Connecting regulated digital asset platforms to Public Blockchains

by **ADDX**

Abstract

This paper summarises the initial exploration and findings of ADDX, as part of the MAS Financial Sector Technology and Innovation (FSTI) Proof-of-Concept (PoC) Grant, on the topic of blockchain interoperability. It focuses mainly on asset interoperability and goes in detail on the experimentation done by ADDX for our own specific use case (digital token exchange platform). The paper further identifies asset interoperability issues from a regulated practitioner's standpoint and provides some thoughts about how to overcome them.

Acknowledgements

Monetary Authority of Singapore (MAS)

For awarding the Proof-of-Concept (PoC) grant to ADDX for this research project on blockchain interoperability. The MAS FSTI PoC scheme [1] provides funding support for experimentation, development and dissemination of nascent innovative technologies in the financial services sector.

[1] https://www.mas.gov.sg/development/fintech/mas-fsti-proof-of-concept-grant

Contents

01 | Executive Summary

Blockchain technology, while in its nascent phase, is maturing at a fast pace. The technology is often lauded for providing distinct advantages over traditional centralised databases, most notably due to blockchain's distributed architecture, which allows many participants to join the network via nodes (could be public or private in nature). Blockchains by design provides resilience, security and immutability that its supporters believe guarantees the protection of its users' personal data (e.g. identity) as well as their hosted digital assets.

As more parties begin experimenting with blockchain technology for real-world use cases, such as in supply-chain, healthcare and capital markets, it led to the need for a heterogenous ecosystems of available blockchains, with each serving different and distinct use cases for different stakeholders.

While having different blockchains for different use cases is beneficial for innovation in the space, each blockchain has its own limitations; such as security risks, transaction throughput limits, and limited user base. Furthermore, some projects have requirements that are just not feasible to implement on a single blockchain. As such, it has become evident that there is a need to provide for interoperability between blockchains in order to explore synergies between different solutions as well as creating new and exciting use cases.

ADDX, a digital token exchange platform, designed to administer, create, and trade digitised security tokens, was built using a private blockchain, making it inherently a closed system, which potentially limits the growth plans of ADDX. In view of this, ADDX is looking to investigate how blockchain interoperability solutions - in particular side chains, can help overcome this obstacle. ADDX intends to build a token bridge to connect our permissioned private blockchain to the Ethereum Mainnet (public blockchain) to explore how we can increase transparency of transactions and also allow community-driven growth of our platform functionalities by leveraging the innovation of open source projects that thrive on Ethereum.

02 | Introduction

2.1. ADDX: Your entry to private market investing

Founded in 2017, ADDX is fully regulated by MAS as a platform for the issuance, custody, and secondary trading of digital securities. ADDX is designed to bring private market investments that would normally be distributed to the wealthier high net worth and ultra-high net worth investment community to accredited investors who can buy in at levels such as USD 20,000 or lower. The democratisation of the private capital markets is thereby putting previously out-of-reach investments in the hands of underserved investors. Currently, the ADDX platform already serves investors from 27 countries, spanning Asia, Europe, the Americas (excluding the US), Australia and New Zealand.

Private market investments are huge and growing at a rate of 10% annually, however access is limited to most due to limited liquidity and no visibility to exit, large minimum investment amount and limited access to deal flows. All securities on the ADDX platform are digitised, which allows the asset to be easily fractionalised, or reduced into smaller investment sizes. This allows users to invest as low as USD 10,000 instead of traditional investing where the investment amount is at least USD 200,000. Security tokens can increase liquidity in the market, partly due to fractionalisation and partly due to the ease of buying and selling in a market which is accessible round the clock. Thus, the lower concentration risk and liquidity risk results in a broader pool of investors to invest in private markets on the ADDX platform.

ADDX is owned and operated by ICHX Pte. Ltd., which has been approved by MAS as a recognised market operator (RMO) and it has a capital markets services (CMS) license to deal in securities and collective investment schemes and provide custodial services. It is currently allowed to only deal with accredited and institutional investors.

ADDX employs blockchain and smart contract technology to tokenise and fractionalise multiple types of assets, such as private equity, wholesale bonds and unicorn funds, and the protocol facilitates both transparency and instantaneous trading for liquidity. Investors can trade their securities on the ADDX exchange, which settles trades instantly, compared to the two or more working days needed on other exchanges. Digital securities are significantly

more efficient than traditional ones as they allow much broader access to the private markets by both issuers and investors, matching capital with fundraising companies at a faster speed and lower cost and thus reduces uncertainty in a rapidly changing business landscape.

2.2. Background

ADDX's core business is to create a seamless flow for private market investors without the need for various intermediaries that make up the current investment process. ADDX provides a one-stop platform from issuance to custody to the trading of securities in a digitised (tokenised) format. Currently, the ADDX platform runs on a private permissioned blockchain – this represents the centralised solution that allowed us to develop a fully-functional solution quickly.

ADDX's private blockchain is operated using the open source Ethereum Geth client [2] (Ethereum Virtual Machine aka EVM based) and runs on the Clique [3] Proof of Authority consensus protocol. Real world assets like funds and equity are converted into digital tokens (digitised securities or security tokens) via the use of Ethereum Smart Contracts. The tokens used conform to the ERC-20[4] standard.

[2] https://github.com/ethereum/go-ethereum
[3] https://github.com/ethereum/EIPs/issues/225
[4] https://eips.ethereum.org/EIPS/eip-20

2.3. ADDX Private Blockchain

A major design decision made at a very early stage since the conception of ADDX was the use of a private blockchain. Some of the reasons (other than regulatory requirements) as to why a private blockchain was preferred for ADDX's use case are as follows:

1. Being on a private blockchain allows ADDX to innovate and develop a fully functional solution quickly. By controlling access to our blockchain, i.e. by allowing only authorised sealers to mine and only whitelisted IP addresses to connect to our blockchain, we create a safe and secure environment and significantly reduce the likelihood of hacks on our platform as compared to a public chain. Operating on a public chain would mean that ADDX is exposed to anyone who has an internet connection, and would make ADDX susceptible to hacks like the famous DAO hack on Ethereum[5].

2. It enables ADDX to tune the blockchain according to our requirements. ADDX requires the blockchain to have high throughput so that we are able to process transactions quickly with finality. Using a private blockchain allows ADDX to tune variables like block time, gas limits and gas costs in order to achieve our desired outcome. On a public blockchain, we will be limited by the block time (e.g. ~14 seconds on Ethereum Mainnet[6]) and transaction fees.

While operating on a private blockchain has brought about many advantages and development flexibility, it has also created some hurdles on the growth plans for ADDX. We foresee these same hurdles to apply to other regulated financial sector players which operate on a private blockchain infrastructure to deliver their services, and hence we could benefit from their solutions that address such limitations.

[5] https://www.cryptocompare.com/coins/guides/the-dao-the-hack-the-soft-fork-and-the-hard-fork/
[6] https://etherscan.io/chart/blocktime

2.4. Challenges

Any Financial Institution (FI) that operates on a private blockchain is inherently operating within a closed system. ADDX currently falls into this category, and for the purposes of this document we shall use ADDX as an archetype for other FIs operating in a similar fashion.

Operating within a closed system has advantages as described above, but it limits liquidity and participation as access to the private blockchain is restricted. In the case of ADDX, security token issuances (STOs) offered on the ADDX platform only allow investors who onboarded on the platform and have an account created on ADDX's private blockchain to participate.

Likewise, secondary trading of ADDX issued tokens can only be done between participants who exist on ADDX's private blockchain. In addition, innovation on ADDX's private blockchain is limited to ADDX's own development team, thus all new features and applications for tokens have to be built inhouse. As such, the value discovery of ADDX-issued tokens is limited to only within ADDX's private blockchain ecosystem, and ADDX's clients are limited to using features and tools built by ADDX.

03 | Proof of Concept: Asset Interoperability

3.1. Blockchain (Asset) Interoperability

In order to extend ADDX's reach as a centralised platform, we explored on the topic of blockchain interoperability. In particular, we wanted to see how we could have ADDX's issued assets co-exist on the ADDX private blockchain as well as on other blockchains.

Interoperability here refers to the technical interoperability of a pair of blockchains, i.e. cross-blockchain communication. In cross-blockchain communication, there are two blockchains: source blockchain and target blockchain. Source blockchain is the blockchain in which the transaction is initiated from, to be executed on a target blockchain.

Cross-blockchain communication can be achieved via communication protocols. There are two main types of cross-blockchain communication protocols: cross-blockchain and cross-chain. The main difference in the two communication protocols is that cross-blockchain is for the communication of two heterogenous (different) blockchains whereas cross-chain is for the communication of two homogenous (similar) blockchains. For the purpose of this PoC (which is aligned with ADDX's use case), we are interested only in cross-chain communication protocols which allows the private blockchain (EVM-based) to interoperate with another EVM-based blockchain. In this PoC, ADDX is looking to interoperate with the Ethereum Mainnet (EVM-based).

There are many blockchain interoperability solutions that exists out there such as sidechains, notary schemes, hashed time locked contracts, trusted relays etc. As ADDX is interested in the value discovery of assets issued on ADDX private blockchain, the sidechains/relays scheme[7] are the preferred solution.

[7] Relays are between blockchains and those blockchains are using behaviour from others (bidirectionally or unidirectionally); Relays include the presence of sidechains; Without a sidechain, there are no relay solutions

3.2. Sidechains/Relays

In a sidechain/relay scheme, one blockchain (mainchain) considers another blockchain (sidechain) as an extension of itself[8]. The mainchain is attached to the sidechain via a cross-chain communication protocol (CCCP). An example of a CCCP relevant to this PoC is a two-way peg, a mechanism for transferring assets between the mainchain and the sidechain.

A two-way peg works as such: a user on the mainchain sends tokens to a protocol that locks assets. The funds are locked on the mainchain and the corresponding number of tokens are created on the sidechain. The user can then use the tokens on the sidechain. Eventually, the user will be able to transfer the tokens back to the mainchain, causing the assets on the sidechain to be locked or destroyed, depending on the implementation of the two-way peg. There are a few major types of two-way pegs: Simplified payment verification (SPV), centralised two-way pegs, and federated two-way pegs.

In the context of ADDX's system, ADDX's private blockchain is the mainchain, while Ethereum Mainnet is the sidechain. As for the two-way peg, the centralised form is used due to the necessary controls required to be in place as a regulated entity. For the purpose of the rest of this paper, the two-way peg will be referred to as a token bridge.

[8] Side chains are not necessarily 'secondary', and mainchains can be sidechains of each other.

3.3. Objective and Scope

The ideal state is for ADDX to demonstrate that we are able to transfer ADDX's assets from ADDX's private blockchain over to the Ethereum Mainnet and vice versa in a regulatory-compliant and secure way, and at the same time ensuring that the total amount of assets on both chains remain constant (i.e. no token duplication occurs). For the purpose of the PoC, in order to save on gas fees and associated transaction costs, asset transfers were done from a local test blockchain (representing ADDX's private blockchain) to one of the available Ethereum Testnets (Ropsten in our case). To achieve this, a token bridge application was built to connect the blockchains. Demonstrating a successful 'bridge' of assets from the test blockchain to the Ropsten Testnet and back was sufficient for a successful outcome. Note that the following assumptions are made for the purpose of the PoC:

1. Assets all originate from the ADDX private blockchain
2. Only users who have onboarded on the ADDX platform can perform the bidirectional bridge (whitelisted users)

3.4. Methodology

During the initial phase of the PoC, a significant portion of time was spent researching on the topic of blockchain interoperability to gain an understanding of it and its available solutions, and thereafter pick the most appropriate solution for ADDX's use case and future plans.

After the initial discovery process, the sidechain/relay scheme was chosen as the appropriate solution for ADDX, and we have decided to build a token bridge to demonstrate the expected use case. Technical solutioning (technical design and architecture) for the token bridge PoC was then done before the actual development process began. The development of the token bridge backend was prioritised as it involved the core logic of the token bridge. Relevant user flows (UI/UX) were subsequently prepared to support in the development of the front-end application.

Following the completion of the core token bridge, we then proceeded with our internal software development lifecycle process to ensure the application built met our companies' development standards. This comprised Quality Assurance (QA) and User Acceptance Testing (UAT). A comprehensive internal security audit (code coverage, smart contract security analysis and source code security scan) of the software components built was also done.

Finally, after the Software Development Life Cycle (SDLC) process was done, we ran a full end-to-end flow and demonstrated a successful 'bridge' of assets from the test blockchain to the Ropsten Testnet and vice versa.

3.5. Token Bridge Overview

Figure 1 below shows a diagram of how the token bridge works, followed by a description in the context of ADDX's use case.

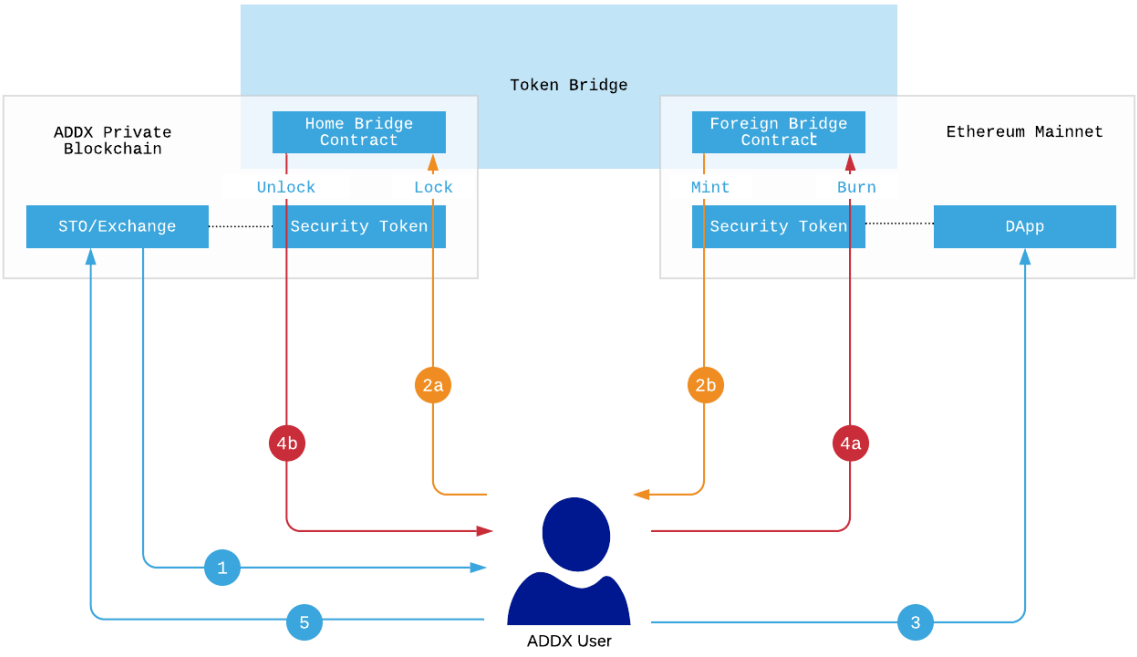


Figure 1. Token Bridge Process Flow

With reference to Figure 1 which represents a specific application of the token bridge to the ADDX platform's use case:

1. An ADDX user first acquires security tokens via an STO issuance or via a successful trade on the exchange

2a. When the ADDX user wants to transfer his tokens to **Ethereum Mainnet**, he/she will **lock** the security tokens on a **bridge contract** on the **ADDX private blockchain**.

2b. The bridge will be notified about the **lock** on the **ADDX private blockchain** and will then proceed to perform the minting of tokens on **Ethereum Mainnet**.

3. The ADDX user will be able to use the security tokens on **Ethereum Mainnet** and use decentralised applications (DAPPs) like a decentralised exchange (DEX) to sell his tokens etc. (within the allowed restrictions).

4a. Any ADDX user who has security tokens that he/she would like to transfer back to the ADDX private chain can do so via the **bridge contract on Ethereum Mainnet**. The tokens on **Ethereum Mainnet** will be burnt by the bridge contract.

4b. The bridge will be notified about the tokens burned on **Ethereum Mainnet** and will then proceed to release the tokens from the **bridge contract** on the **ADDX private blockchain**, returning the tokens to the user.

5. The ADDX user will be able to use tokens on the ADDX platform as per normal.

3.6. Design and Architecture

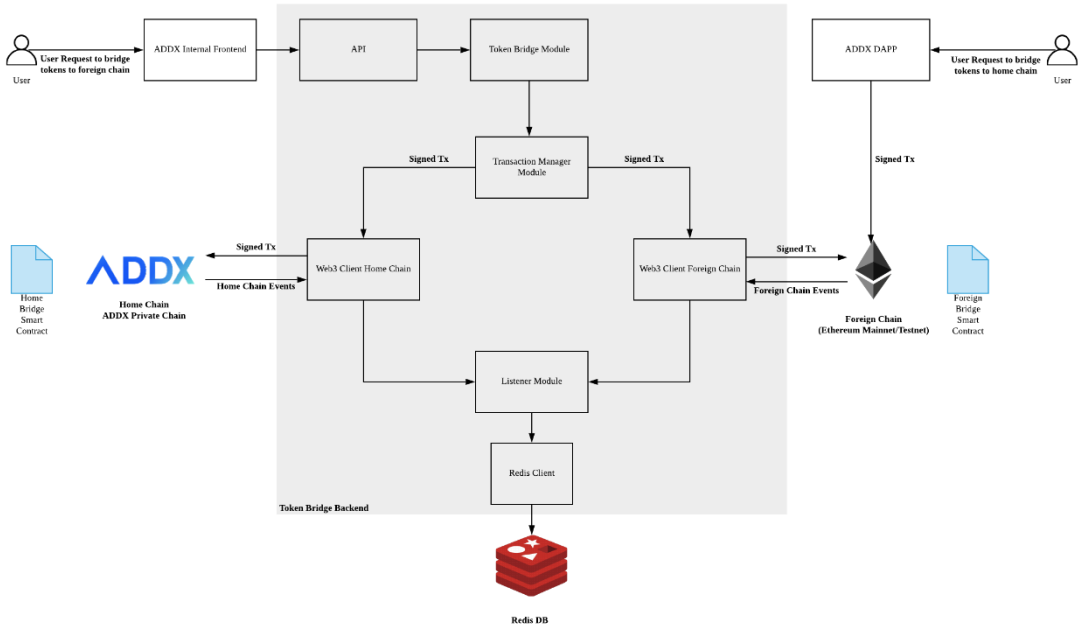


Figure 2. Token Bridge Technical Design & Architecture

With reference to figure 2 above, the proposed token bridge design comprises of a few key technical components namely:

1. **Redis** - regularly saves the current state of the service. The saved state will be used in case of service shutdown or restart and as a potential source of data for analysis.

2. **Listener Module** - uses Web3 to connect to both blockchain networks and triggers token bridge module as soon as an event is processed and has its state persisted in Redis.

3. **Token Bridge Module** - creates corresponding smart contract call transactions for Home Bridge, Foreign Bridge and Mainnet Token Contracts.

4. **Transaction Manager Module** - signs the transactions from Token Bridge Module and forwards them to either the Home Chain or Foreign Chain.

5. **Home Bridge Smart Contract** - manages the locking and unlocking of tokens on the **home** chain (ADDX) side.

6. **Foreign Bridge Smart Contract** - manages the minting & burning of tokens on the **foreign** chain (Mainnet/Testnet) side.

7. **Mainnet Token Smart Contract** - represent ADDX assets on the **foreign** chain side.

8. **ADDX Internal Frontend** - frontend for ADDX onboarded users to use the token bridge via the ADDX platform

9. **ADDX DApp -** frontend integrated with web3 tools like Metamask which allows (whitelisted) users to bridge tokens from their Ethereum accounts back to the ADDX platform

Each technical component described above were developed as part of building the token bridge PoC. Refer to Exhibit A in the Appendix for a sequence diagram showing how each of the components interact with one another during a single round trip. Note that the token bridge backend is EVM agnostic (i.e. It will work with any EVM-based blockchain with only minor tweaks in configuration required). For the ADDX internal frontend and the ADDX DApp, mock-ups that were done are shown in Figure 3 and Figure 4 below.

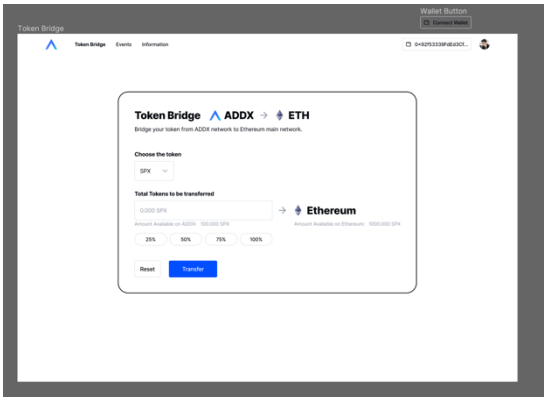


Figure 3. ADDX Internal Frontend Mockup

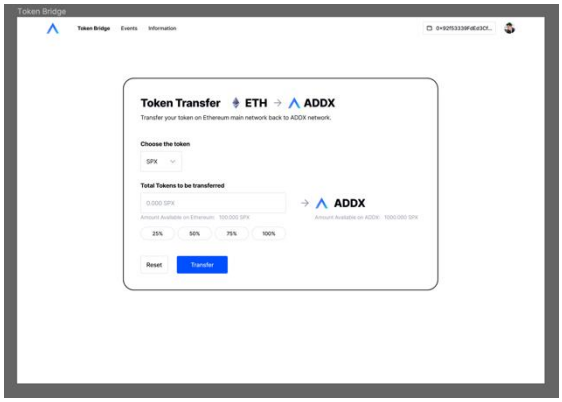
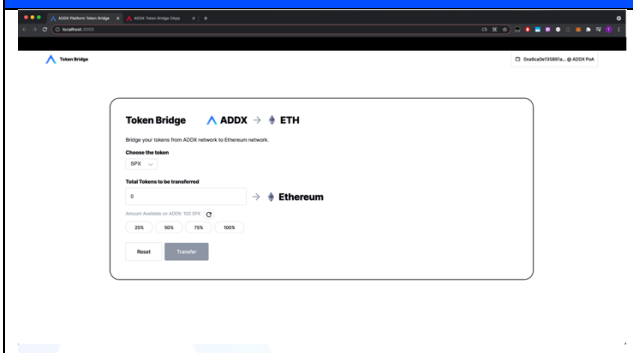
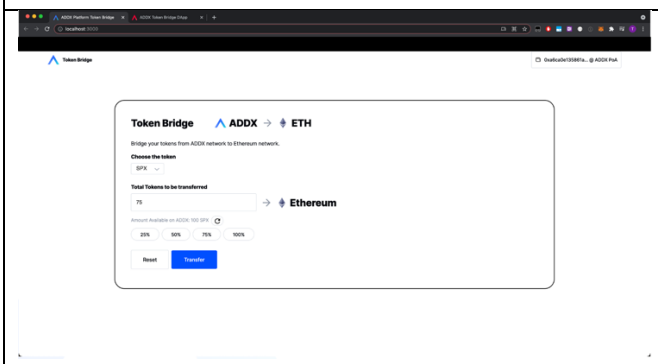
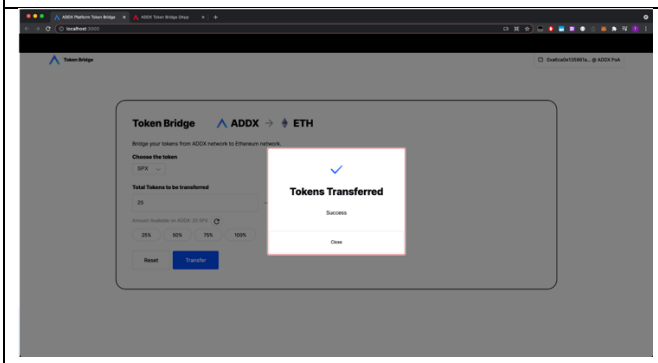
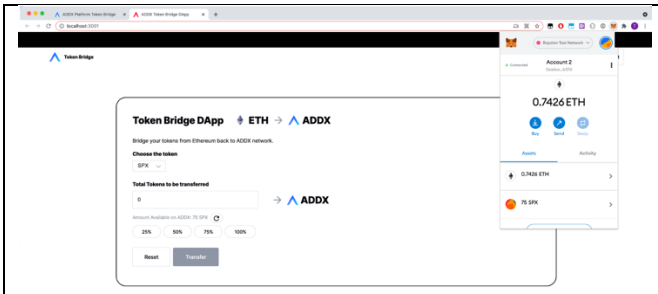
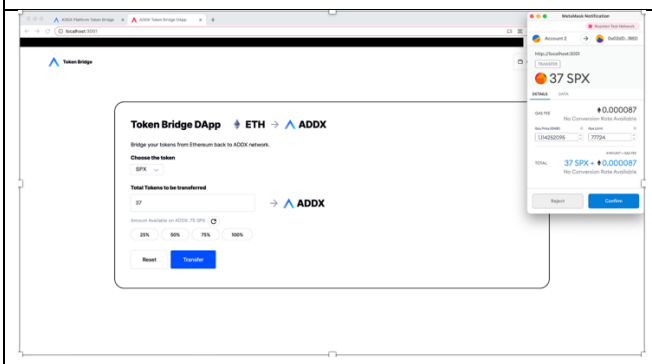
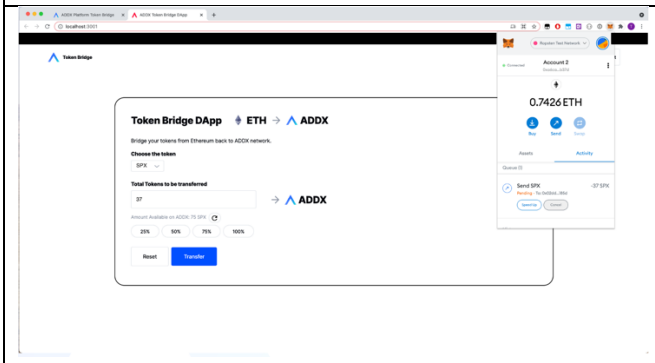


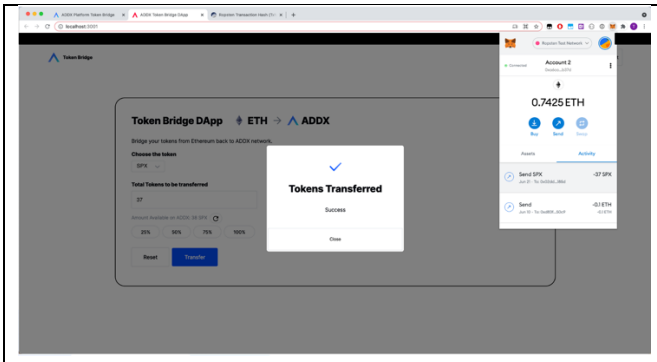
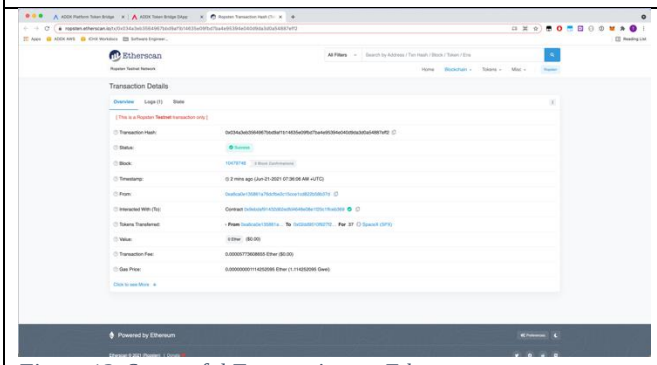
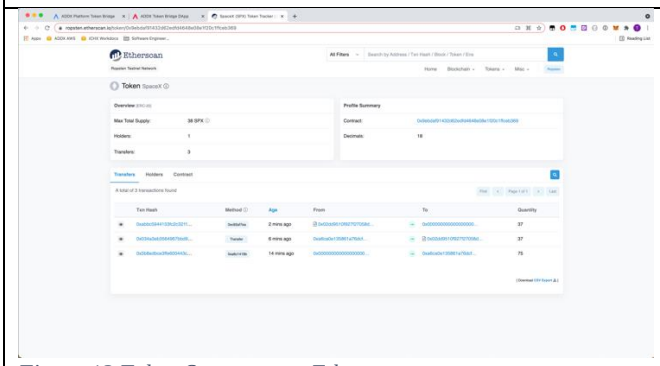
Figure 4. ADDX DApp Mockup

3.7. Bridging assets from ADDX to Ethereum and back

After developing the technical components of the token bridge, the application was deployed and connected to a test blockchain (representing ADDX's private chain) and the Ropsten Testnet (representing Mainnet). A full flow of the expected use case was carried out. Relevant screenshots demonstrating a full successful roundtrip are shown in the following table.

Screen Shots	Notes
 *Figure 5. Initial Balance on ADDX Internal Frontend*	- Assuming the user obtained 100 SPX from an issuance/secondary trading on ADDX Platform - User starts with 100 SPX on the ADDX Private Chain as shown on the ADDX Internal Frontend
 *Figure 6. User inputs token on ADDX Internal Frontend*	- User intends to transfer 75 tokens over to Ropsten Testnet
 *Figure 7. Successful bridge from ADDX Internal Frontend*	- Transfer of 75 SPX to Ropsten is successful - User has 25 SPX remaining on ADDX Platform

 *Figure 8. Receive Tokens on Ropsten*	- User receives 75 SPX (we named it MNT) on his Ropsten account - This is reflected on the user's Metamask wallet as well
 *Figure 9. Confirm transaction on ADDX DApp*	- User would like to send 37 SPX from Ropsten back to ADDX Private Chain - The transfer is facilitated by the Metamask Wallet where his tokens are stored - The 37 SPX will be sent to the foreign bridge contract where it will be burnt (sent to the zero address) - User will have to be pay transaction fees on Ropsten. In this case, transaction fee is 0.000087 ETH.
 *Figure 10. Pending Transaction on ADDX DApp*	- After user submits the transaction, it will be in a pending state as it waits to be included in a block

 *Figure 11. Bridge Success on ADDX DApp*	- Once the transaction has been included in a block, the transaction is confirmed - User will receive the Tokens Transferred notification to indicate a successful transfer. - User now has 38 tokens remaining on Ropsten
 *Figure 12. Successful Transaction on Etherscan*	- Etherscan Transaction showing the successful transfer of 37 SPX from user to foreign bridge contract
 *Figure 13.Token Summary on Etherscan*	- Etherscan Page showing the summary of all transfers of SPX Tokens - Note that tokens sent to foreign bridge contract are automatically burned (sent to 0 address) - This is to ensure total supply of tokens on Ropsten and ADDX Private Chain is fixed

04 | Lessons Learnt

From the PoC, there have been many lessons learnt along the way that could be useful to other FIs attempting to build an asset interoperability solution to connect their own blockchain solution to another. The sections below describe the lessons which we think will be most helpful to the reader.

4.1. Degree of Decentralisation

The two-way pegging of the token bridge is realised via cross claims (i.e., locking/burning asset on source blockchain and unlocking or creating its representation on the target blockchain). For cross claims, two nodes are required from different blockchains, where one performs one operation in a source blockchain in exchange for its counterparty performing other operations on a target blockchain – and each party logs operation in case a dispute occurs. Given ADDX is a regulated platform and relevant controls need to be in place, the nature of the cross claims should be done by a trusted party via a centralised two-way peg as mentioned before. As the nature of asset interoperability in ADDX use case is of a centralised nature where only trusted parties are involved, mechanisms for blockchain interoperability in an untrusted environment such as inclusion proofs and collateralisation are not required. Currently, ADDX will act as the trusted party and will mediate any dispute about a mismatch of asset balances. If a third party is required to mediate the dispute, the relevant information and data can be easily provided and verified to the party as the data is readily available on both blockchains.

4.2. Technological Feasibility

For FIs looking to explore on the topic of blockchain interoperability, the PoC has given a glimpse of the technical requirements for just a subset of blockchain interoperability involving sidechains/relays. A technical team comprising of a wide array of skills are required to build a fully functioning interoperability solution. In addition, on top of building the core application, given the exposure of an FI to a public chain, the FI will be potentially exposed to hacks, and would need to have significant investments to ensure they are well protected.

One way to reduce the technical requirements to achieve interoperability would be to use readily available enterprise solutions or open-source solutions. The open-source solutions generally refer to the smart contracts for blockchain operation on the public chains. Popular smart contract protocols need to undergo intensive smart contract audits and will provide such reports before the decentralised community trusts and uses them. In some cases, open-source smart contract protocols offer an enterprise option and using them would be akin to a simple API integration. This will greatly reduce the capital intensiveness for maintaining a large technical team as well as for performing security audits. Nevertheless, going for a third-party based solution would still require the FI to do their own IT Vendor due diligence as a standard best practice.

4.3 Regulatory Considerations

Last but not least, regulated FIs need to have all of their processes compliant with the current regulations in force. As part of adhering to best practices and regulations laid out in the Payment Service Act and PSN02 Notice published by MAS, measures need to be in place to ensure the prevention of money laundering and countering the financing of terrorism.

In ADDX's case, for users to be able to be able use the token bridge, they would first have to whitelist a Mainnet account. These accounts will have to undergo wallet screening where the history of the wallet is analysed and checked against known risks to prevent sanctioned addresses or customers (by OFAC, or other authorities) from being whitelisted and onboarded onto ADDX. Additionally, any inbound asset bridge transactions to the ADDX Private Chain will need to undergo transaction monitoring to detect any high-risk crypto transactions as well as tracing the source and destination of funds.

05 | Conclusion

5.1. Outcomes

Building a bridge to allow assets to be transferred from ADDX private blockchain over to the Ethereum Mainnet opens up many new possibilities and use cases for assets that currently exists only on ADDX's private blockchain. It also allows ADDX's private blockchain to benefit from the tools and community that thrive on Ethereum Mainnet. The learnings from this PoC can be shared with other industry players, in order to accelerate development of solutions that enhance the vibrancy and growth of blockchain-based regulated FIs going forward.

Applying the token bridge solution to ADDX specifically will bring about many advantages:

1. Having ADDX assets on the Ethereum Mainnet in an interoperable manner by abiding to existing token standards such as ERC-20, would allow the assets to automatically be usable on a variety of applications built on Ethereum such as Metamask and Nifty Wallet (Asset Management), AirSwap and IDEX (Decentralised Exchanges), Dharma Protocol (lending) and many more.

2. Being able to leverage such innovation from the open source community will enable many new functionalities for ADDX-issued assets that were previously unavailable on the ADDX platform itself – all made possible just by building a token bridge.

In addition, getting on the Ethereum Mainnet would also allow digitised securities listed on ADDX to be exposed to the appropriate subset of the vast user base on Ethereum (146 million as of 1 April2021[9], of which a certain proportion will be Accredited investors that can be onboarded as ADDX users before they can buy/sell such securities). This would greatly enhance our user reach, and ADDX being a closed system would no longer be an issue. We see similar advantages for other regulated platforms using a token bridge solution as well.

[9] https://consensys.net/reports/defi-report-q1-2021

5.2. Commercialisation

For the token bridge to move beyond the PoC, more development effort would be required to take the solution from PoC to become an enterprise-grade solution as well as necessary process flow integrations to the current user experience of the ADDX Platform. Additionally, as ADDX is a MAS-regulated entity and our digitised assets are required to interoperate with both our private blockchain as well as Ethereum's Mainnet, we would like to get more clarity from MAS on the operational protocols in the following areas, to ensure that we are always compliant with the relevant regulations before going live with the solution:

1. Compliant operation on a public blockchain
2. KYC and identification on a public blockchain
3. Dispute resolution when smart contracts do not work as expected
4. Necessary controls required on asset transfers and issuance
5. Financial products working with decentralised applications
6. Conditions under which an asset bridge across blockchains is allowed

5.3. Other Applications

This PoC explored the feasibility of blockchain interoperability which connects a regulated FI to the public or open the decentralised Ethereum network. Besides the technical enablers required to allow the two-way asset pegging between the ADDX private chain and Ethereum Mainnet, there are many regulatory and compliance hurdles that have to be crossed as well.

The PoC serves as a sandbox experiment as an example to the wider fintech community of how one would integrate a regulated FI, which issues digitised securities, with a public blockchain. The financial industry can use this knowledge and experience gained to participate in the setting up of a regulatory framework as a reference for future FIs looking to experiment with such technology. This will provide a clear roadmap for other regulated FIs on how to operate on a public blockchain in a legally compliant manner.

The knowledge and expertise gained on the topic of blockchain interoperability used in this PoC can be extended for many other use cases. FIs operating their own blockchains or using other blockchains can now look at potentially bridging their networks, forming partnerships

and synergies with another (FIs') blockchain. Furthermore, there could now be many new use cases and synergies discovered when capital market products cross over to the decentralised world, where products such as decentralised loans can be built on top of them.

5.4. Further Areas of Research

In this PoC, ADDX only explored on a single type of blockchain interoperability – asset interoperability between two EVM based blockchain. As an immediate extension to this, ADDX could look at interoperability of assets the ADDX private blockchain with non-EVM based blockchains such as Solana (cross blockchain). Further areas of research include exploring the different interoperability layers between blockchains on top of asset interoperability such as data interoperability.

06 | Glossary

Blockchain
digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain.

Block Time
measure of the time it takes to produce a new block, or data file, in a blockchain network.

Block Gas Limit
maximum amount of gas of all transactions that can fit in a single block.

Burning
burning happens when a cryptocurrency token is intentionally sent to an unusable wallet address to remove it from circulation.

Ethereum
decentralised, open-source blockchain with smart contract functionality.

Ethereum Mainnet
mainnet is the primary public Ethereum production blockchain, where actual-value transactions occur on the distributed ledger.

Ethereum Testnet
networks used by protocol developers or smart contract developers to test both protocol upgrades as well as potential smart contracts in a production-like environment before deployment to Mainnet.

EVM
refers to the Ethereum Virtual Machine which is a runtime environment for the Ethereum blockchain.

Finality
the assurance or guarantee that cryptocurrency transactions cannot be altered, reversed, or cancelled after they are completed.

Gas
the cost necessary to perform a transaction on the Ethereum network.

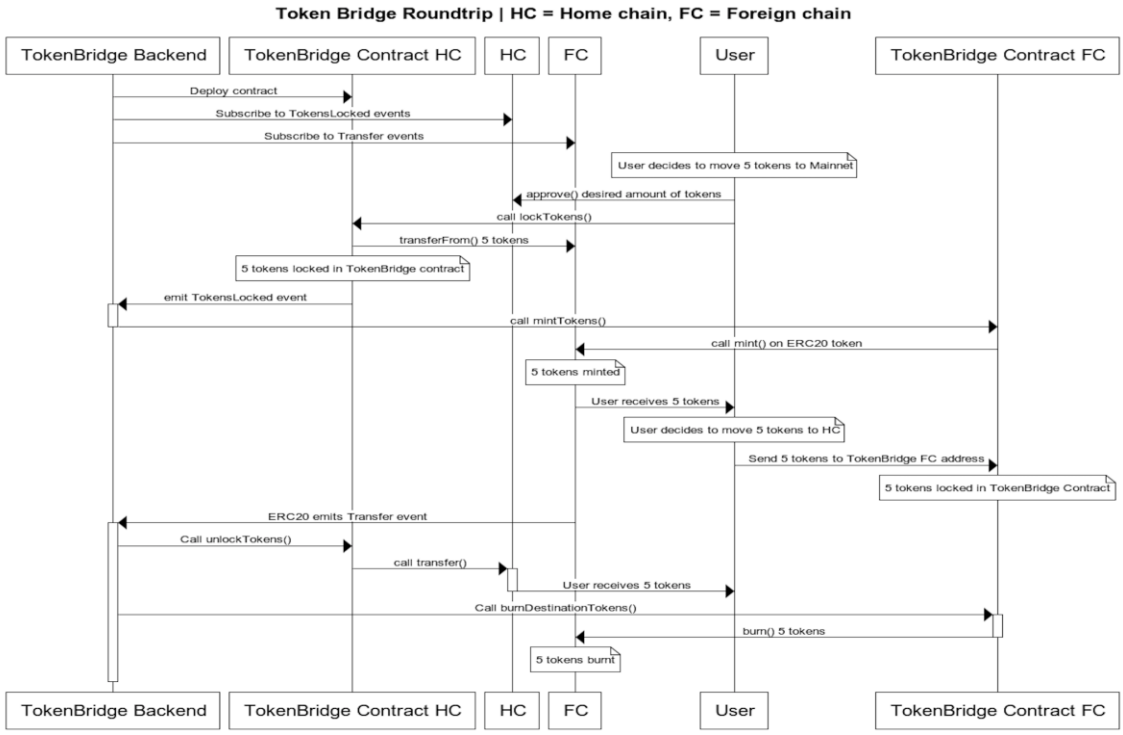
Gas Fee
transaction fees that users pay to miners on the Ethereum network to have their transaction included in the block.

Minting
minting happens when new cryptocurrency token come into existence adding to the existing circulation

Private Chain
permissioned blockchain which work based on access controls that restricts the people who can participate in the network.

07 | Appendix

Exhibit A. Token Bridge Sequence Diagram



About ADDX

The ADDX platform is established and operated by ICHX Tech. Pte. Ltd. ('ICHX'.) ICHX is regulated by the Monetary Authority of Singapore as a capital markets services licensee for dealing in capital markets products and providing custodial services, and a Recognised Market Operator. Company Registration Number 201731973M.

Disclaimer