PROJECT ENDOR: BLOCKCHAIN-BASED SECURITIES EXCHANGE

Final Report

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1 Executive Summary

SMEs form a key component of any economy, accounting for a significant portion of global employment and GDP. Yet, SMEs often face financing and liquidity challenges, and as a result their growth is often inhibited. Current exit options, such as an Initial Public Offering (IPO), are only suitable for larger SMEs due to its high cost and eligibility requirements. For the vast majority of SMEs, there is no ready market for private securities, and no way to enable price discovery and capital recycling for investors.

Project Endor is designed to enable secondary trading of private company securities in a centralized, transparent, and efficient manner. It provides a new way to achieve partial liquidity that is more cost effective, allows smaller offer sizes and with "light touch" listing rules. At the same time, it enables Accredited Investors the ability to access and participate in promising private SMEs.

Global stock exchanges, including NASDAQ, ASX, and JPX have been looking to use blockchain to reduce costs, increasing transaction speed and improve settlement efficiency[1]. However, concerns over blockchain's throughput and scalability has limited actual deployment over conventional exchange trading systems. In contrast, Private Exchanges, which are expected to have lower liquidity given the nature of the underlying assets, can immediately benefit from blockchain's features, without being hindered by the current limitations.

CapBridge has partnered with ConsenSys, a world leader in blockchain technology solutions, to deliver a next generation, blockchain-based securities exchange. CapBridge and ConsenSys intend to build towards a fully compliant securities exchange on the public Ethereum, and roll-out in a phased and thoughtful approach in order to ensure all requirements are met. Unique design aspects of our blockchain-enabled exchange include a hybrid orderbook, decentralized custody, fiat settlement, and restriction to accredited investors. This is also expected to be the first regulatory-compliant private exchange with tokenized securities.

[1] https://www.nasdaq.com/article/how-stock-exchanges-are-experimenting-with-blockchain-technology-cm801802

2 Overview of Project Endor

2.1 Background

Project Endor is designed to enable partial listing and trading for private companies, creating an exit that is more cost-effective and flexible with “light touch” listing rules. SMEs that do a partial listing set aside a portion (10%-30%) of their shares to be valued, converted and listed as “Private Securities”. The Exchange maintains an online bulletin board style “order book” for Private Securities shareholders trade with one another. Buyers then transfer funds to 3rd party escrow for settlement, and the registrar of Private Securities are held by licensed entities. Investor participation is limited to Accredited Investors (“AIs”), who can directly register and access the Exchange without the need for brokers or other intermediaries. Liquidity is expected to increase when mandatory disclosures are made by the company, which are far less than that required of publicly listed entities. Overall, it is expected that the trading of these private SPV securities will be up to a portion of the liquidity of typical publicly listed entities.

2.2 Existing Technology Systems & the Potential of Blockchain

Existing IT securities systems used by stock exchanges are highly mature, enterprise-grade systems, designed to support both high volume and frequency of transactions between multiple parties. These includes the exchange itself, service providers (e.g. custodians, escrows) and other intermediaries (e.g. banks, brokers, etc…). While very powerful, these trading systems are highly expensive, costly to maintain, require high levels of configuration, and extensive ongoing technical support. As such, they are unsuitable for a private exchange, where the liquidity and number of market intermediaries are expected to be low.

More importantly, in conventional systems, each party independently maintain their own records of every shareholding and transactions, as their IT database and system are both fragmented and complex. Continuous, manual reconciliation between parties are required for every transaction- leading to duplication of effort, high unnecessary costs and longer settlement time. In the absence of a universal database, potential issues such as for data errors, data manipulation, reconciliation lags and other disputes may occur.

Blockchain is an emerging and potentially disruptive technology that can eliminate these complexities – blockchain provides the ability to create a single version of the truth, thereby unifying the same underlying securities dataset among all participants and eliminating fragmentation, reconciliation, and other complexities. On more sophisticated blockchain systems like Ethereum, there is additionally a “Smart Contract” layer, where any entry to the database must follow a pre-determined business logic, thereby ensuring standardization of data and business processes among all system participants. All actions must be “signed” by parties using their own unique cryptographic key which is used to manage user access control, security, transparency and traceability. Once data is inputted into the system, it is essentially “immutable” due to the underlying cryptographic infrastructure and network distribution. This further reduces the possibility for data errors or manipulation, and reduces the need for reconciliation, providing operational and costs benefits to all parties.

Project Endor is being designed to be deployed to the public Ethereum Network. The public Ethereum network is a suitable platform to launch the Private Exchange – with 3+ years of production deployment with 100% uptime, a proven ability to tokenize assets, smart contracting capabilities, and a resilient network of peers that spans a global userbase, no other blockchain network is as mature at this point. As the platform evolves, Ethereum should be able to support advanced features including, but not limited to, smart contract based corporate action including dividends, share splits, voting, etc., and integration with other platforms.

2.3 Expected Benefits of Blockchain

Blockchain offers the following benefits especially in the case of capital markets, one of the most exciting use cases.

2.3.1 Transparent real-time data, reduced error, and reduced fraud

Each and every transaction published to the blockchain is visible to all participants across the value chain. This means that the exchange, investors, licensed entities, regulators and policymakers have access to real time market data that they can use to identify potential risks and respond accordingly in a timely manner.

In addition, because blockchain utilizes smart contracts that require specific inputs and produce deterministic outputs, the likelihood of error is greatly reduced as incorrect inputs will be rejected by the network. This reduced dependence on human input means reduced room for human error. In a similar way, fraud can also be reduced as the blockchain requires specific digital signature which is highly improbable to duplicate.

2.3.2 Faster settlement times

Blockchain offers fast and seamless verification and settlement of transactions. Each and every transaction is accompanied by a digital signature providing near instant authentication. When a new transaction is published to the network, the network automatically validates ownership rights can confirm that transaction in a matter of seconds, not hours or day. This newfound speed has immense benefits and will allow the industry to deploy capital more effectively and efficiently.

2.3.3 Lower risk resilient infrastructure

The infrastructure supporting blockchain networks is highly resilient. For the public Ethereum network, as of September 14th, 2018, more than 14,000 nodes were up and running.[2] Each of these nodes adds redundancy in data storage and transaction processing, and increases the degree of fault tolerance in the network as a whole. As such, the greater the number of nodes that are online, the smaller the risk of disruption of service.

Additionally, as the number of individual participants increases, the likelihood of a 51% attack (also called a majority attack) decreases. As the network grows, collusion among participants acting against the interests of the network as a whole becomes increasingly difficult, and the cost to acquire the necessary hardware grows exponentially.

[2] https://www.ethernodes.org/network/1

Finally, while the Ethereum network has suffered from congestion in the past from events like the launch of like CryptoKitties[3], Ethereum's infrastructure has allowed it to maintain 100% uptime since its launch more than 3 years ago on July 30th, 2015.

These factors all make large blockchain networks incredibly resilient and an idea substrate to begin building new financial infrastructure.

2.3.4 Lower counterparty risk and Integrated DvP

A large part of risk in transactions comes from counterparty risk – the risk that a trading partner defaults on their obligations. In the case of blockchain, both sides of a trade can verify the possession and ownership rights of their counterparty as the blockchain provides a complete chain of custody of each asset and uses public key cryptography to verify ownership over those assets. If integrated delivery versus payment (DvP) is used, the transactional risk can be greatly reduced even further as either both assets would trade hands or neither would.

2.3.5 Programmable assets

Assets on a blockchain can be programmed to exhibit arbitrarily complex behaviours programmed to their particular use case. For companies, these can include digital governance and voting mechanisms, as well as for distribution of dividends. In a similar way, the assets can be programmed to exhibit behaviours that would include autonomous regulatory compliance. This includes the enforcement of KYC requirements or requiring regulatory approval before specific assets can change hands as may be required for shareholders in regulated entities. This autonomous regulatory compliance can greatly reduce the cost of both compliance for firms and for regulators to enforce those rules. In many cases, new standards can be created for assets of a particular type or likeness (jurisdiction, asset class, etc.) that can be use across an entire sector thus driving further efficiency.

[3] https://qz.com/1145833/cryptokitties-is-causing-ethereum-network-congestion/

3 Platform Overview

3.1 POC Objectives

The POC of the Private Exchange was defined to demonstrate the following capabilities using smart contracts deployed on an Ethereum blockchain:

1 Ability to tokenize securities

Approach

Securities will be represented by standardized smart contracts leveraging existing standards and design patterns

2 Ability to trade tokenized securities

Approach

Trading of tokenized securities will be conducted through a simple via bulletin-board / marketplace style platform

3 Ability to restrict trading of tokenized securities to AIs

Approach

While the platform may be deployed on the public Ethereum blockchain, only pre-approved, KYCed investors will be allowed to trade using the platform.

1. **Ability to tokenize securities** – securities will be represented by standardized smart contracts leveraging existing standards and design patterns.

2. **Ability to trade tokenized securities** - Trading of tokenized securities will be conducted through a simple via bulletin-board / marketplace style platform

3. **Ability to restrict trading of tokenized securities to accredited investors** – while the platform may be deployed on the public Ethereum blockchain, only pre-approved, KYC'd investors will be allowed to trade using the platform.

Future versions of the platform are expected to demonstrate additional capabilities which could include price discovery (auctions), corporate actions, and integrated DvP.

3.2 Core Principles of POC Design

The following core principles were used to guide the development of the POC:

1. **Only key processes will be deployed on-chain** – not every process needs to be executed on the blockchain. Only key processes that benefit from being in a "trustless" environment should be deployed on-chain.

2. **Reduce single point of failures as much as possible** – as much as possible, remove or reduce the reliance any user or entity would have on centralized systems or parties for day-to-day operations.

3. **Be agile and take feedback from key stakeholders** – Conduct frequent review with key stakeholders to ensure designs meet requirements, including market participants, compliance and regulatory requirements

3.3 POC System Design and Architecture

3.3.1 Key POC Features

The Private Exchanges POC has three key features:

- Non-custodial exchange;
- A hybrid orderbook;

- On-chain, post-trade asset settlement enforced by transaction governor

3.3.1.1 *Non-Custodial Exchange*

The Private Exchange is defined as a *non-custodial exchange*.

A non-custodial exchange is a type of trading platform that is deployed on a public blockchain that enables direct asset exchanges using blockchain-based smart contracts. Transactions on the exchange initiated and authenticated directly by users via their private keys.[4] Upon submitting transactions to the exchange, the platform's smart contracts enforce a predefined trading and settlement workflows that provides governance over each transaction. At no point, however, does the platform take custody of the user's assets. This drastically lowers the risk profile of the platform compared to its centralized counterparts. In this model, the investor(s) are in complete control of their assets throughout the lifecycle of a trade, eliminating the 'honeypot' of assets or keys for hackers to steal that is standard among centralized exchanges, thus reducing overall risk.

For the POC, MetaMask will be used, however in the future any number of wallet solutions may be used including both hardware and software wallets.

3.3.1.2 *Hybrid Orderbook*

The orderbook for the Private Exchange has two parts: an off-chain orderbook, and an on-chain orderbook.

The off-chain orderbook is held on the Private Exchange server. It maintains a complete, up-to-date list of all open orders as well as order history. Orders placed through the off-chain orderbook will be visible in the on-chain orderbook with the exception of the digital signature authorizing a user to fill that order directly – that signature is instead kept confidential on behalf of the investor until the trade is filled.

The off-chain orderbook will maintain both a full list of orders from the off-chain orderbook sans investor signatures, as well as orders published directly to the blockchain. This allows the platform to take advantage of the global reach of the platform while providing options for users and maintaining fault tolerance for the Private Exchange. Users can choose whether or not they want to go through the Private Exchange's off-chain orderbook or speak directly to the blockchain – speaking through the off-chain orderbook adds privacy and enhances the user experience, but speaking directly to the on-chain orderbook on the blockchain may be preferable for integration with other 3rd party applications. This is only possible because the Private Exchange maintains key business logic on-chain ensuring that all rules are enforced regardless of which route a user takes.

3.3.1.3 *On-Chain Asset Settlement Enforced by Transaction Governor*

The Ethereum blockchain will be used as the settlement layer for all assets supported by the Private Exchange. The blockchain layer contains both asset registry contracts as well as the

[4] Investors or a designated, trusted, 3rd party - investor has the choice of how to manage their own keys and assets

transaction governor contracts that enforce the rules of the Private Exchange – this includes the on-chain 'whitelist' for enabling only approved users to participate and use the platform (e.g. for KYC).

3.3.2 User groups for the POC

The POC will support the following user groups:

- Investor
- Administrator/operator
- Regulator
- Escrow

Additional groups including Issuer and Custodian will be added in future iterations for the platform.

3.3.3 POC Technical Architecture

The platform can be broken up into 3 layers – Client, Server, and Blockchain – as seen in *Figure 1 - High level technical architecture* below. Further details about each component have been provided in *Table 1*.

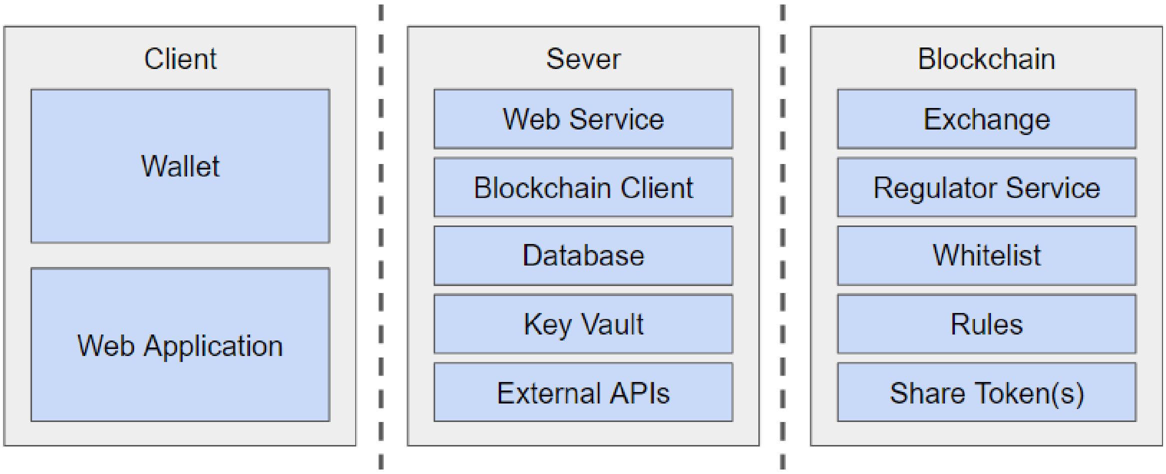

Figure 1 - High level technical architecture

- **Client** – The Client takes data from the Server and serves it up in an intuitive and smooth user experience. When a user submits a request, the Client will fetch the appropriate data for the user or push updates from the user to the Server. When the user performs an action that requires a signature, the Client will send a request to the user's Wallet and accept a signed piece of data in response which it will then pass to the Server.

- **Wallet (Client side)** - The Wallet sits on the Client side of the stack manages private keys on behalf of the user. Each user instantiates their own Wallet on their own machine or offline. Their Wallet then allows them to sign requests that are submitted from the Client to the Server or directly to the Blockchain. Without authentic signatures from the Wallet of an authorized user, neither the Server nor Blockchain will process the requests (e.g. to whitelist a user or process a trade). MetaMask is being used for the POC, however additional options will be available to the user for future releases including a combination of software wallets, hardware wallets, and 3rd party managed wallets.

- **Server** – The Server contains all of the platform's business logic to validate incoming requests from the Client and to push them to the blockchain as well as the external connections to services like Salesforce and the off-chain orderbook. Note that while requests are signed and sent to the blockchain layer from the Server, this layer has no on-chain authorizations of its own and is solely serving to enhance the user experience of the blockchain by eliminating the need for end-users to procure gas for using the Ethereum network. Requests sent to the Server could be directly sent to the blockchain instead.[5]

- **Blockchain** – The Blockchain contains a series of smart contracts including the exchange that maintain logic for updating the asset balances of the various investors, transaction governors which contain the whitelists and transaction rules and assigns roles and permissions to users, and token contracts which are deployed for each asset. Transactions can be either accepted directly from users or through the Server.

The architecture has been designed as such specifically to introduce fault tolerance and limit the impact of a Server outage, reducing overall risk. The Server layer is parallelizable, capable of being run on different systems and infrastructure or even by different parties – the on-chain logic is still enforced regardless of who is submitting transactions to the network.[6] The Server, which is primarily used for building, adding gas to, and submitting transactions, has no on-chain role or authorizations and is primarily a user experience enhancement tool. The Server holds no custody of assets beyond a limited amount of ETH required to pay gas for transactions (possibly only enough for a single day's operation).

[5] Requests that are sent to the blockchain vary in structure from those sent to the Server and require that the user pays their own gas fees, however the capabilities of the end user remain the same as logic for processing requests is kept on the blockchain.

[6] The ability for 3rd parties to run the platform is, in part, is what will lead to the formation of a "network" of exchanges that can interact with each other and form global marketplaces.

Table 1 - Description of architectural sub-components

Application Component	Description	Layer
Wallet (MetaMask)	Manages private keys (custody of assets) on behalf of the user and enables user authentication to the platform for administrators, issuers, escrow agents, regulators, etc. Users download MetaMask and generate their own wallet offline, after which they register their public address with the platform. Future versions of the platform will support other alternative wallet and custody solutions.	Client
Web Application	User interface / front end for the application	Client
Web Service	Encompasses all off-chain processing for the platform. It also handles the submitting transactions to the blockchain for all on-chain processes and maintaining data synchronization with the blockchain through the Blockchain Client. The orderbook is currently maintained entirely off-chain.	Server
Blockchain Client	Responsible for communicating with the blockchain on behalf of the platform	Server
Database	Databases for the platform.	Server
Key Vault	Provided by Microsoft Azure. HSM in Azure data centres that handles keys that are used to sign transactions submitted to the blockchain (does not have any authorizations, only supplies gas to power transactions)	Server
External APIs	Connects the platform to external services like Salesforce for federated login and payment gateways	Server
Exchange	Main smart contract for processing on-chain orders, trades, and actions	Blockchain / Smart Contracts
Transaction Governor	Service that connects rules to trades and asset transfers.	Blockchain / Smart Contracts
Whitelist	On-chain whitelist for users onboarded to the platform	Blockchain / Smart Contracts
Rules	Maintains on-chain rules for the platform deployed by the administrator	Blockchain / Smart Contracts
Share Token(s)	Asset/token registries that serve as the blockchain-based CSD for the platform	Blockchain / Smart Contracts

3.4 Key POC Processes

3.4.1 Investor Onboarding

The user onboarding process will leverage both on- and off-chain processes. In addition to login using a username (email address) and password and a mobile device for 2FA via OTP, each user will also use an Ethereum wallet (for the POC, this will be done via MetaMask). The public address of this wallet will be disclosed to the platform during the onboarding process.

3.4.2 Placing and Filling an Order

The process of placing and/or filling an order can be done by sending transactions directly to the blockchain or by using the assistance of the Private Exchange's Server. Buyer and Sellers create orders by making an order, verifying an OTP, and using their unique signature. Once on the orderbook and matched, additional verifications are performed, such as both buyer and seller being on the on-chain whitelist, and only after all verifications have been passed will the trade be submitted to the blockchain. For final settlement, the tokens are transferred when the funds are confirmed to be received by the Escrow agent.

3.5 Comparison of Blockchain to Non-Blockchain Process

As mentioned above in *2.3 Expected Benefits of Blockchain,* blockchain has the potential to unlock numerous benefits for capital markets in the long run.

With today's POC, we expect to see faster settlement times for transactions than otherwise possible with today's infrastructure. *Table 2 - Comparison of non-blockchain and blockchain processes for trade settlement* compares the settlement process and times for non-blockchain exchanges and today's Blockchain Private Exchange POC.

Table 2 - Comparison of non-blockchain and blockchain processes for trade settlement

Activity	Non-Blockchain Private Exchange	Blockchain Private Exchange
Pre-Trade Verification of Holdings	CapBridge to verify with 3rd party Trustee that Sellers have the Securities	As all parties use a single database, there is no need to verify with Trustee that Sellers have the required number of Securities when a Sell Order is placed on CapBridge
Cash Settlement	Up to a few business days for Escrow to confirm receipt of funds and instruct Trustee to update shareholdings	As all parties use a single database, Escrow can directly update the blockchain as funds are received.
Update of Shareholdings	Up to few business days for Trustee to update the registrar and update CapBridge, Buyer, and Seller	As all parties use single database, there is no need to reconcile shareholdings. Buyer and Seller directly hold custody of the Assets.

4 Challenges and Design Constraints

While blockchain does offer a large number of benefits, those benefits don't come without challenges or new design constraints.

4.1 Privacy on Public Blockchains

Privacy becomes a challenge when building infrastructure using the public Ethereum blockchain.

In the public Ethereum network's current state, it is computationally expensive to run complex privacy solutions like zk-SNARKs on the public Ethereum blockchain. As such, any data that is used as an input for logic processed on-chain as plaintext (i.e. not encrypted). This means that the balances of assets belonging to each public address would be readily retrievable by any party while viewing the network. Note that only the addresses (which are pseudo-anonymous) are visible alongside their balances, not the real identities of said users.

The visibility of this data offers both benefits and drawbacks. The benefits of this visible data include reduced information asymmetry and more transparent cap tables which could benefit investors. Individual investors, however, may not want their holdings disclosed pre- or post-trade, which may pose challenges for adoption.

While it is anticipated that the industry will mature and new privacy mechanisms will become available, there are alternative measures including the ability to register multiple and/or single use addresses for investors, helping to distribute a portfolio over any number of independent identities.

4.2 Scalability of Public Ethereum

Public Ethereum in its current state has a very limited transaction throughput. While various scaling solutions like Sharding, Truebit, Plasma, and State Channels are at various stages of development, not all of them are applicable to the Private Exchange platform, and many are a long way from production release.

While this is a challenge for high-frequency trading platforms, the Private Exchange is not intended to support high frequency trading, and transaction volumes are not anticipated to grow beyond what public Ethereum can handle in the near term. Additionally, because trades are settled over multiple days, if transaction volumes do spike above what the network can handles, transactions will be spread over multiple blocks by the network.

As scaling solutions continue to develop, this may open up the door to additional features or redesign of key processes.

4.3 Nascency of Public Ethereum

As blockchain technology, including Public Ethereum, are incredibly nascent, frequent changes and updates are expected. New updates will need to be monitored frequently for potential impact for the platform.

5 Results of Pilot Launch

5.1 Pilot Launch and User feedback

Once the platform was developed, a network testing was conducted to simulate the effects of network congestion and spam attacks, and additional testing was conducted to help estimate the platform's capacity and throughput on the public Ethereum network. In addition, user testing with end users was conducted on the Ropsten testnet to allow users to experience the platform in a similar environment as it was designed for, i.e. public Ethereum, without the risk or cost associated with using mainnet and allowed them to use publicly available tools like MetaMask and Etherscan.

5.2 Operational Findings and Benefits

5.2.1 Improvement in Outcomes within Investor's Trading and Order Process

Based on user feedback on from the Trustee and Escrow, there is sufficient confidence to leverage the smart contract with its built-in business logic and authentication mechanisms to increase the efficiency of the trade settlement process. Trustee can save significant manpower effort, as the blockchain smart contracts automatically verifies the validity of each sell order, and allows for faster settlement of trades, which can take up to a total of 4 business days in the manual system. Likewise, Escrows can directly update the blockchain whenever funds are received, and all parties can directly query the blockchain for all prior transactions and existing shareholdings. Further analysis will need to be done to estimate the actual costs savings.

5.2.2 Greater Transparency

As mentioned above sections, using blockchain as the settlement layer offers great benefits to the platform. In the POC, we were able to demonstrate the reduction in information asymmetry and increased auditability of the platform. For the POC, both orders and trades were deployed to the platform's blockchain smart contacts. As a result, key information such as orderbook, current shareholding(s), and price history can be derived directly from the blockchain by anyone with access to the public Ethereum network (i.e. anyone with an internet connection). Access to this information will allow market participants to identify trends, make decisions, and even identify suspicious trading activity indicative of price manipulation, helping to increase the fairness of markets for all participants.

6 Summary

Project Endor is designed to enable secondary trading of private company securities in a centralized, transparent, and efficient manner. It leverages the public Ethereum network to enable greater transparency, faster settlement time, higher resiliency, better compliance and greater automation as compared to conventional systems. Key design considerations for deploying on public networks are also identified and addressed, including factors such as whitelisting, privacy, scalability, security and costs.

As part of the POC, a pilot launch with user testing with beta users was conducted, with key user feedback and insights consolidated and areas of improvements identified. Network testing was conducted to simulate the effects of network congestion and spam attacks of public networks. Additional testing also demonstrated that the platform’s capacity and throughput on the public Ethereum network was sufficient for the expected trade frequency in the early phase. This gives scaling solutions currently in development time to mature.

This POC demonstrates a working model for a regulatory-compliant, private exchange with tokenized securities built on the public Ethereum network. Future developments will focus on improving usability, scalability, payment options, while expanding to new features such as digital corporate actions when appropriate.