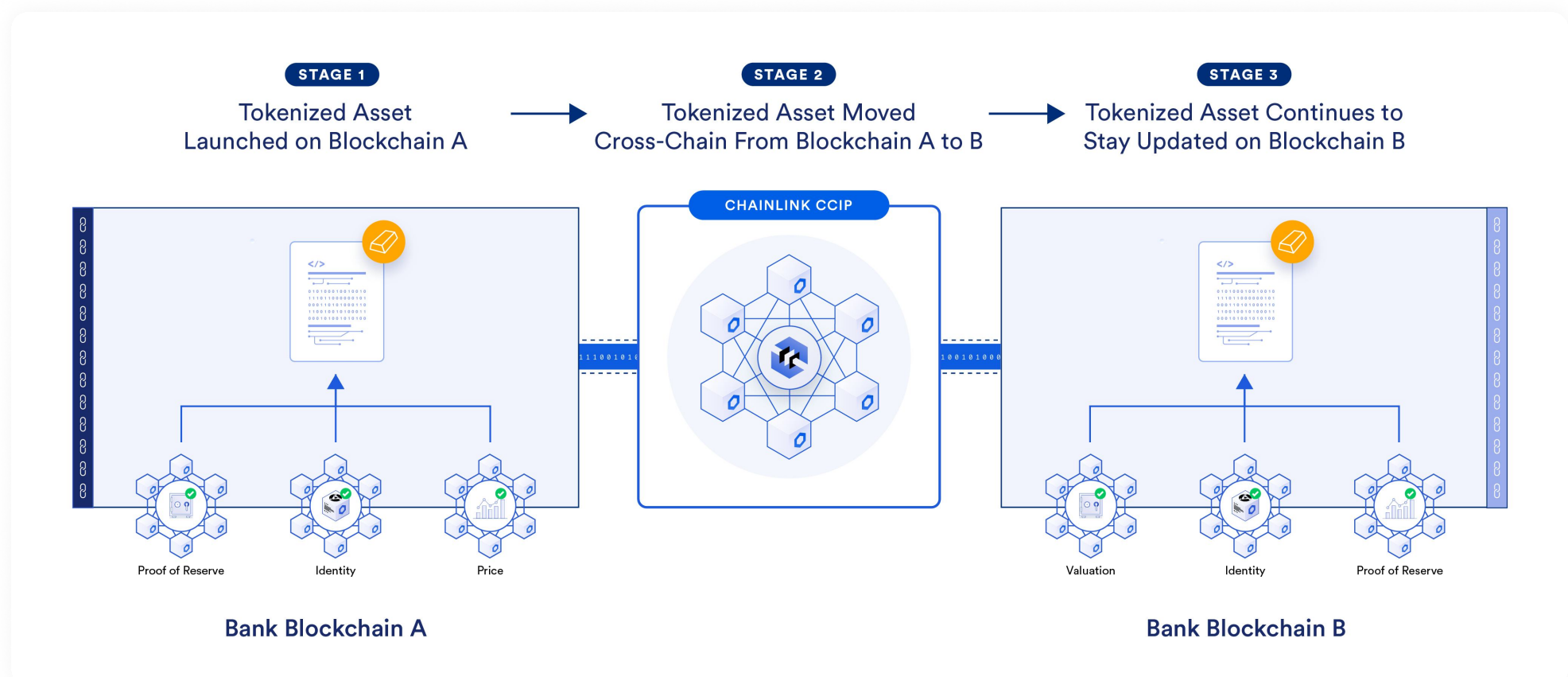


Cross-chain interoperability is especially critical in order for tokenized assets to reach their full potential. Banks, financial market infrastructures, and DeFi protocols are increasingly recognizing that there will be hundreds, potentially thousands of different public and private blockchain networks, particularly if there is specialization around catering to specific asset classes and geographies. Without a secure blockchain interoperability standard, this would lead to fragmented islands of liquidity that prevent the growth of new onchain markets.
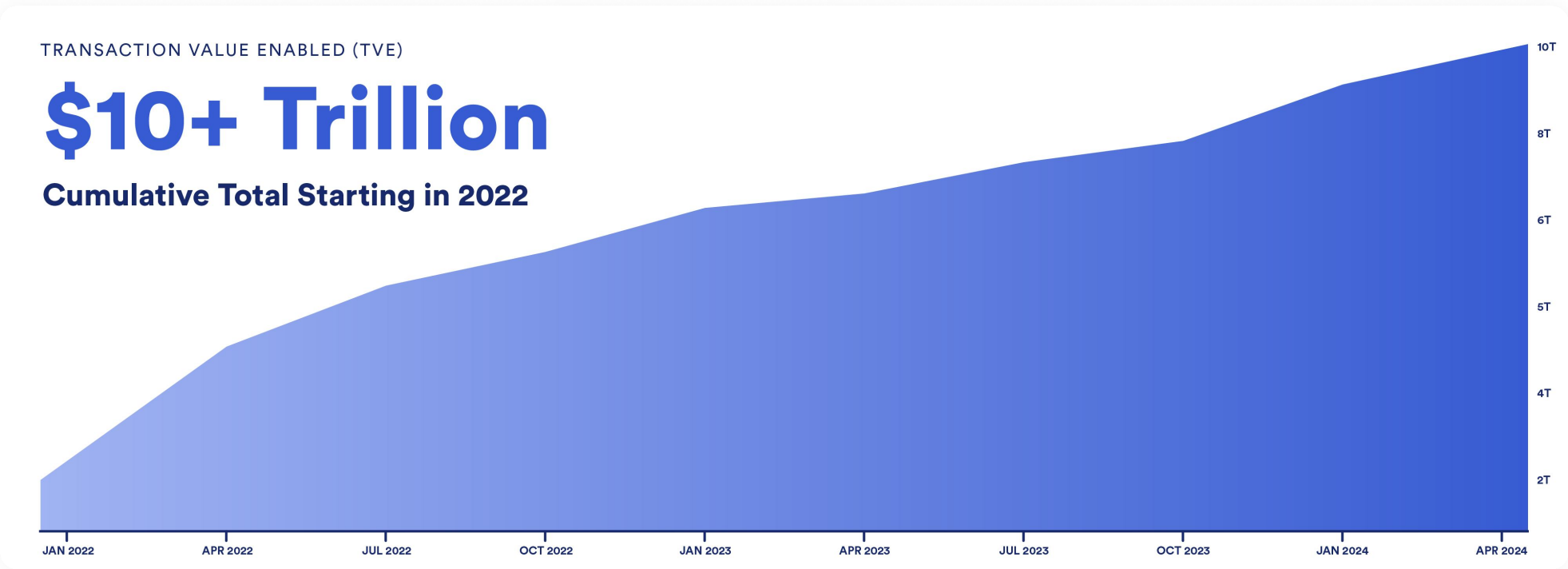
Chainlink is the only cross-chain interoperability platform that includes a way to manage various global policies through an independent Risk Management Network, which can help ensure compliance with regulatory rules and organizational policies. Chainlink enables institutions to apply predefined controls and limits across transactional activity, including policies around identity, KYC/AML, legal requirements, token pools, on/off ramps, organizational restrictions, and various forms of cross-chain security mechanisms.

Chainlink is critical infrastructure for providing each of these additional services needed to support liquid, secure, and compliant secondary markets for tokenized assets. Furthermore, the industry-leading security standards established by Chainlink can serve as a key risk management tool for asset managers, effectively enabling them to filter the trustworthiness of a tokenized asset based on various levels of verifiability and security put in place for servicing the asset.

## The Chainlink Platform

Chainlink is the industry-standard platform for onchain data, cross-chain interoperability, and blockchain abstraction. Chainlink Price Feeds went live in 2019 to serve the growing demand from the decentralized finance market for onchain access to high-quality, tamper-proof market data. Since then, Chainlink has turned into a fully fledged decentralized computing platform that has enabled $10+ trillion in transaction value, helping to secure tens of billions of dollars for the largest dApps in the decentralized finance ecosystem and propelling the digital asset industry through its initial adoption phase.

Now, with the emergence of the tokenization megatrend, the Chainlink platform can support institutions in enabling enhanced programmability, strategic optionality, and the highest possible level of security and reliability when bringing trillions of dollars of assets onchain.

TRANSACTION VALUE ENABLED (TVE)

# $10+ Trillion

**Cumulative Total Starting in 2022**

| JAN 2022 | APR 2022 | JUL 2022 | OCT 2022 | JAN 2023 | APR 2023 | JUL 2023 | OCT 2023 | JAN 2024 | APR 2024 |

# 12.5+ Billion

**Cryptographic Truth Data Points Delivered Onchain**

| JUL 2021 | JAN 2022 | JUL 2022 | JAN 2023 | JUL 2023 | JAN 2024 |

Chainlink services have a multi-year history of high uptime and tamper-proof security, even during the blockchain industry's most volatile and unpredictable conditions. Chainlink's unparalleled security standards have been pioneered by a world-class research team, including well-known researchers such as Ari Juels and Dahlia Malkhi, and enforced by decentralized oracle networks made up of independent, Sybil-resistant nodes operated by leading enterprises such as Deutsche Telekom MMS, LexisNexis, and Swisscom.

# Chainlink Node Operators

The Chainlink Network is powered by a geographically distributed collection of Sybil-resistant, security-reviewed node operators with significant experience running mission-critical infrastructure.

| 12.5B+ | 980+ | 17+ | 10+T |
|---|---|---|---|
| DATA POINTS DELIVERED ONCHAIN | TOTAL ORACLE NETWORKS | BLOCKCHAINS & L2S SUPPORTED | TOTAL VALUE ENABLED |

### Enterprise Nodes

Telecommunications firms with decades of experience operating backend infrastructure for the Web2 economy.

T··Systems   vodafone   swisscom

+ MANY MORE

### DevOps Nodes

Specialists in operating blockchain infrastructure such as PoS validators, PoW mining pools, and full node RPC providers.

coinbase CLOUD   INFURA   BLOCKDAEMON

+ MANY MORE

### Community Nodes

Organizations from within the Chainlink community that have demonstrated a high level of reliability and performance.

linkpool   Link River   LinkForest.io

+ MANY MORE

The Chainlink platform offers a variety of services that enhance a tokenized asset offering while introducing little-to-no additional trust assumptions when used in combination. Let's look at how these services enhance the programmability of tokenized assets while maintaining the highest standards of security.

## The Chainlink Platform

**CROSS-CHAIN**

**CCIP**
Move data and value between existing systems and any public or private blockchain. Architected with multiple decentralized oracle networks and a state of the art Risk Management Network, CCIP is the only interoperability protocol that operates at the fifth level of cross-chain security.

**DATA**

**Data Streams**
Leverage low-latency market data to power next-generation DeFi markets.

**Market and Data Feeds**
Integrate ultra-secure onchain data to trigger smart contracts in DeFi and beyond.

**Proof of Reserve**
Verify cross-chain and offchain reserves backing tokenized and wrapped assets.

**COMPUTE**

**Functions**
Connect a smart contract to any API and run custom computation in minutes.

**Automation**
Automate smart contracts in a decentralized way with time or event-based triggers.

**VRF**
Use verifiably random numbers to ensure fair outcomes in games, NFTs, and more.

## Interoperability

**KEY CONSIDERATIONS:**

- **Is the tokenized asset cross-chain enabled?**
  If not, it will likely have low liquidity and be inaccessible to many counterparties.

- **Is the tokenized asset using the most secure cross-chain protocol?**
  If not, it could be subject to numerous bridge hacks and exploits.

- **As an asset manager, can your backend system connect to all blockchains through one middleware integration?**
  If not, you will need to expend time and resources to connect to each chain individually.

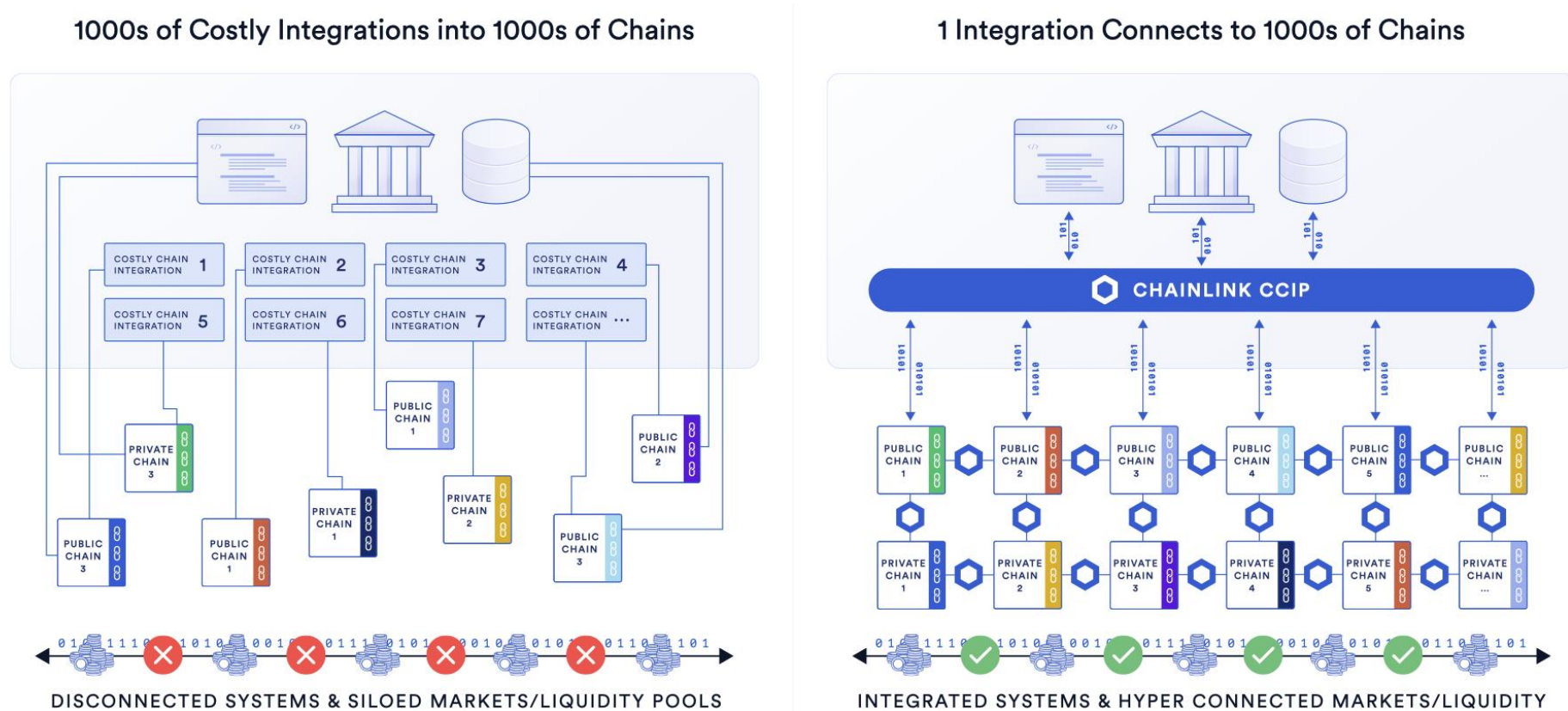A critical component of tokenized assets is the need for them to move across public and private blockchains. The blockchain industry is increasingly becoming multi-chain, as a variety of blockchain ecosystems already exist, with many banks, applications, and even asset issuers also wanting their own blockchains. At the same time, institutions should not have to pick a single blockchain or rearchitect their existing systems to interact with tokenized assets. Thus, if there is to be a robust and liquid market for a tokenized asset, it must be accessible to buyers and sellers across different blockchains. This necessitates secure cross-chain interoperability infrastructure, which can also serve as a single abstraction layer that enables institutions to use existing interfaces and messaging standards to interact with tokenized assets across all blockchains.
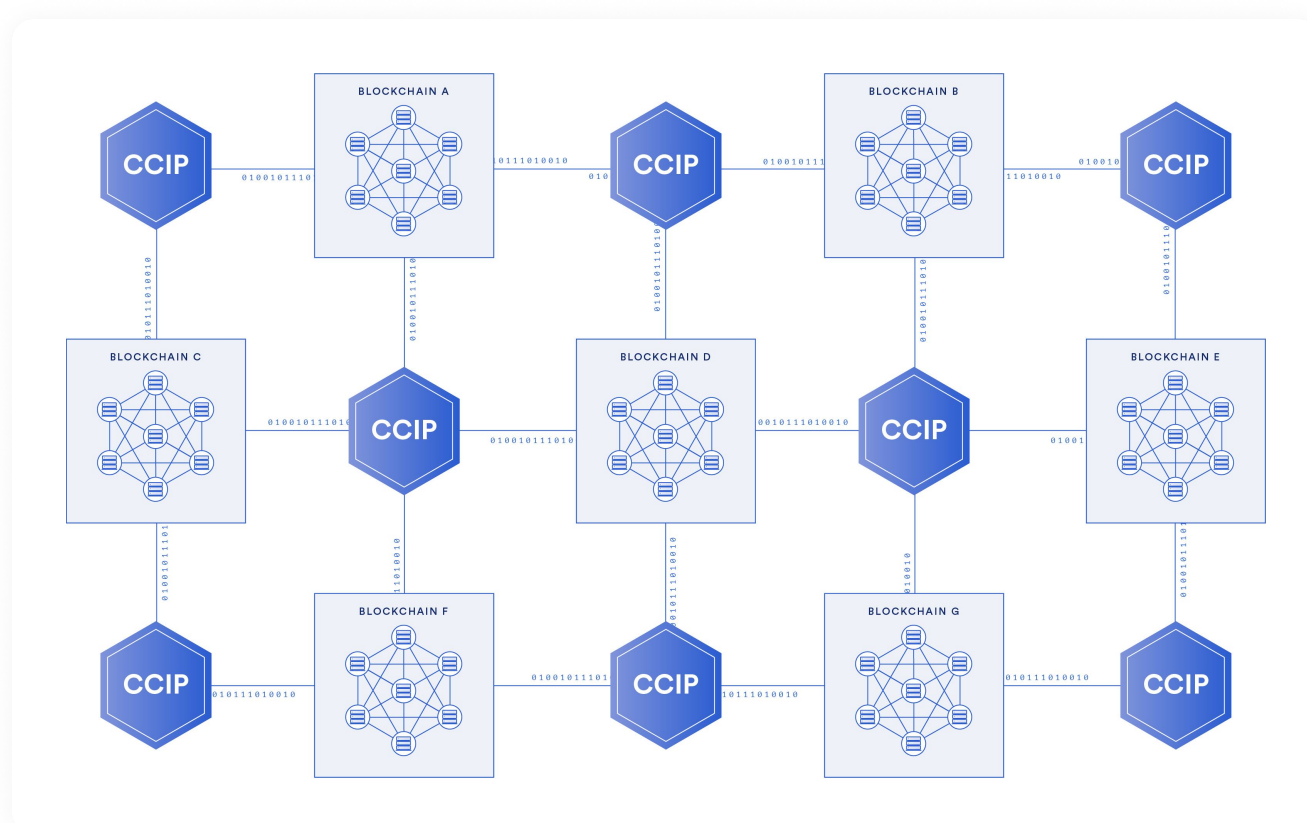


The problem is that blockchain interoperability is complex, hence why it is the most vulnerable and commonly targeted component of the tokenized asset tech stack. To date, there have been $2.8+ billion dollars lost due to cross-chain hacks and exploits. Given the level of risk involved, evaluating the security of the blockchain interoperability protocol used to move assets across blockchains is critical for asset managers when looking to move assets cross-chain on behalf of clients and evaluating cross-chain native tokenized assets they may want to purchase.

Chainlink Cross-Chain Interoperability Protocol (CCIP) is the most secure and reliable blockchain interoperability protocol in the industry. CCIP serves as both a blockchain abstraction layer for interacting with tokenized assets across blockchains directly from an existing backend system via a single middleware integration, and as a cross-chain messaging protocol for transferring data and tokens across public and private blockchains.

1000s of Costly Integrations into 1000s of Chains

1 Integration Connects to 1000s of Chains

DISCONNECTED SYSTEMS & SILOED MARKETS/LIQUIDITY POOLS

INTEGRATED SYSTEMS & HYPER CONNECTED MARKETS/LIQUIDITY

CCIP establishes level-5 cross-chain security by using multiple decentralized networks to secure a single cross-chain transaction. CCIP is the only cross-chain protocol with built-in oversight by an independent Risk Management Network, which monitors the network for anomalies and malicious behaviors and can trigger a temporary emergency shutdown if such activities are detected. The Risk Management Network has a completely different codebase written in a different programming language to the main CCIP codebase, was developed by a distinct development team, and is operated by a different set of oracle node operators from those validating cross-chain transactions on CCIP.

Notably, CCIP is the only cross-chain interoperability platform that includes a way to manage various global compliance and regulatory policies. Through the Risk Management Network, CCIP enables institutions to apply predefined controls and limits across transactional activity, including policies around identity, AML/KYC, legal requirements, token pools, on/off ramps, organizational restrictions, and various forms of cross-chain security mechanisms.
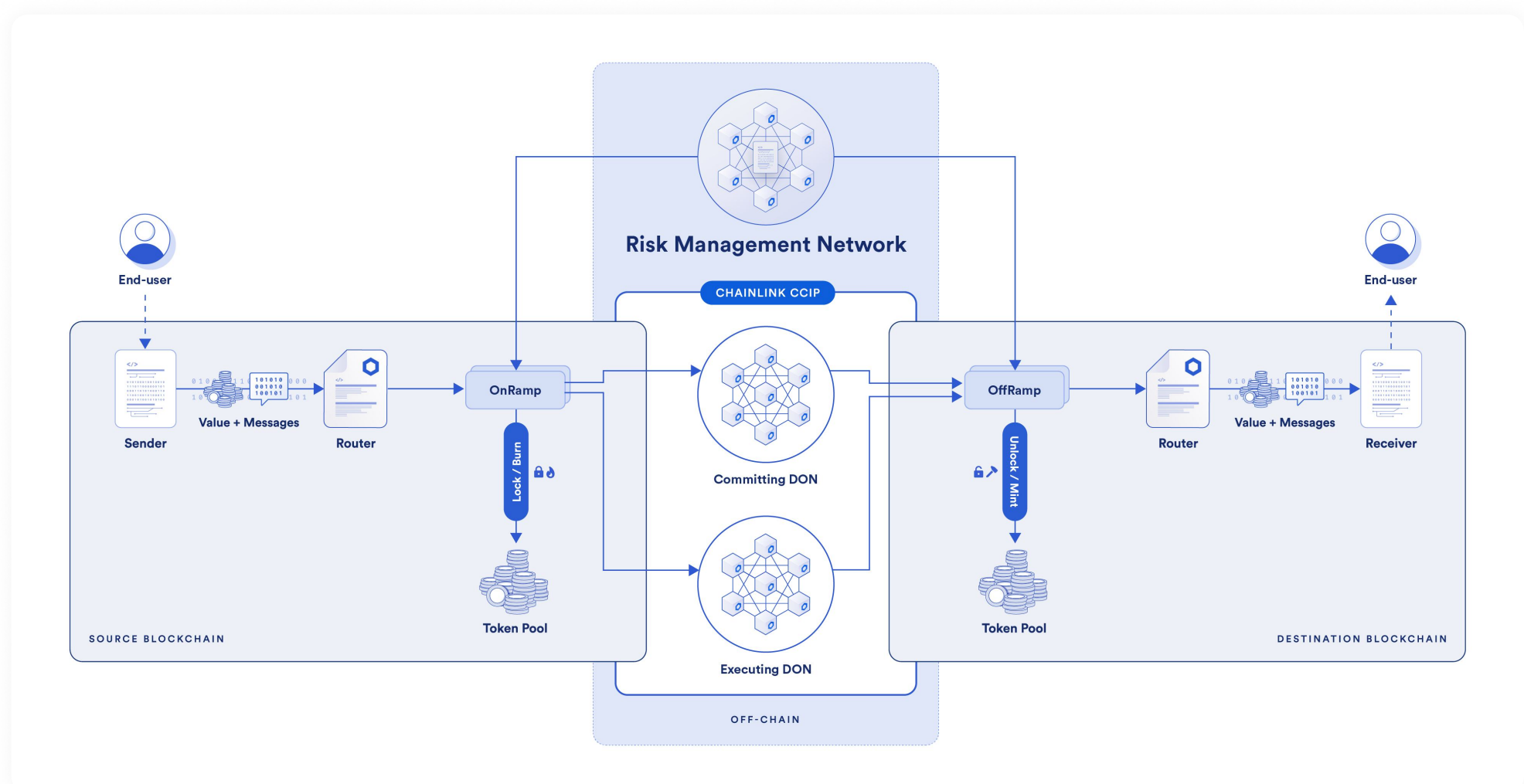


Major financial institutions and financial infrastructure providers are already collaborating with Chainlink on how to use CCIP to unlock the potential of blockchain technology and tokenized assets, including Swift, DTCC, and ANZ Bank.

# Proof of Reserve

**KEY CONSIDERATIONS:**

- **Does the tokenized asset have a secure proof of reserve mechanism?**
  If not, it could be susceptible to infinite mint attacks.

- **Is the minting mechanism of the tokenized asset secure and protected by circuit breakers?**
  If not, it could be susceptible to infinite mint attacks and the minting of unbacked tokens.

- **Does the tokenized asset have a transparent proof of reserves mechanism?**
  If not, user confidence in the asset may remain low.

- **Can automated circuit breakers be implemented for risk management?**
  If not, the tokenized asset may create toxic debt due to undercollateralization.

Since tokenized assets are onchain representations of an asset or basket of assets existing offchain (e.g., stored in a bank, with a third-party custodian, or on another blockchain), asset managers need information about the offchain or cross-chain reserves if they are to make informed decisions about buying or selling onchain tokenized assets. As a result, the ability to directly verify certain information about the reserves onchain is critical, especially when automating onchain asset management strategies.

When it comes to tokenized assets, there are five key reserve risks that must be considered.

1. **Market value risk:** The overall value of the collateral held by the issuers in one or many different custody accounts.

2. **Liquidity risk:** The depth at which the market could absorb a large redemption from an issuer without significant changes in quoted vs. transacted prices.

3. **Duration risk:** The sensitivity of the underlying collateral to interest rate movements.

4. **Liability risk:** Whether specific positions are pledged as collateral or on loan to other institutions.

5. **Minting risk:** The ability of the asset issuer to freely mint new tokens without security mechanisms in place that help prevent overminting.

Chainlink Proof of Reserve (PoR) enables the autonomous, reliable, and timely verification of offchain or cross-chain reserves backing tokenized assets. PoR utilizes oracle networks that attest to the cross-chain or offchain reserves backing tokenized assets, resulting in a transparent onchain audit trail for consumers, asset issuers, and other smart contract-based applications. Chainlink PoR sources onchain data (i.e., for wrapped assets such as WBTC), custodian APIs, or third-party offchain attestations (e.g., from reputable auditors).

Chainlink PoR can reduce risk and increase efficiency in a tokenized asset workflow by automatically supplying data pertaining to the risks outlined above prior to a purchase, which may be used to trigger circuit breakers, such as in the case that the asset's collateralization is found to fall below a predefined threshold. By proving the cross-chain and offchain collateral reserves backing tokenized asses, Chainlink PoR can promote better risk management by asset managers while also helping prevent systemic failure and contagion.
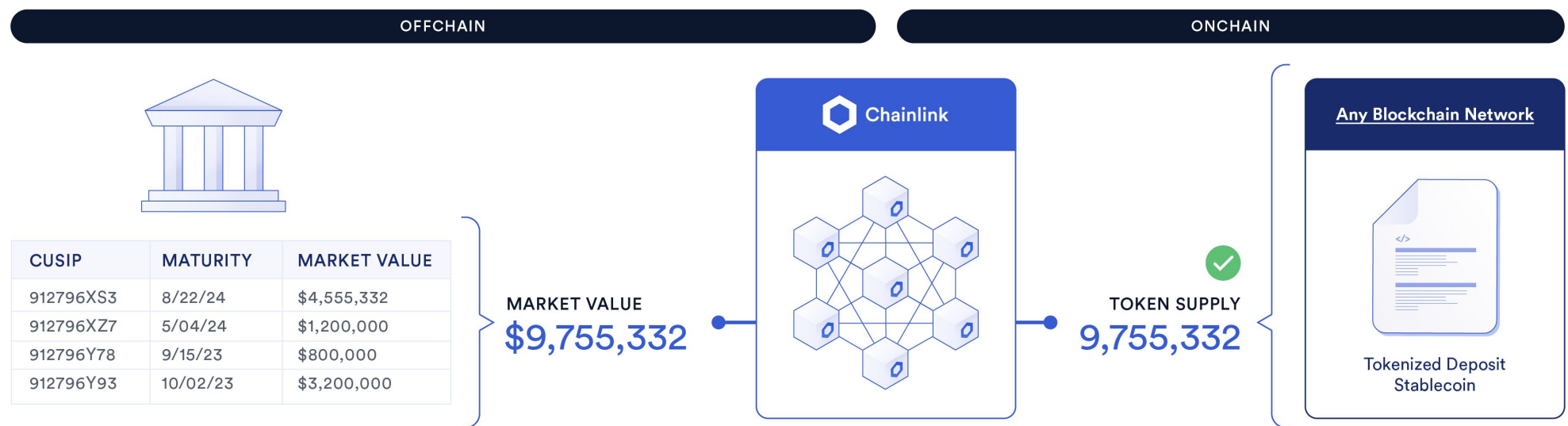
One of the key risks for tokenized assets is the minting of more tokens than the current market value of the offchain collateral. Chainlink PoR can be used to trigger a circuit breaker connected to the minting function of a tokenized asset, which prohibits the minting of more tokens if it determines that the collateral value fell below a certain threshold.
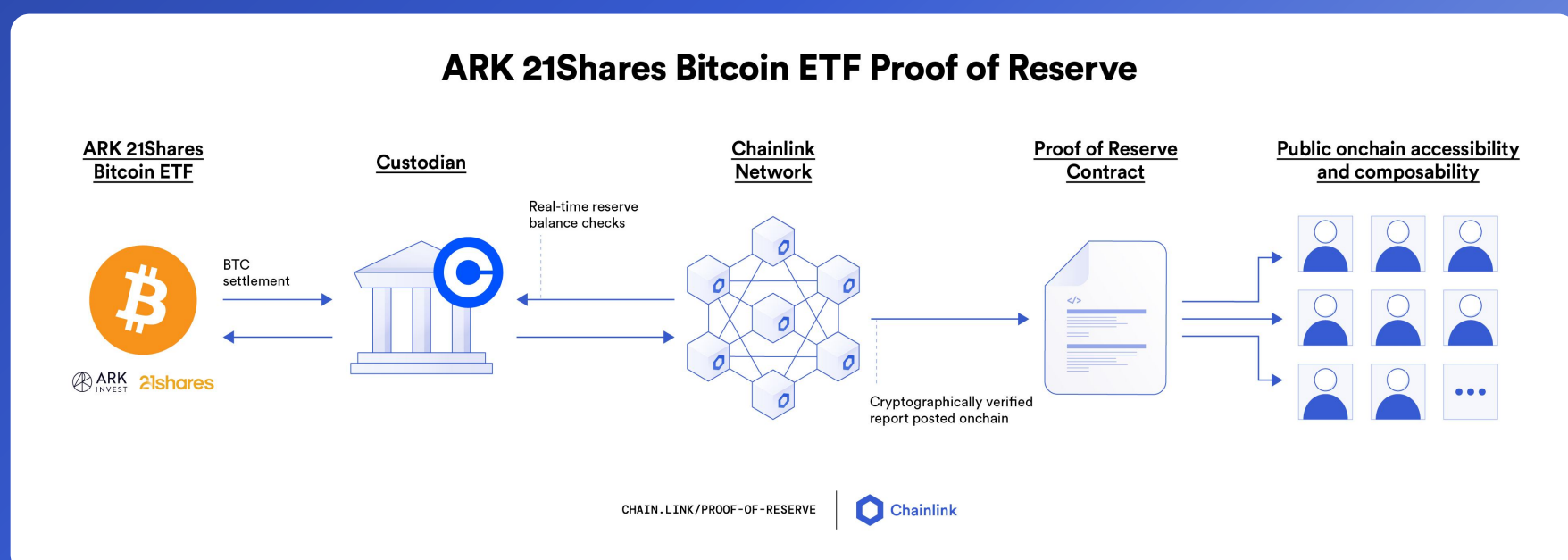
## CASE STUDY: 21Shares Integrates Chainlink Proof of Reserve to Increase Transparency of ARK 21Shares Bitcoin ETF

Asset managers Ark Invest and 21Shares launched the ARK 21Shares Bitcoin ETF, ARKB—a leading spot Bitcoin exchange-traded fund (ETF) with over $2.7 billion in assets under management.

21Shares integrated Chainlink Proof of Reserve on Ethereum to enhance the transparency of the Bitcoin reserves backing the ARK 21Shares Bitcoin ETF. By integrating Chainlink Proof of Reserve, 21Shares can offer clear visibility into ARKB's Bitcoin reserves.

With ARKB's underlying bitcoin reserve and reserve history publicly available through Chainlink Proof of Reserve, ARKB investors have increased assurances and confidence that ARKB is fully backed by Bitcoin holdings. This PoR feed is a type of offchain reserves feed that pulls reserves data directly from Coinbase. As Coinbase has direct access to the accounts or vaults holding the reserve assets, it can calculate the total value of reserves and report the data onchain via Chainlink oracles.

In the initial press release, Ophelia Snyder, co-founder and president at 21 Shares US, stated, "By integrating Chainlink, the industry leader in Proof of Reserves for tokenized assets, we're setting a new standard for combining transparency and security in digital asset management. This collaboration allows us to offer an unmatched level of insight and safety for our investors' holdings for ARKB, reinforcing 21Shares' commitment to leading the way in secure, transparent asset management."

### ARK 21Shares Bitcoin ETF Proof of Reserve

## CASE STUDY: Backed Integrates Chainlink Proof of Reserve to Increase Transparency of bToken Reserves

Backed issues onchain bTokens that represent ownership of a structured product, where each structured product is backed 1:1 by the underlying asset, and bTokens are redeemable for their cash value.

Backed integrated Chainlink Proof of Reserve to increase the transparency of its bToken reserves. This integration provides market participants with higher assurances that each bToken is backed 1:1 by the underlying asset.

Integrating an onchain data feed for bTokens via Chainlink Proof of Reserve enables DeFi protocols to have near real-time insights into the collateralization of bTokens, helping lower ecosystem risk in case of outlier events and increasing confidence in the redeemability of bTokens.

*"Asset managers see the benefits of tokenization and they are already making moves towards this. We believe in a future in which financial systems will be fully globalized, instantaneous, and run on blockchain rails. Backed is the tokenization platform that will enable this transition. Our approach has been to grow the ecosystem as fast as possible, and that requires secure and reliable third-party data infrastructure.*

*We are happy to have Chainlink as our close partners in bringing real-world data on-chain. The industry-standard Chainlink Price Feeds and Proof of Reserve support enhanced capabilities and bolstered security for our tokenized real-world assets."*

BACKED  **Adam Levi, Co-Founder at Backed**

## Data Services

> **KEY CONSIDERATIONS:**
>
> - **Does the tokenized asset have a secure proof of reserve mechanism?**
>   If not, it could be susceptible to infinite mint attacks.
>
> - **Is the minting mechanism of the tokenized asset secure and protected by circuit breakers?**
>   If not, it could be susceptible to infinite mint attacks and the minting of unbacked tokens.
>
> - **Does the tokenized asset have a transparent proof of reserves mechanism?**
>   If not, user confidence in the asset may remain low.
>
> - **Can automated circuit breakers be implemented for risk management?**
>   If not, the tokenized asset may create toxic debt due to undercollateralization.

Beyond proof of reserves, tokenized assets require connection to a variety of additional data sets to facilitate the full life cycle of transactions. Without data, tokenized assets remain a mere onchain representation of an offchain asset with no additional capability or utility. Not only will offchain data need to be relayed onchain, but onchain data will need to be relayed back offchain to keep offchain systems in sync with blockchain networks.

Important data that may need to be communicated between onchain and offchain systems include:

- **Exchange rates and trusted mark-to-market valuations** in order to properly price assets, determine collateralization of loans, and facilitate transactions that involve multiple currencies.

- **Status updates** to ensure offchain systems are aware of the current state of transactions and assets onchain.

- **Financial market data** such as liquidity profiles, interest rates, funding rates, dividends, and more in order to manage risk onchain and facilitate fair market transactions.

- **Compliance data** such as KYC/AML, counterparty restrictions, account or asset restrictions, legal requirements, and more in order to uphold regulatory rules and organizational policies.

- **Other data**, such as ESG data, proxy voting, settlement instructions, and more as a way to service assets onchain.

Given that oracle data automates the triggering of smart contracts, it's imperative that financial institutions carefully evaluate the security of the oracle protocol servicing the tokenized asset before launching or interacting with it. Oracle exploits are a well-known attack vector, with $500+ million dollars in oracle data-related exploits having occurred in DeFi to date.

Chainlink is the industry standard for market data in DeFi, having securely and reliably enabled over $10 trillion in transaction value for DeFi applications. Chainlink Data Feeds utilize decentralized oracle networks made up of reputable node operators to aggregate data from high-quality sources and deliver it onchain without any single point of failure.

**CASE STUDY: Paxos Adopts Chainlink's PayPal USD Price Feed**

PayPal launched its USD-backed PayPal USD (PYUSD) as a way to integrate blockchain technology into its payments platform. PYUSD is a programmable stablecoin backed by dollar deposits, US treasuries, and cash equivalents and is issued by Paxos, a blockchain infrastructure and tokenization platform regulated by the New York Department of Financial Services. PYUSD is transferable on Ethereum, where it can serve as collateral in DeFi protocols and facilitate onchain payments.

Reserves are held in US dollar deposits, US treasuries, and cash equivalents, helping ensure that customer funds are available for 1:1 redemption with Paxos. In addition, Paxos issues monthly reserve reports and attestations.

To accelerate the adoption of PayPal USD (PYUSD), Chainlink supports a PYUSD Chainlink Price Feed on the Ethereum mainnet. This PYUSD Price Feed helps provide Paxos and PayPal with highly accurate, reliable, and decentralized market data for PYUSD onchain, providing users the information needed to help create secure markets around PYUSD and integrate it to facilitate a variety of use cases.

PYUSD serves as an example of how Chainlink's enterprise-grade data infrastructure can help large enterprises and premier financial organizations enter and grow the onchain economy, advancing the use of tokenized assets across everyday use cases and helping scale the onchain financial system to billions of users across the globe.

> *"Asset managers have a significant opportunity to participate early in the tokenization market, as a vast amount of assets are set to move onchain to unlock better liquidity, transparency, and accessibility for financial markets. Paxos enables financial institutions and enterprises to issue tokenized assets onchain, while Chainlink's industry-standard platform helps enrich the tokenized assets with additional programmability and key capabilities."*

**PAXOS**    **Nick Robnett, Senior Director of Stablecoin Partnerships, Paxos**

# Identity

**KEY CONSIDERATIONS:**

- **Can identity information be confidentially shared between onchain and offchain applications?**
  If not, the servicing of the tokenized assets may be hindered.

- **Can an asset issuer verify who's interacting with the tokenized asset they have issued?**
  If not, prohibited users may interact with the token.

Since tokenized assets represent ownership of offchain assets, it can be important for asset issuers, financial market infrastructures, and asset managers to understand who owns those assets as both a way to meet certain compliance requirements and mitigate risk. However, revealing such sensitive information onchain for anyone to see is unfeasible, meaning the security of the oracle solution around maintaining privacy is critical.

Many databases hold sensitive information and are trusted by various users and institutions, including governments and large corporations, who value the high level of security provided by reliable custodians to safeguard their data. In such environments, identity oracles play a crucial role—they use a cryptographic technique known as a zero-knowledge proof to confirm the authenticity of data within these trusted databases or systems. Crucially, this process can be done without revealing the actual data to either the public or the oracle itself. The identity oracle can verify certain information, such as identity data and financial details, or access key governmental records without transferring any data out of the secure database. This method avoids spreading information across numerous systems with uncertain access security and enables institutions to store confidential information in trusted locations and control access to it selectively.
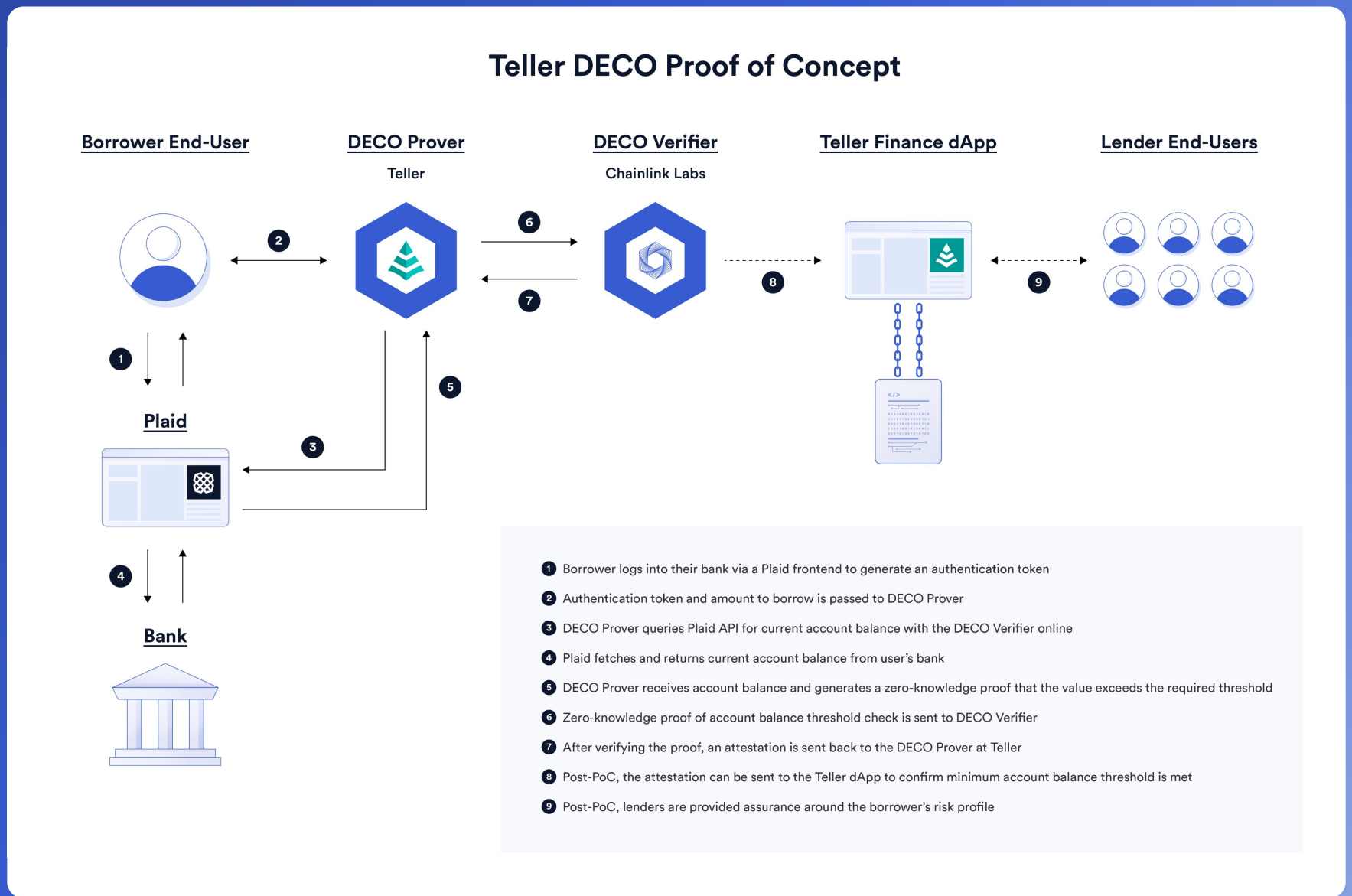
Chainlink DECO is a privacy-preserving oracle protocol in development that utilizes zero-knowledge proof technology to enable institutions and individuals to prove the provenance and verify the ownership of tokenized assets without revealing personal information onchain or to third parties.

# CASE STUDY: DECO Proof of Concept With Teller for Undercollateralized Lending

Chainlink Labs engaged in a series of alpha test proof of concepts with key partners to validate the functionality and viability of DECO in various smart contract use cases. DECO was used in the PoCs to generate zero-knowledge proofs that proved facts about sensitive information, which was sourced from a range of different data providers, all without compromising on data privacy or requiring server-side modification by data providers.

One of these PoCs was with Teller, a DeFi protocol marketplace for digital asset lending that supports undercollateralized loans. Teller used the DECO protocol to prove that the sum of a user's offchain bank accounts had a balance exceeding a dynamic threshold specified by the requested loan amount. If the sum of a user's account balances exceeds the threshold, then their risk profile as a borrower would be reduced, allowing for significantly lower collateral requirements for loans. For example, if a borrower requested a loan of $5,000, then the user would have to prove that they hold at least $5,000 US dollars in their bank account to showcase their ability to repay the loan.

With DECO, information about borrower creditworthiness can be proven without concerns around data privacy. Crucially, users are able to keep sensitive information like their name, financial status, and data access credentials private, while proving derived claims about themselves.



**Teller DECO Proof of Concept**

1. Borrower logs into their bank via a Plaid frontend to generate an authentication token
2. Authentication token and amount to borrow is passed to DECO Prover
3. DECO Prover queries Plaid API for current account balance with the DECO Verifier online
4. Plaid fetches and returns current account balance from user's bank
5. DECO Prover receives account balance and generates a zero-knowledge proof that the value exceeds the required threshold
6. Zero-knowledge proof of account balance threshold check is sent to DECO Verifier
7. After verifying the proof, an attestation is sent back to the DECO Prover at Teller
8. Post-PoC, the attestation can be sent to the Teller dApp to confirm minimum account balance threshold is met
9. Post-PoC, lenders are provided assurance around the borrower's risk profile

# Automation

A supporting piece of infrastructure for smart contracts that can create efficiency while ensuring the security of workflows is automation. For instance, asset managers may want to automate the buying/selling of assets or the rebalancing of customer portfolios based on time schedules or new market information. Furthermore, financial institutions may want to automate the cadence at which data is relayed onchain or automate functions within smart contracts, such as checking loan collateralization or distributing dividends. If certain trigger thresholds are met, then the automation infrastructure can call the smart contract function and reliably execute the predefined onchain action.

Chainlink Automation is an ultra-reliable, performant, and gas-efficient smart contract automation solution that enables users to offload their expensive onchain computation offchain to Chainlink decentralized oracle networks (DON) at a fraction of the cost while maintaining the same cryptographic guarantees. Chainlink Automation is an important component of the Chainlink platform as a way to connect and enhance other Chainlink services such as Chainlink Data.

# The Need for a Chainlink DeFi Yield Index



A CHAINLINK PRODUCT RESEARCH REPORT
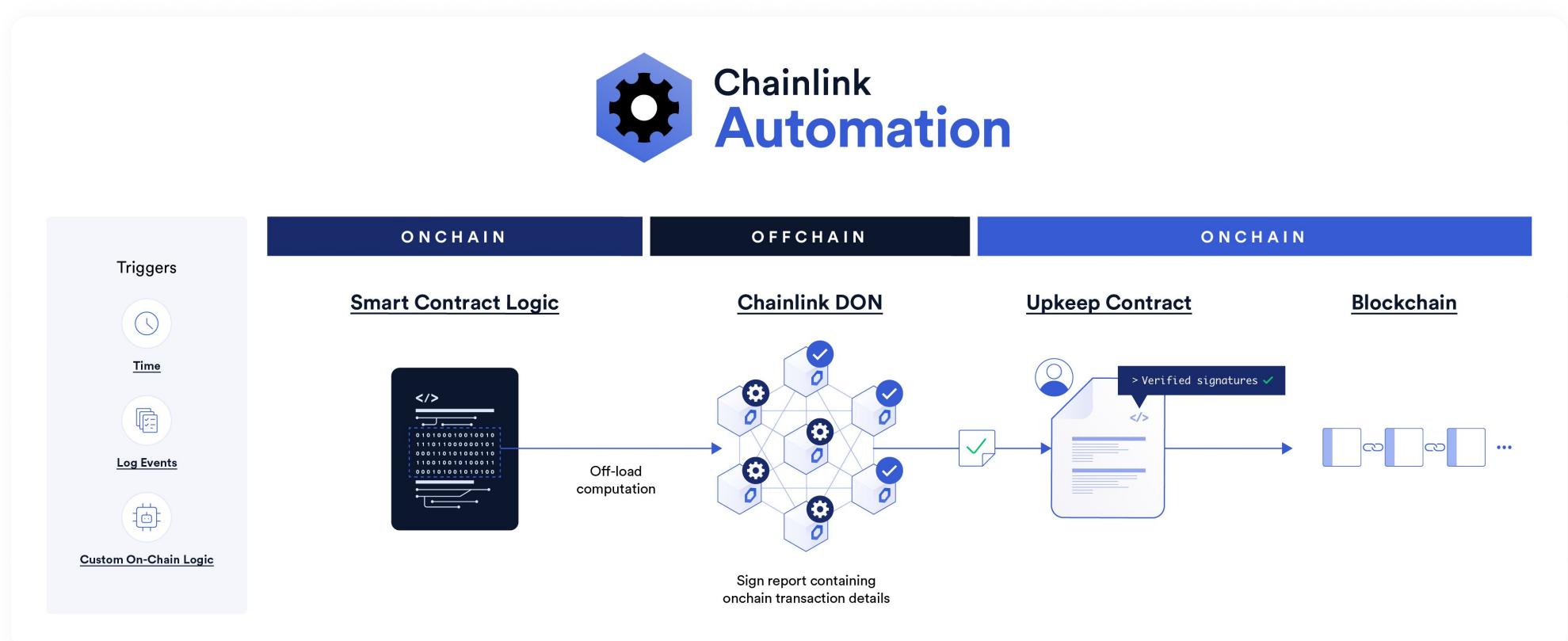
The Need for a
**Chainlink DeFi Yield Index**

◆ Chainlink

One example of how the Chainlink platform can enable more robust financial services is the Chainlink DeFi Yield Index (CDY Index)—an in-development data product introduced in a recent product research report.

The CDY Index aggregates market-wide DeFi lending rates and delivers them onchain to be consumed by smart contracts. Designed with a focus on accuracy, robustness, and market representativeness, the CDY Index would enhance the discoverability of onchain lending opportunities, improving capital efficiency and liquidity.

With a proven history of security and reliability, Chainlink is substantially qualified to construct an aggregate market-wide DeFi lending yield index because the Chainlink platform is deeply embedded in DeFi, and Chainlink's decentralized data aggregation methodologies have proven to be accurate and robust. Nearly all major lending protocols, including Aave and Compound, use Chainlink Price Feeds to power their functionality.

The Chainlink DeFi Yield Index will be able to offer enhanced opportunities for a variety of market participants:

- **Capital allocators** can discover yield opportunities they had previously not considered. The CDY Index will give traditional financial institutions a window into DeFi and help them evaluate new ways to earn yield, manage risk, and deploy capital more efficiently.

- **Lending protocols** can benefit from increased inflows facilitated by the CDY Index. More assets available for lending leads to higher fee revenue for the protocols, which can be used to enhance protocol features, security measures, and overall user experience.

- **Users** can benefit from higher liquidity as new inflows lead to deeper liquidity pools, reducing slippage and providing users with better access to loans or the ability to exit positions more efficiently. These benefits can attract more borrowers, leading to higher protocol revenue and potentially higher yield for liquidity providers.

To find out how your organization can benefit from the Chainlink DeFi Yield Index, reach out to our team.

# Capitalizing on the Tokenization Opportunity

The increasing adoption of tokenization and blockchain technology in asset management signifies a seismic shift in market infrastructure for the financial services industry. Now is the time for asset managers to position themselves at the forefront of this significant shift, ready to capture a piece of a major market opportunity.

The Chainlink platform stands as the gateway to this opportunity, helping asset managers bridge the gap between traditional and onchain finance. With its suite of tokenized asset services, the Chainlink platform enables asset managers to build secure and advanced programmability into their tokenized asset offerings while also serving as a risk assessment framework when evaluating the security and capabilities of other assets.
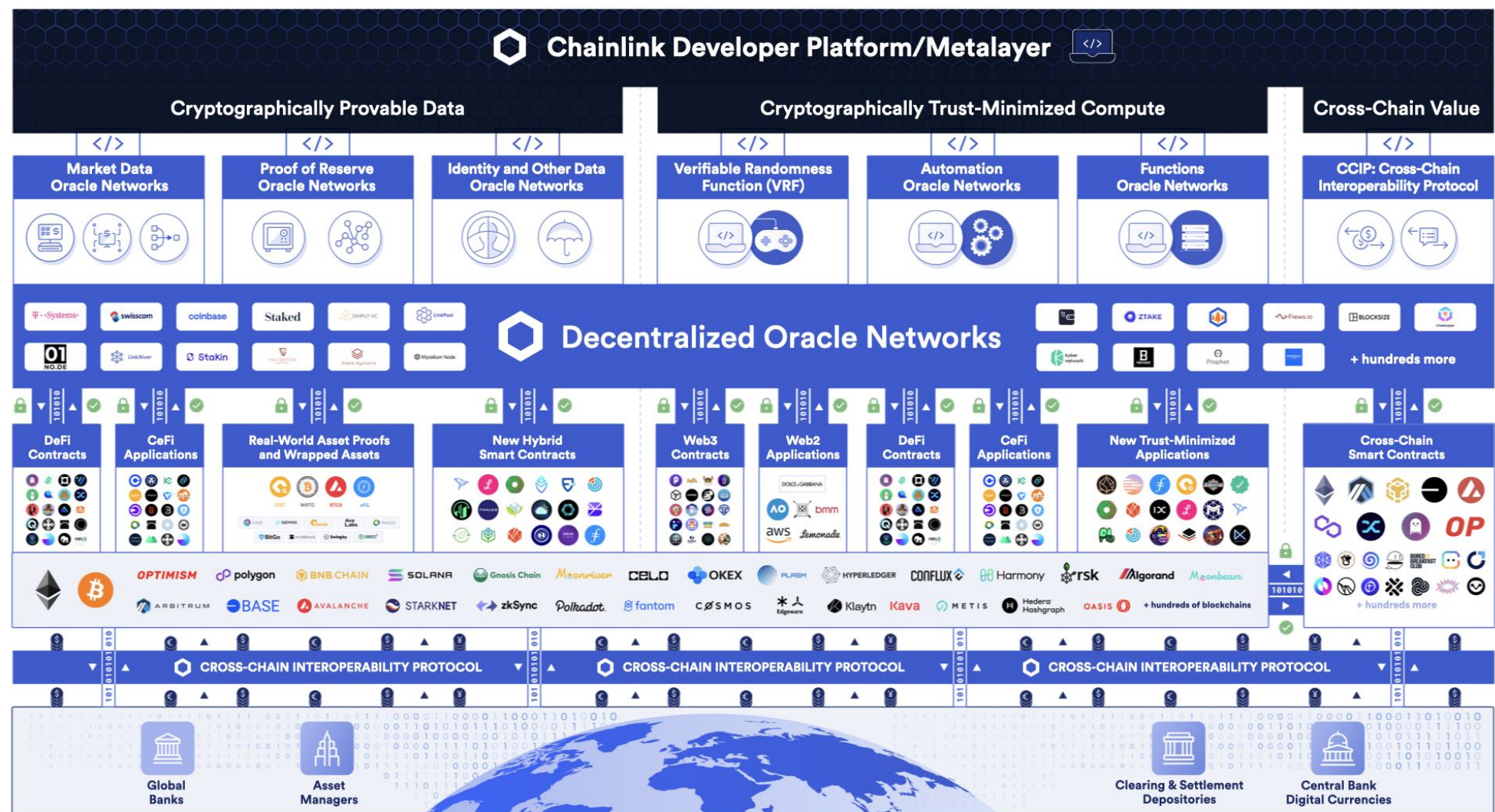


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If you're interested in how Chainlink can support your tokenization strategy, reach out to our team.