



VeloxChain

CONNECTING URBAN MOBILITY ON BLOCKCHAIN



Veloxchain.io



Connecting Urban Mobility on Blockchain

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1. Introduction

Ethereum is a decentralized computing platform where users deploy smart contracts to perform computations. Nobody controls the Ethereum network and users completely control their own smart contracts - it is a trustless environment. This is a fantastic platform on which to build a decentralized ecosystem which uses smart contracts to process transactions.

One of the application areas for blockchain is Internet of Things (IoT). For example, BMW, General Motors, Ford and Renault¹ have launched their own blockchain research projects for the automotive industry, seeking to leverage IoT and blockchain technologies for a smart transport network.

VeloxChain is an open-source blockchain-based protocol and marketplace for shared mobility services. Our ambition is to democratise the sharing mobility market and accelerate the world's transition to an open and seamless mobility. We provide a one-stop solution for all participants in the ecosystem from developers, mobility providers, and end-users, ultimately, benefiting from global network effects.

VeloxChain is empowered by several critical technologies:

1. Dual-token Proof-of-Stake chain with high transaction throughput and stable cost of smart contract execution.
2. Privacy-preserving solution by Zero-knowledge Proofs.
3. Enterprise Collaboration Solutions leveraging Zero-Knowledge Proof and private cryptographic search algorithms on VeloxBiz.

In the following sections, we will explain our technologies in detail, beginning first with blockchain.

2. VeloxChain's Design Principles

Blockchain technology leads fuzzier APIs to allow more agile integration of new systems, automate data and payment process among stakeholders; however, blockchain technology is still at the early stage and in order to meet rigorous end-user applications requirements such as **low latencies, immediate transaction**

finality, high performance, excellent scalability and support multi-level of data privacy.

Ethereum with less than 15 tx/s with 15 000 nodes² and delaying Ethereum's Casper (Proof of Stake) and Sharding until 2020³, even Zilliqa blockchain with sharding solution only achieves 2488 tx/s with 3600 nodes or EOS achieves 3097 tx/s⁴ with Delegated Proof-of-Stake and 21 block validators. Blockchain protocols are a form of a distributed system, it inherits properties from CAP theorem - Consistency, Availability and Partition tolerance. Especially, the public protocol faces more difficulties where is unable to control the bandwidth and hardware limitation of random public miners (block validators). Each consensus has own advantages and disadvantages in terms of security. At the time of writing, **there is no existing one-size-fits-all protocol which achieve planetary-scale with million transactions to serve all applications in the world.**

Beyond scalability consensus solutions, there are two promising scalability directions:

- **Sharding**⁵: Similar to sharding concept in the traditional database distributed system, shading divides the chain into small groups (shards) for parallel transaction processing, to increase transaction throughput of the whole blockchain ecosystem. There are two main stages in sharding solutions: transaction sharding and stage sharding. State sharding is more complicated and challenging as involving cross-shard communication where the receiver is a smart contract account. Zilliqa was the first protocol implementing sharding solution; however, currently it is not able to store commitment of zero knowledge of proof. In our viewpoint, sharding in blockchain still at the early stage.
- **Multi-chain**: this solution allows many child chains sync and communicate with each other through a parent chain. For example, Plasma sidechains such as Loom network with DPOS to interact with Ethereum; however, it is not practical with the current Ethereum transaction speed (15 tx/s). And interoperability blockchain projects like ICON, Polkadot and AELF are also potential solutions to improve decentralized features.

The major feature of blockchain is transparency which is demonstrated well by the first blockchain - BitCoin and Ethereum is the distributed and transparent computer which no one entity controls the network. Anyone can write or read data to the Ethereum network. Although Ethereum users address the privacy problem by issuing pseudonymous addresses (a pair of ECDSA public-private key), it is still possible to find out who's addresses they are through various techniques. The practical solution is to use homomorphic encrypted end-to-end transactions mean only the parties involved in the transaction revealing the data. Homomorphic encryption (e.g. Zero-knowledge proofs) allows for computations to be done on encrypted data without first having to decrypt it. In other words, this technique allows the privacy of the data/ transaction to be preserved while computations are formed transparently on the blockchain, without revealing that data/ transaction. However, there are two major challenges making homomorphic encryption becoming mass-adoption in the blockchain industry.

- Firstly, a computation performed on the encrypted data usually is much higher than a normal transaction; it means computing (encrypt (A) + encrypt (B)) >> computing (A+B). Thus, **it is unrealistic to execute proof transactions directly on Ethereum blockchain** because Ethereum transaction is very costly.
- Secondly, as mentioned above, blockchain protocols are a form of the distributed system; therefore, blockchain consensus is perhaps familiar with senior engineers who work on high distributed database computing system like Google, Facebook or Uber. However, **implementing homomorphic encryption techniques required DApp developers having the advanced cryptographic knowledge** to provide strong mathematically provable guarantees for the privacy of data and transaction.

VeloxChain addresses these issues by design a dual-token Proof-of-Stake chain with near-zero transaction fee while VeloxDev packages allow Dapp developers implement Zero-knowledge proof with minimum cryptographic knowledge.

An undeniable fact is that Ethereum has the largest developer community of decentralized applications with various development tools and Solidity is a standard learning smart contract language for DApp developers. Therefore, **VeloxChain**

provides the same functionalities as standard Ethereum to migrate Ethereum developers build DApps on VeloxChain without learning-curve; this means that:

- VeloxChain uses Elliptic Curve Digital Signature Algorithm (ECDSA)⁷ to generate public-private keys and authenticate the signature. ECDSA uses the algebraic structure of elliptic curves over finite fields ($y^2 = x^3 + ax + b$). Similar with Ethereum, VeloxChain use a Koblitz curve secp256k1⁸: $y^2 = x^3 + 7$ (where $a = 0$ and $b = 7$), it looks like this:

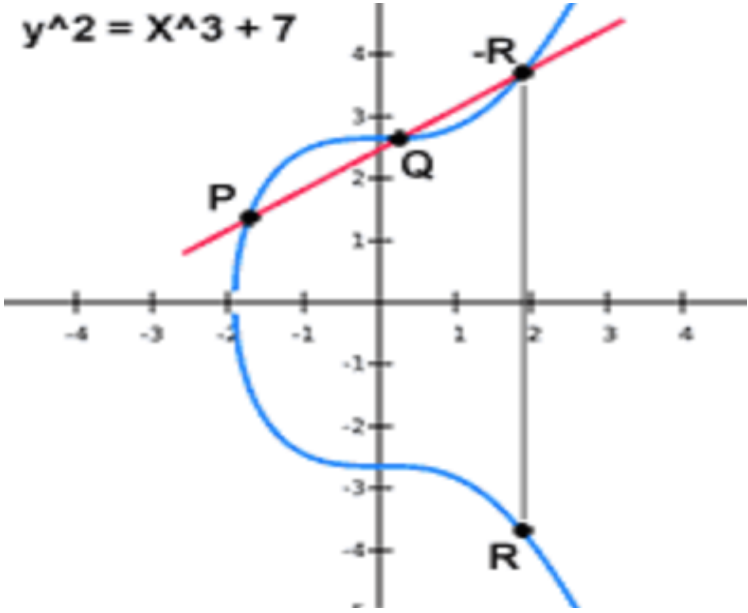


Figure 1. Koblitz curve secp256k1

- VeloxChain support for all EVM smart contracts (solidity and viper) and development tools, IDE, wallets and client software working with Ethereum chain.

To the best of our knowledge, it is very challenging or even impossible to have a one-size-fits-all protocol. And mentioned in the business white paper, we strongly believe that blockchain is the ideal technology to address many painful problems of sharing-mobility industry. VeloxChain technical philosophy implementation is the best balance between practicality and decentralisation. Therefore, we run VeloxChain protocol to decentralize and connect sharing-mobility applications. VeloxChain release dual-token PoS consensus, supporting EVM smart contracts (solidity and viper) and data privacy-preserving to solve

needs for its user now. We will actively embrace in theoretically superior alternatives lacking a usable, production-ready implementation.

3. VeloxChain Infrastructure Technologies

3.1. Dual-token Proof of Stake Chain

It is widely accepted that a blockchain-based system is as secure and robust as its consensus model. The best consensus model will be one which best balances the following three following factors:

- Decentralization: Any node freely participates in processing transactions, and publishing a block without the use of a central authority or service.
- Security: The system has to prevent double- spends, keep data in sync. There are no conflicts when data get merged. All nodes see same data at the same time.
- Scalability: The system has to provide sufficient transaction throughput to serve enterprise-scale or even planet-scale needs, especially when the network size increases.

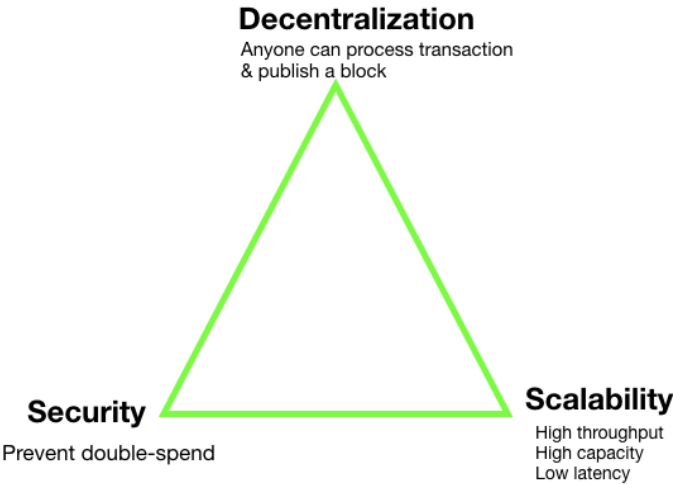


Figure 2. Three crucial factors of blockchain consensus algorithms

Following is a table listing different types of consensus algorithms, and highlighting the strengths of each.

	Types of Consensus				
Features	PoW	PoS⁶	PoET	BFT * and variants	Federated BFT
Blockchain Type	Permission-less	Both	Both	Permissioned	Permission-less
Blockchain	BitCoin, Ethereum	TomoChain, EOS, OmiseGO	Intel Ledger	Hyperledger Fabric	Ripple & Stellar
Transaction finality	Probabilistic	Probabilistic	Probabilistic	Immediate	Immediate
Transaction rate	Low	High	Medium	High	High
Scalability of peer network	High	High	High	Low	High
Trust model	Untrusted	Untrusted	Untrusted	Semi-trusted	Semi-trusted
Adversary Tolerance	<= 25%	Depends on specific algorithm used	Unknown	<= 33%	<=33%

* Note: BFT is Byzantine Fault Tolerance

Figure 1. A comparison of blockchain consensus mechanisms

We believe that the PoS with on-chain governance philosophy of design which achieves the best balance of three factors above by leveraging the economic-game theory. One of the primary criticisms of DApps/Blockchain is the volatile cost of smart contract execution, therefore, enterprises are not able to estimate their IT infrastructure cost. Although Ethereum has *GasPrice* ($ETH = GasAmount * GasPrice$)

to reduce the volatility of Ether price, it is very inconvenient for users or DApps developers to adjust the *GasPrice* automatically whenever Ether price changes.

We propose a Dual-Token Proof-of-Stake consensus which has a 2-second block time with over 1500 tx/s and BFT security guarantee. With the Dual-Token PoS consensus, DApps on VeloxChain have not suffered the volatility of Velox token price. In other simple words, without any adjustment such as *GasPrice*, VeloxChain DApp enterprises or developers are able to run DApps and pay a fix monthly fee regardless Velox token price.

We believe that our Dual-token PoS with on-chain governance features create a more decentralized ecosystem and fair distribution of value among stakeholders who take responsibilities for the development of the ecosystem.

3.2. Privacy-Preserving Solution with Zero-Knowledge Proofs

“Zero-Knowledge Proof are really mindboggling”

Sergey Brin, Google co-founder⁸

Blockchain is supposed to be a transparency machine in which anyone can join the network and as a result, view all information on that network. If the confidential transaction is only between the two parties involved in the transaction, why do we need a consensus (blockchain)? In fact, **ZKPs and blockchains complement each other. A blockchain is used to make sure all parties can agree on some state which may or may not be encrypted, a trustless reference source. ZKPs allow you to be confident about some properties of that state.** We take an example how VeloxChain DApps applying ZKPs. QiQ⁹ is about building the world largest green transport system for everyone to create a trustless ecosystem and community ownership - the first use case in the VeloxChain business paper. Leveraging decentralised autonomous organization (DAO¹⁰) architecture, QiQ allows entrepreneur doing crowdfunding from crypto investors and then launch local electric fleet around the world. DAO is used as a blockchain crowd-funding tool and blockchain is used as a payment and immutable accounting system to automatically distribute revenue sharing among stakeholders for examples if the soft-cap is reached, the local fleet operator will launch the s 30% to maintenance & fleet renewal, 20% QiQ platform,

20% DAO investors and 30% local fleet operator. It is a great blockchain application. **However, ZKPs privacy preserving smart contracts can make the amount of crowd-funding privately until the campaign is over and if the crowd-funding campaign is failed, only the campaign owner know the amount. By this way, ZKPs privacy preserving smart contracts may make QiQ entrepreneurs more confident and successful on the crowdfunding campaign.**

Homomorphic encryption¹¹ is a form of encryption that allows computation on ciphertexts, generating an encrypted result which, when decrypted, matches the result of the operations as if they had been performed on the plaintext. The purpose of homomorphic encryption is to allow computation on encrypted data. In fact, Zero Knowledge Proofs (ZKPs) are to use different types of homomorphic encryption and are not new. They were first introduced in a paper “The Knowledge Complexity of Interactive Proof-System”¹² in 1985 by S Goldwasser, Silvio Micali and Charles Rackoff. ZKP is a mathematical expression which allows two parties (a prover and a verifier) to prove that a state is true, without revealing any information about that thing apart from it being true. The design of a zero-knowledge proof must satisfy three properties:

- **Completeness:** if the prover and verifier are honest, the zero-knowledge proof always returns “true”
- **Soundness:** It is impossible for dishonest prover to convince a verifier to return “true”
- **Zero-knowledge:** the verifier learns nothing about the input (zero-knowledge)

In the cryptocurrency, there are few prominent blockchain projects using ZKPs such as ZCash, ZeroCoin, ZCash. Each of projects use different ZKPs techniques (e.g Zk-Snarks and Bullet-proofs). Zk-Snarks are used in ZCash protocol which has an efficient verifier time but require a trusted setup for the generation of a common reference string (CRS). While Bullet-proofs is not required a trusted setup and has a practical linear verification time.

VeloxChain applies bullet-proofs techniques which utilised RSA-factory challenging¹³ and without a trusted setup. Bullet-proof is a proof you did something or know something without revealing any other information other than you did it. For example, proving that you know a deal amount without actually telling the deal amount. However, in some cases, bullet-proofs have worse verification time on-chain and our future research solution is to run off-chain verification on trusted execution environment such as Intel SGX¹⁴.

3.3. Data privacy-preserving collaboration in VeloxBiz

As mentioned in our business paper, sharing personal mobility device (e-bike, scooter, and Segway) service is the new rising star expected to tackle the congestion issue and reduce commute time. However, it faces 2 big problems. **First, the supply level of vehicles into the market.** Because oversupply threatens the socio-economic development of a city, but undersupply will shift users towards car usages. Second, **the trust issue between merchants** prevents them from efficiency cooperation, for instance, accounting auditing. Our solution is that we build a protocol that allows government and fleet operators to collaborate and manage the fleet supply by areas. Besides, we also offer tools for fleet operators to launch PMD sharing services and share revenue with multiple suppliers. As a result, **users can access to a much sizeable pool of PMD fleet but the market always meet at equilibrium point.**

VeloxBiz is the “Alibaba” marketplace for mobility and transport sectors where vehicle suppliers, local fleet operators, and retail service providers can co-create and launch shared-mobility services (e.g. bike-sharing, scooter-sharing...). VeloxBiz offers shared mobility operators the tools to leverage blockchain technology for revenue sharing with vehicles suppliers and reducing the technological cost of running a world-class fleet management system. We believe that merchants do not want disclosure of their commercial information such as supplier relationships and costs. Therefore, confidentiality for data is a fundamental requirement for the VeloxBiz platform. We design anonymous collaboration layers to hide the real identity and a cryptographic search engine modelled by smart contracts to manage and share sensitive data in VeloxBiz platform.

3.3.1. Anonymous Collaboration Layer with Zero Knowledge Proof

Anonymous Collaboration Layer allows merchant A and merchant B to prove their collaboration anonymously by the merchant A obtains a credential from the merchant B so that at some later point in time, the merchant A is able to construct a non-interactive proof of his credential to perform authenticated transactions. The VeloxChain masternodes accept the request only if the attached proof is valid.

The following example describes how the anonymous collaboration layer works in practice. Let's suppose that there is a public bulletin board, one which is physical and everyone can access. There are two actors in the merchant market platform **VeloxBiz**: the scooter supplier A collaborate with the scooter-sharing fleet operator B that the scooter-sharing fleet operator B provides his scooter data and revenue transaction to the scooter supplier A and then the scooter supplier A can view data trip, track preventive maintenance and repairs for scooters. In this scenario, the scooter supplier A which plays the role of a data consumer and the scooter-sharing fleet operator B who plays the role of a data owner.

To produce a new credential for the scooter supplier A, the scooter-sharing fleet operator B firstly generates a pseudonym S for the party A and commits S using a secure digital commitment scheme. The resulting commitment C can be opened using a random number r known by the party A. The party B pins C to the bulletin board, there is a set $S_C = (C_1, C_2, \dots, C_n)$ of commitments in the board. At a later point, the party A is able to prove possession of such credential by producing two statements in zero-knowledge:

- He knows a commitment $C \in S_C = (C_1, C_2, \dots, C_n)$.
- He knows the opening r for the commitment.

The VeloxChain is used as a public bulletin board. Both the data owner and data consumer are able to access the public parts of the data stored on the blockchain. The public parts contain the commitments that we have described.

We now present a concrete construction using cryptographic accumulator proposed by Josh Benaloh¹⁶, and later improved by Jan Camenisch¹⁷. The accumulator scheme comprises four algorithms:

- $AccumSetup(\lambda) \rightarrow params$. Generates two primes p, q , computes $N = pq$, sample $u \in QR_N$. Output (N, u) as the parameters.
- $Accumulate(C) \rightarrow A$. On a set of primes $C = \{c_1, \dots, c_n\}$, outputs accumulator $A = u^{c_1 \dots c_n} \bmod N$.
- $GenWitness(v, C) \rightarrow \omega$. Input a prime number $v \in C$, outputs a witness $\omega = Accumulate(C - v)$.
- $AccVerify(\omega, v, A) \rightarrow \{0, 1\}$. Verifies $A = \omega^v \bmod N$. The security of the scheme is based on the harness of Strong RSA and Discrete Logarithm assumptions.

The description of the anonymous authority layer consists of four algorithms:

1. $Setup(1^\lambda) \rightarrow params$. On the input parameter λ , run the algorithm $AccumSetup(1^\lambda)$ to obtain (N, u) . Generate primes p, q such that $p = 2^w q + 1$ for $\omega \geq 1$. Let G be the subgroup of Z_q^* and select two random generator g, h such that $G = [g] = [h]$.
2. $GenCred(S, params) \rightarrow (c, skc)$. Given pseudonym $S \in Z_q^*$, select a random $r \in Z_q$ and compute $c \leftarrow g^S h^r$ such that c prime and $c \in [A, B]$, where $2 < A$ and $B < A^2$. Set $skc = r$ and output (c, skc) , submit c to the blockchain.
3. $ShowCred(params, S, c, skc, S_c) \rightarrow \pi_S$. Given data consumer pseudonym S , a credential c and its secret key skc , compute $A = Accumulate(params, S_c)$ and $\omega = GenWitness(params, c, S_c)$ and output the following proof of knowledge:

$$\Pi_S = ZKSoK\{(c, w, r, S) : AccVerify((N, u), A, c, \omega) = 1 \wedge c = g^S h^r\}$$
4. $VerifyCred(params, \pi, S_c)$. Given a proof Π_S , and the public set of credential S_c , first compute $A \rightarrow Accumulate(params, S_c)$, then verify that Π_S is the aforementioned proof of knowledge on c, S_c . if the proof verifies successfully, output 1, otherwise output 0.

The zero-knowledge proof which appears in step 3 of the scheme is a non-interactive proof that only requires one round of communication. Camenisch presents an interactive zero-knowledge proof of knowledge in which an accumulator contains a committed value. The construction of the non-interactive proof in step 3 leverages a Fiat-Shamir transform on the interactive proof. This is shown in the process flow diagram on the following page.

The *Setup* algorithm is performed by the data owner to generate system parameters. Next, when the data consumer wishes to obtain a credential for data access, he sends a request to the data owner together with his pseudonym S . At this point, the data owner runs the *GenCred* routine on this input S to generate a digital commitment and its secret key skc .

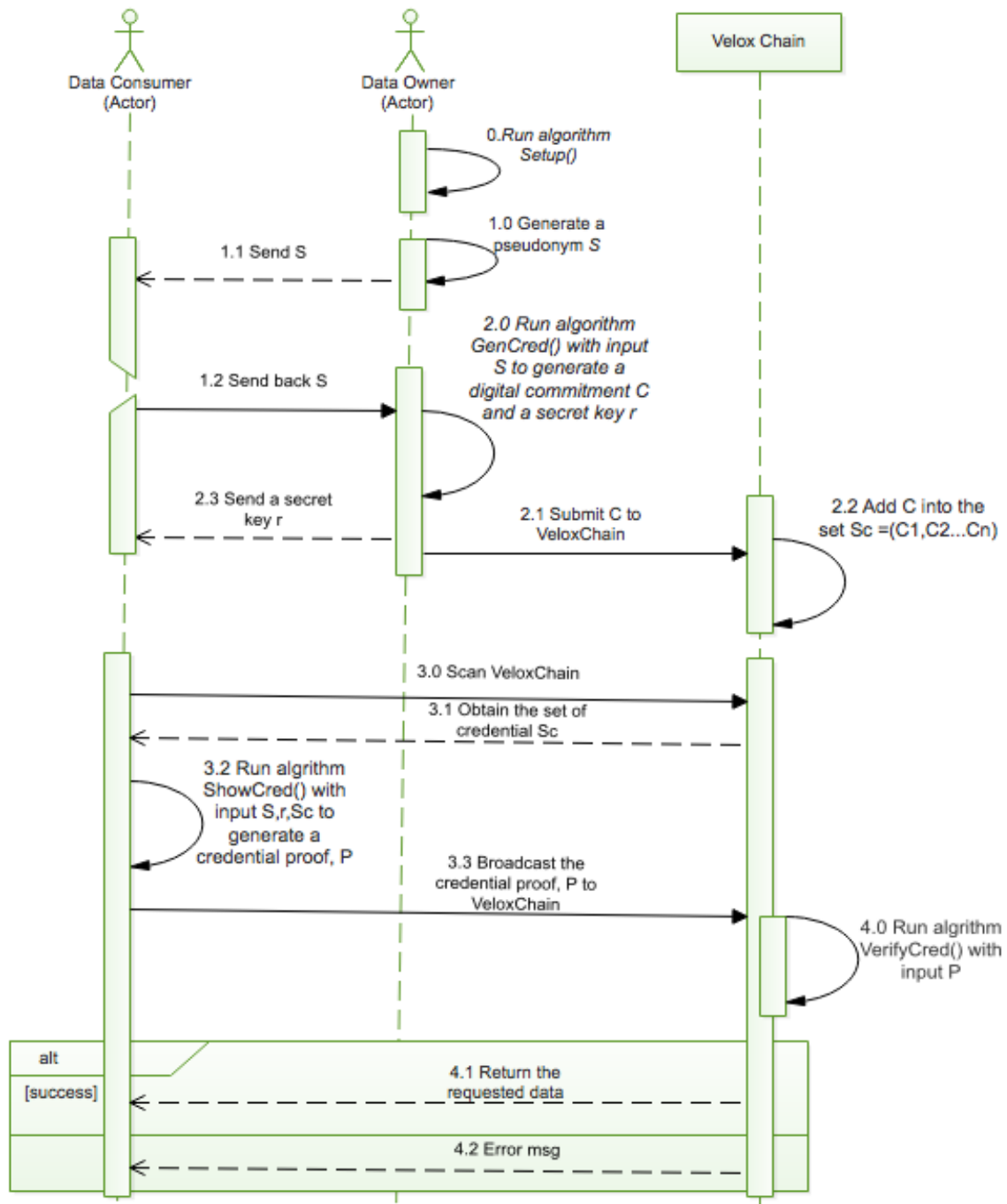


Figure 5. Sharing Data in the Anonymous Collaboration Layer

When the data consumer wishes to show his credential, he first scans through the VeloxChain to obtain the set S_c consisting of all credential issued by the data owner. He then runs the *ShowCred* routine to generate a credential proof, and broadcasts it to all masternodes for verification. The masternodes also collect the set of credentials in the blockchain and validate the proof using the *VerifyCred* algorithm. The credential certification is accepted if the last routine outputs 1.

The data consumer and the blockchain nodes are both required to compute $A \equiv Accumulate(params, S_c)$ which requires a linear scan of the blockchain data. The complexity of the protocol increases linearly with the number of registered data consumers.

With this robust anonymous collaboration layer, the scooter supplier A and the scooter-sharing fleet operator B can work together and exchange data with each other without exposing her/his identity address. It means that it is very difficult to trace the owner of collaboration transactions in VeloxChain but it is also easy to prove someone to participate in the collaboration.

3.3.2. Private Keyword Search Engine

In the VeloxBiz, we provide the distributed data storage layer. IPFS¹⁸ is used to store public and plain-text data while sensitive data are encrypted and stored in the distributed storage.

In order to support sharing sensitive data easily, VeloxChain provides a built-in encrypted data search modelled by smart contracts. The crucial requirement of such a search must be fast return of results without exposing private data. Our solution is that the meta-data (i.e. the fingerprint) of the encrypted data is stored in the VeloxChain and only authorized clients are permitted to use it to conduct searches. The authorization process is done by the Anonymous Collaboration Layer presented in the section 3.2.1 An access key is computed using a hash function (i.e. The fingerprint of the data). The VeloxChain does not store the actual data content, however, it maintains the access key data so that data consumers are able to link real data to the distributed storage layer or peer-to-peer storage.

We denote EKS as the encryption scheme that supports keyword search. The data owner appends a list of *EKS* ciphertext of each keyword to the access key and stores it in the blockchain layer. A data D with keywords W_1, W_2, \dots, W_n is stored in the blockchain layer under the structure: $H(D) || EKS(W_1) || \dots || EKS(W_n)$. An authorized data consumer is able to produce a certain trapdoor Γ_ω that enables a smart contract to test on each data entry whether one of the keywords associated with the access key (eg- the document) is equal to the word W . Given a trapdoor and

EKS ciphertext, the blockchain nodes can only test whether $W = W'$, and nothing else.

A typical keyword search cryptosystem consists of four general algorithms:

1. *KeyGen*: generates cryptosystem key.
2. *Trapdoor*: produces trapdoor T_W for a keyword W
3. *Encrypt*: produces a *EKS* ciphertext for keyword W
4. *Test*: tests whether keyword in the trapdoor is matched to the *EKS* ciphertext.

In the VeloxChain ecosystem, an additional algorithm is required for the data owner to produce a secret search key for the data consumer. We denote that algorithm *KeyDerive*. Three algorithms *KeyGen*, *Encrypt* and *KeyDerive* are performed by the data owner, while *Trapdoor* is run by the data consumer to generate a trapdoor, and finally, the *Test* algorithms is performed by smart contracts or the blockchain peers. We modify the protocol proposed by Raluca Ada Popa¹⁹ to adapt to our environment.

We start the protocol description by reviewing a few concepts related to bilinear maps. We will use the following notation: G_1 and G_2 are two (multiplicative) cyclic groups of prime order p , g_1 is a generator of G_1 and g_2 is a generator of G_2 . A bilinear map is a map $e: G_1 \times G_2 \rightarrow G_T$ with the two following properties:

(1) *Bilinear*: $\forall u \in G_1, v \in G_2$ and $a, b \in \mathbb{Z}$, then $e(u^a, v^b) = e(u, v)^{ab}$, and (2) *Non-degenerate*: $e(g_1, g_2) \neq 1$.

We denote $H: \{0,1\}^* \rightarrow G_1$ and $H_2: G_T \times G_T \rightarrow \{0,1\}^*$ to be two random oracles, and g_1, g_2, g_T are respectively the generators of groups G_1, G_2, G_T . The private keyword search system consists of five algorithms as the follows:

1. *KeyGen*: $k \leftarrow \mathbb{Z}_p$.
2. *KeyDerive*(k, s): $k_s \leftarrow g^{\frac{k}{s}}$.
3. *Trapdoor*(w, s): $T_w \leftarrow e(H(w)^s, k_s)$.
4. *Encrypted*(k, w): Random $r \leftarrow G_T$. Output: $c = (r, H_2(r, e(H(w), g_w)^k))$.
5. *Test*: Parse $c = (r, h)$. Test whether $H_2(r, tk) = h$.

The data owner generates a secret key k for keyword encryption EKS , and derives keys for the data consumers. Each data consumer poses a secret $s \in Z_p$, which can be generated by a mapping from his pseudonym with the data owner. Using k and s , the data owner computes a search key k_s for the data consumer so that later he can use it for trapdoor construction.

The correctness of the protocol follows the two equations:

$$tk = e(H(w)^s, g_2^{\frac{k}{s}}) = e(H(w), g_2)^k, \text{ and } H_2(r, tk) = H_2(r, e(H(w), g_2)^k)$$

The above scheme has data hiding and token hiding properties. Data hiding (privacy) requires that the semi-honest adversary is not able to distinguish between ciphertexts of two values not matched by some token. Token hiding (privacy) requires that the adversary cannot learn the keyword that one searches for. The complexity of the protocol increases linearly with the number of data sets stored in the VeloxChain ecosystem.

4. VeloxChain DApp Architecture

Overall, there are five main layers in VeloxChain DApps:

- **Application Layer:** Besides VeloxGo and Velox Biz, there are significant numbers of sharing-mobility applications built on top Velox ecosystem such as bike-sharing, scooter-sharing, car-sharing. VeloxChain will provide SDK and firmware libraries to allow existing sharing-mobility application integrating easily.
- **Middle Layer:** there are SDKs and APIs allow third-party systems, IoT, and smart vehicles to interact easily with the Velox Ecosystem.
- **Service Layer:** Service Layer is distributed systems hosted by VeloxChain or mobility providers. The service layers play as a “bridge” communication among applications and decentralised layer. While on-chain communication allows merchants to communicate by filtering event log or interacting directly with smart contracts; the service layer

enable off-chain peer-to-peer communications between merchants such as the scooter-sharing app can broadcast a message to other merchants to look for alternative transport mode (bike, car or even their competitor scooter) if that particular company has no scooter available, it is a win-win deal and VeloxChain smart contracts ensure revenue-sharing among merchants automatically. In the bridge service layer, there are some core components:

- Cache and indexing data module: allow the bridge server to sync data from decentralized layer and then index the data to provide a fast search engine.
 - Order Queuing module: allow stakeholders to communicate with each other such as booking, accepting or cancelling a request. The queuing module can handle communication between users and vehicle providers, or among sharing-mobility service merchants
 - Meta Transaction Relay module: allow service layers to fuel gas of transactions or forward transactions to the decentralised layer.
 - Pricing and payment module: allow sharing-mobility service to use fiats or cryptocurrencies as payment methods.
- **Abstraction Layer:** are zero-knowledge of proof, keyword privacy-preserving search, payment channel smart contract- frameworks which enables seamless integration into the Velox Chain.
 - **Decentralisation Layer:**
 - Public blockchain protocol for the sharing-mobility industry: VeloxChain support with Ethereum Virtual Machine (EVM) smart contracts (solidity and viper), use a dual token Proof-of-Stake consensus with over 1000 tx/s and 2 second block-time and have data privacy-preserving features, key management feature.

- P2P storage layer: There is P2P storage layer which enable smart contract communicate directly with external data instead of storing data in the chain.

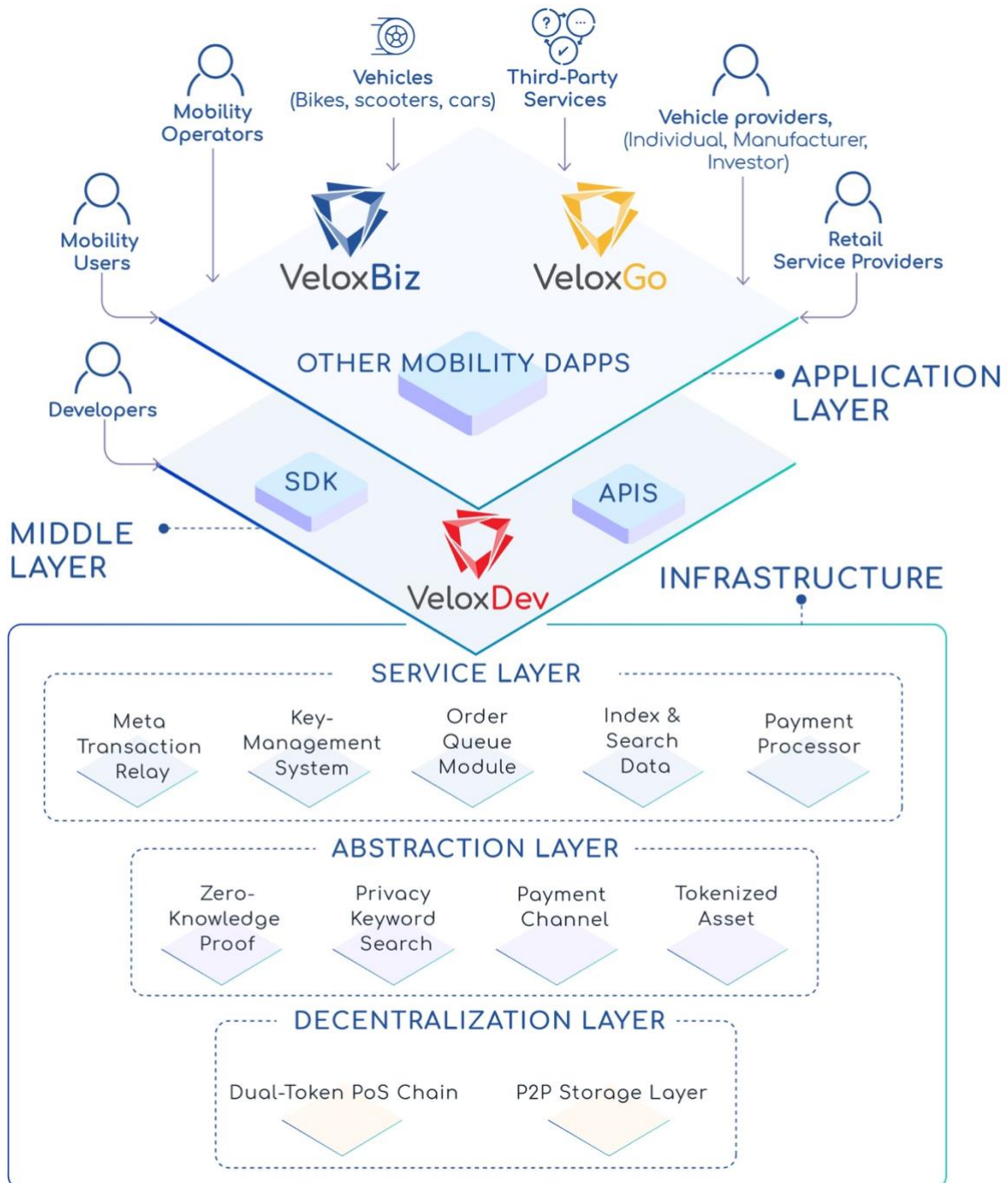


Figure 2. High-level Architecture of VeloxChain Ecosystem

4.1.1. Meta Transaction Relay Protocol

All on-chain transactions on blockchain are paid using transaction fees known as *gas*. Many people, however, have little-to-no knowledge about blockchain and hold no Velox token. Therefore, without meta transaction relay service, we can imagine the customers like Join use a scooter-sharing DApp from merchant B:

1. Join know about the scooter-sharing DApp through his friend and download it to try.
2. Join try to create an account and book a scooter from merchant B; but he realizes that he has no *VeloxDollar* to perform on-chain transactions.
3. Join has to go to his favourite exchange, doing KYC and wait for few days to buy some *VeloxDollar*. And then he is able to perform on-chain transactions.

Consequently, it is a terrible user experience to force all users to buy and then hold token to use sharing-mobility services on VeloxChain. Meta Transaction Relay aims to solve this problem by allowing a third-party to fuel gas of transaction (fund) and then replay the transaction for the users.

How the meta transaction relay magic works in the practical example. Firstly, Join download the scooter-sharing DApp from merchant B. Although Join holds no token, he can sign the transaction and send this transaction to a relayer server which probably to hosted by the merchant B. This relayer server can pay the gas for this transaction and then forward it to Velox Chain through the *relayMetaTx*²² protocol. As a result, Join does not require to hold token and the merchant B is able to pay his users on-chain transactions.

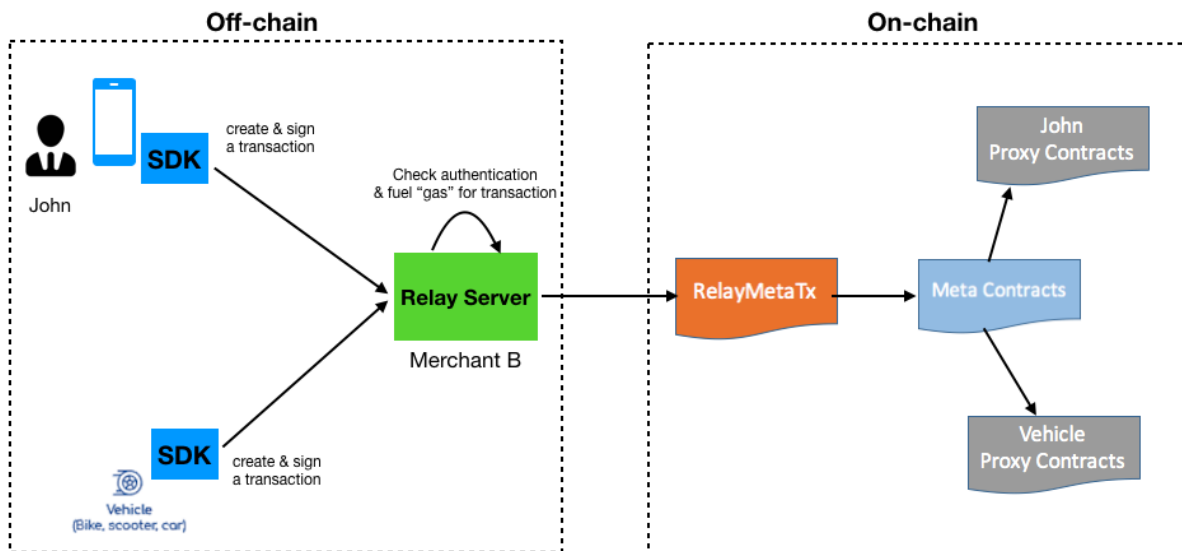


Figure 7. Meta Transaction Relay Service.

4.1.2. Payment Channel

The payment-channel²⁰ smart contract framework allows us to transfer token near-instantly off-chain and with low-fees by using digitally signed and hash-locked²¹ transfers. In the payment channel, users have to setup an on-chain deposit to open a payment channel smart contract, and then users can perform token transfers instantaneously, without limit, as long as the net sum of their transfers does not exceed the deposited tokens. Finally, users have to close the payment channel by calling functions `cooperativeClose()` or `uncooperativeClose()` in the smart contract `TransferChannels.sol`²² which requires on-chain transactions. VeloxChain leverages multi-signature smart contracts and payment-channel technology to enable automatically revenue-sharing models among stakeholders.

4.1.3. Vehicle Ownership and Tokenization from ERC721

VeloxChain has developed a Vehicle-Ownership protocol to share ownership information. Vehicle owners can prove their ownership and report the location of stolen the smart vehicle by referencing immutable records on the blockchain. When a smart vehicle is stolen, the police are able to see the latest position to respond instantly. Potentially, insurance companies could automate claim processing for such losses through a smart contract running on the blockchain.

We have often heard how the Ethereum ERC721 smart contract is non-fungible, meaning that tokens of the same class or contract can hold a different value. The Cryptokittie²⁴ project is one interesting application. Cryptokitties are unique (and collectible) assets because each is tokenized with a different ERC721, having a different value. For this reason, we developed the Vehicle-Ownership protocol²⁵ using ERC721 tokens from OpenZeppelin²⁶. Each ERC721 represents a different vehicle, and the value of the Vehicle-Ownership token is based on the metadata of token including vehicle technical information, picture, owner's information, supplier, and manufacturer. Ownership is determined by an array of token *indexes* or *ids* that is mapped to owner address.

Each Vehicle-Ownership token holds metadata which is the URI of the vehicle information record, such as manufacturer, vehicle technical information, images storing in the distributed storage layer. Whenever users create a new Vehicle-Ownership token, the matching engine scans through all tokens using our searching engine (described in section 2.2.1); and if the matching engine finds any Vehicle-Ownership token with the same metadata, the system suggests users merge or transfer their token between users.

Consider this simple example: Alice bought a Volata smart bicycle from Bob. This bike has a computer chip IMEI: VOLATA123456789. With the bike, Alice obtains a new Vehicle-Ownership token. But the matching engine detects that Alice's token has the same metadata (i.e.- IMEI code) as another vehicle-ownership token held by the bike manufacturer. The system notifies Alice and the manufacturer to merge these Vehicle-Ownership tokens. This could be accomplished by Alice burning the token received from Bob and the manufacturer sending Alice the token in its possession, by a multi-signature contract.

5. Comparision

We provide some comparison with related works:

- **Secure Multiparty Computation (SMC):** the scenario of the parties who want to compute the output of a function f , a scenario such as a comparison evaluation. Each party i owns a private input x_i . After a

procedure, they obtain the result $f(x_1, \dots, x_n)$. The result may belong to one certain party or be shared between the participating parties as (y_1, \dots, y_n) depending on the purpose of the protocol. This procedure is called multiparty computation (MPC). If the output of function f in a secure way such that the i th party knows y_i and gets nothing more than that, the procedure is called secure multiparty computation (SMC). **The main challenge of SMC requires interaction between parties and the presence of trusted third parties which are unrealistic in many applications; while non-interactive zero knowledge proof does not require the interaction between proofer and verifier.** Therefore, we choose ZKP technologies to provide data privacy preserving for VeloxChain applications. However, SMC has attracted a significant attention from the blockchain industry such as WanChain – the world first blockchain with secure multi-party computing, but WanChain is just a Ethereum-fork chain with PoW-based consensus having terrible performance and in the many cases, the computation complexity of SMC is much higher than ZKP.

- **Proof-Of-Stake (PoS) Consensus:** The PoS has become the very promising consensus for designing an efficient and cost-effective permissionless blockchain. Similar with other PoS consensus like EOS, Ethereum Casper, Cardano, Tendemint and TomoChain, VeloxChain dual-token Proof-of-Stake also provide Byzantine fault tolerance (BFT) security guarantees. We also leverage some great techniques from related initiatives such as:
 - Depositing Token mechanism: it is utilised from Ethereum Casper and Cardano chain, masternodes (block validators in Ethereum Casper) have to deposit tokens. However, in VeloxChain, we create VeloxDollar - a stable token for paying smart contract execution, separately from Velox - the governance token and has a high volatility price.
 - Masternode voting mechanism: Similarly to EOS, masternodes (block created or witness in DPoS) are elected through the voting system. However, in VeloxChain, the transaction is not free, we use the same transaction fee mechanism as Ethereum to minimum Spam Attack; moreover, masternodes have to deposit a certain amount of Velox token to be listed for voting.

6. Conclusion

We present the design of the Dual-token Proof-of-Stake protocol which provides rigorous security guarantees and user-friendly stable cost for smart contract execution. We also proposed the data privacy-preserving solution on the first marketplace - VeloxBiz: the client encryption is leveraged for data security, zero-knowledge of proof is designed for the processes of anonymous credential grant,

proving credential and private keyword search are used for searching on the encrypted dataset.

Future work: Currently VeloxChain implements zero-knowledge proof techniques and leverage to third-party developers by API or SDK connection. However, we will develop VeloxDev tools providing a compiler which enable developers to build privacy preserving application without knowledge of zero-knowledge proofs. At the same time, VeloxChain will actively embrace in scalability solutions (e.g. sharding and multi-chain techniques) to provide better transaction processing performance.

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