



APOLLO

The Future of Wealth Management

Ultra-efficient portfolios of traditional and alternative investments powered by tokenization

FOREWORD

J.P. Morgan



J.P. Morgan has been at the forefront of blockchain technology ever since we created Quorum (now Consensys Quorum), a business-focused Ethereum fork with embedded privacy, in 2015.

Reflecting on our blockchain achievements since then, the future always started with a bold idea.

In 2016, we envisioned a world where traditional assets could be represented on blockchains for seamless settlement and instantaneous exchange for cash. In 2019, we realized that vision through the creation of the JPM Coin System, a blockchain-based account ledger and payment rail, and in 2020 through the creation of Onyx Digital Assets, our multi-asset tokenization platform on which we have settled over \$900 billion of tokenized U.S. Treasuries to date, and through which we continue to bring innovative products to market.

In 2017, in collaboration with the Monetary Authority of Singapore (MAS), we envisioned a multi-bank payment network as part of Project Ubin, a project wherein we undertook a variety of technical explorations over multiple years. In 2021, we realized that vision with DBS and Temasek when we jointly launched Partior – the world’s first multi-bank blockchain network.

And today in 2023, in collaboration with Apollo, we have a new, bold vision: Creating a step change in the asset and wealth management industry through a new paradigm for portfolio management.

In this future, we envision personalized investment portfolios at scale, with vastly simplified and streamlined order execution and settlement processes, regardless of whether investing in traditional funds or alternative investments. A future where portfolios can be automatically rebalanced in real time, at scale, across blockchain networks. In its final form, we see wealth managers being able to include alternative investments in model portfolios, providing investors with better access to portfolio enhancing investments – not through sweeping changes to regulations or removal of investor protections, but through streamlined, automated processing and settlement of trades in an asset class-agnostic manner. This future is powered by blockchain technology, smart contracts and the tokenization of assets.

In the pages that follow, we expand on this vision and share details of an early-stage proof-of-concept that we have built – a seed of an idea, but one that we invite the industry to join us in making a reality, just like those early projects. We know this is a long journey, but as before, we believe we can get there.

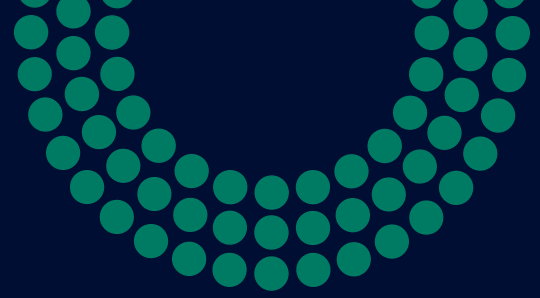
We wouldn’t have been able to execute on this project without our incredible collaborators. Thank you to Apollo, WisdomTree, J.P. Morgan Private Bank, Provenance Blockchain, Ava Labs, Oasis Pro, Axelar, LayerZero, and Bionomy, and of course, thank you to MAS for pioneering the way with Project Guardian.

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Managing Director, Head of Blockchain and Onyx Digital Assets
Onyx by J.P. Morgan

FOREWORD

Apollo



Apollo is in the business of empowering retirees, building and financing stronger businesses and helping to drive a more sustainable future. We aim to generate excess returns for our clients through our asset management business and provide a suite of retirement savings products through our retirement services business, Athene.

We define Alternatives as simply an alternative to publicly traded stocks and bonds. Alternatives seek to generate excess return per unit of risk across the risk-reward spectrum, from investment grade credit through to private equity. The benefits of including Alternatives in portfolio construction include access to a growing private markets opportunity set with the potential for excess risk-adjusted returns, greater diversification, and lower volatility profiles when compared to public markets equivalents. Empirical studies show that including Alternatives in a portfolio improves risk-adjusted returns while reducing volatility.

However, access to Alternatives has historically been limited to sophisticated institutional investors. We believe more retirees and individual investors should have greater access to institutional quality, diversified investment products, in formats tailored to their specific needs.

We are committed to democratizing access to Alternatives by developing a suite of investment and retirement savings products suitable for different individual investor needs, as well as investing extensively in education, including on-demand, no-cost content via Apollo Academy.

We are also investing in emerging technologies and rolling up our sleeves in the code to explore how we can make it as easy to invest in Alternatives as it is to invest in public stocks and bonds. We are curious about how young technologies can broaden access to institutional quality products while creating innovative and seamless client experiences.

We hope this technological project helps us level set on current state limitations and start an industry dialogue on how we can build the future of asset management together. To unlock the benefits of Alternatives for more retirees, we are investing in tomorrow's technology, today.

Industry collaboration will be key to the market infrastructure expansion required to expand access to Alternatives. Open-mindedness to how nascent technologies can create new experiences is a prerequisite.

Special thanks to the Monetary Authority of Singapore (MAS), J.P. Morgan, our digital strategy collaborators, industry thought partners, and Apollo's leadership team for actively participating on this journey into the future.

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Vision statement

Creating a step change in the asset and wealth management industry through a new paradigm for portfolio management

The continued development of multi-party, multi-asset shared ledgers with automated workflows - enabled by blockchain technology - has created new possibilities for asset and wealth management firms.

Within the wealth management industry, building and managing discretionary portfolios for wealthy individuals is a \$5.5 trillion business¹ that enables millions of investors to meet their financial goals. The top firms in this space have built robust and sustainable businesses that have delivered results for their investors. However, wealth management firms' ability to create innovative solutions and realize further efficiencies on today's legacy technology infrastructure is limited.

Blockchain technology, tokenization and smart contracts² could open a broader design space on which firms can build the next generation of managed solutions, including alternative investment funds that historically have been more difficult to access.

Alternative investments ("alts"), such as private equity, private credit, real estate, and infrastructure, can offer attractive risk-adjusted returns as well as portfolio diversification benefits, generally in exchange for less liquidity. As a result, some of the world's most sophisticated institutional investors allocate a significant portion of their assets to these investments. Demand from individual investors for alternative investments continues to grow, but adoption lags that of public and traditional investments. Key challenges stem from the less liquid nature of the underlying assets, limited access and a lack of investor and advisor education.

These challenges have limited the inclusion of alts in model portfolios, which are standardized investment solutions, typically designed and offered by private banks, wirehouses and registered investment advisors (collectively referred to as wealth managers in this paper), that represent different risk-return preferences and objectives for investors. Solving the alts-related challenges represent a massive opportunity for wealth managers – and potentially institutional allocators – to offer higher quality portfolios more efficiently. It also presents an opportunity for alternative investment managers to further distribute their solutions, and for investors to benefit from the financial security that comes from more resilient multi-asset class portfolios.

To-date, alternatives managers have focused on expanding individuals' access through the development of semi-liquid product structures. These products typically offer periodic liquidity that gives investors more flexibility compared to multi-year lockups of institutional funds, while still being an appropriate match for the underlying investment holdings.

¹ The Cerulli Report U.S. Managed Accounts 2023 Decisions About Discretion

² Tokenization refers to the process of representing an asset's ownership records on a multi-party, multi-asset, single-source shared ledger using blockchain technology, while smart contracts are self-executing computer code libraries that encode rules-based workflows and can automate asset and value transfer between multiple parties on the shared ledger.

Note: The information herein is provided for informational and discussion purposes only and should not be construed as financial or investment advice, nor should any information in this document be relied on when making an investment decision. All funds mentioned herein are hypothetical and for illustrative purposes only. Opinions and views expressed reflect the current opinions and views of the authors as of the date hereof and are subject to change. Please see the end of this document for important disclosure information.

Looking ahead, however, we believe these efforts can be significantly accelerated with the development of new capabilities in operational processing, availability of secondary liquidity by tokenizing fund positions on a shared ledger system, availability of detailed reporting and consolidation of fragmented investor ownership registries (which will continue to fragment with the emergence of tokenization across new blockchain network registries).

Our goal in this project, therefore, was to identify a technology approach that could enable a wealth manager to easily construct, deploy and automatically manage model portfolios at scale, across traditional and alternative assets, allowing a seamless investor experience with improved transparency.

In this paper, we present a proof-of-concept (POC) that demonstrates how emerging technologies, such as tokenization and smart contracts, could potentially achieve this goal.

The vision for this technology layer is to enable the management of many separately managed accounts at scale, preserving unique investor-level account customizations and reporting, while enabling the wealth manager to effect changes to all portfolios by adjusting their reference model portfolios. With the use of blockchain technology, it may be possible to expand the coordination and transaction of more types of assets across multiple managers on shared ledgers to accrue even more efficiency and expand the investable universe and potential liquidity. Testing these technologies, we aim to address the following:

- How can we improve the efficiency and scalability of order execution and settlement across multiple asset classes and ownership registries?
- How can we enable the inclusion of alternative investments in model portfolios, given their operational differences and limited liquidity compared to traditional public assets?
- How can we overcome the fragmentation and interoperability challenges posed by multiple ownership registries developed on different technology protocols?
- How can we simplify the use of multi-asset, shared ledgers through the abstraction of technical complexities unique to the use of blockchain technology?

Onyx by J.P. Morgan (Onyx) and Apollo approached this project from a solution-agnostic perspective and consulted with experts and practitioners within wealth management, alternative asset management and fund administration. Onyx and Apollo collaborated with a leading asset manager and pioneer in fund tokenization, WisdomTree, and invited input from several industry experts who are leaders in their respective fields: J.P. Morgan Private Bank, Provenance Blockchain, Ava Labs, Oasis Pro, Axelar, LayerZero, and Biconomy. Each participant contributed expertise and/or infrastructure to design and implement a technical POC that showcased the following capabilities:

- Ownership record-keeping across multi-party, multi-asset shared ledgers
- Automated portfolio deployment of cash into tokenized alternative investment and traditional investment fund vehicles³
- Cross-asset model portfolio rebalancing through automated order execution and settlement across alternative investments, public assets, and cash
- Communication and interoperability across ownership records
- Improved user experiences through the abstraction of back-end technical complexities³

³ Notably, the Singapore Variable Capital Company ("VCC") which has the flexibility to support open- or closed-ended funds and can potentially serve as the structure to underpin the investor's separately managed account envisioned in this POC.

This POC was conducted under the Monetary Authority of Singapore's (MAS) collaborative initiative, Project Guardian, which seeks to explore asset tokenization and cross chain interoperability on permissioned blockchain networks. This POC is one of several industry pilots that are taking place under Project Guardian. All of the infrastructure used in the POC was private and permissioned, and no real value was transacted.⁴

The main sections of this paper are as follows:

- **Current state:** describes limitations in discretionary portfolio management in the wealth management industry
- **Thesis:** describes how tokenization could harmonize the treatment of public and private assets in portfolio management, creating significant value for asset and wealth managers and investors
- **The proof-of-concept:** elaborates on delivering a scalable, next generation system for seamless portfolio management
- **Behind the scenes:** provides a technical deep-dive into the proof-of-concept
- **Key learnings:** elaborates on benefits and considerations
- **Industry call-to-action:** expands on how the future of wealth management combines public and private assets efficiently to deliver better portfolios

⁴ <https://www.mas.gov.sg/schemes-and-initiatives/project-guardian>

Current state

Limitations in discretionary portfolio management in the wealth management industry

Wealth management firms work with clients in a variety of capacities. Their offerings can generally be broken down as advisory or discretionary:

- **Advisory:** In an advisory or brokerage relationship, the wealth management firm provides an investor with advice, generally through a series of individual trade or fund recommendations. If the investor agrees, he/she can act on that advice, but the wealth management firm cannot act on the investor's behalf.
- **Discretionary:** In a discretionary relationship, the investor and portfolio manager (PM) agree on an investment objective, allowing the PM to make ongoing investment decisions on behalf of the investor without requiring further approvals. To provide this service at scale, the chief investment officers ("CIO") at these firms define *model portfolios* representing collections of assets combined to achieve different risk and return profiles. For example, a balanced ESG-focused portfolio would seek long-term capital appreciation with moderate volatility by investing in strategies across multiple asset types that emphasize sustainability. These model portfolios contain approved investments and recommended weightings by asset class as a template for PMs. An example model portfolio allocation may have 50% in equities, 30% in fixed income and 20% in alts.

Public assets such as equities, exchange-traded funds (ETFs), and mutual funds benefit from industry-wide settlement venues, straight-through processing technology, improved real-time access to asset and market data, a broader range of market participants, and therefore, increased liquidity and accessibility. As a result, these assets are well suited to the discretionary model.

In contrast, alts are commonly offered on an advisory basis, where a wealth management firm curates a short list of approved funds from which clients can select and invest. If clients agree to subscribe to these funds, wealth managers guide clients through the process; however, clients ultimately must complete the subscription documents themselves and direct the movement of funds. The result is that the process of subscribing individual investors to alts has embedded friction, which limits distribution at scale, despite the portfolio enhancing characteristics that alts can offer.

Problem statements

1. Adjusting portfolio allocations across asset types (both public and private) requires multiple systems, manual processes and multiparty reconciliation.

The process of adjusting portfolio allocations through transaction order management, execution and settlement involves multiple systems and manual intervention by disparate teams. It is not uncommon for PMs to manually calculate trades on spreadsheets and submit trade tickets to operations teams specializing in processing transactions for specific investment vehicles. The operations professionals then interface with the funds' transfer agents or trading venues to submit orders and coordinate cash movement. An extensive reconciliation process across multiple participants is required to ensure investors' cash and investment balances reflect the PM allocation plan. This process regularly occurs for dozens of investment options over tens of thousands of client portfolios.

These friction points also negatively affect client outcomes. Inefficiencies related to receiving cash proceeds from sell orders results in PMs maintaining a cash buffer to ensure they can simultaneously place buy orders. This excess cash is a meaningful opportunity cost for the end investor and prevents them from maximizing their potential returns.

2. Alternative investment funds are not commonly included in model portfolios due to operational processing requirements and limited liquidity

Portfolios that include alts have historically delivered better risk-adjusted returns than portfolios without them.⁵ Despite this, CIOs at wealth management firms are generally not facilitating robust allocations to private alts within their discretionary portfolios for two main reasons:

- Operational processing requirements can be high-touch, non-standard and fragmented.
 - Subscribing to alts typically requires paper-intensive subscription and redemption processes that do not easily scale to a broad swathe of investors.
 - Operational processing of alts involves coordinating across several stakeholders, such as fund administrators, transfer agents, general partners (GPs), wealth managers and distributors, and end investors.
 - Operationally cumbersome and manual complex reconciliations resulting from an ecosystem of disconnected systems, make it difficult to scale alternatives to a broader set of investors at lower allocation sizes.
 - Checking and detailed documenting of investor identity, AML/KYC status, and suitability creates significant frictions that discourages service providers from adding alts to discretionary portfolios.
- Liquidity is limited given the nature of the underlying investments and the less-mature market infrastructure technology.
 - Alts can generate excess returns compared to public assets because the underlying investment strategies have more flexibility to invest in higher returning assets that may be less liquid and held for a longer investment period. As a result, alts fund structures are less liquid than public assets.

⁵ <https://www.apollo.com/insights-news/insights/2022/07/how-alternatives-can-address-your-portfolio-blues.html>

Additionally, recommending an allocation to alts often presents a learning curve for both wealth managers and their individual investors. Unlike traditional assets like stocks and bonds, alts encompass a wide range of asset types, each with its own unique characteristics, risks, and potential returns. Understanding and explaining these nuances requires a significant amount of time, effort, and reference information, which can be daunting for wealth managers managing a large set of clients, and especially individual investors who may not be focused on learning about financial products full-time.

3. Access to and distribution of tokenized assets is fragmented across blockchain networks

In recent years, tokenization of assets has gained traction and adoption across industries, often to address the operational inefficiencies described above. The inherent capabilities of blockchain networks to unify bookkeeping and computation make it possible to leverage tokenization of traditional assets and the benefits that come therefrom.

While traditional assets have been represented on blockchain networks through standardized token representations and logic, these ecosystems have developed in a fragmented manner - creating tradeoffs where benefits are gained at the expense of aggregated liquidity. Consequently, dozens of permissionless public and permissioned private networks have resulted in isolated ecosystems, with disjointed users, applications, and liquidity pools. These networks employ different security models, consensus mechanisms, and development environments, preventing value and data flow between networks. This fragmentation has spurred the emergence of interoperability protocols that act as bridges that connect disparate digital islands. Just as tokenization standardized asset representation on-chain, interoperability solutions aim to standardize how these siloed ecosystems communicate to enable seamless cross-chain transactions while still allowing decentralized development to continue within each chain.

What is tokenization?

Tokenization refers to the process of representing an asset's ownership records on a multi-party, multi-asset shared ledger using blockchain technology, while smart contracts are self-executing computer code libraries that encode rules-based workflows to automate asset and value transfer between multiple parties on the shared ledger. This fusion of data and computation makes automated, near instantaneous settlement feasible by bringing together multiple asset types to share the same tech platform, transactional protocol, and tech standards.

The resulting normalization can enable significant improvement over today's lengthy, multi-party processes involving siloed data and costly reconciliations.

Over the past decade, two standard methods of tokenizing traditional assets have emerged:

1. **Asset-Backed Tokenization:** In this approach, the traditional asset continues to be recorded and custodied in existing legacy systems like transfer agent registries, bank ledgers, or trust company or custodian accounts. The traditional asset is immobilized in underlying ledgers and a digital pointer (in the form of a smart contract based token) is then created on a blockchain as a representation of an investor's claim on the asset. This establishes a digital twin of the traditional asset, similar to how depository receipts mirror securities held in custody. The value of asset-backed tokens is the same as the underlying asset – because the blockchain-based representation is not a new asset.

2. Native Asset Tokenization: In this approach, the financial instrument itself is issued natively as a smart contract based token on a blockchain, encapsulating the inherent contractual rights and obligations without requiring external asset backing. Bonds, equities, fund shares and many other financial instruments can be represented as native tokens. They are valued in the same way as 'non-blockchain' asset types but the books and records of ownership and transfer exist only on the blockchain without necessarily depending on legacy tech systems.

Tokenization of assets is a concept that has been around for several years, and steady progress has been made more recently to demonstrate how multiple asset types across multiple jurisdictions can be tokenized using both the asset-backed and native issuance approaches (See timeline on page 15).

In 2015, Ethereum was the first platform that uniquely enabled developers to build decentralized applications and deploy them on its public network. This sparked substantial experimentation, as developers leveraged Ethereum's ability to run compatible apps built anywhere. In 2016, institutions like J.P. Morgan adapted blockchain technology to represent traditional assets as tokens on private blockchain networks, entirely disconnected from legacy systems. Early small-scale experimentation with tokenized commercial paper, bonds, receivables and real estate demonstrated potential benefits. However, lack of connectivity to legacy infrastructure resulted in these efforts not reaching any meaningful scale.

After the initial waves of experimentation, a new model emerged that saw legacy systems integrate with blockchain networks. This made it possible for traditional assets to continue to reside on traditional ledgers, whilst creating “digital twins” on blockchain-based recordkeeping systems. By bridging legacy infrastructure with blockchain networks, traditional assets could be mobilized to take advantage of the efficiencies and automation that blockchains enabled. This integrated model has seen broad adoption, with trillions in financial instruments tokenized across permissioned institutional networks beginning in 2017.⁶

Overall, as interest in tokenization of traditional assets has grown and digital asset infrastructure has matured, many banks and fintechs now offer “tokenization services” to assist issuers in digitally issuing and distributing products on blockchain networks. Licensed providers that are integrated across multiple blockchains can bridge both permissioned and permissionless networks as well as legacy systems - offering a convenient on-ramp. For example, in this POC, Onyx tokenized representations of Apollo and WisdomTree funds on Onyx Digital Assets, J.P. Morgan's flagship multi-asset tokenization platform and Ethereum-based permissioned blockchain network, and Oasis Pro tokenized representations of other Apollo funds on a Provenance Blockchain permissioned zone.

The continued experimentation with tokenized assets by global financial institutions such as banks, custodians, fund administrators, and asset managers points to a potential future where multiple participants can transact across multiple assets types in a seamless and automated way, enabling new approaches to portfolio construction, management, and distribution at scale.

⁶ Onyx by J.P. Morgan; <https://www.broadridge.com/article/capital-markets/dlr-transacts-1-trillion-a-month>

Key milestones in Traditional Financial Assets Tokenization

Laying the foundations for the transformation of the global financial infrastructure



2016 - 2017

MAS Tested a digital representation of SGD for interbank settlement on R3 Corda, with privacy on permissioned Ethereum (Quorum)
J.P. Morgan, National Bank of Canada Issued \$150mm certificate of deposit on permissioned Ethereum (Quorum)
MAS Tested Interbank Real-Time Gross Settlement Systems across R3 Corda, Hyperledger Fabric, and permissioned Ethereum (Quorum)
LuxDeco Issued bond denominated in ether on Ethereum
Tether Surpassed a market cap of \$1bn USD Stablecoin, USDT, on Ethereum



2018

Credit Suisse, ING Conducted €25mm securities lending transaction on R3 Corda
Sberbank Completed ₱750mm rubles commercial bond transaction on Hyperledger Fabric
MAS, SGX Developed DVP capabilities to enable asset settlement on permissioned Ethereum (Quorum) and on permissioned Anquan
World Bank, Commonwealth Bank of Australia Issued AU\$110mm bond on permissioned Ethereum (*Bond-i*)
Paxos Issued USD Stablecoin, USDP, on Ethereum
Centre (Circle, Coinbase) Issued USD Stablecoin, USDC, on Ethereum
St. Regis Aspen Issued real estate equity on Ethereum
Komgo Issued digital letter of credit on permissioned Ethereum



2019

J.P. Morgan Launched USD payments product, JPMCoin, on permissioned Ethereum (Quorum)
BBVA Issued green structured bond on Hyperledger Fabric
Societe Generale Issued €100mm covered bond on Ethereum
MAS, Bank of Canada, Bank of England Tested cross-border and cross-currency CBDC payments on permissioned Ethereum (Quorum) and R3 Corda
Franklin Templeton Recorded money market fund share ownership on Stellar
Santander Issued \$20mm bond on Ethereum
Paxos Recorded allocated gold ownership on Ethereum
Bank of China Issued ¥19.4bn bond on Neo



2020

Jefferies, Nomura, Tilden Park Capital, DoubleLine Issued asset-backed security based on \$159mm loans originated on Provenance Blockchain
Vanguard Completed pilot of asset-backed security on Symbiont DLT
MAS, Temasek, J.P. Morgan Developed multi-currency payments network supporting DVP settlements, conditional payments and escrow for Trade, and payment commitments for Trade Finance on permissioned Ethereum (Quorum)
Olam International, SGX, HSBC, Temasek Issued S\$400mm syndicated bond on Canton
J.P. Morgan Launched Intraday Repo with U.S. Treasuries and USD (JPMCoin) on permissioned Ethereum (Onyx Digital Assets)



2021

DBS, J.P. Morgan, Temasek Launched Partior, platform to digitize M1 commercial bank money to reduce current frictions and latency for cross-border payments, trade transactions and foreign exchange settlements on permissioned Ethereum (Quorum)
EIB, Goldman Sachs, Santander, Societe Generale Issued €100mm bond on Ethereum
Societe Generale Issued €5mm structured note on Tezos
Arca Labs Issued 40 Act Treasuries Fund on Ethereum
Banque de France, Euroclear Completed pilot settlement of French Government Bonds for CBDC on Hyperledger Fabric



2022

Apollo Completed origination and ownership transfer of digital mortgages on Provenance Blockchain
BlockTower, MakerDAO Issued \$220mm credit fund on Ethereum
BNP Paribas Issued renewable energy bond on Ethereum
BNY Mellon, Goldman Sachs Executed agency securities lending transactions on R3 Corda (HQLAx)
KKR Enabled access to private equity fund on Avalanche
Apollo Enabled access to private fund on Provenance Blockchain
Hamilton Lane Enabled access to private equity and private credit funds on Polygon
J.P. Morgan Executed FX transaction (SGD/JPY) on Polygon, as part of MAS Project Guardian
EIB, Goldman Sachs, Santander, Societe Generale, Banque de France, Banque Central du Luxembourg Issued €100mm bond on permissioned Canton (GS DAP)
Sberbank Recorded gold ownership on Hyperledger Fabric, accessible by Ethereum
WisdomTree Enabled access to a variety of mutual funds on Ethereum and Stellar



2023

EIB Issued £50mm bond on Hyperledger Fabric (HSBC Orion)
HKMA Issued HK\$800mm green bond on both permissioned Canton and Hyperledger Besu
Siemens Issued €60mm bond on Polygon
Franklin Templeton Issued 40 Act money market fund on Stellar and Polygon (last reported AUM of \$270mm as of April 2023)
Paypal Issued USD Stablecoin, PYUSD, on Ethereum
Citi Agented over \$900bn in syndicated loan commitments on Canton (Versana)
UBS Issued VCC money market fund on Ethereum, as part of MAS' Project Guardian
J.P. Morgan, Blackrock, Barclays Tokenized money market fund shares for collateral on permissioned Ethereum (Onyx Digital Assets)
J.P. Morgan, Apollo, WisdomTree Tested automated discretionary portfolio construction and rebalancing across multiple asset types (USD, private funds, mutual funds) on permissioned Ethereum (Onyx Digital Assets), Provenance Blockchain, and Avalanche, as part of MAS' Project Guardian

Disclaimer: This list is not comprehensive of all tokenization events.

Sources: Apollo, BBVA, BlockWorks, Bloomberg, BNP Paribas, Business Insider, Business Wire, Centrifuge, Coindesk, Cointelegraph, Credit-Suisse, DTCC, Euroclear, Fintech News, Finyear, Forbes, Franklin Templeton, Global Finance, HKMA, HSBC, Ledger Insights, Marketplace Capital, NBC, Reuters, Santander, Siemens, Societe Generale, Vanguard, World Bank, Yahoo

Note: Following Consensys' August 2020 acquisition of Quorum, the project was rebranded to Consensys Quorum.



Thesis

Tokenization could harmonize the treatment of public and private assets in portfolio management, creating significant value for asset and wealth managers and investors

Taking meaningful steps towards realizing our vision revolves around delivering two key theses.

1. Creating new, connected infrastructure can streamline, simplify and normalize the investment and operational processes related to building and managing portfolios

This technology change could revolutionize the wealth management business by fundamentally redesigning how portfolios are accessed, assembled and managed. Ultimately, we believe this could result in providing clients with better access to higher quality investment portfolios in a more efficient and personalized manner.

Achieving this could revolutionize the discretionary portfolio management business by enabling the seamless deployment and automatic rebalancing of a large number of portfolios. Additionally, it could make the case for including alts in discretionary model portfolios significantly stronger as operating standards between traditional assets and alts converge. Successful implementation in the near term would be most beneficial to the group of individual investors who are currently able to invest in alts (but may be under-allocated). Examples of these investors include Qualified Purchasers, Accredited investors, and knowledgeable employees of asset managers. They could find it easier to initiate or increase their portfolio allocation to alts, which could grow the demand for alts without any change to investor suitability requirements.

2. The tokenization of alts can reshape the alternative investment landscape, making it more inclusive, transparent and efficient

Once a small allocation, alts have now become a core investment strategy for institutional investors. These investments—which include non-traditional asset classes such as private equity, private credit, real estate and infrastructure – have emerged as a cornerstone of institutional investor allocations, while individual investors have largely missed out on higher-quality portfolios.

We believe tokenization can increase access to alts by simplifying downstream processes and reducing cumbersome operational workflows. When combined with potentially improved liquidity, tokenization could enable PMs to include private alts into discretionary portfolios, improving their quality in the process.

More broadly, the tokenization of private alts funds represents a \$400 billion annual revenue opportunity for alts fund managers and distributors.⁷ Including these investments in model portfolios and developing new client-friendly features such as automated capital calls and investor-level personalization could help unlock this opportunity.

⁷ Source: Revenue opportunity estimates are based on projections from Bain and Onyx by J.P. Morgan's market research.

Potential benefits to validate

- **Greater efficiency:** Leveraging smart contracts to represent and record the ownership of assets could collapse the PM and operations roles into a single automated process, enabling portfolios to be deployed and rebalanced programmatically at scale. The presence of cash and fund ownership records on a shared ledger, combined with smart contract-enabled trade execution, could limit the need for costly reconciliations and occurrence of trade errors. At scale, the time and cost savings could allow wealth managers to reinvest in research and client-facing services like educating clients on how alts could fit into their portfolios. Efficiency benefits could accrue to others in the ecosystem as well, including asset managers, fund administrators, and other service providers.

From an investor perspective, eliminating these friction points could enable PMs to be fully invested more consistently, meaning their portfolios would experience less cash drag. Assuming the average PM holds ~3% cash and a balanced portfolio could generate ~8% over cash in the long-term, the net result to a client is a ~24bps reduction in costs.⁸

- **Potentially improved liquidity:** Given the ease of sharing information across multiple parties on the same ledger system, and the ability to easily transfer ownership of tokenized assets, representing assets such as alts on a blockchain could potentially facilitate better liquidity markets for these assets. Today, selling an alts holding on a secondary market is typically a manual process negotiated on a bilateral basis. This can become problematic for individual investors, as oftentimes their holdings are not large enough to attract buyers given the time and paperwork required to complete a transaction. Simplifying these operational processes using smart contracts, coupled with alternative liquidity methods, such as the automated netting of subscriptions and redemptions, could add additional liquidity levers.
- **Enhanced investment outcomes through alternative investments:** Streamlined processes and enhanced liquidity, as described above, could allow alternatives to be included in model portfolios and improve expected returns for investors and/or reduce volatility. It may also be possible to automatically rebalance portfolios based on changes to model portfolios, which could minimize deviations from target asset allocations, resulting in portfolios that align better with their optimal state.
- **Combining the efficiency of robo-advisory with the alpha of active management:** Automated portfolio construction and management could provide a streamlined experience similar to robo-advisory offerings, but with a dedicated PM and higher potential returns through three sources of alpha: 1) the inclusion of alts; 2) manager due diligence on active strategies (e.g. identifying a top large cap growth fund); and 3) setting top-down asset class allocations based on CIO macro insights.
- **Flexibility and broader access:** Leveraging interoperability solutions to connect distinct blockchain networks could provide access to tokenized investments across disparate chains, allowing PMs to build holistic solutions with the inclusion of these investment opportunities, which otherwise might not be accessible.

⁸ Cash drag is calculated assuming a 3% allocation to cash could be invested in a portfolio earning 8% over the long-term, the product of which is 24bps.

The proof-of-concept

Delivering a scalable next-gen system for seamless portfolio management

With our vision, problem statements and thesis defined, we constructed a POC to prove how portfolio management systems built using new technologies, such as blockchain and smart contracts, could provide the early-stage proof points needed to validate our assumptions.

We looked to demonstrate one simple, yet powerful, idea in the POC:

Enable a portfolio manager to seamlessly manage a large number of discretionary portfolios, comprised of an array of tokenized traditional and alternative investments across various blockchains, all whilst preserving unique investor-level account customizations.

To execute this idea, we brought together a multifaceted group of fund managers, blockchain infrastructure providers, interoperability solutions and tokenization platforms to work in concert to create an end-to-end ecosystem of assets and connected networks.

In recognition that blockchain technology and blockchain ecosystems are still relatively nascent, we wanted to explore a diversity of protocols and solutions. Specifically, we wanted to connect Ethereum Virtual Machine (EVM) and non-EVM blockchain networks and to experiment with different interoperability design paradigms.

Furthermore, we sought to explore how modern architectures, enabling permissioned public blockchain infrastructure instances, could be leveraged.

To explore how the solution could provide frictionless user experiences to traditional wealth managers, we leveraged Account Abstraction technology that removes the complexities of managing keys and holding cryptocurrencies that are typically required in some networks to pay for network fees.

Finally, we designed a front-end portfolio construction and management prototype called Crescendo to illustrate how to bring the vision to life for both PMs and investors.

We set up the POC as follows:

- Onyx Digital Assets was used as the base chain that connected to other blockchain networks in the project via designated interoperability solutions. Onyx Digital Assets is a general-purpose tokenization platform that Onyx established in 2020 and has processed more than \$900 billion of tokenized assets since launch. As an EVM blockchain with connectivity to J.P. Morgan infrastructure, Onyx Digital Assets provided the optimal launchpad for executing the POC.
- A representative PM established discretionary portfolios, model portfolios and cash balances for investors on Onyx Digital Assets. Each discretionary portfolio was linked to a specific model such that the portfolio would track the target asset allocation as defined in that model.⁹
- Representative traditional and alternative investment strategies (fund vehicles) from J.P. Morgan Private Bank, Apollo and WisdomTree were tokenized on three blockchain networks: Onyx Digital Assets, Provenance Blockchain and Avalanche. All three instances were established as permissioned networks—a permissioned zone in the case of Provenance Blockchain, and a permissioned subnet in the case of Avalanche (for ease we will refer to these permissioned instances simply as Provenance Blockchain and Avalanche). A standardized token, the Onyx Digital Assets Fungible Asset Contract (ODA-FACT), was used to enable consistent interaction and represent funds on each network. Using the ODA-FACT token standard, Onyx tokenized J.P. Morgan, Apollo and WisdomTree funds on Onyx Digital Assets, and WisdomTree funds on the Avalanche chain. Oasis Pro tokenized Apollo funds on Provenance Blockchain.¹⁰
- Interoperability solutions were put in place to provide connectivity between the networks. Specifically, Axelar was used to connect Onyx Digital Assets (an EVM chain) to Provenance Blockchain (a non-EVM chain), and LayerZero was used to connect Onyx Digital Assets to Avalanche (also an EVM chain).
- Account abstraction infrastructure and contracts were established on Avalanche to enable “gasless” interactions for the fund manager operating on that network through Biconomy.

⁹ The model portfolio allocations illustrated in this report and POC are not intended to represent actual model portfolio allocations. Instead, these are representative allocations used to demonstrate the technological capabilities of the POC.

¹⁰ Please note: WisdomTree tokenizes WisdomTree digital funds today through their own tokenization platform and transfer agency. This proof of concept is intended to showcase the end-to-end ability to streamline portfolio management processes and is not intended to be representative of WisdomTree’s existing infrastructure for tokenized funds in the market today.

With the infrastructure in place, we executed a series of tests to demonstrate what the next generation of portfolio management could look like:

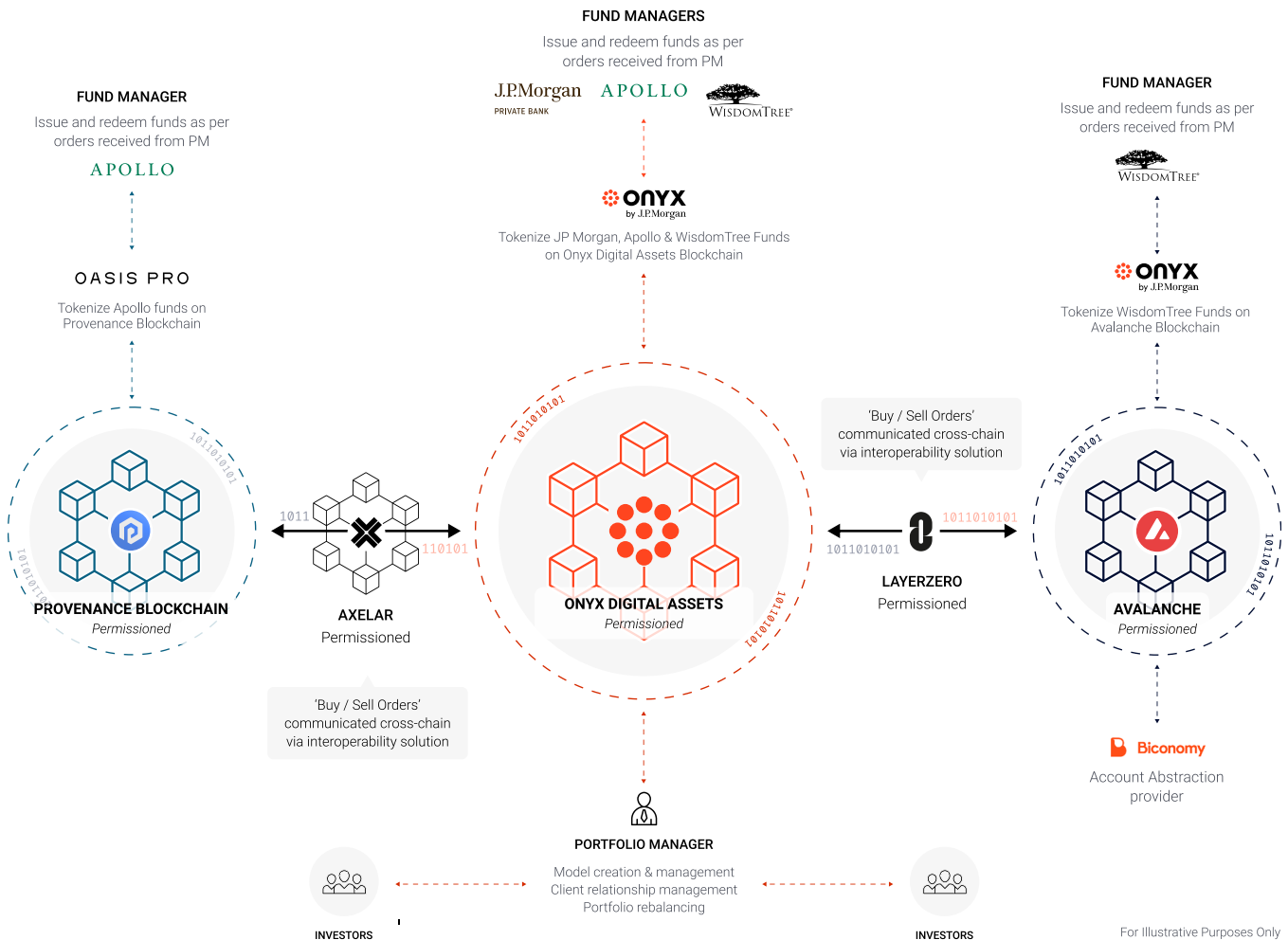
Notably we showed that the PM was able to update the target asset allocation for a given model (i.e., replace one asset for another), and the system automatically rebalanced all investor portfolios that tracked that model by initiating, placing and settling orders to redeem from and subscribe into the relevant funds, even though those funds were held on three different chains.

Additionally, we showed that when an investor deployed more capital for investment, the system could automatically place and settle orders in the right allocations according to the model, irrespective of what asset types were included in the model, or on which chain those assets were recorded.

Essentially, by tokenizing funds and representing discretionary portfolios as smart contracts, we showed how tens of thousands of portfolios could be programmatically linked to representative models and automatically rebalanced en-masse when changes to those models occurred—even when these models included alternative investments.

The multi-chain, multi-portfolio, multi-manager POC ecosystem and the Crescendo portfolio management solution are illustrated in the images below.

End-to-end portfolio management & interoperability POC



MSCI WORLD - MTD. ↑ 5.6% YTD. ↑ 10.0% S&P 500. ↑ 5.5% ↑ 10.0% BARCLAYS GLOBAL AGG. ↑ 2.0% ↑ 4.5%

ONYX by J.P. Morgan Crescendo

CONNECTED

Model Dashboard

Dashboard Clients Resources CREATE NEW +

Overview
Key stats, latest resources and recommended actions
840 clients

Conservative
Capital preservation focus with a lower risk / return profile
YTD Returns ↑ 7.2%
120 clients

Balanced
Capital appreciation focus with a moderate risk / return profile
YTD Returns ↑ 8.2%
80 clients

Growth
Capital appreciation focus with a higher risk / return profile
YTD Returns ↑ 7.4%
85 clients

Conservative ESG
Lower risk / return profile with an emphasis on sustainability-focused investment strategies.
YTD Returns ↑ 8.2%
110 clients

Growth ESG
Higher risk / return emphasis on sustainable investment strategies.
YTD Returns ↑ 9.5%
110 clients

Welcome Cathy

Total AUM: \$4.9 bn

Total Models: 7

Total Clients: 840

Settlement Networks: Onyx Digital Assets, Provenance, Avalanche

Model Risk / Return Projection

Model Performance Overview
Cumulative performance comparison of all active models
ALL 3Y 12M 2Y 6M 3M

Recommended Actions
Your AI assistant

- Review message received from Kirsten Jones
- Schedule meeting with Jane you haven't met for a while
- Review model 'Conservative' - this hasn't been updated in 9 months

Latest Resources

- Why Alternatives in Your Retirement Portfolio
- The Outlook for the 60/40 Portfolio
- Minds on the Market from Our Strategists
- Can Alternatives Replace Public Equity?
- WisdomTree's Digital Gold Token Uses Blockchain Technology

The PM's landing page on Crescendo offers a snapshot of their model portfolios, key statistics related to performance, and relevant resources. This is their one-stop shop for creating new model portfolios and engaging with investors.

MSCI WORLD - MTD. ↑ 5.6% YTD. ↑ 10.0% S&P 500. ↑ 5.5% ↑ 10.0% BARCLAYS GLOBAL AGG. ↑ 2.0% ↑ 4.5%

ONYX by J.P. Morgan Crescendo CONNECTED

Model Dashboard

Dashboard Clients Resources CREATE NEW +

Overview
Key stats, latest resources and recommended actions
840 clients

Conservative
Capital preservation focus with a lower risk / return profile
YTD Returns ↑ 7.2%
120 clients

Balanced
Capital appreciation focus with a moderate risk / return profile
YTD Returns ↑ 8.8%
80 clients

Growth
Capital appreciation focus with a higher risk / return profile
YTD Returns ↑ 7.4%
85 clients

Balanced Passive
Moderate risk / return profile with an emphasis on sustainability-focused investment strategies.
YTD Returns ↑ 8.2%
110 clients

Growth ESG
Higher risk / return emphasis on sustainable investment strategies.
YTD Returns ↑ 9.5%

Model Overview

Fund Class Allocation

Settlement Networks

Total Funds (13)

- Apollo - Private Credit Fund (ALTS | PRIVATE CREDIT) | ESG | QP / AI | Apollo | ↑ 11.89%
- Apollo - Real Estate Fund (ALTS | REAL ESTATE) | QP / AI | Apollo | ↑ 15.12%
- WisdomTree 500 Digital Fund (EQUITIES | US LARGE CAP) | Passive | WisdomTree | ↑ 18.89%
- WisdomTree Long Term Treasury Digital Fund (FIXED INCOME | CORE FIXED INCOME) | WisdomTree | ↑ 6.2%

Historical Performance

ALL 3Y 2Y 12M 6M 3M

Clients (120)

Name T1	QP/AI T1	Amount T1	Related Accounts T1	30d Change T1	1Yr Change T1	Profile
Jones, Kirsten ID: 783H88370	QP	\$4,046,352	2 Accounts	↑ 3.40%	↑ 6.15%	PROFILE
Megg, Caelan ID: 783H88370	AI	\$8,801,044	0 Accounts	↑ 3.28%	↑ 6.18%	PROFILE
Becker, Michael ID: 783H88370	QP	\$2,958,422	0 Accounts	↑ 3.37%	-	PROFILE
Lanigan, Jason ID: 783H88370	QP	\$1,985,500	2 Accounts	↑ 3.31%	↑ 6.00%	PROFILE
Captain, Jason ID: 783H88370	QP	\$39,818,726	3 Accounts	↑ 3.45%	↑ 6.33%	PROFILE
Feinstein, Steve ID: 783H88370	AI	\$1,790,003	1 Accounts	↑ 3.25%	↑ 6.08%	PROFILE
Little, Mike ID: 783H88370	QP	\$3,828,212	0 Accounts	↑ 3.25%	↑ 6.11%	PROFILE
Sayre, Tom ID: 783H88370	QP	\$3,877,961	2 Accounts	↑ 3.37%	-	PROFILE

Page 1 of 15

The portfolio manager can click into one of their model portfolios and view details such as model performance, fund allocations, fund performance, and subscribed investors.

Behind the scenes








A technical deep dive into the proof-of-concept

This section provides a technical walkthrough of the entire POC, however, does not provide explanations of underlying blockchain concepts (e.g., consensus protocols or smart contracts).

To deliver the POC, the Onyx team:

- 1.** Established and operated Onyx Digital Assets test blockchain and platform infrastructure
- 2.** Collaborated with Provenance Blockchain, Ava Labs, Axelar, LayerZero, and Biconomy to set up the required blockchain, interoperability and Account Abstraction infrastructure
- 3.** Developed core smart contracts and off-chain services to represent model portfolios, discretionary portfolios and funds
- 4.** Built an automated portfolio rebalancing system with end-to-end cross-chain trade execution and settlement
- 5.** Designed Crescendo, the front-end portfolio construction and management prototype that illustrated how the vision could be brought to life for both PMs and investors

Infrastructure overview

Infrastructure	Description
 Onyx Digital Assets	Permissioned EVM chain used for registering test fund assets (from J.P. Morgan Private Bank, Apollo, WisdomTree), model portfolios, investor portfolios, order routing and cash settlement via deposit tokens. Additionally, enabled rebalancing and connectivity to interoperability platforms.
 Avalanche subnet (Avalanche)	Permissioned instance of the Avalanche blockchain used for registering fund assets from WisdomTree.
 Provenance Blockchain Zone (Provenance Blockchain)	Permissioned instance of Provenance Blockchain used for registering fund assets from Apollo.
 Axelar	Permissioned instance of the Axelar blockchain (and related off-chain infrastructure) used for cross-chain message passing and secure interoperability between Onyx Digital Assets and Provenance Blockchain Zone.
 LayerZero	Cross-chain message passing protocol and secure interoperability services (Oracles and Relayers) between Onyx Digital Assets and the permissioned Avalanche subnet.
 Oasis Pro	Tokenization platform used for deploying Apollo fund tokens on Provenance Blockchain. Oasis Pro implemented the ERC-20 token standard in ProvWasm using Provenance Blockchain Markers and extended the standard to include the Mintable and Burnable interfaces from the ODA-FACT token standard.
 Biconomy	Full-stack Account Abstraction solution that leverages ERC-4337. The components used include the Smart Accounts Platform, Paymaster and Bundler. The main use case in the POC was deploying a Paymaster to cover gas fees incurred by the fund manager on the permissioned Avalanche subnet.

Smart contracts and technology build overview

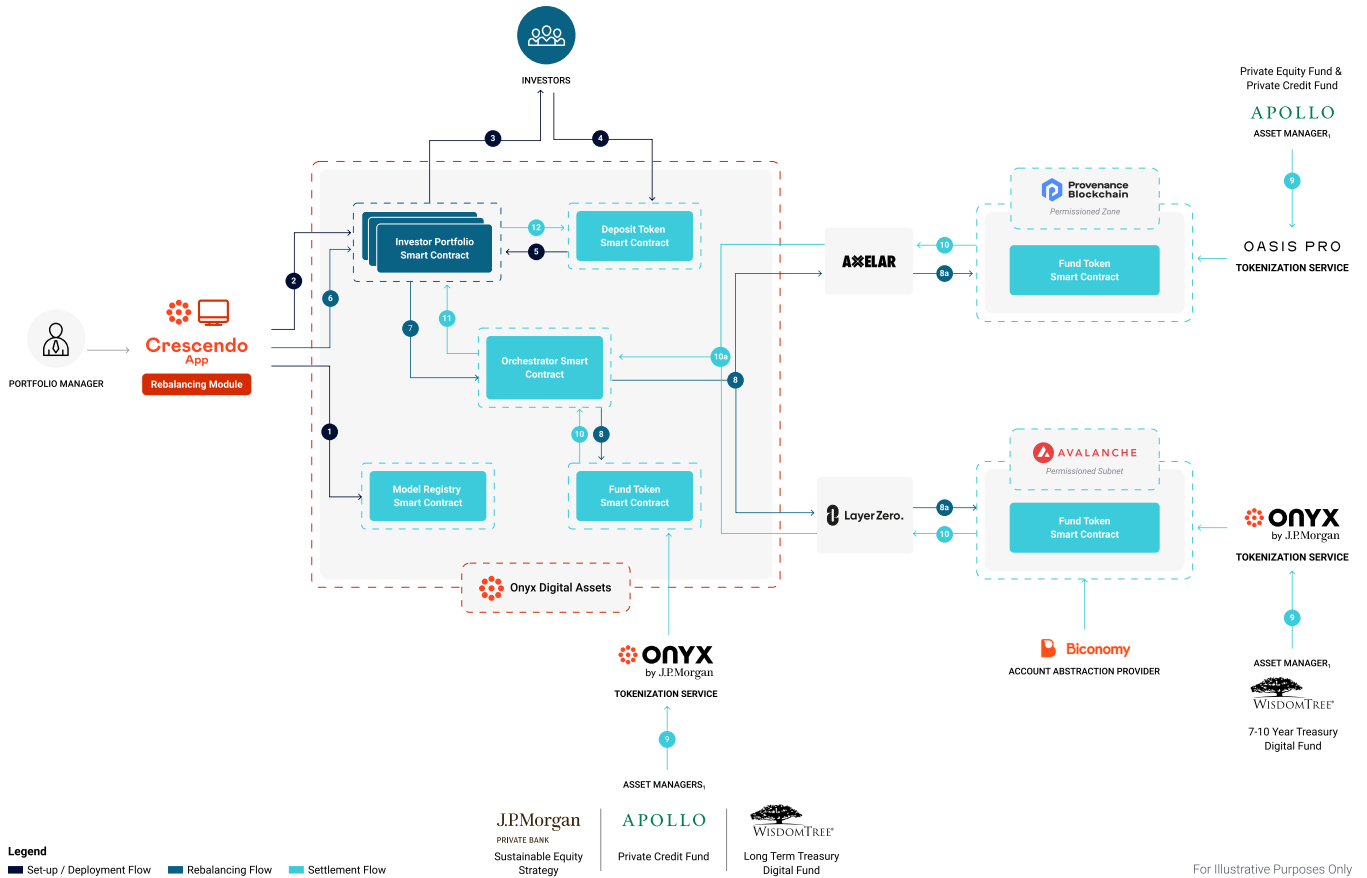
Technology components	Deployment location	Description
Investor Portfolio Smart Contract (Portfolio Smart Contract)	Onyx Digital Assets	Records all of an investor's cash and asset positions across multiple fund investments within a specific portfolio, while linking to a target model portfolio.
Model Registry Smart Contract	Onyx Digital Assets	Tracks inventory of all model portfolios and enables on-chain, transparent linkages between the models and the portfolios that subscribe to them.
Fund Token Smart Contracts (Fund Token Contract)	Onyx Digital Assets, Provenance Blockchain and Avalanche	<p>Tracks fund unit ownership, handles activity such as subscriptions/redemptions and controls the fund lifecycle. Only test funds were used.</p> <p>Leveraged the ODA-FACT token standard.</p> <p>See: Expanded overview of proof-of-concept components: Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard.</p>
Deposit Token Contract	Onyx Digital Assets	Issues USD deposit liabilities and provides the book of record (ledger), executing of deposit issuance, redemption and transactions, and access controls. Only test deposit liabilities were represented.
Rebalancing Module	Off-chain	An off-chain service that computes trade orders to align the investor's portfolio to target model allocations.
Orchestrator Smart Contract (Orchestrator)	Onyx Digital Assets	Receives orders from the Rebalancing Module, routes orders to target chains for execution and coordinates settlement by linking cash and asset legs.

Overview of end-to-end on-chain portfolio rebalancing and order flow

With the infrastructure setup complete and on-chain and off-chain components in place, we executed an end-to-end workflow, inclusive of three rebalancing scenarios.

Step	Description
Fund setup	Fund managers (Apollo, WisdomTree and J.P. Morgan Private Bank) provided investment strategies, opening them to investment.
Model and portfolio creation	The PM created a series of investment models and set up discretionary portfolios to follow these models for a number of investors.
Scenario 1: Initial investment	The investor sourced cash and deposited it into the Portfolio Smart Contract, preparing for investments to be made on their behalf.
Rebalancing	The investor's portfolio as represented by the Portfolio Smart Contract was 100% invested in cash, requiring initial deployment. The Rebalancing Module automatically calculated the subscription orders required to align the investor's portfolio with the model.
Order routing and submission	These orders were routed to Onyx Digital Assets and then across to Provenance Blockchain and Avalanche through the interoperability infrastructure, Axelar and LayerZero; fund managers received orders and could see that cash had been positioned for settlement on Onyx Digital Assets.
Order execution and settlement	Subscription orders were approved, the fund managers issued fund units to the portfolio and messages confirming settlement were sent back to Onyx Digital Assets.
Scenario 2: Cash infusion	The investor deposited additional cash into their portfolio, causing the steps; rebalancing, order routing and submission, and order execution and settlement to repeat, with different orders now placed.
Scenario 3: Model change	The PM updated the investment allocations for one of their models, which automatically rebalanced all subscribed portfolios (repeating the steps; rebalancing, order routing and submission and order execution and settlement).

A comprehensive description of each step can be found below. To contextualize the workflow, we have described the steps from the perspective of the various ecosystem participants and included prototype samples from the illustrative PM and investor portfolio construction and management application, Crescendo, that was designed for the POC.



Note: Asset Managers can deploy funds onto any settlement network (one or multiple) where they would like to make their funds available to investors. Hypothetical funds from Asset Managers are deployed on settlement networks and are not part of live product offerings. There is no guarantee that J.P. Morgan, Apollo, or WisdomTree will develop or offer such solutions.

Step	Description
1	Portfolio Manager creates the model and deploys to the Model Registry Smart Contract on-chain
2	Portfolio Manager sets up discretionary portfolios to follow these models for a number of investors (there's one Investor Portfolio Smart Contract per investor)
3	Investor's portfolio is linked to the selected model and the investor
4	Investor establishes cash balance on-chain through the Deposit Token Smart Contract
5	Investor transfers required Deposit Token amount to their Investor Portfolio Smart Contract, preparing for investment
6	The investor's portfolio is 100% invested in cash, requiring rebalancing. Subscription orders required to align the investor's portfolio with the model are calculated by the Rebalancer Module – and routed to the Investor's Portfolio Smart Contract
7	The orders are sent from the Investor Portfolio Smart Contract to the Orchestrator Smart Contract where the orders are queued and routed to the relevant chains – with funds on Onyx Digital Assets, Provenance Blockchain, and Avalanche
8	For funds on Onyx Digital Assets, orders are received by the asset managers on Onyx Digital Assets (Apollo, J.P. Morgan Private Bank, and WisdomTree) who can see that cash had been positioned for settlement on Onyx Digital Assets
8a	For funds on Provenance Blockchain and Avalanche, orders are routed from Onyx Digital Assets to Provenance Blockchain and Avalanche through the interoperability infrastructure, Axelar and LayerZero; asset managers (Apollo on Provenance, WisdomTree on Avalanche) receive the orders and can see that cash had been positioned for settlement on Onyx Digital Assets
9	Orders are approved by the asset managers and fund units are issued to the relevant investors. On Avalanche, Biconomy's Account Abstraction infrastructure is leveraged to cover gas fees incurred by the Asset Manager when approving orders
10	For funds on Onyx Digital Assets, messages confirming settlement are sent to the Orchestrator Smart Contract on Onyx Digital Assets
10a	For funds on Provenance Blockchain and Avalanche, messages confirming settlement are sent back to Onyx Digital Assets from Provenance Blockchain and Avalanche through the interoperability infrastructure, Axelar and LayerZero - hitting the Orchestrator Smart Contract on Onyx Digital Assets
11	The messages confirming settlement are sent from the Orchestrator Smart Contract to the Investor Portfolio Smart Contract where record of the asset positions across multiple fund investments within a specific portfolio are held
12	Finally, once state of all orders in the Investor Portfolio Smart Contract are recorded as settled, Deposit Tokens are transferred from the Investor Portfolio Smart Contract to the respective asset managers address on ODA

The end-to-end flow of Project Guardian shows the interaction of PM, investor, smart contracts, technology and infrastructure providers, and fund managers.

Note: Asset Managers can deploy funds onto any settlement network (one or multiple) where they would like to make their funds available to investors. There is no guarantee that J.P. Morgan, Apollo, or WisdomTree will develop or offer such solutions.

Fund Setup

Fund managers provided investment vehicles, representing alternative investment, fixed income and equity strategies for tokenization onto their chosen blockchain (Onyx Digital Assets, Provenance Blockchain or Avalanche). Setting up each of the funds resulted in deploying a Fund Token Contract, with the respective fund manager's signature, indicating the fund as authenticated and open for subscription.

The fund manager played the roles of both tokenization agent and token administrator, which are two role types defined by the ODA-FACT token standard (see **Expanded overview of proof-of-concept components: Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard** section for further details). This allowed the fund manager to retain control of all relevant functionality—primarily minting and burning fund units—throughout the workflow. In a live state, transfer agents or other entities designated by the fund manager would likely play these roles.

Model and portfolio creation

The PM created model portfolios by entering basic information, such as the name and the objective.¹¹ An entry was created for each model in the on-chain Model Registry Smart Contract on Onyx Digital Assets, consisting of model metadata and PM details.

Then, the PM selected specific funds and set percentage allocations to each—these constituted the model portfolio's strategy. Allocation detail was not stored on-chain.

A snapshot of the representative model that was used is shown below.

¹¹ This step refers to the input of a model portfolio which is constructed outside of this framework using proprietary tools and research.

Balanced ESG Model¹²

Asset class	Sub-asset class	Investment vehicle	Fund manager	Settlement network	Tokenization provider	Allocation %
Equities	U.S. Large Cap	J.P. Morgan Private Bank Sustainable Equity Strategy	J.P. Morgan Private Bank	Onyx Digital Assets	Onyx	35%
Equities	European Large Cap	J.P. Morgan Private Bank European Sustainable Equity Strategy	J.P. Morgan Private Bank	Onyx Digital Assets	Onyx	15%
Fixed Income	Core Fixed Income	WisdomTree 7-10 Year Treasury Digital Fund	WisdomTree	Avalanche	Onyx	30%
Alternative Investments	Private Equity	Apollo — Private Equity Fund	Apollo	Provenance Blockchain	Oasis Pro	10%
Alternative Investments	Private Credit	Apollo —Private Credit Fund	Apollo	Provenance Blockchain	Oasis Pro	10%

The PM was also responsible for creating each investor’s discretionary portfolio(s). For each portfolio created, a **Portfolio Smart Contract** was deployed onto Onyx Digital Assets, which specified investor and PM details and linked the portfolio to the relevant model it intended to track.

In the POC workflow, the Portfolio Smart Contract that the PM set up for the investor followed the Balanced-ESG model, as shown above.

Additionally, the Portfolio Smart Contract contained **position tracking** functionality. This allowed the Portfolio Smart Contract to capture all settlement activity confirmations, across all networks.

¹² Balanced ESG is a stylized, representative model portfolio used in this POC. A live discretionary portfolio would be more diversified than our illustrative model. The underlying investment vehicles are provided for illustrative and discussion purposes only and are not necessarily investable.

MSCI WORLD - YTD. ↑ 5.5% YTD. ↑ 10.0% S&P 500. ↑ 5.5% ↑ 10.0% BARCLAYS GLOBAL AGG. ↑ 2.0% ↑ 4.5%

ONYX by J.P. Morgan | Crescendo CONNECTED

Create Model Portfolio - Balanced ESG

Basic Information

* Required fields

Model Name *
Balanced ESG

Investment Objective
Long-term capital appreciation with moderate volatility and an emphasis on sustainability-focused investments. 47 / 140

Investor Requirement
Qualified Purchaser

Model Score

Relative rating of this portfolio's projected risk and return characteristics.

Overall Score
78/100

- 6.0 Projected Returns Good
- 5.0 Projected Risk Good
- 5.0 Stress Test Loss Good
- 8.0 Liquidity Great
- 8.0 Fees Great

Fund Builder

Configure the model based on investment strategies and risk tolerance

Total assets of allocation: **100%** ADD FUND +

Fund Name T1	Requirements T1	Fund Manager T1	Settlement Network T1	Allocation	
JPM Private Bank Sustainable Equity Strategy New EQUITIES US LARGE CAP	ESG	JPM PB	Onyx Digital Assets	35%	REMOVE ▼
JPM Private Bank European Sustainable Equity Strategy New EQUITIES EUROPEAN LARGE CAP	ESG	JPM PB	Onyx Digital Assets	15%	REMOVE ▼
Apollo - Private Equity Fund New ALTS PRIVATE EQUITY	ESG QP/AI	Apollo	Provenance	10%	REMOVE ▼
Apollo - Private Credit Fund New ALTS PRIVATE CREDIT	ESG QP/AI	Apollo	Provenance	10%	REMOVE ▼
WisdomTree 7-10 Year Treasury Digital Fund New FIXED INCOME CORE FIXED INCOME		WisdomTree	Avalanche	30%	REMOVE ▼

CANCEL CREATE

On Crescendo, the PM can create new models by adding in specific model details such as the model name and model objective.

Select Investment Model
Select the model that best meets your needs

All Models (6) Passive ESG

- Balanced ESG** Recommended by Cathy
Long-term capital appreciation with moderate volatility and an emphasis on sustainability-focused investments.
- Conservative**
Capital preservation focus with a lower risk / return profile.
- Balanced**
Capital appreciation focus with a moderate risk / return profile.
- Growth**
Capital appreciation focus with a higher risk / return profile.
- Conservative ESG**
Lower risk / return profile with an emphasis on sustainability-focused investment strategies.
- Growth ESG**
Higher risk / return profile with an emphasis on sustainability-focused investment strategies.

Balanced ESG Recommended

Long-term capital appreciation with moderate volatility with an emphasis on sustainability-focused investments.
[Read more](#)

Allocation **Funds (5)**

- US Large Cap 35%
- Core Fixed Income 30%
- European Large Cap 15%
- Private Equity 10%
- Private Credit 10%

Projected Risk / Return Statistics

Returns	Volatility	Equity Beta	Stress Loss
7.9%	9.9%	0.55	-14.2%

[CHOOSE THIS PORTFOLIO](#)

Allocation **Funds (5)**

- JPM PB Sustainable Equity Strategy 35%
EQUITIES | US LARGE CAP
ESG JPM PB
- JPM PB European Sustainable Equity Fund 15%
EQUITIES | US LARGE CAP
ESG JPM PB
- Apollo - Private Equity Fund 10%
ALTS | PRIVATE EQUITY
ESG QP / AI Apollo
- Apollo - Private Credit Fund 10%
ALTS | PRIVATE CREDIT
ESG QP / AI Apollo
- WisdomTree 7-10 Year Treasury Digital Fund 30%
FIXED INCOME | CORE FIXED INCOME
WisdomTree

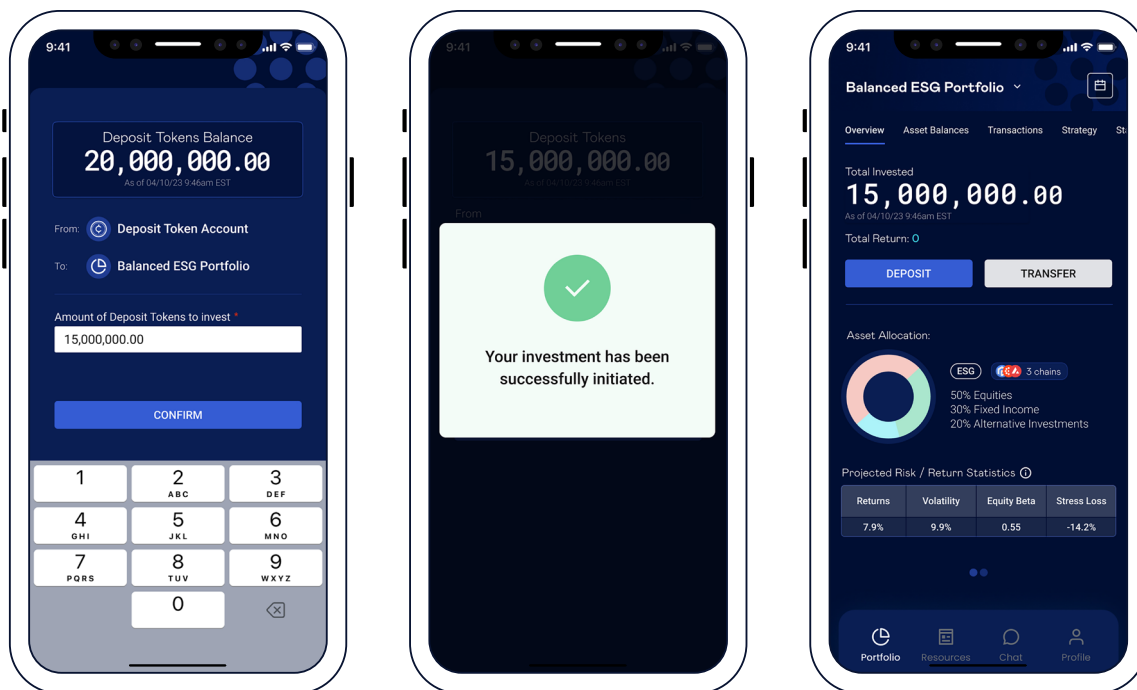
The Crescendo mobile application is the investor's one-stop shop for viewing available investment models, connecting with their PM, accessing resources and tracking their portfolio's performance.

Scenario 1 — Initial investment

The investor needed to establish a balance of cash on-chain to conduct the initial investment. The investor requested this balance, and upon acceptance, deposit tokens were issued to the investor's blockchain address on Onyx Digital Assets. This action enabled the transfer of cash from off-chain to on-chain.

The Deposit Token Contract also implemented the ODA-FACT token standard (see: **Expanded overview of proof-of-concept components: Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard**). Note that this method of implementing deposit tokens was chosen to promote fungibility and interoperability across the environments of issuance and settlement.

The investor later deposited their on-chain cash to the Portfolio Smart Contract, signaling it was ready for investment. This simultaneously emitted a deposit event onto the blockchain in the process.



On Crescendo, the investor can easily allocate their chosen balance of Deposit Tokens to be invested into a selected model.

Rebalancing

This deposit event (from the Investor's initial investment) triggered the PM's Rebalancing Module for the initial deployment of cash. The Rebalancing Module calculated required trades by first comparing the existing composition of the portfolio—which under Scenario 1 was 100% cash versus the target portfolio allocations, and then determining the quantities of fractional fund shares to be purchased. To make this calculation, the Rebalancing Module retrieved the latest net asset value information from an off-chain reference data service. In a future state, a series of oracles could source this information.

All orders were automatically augmented with blockchain data, simultaneously submitted onto Onyx Digital Assets and passed to the Orchestrator for onward relaying. The blockchain transactions containing the orders were signed by the PM's private key, given their discretion and control over investments in the portfolio. Each order contained information about the asset, settlement location, amount, trade direction (buy/sell) and other necessary details.

Review Ali's New Investment

Portfolio Rebalancing...

- 1/5 | Buy 1,500 Units of Apollo – Private Equity Fund Transaction Completed
- 2/5 | Buy 1,500 Units of Apollo – Private Credit Fund Transaction Completed
- 3/5 | Buy 5,250 Units of JPM Private Bank Sustainable Equity Strategy Transaction Completed
- 4/5 | Buy 2,250 Units of JPM Private Bank European Sustainable Equity Strategy Transaction Completed
- 5/5 | Buy 4,500 Units of WisdomTree 7-10 Year Treasury Digital Fund Moving \$4.5MM to WisdomTree

Historical Performance
No Data Available

Total Assets:

- JPMorgan Chase Bank Cash Balance: \$30,000,000.00
- Deposit Tokens Blockchain deposits Balance: \$15,000,000.00

Total Funds (5)

- JPM Private Bank Sustainable Equity Strategy 35%
- JPM Private Bank European Sustainable Equity Strategy 15%
- Apollo - Private Equity Fund 10%
- Apollo - Private Credit Fund 10%
- WisdomTree 7-10 Year Treasury Digital Fund 30%

CANCEL ACTIVATE

With just one click, the PM rebalances the investor's portfolio to align with the selected model. Trade orders are sent to the relevant blockchain networks for each specific fund, while – Deposit Tokens are moved on ODA from the investor to the relevant Fund Managers.

Order routing and submission

The Orchestrator routed and processed each order sequentially and synchronously (i.e., Order #1 needed confirmed settlement before Order #2 could be relayed and settled— and so on, until all orders for a given portfolio had been completed). Project Guardian demonstrates an automated rebalancing solution for portfolios consisting of open funds recorded on multiple distributed ledgers. This solution can be further scaled up to support rebalancing of tens and thousands of such portfolios.

For each order, the Orchestrator submitted cash transfer instructions to the Deposit Token Contract on Onyx Digital Assets. These instructions resulted in the movement of cash from the investor's Portfolio Smart Contract to an account in preparation for settlement. While in this account, neither the PM nor the investor could access or move the funds, guaranteeing the settlement of the cash leg.

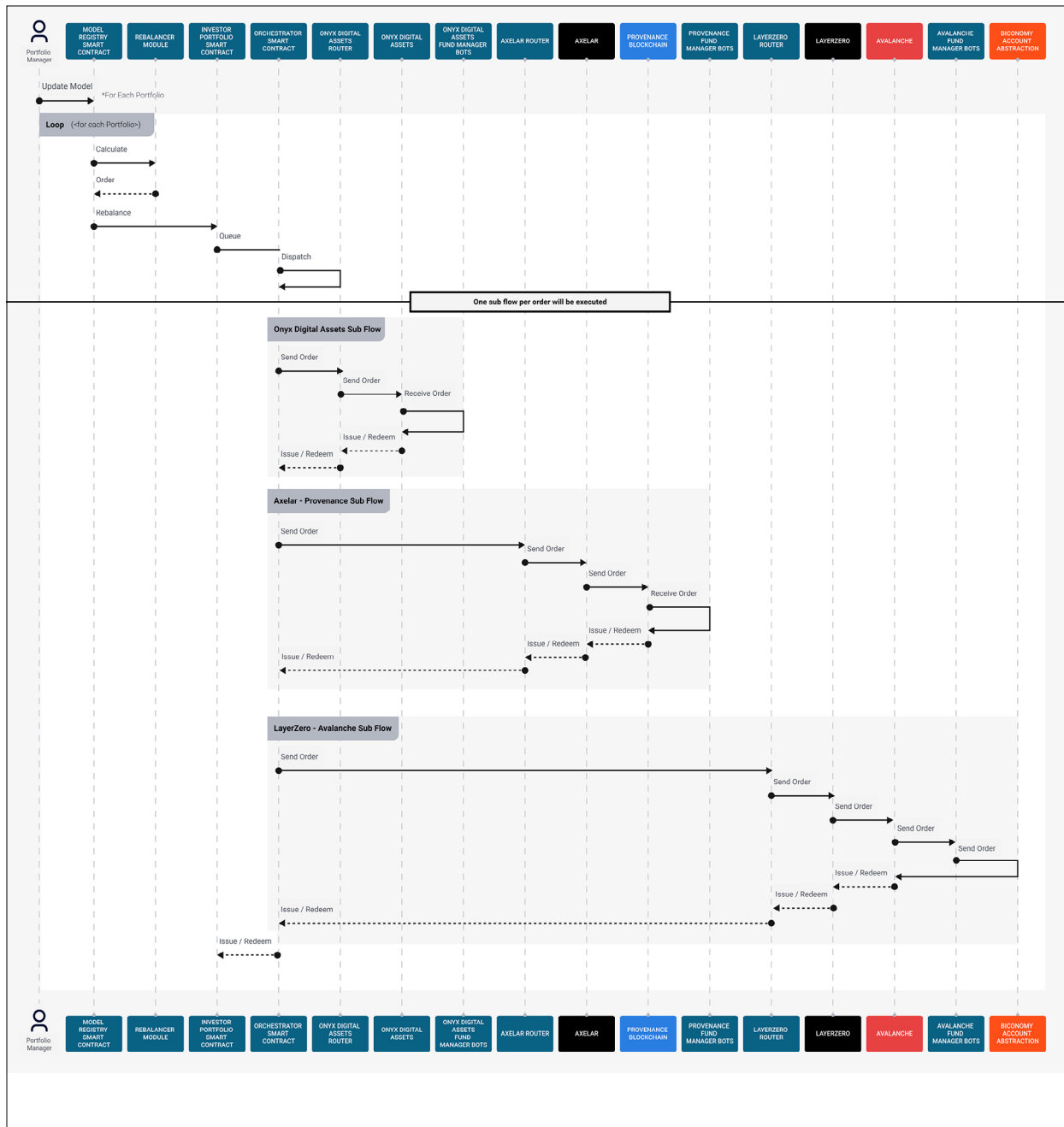
The Orchestrator also routed each order to:

A local router contract for funds deployed on Onyx Digital Assets	On Onyx Digital Assets, a local router contract sent the order to the Fund Token Contract. The fund manager received and registered the order.
LayerZero endpoint contracts for funds deployed on Avalanche	Once LayerZero endpoint contracts on Onyx Digital Assets received the order and the transaction was committed on Onyx Digital Assets, an event was emitted. Off-chain LayerZero services—an oracle and relayer—picked up the event as a message containing the order, signed it, and transmitted it directly to the LayerZero endpoint contracts hosted on Avalanche. This LayerZero endpoint contract ingested the message and validated it, enabling the order to be propagated to the relevant Fund Token Contract on Avalanche.
Axelar gateway contracts for funds deployed on Provenance Blockchain	Once Axelar gateway contracts on Onyx Digital Assets received the order, an event was emitted. An off-chain relayer picked up the message containing the order and transmitted it to a private instance of the Axelar blockchain for validation. Once the message had been validated, another off-chain relayer (the executor) propagated the message to the relevant Fund Token Contract on the Provenance Blockchain.

See the **Expanded overview of proof-of-concept components: Cross-chain interoperability** section for more details.

On all three chains, the order propagated to the Fund Token Contract effectively requested the fund manager to “mint” or issue fund units to the portfolio. The request could be considered an on-chain recordation of the PM’s order that would then automatically reconcile against the settlement when the fund manager later accepts the request. **This automated reconciliation and trade acceptance represents a step change over the current order execution and settlement process in BAU infrastructure.**

For the initial investment, all orders were subscription orders. However, as the rebalancing module outputs redemption orders for other types of rebalancing events (e.g., **Scenario 2—Cash infusion; Scenario 3—Model change**), this step results in a request for the fund manager to “burn” or redeem fund units from the portfolio as shown below.



Sequence diagram of the Project Guardian flow which showcases the interaction between the smart contracts, interoperability solutions, account abstraction infrastructure, and blockchain networks.

Order execution and settlement

The fund manager received the request to “mint” fund units to the portfolio.

- For assets held directly on Onyx Digital Assets, fund units were minted to (or burned from) the Portfolio Smart Contract of the investor.
- In the case of Avalanche and Provenance Blockchain, fund units would be minted to (or burned from) blockchain addresses on each network,— specific and unique to each portfolio. The PM held the private keys corresponding to these addresses.

On Onyx Digital Assets and Provenance Blockchain, the fund manager directly accepted the request—signing and executing the acceptance transaction with a private key that corresponded to their externally owned account on-chain.

In contrast, on Avalanche, we leveraged Biconomy’s on-chain and off-chain ERC-4337 infrastructure to implement Account Abstraction and abstract away the gas fees that the fund manager may typically incur on an Avalanche subnet. Here, a Smart Contract Wallet was used for the fund manager, instead of an externally owned account.

See the **Expanded overview of proof-of-concept components: Account Abstraction** section for more details.

The fund manager’s acceptance of the request resulted in the issuance of fund units to the portfolio. This constituted both order execution and settlement, compressed into one action. For greater efficiencies, fund managers could look to automate the acceptance functionality, provided an order meets a set of predetermined rules. We tested this functionality when we executed the rebalancing activity over a larger series of portfolios (**see Scenario 3—Model change**).

A settlement confirmation was passed back to the Orchestrator on Onyx Digital Assets through the same channel (the local router on Onyx Digital Assets, Axelar or LayerZero) that originally routed the order. The Orchestrator then sent the confirmation to the Portfolio Smart Contract, where it was logged. Simultaneously, the Orchestrator finalized cash movements to the relevant fund manager’s blockchain address on Onyx Digital Assets, completing settlement.

Scenario 2 — Cash infusion

We chose to test another rebalancing scenario by simulating an event that may cause a unique portfolio to deviate from its model. A cash infusion is a common event that results in such deviation, which effectively dilutes the allocation percentages of the portfolio's investments.

In this step, the investor added cash to the portfolio. Upon receipt of the additional cash, the Rebalancing Module automatically computed the new orders, repeating the steps; rebalancing, order routing and submission and order execution and settlement. This resulted in the portfolio returning to alignment with its optimal state.

We believe this flow is extensible to changes in underlying fund valuations as well.

Scenario 3 — Model change

Lastly, to demonstrate the ease with which a PM could implement a discretionary change across an entire client base, we tested the scenario where a PM replaces a fund in a particular model portfolio.

In this case, the PM replaced "Apollo – Private Equity Fund" with "Apollo – Equity Replacement Fund" in the Balanced ESG model, necessitating a subscription and redemption across 100 distinct portfolios that were mapped to this model. Upon making the change, the Rebalancing Module automatically kicked off rebalancing across all portfolios, with all order routing, submission and settlement activity following immediately. Executing the change to the model and the subsequent rebalancing activity did not require a single step of manual intervention.

This final step—to us—encapsulated the essence of what we sought to achieve: the automatic rebalancing of a large number of portfolios through a single change in a reference model. The successful completion of this aspect of the POC represents a step change improvement compared to the current state whereby portfolio managers and teams of operational professionals calculate, prepare, place, settle, reconcile and report on trades across their client portfolios.

MSCI WORLD - MTD. ↑ 5.5% YTD. ↑ 10.0% S&P 500. ↑ 5.5% ↑ 10.0% BARCLAYS GLOBAL AGG. ↑ 2.0% ↑ 4.5%

ONYX by J.P. Morgan Crescendo CONNECTED

Balanced ESG - Edit Model

Basic Information

* Required fields

Model Name *
Balanced ESG

Model Objective
Long-term capital appreciation with moderate volatility and an emphasis on sustainability-focused investments. 47 / 140

Investor Requirement
Qualified Purchaser

Model Score

Relative rating of this portfolio's projected risk and return characteristics.

Overall Score
78/100

- 6.0 Projected Returns Good
- 5.0 Projected Risk Good
- 5.0 Stress Test Loss Good
- 8.0 Liquidity Great
- 8.0 Fees Great

Fund Builder

build a fund based around aims, objectives and tolerance

ESG Compliant ✓
Environmental, Social and Governance (ESG) issues are now front of mind for the asset management industry.

Passive ✓
A passive fund is an investment vehicle that tracks the stock market and replicates its performance.

Fund Allocation
Configure your model based around the aims, objectives and tolerance

Total assets of allocation: **100%** ADD FUND +

Fund Name T1	Requirements T1	Fund Manager T1	Settlement Network T1	Allocation	
Apollo - Equity Replacement Fund New ALTS PRIVATE EQUITY	ESG QP/AI	Apollo	Provenance		REMOVE
JPM Private Bank Sustainable Equity Strategy EQUITIES US LARGE CAP	ESG	JPM PB	Onyx Digital Assets	35%	REMOVE
JPM Private Bank European Sustainable Equity Fund EQUITIES EUROPEAN LARGE CAP	ESG	JPM PB	Onyx Digital Assets	15%	REMOVE
Apollo - Private Equity Fund ALTS PRIVATE EQUITY	ESG QP/AI	Apollo	Provenance	10%	REMOVE
Apollo - Private Credit Fund ALTS PRIVATE CREDIT	ESG QP/AI	Apollo	Provenance	10%	REMOVE
WisdomTree 7-10 Year Treasury Digital Fund FIXED INCOME US TREASURY		WisdomTree	Avalanche	30%	REMOVE

Clients (100)

Name T1	Amount T1	
Ali Russo ID: 783H88370	\$20,000,000	PROFILE
Megg, Caelan ID: 783H88370	\$8,801,044	PROFILE
Becker, Michael ID: 783H88370	\$2,958,422	PROFILE
Lanigan, Jason ID: 783H88370	\$1,985,500	PROFILE
Captain, Jason ID: 783H88370	\$39,818,726	PROFILE
Feinstein, Steve ID: 783H88370	\$1,790,003	PROFILE
Little, Mike ID: 783H88370	\$3,828,212	PROFILE
Sayre, Tom ID: 783H88370	\$3,877,961	PROFILE
Hildebrand, Eric ID: 783H88370	\$2,958,422	PROFILE

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CANCEL

BACK SAVE CHANGE

The PM can easily adjust any given model in Crescendo by removing funds, adding funds, or amending the allocations.

MSCI WORLD - MTD. ↑ 5.5% YTD. ↑ 10.0% S&P 500. ↑ 5.5% ↑ 10.0% BARCLAYS GLOBAL AGG. ↑ 2.0% ↑ 4.5%

ONYX by J.P. Morgan Crescendo

CONNECTED

Balanced ESG

Basic Information Model Score Overall Score

Relative rating of this portfolio's projected risk and return characteristics. **81/100**

Portfolio Rebalancing..

1/2 | Sell Apollo – Private Equity Fund Provenance

- 1/100 | Sell 2,000 Units of Apollo – Private Equity Fund
Moving \$2MM to Ali Russo
- 2/100 | Sell 880 Units of Apollo – Private Equity Fund
Moving \$880K to Kevin Max
- 3/100 | Sell 296 Units of Apollo – Private Equity Fund
Moving \$296K to Jason Chu
- 4/100 | Sell 198 Units of Apollo – Private Equity Fund
Moving \$198K to Aris Mariana

2/2 | Buy Apollo – Equity Replacement Fund

JPM Private Bank European Sustainable Equity Fund EQUITIES EUROPEAN LARGE CAP	ESG	JPM PB	Onyx Digital Assets	15%	REMOVE
Apollo - Private Equity Fund AUS PRIVATE EQUITY	ESG QPVA	Apollo	Provenance	0%	REMOVE
Apollo - Private Credit Fund AUS PRIVATE CREDIT	ESG QPVA	Apollo	Provenance	10%	REMOVE
WisdomTree 7-10 Year Treasury Digital Fund FUND HYBRID CORP. FIXED INCOME		WisdomTree	Avalanche	30%	REMOVE

Little, Mike ID: 783H88370	\$3,828,212	PROFILE
Sayre, Tom ID: 783H88370	\$3,877,961	PROFILE
Hildebrand, Eric ID: 783H88370	\$2,958,422	PROFILE

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Once the PM is happy with the model adjustments, the PM can seamlessly update all of the investor portfolios aligned to that specific model. Crescendo sends the calculated sell orders to the relevant blockchain networks for settlement, upon confirmation of settlement and movement of Deposit Tokens on Onyx Digital Assets, the buy orders are sent to the appropriate blockchain networks for settlement.

Expanded overview of proof-of-concept components

The following section provides an in-depth look at the key blockchain-specific technologies and new infrastructure tested in this POC:

- **Cross-chain interoperability:** required to transmit messages containing financial transactions across networks in a secure manner
- **Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard:** extends the ERC-20 standard, promotes the portability of assets across a single blockchain network, and introduces control requirements necessary for financial products
- **Account Abstraction:** a means of simplifying the user experience for users interacting with blockchain networks, specifically the process of covering gas fees and implementing programmability

Cross-chain interoperability

As blockchain ecosystems proliferate, cross-chain interoperability becomes ever more critical. For Layer 1 blockchains, we see two main approaches to achieve cross-chain interoperability:

1. **Asset transformation:** Also known as asset bridging, in this approach an asset moves from one blockchain to another. Two methods for achieving this are as follows:
 - **Wrapped assets** — assets are locked on the source chain and minted (created) as wrapped assets on the destination chain.
 - **Native assets** — assets are burned on the source chain and minted (created) as native, non-wrapped assets on the destination chain.
2. **Cross-chain messaging:** Assets remain on the source chain and messages are sent between the source and a destination chain. Messages may include data containing instructions for execution on destination chains, confirmation of transfers or business data.

We believe cross-chain messaging likely has several advantages over asset transformation:

Single source of truth	Asset transformation could create ambiguity about the definitive source of truth for a given bridged asset. In addition, investors may view an asset which exists on one chain differently from its wrapped equivalent on a different blockchain. Cross-chain messaging, in contrast, ensures assets remain on their source chain, avoiding duplication of assets across ledgers.
Flexibility	Cross-chain messaging enables user-defined messages to be sent between chains, potentially providing utility beyond instructing movement of assets. For example, messages could be sent which confirm asset movement on a destination chain, transmit business data maintained on a different blockchain (e.g., a client's KYC status) or leverage the benefits of Account Abstraction.
Reduced risk of asset theft	There are numerous examples in public blockchain ecosystems where the asset transformation approach has enabled malicious actors to gain access to private keys and steal user's tokens. A successful malicious event with cross-chain messaging, however, could have a lower impact since an attacker's actions could be restricted to simply sending invalid messages or denying access to the service, as opposed to obtaining unauthorized access to user's assets. This proposed benefit would depend on careful design and require rigorous testing and robust security audits to validate.

The following requirements were established to assess different cross-chain messaging solutions for the POC:

- **Low integration overhead:** Solutions should not require onerous integration effort nor significant application re-write but should have high potential for reuse.
- **Breadth of supported chains:** Solutions should support a high number and type of blockchains (i.e., multiple EVM and non-EVM chains).
- **Scalability:** Solutions should minimize the number of required connections between systems. Connectivity at a blockchain-to-blockchain level was seen as the most scalable approach.
- **Decentralization:** Interoperability solutions should allow for the decentralization of both technical infrastructure and governance mechanisms.
 - Decentralized infrastructure provides more flexibility for developers and operators to select their preferred setup.
 - Decentralized governance could take the form of distributed validators checking each other's behavior or an aggregate configuration of different organizations, individually verifying messages.
- **Security:** In addition to decentralized architectures providing an element of security, other important features for the project were customizable security configurations, prevention of malicious actions and appropriate audit trails.

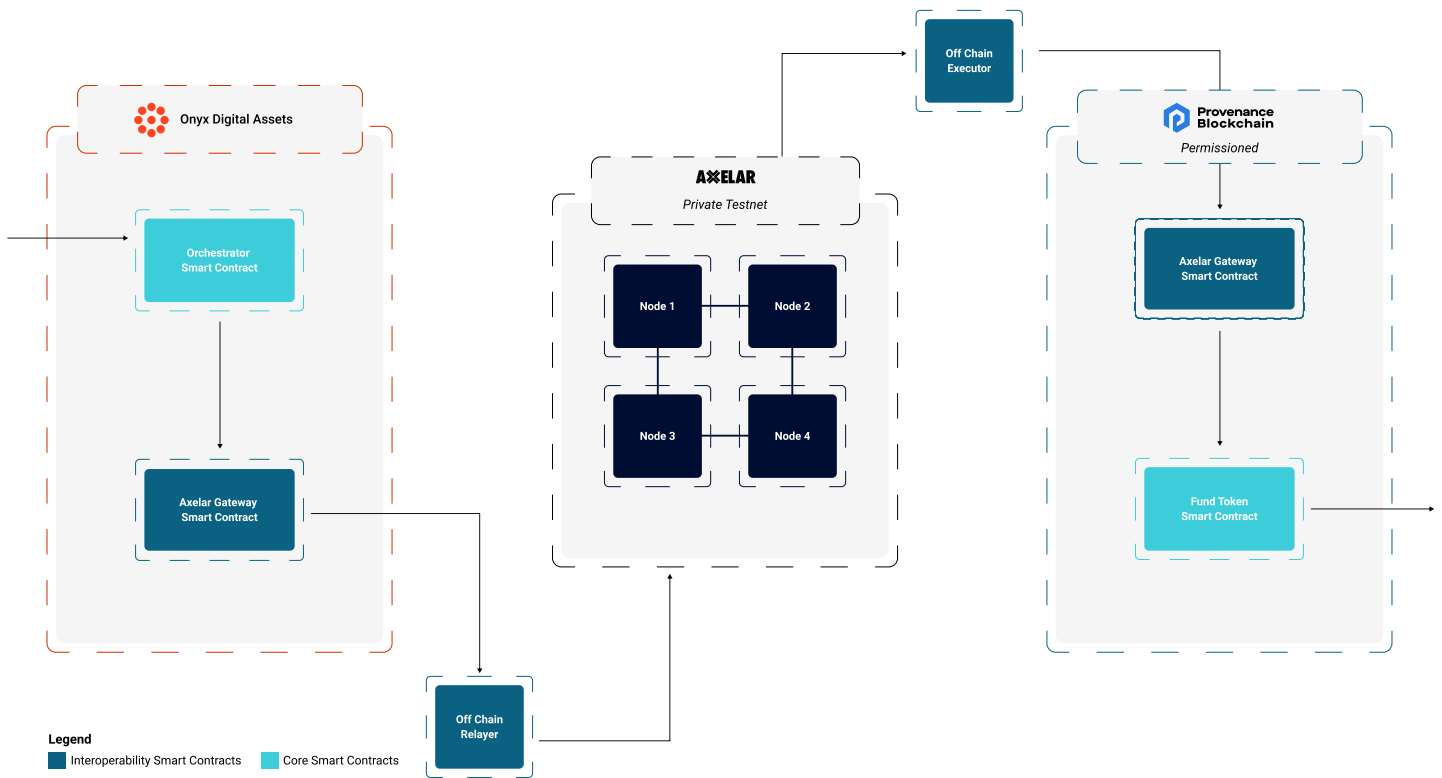
Consistent with the criteria above, instances of Axelar and LayerZero were implemented for exploration in the POC.

Implementation in the proof-of-concept

To enable cross-chain messaging, Axelar deployed smart contracts (known as gateways) on Onyx Digital Assets and the Provenance Blockchain. LayerZero achieved connectivity by deploying smart contracts (known as endpoints) on Onyx Digital Assets and the permissioned Avalanche subnet. Gateways and endpoints are deployed at the blockchain layer, providing sufficient scalability. Both Axelar and LayerZero modified their typical interchain setup to meet the POC's requirements for privacy and access management.

As Axelar and LayerZero are well-documented open systems, this report focuses on our POC's high-level flows and customizations.

Axelar



The process flow of the Axelar interoperability solution including on-chain smart contracts and off-chain infrastructure, facilitating message transfer between ODA and Provenance Blockchain.

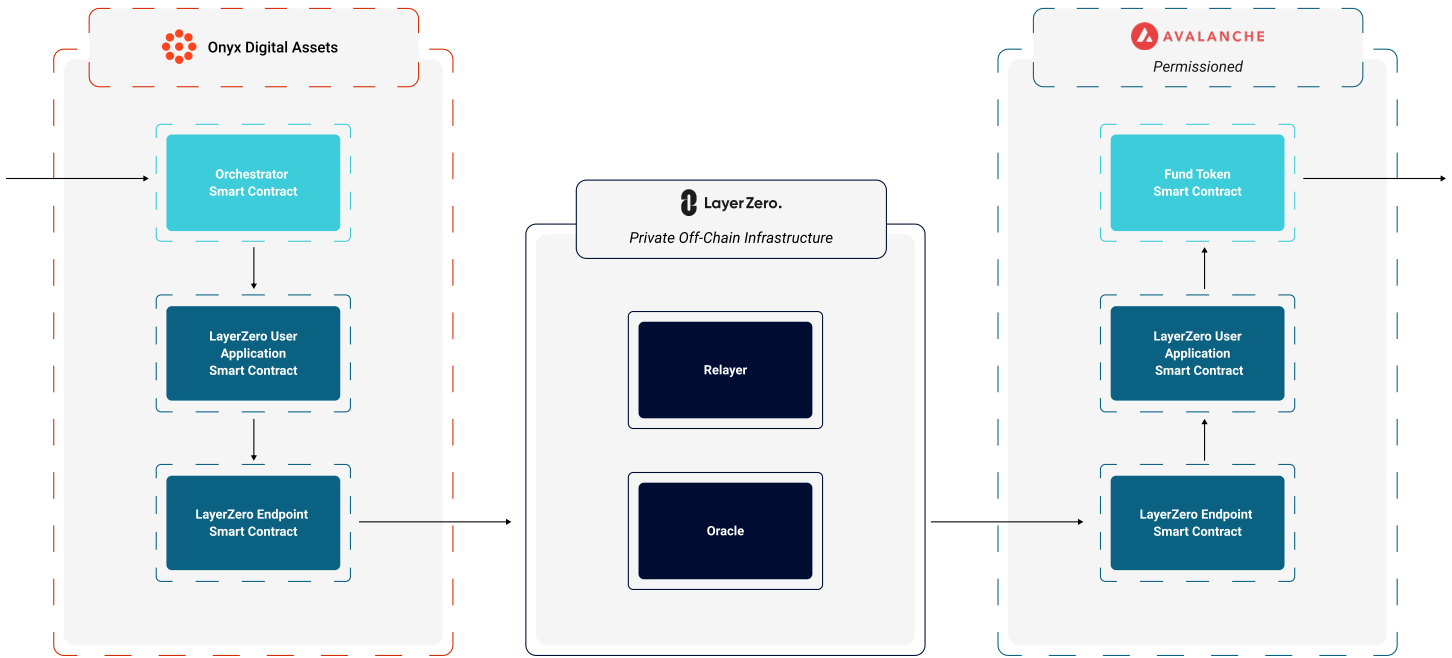
Axelar is a decentralized blockchain that acts as a hub, in a hub and spoke network of blockchains. In addition to supporting Cosmos-based blockchains, the Axelar blockchain validates messages using proof-of-stake consensus by public permissionless nodes. Off-chain relayers deliver messages between the Axelar blockchain and destination chains.

For this POC, Axelar deployed and operated a private permissioned Axelar testnet (for message validation) and private off-chain relayers (for message passing).

Workflow

- 1.** The Orchestrator sends a message to the Axelar gateway contract on the source chain.
 - a. During order routing, the source chain was Onyx Digital Assets, and the message contained the order.
 - b. During settlement, the source chain was Provenance Blockchain, and the message contained the asset-leg settlement confirmation. This activity emitted an event.
- 2.** An off-chain relayer listened for this event, and then delivered the message to the Axelar blockchain.
- 3.** Validators on the Axelar chain confirmed the validity of the message.
- 4.** Another off-chain service, known as an executor, on the destination chain picked up the message that had been validated by Axelar.
- 5.** The executor checked the validated message for destination details, and finally delivered the message to the destination chain's Axelar gateway contract. During order routing, the destination chain was Provenance, and during settlement, the destination chain was Onyx Digital Assets.
- 6.** The message was transmitted to the relevant contract, the Fund Token Contract, during order routing and the Portfolio Smart Contract during settlement.

LayerZero



Legend
■ Interoperability Smart Contracts ■ Core Smart Contracts

The process flow of the LayerZero interoperability solution including on-chain smart contracts and off-chain infrastructure facilitating message transfer between ODA and Avalanche.

LayerZero uses oracles and relayers chosen by application developers to validate and pass messages between chains. A decentralized set of entities can configure and/or operate dedicated off-chain relayer and oracle instances for routine interoperability across their permissioned blockchains, allowing controlled messaging while avoiding centralization.

For this POC, LayerZero provided private permissioned relayers and oracles to listen for events, coordinate message passing and provide signatures.

Workflow

- 1.** The Orchestrator sends a message to the LayerZero 'user application' contract on the source chain.
 - a. During order routing, the source chain was Onyx Digital Assets, and the message contained the order.
 - b. During settlement, the source chain was Avalanche, and the message contained the asset-leg settlement confirmation.
- 2.** The source chain LayerZero user application contract translated the message into a 'sendMsg' function and delivered it to the LayerZero endpoint contract. This activity emitted an event.
- 3.** Both the oracle and relayer listened for events emitted by the LayerZero endpoint, and upon receipt, picked up the message.
- 4.** The oracle signed and transmitted the transaction hash to the LayerZero endpoint contract on Avalanche, emitting an event back to the relayer.
- 5.** Upon receiving the emitted event that the transaction hash has been received by the LayerZero endpoint contract on Avalanche, the relayer signed and transmitted the transaction message to the destination chain LayerZero endpoint.
- 6.** The destination chain LayerZero endpoint validated the message by comparing the transaction hash against the transaction and ensured that user application configuration on the receiving (destination) contract matched that of the sending (source) contract. If successful, the message was committed on Avalanche, the destination chain.
- 7.** The destination chain LayerZero endpoint submitted the message to the destination chain user application contract.
- 8.** The destination chain user application contract executed the message, completing the interoperability workflow.

Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard

Token standards provide a blueprint for the creation of, the operation of, and the interactions with tokens on a blockchain. By aligning to a standard, tokens gain interoperability and a consistent experience, while developers and users benefit from familiarity across applications.

As various tokenized assets are onboarded to Onyx Digital Assets, token standardization enables building shared services and interoperability across the platform. Permissioned roles can consistently perform actions like minting and burning, and assets can be ported across diverse applications.

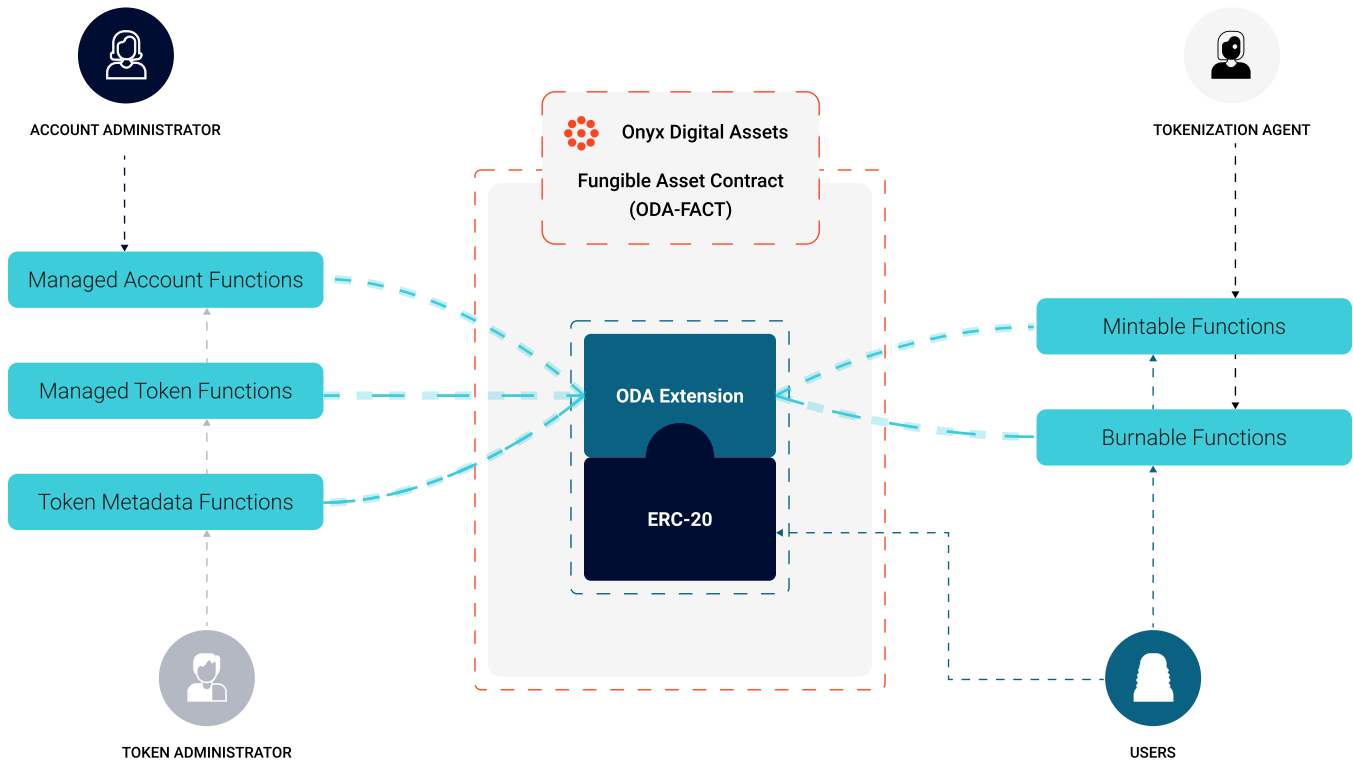
To that end, the ODA-FACT token standard was developed by Onyx to provide a consistent way of representing fungible financial assets on the Onyx Digital Assets blockchain. This Onyx Digital Assets standard is ERC-20 compliant for simplicity and interoperability, but extends ERC-20 to address additional requirements like standardized minting, burning and enhanced controls. The ODA-FACT token standard was also implemented for the cash leg (deposit tokens) of the transactions to maintain fungibility.

ERC-20 compliance in the ODA-FACT token standard ensures:

- Simplicity and developer-friendly usability
- Easy deployment of ERC-20 applications from other chains
- Interoperability with existing ERC-20 tokens

However, ERC-20 alone lacks certain features that we have needed across different projects involving traditional assets, leading us to extend the standard to include functions suitable for transactions with regulated financial instruments.

Key features of the Onyx Digital Assets FACT include:



Visual representation of the Onyx Digital Assets Fungible Asset Contract (ODA-FACT) token standard showcasing how it expands upon the ERC-20 token standard.

Key features of the ODA-FACT token standard include:

Feature	Description
Managed token	Allows permitted deactivation and reactivation of Tokens. Needed for sanctions or admin actions — for instance, token administrators may wish to temporarily cease all activity with tokens that represent sanctioned assets.
Managed account	Allows permitted locking of balances and disallowing of accounts. Important for security measures — for instance, token administrators may wish to prevent certain entities from further transacting with their tokens. Allows permitted locking of balances and force transfer/burn of locked balances within a specific account. Useful for Account Administrators in the event of a default scenario.
Mintable	Requires authorized mint requests before increasing token supply to an account, also reducing reconciliation. Provides an audit trail of all requests and corresponding actions (acceptance or rejection) for a Tokenization Agent and a requesting party.
Burnable	Requires authorized burn requests before decreasing token supply from an account. Provides an audit trail of all requests and corresponding actions (acceptance or rejection) for a Tokenization Agent and a requesting party.
Token metadata	Allows setting metadata like a URI to link off-chain instrument data.

Implementation in the proof-of-concept

- The Fund Token Contracts and the Deposit Token Contract implemented ODA-FACT on the EVM chains. The use of the standard ensured fungibility of the cash and asset leg in a streamlined fashion. Deposit Token standards may vary from the ODA-FACT token standard when issued at scale based on the specific characteristics of cash that differ from assets.
- For the non-EVM chain, Provenance Blockchain, Oasis Pro deployed the fund tokens in ProvWasm using Provenance Blockchain Markers and extended the tokens to include the Mintable and Burnable interfaces of the ODA-FACT in order to interact with the system.
- For the deposit tokens, the request and acceptance flows from the Mintable and Burnable feature set of the ODA-FACT token standard were used to facilitate deposit token issuance and redemption. This represented the movement of cash from legacy demand deposit accounts to on-chain blockchain addresses. The standard ERC-20 transfer functionality was also utilized in all settlement activity.
- For the Fund Token Contracts, the request and acceptance flows from the Mintable and Burnable feature sets of the ODA-FACT token standard were used to facilitate investment processing. The fund manager minted or burned units based on authorized requests, representing how share issuance and redemption take place in response to the receipt of valid subscription and redemption orders.
- Fund managers assumed the role of tokenization agent and token administrator for the Fund Token Contracts; albeit many of the associated functions are typically played by transfer agents.

Account Abstraction

ERC-4337¹⁵ / Account Abstraction is a framework for smart contract wallets ('SCW') that broadly improves the experience users have when interacting with EVM chains. It was designed with flexible validation and execution logic at its core and is projected to become the de facto account standard.

Prior to Account Abstraction, externally owned accounts (EOAs) on EVM chains were inflexible. The programmability that Account Abstraction affords allows for on-chain accounts to inherently have the following capabilities:

- **Account recovery:** users can recover access to their account without seed phrases if private keys are lost by defining custom logic, such as social recovery.
- **Transaction guardrails:** scenario-based rules can trigger different transaction signing requirements, like multi-signature for certain transaction amounts or asset types.
- **Gas fee abstraction:** "Paymaster" functionality can allow for gas to be paid in different tokens or on behalf of users to simplify gas fee management and encourage usage.
- **Transaction batching (Multicall):** multiple transactions can be combined into a single batch that only requires one signature. This removes the need to sign multiple individual transactions, saving time and reducing transaction costs.
- **Session keys:** users can give trusted dApps permission to automatically sign transactions for a specific period, preventing multiple signature requests within the allocated time window.

¹⁵ <https://eips.ethereum.org/EIPS/eip-4337>

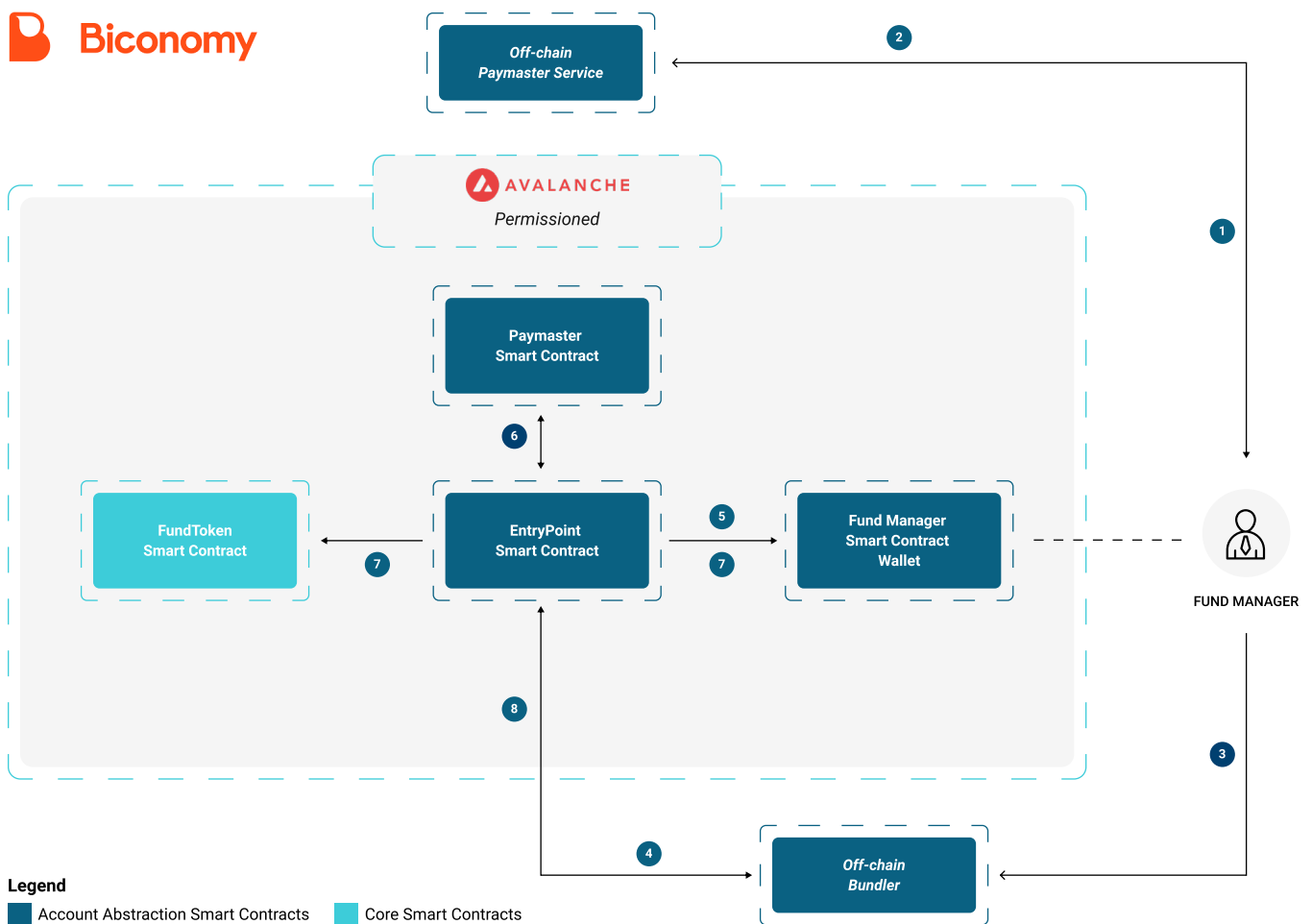
Implementation in the proof-of-concept

For the POC, we focused on gas fee abstraction enabled by Paymaster functionality. Avalanche permissioned subnets require gas tokens for transactions, which also applied to the POC, although only test gas tokens were utilized.

This resulted in the fund manager needing sufficient gas fee balances to cover transaction costs. Many financial institutions are uncomfortable with the process of acquiring or holding gas tokens, and therefore exploring the gas abstraction functionality of ERC-4337 was pertinent.

We leveraged Biconomy's Paymaster infrastructure to abstract away gas fees for the fund manager. The following diagram details the workflow for a transaction sent by the fund manager from their smart contract wallet.

BiconomySDK Account Abstraction



BiconomySDK Account Abstraction Flow

Step	Description
1	Leveraging the BiconomySDK, the fund manager creates a 'UserOperation' containing their transaction intent which is sent to the off-chain Paymaster service
2	The off-chain Paymaster Service verifies eligibility for sponsorship, returns the 'paymasterAndData' field and signs the 'UserOperation' which is returned to the Fund Manager
3	The Fund Manager then signs the 'UserOperation' and the BiconomySDK sends it to the off-chain Bundler
4	The Bundler then converts the 'UserOperation' to a 'handleOps' transaction and submits it to the EntryPoint Contract
5	The EntryPoint Contract performs validation as per the verification and authentication defined by the Fund Managers Smart Contract Wallet
6	The EntryPoint contract then performs validation on the paymaster specified in the userOp. If paymaster passes verification & agrees to pay the gas, then it deposits the amount on EntryPoint
7	The EntryPoint Contract calls the execution method on the Smart Contract Wallet to begin execution of the userOp
8	The EntryPoint Contract refunds the Bundler by transferring the relevant gas amount from the paymaster's deposit

Diagram illustrating the on-chain and off-chain components of Biconomy's Account Abstraction infrastructure which enabled the abstraction of gas fees for the Fund Manager on Avalanche.

By leveraging a smart contract wallet, we were able to provide a seamless way for the fund manager to deploy Fund Token Contracts and accept minting and burning requests without the need to obtain gas tokens to cover the required transaction fees.

Key learnings

Potential benefits and considerations

This POC was an ambitious effort to take the first steps towards our vision of **creating a step change in the asset and wealth management industry through a new paradigm for portfolio management.**

As we have outlined in this report, we sought to answer the following key questions within the POC:

- How can we improve the **efficiency and scalability** of order execution and settlement across multiple asset classes and ownership registries?
- How can we enable the **inclusion of alternative investments** in discretionary portfolios, given their operational difficulties and limited liquidity compared to traditional public assets?
- How can we overcome the **fragmentation and interoperability** challenges posed by multiple ownership registries developed on different technology protocols?
- How can we **simplify the use** of multi-party, multi-asset shared ledgers through the abstraction of technical complexities unique to blockchain technology use?

Potential Benefits

The POC yielded several learnings that validated potential benefits for the major actors involved in delivering discretionary portfolios, inclusive of alternative investments, to wealthy individuals.

- **Wealth managers:** a wealth management firm with 100,000 client portfolios could collapse their monthly rebalancing process from more than **3,000 operational steps into a few clicks.**
- **Investors:** eliminating cash drag through programmatic rebalancing and near-instant settlement **could reduce costs by almost 20%.¹⁴**
- **Asset managers, wealth managers and distributors:** could potentially capture a **\$400 billion** annual new revenue opportunity through broader distribution of alternative investments to High Net Worth Individuals.
- **Service providers (fund administrators, transfer agents etc.):** leveraging automation and digitization, could lead to increased efficiency, cost reduction, enhanced transparency, and reduced risk.

These and other benefits are expanded on below.

¹⁴ Using 1.09% average discretionary portfolio management fee from the Cerulli Report U.S. Managed Accounts 2023 Decisions About Discretion as of Q4 2022 and assuming 24bps of cash drag.

Efficiency and scalability

By deploying smart contracts representing discretionary portfolios, we successfully showed how tens of thousands of portfolios could be programmatically linked to representative models and automatically rebalanced en-masse when changes to those models occurred—even if these models include alternative investments. This solution could give wealth managers a “one-click” experience that aligns their investor base seamlessly, automatically updating investment strategies and reducing the operational back-office processing for distributing and settling associated orders. Assuming a wealth management firm has 100,000 client portfolios rebalanced monthly, this solution has the potential to collapse more than 3,000 operational steps into a few clicks.

Further, utilizing blockchain’s ability to enable near-instant settlement, clients could remain fully invested thereby limiting cash drag, resulting in a savings of ~24bps per annum (assuming ~3% cash and a long-term return of 8% over cash).

Inclusion of alternative investments in discretionary portfolios

Tokenization of private alts funds represents a \$400 billion annual revenue opportunity for alts fund managers and distributors.¹⁵ As stated previously, the primary driving factors that prevent alternative investments from being included in model portfolios are their lack of liquidity and the cumbersome investment process. While liquidity challenges cannot be solved in a POC (see **Practical considerations and challenges** section below for proposals on how these could be addressed), we demonstrated how leveraging blockchain technology and tokenization could address the operational challenges. By representing traditional and alternative investments as tokenized funds, the funding, order execution and settlement processes for both asset classes can be standardized and automated. This standardization could simplify how investments in alternatives are processed by replacing manual subscription processing with automated, straight-through processes that leverage smart contracts for payments and investor register updates. Pairing this new technological approach with different liquidity solutions could enable wealth managers to confidently include alternatives in discretionary and model portfolios, offering higher quality portfolios to their clients.

Broadening the investable universe with ledger interoperability

There are numerous findings to highlight on this front:

- Despite the growing number of blockchains vying for fund manager attention, and the increasing deployment of tokenized funds across various networks by fund managers, wealth managers can be entirely agnostic and impartial to the evolving landscape. This is thanks to a variety of interoperability solutions and the possibility to establish a portfolio management capability allowing portfolios to be managed from a centralized place. By extension, this would mean that fund managers could be equally agnostic to the plethora of blockchains, provided their distributors’ systems were suitably connected across this landscape.
- Wealth managers can automatically deploy, manage and monitor cohesive strategies consisting of tokenized assets without moving the underlying assets from their ledger of record when their systems leverage interoperability solutions that are scalable, well-connected and simple to implement.
- By enabling fund managers, PMs and investors, who may all operate on different networks, to connect to one another using these interoperability solutions seamlessly, the market size and liquidity of assets could be broadened.

¹⁵ Source: Expected revenue opportunity estimates are based on projections from Bain and Onyx by J.P. Morgan’s market research.

Improving the blockchain user experience

By leveraging novel Account Abstraction concepts such as a Biconomy's Paymaster service, we could abstract away the complexities of interacting with blockchains from the fund manager, who could seamlessly approve investment orders without needing to first obtain or hold cryptocurrency to pay for blockchain transaction fees. This experience is much closer to today's process, can easily be expanded to many blockchain networks, and can reduce the overhead and risk associated with managing blockchain private keys, and purchasing and protecting tokens required for transaction fees.

Further, the implementation of interoperability solutions, as described above, abstracted away the need for a PM to concern herself with accessing assets across disparate blockchains or to manage blockchain private keys associated with those different chains.

Practical considerations and challenges

Investment universe

The universe of tokenized investments must hit critical mass i.e., with respect to how many assets under management a wealth manager could deploy, the breadth of tokenized offerings available by asset class and a coalescing around operating models. While there continues to be many announcements in this space, the reality is that today you cannot build a robust portfolio of tokenized investments. The total inventory of tokenized real-world investments is approximately \$1.3 billion¹⁶ and is almost entirely composed of tokenized U.S. treasuries and private loans. It will take time for a respectable marketplace of tokenized investments to emerge, but there is demand from both fund managers and investors to further tokenize investments.

Liquidity

In our POC, we used subscriptions and redemptions placed directly with the fund managers as the mechanism by which investors entered or exited investment vehicles. To make this real, we would need to extend this work to consider purchases and sales on secondary markets so we could consider the full range of options to enter and exit positions. Similarly, we believe there is merit in exploring how alternative investment funds with capital calls could be included in this context.

As mentioned earlier, alternative investment funds require additional liquidity considerations, given they are generally less liquid than traditional investments. While tokenization has the potential to enhance liquidity by creating a more efficient secondary transaction process, this technology does not, in and of itself, create liquidity. We think a potential future state would allow for a stack of liquidity solutions that could give wealth managers enough comfort to include alternatives in their discretionary model portfolios.

¹⁶ <https://app.rwa.xyz/> as of October 6, 2023

This stack could consist of the following options:

- Direct redemption instructions placed with the fund manager following their stated redemption terms (e.g., quarterly redemption with 90 day's notice)
- A transfer of the investment at net asset value to another client within the distributor's client base
- Liquidity netting within or across distributors¹⁷
- Secondary sale of the holding to another investor
- Secondary sale of the holding to a designated market maker onboarded to the platform
- A liquidity tail guarantee program whereby the fund manager guarantees that an investor will receive redemption proceeds within a stated time frame (e.g., 18 months from the first effective redemption date)

Fund Structure

As more fund offerings are tokenized, fund managers may further explore innovative structures like Singapore-based VCCs, which were established in 2020 and have the built-in flexibility to invest across underlying asset types and operate as either open-end (subscription/redemption) or closed-end (capital call/distribution) vehicles. This flexibility could make VCCs the preferred tokenized fund structure as more assets come on-chain. VCCs could also be used for investors with particular tax needs or who prefer the simplicity of a single line item.

Regarding the ability to accommodate open- and closed-end vehicles, we believe there is a significant opportunity to deliver a better experience in traditional capital call-style investment vehicles. We believe tokenization could play a significant role in automating the capital call process and limiting cash drag by allowing investors to place funds in temporary investments like liquid model portfolios or yielding assets like money market funds.

Blockchain-based records

To bring this initiative to life, different blockchain networks should serve as either the official books and records of investor ownership or must be closely aligned and automatically synced with record keeping systems. We would also further consider how to create value and efficiency by bringing concepts like AML/KYC, investor accreditation and suitability on-chain to help drive appropriate investment selection. This would require meaningful integration work by fund managers, wealth managers and fund administrators. The global regulatory landscape on this topic also continues to evolve across jurisdictions. In the U.S. there is ambiguity around the use of blockchain ledgers as the primary source for ownership records of registered funds. In contrast, some countries such as Germany, Luxembourg and Singapore have passed legislations to enable blockchain-based record keeping.

¹⁷ Liquidity netting refers to providing liquidity to investors seeking to exit from new investors into a fund. We designed what this could look like in our POC but did not incorporate given time constraints. In summary, this concept can be automated using smart contracts to provide another liquidity avenue for alternatives investors by connecting multiple distributors via a Rebalancing Module.

Implementation and education

This POC explores an audacious change to how model portfolios are delivered to end investors. To gain adoption, the benefits to wealth managers, fund managers, fund administrators and investors must be compelling enough for firms to make the necessary investments to implement this solution. Additionally, education will be key for potential entrants into this space, as there are many misconceptions about blockchain technology and tokenization.

Privacy

Due to the transparent nature of blockchain technology, deploying all of the model details on-chain would risk exposing the wealth management firm's intellectual property publicly. As a result, in our proof-of-concept, we deployed the model and limited data on-chain, with the remaining information stored off-chain as reference data (i.e., fund manager, fund ID, blockchain, and % allocation were all off-chain). Further investigation around the balance between transparency and privacy would be required in a live state.

Industry call to action

The future of wealth management combines public and private assets efficiently to deliver better portfolios

We invite like-minded market participants to join us in further advancing this vision.

Consistent with the goals of Project Guardian, we believe our POC is a critical moment at the intersection between traditional finance and blockchain technology. As discussed in the Practical considerations and challenges section, there are several hurdles to overcome; however, none seem insurmountable. We view our contribution to Project Guardian as the first step of a journey into the complex business of delivering higher quality discretionary investment portfolios in a thoughtful and efficient manner to improve the end investor's experience and results.

We plan on continuing our journey to realize this vision and welcome curious wealth managers, asset managers, technologists, and legal, regulatory and compliance professionals to reach out to discuss further. We invite market participants to help further advance this vision for the industry through constructive discussion and debate, product development, technology advancement, market structure and behavior change.

We believe a robust network of marketplace participants has the best chance of solving these key pain points and identifying additional barriers to overcome. Join us as we work towards the future of wealth management.



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