FERRUM NETWORK WHITEPAPER

V0.5 – WORK IN PROGRESS

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By Naiem Yaganeh, PhD and Ian M. Friend, Esq.

ABSTRACT

Ferrum Network is a high-speed interoperability network built for real-world financial applications. It is comprised of two interconnected elements: (1) a DAG-based interoperability network that can connect to nearly any blockchain enabling peer-to-peer transactions of any digital asset in milliseconds, and (2) the vertically integrated financial applications running on the network that allow users to buy, sell, transact, exchange and store any digital asset without taking custody of those assets. The network is powered by the native Ferrum Network utility token, or FRM. Each transaction requires a nominal of FRM be spent and burned to attach proof to the transaction and as an anti-spamming measure. Our product line includes a *live* fiat gateway plus payments app called Kudi Exchange. Kudi Exchange is a fast, low cost platform for buying and selling digital currencies combined with a revolutionary peer-to-peer payments app allowing users to instantly send fiat currency with no banking intermediaries. It is also the first fiat-to-crypto exchange in West Africa with access to a U.S. Dollar backed stable coin. Our non-custodial crypto wallet, UniFyre Wallet, will allow users to transact any digital asset with no counter-party risk, and provides revolutionary capabilities such as risk-free OTC trading, instant market trades, and safety features to prevent accidental loss. Later we will address our remaining products: a high-speed cross-chain decentralized exchange, and a low-cost cold wallet application that operates on an offline Android phone. Imagine sending Bitcoin in milliseconds, exchanging any asset peer-to-peer over a high-speed interoperability network, or sending digital fiat with no intermediary. It is all possible with Ferrum Network.

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1.0 Introduction and Problem Statement

We live in a multi-token world, with thousands of digital assets residing across hundreds of separate blockchains. Bitcoin, Ethereum, Ripple, IOTA and EOS are all examples of major digital currencies with their own unique use cases. The ecosystem benefits from a wide variety of networks, tokens, and projects, all aiming to build a fairer, more inclusive world.

However, a fundamental challenge remains – how to enable communication, transaction and exchange across hundreds of separate and distinct networks? In other words, how can we enable the myriad blockchains to *interoperate*.

The challenge posed by interoperability goes beyond academic theory – it is a fundamental issue that pervades the entire crypto ecosystem and directly impacts all crypto users. It is a primary reason why we have not meaningfully achieved Satoshi Nakamoto's vision of a "purely peer-to-peer version of electronic cash that allow online payments to be sent directly from one party to another without going through a financial institution".[i] It is one reason the vast majorities of currencies are exchanged through traditional, trust-based centralized exchanges.

The current solutions to the challenge of interoperability, such as atomic swaps and decentralized ERC-20 networks[ii] are laudable, yet greatly limited in terms of speed, scalability and functionality. To date, a decentralized network enabling the fast, inexpensive and functional exchange of any digital asset across any blockchain has not been successfully implemented. Instead, powerful centralized exchanges have been erected, wielding outsized influence over the ecosystem, introducing third-party risk, and undermining Nakomoto's original vision. At the same time, many existing offerings of decentralized

exchanges are not satisfactory due to a combination of limited token offerings, poor user experience, and slow transaction times.

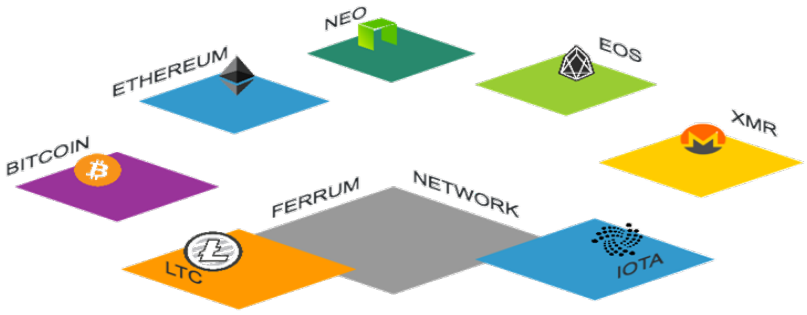

Figure 1: Ferrum Network's Interoperability Diagram

Enter Ferrum Network, enabling the fast and inexpensive peer-to-peer exchange of any digital asset, regardless of originating blockchain. Ferrum is a decentralized platform where users can manage, transact and exchange their digital assets without passing the custody of their assets to a third-party. Built on a directed-acyclic graph (DAG) network[iii], Ferrum has inherent advantages over traditional blockchains in terms of speed, cost and scalability[iv]. By utilizing Ferrum's groundbreaking technology to securely import and export value across chains, users can deposit any asset into Ferrum Network creating a proxy token that can be transacted and exchanged using the UniFyre Wallet or other forthcoming exchange products. To get started with Ferrum Network products, users can purchase their digital assets directly with fiat money using our fiat gateways, beginning with our West African based fiat gateway, Kudi Exchange.

The Kudi Exchange and mobile wallet allows users to purchase Bitcoin and other digital assets directly with fiat. The mobile wallet even allows users to send digital fiat money peer-to-peer using just What's App and SMS numbers. No database, and no intermediaries are

needed. In addition, Kudi Exchange will be the first and only platform on the continent of Africa to offer the U.S. Dollar backed stable coin, Gemini Dollar.

The next product in our line of financial application that runs on the network will be the UniFyre Wallet, which will have unique features for sending and receiving transactions that allow users to engage in risk-free and near-instant peer-to-peer exchanges of the following digital assets, with many more being integrated: Bitcoin, Ethereum, Ripple, True USD, Gemini Dollar, and the Ferrum Token, FRM. As of this writing, BNB, EOS, NEO and other major assets are being integrated into the Ferrum Network. Because both parties must authorize a transaction before it is executed, the UniFyre Wallet also enables risk-free, near instant over-the counter (OTC) trading at a fraction of the usual cost.

In addition, users will be abe to trade their assets over Ferrum's user-friendly yet sophisticated decentralized exchange, the Infinity DEX. The Infinity DEX will have advanced features such as decentralized risk-free high frequency trading, margin smart contracts for short selling assets, and an AI trading assistant; features that exist nowhere else in the DEX space. Users can engage in countless fast and inexpensive transactions over the Ferrum Network, and at any time they can securely withdraw their assets back to their original blockchains.

Finally, to further our vision of cryptocurrencies being used for day-to-day needs, we realized we could not ignore the problem of storing private keys for the wallet. For the first time, users will be able to store their assets safely and securely with our low-cost, ultra secure cold storage application: The Sub-Zero Wallet. The Sub-Zero Wallet solves two major problems in the cold-storage market: accessibility

and cost. For the first time, anyone in the world can turn an old Android phone into the most secure and mobile cold-storage solution. The app allows users to securely store digital assets offline, and when ready to exchange and transact, instantly send those assets to a hot wallet (UniFyre Wallet) using QR codes. Because the Sub-Zero Wallet will run on the Ferrum Network, it will be automatically integrated with our decentralized exchange technology allowing you to seamlessly move your assets from cold storage onto an exchange or wallet.

Note that the Infinity DEX and Sub-Zero Wallet will not be released until the latter half of 2020, as we are presently focused exclusively on the Kudi Exchange, UniFyre Wallet, and the Ferrum Network main net.

Ferrum Network will run on its native utility token, the Ferrum Token, or FRM, as the "gas" of the network. Spending FRM is necessary to prevent malicious actors from spamming the network and attach proof to the transaction. It will also be used to execute transactions, import/export value, and enable use of our products. Spending FRM burns FRM, so the system inherently limits the supply.

Welcome to Ferrum Network – the first high-speed interoperability network for real-world financial applications.

1.1 The Background and Introduction to Ferrum Network

When Satoshi Nakamoto developed the Bitcoin network in 2008, no one could have predicted the proliferation of thousands of other digital assets, each with their own special use case, value proposition and network. We view the pace of innovation and proliferation of utility tokens as a net positive, but one that poses unique challenges.

Blockchain technology, the distributed, consensus-based ledger underpinning most decentralized networks, does not readily lend itself to cross-chain communication. In practical terms this means that a holder of bitcoin cannot conduct a peer-to-peer exchange with a counterparty that holds Ethereum. The existing solutions to this seemingly simple problem have proven costly, risky, ineffective and slow, or involve moving the transactions completely off-chain[v].

The simplest (and most costly) means of exchanging digital assets that reside on separate blockchains is through a centralized exchange. However, since these institutions hold user's assets, they are the antithesis of Nakamoto's vision of "a purely peer-to-peer version of electronic cash allow online payments…without going through a financial institution". Moreover, the security flaws inherent in centralized custody solutions has been repeatedly demonstrated, from the Mt. Gox hack in 2014[vi] to the Coincheck hack in 2018[vii], and many in between. Moreoever, the absence of privacy imposed by centralized exchanges is contrary to the open and free financial system that the crypto ecosystem is striving for. While their ease-of-use, advanced trading features, and ability to act as a fiat onramp suggests that centralized exchanges will continue to play a key role in the ecosystem, their value is limited due to custodial risks, lack of privacy and exorbitant fees. The world of cryptocurrencies deserves a decentralized alternative.

Recognizing the limitations of centralized exchanges, numerous decentralized or semi-decentralized exchanges (DEXs) have arisen, which purportedly enable the peer-to-peer exchange of digital assets. However, none of the existing DEX solutions satisfy the needs of the market. First, the vast majority of DEXs are not interoperable and are limited to ERC-20 tokens. Traders of top digital assets including

Bitcoin, Litecoin, EOS, IOTA, NEO, Stellar, Ripple, etc. are excluded. Second, many DEXs leave users wanting in terms of user experience, functionality, and transaction speeds. Alternative technologies that attempt to solve the problem of interoperability such as atomic swaps, are inherently slow and have not been meaningfully implemented.

Ferrum Network has solved these problems by building a blockchain agnostic network from the ground up. Utilizing breakthrough cryptography techniques for secret sharing without a trusted dealer, and innovative techniques based on quorums, Ferrum enables the fast and inexpensive exchange of nearly any asset, regardless of originating blockchain. Because all transactions occur within Ferrum's directed acyclic graph (DAG) network, which is designed specifically for this specific use case, transactions are faster and less expensive than other decentralized networks that require communication and relays between separate blockchains.

This is how Ferrum Network works: users will create their private UniFyre Wallet that only they control via private key. With the click of a button, users can securely import their assets into the Ferrum Network, creating a proxy of said assets, which are safely held in their UniFyre Wallet. Want to exchange Bitcoin directly for Ethereum? The UniFyre Wallet will enable users to easily trade their tokens over-the-counter (OTC) with no counterparty risk. Since each party must accept the transaction before it is executed, Ferrum users can conduct risk-free decentralized OTC trades at a fraction of the time and cost of a typical OTC trade with the user-friendly UniFyre Wallet. Moreover, Ferrum's unique system of accepting transactions will eliminate the risk of users sending their tokens to the wrong address.

Like Coinbase and Coinbase Pro, the UniFyre Wallet will be connected to Ferrum's decentralized exchange, the Infinity DEX. The

Infinity DEX and accompanying order book seamlessly and anonymously connects makers and takers, enabling the peer-to-peer exchange of almost any digital asset via simple-to-execute market orders and/or limit orders, with near-zero fees. This means users can exchange almost their assets without having to trust an intermediate third party, and the transaction can be completed in less than second at a fraction of the cost of a centralized exchange transaction. In addition, the Infinity DEX will offer such advanced trading features as high frequency trading, short selling, and AI driven trading assistance - offerings completely unique to the DEX space.

Ferrum Network and its line of decentralized products run on its native utility token, the Ferrum Token, or "FRM". As the gas of the network, users spend small amounts of Ferrum Tokens to execute functions across the network and prevent malicious actors from spamming the network. FRM is also necessary to use Ferrum products, like the Infinity DEX and Sub-Zero wallet. Because Ferrum Tokens are burned whenever they are spent, the system inherently limits the supply.

In sum, Ferrum Network and its line of financial products will offer the features, functionality, and breadth of offerings of a centralized network, but without the custodial risk, privacy concerns, and exorbitant costs associated with the centralized alternative.

1.2 The Problems with Centralized Exchanges

Blockchain and cryptocurrencies were supposed to provide a trustless decentralized means for peer-to peer transactions. However, in reality, a vast majority of cryptocurrencies are held and transacted through a few large institutions and centralized exchanges[viii]. The

current situation is far from the promised world of decentralized transactions and community owned currencies, and is more akin to the traditional, but less effective banking system, with accompanying scalability issues and expensive transaction fees. In our view, this is one of the biggest failures of cryptocurrencies, and the need to address this problem is keenly felt by the community.

The problems with centralized exchanges have been well documented. First and foremost is the issue of trust. Users entrust their private keys to centralized entities, such that if the exchange is hacked or goes down, users' funds are at risk. This risk is amplified in the centralized context because there is a single point of failure, and the "honey pot" scenario, i.e. the substantial funds held by centralized exchanges, attracts hackers. Second, centralized exchanges often charge high transactions fees. Third, centralized exchanges effectively act as walled gardens, greatly limiting the number of projects who wish to list their digital asset on the exchange, and exacting exorbitant costs for the right to list a token. For instance, according to a Business Insider investigation, as of March 2018, centralized exchanges were charging $50,000 to $1,000,000 to list a token[ix]. The result is that early adopters of nascent projects effectively have no means of exchanging their tokens. Finally, centralized exchanges require that users sacrifice their privacy to simply enter into a financial transaction. It seems we have returned to a system where centralized gatekeepers wield most of the power, increasing risks and costs, while at the same time harming innovation and privacy.

Currently, there is a lack of organic solutions for communities to utilize decentralized technologies. Instead, they need to rely on centralized exchanges, or look to a decentralized alternative, all of which have significant shortcomings.

1.3 The Problems with Many Existing Decentralized Exchanges

2018 was often hailed as the "year of the DEX". And while many decentralized exchanges are now operational, and we salute their trailblazing efforts, none have credibly solved the fundamental problem of interoperability. For instance, most of the existing solutions run on top of the Ethereum network, meaning they use smart contracts and payment channels to facilitate exchange, however they only support ERC-20 tokens (see 0X Protocol[x], Airswap[xi], IDEX[xii], etc.), and therefore exclude many of the most important digital assets. While certain cross-chain solutions have been proposed, such as atomic swaps, these are severely restricted in terms of speed and scalability, as the swap is limited to the speed of its slowest network[xiii]. It is a serious concern that in 2018 users still cannot engage in a near-instant and inexpensive peer-to peer exchange of Bitcoin and Ethereum. The inability to quickly engage in cross-chain transactions is a massive impediment not only to the widespread use of decentralized exchanges, but also to the goal of cryptocurrencies being used for every day transactions.

The current DEX offerings also suffer from a lack of functionality and difficulty of use. It is impossible for ERC-20 DEXs to offer high frequency trading because the transaction times are limited by the speed of the Ethereum network[xiv]. The ideal DEX should offer market and limit orders, provide users with a simple and easy to use interface, and offer advanced features that satisfy the needs of professional traders. The Infinity DEX caters to both the novice and professional with a simple intuitive interface and will offer advanced features such

as high-frequency trading, short selling, and AI driven trading assistance.

1.4 The Problems with Over-The-Counter Trading

TABB Group, an international research company, estimates that the market for over-the-counter trading is at least two to three times larger than the retail exchange market, processing more than $12 billion worth of daily trades[xv].

These OTC trades are not done over an exchange, but rather through private brokers. These trades typically require layers of middlemen, including lawyers, escrow services and other intermediaries, which greatly increase the costs and slow transaction times to days. The primary reason for these middlemen is the absence of trust inherent in all OTC trades. How do parties know the counterparty will uphold their end of the transaction? But what if there were a way to eliminate the problem of trust and yet keep the OTC trade completely private and off an exchange?

Now, OTC traders can use their Fe Wallet for their OTC trades. Two users can agree on a price and execute a private trade without being concerned that the counterparty will not complete their end of the transaction. This is because Ferrum has a built-in feature that requires parties to accept transactions before they are executed. If both parties do not accept the transaction, it can be rolled back. In the normal OTC context, if Whale A wishes to sell 10,000 BTC to Whale B in exchange for 300,000 ETH, he cannot know whether Whale B will actually send him the ETH following the trade, and blockchains do not permit the "roll back" of transactions. However, using the Fe Wallet, Whale A can send the BTC, with the condition that Whale B send the

ETH, and the transaction will not be executed until both parties accept the transaction. In the future, Ferrum will enable the exchange of digital fiat currencies, thereby offering OTC traders a forum to conduct private, trustless trades using both crypto and fiat without reliance on costly and inefficient middlemen.

1.5 The Problems with ERC-20 Tokens

While Ferrum is a strong supporter of the Ethereum Project and acknowledge its groundbreaking technology, we also believe that there are certain limitations with the ERC-20 standard that must be solved if cryptocurrencies are to live up their original promise.

First, Ethereum's current transaction rate, approximately 15 transactions per second, is far too slow for global adoption. And while Ethereum's current solutions for scaling such as Sharding, Raiden, and Plasma are all interesting, they are yet to be implemented and adopted. Second, the ERC-20 standard is susceptible to bugs and user mistakes because it allows users to send ERC-20 tokens to the wrong addresses, which has directly led to substantial unnecessary monetary losses. Third, ERC-20 Tokens are not first-class citizens of the Ethereum network. Instead, they are generated using a specific type of smart contract that manages massive hash-maps that maps every address to its balance. This is one of the primary reasons that the transactions on ERC-20 tokens are not scalable. While the new ERC-223 standard may resolve some of these problems, the core issue of scalability remains. In short, ERC-20 tokens have been wonderful for the growth of the crypto ecosystem but have significant shortcomings that can be improved upon.

1.6. Scalability and Volatility Discourage Bitcoin as Medium of Exchange

At present, Bitcoin is a good store of value, but not a good currency. For something to achieve status as a currency, it must be a store of value, unit of account, and medium of exchange. Bitcoin and a few other major cryptocurrencies have established themselves as a good store of value and unit of account. However, for cryptocurrencies to be used as an everyday medium of exchange, they must solve the issues of scalability and fees.

We can think of Bitcoin as digital gold. The scarcity of gold has made it a global store of value that can be used to back the value of other assets. However, like gold, Bitcoin cannot be practically used in day-to-day transactions. Moreover, the price volatility of Bitcoin dissuades most from transacting with it. Until the problems of scalability, fees, and volatility are solved, Bitcoin will struggle to become a truly viable currency. We believe these issues constitute nothing less than an existential threat to the entire cryptocurrency ecosystem, and the need to address them cannot be overstated.

2.0 Our Solution: The Ferrum Network

At its core, Ferrum Network is a decentralized exchange and transaction network. By utilizing existing and novel technologies, Ferrum Network allows users to cryptographically represent other digital assets, which can then be used as a medium of exchange for other digital assets, whether they are backed by centralized or decentralized technologies. We propose a protocol called Ferrum and its implemented cryptocurrency proxy called Fe. The value of every Fe is pegged to another cryptocurrency, and it can be imported or

exported in relation to the underlying cryptocurrencies it represents. For example, users can convert their Bitcoins to a Fe equivalent, and execute countless fast transactions on the Ferrum Network with minimal costs, thereby avoiding the slow transaction speeds and high fees experienced in the Bitcoin network.

Users can further convert their Fe back to any other originating cryptocurrency supported by the Ferrum Network. We further propose an implementation of Ferrum based on a directed acyclic graph (DAG) ledger. We utilize concepts that we call Proof of Burn, External Proof, and Futures to enable this cross-chain exchange.

Ferrum Network runs on its native token, the Ferrum Token, or FRM, as the gas of the network. As a true utility token, the FRM is necessary to prevent malicious actors from spamming the network and to present proof to the network in order to run transactions. It is also used to increase transaction speeds, activate the Sub-Zero Wallet, reduce fees on the Infinity DEX, import and export value to and from the Network, among other functions. Finally, Kudi Exchange will cost FRM to use, but Kudi has agreed to pay this cost for users up to a per-user limit for a promotional period

2.1 The Ferrum Network Overview

Ferrum Network is a decentralized DAG-based infrastructure platform that is designed to achieve the following functions: a mechanism for importing and exporting value from other networks; a fiat gateway (the Kudi Exchange); a decentralized exchange (the Infinity DEX); non-custodial wallet (UniFyre Wallet); a cold-storage application (Sub-Zero Wallet); a protocol for tokenizing fiat currencies; a payment solution for the everyday use of cryptocurrencies; and

other functions in early development that are beyond the scope of this whitepaper.

2.1.1 The Network: A Decentralized Directed Acyclic Graph

Bitcoin was the first widely known decentralized cryptocurrency. In his whitepaper, Satoshi Nakamoto set forth his vision for the cryptocurrency Bitcoin, and presented a secure mechanism which became known as "blockchain" for storing transactions. Blockchain is a Merkle Hash Tree [1] that is pruned into a Merkle Hash linked list by competing miners. Figure 1 (a) shows a blockchain where blocks are linked together. Blockchain, a revolutionary technological breakthrough, nevertheless suffers from the problem of scalability. We believe that another method of implementing decentralized ledgers by decentralized network, known as a DAG based network, is a more effective solution. DAG is short for Directed Acyclic Graph, which describes the data structure that represents transactions in these networks. Figure 1(b) illustrates transactions in a DAG based network.

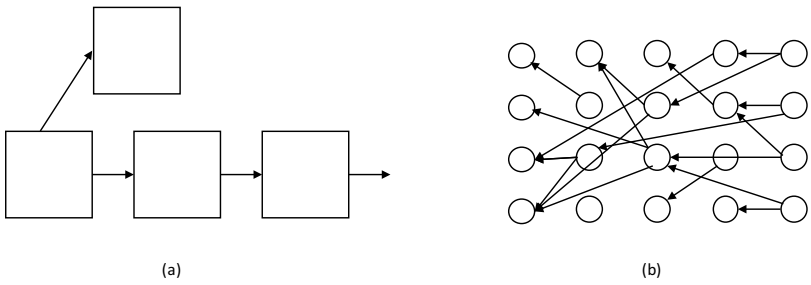

Figure 1 Blockchain (a) versus DAG (b)

In general, a DAG-based cryptocurrency network works in the following manner. The transactions issued by nodes constitute a graph, which is the ledger for storing transactions. When a new transaction arrives, it selects two other transactions to approve. These approvals are represented by directed edges, as shown in Figure 1 (b).

By following the approval path of the transactions, eventually we reach the transaction. This is the first transaction that initiates the graph. The origin transaction does not necessarily issue any tokens. However, one of the breakthroughs of the Ferrum Network is that it allows the issuance of tokens backed by an external network, or originated in the Ferrum network.

2.1.2 Import/Export Mechanisms and External Exchange Transactions

One of Ferrum Network's unique value propositions is its ability to securely import value from outside networks/blockchains, and then securely export it back to its original networks/blockchains. This is achieved in part using proxy tokens. For instance, Fe(BTC) is the proxy token of BTC in the Ferrum network. Proxy tokens in Ferrum are guaranteed to have the same value of their backing tokens. The challenge here is to develop a technology that is resilient to market forces. The technology should prevent situations where demand for Fe(BTC) grows faster than demand for BTC or demand for Fe(BTC) drops faster than demand for BTC.

For a simple example, one can think of BTC as cash and Fe(BTC) as a certified bank check. Users can go to bank and lock their cash, and the bank gives them a certified check that is effectively the same as cash. Market forces do not change the value of certified check compared to cash because any time people want to acquire large number of certified checks, they can go to the bank and bank will create as many certified checks as there is locked cash. If people decide to re-acquire the cash, they return to the bank, and the bank will destroy the certified check and unlock the cash. If there is enough

cash in the safe for every certified check produced, there will not be a divergence in the value of the certified checks versus cash.

In above example, it is vital for the bank to secure its safe. If a thief steals the safe, suddenly those certified checks are not backed by cash. Therefore, the security of value lock/unlock techniques is of paramount importance.

Ferrum can also represent proxy tokens other than Fe(BTC). The technology that provides security guarantees for importing value is critical. We have developed several techniques that provide various types of guarantees, which are suitable for external networks with different characteristics. These techniques are discussed in more detail in section 3 of this paper, and in Ferrum Network's Technical Paper.

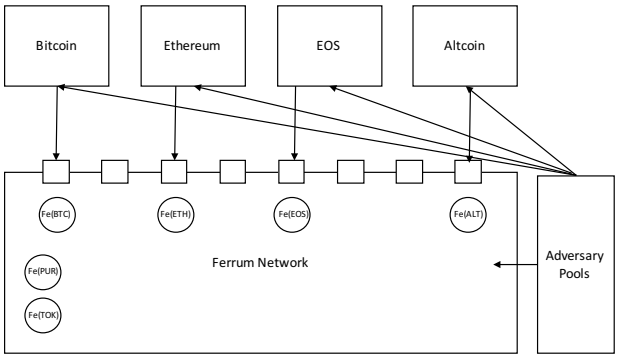

Figure 2 - Ferrum Network can import value from other networks. It also has local tokens such as Ferrum FRM token or user created tokens

The following procedure is the general algorithm for transferring value (v) from network X, to Ferrum:

1. Lock or destroy v in the external network X
2. Present the proof from 1 to the Ferrum Network. This allows you to create v of Fe(X)

To export the value back to the original network, the following procedure should be used:

1. User destroys v proxy tokens Fe(X)

2. Ferrum network validates that 1 has happened and unlocks v tokens from external network X
3. User transfers the unlocked tokens to their address in the external network

In Section 3, we present techniques to securely lock value in the external network and to unlock it after validating the destruction of proxy tokens.

In addition to proxy tokens, Ferrum Network has its native utility token (FRM), and other tokens that network users or dApps can create (similar to ERC-20 tokens). Moreover, Ferrum's proxy tokens and native tokens can interact within the Ferrum Network, where they can be exchanged or used in transactions.

In Figure 2, we see users import value from external networks into the Ferrum Network. An adversary pool, essentially a set of adversaries, act to ensure that the user has destroyed his proxy tokens before he can unlock the value in the external network. Figure 2 also shows the native tokens that are originated in the Ferrum Network.

It is important to note that most day-to-day users will never need to lock or unlock values in the external networks in order to acquire Ferrum proxy tokens. There is a much simpler and faster method for users in the Ferrum Network to exchange X for Fe(X): a user can simply exchange BTC with Fe(BTC) using the external exchange protocol. This is as simple as sending BTC to a Fe(BTC) holder and receiving Fe(BTC) from them. Ferrum Network has built-in solutions to allow this exchange without counterparty risk. We present the details of such external exchange algorithm in Section 3.

2.1.3 Fast Decentralized Exchange

Most digital asset exchanges are done through traditional centralized exchanges. A centralized exchange works by holding the user's assets in their data sources. The primary concern with centralized exchanges is that users must trust exchanges with their assets, and there have been several high-profile hacks resulting in significant and often unrecoverable monetary losses. Decentralized exchanges, on the other hand, eliminate counter party risk because they do not hold user's assets. Figure 3 shows how Ferrum Network is positioned in relation to decentralized exchanges. Such decentralized exchanges do not hold user's assets, rather a centralized order book matches the bidder and asker, and transactions are then settled on the decentralized network.

As depicted in Figure 3, Ferrum Network can function as the settlement layer for other decentralized exchanges. However, the primary breakthrough is Ferrum Network's own decentralized exchange – the Infinity DEX. The Infinity DEX with order book for matching buyers and sellers, enables fast and secure decentralized transactions without counterparty risk, for nominal fees. As of this writing, users can engage in decentralized trades of following digital assets using the Infinity DEX, and the trades settle in less than a second: BTC, ETH, XRP, TUSD, Gemini Dollar and FRM. In the near-future, Ferrum will also integrate NEO, BNB, EOS, among others.

As more networks securely plug-in to the Ferrum Network, users will be able to directly exchange any variety of tokens. Because Ferrum is blockchain agnostic, it can be used to exchange any digital asset assuming its host network is securely plugged into the network. Since it runs on a DAG, these transactions can be executed in a fast, scalable and cost-effective manner. In addition, the Infinity DEX will

have an intuitive interface for regular users, and advanced features for professional trades such as high frequency trading, short selling, and AI driven trading assistance.

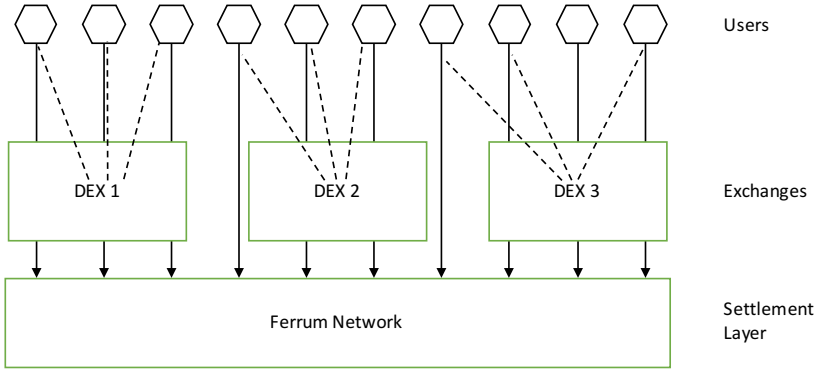

Figure 3 - Decentralized exchanges do not hold users funds. They just connect bidders and sellers. Transactions get settled on a decentralized network.

2.1.4 Non-Custodial Wallet (UniFyre Wallet)

Ferrum Network has also built the UniFyre Wallet for the secure management of digital assets, as well as simple market trades, risk-free over-the-counter transactions and simple risk-free payments. Users connect to Ferrum Network through their private UniFyre Wallet. Because Ferrum is decentralized, the network does not have access to a user's private key. Similarly, the way UniFyre Wallet holds assets is also decentralized - the tokens and the private key are distributed across the network's nodes. The UniFyre Wallet is designed to be very user-friendly, intuitive and analogous to centralized alternatives.

2.1.5 Token Platform

Currently the Ethereum network is used for issuing ERC-20 tokens. ERC-20 Tokens are not first-class citizens of the Ethereum

network. Instead, they are generated using a specific type of smart contract that manages gigantic hash-maps. This is one of the primary reasons that transactions with ERC-20 tokens are not scalable.

Ferrum is designed to allow developers to create new tokens that can be transacted and exchanged in a scalable manner. As explained below, Fe(BTC) or Fe(ETH) are tokens that are backed by external value. In Ferrum, we introduce a new type of transaction, which we call the Genesis Transaction. The Genesis Transaction issues a new set of tokens that are not backed by anything. A Genesis Transaction has the following extra fields: Number of tokens and Is Open Ended. The Genesis Transaction can be created by a smart contract or a normal account. The creator of an open-ended Genesis Transaction can create more Genesis Transactions. The only account able to spend from the Genesis Transaction is the originator, being a normal account or a smart contract.

As Ferrum Network continues to develop, it will be built to allow developers to issue their own native tokens, which can be recognized and transacted similarly to other native or imported tokens in the Ferrum network.

2.1.6 Tokenizing Fiat

The protocols that allows Ferrum Network to see across networks is simple enough that is not specifically bound to cryptocurrencies. An entity holding digital fiat currencies can also exploit such protocols to generate Fe(EUR), Fe(AUD) or any other currency in the world. Once fiat currencies are entered the Ferrum network, they can be freely transacted or exchanged by each other or any other digital asset.

In a hypothetical scenario, an European financial institution can provide the following public interfaces to their bank account database, which would enable the generation of Fe (EUR): 1) a funding lock account number that has no owner, whereby any transactions sent to that account are not reversible; 2) the ability of users to expose their bank account numbers without the need to expose the account value; and 3) a public ledger that shows that the transactions happened between the exposed accounts.

Such an interface is enough to enable generation of Fe(EUR) in the Ferrum network without requiring trust to the financial institution. A decentralized database can create a duplicate record of the published transactions, thus removing the ability of the financial institution to modify the transaction history.

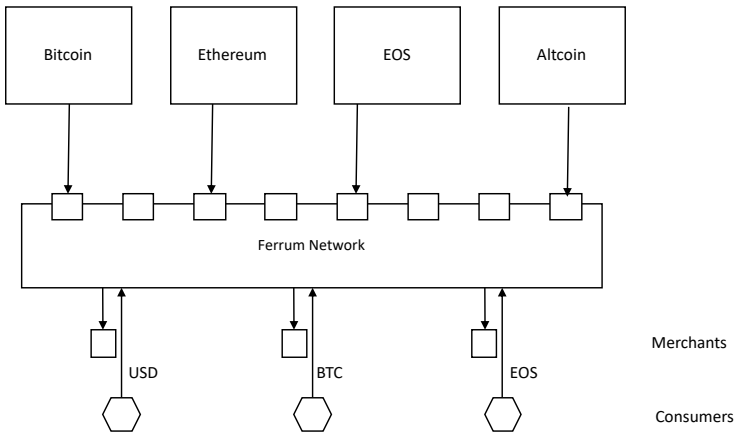

Figure 4 - Payment Solutions using the Ferrum Network. Merchants and services can accept any fiat or crypto currency

By utilizing the Ferrum Network as their transaction layer, financial institutions, merchants and payment solutions can develop applications that provide or accept payments in a wide range of digital

or real-world assets. Figure 4 shows how Ferrum Network connects consumers and merchants to the Internet of Value.

2.2 Ferrum Advanced Features Overview

Ferrum Network was designed with the following vision: to be the first interoperability network to facilitate the seamless transaction and exchange of both cryptocurrencies and fiat currencies, and to remove the barriers that have impeded the use of cryptocurrencies for everyday transactions. In furtherance of this vision, we have developed products that run on the network including the UniFyre Wallet, Infinity DEX, and fiat gateway protocol (Kudi Exchage), and will be implementing additional protocols such as low latency transactions, dApps, and sub networks.

2.2.1 Data Layer

The Ferrum Network ultimately requires a highly scalable, distributed, and decentralized hash-map for storing data. The community is working to solve this challenge. Ferrum Network is designed with the idea of replaceable data layer in mind. We will replace the data layer with an appropriate technology once a fast, reliable, and mature option is available.

2.2.2 Low Latency Transactions

A useful financial transaction system is expected to be highly reliable and support a very high throughput of transactions. These properties are essentially trivial in distributed centralized systems, but they are quite difficult to achieve in peer-to-peer decentralized

systems. The beauty of graph-based transaction systems such as Ferrum Network is that it enables us to mix these two approaches: distributed centralized nodes with peer-to-peer decentralized nodes, but without compromising trust. For instance, flag bearers, inspired by IOTA implementation, are very powerful distributed nodes that process all transactions and facilitate the graph's convergence.

Imagine a chaotic medieval army marching through a complicated terrain. Several soldiers in front of the line are carrying tall flags, while the large army follows them. These flag-bearer soldiers are not commanders and have no authority, but their existence brings order to the chaotic army. Flag bearers in the Ferrum network function as similar nodes. They are not trusted to validate transaction, but they are expected to submit "zero" value transactions that converge the graph, and they are expected to choose a consistent convergence path for the graph. In return they can submit 0 value transactions without fees or proof of work. In other words, flag bearers are nodes that are trusted only enough that they will not spam the network. If a flag bearer starts spamming the network or chooses inconsistent convergence paths for the graph (e.g. paths with double spending) the community will stop following the flag bearer.

2.2.3 The Ferrum dApp Paradigm

Ferrum Network enables users to write their code using their favorite language, whether that be Python, Go, Java, etc., and package it with all the dependencies. They can use their existing tooling and programming knowledge to write a decentralized application (or dApp). This immediately increases the number of people who can contribute to the decentralized ecosystem.

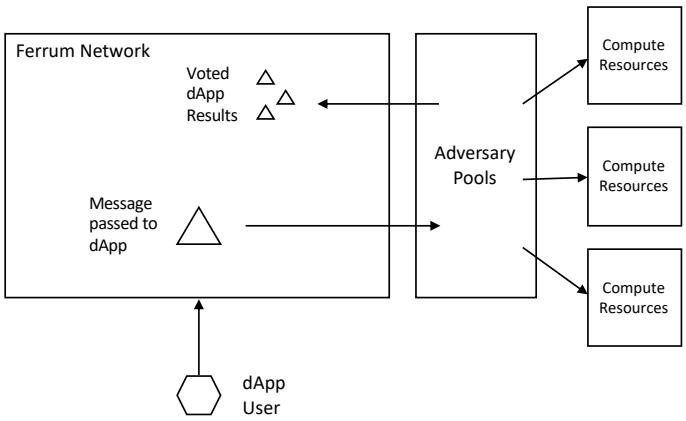

Figure 5 - Ferrum dApp Paradigm - Decentralized apps are run by adversary pools more like a decentralized cloud service than a smart contract

Currently, a user can write an application, package it with dependencies and run it on one of the common cloud providers such as Amazon (AWS), Microsoft (Azure), or Google Compute Cloud. Naturally, they pay the cloud providers for the resources they use. Conversely, Ferrum Network turns this model upside down by allowing users to present their compute resources to the Ferrum network, which means users can run decentralized applications and get paid for their resources in FRM.

We propose a flexible protocol that allows users to choose a trade-off between security and cost. Ferrum's decentralized application model is also scalable because the relationship between compute power required for the network and the scale of the network is linear.

2.2.4 The Ferrum Family of Networks for Scalability and Specialization

Ferrum Network is designed with flexibility, scalability and specialization in mind. Ferrum side networks can seamlessly interact

with the main Ferrum Network, while keeping their load off the main network, thereby improving scalability and facilitating innovation and specialization.

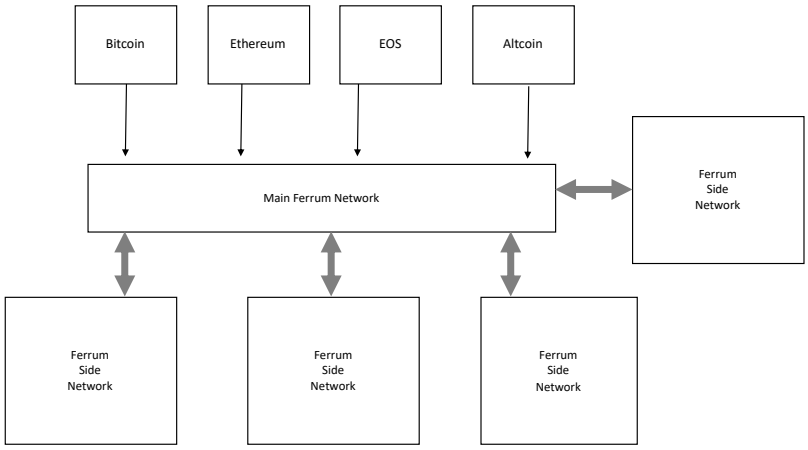

Figure 6 - Ferrum Side Networks - side networks can seamlessly interact with the main Ferrum network while keeping their load off the main network.

In addition to scalability, Ferrum Colonies enables the specialization of sub-networks. For example, a small nation state decides to adopt a digital currency, which they control completely, yet must interact with the external world. They can adopt a Ferrum spin-off for their economy and issue their currency without worrying about being dependent on a network they do not control. Another example is a side network adopted by a scientific community to study Genome models. Such a network has specialized needs, such as memory and processor heavy smart contracts, or high bandwidth, and they may wish to limit submitting transactions on the network only to the members of the community. Such a sub-network can create a Ferrum spin-off for their specialized needs, yet be able to interact to the external world, sell their results, receive money, and so forth, all through their connection to the main Ferrum Network. Although Ferrum Network makes interaction between networks possible, the

Ferrum side networks have a much tighter interaction, such that the movement of value and logic will be nearly seamless.

2.2.5 Decentralized Payments Solutions

Ferrum is designed from the ground up to support tokens that represent external assets. It provides mechanisms to secure the transfer of assets from other networks. In addition to crypto assets, it can represent real-world assets such as fiat currencies.

Ferrum Network envisions a day in which merchants and consumers can transact in cryptocurrencies for every day purchases over the Ferrum Network. To this end, Ferrum Network will be building a decentralized payment solution. Using the Ferrum Network, merchants and services will be able to accept and seamlessly transact with any cryptocurrency in a fast and scalable manner. For instance, by creating a proxy BTC on the Ferrum Network, consumers will be able to quickly and cheaply purchase a cup of coffee, which would not otherwise be possible using the Bitcoin network due to its relatively slow transaction times and high fees.

2.3 Tokens and Proxies in the Ferrum Network

To help solve the issues with scalability and interoperability, users can transfer any digital asset to the Ferrum Network, where a proxy of that token is generated. The proxy token can then be transacted and exchanged over the Ferrum Network in a cost-effective and scalable manner. However, users can rest assured that the proxy represents and is backed by external value.

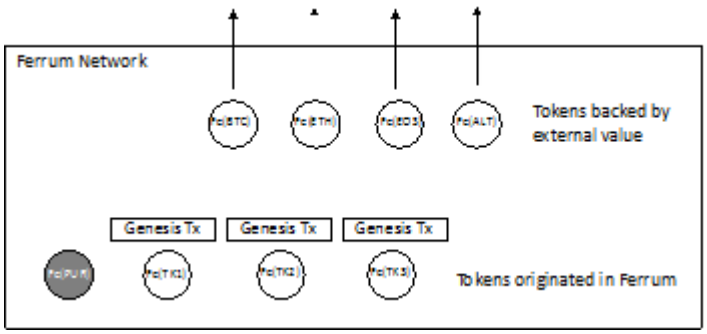

Figure 7 - Ferrum hosts both proxy tokens and tokens initiated from within the ferrum network

The subjects of transactions on the Ferrum network is "Fe", which, for the lack of better world we refer as a cryptocurrency. Fe, however, is not a cryptocurrency in and of itself. Instead, the value of Fe is a function of the values of external cryptocurrencies it represents. To clarify, imagine the following scenario: Alice generates 1 Fes by transferring one Bitcoin to the Ferrum network. She then generates another Fe by transferring one Ether to the Ferrum network. Alice now has 2 Fes but her total wealth is 1 Bitcoin and 1 Ether. We represent Alice's wealth as 1 Fe(BTC)+ 1 Fe (ETH). The general form of Alice's wealth is $\sum\sum_i a.Fe(i)$ where i is the external cryptocurrency and Wi is the amount for i. In-fact, a Fe wallet is nothing but a surrogate for a portfolio of external cryptocurrencies.

Alice then sends all of her Fe(ETH), plus 50 percent of her Fe(BTC) to Eve for her birthday gift. Alice now has only 0.5 Fe(BTC), and Eve has 1 Fe(ETH) and 0.5 Fe(BTC). Eve can decide to get back some actual Bitcoins by engaging in a Future transaction with Mike. The future transaction can be described as: "Transfer 0.5 Fe(BTC) from Eves Fe wallet to Mike's Fe wallet, under the following condition; Transfer of 0.5 Bitcoin from Bitcoin Wallet W0 to Bitcoin Wallet W1 has happened before tomorrow 12:00pm". Wallets W0 and W1 are Bitcoin

wallets where Mike and Eve have agreed upon before starting the Future transaction. If the external transaction is completed before the agreed time, Eve's Fe would be invalidated and Mike would own 0.5 Fe(BTC). Otherwise Fe would be release back to Eve and Mike ends up with nothing.

In other words, by utilizing a proxy, Ferrum Network can achieve the best of both worlds: users can still exchange and transact their favorite digital assets but are no longer limited to the scalability and throughput of their native networks.

2.4 The Ferrum Token (FRM) as Transaction Fee

To prevent spamming the network, every Ferrum transaction needs to present a proof of work. The Ferrum Network's proof of work is designed to be solvable in a few minutes using a normal laptop’s compute power, but this is not a practical solution for real-life users of the network and is especially limiting to users who need to run fast and/or voluminous transactions. Proof of work attached to the transactions is also used to increase the weight of the transaction, and its chance of being picked up by other nodes for validation. This removes the need for dedicated mining nodes.

We propose the native Ferrum Token, or FRM, which can be used in lieu of proof of work, or in addition to it. Users can therefore add weight to their transactions by spending FRM instead of, or in addition to, proof of work. When FRM is used to execute a transaction, the token is burned.

3. Use Cases

Ferrum Network is a decentralized interoperable network enabling the seamless transaction and exchange of any digital asset. In furtherance of this vision, Ferrum Network has developed the UniFyre for OTC/peer-to-peer transactions, and the Infinity DEX – a simple yet sophisticated decentralized exchange for novice and professional traders alike. Ferrum is also building fiat gateways to enable users to exchange fiat with cryptocurrencies in a fast and decentralized manner.

In May 2019, Ferrum launched the Kudi Exchange, a fiat gateway plus payments app for high-speed, low-cost transactions of digital currencies and fiat currency (the Nigerian Naira). This exchange is now live with approximately 3000 users and growing daily.

In addition to the above products, the network also enables additional functionalities, such as a transaction layer; a platform for issuing new tokens and dApps; a consumer payment platform for fiat currencies and cryptocurrencies; a nation states currency platform; and private and enterprise networks connected to the outside world. A detailed discussion of these future cases can be found in the Ferrum Network Technical Paper.

3.1 The UniFyre Wallet

Users connect to the Ferrum Network through their private UniFyre Wallet. Because Ferrum is decentralized, the network does not have access to a user's private key. Similarly, the way UniFyre Wallet holds assets is also decentralized - the tokens and the private key are distributed across the network's nodes.

The UniFyre Wallet is designed to be very user-friendly, intuitive

and analogous to centralized alternatives. Experienced crypto users will feel an immediate familiarity, while novices should grasp its functions with ease. The following is a brief description of the Ferrum Wallet's functions.

The Dashboard should be familiar to anyone with a Coinbase account; it allows users to see their balances, market data and more. The Wallet's "Deposit" function allows users to deposit tokens into Ferrum Network. Following the simple steps set forth on the Wallet interface, depositing can be achieved simply with a QR code or other familiar means. Ferrum Network then generates a proxy token(s) that appears in their wallet nearly instantly by submitting a special type of cross-chain transactions that points to the transaction in the original network. A small amount of FRM tokens is required to import digital assets into the Network and UniFyre Wallet. Once inside the Wallet, users can exchange their tokens peer-to-peer, execute near-instant market trades, or connect to Ferrum's decentralized exchange.

The "Send" function enables users to send their tokens to any other user in the Ferrum Network, much like one can do with a centralized wallet, but with some additional features and protections. Notably, senders can request confirmation from the counterparty, which requires that the counter party "accept" the transaction before it is executed. This feature is critical in preventing accident loss of a user's digital assets and distinguishes a Ferrum transaction from a traditional Bitcoin transaction.

3.1.1 Direct OTC and Peer-to Peer Trading

In those instances where the counterparties are known to each other, the UniFyre Wallet also enables a direct OTC exchange through

the “Direct OTC Trade” function. This feature allows parties to select the amount of cryptocurrency they wish to send in exchange for an amount/type of crypto currency they wish to receive. After those material terms of the transaction are determined by the parties, the user inputs the UniFyre Wallet address of the counter party and “requests exchange”, at which time the transaction will appear in the counterparties’ Wallet, where they can accept or reject the transaction. The requirement that both parties accept a transaction before it is executed offers a layer of security absent from a typical Bitcoin exchange, wherein once a transaction is sent, it cannot be rolled back or cancelled. An OTC Exchange is executed for a small amount of FRM for running the transaction on the network. Once accepted, the trade executes almost instantly. In sum, the Direct OTC Exchange using the UniFyre Wallet is the fastest, least expensive and most trustworthy means of conducting a decentralized peer-to-peer exchange.

3.2 The Ferrum Sub-Zero Wallet

Ferrum Network’s decentralized products empower users by giving them control of their assets. Such empowerment means that users also must hold their private keys securely. Unfortunately, there is a gap in the market when it comes to keeping a decentralized wallet secure. The Ferrum Sub-Zero wallet is designed to address this gap.

To ensure that private keys remain untouchable by the most sophisticated hackers, there is only one real solution: to keep the keys offline. Any form of connectivity eventually makes the private keys vulnerable to future hacks. Even state of the art hardware wallets designed for securely holding private keys are connected by a wire to a USB port on the laptop. This fact, plus their proprietary design

makes hardware wallets such as Tezor, or Ledger Nano sub-optimal solutions for complete offline safety. In addition, other cold storage solutions are not mobile because they must be connected to a computer.

Ferrum Network's Sub-Zero Wallet will employ an interesting technique to handle offline security and address mobility. A Ferrum Sub-Zero wallet is not connected to the network in any physical means, however it is able to communicate with its sister hot wallet through a series of QR codes. Users will only need an Android phone to set up a Sub-Zero ultra-cold wallet and secure their assets. Not only will Sub-Zero be more secure than hardware wallets, it will also be much easier to use, less expensive, more accessible to every day users around the world, and mobile-friendly.

3.3 The Infinity DEX

The Infinity DEX will operate much like a centralized exchange, matching makers and takers over an intuitive and simple order book and matching engine. However, all trades are conducted over Ferrum's decentralized network. Like any centralized exchange, buyers and sellers can execute market orders, limit orders, and stop orders. The interface will be familiar to everyone in the crypto community and easy for novices to use.

3.3.1 Infinity DEX Advanced Features

With the Infinity DEX, we aim to build the best decentralized digital asset exchange in the world. We believe it is not enough for an exchange, even if it is decentralized, to be very fast and inexpensive.

By learning from our team with significant experience in the FinTech space and on Wall Street, the Infinity DEX will launch advanced features that are currently only available to sophisticated, high-net worth investors such as hedge funds. With the use of artificial intelligence, we will make those advanced features easy to use for the average retail customer.

3.3.2 Investor's AI Assistant

In most exchanges, user can usually place market, limit, or stop orders. These are useful tools for executing a trade, but they do not help with decision making about trades. An informed trade decision about a trade, at minimum should take several pieces of information into account:

- Market sentiment about the asset;
- News articles, tweets and public Telegram chatter about the asset;
- Trades of co-related assets in the same and other markets; and
- Short term and long-term technical movements of the price

In addition to the above, several other techniques such as hedging positions and forming an optimal portfolio can affect short-term and long-term results for an investor.

Ferrum's AI Trading Assistance will monitor news outlets, Twitter feeds, and public Telegram chatter for any relevant mention of digital assets. It will then combine that stream of data with price and order book information from the market to identify critical moments for the price movements. Users of the Infinity DEX will be notified, according

to different AI algorithms, what critical movements are possible, and let the user make an informed decision about entering or exiting a position.

3.3.3 Margin Trading with Infinity DEX

Another feature of the Infinity DEX will be a marketplace for users to borrow digital assets from each other. Imagine Bob believes that the price of ETH will go down compared to BTC. Whereas, Alice holds hundreds of ETH tokens and has no intention of selling any time soon. Through the Infinity DEX, Bob and Alice can enter into a margin short sell smart contract, where Bob can borrow ETH from Alice by putting a deposit and selling it for BTC. If the price of ETH drops as Bob predicted, he can buy back the ETH plus some fee and release his deposit. Bob has made a profit and Alice has made some income by lending her ETH to Bob. On the other hand, if the price of ETH increases compared to BTC, Bob may need to exit the position and lose his deposit or increase the margin on his deposit. This is known as short selling in equity markets.[xvi]

In the crypto market, brokers typically provide margin accounts and allow investors to short tokens, but Ferrum will provide that functionality using its peer-to-peer marketplace and smart contracts.

3.4 Fiat Gateways

While Ferrum strives to be the best wallet and exchange even compared to the centralized options, it is important that we allow users to access fiat money. The world of fiat money is governed by financial regulations and there is no decentralized solution for access to fiat. In that sense, UniFyre Wallet will provide features for users to

access the traditional banking network, based on their geographical location. To ensure complete compliance with local regulations, we propose three methods to implement a fiat gateway.

3.4.1 XRP as Intermediary Cryptocurrency

In this model, Ferrum will integrate with existing fiat gateways that support XRP/fiat pairs, such as Bitfinex or Kraken. For example, if user wants to buy Bitcoin with EUR, Ferrum will use the fiat gateway's API to buy Ripple (XRP) with EUR, immediately transfer that XRP to the Ferrum network and exchange it to Bitcoin. This process should take around 10 seconds to complete depending on the speed of the fiat gateway. Although this model is not ideal, it is still a significant improvement over directly using the fiat gateway for BTC or ETH transactions because of the increased speed of the Ferrum Network.

In order to sell Bitcoin for EUR in Kraken (without using Ferrum), a user must send their BTC to Kraken. This may take several minutes up to an hour(s) for the BTC to reach Kraken, during which time prices may have changed considerably. Conversely, because Ferrum will use intermediary XRP, and the BTC transactions inside the Ferrum Network are instant, the time from a sell request to EUR appearing in the user’s account can be as little as a few seconds, thereby reducing the risk of price fluctuations.

3.4.2 Direct Integration of Ferrum with Fiat Gateways

In this model, Ferrum will partner with established fiat gateways in various locals. Ferrum tokens can be listed directly on the fiat gateway, therefore users can buy Bitcoin directly in Ferrum network

with fiat currency. This is a medium-term goal and will be achieved after the mainnet launch.

3.4.3 Ferrum Fiat Gateway

All the above options for a fiat gateway have a major drawback in that Ferrum will not have control over the fiat transfers, and therefore will not be able to innovate and reduce costs. Nonetheless, Ferrum will be pursuing the path to fiat gateway and direct access to the banking system. The process of securing licenses and adhering to local regulatory requirements will take time, and may happen in some locals before others, but once achieved, Ferrum will be able to reduce the cost and improve the speed of transactions with fiat currencies.

3.4.4 West African Fiat Gateway Through the Kudi.Exchange

Africa is a continent where cryptocurrency is used for everyday needs. Therefore, we believe it is a great market for adoption of fast, secure and easy-to-use crypto currencies. For that reason, we have launched Kudi Exchange, a fiat gateway plus payments app in West Africa.

Kudi Exchange is a fiat-to-crypto exchange based in Nigeria, which is a country with 200 million people, the 7th highest Bitcoin volumes in the world[xvii], and the highest searches for the word "Bitcoin" on Google[xviii]. It is also a country with a relatively underdeveloped banking system.

Kudi Exchange can be thought of as a Coinbase plus peer-to-peer Venmo. It allows users to quickly purchase digital assets like Bitcoin, Ethereum and XRP, for at a lower cost than the competition.

Moreover, using the Kudi mobile app, users can send fiat currency the Naira to other Kudi users peer-to-peer for no transaction fees, sent directly to their phone or What's App number. These Naira transactions are orders of magnitude cheaper and faster than the alternative, and do not require any banking intermediaries.

Finally, the Kudi Exchange will be the first exchange in Africa to offer a U.S. Dollar backed stable coin, Gemini Dollar, through Ferrum Network's co-marketing partnership with Gemini.

4.0 Project Funding

Ferrum Network is committed to the long-term success of the project and is therefore interested in partnering only with those who share our vision and are willing to contribute to the long-term success of the project. To help build a robust user base and network, Ferrum Network will conduct a token offering in accordance with the laws of Malta. The details of the token sale will be released publically in the near future. Please contact the Team to request the information privately*.

5.0 Roadmap

Ferrum is unique in that we began developing and testing the technology prior to raising any funds to ensure that our vision would be viable. A timeline of our progress, and a roadmap of estimated dates of future developments and milestones can be found on the Ferrum Network website.

6.0 Team

Ferrum Network is comprised of experienced professionals from across the spectrum, from technology, finance, law, to the world of blockchain and cryptocurrencies. A list of these professionals can be found on the Ferrum Network website.

7.0 Conclusion

Ferrum Network is a blockchain-based FinTech company with products, users and network utility. We're bringing world-class financial applications to emerging markets and aim to empower millions of people around the world with non-custodial financial applications. Our advanced financial products run on top of a DAG-based interoperability network that connects to nearly any blockchain and works natively with fiat currencies. It's like the Lightning Network, but for every blockchain. Our test-net is already interoperable with the Bitcoin network, Ethereum network and Ripple network.

Our current product line includes a fiat gateway for emerging markets (Kudi Exchange) and a non-custodial wallet (UniFyre Wallet) for risk-free OTC transactions of any digital asset. Later we will introduce other products to the Ferrum Network ecosystem.

All of our products and transactions run on top of Ferrum Network. Every time a transaction occurs, it requires a small amount of FRM be spent and burned. Therefore, when fully scaled, tens of thousands of FRM will be spent and *burned* daily through our African users alone. Ultimately hundreds of thousands of tokens will be continuously burned once the UniFyre Wallet is released worldwide.

For more information on Ferrum Network, please visit our website: https://ferrum.network/ or contact the team.

[i] https://bitcoin.org/bitcoin.pdf

[ii] https://media.consensys.net/state-of-decentralized-exchanges-2018-276dad340c79

[iii] https://ericsink.com/vcbe/html/directed_acyclic_graphs.html

[iv] https://ieeexplore.ieee.org/document/8416434

[v] https://lightning.network/lightning-network-paper.pdf

[vi] https://www.wired.com/2014/03/bitcoin-exchange/

[vii] https://www.reuters.com/article/us-japan-cryptocurrency-q-a/the-coincheck-hack-and-the-issue-with-crypto-assets-on-centralized-exchanges-idUSKBN1FI0K4

[viii] https://coinmarketcap.com/rankings/exchanges/

[ix] https://www.businessinsider.com/cryptocurrency-exchanges-listing-tokens-cost-fees-ico-2018-3

[x] https://0xproject.com/pdfs/0x_white_paper.pdf

[xi] https://swap.tech/whitepaper/

[xii] https://idex.market/whitepaper

[xiii] https://arxiv.org/pdf/1801.09515.pdf

[xiv] https://courses.csail.mit.edu/6.857/2018/project/Hao-Chang-Lu-Zhang-CCExch.pdf

[xv] https://www.ccn.com/otc-is-much-larger-than-bitcoin-exchange-volume-where-real-whales-trade/

[xvi] http://people.stern.nyu.edu/mbrenner/research/short_selling.pdf

[xvii] https://totalcrypto.io/bitcoin-adoption-trading-volume-country/

[xviii] https://bitcoinist.com/top-5-countries-where-google-searches-for-bitcoin-just-tripled/

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