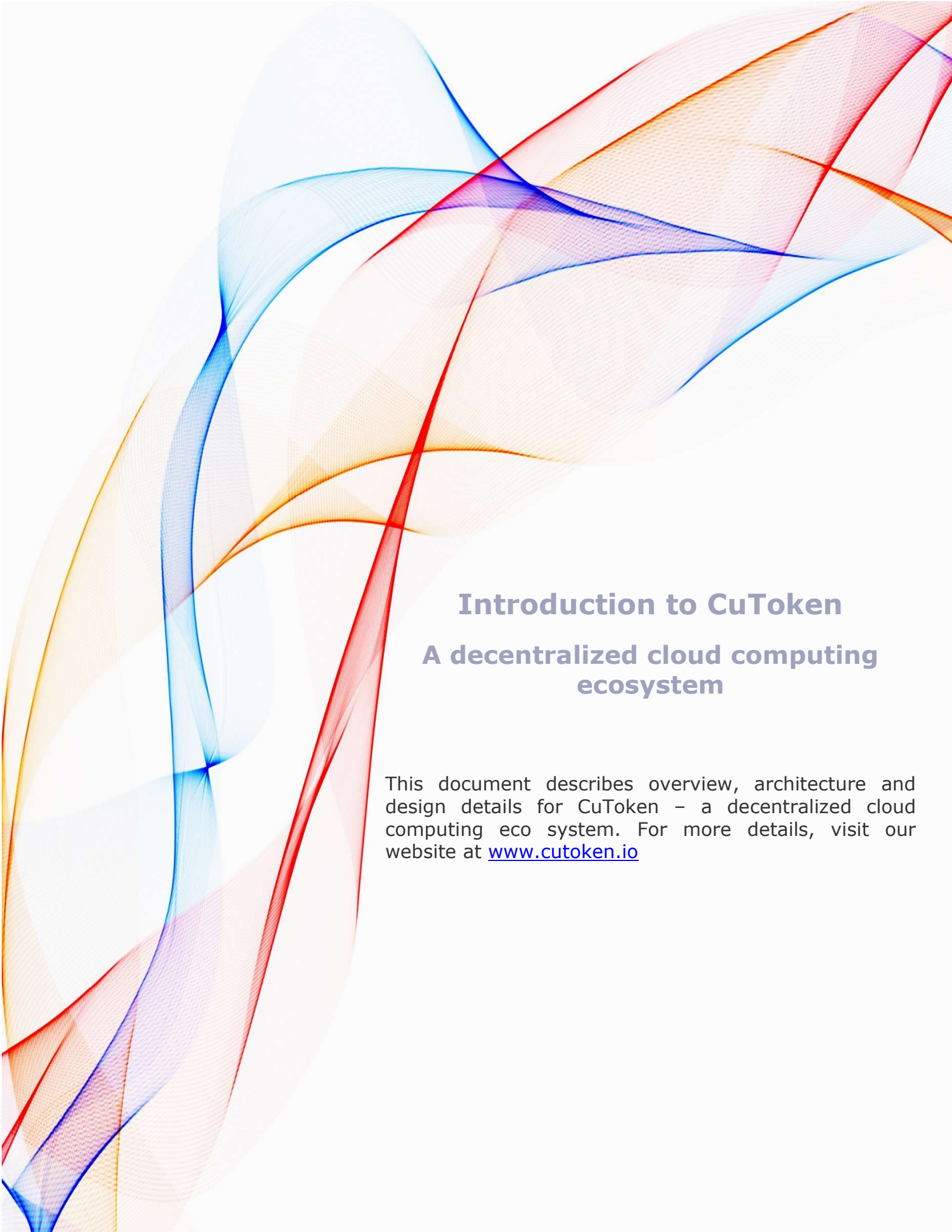


Introduction to CuToken

A decentralized cloud computing ecosystem

This document describes overview, architecture and design details for CuToken – a decentralized cloud computing eco system. For more details, visit our website at www.cutoken.io

Vision Abstract:

CU-Token (CuToken) is a blockchain based decentralized cloud computation platform where Computation power can be offered and purchased in a truly open, decentralized, cost-effective and reliable way. The platform protocols are designed to ensure steady availability of computational power in a fair and incentivized way. Processing power can be exchanged in real time and anonymously, allowing resource intensive applications to have an ever-increasing scalability without any interruption.

1. Introduction

With the growing need for connected computation power, cloud computing is getting more essential commodity than it was ever before. There are already a very few big organizations in the market providing their services while a few others are gearing up too.
This enterprise offered cloud computing may not serve the need for many for various reason. High cost, customization, limited access, workload restriction and central trust being major concerns for many. For example, AWS and Google platform currently does not allow certain type of computation job to get run on their platform unless you pay high charges. They might not even provide low level access and tools you might require for your work.

In this paper we propose the concept of peer-to-peer decentralized cloud computation. In this paradigm, the buyer proposes the requirement and pricing and gets an unrestricted access to computing resources based on the needs at a competitive pricing. On the other hand, people with excess computational power such as with mining equipment or other hardware can take advantage to lease their resources and earn higher incentives.

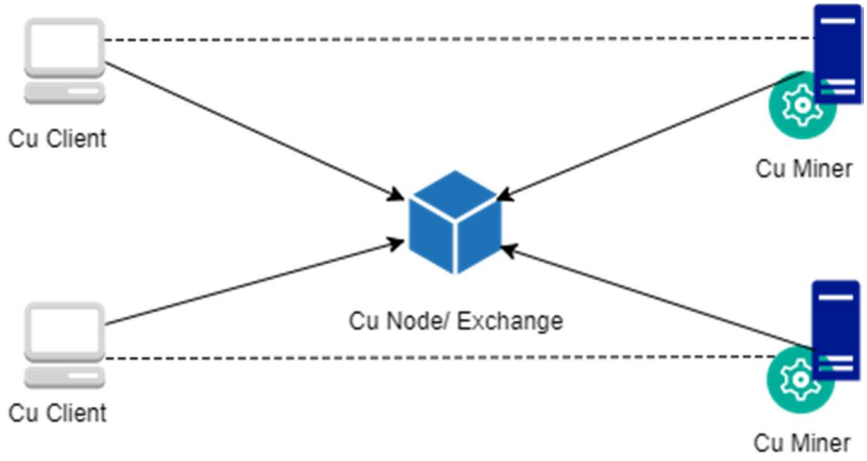
There already exist few decentralized platforms which focus on a specific use-case of cloud computing like making a super computer grid. CuTopia on the other hand aims to be a generic and open platform where a user can run any kind of workload from simple database server to machine learning nodes to a distributed cluster or a distributed computing grid. The use-cases are only bound by the imagination of consumer.

2. System Overview

2.1. System Proposal and high-level Overview

CuToken is a compute token around which a decentralized computational platform known as CU-Topia (CuTopia) has been created. CuTopia allows its participants to exchange computational power in lieu of crypto tokens knows as CuToken.
The philosophy is to convert computation requirement into precisely measurable Computation Unit (CU) and define incentives based on units required or offered.

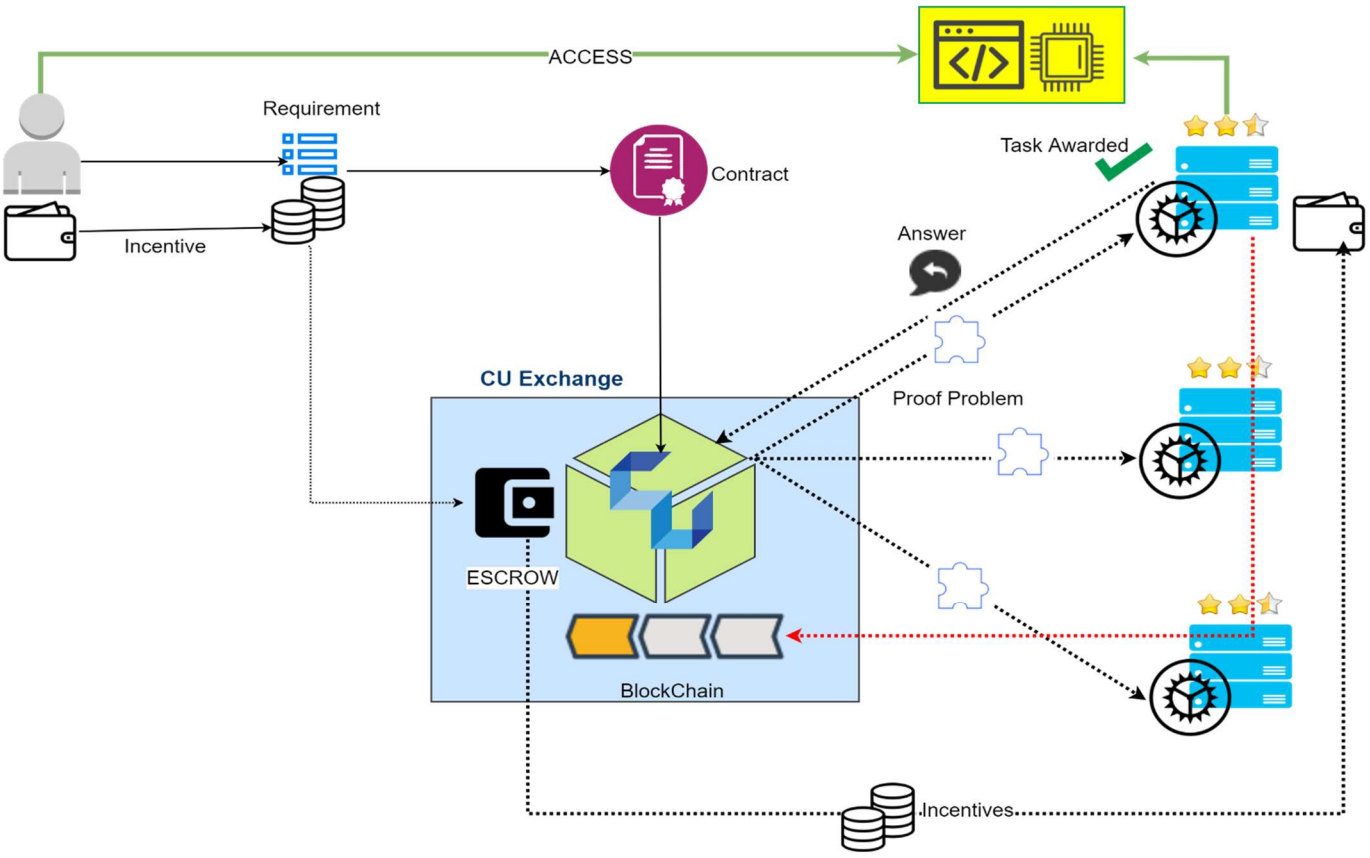
The system is designed using open source technologies for transparency, reliability and extension.



As a simplified overview of system, a customer who want to get a complex computation task executed which require a significant computational power, can join the CuTopia network by installing CuClient and obtain incentives in form of CuTokens. Once on the network, customer can define the computation requirement which includes the task, incentive, priority and ETA in CuClient. CuClient convert this requirement to a smart Computation Indenture (CI) which is very similar to a smart contract. CuClient then deduct the mentioned incentive amount from customer account (wallet), and sent the CI along with the incentives to central exchange known as CuExchange.
CuExchange deposits the incentives to escrow account and add the incoming CI to IndentureQueue and broadcast this event to miners. All miner nodes in the network listen for this event and download the incoming CIs. Based on the mentioned incentives, interested miners are presented with a proof of capacity problem by exchange to ensure that miners have the required computation power available. Miner who solve the problem first, is awarded the contract. Once awarded, try to execute the task and on completion, sends the result back to exchange.
On Exchange, results are validated through consensus and if found correct, miner is awarded the promised incentives by the escrow.

Upon completion, a transaction is created and appended to the block which include details about the task, execution, miners and incentive distribution. This block is then appended to a public blockchain. Also another transition is generated about quality of service for the engaged miner and is added to the miners' reputation blockchain called RepChain. Blocks once appended to Main blockchain and RepChain cannot be changed, hence this acts as a proof of work and award for any current and future references. RepChain helps in determining Miners history and reputation based on historical feedbacks.

HOW IT WORKS



3. Key Strengths

The platform has been designed and is being implemented ground-up around following central strengths.

3.1.1. Decentralized

CuToken ecosystem also known as CuTopia is totally decentralized. Computation power is arranged between participating nodes in a fair and open manner. Any computational requirement along with the incentives is published to the exchange and all participating nodes can transparently download this information in real time and can compete to earn the incentives by fulfilling the computational indenture.

All mining participants known as CuMiners have access to all the information available on exchange and any nodes if goes offline does not impact the system in anyway. Network dynamics remains unaffected by nodes joining or leaving networks. CuExchange itself is completely decentralized with multiple exchanges competing based on fee and reputation.

3.1.2. Secure

By default compute jobs run in their own virtual machines ensuring security for both buyer and seller of compute power. Access to these resources can be protected by standard methods including PKI.

3.1.3. Reliable

The reliability part comes from multiple factors. Firstly, the decentralized nature brings openness which means all available nodes compete for executing the task and earning the incentive. This takes away the dependency on any central authority or node. Every task is equally visible and accessible to all available node.

Secondly, all miners have to prove their capacity by solving a capacity proof problem to be eligible to compete for a contract.

And lastly, CuTopia maintains a reputation Chain based on all historical data which helps in generating rating for each miner and only quality miners with higher rating can participate in the contract.

3.1.4. **Generic**:

CuToken is designed as a generic platform where any kind of workload can be run on the leased computing resources for any kind of use-cases with few simple clicks. This opens up endless possibilities for buyers from running a simple compute task to design and run a storage cluster or a distributed tensor flow grid.

3.1.5. **Application-Ready**:

CuTopia provides buyers a large choice of computation image containers for different kind of work load and system configuration, which they can choose and deploy within seconds to get started with their work.

3.1.6. Trustless and Fair

CuToken platform works through a well-defined API driven open network. Any requirement or transaction is broadcasted to network and is not locked in a central authority. All transactions and network participation happen in open network and remain

available to anyone in the network. Pricing is offered through proposed Incentives for which the offering parties have to compete. This result in dynamic, fair and competitive pricing which remains much more cost-effective than any traditional commercial service providers.

3.1.7. Incentive Driven and Cost- Effective

One of the strongest foundation of the platform is its incentive driven nature. Participating parties decide and compete for the cost of computation which makes it dynamic and fair. There is no central authority or platform to play any role in deciding the pricing. Indicative incentives are calculated by the platform based on the required task and ongoing rates. One can publish a task below or above the ongoing rate. This ensures that more mining nodes come online during peak times when the incentive goes higher and incentives to be lower when too much compute power is available in the network.

3.1.8. Automated

All components of CuToken platform are built around a common open-source base framework known as Plexus. Plexus exposes its functionality through well-defined API which enables all CuTopia components to talk to each other through these common APIs in a seamless manner. This enables the system to minimize human interaction and allows different nodes in the network to talk to each other seamlessly in a logical flow to achieve various tasks such as floating Compute Indentures, incentive transactions, result validation and incentive rate determination to name a few.

4. Use Cases overview

CuTopia can be used in many ways because it does not put any restriction or constraints around the supported work load. Hence there are practically innumerable use case a consumer can use the platform. Few of the use-cases presented below are most frequently used scenarios in a cloud computing ecosystem.

4.1. Scalability

Buyers can purchase power on-demand to achieve cost effective real time low cost elastic scalability for applications of their choice.

4.2. Reliability

Due to the decentralized nature of CuTopia eco-system, compute clusters are more robust to failures and are generally fault tolerant. More importantly the reliability of the clusters is not tied to any single cloud provider.

4.3. Generic Computation

Buyer can run any generic computation task without any limitation to harness raw CPU/GPU power for any processing.

4.4. **AI and Machine Learning**

CuTopia can make available all compute resources including GPUs to customers at competitive prices. We hope this will make AI/Machine learning affordable by reducing price gouging by existing cloud providers.

4.5. **Storage**

Buyer can lease computational resource with larger storage capacity of varying degree of IO speed and cloud access interfacing.

4.6. **Content Hosting**

Buyer can lease resources to host their content in cloud for all reasons private and public.

4.7. **Crypto Currency Mining**

Buyer can lease GPU/CPU resources to mine profitable crypto currency without actually owning hardware or directly paying electricity bills.

4.8. **Application License sharing**

Buyers can lease a resource with a specific licensed software or Application pre-installed on leased image for a limited use without actually buying the full application.

4.9. **P2P Content Sharing**

Buyer can lease resources to host and share contents like media and documents and can share them within network to earn CuTokens. Due to the decentralized nature of the network, it's an effective tool against censorship.

5. System Components: Introduction and Interaction

This section presents the list of actors and important system components. Each of these components play important role in the system. The section goes into details of every component and system architecture details in later part.

Components:

1. **Buyer / Consumer**: A person or system running a CuClient and has a requirement for computation power

2. **CuClient**: A Client side software encompassing plexus to enable customers interact and integrate with CuTopia to buy computing resource.

3. **Plexus**: CuTopia Technology stack defining and implementing APIs for communication, data exchange, transaction between different components.

4. **CuMiner**: Node running hardware to offer computation power by accepting and executing Computation Indenture.

5. **CuExchange**: Decentralized node running exchange and other related infrastructure

6. **CuToken:** Usage token to be used on CuTopia eco-system from end to end.

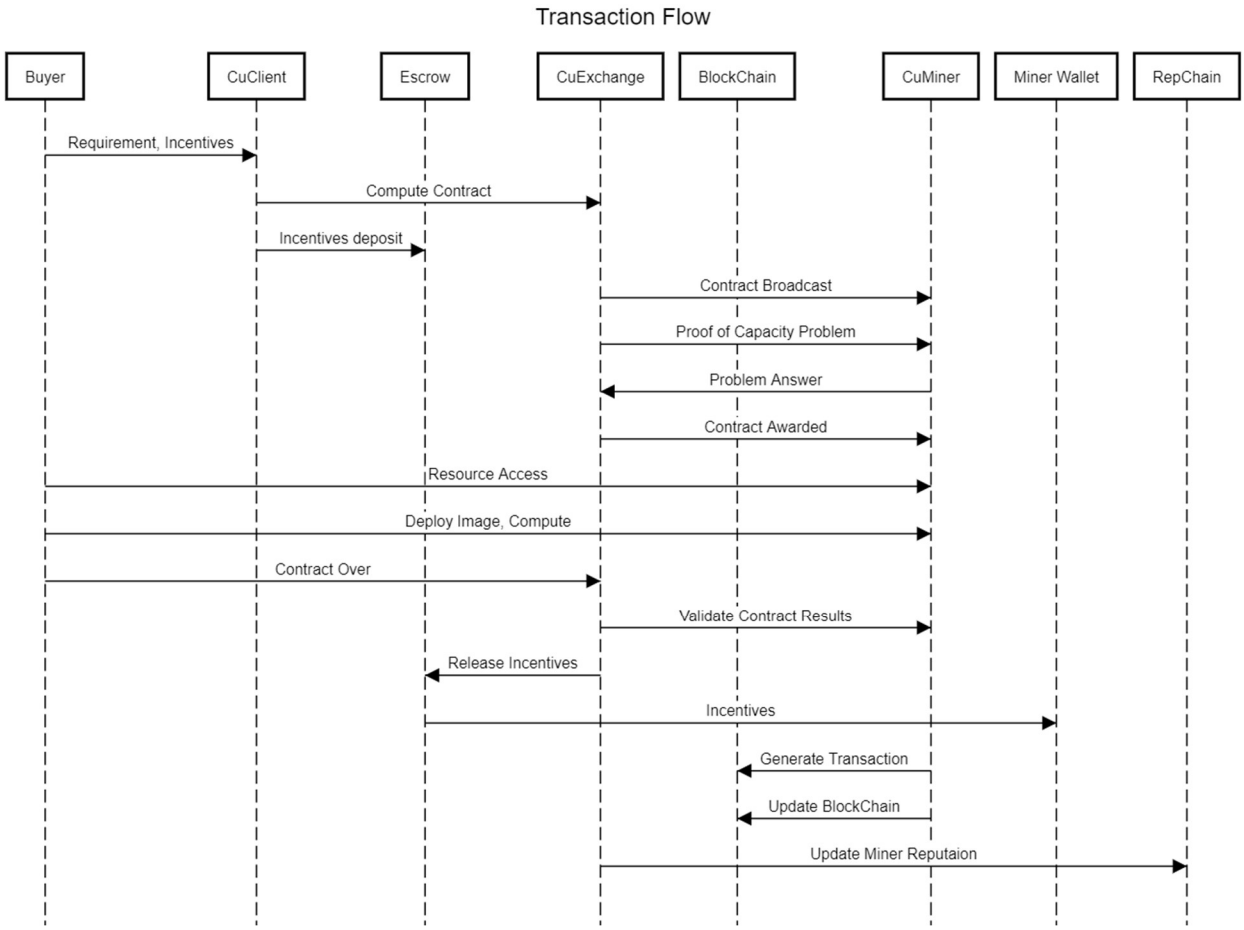
7. **CuWallet**: An ERC20 compatible Crypto Currency wallet for sending and receiving CuToken crypto Currency.

8. **IndentureQueue**: A work queue on CuExchange containing all incoming, pending and in-progress computation indentures from consumers.

9. **RepChain**: Public Blockchain consisting miner reputation rating records based on historical participation and execution of past contracts.

10. **Escrow**: One of the Node types responsible for execution verification and incentive distribution. Multiple escrows can compete in the eco-system based on their reputation and fee.

Figure: Component Interaction sequence in a transaction



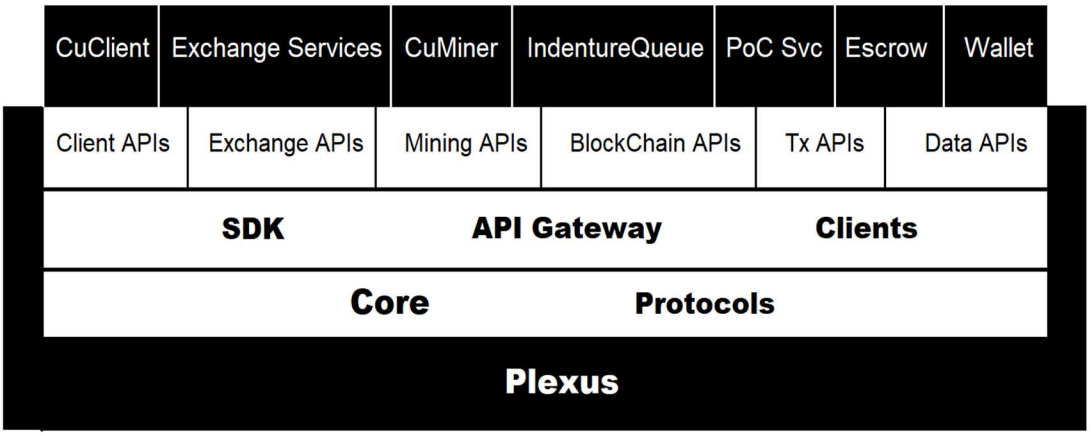
6. System Details and Architecture:

6.1. Plexus:

Plexus is an SDK providing easy access to CuToken ecosystem also known as CuTopia . Plexus also defines standards on how a computation task can be converted to an Indenture which is self-executable both in terms of compute task and incentive payments. Plexus is the well-defined protocol glue which binds all different components of CuTopia and ensure all components communicate and interact in a way expected by the system design.

Parts of plexus are built and packaged into applications depending upon what function the application is supposed to perform.
Main responsibilities and functions provided by Plexus are:

- Convert a computation task to Computation Indenture (CI)
- Sending Computation Indenture to CuExchange (CuEx)
- Exposing APIs on CuExchange for miner where they can fetch list pending CI
- Implementing and exposing APIs to validate proof of work done by miners
- Communicating with Escrow to hold, release and reverse incentives based on CI request and proof of work validation
- Getting incentives released from escrow.
- Exposing Currency transaction connection points to Wallet and transaction APIs



CuTopia : TechStack Overview

6.2. CuMiner:

CuMiner is a miner client which need to run on mining nodes which are ready to offer computation power by accepting, executing and validating Computation Indentures (CIs). This is one of the most important component of the ecosystem as CuMiner is the one which abstracts the mining power to execute the contract. CI can contains different types of

computation task and CuMiner has to understand them, create necessary infrastructure to get them executed by harvesting available miner power in most efficient way.
CuMiner client provides APIs to:

- Download incoming CIs from CuExchange
- Capabilities to define miner criteria to accept and execute CIs
- Infrastructure

6.3. CuClient:

CuClient is a customer facing interface to interact with CuTopia platform. It exposes its capabilities as REST APIs (Plexus) which can be used by anyone to make business facing websites that lets compute capacity to be sold. Customers can also directly use these APIs in their build and testing environments to fetch compute capacity on demand. Customers define the computation capacity requirement, incentives and computation task type. CuClient convert these human inputs to a smart contract and send them to CuExchange for further processing.

As soon as CuExchange award the contract to miner, CuClient makes the access console available to buyer to access and use computational resources, configure environment, deploy computation images from a vast catalog.

CuClient provides easy and convenient interfacing with CuWallet for seamless transfer of funds. CuClient interact with both CuExchange and CuWallet using Plexus APIs which are public and secure. CuClient also exposes its functionality through command-line interface (CLI) so it can be invoked through scripts or bots for easy automation and better integration with other systems.

6.4. CuExchange:

CuExchange is a specialized node of the CuTopia ecosystem. CuTopia can have multiple independent CuExchange instances running independently making it robust and decentralized. Each exchange is expected to thrive independently and specialize based on their customers. CuExchange serves following use-cases in the ecosystem.

- CuExchange encompasses plexus framework in a user-friendly and easily deployable package.
- All Clients and miners talk to each other to buy and sell computation resources through CuExchange APIs.
- Collaborates with escrow to transfer funds from buyer to seller in a successful scenario.
- Accepts incoming requests from clients and broadcast them to miners
- Validate Contract results for a miner to evaluate contract completion outcome..

6.5. IndentureQueue

Indenture Queue is the central computation task queue originated, updated and maintained by CuExchange.

Plexus framework APIs listens to all the incoming Computation Indentures sent to CuExchange by Plexus Clients and appends them in IndentureQueue.
IndentureQueue can be accessed and differentially updated by CuMiner using Plexus APIs.
This enables every Miner to see exactly same state of IndentureQueue as CuExchange.
Any miner can listen for changes in IndentureQueue and can initiate participation request as soon as a new Indenture is added to the queue. Mining nodes are also expected to propagate any indenture contracts to other nodes on best effort basis.

6.6. Main BlockChain:

CuTopia uses two separate blockchains for two different purpose. CuToken, which is the crypto currency used by CuTopia platform is an ERC20 token, hence all currency transactions are updated on ethereum blockchain.
All successfully executed Computation Indentures (CI) are added to a separate main block chain which is publicly accessible.
A typical CI transaction record can contain:

```
CIRecord {
        cid,
        time,
        clientId,
        sellerId,
        taskId,
        txNumber,
        incentives,
        cutokenTxId,
        status,
        duration,
        taskTypeId,
}
```

These transaction records are then appended to the new block and once the block has sufficient transactions in it, the block is mined by a miner and appended to the blockchain. Miner who verifies the block is provided an incentive as per the prevalent difficulty mining reward rate.

Miners have to use Proof of Work (POW) algorithm to mine any newly generated block.

6.7. RepChain (Reputation Blockchain):

CuTopia is designed to maintain quality and reliability. For this purpose, CuTopia maintains a separate blockchain for sellers reputation (RepChain in short) based on the historical data of every seller about how many contract each one have them have successfully executed, their uptime, their incentive range and compute requirement. For every computation contract a reputation record is generated capturing all these details and is added to the RepChain. The aggregated reputation of each seller is calculated by consolidating all historical reputation data about that seller.

For every incoming computation task (Indenture), based on buyer preferences, CuTopia allows only sellers/miners above a certain reputation threshold to participate in the process. This ensures that buyer will get access to the resources from a reputed seller ensuring quality and reliability of service to buyer and providing more visibility and opportunity to seller for future contracts. Sellers with higher reputation can also command higher incentive for the same job. Users get reliability in return which lets them run things like load balancers that require maximum up-time.

6.8. Proof of Capability Algorithm:

Nodes in cuTopia eco system compete for reserving compute work. A compute job posted on the job chain will always have a minimum compute and other resource set. Based on this, computational challenges would be presented to the competing nodes. The first node to present a viable solution gets to reserve the job. There is no restriction of higher compute capacity jobs from out competing a lower compute node for a requirement matching lower compute node.
For example:
Let us assume a job *J* with requirement *R* be posted on the job chain. Let us assume Nodes N_1 *to* N_x compete for job *J*. Assume compute capacity of nodes be ordered in increasing order from N_1 to N_x. Based on minimum requirement *R*, challenge *C* will be generated by the exchange and broadcasted to all the nodes along with *J*. Based on the incentive provided, all nodes compete to solve *C*. However, due to the high computational capacity of N_x, it will out compete its peers and reserve *J*. This ensures that during peak load when the incentives become higher, bigger nodes can jump in to relieve the demand for a particular requirement *R*.

Implementation details:
We expect many types of proof of capability algorithms to evolve in cuTopia eco system catering to various types of computing resources. Current compute capability algorithm defaults to prime factorization. Challenge consists of a large prime number of given bits *b* which will vary based on the compute requirements. For smaller compute requirements, this is set to low while for larger compute requirements this is set to high.

$C = p*q$ ($p \in \mathbb{P}$, $q \in \mathbb{P}$ where $\mathbb{P}$ represents all prime numbers)

The node that returns p and q wins the right to provide its computational resources.

There are equivalent algorithms under development to test the memory, network, GPU capabilities of nodes.

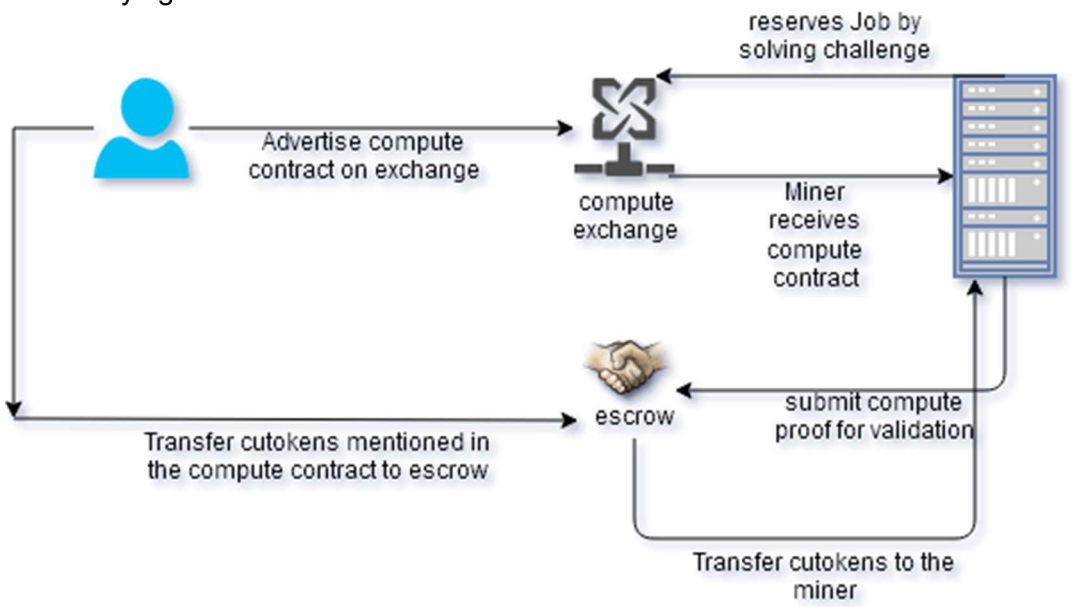
6.9. Access Heartbeat challenges:

In addition to the initial challenge that the nodes solve to reserve a challenge, the winning node will also have to solve periodic challenges broadcasted by the validator nodes (escrows) to be able to finally claim the incentive. These challenges will be directly solved within the container being run and a compute graph will be generated. At the end this compute graph will be submitted to the validating node(s) for payment.

The purpose of these heartbeat challenges is to keep the winning nodes honest by maintaining the quality of compute as promised. The challenges are reduced level in complexity (which still varies based on job requirement).

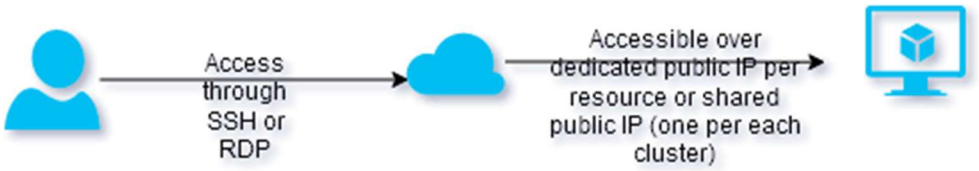
7. Cloud Resource Access and Usage:

CuClient provides access to vast array of compute resources for customers and lets them convert their requirement into a fine grained compute contract which is then advertised across the exchanges participating in cuTopia eco system. Customers can also choose how reliable they want the compute nodes to be. cuClient will then match the nodes with a given past reputation taken from repChain. Before advertising the compute contract on the exchange, cuClient also transfers the required amount of cutokens to the escrow which signs the compute contract after verifying the transfer.



Once the cluster advertisement goes to the exchange, miners match the advertisement with their own machine capabilities before trying to reserve these jobs. Each job includes a challenge that captures these capabilities. Every miner tries to solve these challenges and

submit to the exchange to reserve the job. Once a job is reserved, miner is constantly given smaller challenges to solve to prove that computation is indeed in progress.
Resource access:
Clusters once created can have either a dedicated public IP per each node in the cluster (which could depending on market dynamics could cost more) or one dedicated public IP per entire cluster (which could be cheaper).



Compute customers can access resources provided by these clusters through any of the pre-defined means they already included in their container images before hand. For example, they can set their container to run openssh server and add their public key to the list of allowed hosts. Containers can also run VNC/RDP and access them over internet.
At the end of estimated time mentioned in the compute contract, miner submits their entire compute graph to escrow for validation. Once the validation is complete, escrow transfers cutokens it is holding for this Job to the miner who submitted the proof.

8. CuToken: Crypto Currency Details

1.1. **Introduction**:
CuTopia platform uses a specialized crypto currency “CuToken” for all transactions. CuToken is a standard Ethereum based ERC20 crypto token. All CuToken transactions are performed on Ethereum blockchain main network and can be accessed and verified using any standard Ethereum blockchain tool or explorer.

1.2. **Storage:**
CuToken can be stored, accessed or transacted using any Ethereum wallet which supports ERC20 tokens such as MyEtherWallet, MetaMask etc.
CuToken also provides its own wallet “CuWallet” based on ERC20 standards and is better integrated with other system components for seamless usability experience.

1.3. **Transaction:**
Whenever a buyer wants to purchase computing resources, pledged CuTokens are transferred from his wallet to an escrow account. Upon successful execution of contract and verification of results, the amount is deposited to miner’s wallet from the escrow account after deducting a small exchange and escrow fee. In case a contract does not get executed or prematurely gets terminated, the CuTokens are refunded back to buyer’s wallet.
All these transactions happen through Ethereum blockchain and are publicly available for tracking and verification.

1.4. **Mining:**
CuToken can be obtained from participating in ICO or through any supported crypto exchanges. Miners can also earn CuToken when they provide their computational resources to other participants in CuTopia eco-system. Both escrow and exchange charge a small percentage of the mining fee to cover their running expenses.

9. Product and technology roadmap

1. *Q4/2017: Concept and Whitepaper*
2. *Q4/2017: Proof of concept*
3. *Q1/2018: Alpha: Client, Miner, Exchange Node, Console and Wallet*
4. Q2/2018: ICO and Crowdfunding
5. Q3/2018: Live and Operational with Alpha version on Testnet
6. Q4/2018: Test Platform Launch
7. Q1/2019: Beta: Client, Miner and Exchange Node, Console and Wallet
8. Q2/2019: Main Blockchain (RepChain) Launch
9. Q3/2019: Main Platform Launch
10. Q4/2019: Production: Client, Miner, Exchange Node, Console and Wallet
11. Q4/2019: Live and Operational on Mainnet

10. Revenue Model

- Participants in CuTopia ecosystem use CuToken exclusively from end to end. A customer needing compute power need to purchase CuTokens from open market and use the tokens in the eco-system.
- Exchange nodes and escrow nodes charge a percentage of CuTokens as fee for providing the services.
- Majority of fee will go to miners for providing the compute resources.

11. ICO Process

CuTopia plans to sell its usage tokens (CuTokens) primarily through an Initial Coin Offering (ICO) of “CuToken”.

For details about ICO, Pricing, Sales slabs, timelines, progress and other details visit our website at www.cutoken.io

12. References

www.cutopia.network
www.cutoken.io