Crypto.com Chain: The next generation decentralized mobile payment protocol

{chain,contribute}@crypto.com

December 5, 2018
v0.2.6

Abstract

Blockchain technology and cryptocurrencies are a cryptography and security breakthrough as significant as the internet was in 1990s. The technology is however still at a very nascent stage. To generate mass adoption, it will need to find compelling real-life use cases which can appeal to a larger audience than industry professionals and experts. We believe enabling cryptocurrency spending in the real world will be an adoption catalyst. Current traditional payment institutions and existing blockchains have not been able to provide a secure, scalable and decentralized solution to support cryptocurrency payment.

We propose Crypto.com Chain, the next generation decentralized mobile payment protocol, the most efficient and secure way to pay and be paid in crypto, anywhere, any crypto without fees. Crypto.com Chain will deliver on its vision by developing innovative technology components and processes (inc. scalable encryption algorithm to protect users' privacy, utilizing trusted execution environments, sustainable price stability mechanisms, user protection via PoGSD) catered specifically to cryptocurrency payment, while leveraging proven blockchain technology structural design elements.

Table of Contents

1. Introduction to Crypto.com Chain

Current traditional payment infrastructure and existing blockchain powered payment network do not provide a wide-spread, easy to integrate and fast settlement of cryptocurrency in the real world.

Current payment network infrastructures key limitations:

1. Do not integrate with cryptocurrencies systematically;
2. Do not give access to customers nor merchants to reconcile the numbers in a trustless way;
3. Are vulnerable as being the central point of failure;
4. Are expensive to operate;
5. Give low limits on cryptocurrency spending by default;

Existing blockchain-powered payment networks key limitations:

1. Too complex to setup and use;
2. Not friendly to crypto first timers;
3. Rarely supported beyond their own blockchain;

Our vision is to accelerate the world's development, adoption and transition to cryptocurrency. Crypto.com Chain is the best way to pay and be paid in crypto, anywhere, any crypto for free.

2. Design Axioms

Crypto.com Chain, the next generation decentralized mobile payment protocol, will be designed based on the following foundational Design Axioms (DA_n), listed by order of priority ($DA_i > DA_{i+1}$):

DA_1: Secure

- protect from fraud;
- highly compliant.

DA_2: Highly Scalable & Fast

- peak performance on par with centralized payment providers;
- high transactions per second (TPS), targeting 50,000 TPS;
- fast confirmation, targeting $<$ 1 second.

DA_3: Augmented Decentralization
- self-managed settlement;
- phased validator node set evolution;
- automated treasury rewards and sequencing.

DA_4: Upgradable and Fast In Innovation
- flexible process for chain upgrades;
- low dependency on other networks.

DA_5: Data Privacy Protection
- strongly encrypted on-chain transactions, only relevant parties involved in each transaction can decrypt it;
- efficient transaction validation.

DA_6: Inclusive
- integration of new acquirers or customer/ merchant seamlessly with low technical barriers, right incentives and strict penalties.

Decentralized ledger technology, such as blockchain, provides key built-in benefits aligned with Crypto.com Chain Design Axioms:

- it handles double spend naturally,
- it is easier for reconciliation (it even 'removes' the need for reconciliation as long as the blockchain is properly structured),
- it facilitates trustless collaboration,
- it is more inclusive, anyone can join the network,
- it lowers the likelihood of central point of failure.

3. Architecture

Overview

Building a blockchain is not just about software/hardware development. It is the combination of technological design, incentive mechanism, game theory and governance which together nourish a robust system that also allows continuous innovation. Our initially proposed architecture, hence, may undergo future revisions in response to changes in incentives, governance or any external requirements.

As Crypto.com Chain is intended for mobile payments, our proposed architecture needs to reflect the inherently federated nature. The network consists of nodes in different layers where each node layer is designed to serve different needs of different users. This architecture is proposed in line with our Design Axioms where DA_1 and DA_2 are of the highest priority.

We summarize different node types, their permissions and responsibilities in the table below:

Node type	Who can run it?	Rights and obligations	Requirements
Council Nodes	Initially, Crypto.com Chain servers. Will split and extend this to 3rd party entities as the network scales, based on minimum staking requirements and tier-based randomised selection	Council Nodes have the below rights and obligations: • Execute settlement • Maintain a whitelist log of Council Node identities; • Maintain a whitelist log of Acquirer Node identities; • Order transactions and reward CRO in a limited supply; • Provide an escrow ("Proof of Goods & Services Delivered") service; • Verify all transactions; • Send/receive transactions; • Read data.	• Post CRO collateral; • Dedicated IP; • Meet infrastructure requirements; • Comply to privacy policy, *a minimum number of Council Nodes will be deployed across the globe.
Acquirer Nodes	Customer acquirers, Merchant acquirers.	Acquirer Nodes have the below rights and obligations: • Settle on behalf of others; • Send/receive transactions; • Verify related transactions; • Read data,	• Post CRO collateral; • Dedicated IP, *Each acquirer is advised to run multiple nodes to achieve business continuity.
Settlement Agent Nodes	Anyone who has the capability to settle between CRO and currencies deemed stable	Settlement Agent Nodes have the below rights and obligations: • Sell CRO for other currencies deemed stable; • Settle for oneself; • Send/receive transactions; • Verify related transactions;	• Post CRO collateral.

		• Read data.	
Community Nodes	Anyone.	Community Nodes have the below rights and obligations: • Settle for oneself under certain conditions; • Send/receive transactions; • Verify related transactions; • Read data.	• Optionally post CRO collateral.

Crypto.com Chain is open to the public to join, participate and scrutinise related transactions. We do not expect that, for example, mobile clients can do heavy-lifting tasks and have a reliable always-online network connection. For that reason and DA_2, capabilities of Community Nodes are different from other node types.

Trusted Execution Environments

In order to address DA_1, DA_2, DA_3, and DA_5, core functionality of Crypto.com Chain Nodes is designed to run in secure enclaves of Trusted Execution Environments (TEEs). TEEs, such as Intel SGX[1], Arm TrustZone[2], or Keystone[3], are extended CPU instruction sets that isolate code executed in an enclave from the host operating system in hardware-encrypted RAM. TEEs ensure that even the node administrator cannot see private data that enclave code works with. Note that enclave code still needs to follow secure coding practices in order to avoid leaks through memory access patterns etc.

An important feature of TEEs is local and remote attestation. This feature enables nodes or external parties to verify that the code they plan to interact with is indeed the certified Crypto.com Chain code. In case of remote attestation, each node does this step before establishing secure communication channels with other nodes.

In Crypto.com Chain design, TEEs can find several compelling use cases:

[1] https://software.intel.com/en-us/sgx

[2] https://developer.arm.com/technologies/trustzone

[3] An ongoing open-source project for RISC-V: https://keystone-enclave.org

1. **Sealing ledger data**: while all transaction data can be distributed to any node for processing, humans (even node administrators) cannot view these data in their raw form.
2. **"Virtual" hardware wallets**: community nodes can utilize Ledger Trustlet[4]-like software for protecting their private keys.
3. **Payment protocol enhancements**: TEEs have gained popularity in blockchain systems research, as they can offer high transaction throughputs with low latencies (e.g. TeeChain[5] scales Bitcoin payments to tens of thousands TPS with sub-second latencies).
4. **Witnessing external data**: for data from oracles or other blockchain networks, TEEs can be used for attesting data authenticity.

In the light of Foreshadow[6] attack, Crypto.com Chain will not solely rely on TEEs for achieving DA_1 and DA_5:

- Double attestation scheme: as employed by Tesseract[7] decentralized exchange, this scheme protects against potential weaknesses in TEE remote attestation.
- CRO collaterals.
- Additional cryptographic measures for maintaining privacy.
- Writing core parts in Rust[8], a programming language that ensures memory safety and freedom of data races.

Consensus

Council Nodes run a BFT consensus protocol among themselves which resolves the final order of transaction sequences. A transaction is only relayed after both Customer Acquirer and Merchant Acquirer nodes confirm with a Council Node. Multi-signature scheme is used for facilitating such interactions where a signature is collected from both parties and at least 67% of Council Nodes before it is deemed final.

---

4 https://play.google.com/store/apps/details?id=com.ledger.wallet.bootstrap&hl=en_US

5 https://arxiv.org/pdf/1707.05454.pdf

6 https://foreshadowattack.eu

7 https://eprint.iacr.org/2017/1153.pdf

8 https://github.com/baidu/rust-sgx-sdk#rust-sgx-sdk

In addition to transaction ordering, Council Nodes maintain a transparent audit log of Merchant Acquirer, Customer Acquirer, and Council Node identity changes (external gateway IPs, public key certificates etc.). Whenever a Node identity is added, updated or revoked according to a specified policy, at least 67% of Council Nodes need to approve this change.

For a decentralized and robust audit log, we will explore using a skipchain, a shared authenticated data structure proposed in Chainiac[9]. To ensure high availability, the total number of Council Nodes in different locations will have to be greater than a minimum set based on real performance tests.

Governance

Council Nodes are responsible for the governance of the network. The Crypto.com Chain Entity will propose software upgrades for approval by Council Nodes. Following a software upgrade approval and release, any nodes on the network that fail to upgrade after a given grace period will be considered dropping out of the network voluntarily.

Security

Being a public network, security (DA_1) and robustness are critical requirements. Future revisions of Crypto.com Chain design will incorporate a detailed threat model. The main challenges and threats are the following:

DDoS attack

Any write transaction that happens on the network requires a fee payment (by Acquirer Nodes). DDoS attacks will require fee payment as well. By making DDoS costly, rational hackers should be less incentivised to perform such attacks.

Furthermore, DDoS attacks will be further prevented by the Crypto.com Chain staking requirement. Only nodes who stake certain amounts of CRO can conduct write transactions.

[9] https://eprint.iacr.org/2017/648.pdf

Council Nodes and Acquirer Nodes will not be directly exposed to the public internet, but will be accessed through a DMZ-style gateway. DDoS attacks using read operations will be prevented by standard practices, such as rate limiting on the gateway.

Unauthorized access to Acquirer Nodes

Once an attacker has gained access to an Acquirer Node, s/he can only block node's external communication or use its interfaces that interact with its core secure enclave code. An Acquirer Node's private data is sealed in an encrypted enclave.

Supplying fake data or forging transactions would require bypassing remote attestation procedures and stealing private keys of all involved parties which are not stored on that node.

For example, a transaction to withdraw funds would require a collective signature of that node's administrators which could be stored externally in HSMs (plus a signature of at least 67% of the Council Nodes).

Blocking a node's external communication is likely to be detected in the affected node's monitoring systems and result in appropriate actions.

Unauthorized access to Council Nodes

Once an attacker has gained access to a Council Node, besides similar implications as in the case of Acquirer Nodes being compromised, s/he can also try to revoke all honest Council/Acquirer Node identities and add his/her own nodes as Council/Acquirer Nodes.

To prevent this from happening, we designed the Council Nodes to be a multi-signature system: when an Council/Acquirer Node is added/updated/revoked, at least 67% of the Council Nodes have to approve this change. When approved, each change is persisted in a distributed immutable audit log, so that all nodes can verify each change and possibly take an appropriate action (e.g. contacting the affected node's administrators to double check if that change was legitimate).

Supplying fake data of external sources

Apart from CRO data, attacks can be launched using other currencies through the secondary markets. To resolve the potential broadcast of fake blocks by attackers, block messages have to include a multi-signature by at least 67% of all relevant witness nodes (a combination of Council, Acquirer, and Settlement Agent Nodes).

One other possibility are Eclipse Attacks[10] where all witness nodes connect to malicious peers of an external network. Using previously checkpointed blocks with multiple signatures, known counter-measures, such as randomized peer selection and eviction or detection of network anomalies (and extending confirmation times accordingly), need to be implemented to render such attacks infeasible.

Authentic nodes start to behave badly

In the case authentic (non-hacked) nodes start to behave badly, for example, trying to fake transactions to steal funds, they incur the risk of having all (or part of) their staked CRO tokens be forfeited to compensate any impacted counterparty. This should discourage authentic nodes from becoming bad actors.

Authentic nodes exit the network

Nodes should be free to enter or exit the network without impacting the rest of the network.
Historical transactions of such exited nodes are a part of the blockchain history and have already been safely settled.

If any node exits in between a settlement period, the equivalent amount of CRO tokens (with buffer) for unsettled trades will be deducted from their staked CRO.

Collateral/settlement account attack by shift of funds

Collateral accounts where the staked CRO of each node is posted are high risk honey pots.
Council Nodes with multi-signatures could move the funds out of such collateral accounts when a node fails to settle or behave badly.
To make it more robust, these accounts are multi-signature accounts locked by at least 67% of Council Nodes.

Customer settlement accounts and reverse merchant settlement accounts (for refunds) where transient settlement funds sit until the next settlement is done are low risk honey pots.
A multi-signature implementation locked by at least 67% of Council Nodes will be implemented for any cryptocurrency that supports multi-signature. An

[10] https://eprint.iacr.org/2015/263.pdf

attacker has to hack 67% of the Council Nodes to be able to shift the funds out.

Front running and other market manipulation attacks

Since communication among nodes is encrypted and data inside nodes are not accessible (as it is sealed in a secure enclave), an attacker cannot exploit much information for executing trades.

One can possible hijack a node, use its CRO collateral and do transactions against non-CRO currencies that can be easily manipulated on secondary markets for a time sufficient for cashing out in products and services of merchants. To alleviate such issues:

1. A transaction time-limit in units of CRO may be imposed on wallet addresses; and
2. A rigorous KYC process and onboarding process is required for all nodes with writing capabilities on the network.

Privacy

As TEEs are used, data inside secure enclaves is protected: even the node administrators cannot directly view raw transaction data on their nodes.

To further enhance privacy capabilities (addressing DA_1 and DA_5), Crypto.com Chain will include other software-based measures in case of secure enclave breaches. We will explore employing additively homomorphic commitments (as used, for example, in Confidential Transactions[11]), such that data remains private even in case of secure enclave breaches and its processed parts can be securely and verifiably exposed for third-party auditing.

Compliance

Onboarding of Customer and Merchant Acquirers

Customer Acquirers and Merchant Acquirers are onboarded only if they are able to pass CRYPTO.com KYC check[12] and comply with KYC standards when they onboard downstream customers and/or merchants.

As mentioned in the Consensus section, CRO may utilize a Chainiac[13]-style skipchain for robust and decentralized audit logging. Acquirer Nodes

[11] https://people.xiph.org/~greg/confidential_values.txt

[12] Or in future, pass KYC check of any entity that runs other services.

KYC check metadata, identities and policies for updating associated keys will be stored in an entry on the skipchain.

Consumers and merchants (through Community nodes) will also be able to have an entry attesting their identity on the skipchain after passing KYC (performed by Acquirer or Crypto.com Chain Entities). The associated keys could be stored in the user's mobile phone or other devices that interact with the CRO network.

The associated private keys can be securely stored in TEE of the mobile device and interacted with via the CRO Mobile Wallet App. In this way, private keys of consumers and merchants cannot be directly read and can only be used in a restricted way via mobile app interactions with the "virtual" hardware wallet.

Certain transaction types may require the wallet address to be associated with a valid entry in the skipchain. In the scenario where a mobile device is lost, the corresponding Acquirer or Crypto.com Chain Entity would be able to update the skipchain entry according to the set policy. The consumer or merchant will either restore the corresponding wallet on a new device or request an identity update with a new associated key pair.

Crypto.com Chain Entity and Acquirer nodes will be responsible for updating or revoking corresponding identities on the skipchain.

4. Settlement & Price Stability

Routed & Direct Settlement

Routed Settlement

For transactions happening through Acquirer Nodes, the acquirers will be responsible for settling the funds downstream with customers (debit) and merchants (credit).

Direct Settlement

Customers and merchants who establish their own Community Nodes, with enough CRO staked and registered Settlement Accounts will be able to settle directly through the Crypto.com Chain, with the same float account requirements and rules as Acquirers Nodes.

---

[13] https://eprint.iacr.org/2017/648.pdf

This settlement option provides several benefits:

1. Faster downstream settlement: the moment the counterparty settles, the customers and merchants with Community Nodes will settle automatically.
2. Inclusive network: enabling anyone to leverage the power of the Crypto.com Chain network.
3. Transparency: even for Community Nodes that do not meet the settlement requirements but with declared linkage to one of the Acquirer Nodes, they would be able to witness all (encrypted) transactions going through the Crypto.com Chain Network and decrypt those that concerns them. This way, customers and merchants do not have to rely on acquirers' report to check whether a transaction has been processed.

The escrow service, "Proof of Goods & Services Delivered" (PoGSD), will rely on multi-signature wallets and collaterals in the CRO Protocol. If a customer decides to pay a merchant without a collateral or who is not on the CRO network, the CRO Mobile Wallet App will display a warning that PoGSD is not available before that transaction.

Settlement Currencies

All transactions on the Crypto.com Chain are performed using the native blockchain token CRO. As a customer, you will be able to pay using any cryptocurrency paired with CRO. Post transaction authorization, the customer acquirer will deduct the equivalent CRO amount in your selected cryptocurrency wallet for future settlement with the merchant.

As a merchant, you will be paid by default in CRO tokens, but you will have the ability to convert on the spot to currencies deemed stable (inc. stable coins, fiat currencies). Settlement Agents (detailed below) will perform the conversion for merchants and hedge their risk. Settlement time is expected to be around T for crypto conversion, T+2 for fiat conversion.

Settlement Process

Each Customer-Acquirer, Community[14] or Settlement Agent Node[15] is able to compute its own amount of cryptocurrency based on the "last settled block"

[14] For direct settlements

field in the latest block's header and any relevant details (by decrypting its own transaction).

Each of those nodes will be debited of its owed amount in its corresponding accounts such as:

- Customer Acquirer Settlement Accounts, or
- Customer Settlement Accounts, or
- Settlement Agent Settlement Accounts.

Each Council Node will be able to calculate every node's owed amount of cryptocurrency. When the next settlement is due, a Council Node will move the net amount of cryptocurrency:

1. Without any Settlement Agent:
   The amount the customer is paying (the bid amount)
   from:
   Customer Acquirer Settlement Accounts/Customer Settlement Accounts
   to:
   Merchant Acquirer Settlement Accounts/Merchant Settlement Accounts;
2. With a Settlement Agent:
   The amount the customer is paying (the bid amount)
   from:
   Customer Acquirer Settlement Accounts/Customer Settlement Accounts
   to:
   Settlement Agent Settlement Accounts; and
   the offered (coin deemed stable) amount
   from:
   Settlement Agent Settlement Accounts
   to:
   Merchant Acquirer Settlement Accounts/Merchant Settlement Accounts.

Then the Council Node announces the settlement via a special settlement transaction message which consists of:

1. the identifier of the latest block it settles in this round;

[15] For with Settlement Agent trades

2. a signature of the block identifier by the Council Node's identity associated private keys.

To avoid contention where other Council Nodes try to settle the same bulk of block, the Council Node would first broadcast a settlement *attempt* message with

1. the block identifier of the latest block it settles in this round;
2. a signature of the block identifier by the Council Node's identity associated private keys.

Other Council Nodes will pick up this attempt message and append spending signatures to it (based on their own computed result, which should be the same as the one the in-charge Council Node computes). Then the in-charge Council Node with at least 67% of collected signatures will run the settlement job in the background.

The network's next block advancing Council Node picks up this special settlement transaction, validates the settlement[16] and includes it in next block and also updates the last settled block field in the block header.

Settlement Agents

Cryptocurrency asset class is nascent and volatile. Merchants are however looking for price stability to manage and forecast their PnL.

To increase cryptocurrency acceptance with merchants, it is key to be able to provide them with price stable conversion post-settlement options. Settlement Agents will perform this service via CRO currency conversion to currencies deemed stable (transaction details including rates will be recorded on-chain, settlement will happen off-chain).

To become eligible, Settlement Agents will need to:

1. guarantee at least better conversion rate than the Crypto.com Chain benchmark[17] for a defined period of time; and
2. stake CRO tokens.

[16] by tracking movement of funds

[17] Benchmark will be likely calculated using a verified external price source collected using an oracle.

Settlement Agents will receive CRO tokens in exchange for other currencies at settlement times, i.e. [s]% of the CRO token converted. Settlement Agents will be charged by the network a levy and a portion of this levy will be used to reward network participants and ensure long-term sustainability of the protocol.

5. Block Structure & Incentives

The details described in this section, as other technical aspects of the Crypto.com Chain, are subject to revision. The described data structures only highlight a subset of end-user metadata that will be exchanged in protocol messages among relevant nodes. Exact details, handling etc. depend on interactions with the underlying consensus layer, privacy and security mechanisms.

Data Structure

Transaction Data Structure

A committed transaction included in a block consists of at least 5 parts:

A. Encrypted raw transaction data
B. Hash of the raw transaction data
C. Signatures of the hash of the raw transactions by all related parties
D. An access policy of what can be exposed to whom under what circumstances from the raw transaction data (enforced by TEEs). This access policy will refer to one-time keys related to:
    a. the customer's wallet,
    b. the merchant's wallet,
    c. Council Nodes engaged in the escrow service (PoGSD),
    d. related Customer Acquirer Node,
    e. related Merchant Acquirer Node.
E. Protocol version information.

Part A) Raw transaction data will never be revealed directly, as discussed in Privacy. Depending on whether the UTXO or the account model is adopted, it will point to relevant balance-tracking data, e.g. transaction inputs and outputs. The following encrypted data may contain additional obfuscation to prevent data leaks in case of TEE access policy breaches:

1. Customer data
    1.1. Customer wallet address on the Crypto.com Chain
    1.2. Name of the cryptocurrency the customer is to pay
    1.3. Amount of the cryptocurrency the customer is to pay
2. Merchant data
    2.1. Merchant wallet address on the Crypto.com Chain
    2.2. Flexible metadata field for merchant to fill to specify service/product it's offering to the customer
3. Settlement Agent data (optional, only for merchants who confirm a Settlement Agent)
    3.1. Liquidity wallet address
    3.2. Offered currency: most likely a currency deemed stable
    3.3. Offered amount: in unit of offered currency
    3.4. Bid currency: the cryptocurrency the customer is paying
    3.5. Bid amount: in unit of bid currency, the amount the customer is paying
4. Linked Customer Acquirer Node identity (optional, no need if it's a direct trade, must be provided if a via acquirer trade)
5. Linked Merchant Acquirer Node identity (optional)
6. isReverse (a boolean flag, only true for refund cases where a reverse transaction needs to happen)

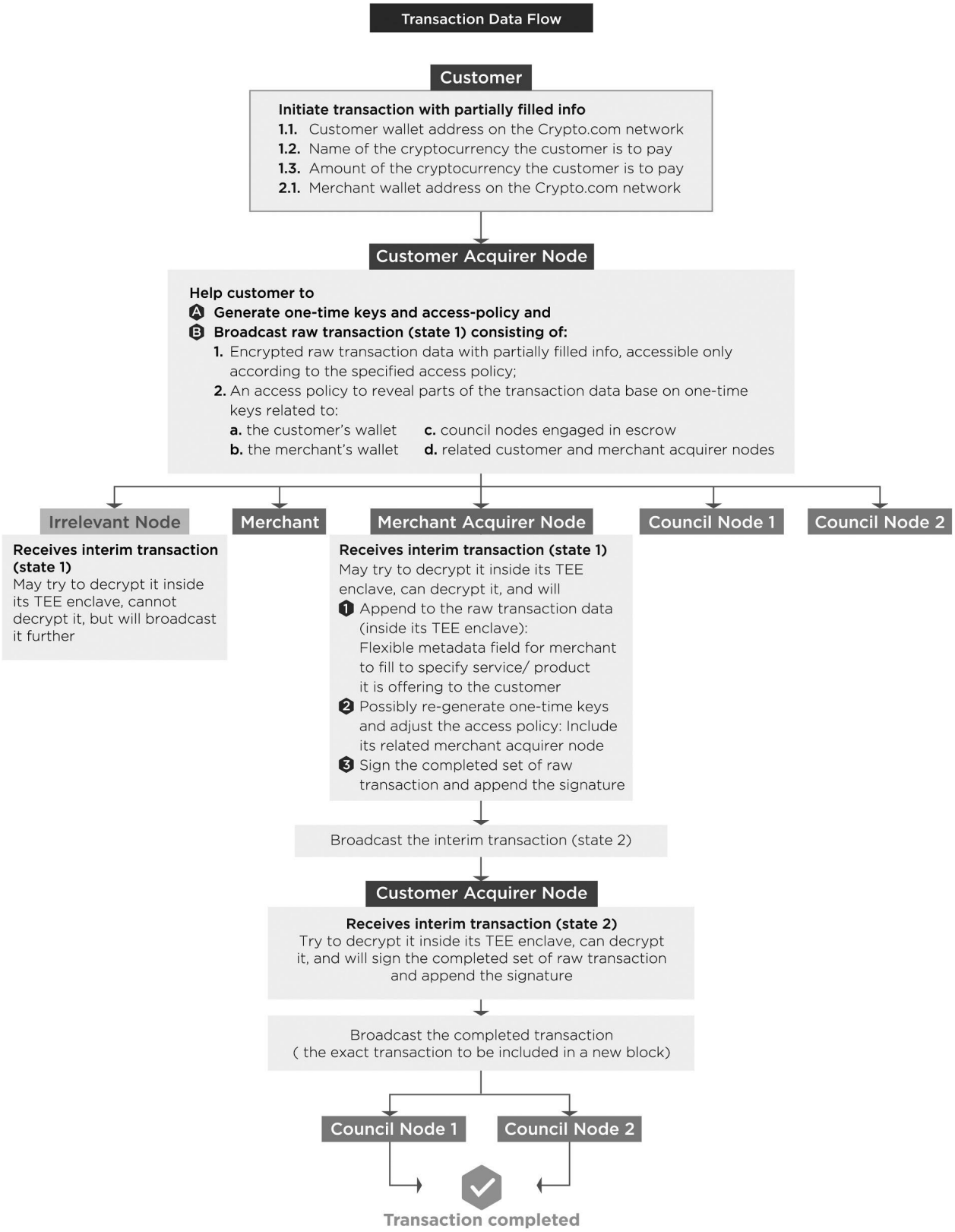
Part C) Signatures collectively contain at least:

7. Customer signature of the hash (a.k.a. Part B of the committed transaction) derived using his/her wallet private key
8. Merchant signature of the hash derived using its wallet private key
9. Customer Acquirer Node signature of the hash derived using the private key tied to its identity (optional, same condition as 3.)
10. Merchant acquirer node signature of the hash derived using the private key tied to its identity (optional)

Signatures of different transactions in the same block may additionally be in the form of one-time linkable ring signatures[18] in order to address DA_5. To communicate transaction data across the network to related parties, interim state transactions will contain some of the above mentioned data.

[18] As in CryptoNote: https://cryptonote.org

Transaction Data Flow Summary:



Block Data Structure

Blocks in the context of this document refer to metadata with groups of transactions that are committed in the same consensus procedure round. Each block consists of a block header and a block details section. The block details sections includes details of the transactions to be confirmed by this block. A part of each transaction's format is described in Transaction Data Structure. The block header will contain at least the following parts:

1. Block identifiers, e.g. the block height (number of blocks since the genesis block)
2. References to the included transactions, e.g. in the form of Merkle tree
3. A collective signature from Council Nodes on the block content (e.g. on the Merkle tree root)
4. A reference to the previous block (e.g. to its Merkle tree root)
5. Identity of the Council Node that produced the block
6. A reference to the last settled block. See Settlement Process for details.
7. Additional metadata, such as timestamps, software versioning or references to external settlement data.

Council Nodes collectively validate and take turns to produce blocks according to the consensus algorithm. A transaction is only added to a block if TEE enclaves of relevant Council Nodes can validate parts of transaction data, such as signatures can be verified and account balances before and after transaction match. The block producing Council Node broadcasts the block to the network.

Since every node has the list of Council Node identities, they can check if the block is really produced by a Council Node based on the collective signature (part 3 in the above block header description) and the identity specified (part 5 in the above block header description). Nodes will only further broadcast this block if the Council Node authenticity check is passed. And if the relaying node is also a Council Node, it will append its own signature to the collective signature part. A block is only deemed final if it includes a multi-signature by at least 67% of all the Council Nodes.

Transaction Fees

In both routed or direct settlement scenario, the merchant and customer can use the Crypto.com Chain for free.

The Crypto.com Chain distributes *[x]* fees to all actors providing services to ensure integrity and successful processing of the transaction.

[x] is calculated based on:

- CRO daily distribution supply, and,
- levy collected from Settlement Agents.

[x] is allocated to participants based on:

- transaction amount processed by Acquirers, and,
- number of transactions validated by Council Nodes

$$[x] = [c_{\%}] + [m_{\%}] + [p]$$

- $[c_{\%}]$ goes to customer acquirer for service rendered,
- $[m_{\%}]$ goes to the merchant acquirer for service rendered,
- $[p]$ goes to the Council Nodes for service rendered,

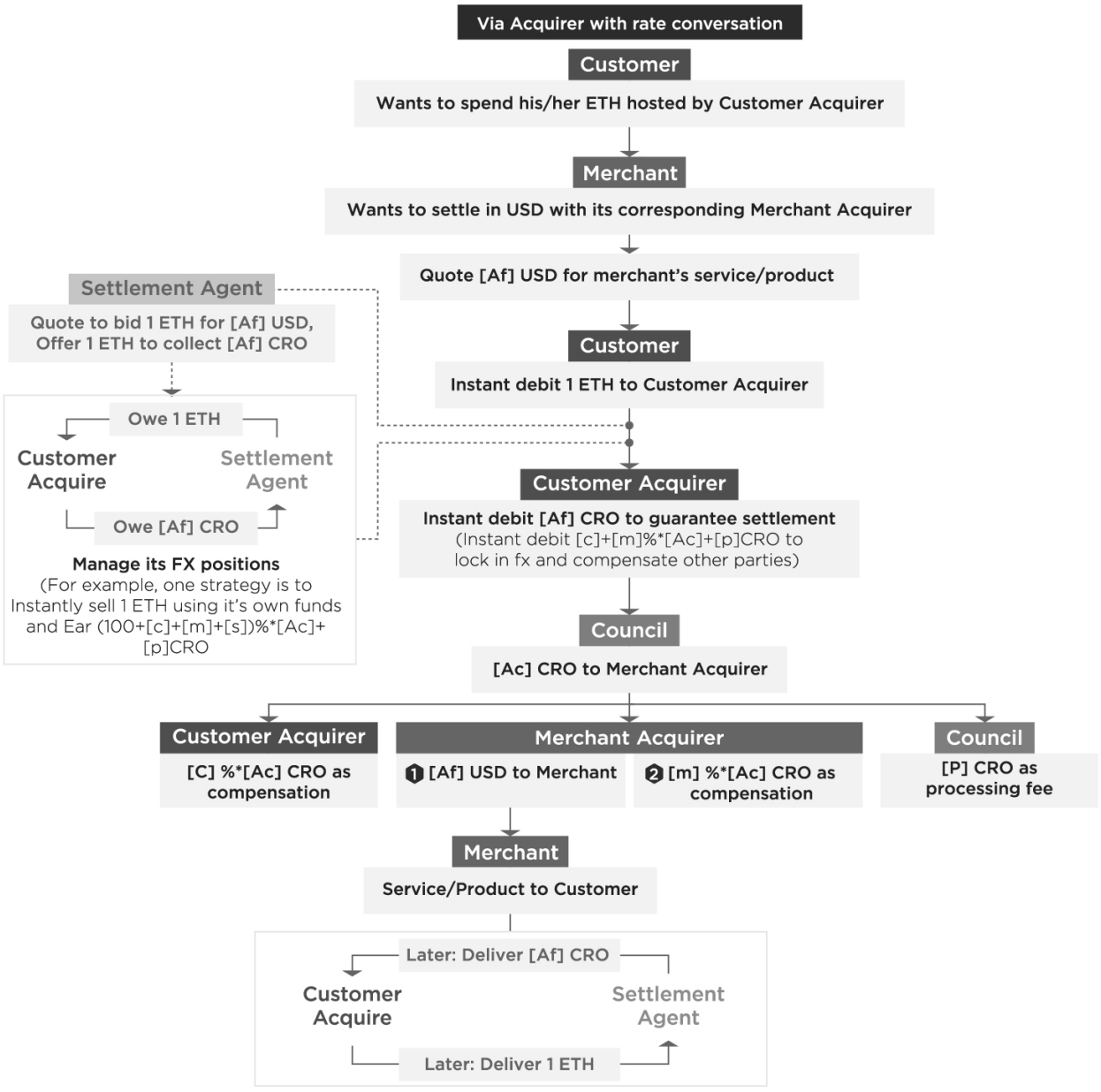
In a direct settlement scenario,

- $[c_{\%}] = 0$
- $[m_{\%}] = 0$

The Crypto.com Chain also requires a transaction fee *[y]* for any write transaction sent by network participants. This transaction fee is added to their stake immediately and given back to the participant at a later stage.

The Crypto.com Chain will extract fees from the Secondary Distribution & Launch Incentives Pool and subsequently the Network Long Term Incentive Pool.

Summary diagram:



Dispute Resolution

Refund

In case of dispute between customer and merchant, both parties will be able to leverage the Crypto.com Chain dispute resolution platform to agree on a win-win outcome (including refund). The dispute resolution handling is facilitated through using multi signature wallets and a built-in escrow service.

When the dispute is resolved, and if a transaction refund is agreed upon, it will be settled on-chain as a reverse transaction processed by Customer/Merchant Acquirer.

Double spending

The consensus algorithm and cryptographic measures are set up, such that double spends are prevented by the network protocol.

6. Resilience & Agility

Network Redundancies

To ensure robustness of the network, a minimum number of Council Nodes spread across the globe will need to be up and running. The minimum number is to be decided based on real performance test to balance 1. robustness against compromising a supermajority of Council Nodes; and 2. efficiency/high-performance.

Network Scalability & Performance

Crypto.com Chain targets to be a distributed network that is able to handle 50,000 transactions per second. Scalability and performance are hot research topics in the blockchain space. While adopting TEEs in the infrastructure may achieve a performant network, we will explore other advances in the field such as sharding, consensus protocol improvements, transport network enhancements etc.

For validating blocks, involved nodes will likely use a variant of the Schnorr signature scheme[19]. The Schnorr signature scheme has been recently proposed for the Bitcoin network[20]. One of its most compelling advantages is that it allows multiple signers to combine their signatures into a single signature.

In later phases, Crypto.com Chain may incorporate recent developments from the blockchain research space in order to meet its network scalability and performance demands.

One such development direction is in blockchain compression approaches. For instance, Coda[21] is a proposed cryptocurrency protocol which introduces a "succinct blockchain". Instead of storing the entire transaction history as in the current blockchain systems, it constructs a constant-sized cryptographic proof of the validity of blockchain state. It does so through

[19] C.P. Schnorr (1990), "Efficient identification and signatures for smart cards", in G. Brassard, ed. *Advances in Cryptology—Crypto '89*, 239-252, Springer-Verlag. Lecture Notes in Computer Science, nr 435

[20] https://lists.linuxfoundation.org/pipermail/lightning-dev/attachments/20180426/fe978423/attachment-0001.pdf

[21] https://codaprotocol.com/static/coda-whitepaper-05-10-2018-0.pdf

recursive composition of zk-SNARKs. Coda promises to reduce the enormous blockchain sizes from hundreds of GBs or TBs to a few KBs.

Some of these directions depend on what exact variant of the PBFT consensus Crypto.com Chain initially adopts. For example, Stellar Consensus Protocol[22] may possibly allow storing only latest account balances across nodes.

Crypto.com Chain will initially use the standard network protocol stack, such as TCP+TLS, for different node-to-node communications. Depending on the performance needs, the later Crypto.com Chain phases may explore other options. For example, QUIC[23] is a recent protocol standard proposed by Google on top of UDP that improves over TCP and TLS. QUIC can achieve better network latencies than TCP and TLS thanks to various features, such as faster connection opening and negotiation, out-of-order packet delivery or forward error correction.

Upgrading the Network

Software development is an iterative process. Until the Crypto.com Chain stabilizes, CRYPTO.com will be able to upgrade the network directly, taking into account community contributions by rigorously reviewing pull requests.

Every transaction and every request will include field related to software versioning.

When a non-backwards-compatible upgrade happens, each honest node would know the version number and the time the version upgrade must start and will drop any request or transaction that is broadcasted with an older version.

When two nodes connect, a handshake procedure must be established with remote attestation and some standard checks.
Connected nodes also periodically check the handshake information with each other; if a connected node is outdated for more than 7 days, it is then disconnected.

[22] https://www.stellar.org/papers/stellar-consensus-protocol.pdf
[23] https://datatracker.ietf.org/doc/draft-ietf-quic-transport/

Augmented Decentralization

In line with DA_3, the capabilities of Crypto.com Chain Council Nodes will be split and the entities operating them will be extended to third parties. Adding new Council Nodes (or removing them) requires an approval of at least 67% of all the Council Nodes.

As these proposals for Council Node set changes require an inspection and decision by Council Node administrators, each proposal will have a set deadline. If a Council Node does not signal a decision after the deadline, it will lose a part of its collateral stake.

This mechanism will enable phased decentralization where third parties can participate as Council Nodes and ensure that the CRO Network can continue to operate regardless of any unforeseen circumstances in the operation of Council Nodes. Regardless of Council Node-operating entities being removed or added, the transfer of value would still be functioning and customers and merchants could still use the network to spend and receive their cryptocurrencies.

As the large scale distributed consensus algorithms and incentive mechanisms mature, the validation capability may be extended to all nodes that posted CRO collaterals.

7. Contribution & Integration

Contribution

Our code will be open source and we will encourage research/peer reviews.
The community will also be able to suggest bug-fixes or additional features by submitting pull requests. The core development team will review and when appropriate merge these pull requests.

Integration - Off The Shelf SDKs

Ease of use and integration drive adoption, hence we will provide acquirers off-the-shelf SDKs and leverage container technologies during integration, paired with easy to comprehend documentation.

8. Conclusion

Crypto.com Chain is a privacy preserving payment network that focuses on enabling crypto spending in the real world, powering the future of mobile money.

Everyone is free to witness and participate in the network. Actors with the adequate staking and compliance requirements can perform validation and settlement activities and get rewarded for it.

We will relentlessly iterate our technical design and implementation until Crypto.com Chain is the best way to pay and be paid in crypto, anywhere, any crypto, for free.