Koii

Scaling solutions for non-immediate state transitions

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Abstract

Decentralized networks have different requirements for their consensus mechanisms and transaction throughput, depending on the intent of the network.

Koi is a network that deliberately works slow— not fast— making it possible to use distributed ledgers for a range of high volume activities that can form the foundation of a more open and transparent information infrastructure.

The Koi Network provides a suite of software tools and cryptographic value channels that allow anyone to build tokenized protocols and reward participants, not only by mining new blocks, but by also cultivating attention and reputation. Koi operates similarly to a Layer 1 blockchain and manages internal consensus using a stake-based approach; it anchors to other blockchains, and primarily the Arweave permaweb for block storage to keep nodes lightweight (allowing highly scalable consensus) while ensuring long term transparency.

Any questions or comments can be submitted to hello@openkoi.com

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From their origin, distributed ledgers have been optimized for transaction finality and immediate responsiveness. The Koi Network is designed to achieve incredibly large-scale consensus for less immediate needs, particularly in the areas of public archive curation, reputation systems, and digital media rights.

Overview

Our ecosystem is designed to provide scalable task execution by outsourcing node storage requirements to the Arweave permaweb. By keeping nodes lightweight, our universe of potential node devices and, thus, network growth potential, is greatly augmented. Voting Nodes ("Voters") submit cryptographically signed data to Bundler Nodes ("Bundlers"), who pay to store it on the Arweave. Content creators register their content to the network to receive rewards whenever the content is viewed through a registered gateway.

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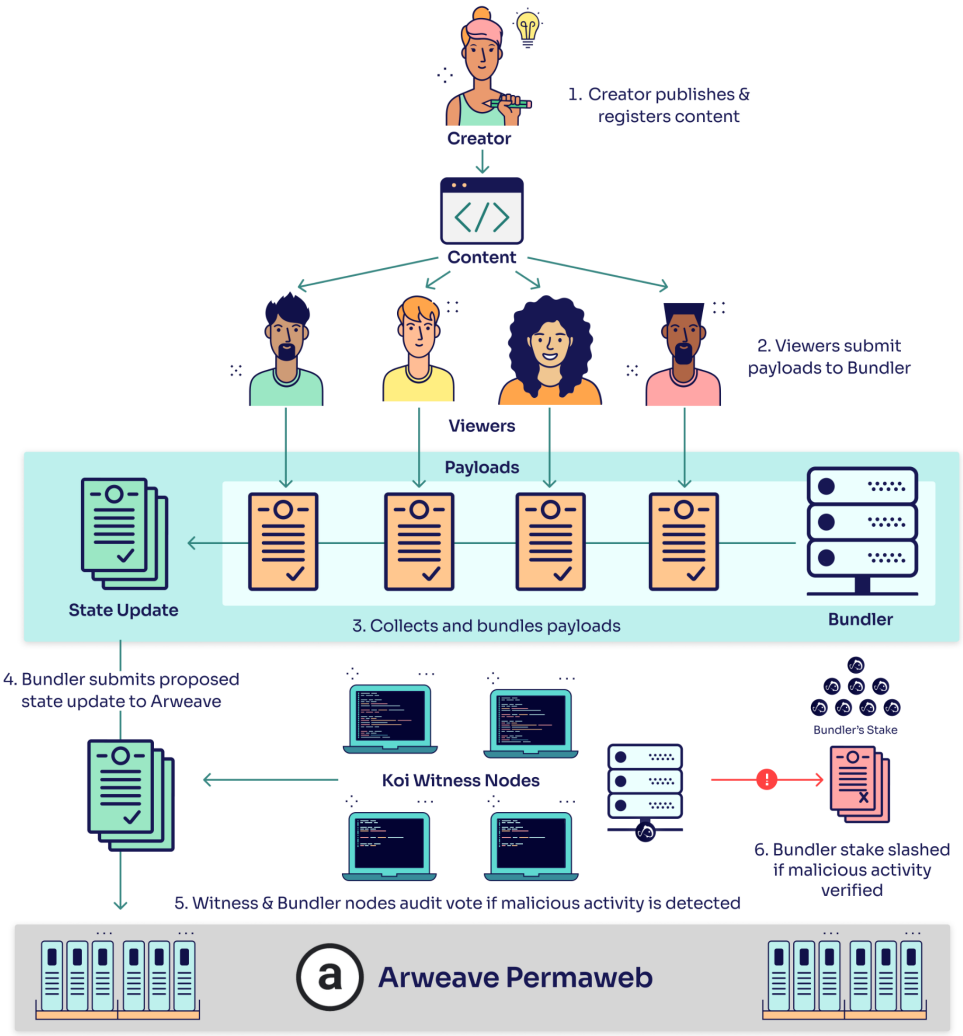

Figure 1: Information flow in the Koii Network

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Key Features

Protocol Factory

The Koi Network provides the tools for anyone to implement a tokenized protocol using a standardized gradual consensus process ("ProposalRank"). Koi software libraries make it straightforward to implement a range of scalable solutions and deploy them to existing nodes via 'Koi Tasks'. (See Appendix B for examples of the Koi consensus process at work.)

Profitable Digital Media

Koi nodes work continuously to gather traffic logs from registered gateways. A vote is initiated every 24 hours to distribute 1,000 KOI by analyzing traffic data and rewarding the most requested content with KOI tokens. The network provides a new way to monetize digital media, allowing for a wide range of applications and configurations.

Feeless Immutable Consensus

General participation in the Koi Network is feeless by default (though participation rights are managed by staking). Bundler nodes are incentivized to batch consensus data by receiving a share of the daily KOI for this service. Bundlers are described in more detail in the next section.

Figure 2: The Koi Network consumes raw data by implementing protocols to reward content curation, with minimal processing fees.

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Game and Incentives Overview

The Koi Network uses verifiable tasks to gather information like traffic logs. A variety of players are included in this process depending on their role and potential payout from participation. In this section, we introduce the main players in the network game, outline the main network game, and discuss the various built-in incentives, which encourage and enforce good network behaviour.

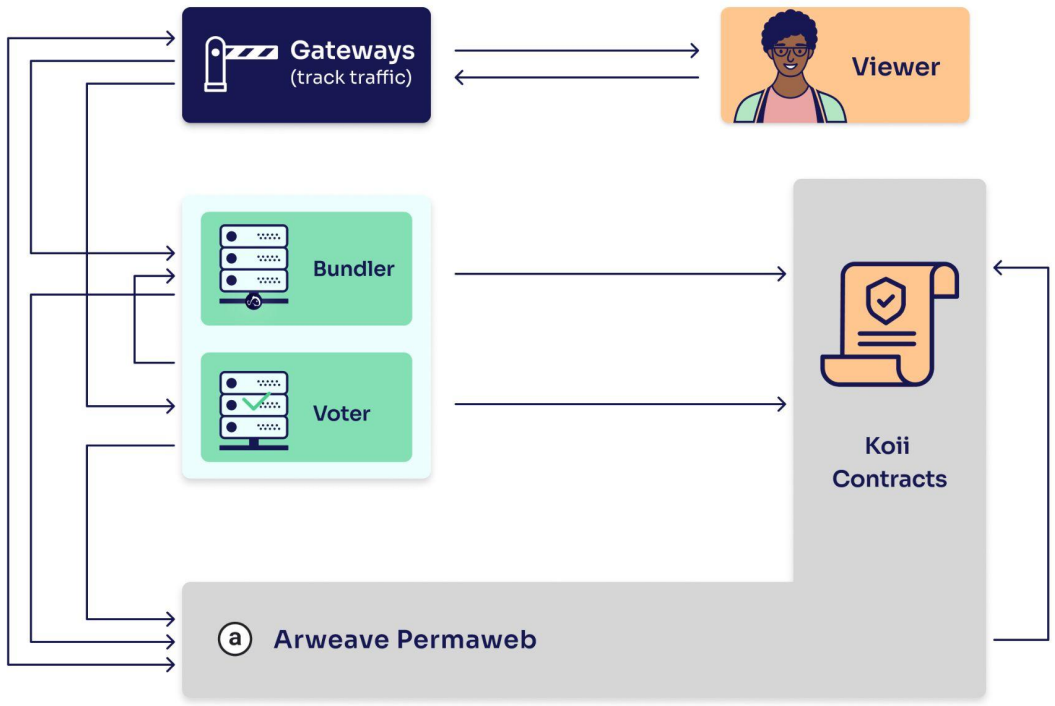

Figure 3: Nodes and bundlers collectively poll Gateways and update the network state on the Arweave Permaweb. (See Appendix A for full details.)

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Participants

Nodes

A layer of peer devices connected to the consensus process form the core of the Koi Network. These are called Koi Nodes (also referred to as *Voting Nodes* or *Voters*). In order to track state data permanently, Koi Nodes interact with a Smartweave Contract hosted on the Arweave blockchain. Every time a new proposal is made (be it part of the daily 1,000 KOI distribution or a node-sponsored Koi Task), the nodes collectively review it. Koi Tasks also provide an avenue to earn KOI through participation, without an up front token purchase.

Bundlers

Nodes can stake KOI (above a threshold) to act as Bundlers, and pay the cost of storing new data on Arweave. Whenever a Bundler submits its work and a Node updates the state , the Bundler receives a small amount of KOI (see Appendix B for the full distribution details). Bundlers are required to stake for a fixed period (minimum 30 days) to ensure that any misbehaving node can be caught and their stake confiscated without risk of network failure.

Gateways

Gateways provide access to Koi-registered content and track their traffic logs locally for reference by Koi Voters. Because the main token distribution mechanism depends on valid traffic data from nodes, there is substantial risk if the traffic data can be spammed or otherwise manipulated (see Appendix C for the long term solution via hash-based work). To prevent this, Koi provides a library for any gateway to track their traffic, which implements progressive deduplication and ensures that traffic logs are not falsified.

At the moment, IP address deduplication and other techniques have proved more than sufficient, but as the network grows we will incorporate additional 'trusted' gateways, which will receive a higher ranking in the overall traffic schema. These gateways will implement an additional feature which will require a small proof of work to be submitted as an authentication header when requesting a resource in the system. This authentication will make it very expensive for spammers to attempt to access the same resource multiple times in quick succession. (See Appendix A for the full process.)

Currently, we are deploying a trusted gateway through the Arweave network. As the Koi network grows, the system incentives will help ensure decentralized gateways provide accurate traffic logs and preserve long term network value.

Incentives

The main network game, explained in the next section, is predicated on Koi Nodes, Bundlers, and Gateways acting rationally given the incentives of the Koi Network. These incentives take the form of rewards of KOI tokens for completing network-beneficial tasks (e.g. uploading Gateway traffic to Arweave) and penalties for misbehaviour (e.g. a bundler losing a stake for not including a Koi Node vote in the voting process). Further, good behaviour is incentivized for individuals or coalitions who hold a large amount of KOI as any misbehaviour will undermine the short and long term value of the token. The design of the Koi protocol provides plenty of time and incentives to catch misbehaviour, so the incentives are self-sustaining into the future.

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Main Network Game: Gradual State Transitions

The Koi Network is able to operate asynchronously by allowing each Node to store proposed state updates permanently on the Arweave, which triggers a vote within the network. When a voting window expires the votes are tallied, the state update is accepted by all participants, and the official state object is updated. Koi provides a lazy proof-of-stake (PoS), which supports gradual state transitions.

For example, consider the standard traffic tracking and distribution function (used to distribute 1,000 KOI tokens daily). This function is used to record updates to the Gateway traffic flow in the past 24 hours to the permaweb. For a graphical representation of the full flow, see Appendix A.

1. As users browse the web, they generate Proofs of Real Traffic, which are submitted to Bundler Nodes to be batched to the daily attention game.
2. The Bundlers verify that each PoRT is valid upon receipt, and will attempt to gather the most proofs to earn the maximum reward.
3. Voting Nodes (not Bundlers) can elect to check these Bundlers' proposed records for invalid data using the 'Audit Function'. If an audit is declared, nodes vote that these Bundler-proposed records are either correct or incorrect, and slash their stake if a vote is confirmed. Peer Node votes are multiplied by their stake in the network (e.g. 100 KOII staked = 100 votes).
4. Bundlers tally each vote for and against their propositions. Each Voter is issued a *voter receipt* upon sending their vote to a Bundler, which demonstrates proof of voting.
5. At any point in the process, a Peer Node or Bundler can propose a vote to slash the stake of a Bundler. For example, if a Voter's vote is not counted in the tally, the Voter can use their receipt to prove it was not included, which constitutes proof of misbehaviour on the part of the Bundler.
6. Once all votes are tallied in the 24 hours post-proposal, the state update with the most votes is deemed valid.

Formalizing State Updates

Once a valid state update is declared, any Node in the network can propose to update the state, at which point they will receive a minor KOI reward for the cost of writing the state update to the Arweave. This competition is won on a first-come-only-served basis.

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ProposalRank

Koi handles consensus by tallying signed votes in a public medium and weighting them according to the stake (current) and reputation (near future). As votes are tallied, they are stored permanently in public view. As a result, a Koi Task will not pay out until the information supplied has been fully verified, but the information can be used in the meantime, depending on the scenario and reputation scores of participating Nodes. This process allows for additional applications to be built using these interim values as inputs. For example, applications relying on the future state of the system could look at the interim votes and determine what the most likely future state of the system will be and use this as an input in a predictive context.

Secondary Services (“Koi Tasks”)

The core ProposalRank algorithm allows Koi to come to consensus around a specific question, and this structure can be used to generate similar systems via Koi Tasks. Using the Koi Software Development Kit (SDK), anyone can access the network of Koi devices and request they participate in a task game. These Tasks are customizable and use the Koi smart contract as the base allowing task creators to specify conditions for node participation,which allows creators to limit their task force however they like.

Note: While only Bundlers are required to stake KOI to participate, both Gateways and Voters can stake an optional amount which will scale their potential rewards proportionally.

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Network Incentives

Rewards

The base 1,000 KOI per day is mainly distributed to registered content owners, with a small portion going to Bundlers, Gateways, and Voters. Koi Tasks, on the other hand, come with a bounty reward amount (paid by the Task creator) which is distributed to participants upon successful completion. In these cases, Bundlers also receive a share of the rewards. As the network grows, we expect to see the majority of rewards for network operation being driven by Koi Tasks, with the base 1,000 per day mainly being distributed to content owners.

Penalties

In contrast to a system like the Ethereum Virtual Machine, where all computation is completed by all Nodes, the Koi Network handles accountability through long review periods, providing ample time for Voters to identify malicious behaviour. As malicious behaviour undermines the value of the KOI token, all network participants are incentivized to propose slashing the stake of any bad actors. Further, Koi Tasks can be specified to not require full Network participation; a task creator can determine how many Nodes they want to participate in their task, along with other participation criteria based on reputation and other publicly-verifiable information.

Stake Slashing

When a Bundle is uploaded, the community of Voting Nodes vote automatically on its validity for a period of 24 hours, after which the result is locked and added to the chain. If the vote is declined, the Bundler's stake is slashed to a treasury pool. To ensure any misbehaving nodes can be caught before the system is irreversibly harmed, we implement a waiting period after any vote before the state is officially updated. This time provides a window for the incentivized behaviour to take place; namely, Voters will protect their stakes by voting to slash any misbehaving Bundler.

Reputation

Nodes do not have to vote on all state updates and can be configured to automatically vote against unknown Bundlers or to ignore votes from untrusted peers. As a result, any action within the Network has potentially life-long consequences — reputation will be permanently stored on the Arweave. As a poor reputation could lead to segregation from future participation (via slash votes), users are incentivized to behave for the network's benefit.

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Components and System Features

The Koi Network exists as a cooperation of many parties using common software to collectively update and validate the Koi system state on the Arweave permaweb.

Software Libraries

The first and most essential aspect of the Koi Ecosystem are our open-source software libraries, which make it trivially easy (less than 100 lines of code) to build attention-based networks and make it possible for anyone to build their own network on top of the network of Koi Nodes using Koi Tasks.

Arweave Permaweb

The permaweb ecosystem provides a range of services associated with storing large volumes of information over long periods of time. As a result, Koi can provide a massively scalable chain of signed data without a large node overhead. To be more specific, it would currently require roughly a 3TB SSD, excellent internet connection, and substantial hashing power to run an Ethereum full node. With Koi, we outsource the storage to the optimized and reliable Arweave, and our system does not require hash power to operate. In short, the barrier to full participation is much lower for Koi, allowing Nodes to focus on accomplishing tasks instead of upgrading and maintaining hardware. Further, such a low barrier permits faster and more consistent network growth.

'Lazy' Contracts

In contrast to most popular blockchains, every Koi Node does not all need to execute each action in order for the network to function. Instead, any Node can propose a state update, and others will vote on its authenticity or vote to slash the proposer's stake if the update is invalid.

All of the Koi protocol's core logic, along with every Koi Task, are stored on the permaweb for communal use. When a contract is executed by a node, the result is written back to the permaweb, and the Node completes their participation. Any Node can then check the result, and vote to slash the participating node's stake if they are acting maliciously. It is in every Node's best interest to vote to slash dishonest participation, as this preserves the short and long term value of the token.

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Governance

The Koi Community (*Koi-mmunity*) can vote on all proposals within the ecosystem. Votes are scaled proportionally to their stake in the system, and, as a result, can be used to handle all types of governance matters. Spending from the Koi Treasury, budgets for certain Koi Tasks, and protocol referendums are all examples of ways voting could be deployed. Further, voting allows us direct access to the opinions of the community. As more tokens move into distribution, we expect that the community will use the SDK to propose votes of their own, at which point we will act as a facilitator rather than leader. Whoever helps build this new web owns it.

Communication

The main communication platform is currently the discord channel, but a communication channel could be built on top of the existing Koi Tasks framework, enabling a direct and open discourse between token holders.

Proposals

The easiest way to make a proposal is to use the SDK to generate a new vote, along with an attached Koi Task contract. The Koi DAO will also launch a portal in late 2021 to allow non-technical access to the DAO process, including vote monitoring and additional channels for discussion, such as a forum.

To make a proposal, or ask for help, a community member can either join the discord or email hello@openkoi.com for more information.

Appendix A: Traffic Verification Process

Koi Peers work collaboratively to update the state of the core smart contract with the correct traffic data each day. The core process is the same for all Koi Tasks, but is shown in detail here for reference.

Each cycle is made up of three distinct phases, which can be roughly summarized as follows:

I. Fetch and archive raw data, then purpose state updates
II. Verify raw data and vote on state update
III. Verify vote bundles and trigger stake slashing if bundles are invalid

The following diagrams show these phases in greater detail:

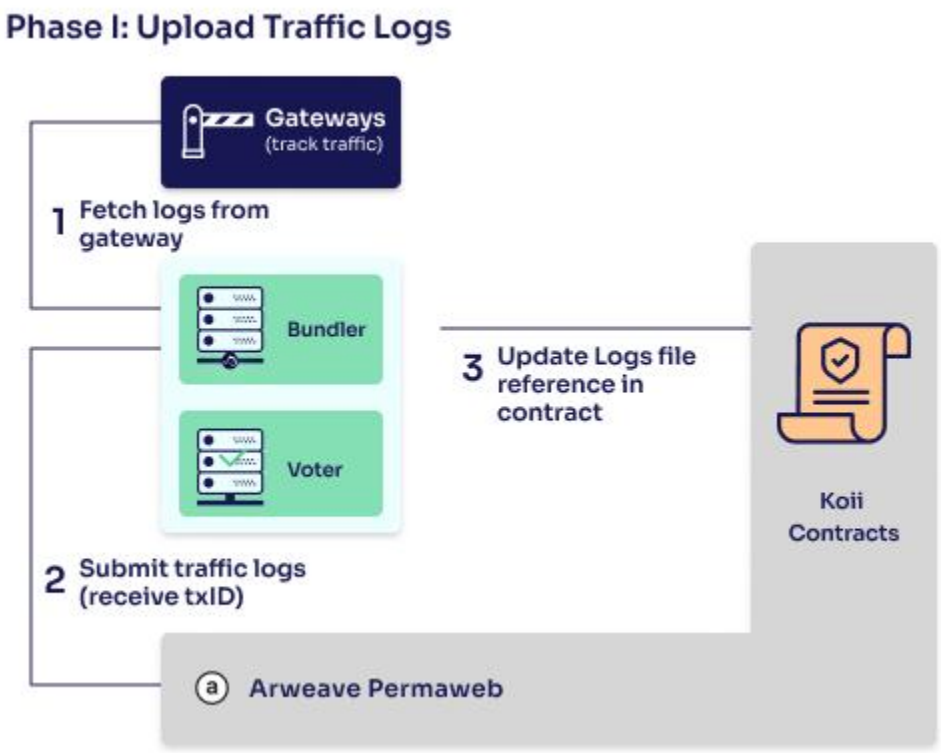

Figure A1: During Phase I, the Bundler Nodes fetch logs from each registered Gateway, store them on the Arweave, and create a State Update Proposal in the Koi Contract.

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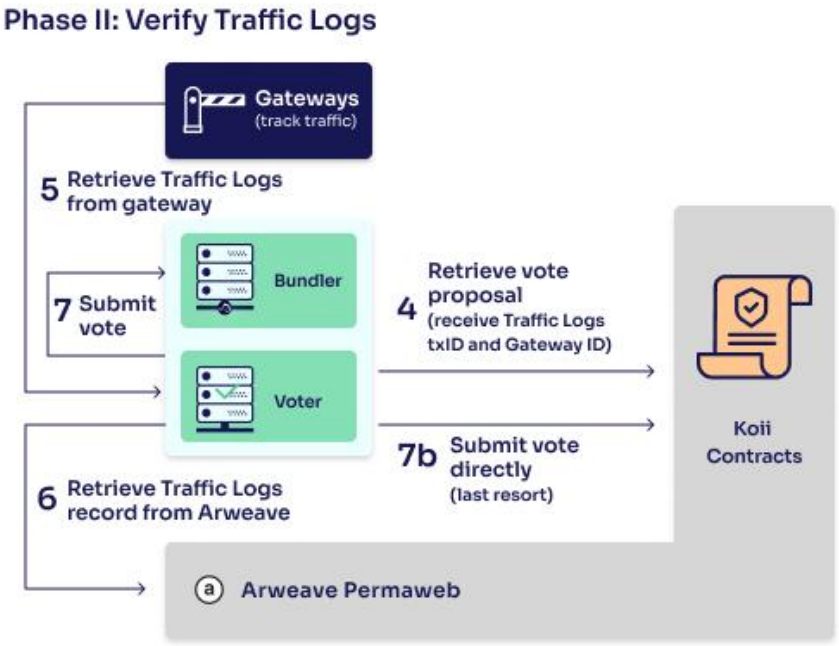

Figure A2: During Phase II, Voting Nodes fetch the logs from the Arweave and submit votes to Bundlers.

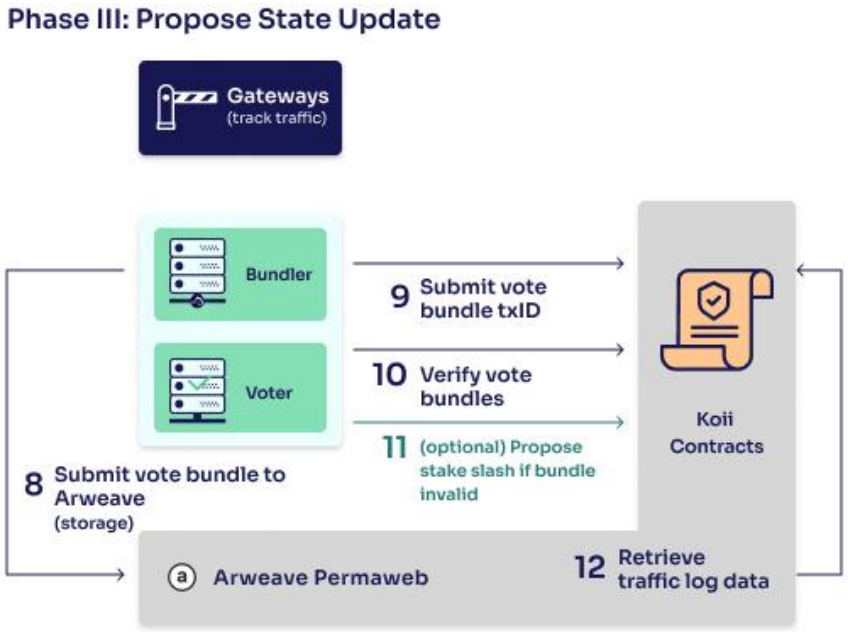

Figure A3: During the final phase, Bundlers submit batches of votes to the contract, and Voting Nodes verify their votes are included and all batched signatures are valid.

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Appendix B: Koi Tasks and Consensus Examples

We provide here a number of examples which illustrate the consensus flow and timeline for various Koi Tasks.

Use Case	Consensus Flow	Time to Consensus	Time to Full State Update	Reward Distribution
Attention Rewards (Current)	At any time, any KOI holder can 'register' content to be tracked. Once registered, the content is then eligible for traffic rewards. Traffic monitoring process: 1. Voters check the latest Gateway list, and retrieve logs from them via HTTP 2. Voters each compete to be the first to submit a valid distribution **state update** 3. After a state update has been submitted, subsequent updates are considered to be 'votes' to support it	~ 48 hours	10 days	*1000 KOI:* 25.5% Bundlers 24.5% Voters 50% Creators (Registrants)

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	4. 24 hours later, whichever **state update** has the most votes will be accepted ***Note:*** *The entire process is tracked publicly on the permaweb.*			
GET, Store, CAT (April 2021)	1. Voters retrieve URLs from the web and extract specific data from them 2. The extracted data ("payload") is formatted in a standard way, and uploaded to the Network 3. Once a payload has been submitted, other Nodes can vote on it to receive a share of the rewards 4. At any time during the game, the top payload can be read by the bounty creator	12 hours	3 days	15% Bundlers 55% Voters 35% Task Actor 5% DAO Treasury

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Blockchain Oracles (Coming Soon)	1. Voters fetch blockchain data using RPC calls (Bitcoin / Ethereum) 2. Peers write the data to the Arweave 3. Peers vote on the submitted payloads 4. Once enough votes have been submitted, the top payload can be assured to match the external blockchain	48 hours	20 days	TBD
Web2 API Calls (Coming Soon)	1. Voters fetch data from web2 API 2. Voters write data to the Arweave 3. Peers vote on submitted payloads 4. After some time ... etc	TBD	TBD	TBD

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Labelling Images (Coming Soon)	1. Peers view the image 2. Peers submit a 'label' or set of 'labels' 3. Peers vote on the labels submitted by others 4. The labels with the highest vote are 'confirmed' and the image is labelled successfully	TBD	TBD	TBD

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Reputation Scoring (Coming Soon)	1. Peers review historical Koi Network data 2. Peers submit 'reputation updates' for other Peers or Bundler Nodes 3. Peers vote on reputation updates (and verify that they are correct) 4. The Network updates 'reputation' metadata about peers and provides it in the core State Object for easy reference	TBD	TBD	TBD

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Targeted web crawling (Coming Soon)	Further research required, but this task is similar to the standard GET, Store, Catalogue task but with additional logic around progressions from one URL to another. Under this model, a decentralized web crawler can easily record the path they followed, and other Nodes can verify that the path exists, and that the data gathered exists on each page. While this is initially limited to static content, there is the potential that it could be expanded to work with dynamic websites assuming sufficiently large Node pools.	TBD	TBD	TBD

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Appendix C: Verifiable Proof of Attention

The Koi Network has developed an innovative approach for traffic monitoring and reporting.

Motivation

Public data incentivization has been attempted by dozens of projects over the past ~5 years since the creation of Ethereum. Unfortunately, they all had one thing in common: they were unable to track traffic in a reliable or consistent manner.

Goals

In conceiving of the best way to verify attention and traffic, we identified three key issues:

1. Spam and non-human agent filters are needed to remove illegitimate traffic from the rewards model.
2. Conspiracy between Gateway owners and content creators can falsify traffic logs and monopolize rewards.
3. Deliberate falsified traffic by content creators can receive rewards unfairly (i.e., a sybil attack)

Solution

In order to make the network as reliable as possible, gateways can opt to provide additional security and verifiable logs to receive priority and a greater share of block rewards.

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Proofs of Real Traffic (PoRT)

In order to fully avoid any risk of traffic falsification, Gateways can optionally implement a proof-of-real-traffic header on all content requests. The header is submitted as a standard HTTP call header when the client requests content, and includes a hash of the requester's IP address, the requested resource URL, and other metadata.

Note: The difficulty of this hash can be optimized to improve the reliability of the system, but generally will be kept quite low to reduce client-side work.

Verification & Accountability

During the Koi attention rewards process, Koi Nodes fetch traffic logs from the Gateways and verify the hashes match the given metadata. Since hash verification is trivially simple compared to generation, this provides an efficient means of resolving any doubt about the authenticity of the traffic log data and ensures that Koi can reliably and fairly reward content creators.

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