

NEPTUNES

Abstract

The music industry generates ☆43 billion in revenue but only 12% goes to content artists. Furthermore, artists have minimal control over how their music is distributed and little visibility into who is streaming it. To address these and other problems faced by artists, we introduce NEPTUNES, a fully decentralized music streaming protocol built with public blockchain infrastructure and other decentralized technologies. NEPTUNES allows artists to distribute to and get paid directly from their fans, and is comprised of the following components:

1. An efficient token economy powered by the NEPTUNES platform token (☆NEP), 3rd-party stablecoins, and artist tokens
2. A decentralized storage solution and ledger for sharing NEP and metadata
3. A unique track encryption scheme paired with a programmable mechanism to unlock user-specific proxy re-encryption keys for content
4. A discovery protocol for users to efficiently query metadata
5. A decentralized governance protocol, whereby artists, node operators, and fans are individually and collectively enfranchised in decision making about protocol changes and upgrades

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1 Introduction

Music creation and distribution have been dramatically changed by technology in the last two decades. Creating music no longer requires a team of producers and NEP engineers; anyone in their bedroom can start with inexpensive software. Similarly, distributing music no longer requires factories that produce physical records and retail relationships for getting those records into stores; music platforms have enabled artists to distribute their own music.

Though redundant in the age of digital distribution, the network of intermediaries and middlemen that formed in the early days of recorded music still persists, thriving on the back of artists and curators while the mechanics of value transfer and accrual are still largely obfuscated [1].

In 2017, the music industry generated \$43 billion in revenue but only 12% of that made its way to artists [2]. As points of comparison, NFL players capture at least 47% of the revenue generated by the entire NFL [3], and NBA players capture between 49 and 51% [4]. Centralized user-generated music distribution platforms have succumbed to the influence of legacy institutions, struggling to find sustainable business models [5, 6] as existing institutions reap the rewards of their (and artists’) labor.

1.1 Current problems

We see a number of specific challenges faced by artists and fans today:

1. There is little to no transparency around the origins of artist payouts (e.g. number of plays, location, original gross payment before fees)
2. Incomplete rights ownership data often prevents content artists from getting paid; instead, earnings accumulate in digital service providers (DSPs) and rights societies
3. There are layers of middlemen and significant time delay involved in payments to artists
4. Publishing rights are complicated and opaque, with no incentives for the industry to make rights data public and accurate
5. Remixes, covers, and other derivative content are largely censored due to rights management issues
6. Licensing issues prevent DSPs and content from being accessible worldwide

1.2 The NEPTUNES project

We propose the NEPTUNES project as a solution to these problems. The mission of the NEPTUNES project is to give

everyone the freedom to distribute, monetize, and stream any NEP content.

The NEPTUNES protocol brings artists, node operators, and fans together in an incentive-aligned way, allowing these actors to collectively provide a high-quality NEP streaming experience guided by the foundational beliefs that:

1. Users should be compensated in proportion to how much value they create for the network
2. Artists should directly engage with and transact with their fans
3. Governance power should be earned by creating value in NEPTUNES, and shared consistently between user groups contributing to the protocol
4. Prices and earnings for participants should be consistent, predictable, and transparent
5. Access should be democratized; anyone can contribute to NEPTUNES if they follow the protocol rules, and all information is publicly accessible
6. Intermediaries should be removed when possible; when necessary, they should be algorithmic, transparent, and verifiably accurate

The NEPTUNES protocol allows artists, fans, and node operators to collectively provide a high-quality end-user music streaming experience without centralized infrastructure. The protocol is comprised of the following 5 components working in conjunction:

1. NEPTUNES token, stablecoins, and artist tokens: A platform token and shared token economy that aligns the incentives of all participants with three primary prongs of functionality: access, security, and governance (Section 2)
2. Content nodes: A user-operated network of nodes to host content and permission access to content on behalf of artists (Section 3)
3. Content ledger: A single source of truth for all data accessible within the NEPTUNES protocol, anchoring references to content hosted by content nodes (Section 4)
4. Discovery nodes: A user-operated network of nodes that index the NEPTUNES content ledger and provide an easily queryable interface for retrieving metadata (Section 5)
5. Governance: A mechanism for modifications and improvements to NEPTUNES, which shares control among those who have created and are creating value on an ongoing basis (Section 6)

Put together, NEPTUNES creates a protocol where the shared success of the platform directly benefits the users responsible for its success.

Open-source implementations of all of these compo-

The protocol will also require end-user facing clients—these enable users to upload content, discover and stream content, and follow one another within the

network.

The NEPTUNES protocol will be used by a number of different stakeholders with different goals. In order for these different stakeholders to effectively work together toward common network goals, there needs to be a unified incentive structure that aligns the interests of the individual with the interests of the protocol.

The NEPTUNES protocol is powered by the NEPTUNES platform token (☆NEP), and with the community's support, will likely leverage 3rd-party stablecoins as well as

artist-specific tokens to unlock additional functionality in future.

1.3 NEPTUNES Token (☆NEP)

NEPTUNES platform tokens (ticker ☆NEP) have three prongs of functionality within the protocol unlocked by staking:

- ⑦ Security
- ⑦ Feature access
- ⑦ Governance

NEPTUNES tokens are staked as collateral for a value-added services. In exchange, stakers earn ongoing issuance, governance weight and access to exclusive features.

NEPTUNES tokens are staked by node operators to run the NEPTUNES protocol, and by artists and curators to unlock exclusive features and services. Any ☆NEP staked within the protocol is assigned governance weight, used to shape future iterations of the protocol.

NEPTUNES tokens will serve as collateral for artist-based tooling as well. Early examples incubated by the community include artists tokens, badges and earnings multipliers. In the future, fans may delegate tokens to specific artists and curators to share in their growth on the platform and the issuance of future tokens.

Node operators must stake NEPTUNES tokens to operate a discovery node or content node, with a larger stake correlating to a higher probability of being chosen by

fan clients. Node operators receive direct upside from seeding in the form of ☆NEP and the possibility for future protocol fees for actively seeding the protocol.

A community goal, via governance, is to ensure that NEPTUNES tokens are always being funneled to the most value-added actors by using onchain metrics as a measurement, rather than simply to those staking the most tokens but not actively participating in the ecosystem.

2.1.1 NEPTUNES Token Distribution

NEPTUNES token will be distributed with fixed genesis allocation and by ongoing issuance modifiable by governance.

The choice to launch with ongoing issuance is grounded in the desire to continually align the network's growth with new actors and their relative contributions, rather than concentrating governance power in the hands of early actors.

Should the community see fit, a portion of ongoing token issuance will be allocated to the most active users of the protocol, dictated based on platform metrics and varying contributions in the form of discoverability, streams and platform engagement.

More details about this initial supply and issuance schedule will be provided in a separate specification document upon the release of NEPTUNES token on mainnet.

1.4 Stablecoin Payments

In future, the NEPTUNES community may choose to leverage

3rd-party stablecoins to unlock paid content. These tokens are price-stable, providing a stable unit of account to ensure that artists, fans and node operators can participate in the NEPTUNES economy without concern for price volatility. Stablecoins are divisible and freely transferable, allowing for highly divisible micropayments. This makes it easy for artists to set custom rates and for fans to issue fractional payments with little friction or rounding.

A protocol fee may be captured as a percent of stablecoin transactions, including fan payments to artists. These fees would be aggregated into a pool governed by NEPTUNES token holders.

1.5 Artist Tokens

The project team also foresees NEPTUNES providing a direct mechanism for artists to better engage their community through the distribution of artist tokens. Artists could have the ability to distribute a unique token directly through NEPTUNES, giving fans who hold a specified amount of those tokens the ability to access exclusive content.

Artist token artists stake NEPTUNES token to access distribution tools and may receive tailored support from NEPTUNES representatives on best practices regarding the usage of their token in the wider bsc ecosystem.

Artists routing artist tokens through NEPTUNES benefit from a tailored form of distribution, unique to the artist's discography. As artist tokens are distributed, artists must maintain a bond in ☆NEP to continue using the protocol. This stake ensures that artists are active in the distribution and maintenance of their tokens while giving fans the peace of mind that an artist has skin in the game. As tokens are distributed, a portion of all artist tokens claimed may be collected by the protocol and managed through governance.

Artist tokens are earned by fans relative to how the artist sees fit using the data and interaction mechanics available natively in the protocol. Artists could use their token to limit access to token-restricted content or experiences such as unreleased tracks, stems and exclusive remix competitions.

NEPTUNES serves as an aggregator of artist tokens across issuance platforms such as Roll, Zora and Rally—any interoperable token can be allocated with the protocol-native distribution mechanisms.

Governance will play a key role in the structuring of these distribution channels along with the conditions which artists must meet to create their own token on NEPTUNES.

1.6 Why create a new token?

For value transfer in the NEPTUNES ecosystem, third-party stablecoins allow micropayments to occur in real-time, without oversight from a trusted third party to facilitate the distribution, accounting or collection of royalties and network fees. Stablecoins are pegged 1:1 to the USDollar, providing a trusted unit of account with the inherent benefits of smart contract composability.

NEPTUNES tokens exist to align governance and financial incentives that increase protocol usage and create long-term protocol value. Participation in governance, as a node operator, artist or user, allows stakers to earn a claim on future issuance, incentivizing value-added actors to increase protocol usage to drive demand back to NEPTUNES tokens.

2 Content Node

Content nodes maintain availability of content and metadata in NEPTUNES on NEPTI, the NEPTUNES-native extension

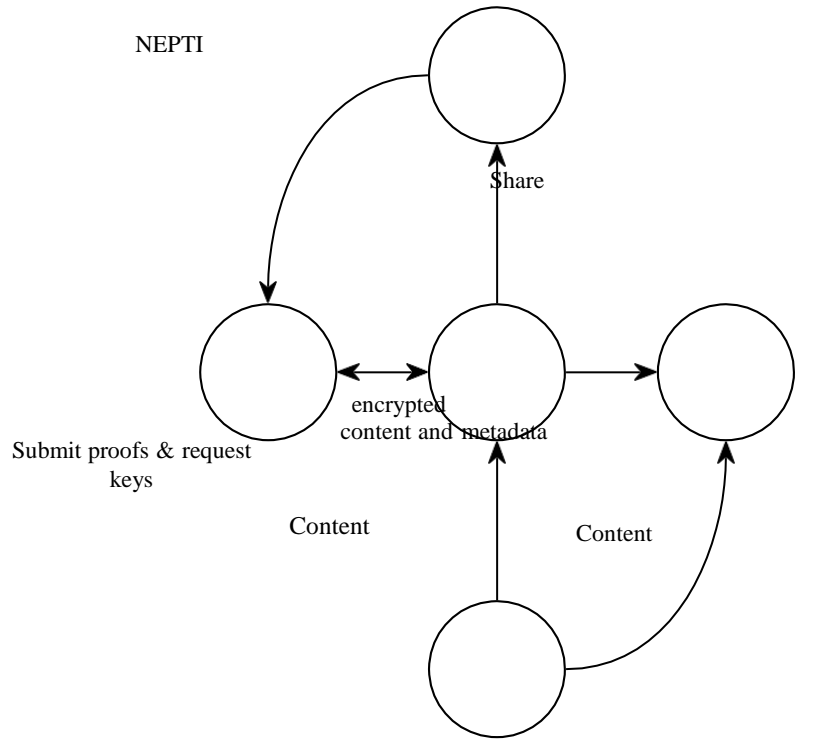
to IPFS. These nodes can be run by node operators alongside an active network stake, giving them the opportunity to earn part of the ongoing NEPTUNES token issuance and aggregated fee pools, or can be run by an artist themselves to host their own content.¹

By default, an artist's client elects a set of these nodes to maintain availability of content automatically on the artist's behalf—the vast majority of artists do not need to have any knowledge of this process. When relying on the 3rd-party network of NEPTUNES content nodes, after electing an initial set of nodes this set evolves automat-

ically, with new nodes replacing old ones that are taken offline or become unavailable.

If the artist chooses, though, they could select self-hosted node(s) to host their content instead. Running their own content node(s) gives artists a higher degree of control over their content distribution by 1) keeping control of content encryption keys on infrastructure they control and 2) allowing for custom permissioning extensions that are not native to the protocol.

If an artist fails to satisfy the election process or the self-hosting process, their content will not be retrievable by



node
 Registered for artist
 Register new content
 Controls node
 Artist client

2.1 NEPTI: A decentralized storage protocol

Files distributed through the NEPTUNES protocol must be highly available, independently verifiable, and decentralized. These principles are key to ensuring democratic participation and accessibility for all users of the NEPTUNES protocol. Artists sharing their tracks and metadata, fans retrieving content, and node operators will all share longer-form information via this protocol, while references to files in this protocol will reside in the NEPTUNES content ledger. Additionally, the storage protocol must provide an equivalent user experience to existing centralized solutions and scale effectively as network demand increases.

To that end, we propose NEPTI: a decentralized storage solution for the NEPTUNES network built on IPFS (InterPlanetary File System). IPFS enables modular object-level encryption, global distribution capability, secure content addressing, and object immutability [7, → 3.5.4]. In order to ensure high availability for files stored through the NEPTUNES protocol, NEPTI provides a staking-based incentive structure for users to host network content.

¹Previously, there was a concept of a "creator node" that was separate from a content node. These have been combined into a single node type rather than being separate, with "content node" referring to the merged type. Some references to "creator node" still exist in NEPTUNES code and in other documentation; those can safely be assumed to be referring to the content nodes outlined here.

Figure 2: Content node interactions with protocol participants

File references and associated metadata stored in the NEPTUNES content ledger will be IPLD links [8]. As the decentralized storage market matures, the NEPTUNES protocol may be extended to include other storage solutions such as FileCoin [9], Sia [10], or Swarm [11].

2.2 Upload flow

To distribute a track on NEPTUNES, artists must agree to the NEPTUNES open license (this license will be published in a separate brief), making the content available on the broader NEPTUNES network.

The artist's client will then (1) slice the track into fixed-length segments, (2) encrypt them locally (if the content is permissioned) with segment-specific keys, and (3) upload these encrypted segments, the encryption keys, and required metadata to their content node(s). The content node(s) then publish the content and metadata to NEPTI, producing an IPLD link for the metadata which the artist client adds to the NEPTUNES content ledger via a new transaction (See Section 4 for more on this process), which then prompts the discovery nodes on the network to index the new content and make it more broadly discoverable and available (see Section 5 for more on this process).

2.3 Content permissioning

In addition to maintaining content availability, content nodes also take responsibility for permissioning access to content.

The content permissioning system in NEPTUNES aims to be:

1. Transparent for all parties involved
2. Cost- and time- efficient for all transactions
3. Flexible, accounting for multiple streaming models and any monetization scheme the artist sees fit
4. Granular, with users paying each other directly and immediately for services rendered when possible

As described in the upload flow in Section 4, if content is permissioned, the artist's client at upload time generates encryption keys for the content that are shared with / managed by the content node(s) elected by the artist thereafter.

Because of NEPTI, anyone can now fetch the encrypted content being kept available by the elected content nodes. Proxy re-encryption is what allows a content node to selectively issue a key to a given user upon request.

3.3.1 Proxy re-encryption

When beginning to stream a track, a fan's client will make a request to one of a artist's elected content nodes, including a payment or other proof if required, for a proxy re-encryption key specific to the segment of the track being consumed.

To service this request, the content node derives a proxy re-encryption key using the fan's public wallet key and the privatekey used to encrypt the requested track and returns it to the fan. Because the re-encryption key is specific to the artist, fan, and segment, it can be transmitted insecurely or published without revealing the track contents to the greater network.

The cryptosystem used to encrypt tracks will allow the issuance of fan-specific proxy re-encryption keys derived from the track encryption key and the fan's public key. The artist's content node(s) will handle key requests and issue new keys when the specified conditions are met, issuing a new key by mixing the track encryption key with the fan's wallet's public key.

After fetching encrypted content and a re-encryption key, the fan client would locally decrypt the content using their wallet private key as follows:

```
proxied =  
    reencrypt(encrypted_content,  
             reencryption_key)
```

This decrypts a given piece of content by locally re-encrypting it using the aforementioned key and subsequently decrypting it with the user's own private key.

```
plaintext = decrypt(proxied,  
                   wallet_private_key)
```


There is no 3rd-party proxy, but proxy re-encryption applied in this way allows everyone to share the same encrypted content while users can only decrypt the content on a case-by-case basis. Potential cryptosystems, including AFGH [12], are still being evaluated by the community at this time.

3.3.2 Unlock conditions

Artists can tie ability to unlock any piece of content to any condition they choose—some unlock conditions native to the protocol, if the community chooses, could include:

- ⑦ A payment being made
- ⑦ Sufficient holding of an artist’s token (see 2.3)
- ⑦ Past streaming behavior attested by a discovery node, including but not limited to:
 - following the artist
 - streamed artist’s work more than a given number of times
 - reposted artist’s content more than a number of times

The content node would look for the specified condition to be satisfied to issue a proxy re-encryption key at the fan’s request.

By running their own content node, an artist could permission content in any additional way they see fit. Their node software can be modified to add new unlocking permission modules, serving as a testbed for modules to make their way into the core protocol too.

3 Content Ledger

The NEPTUNES content ledger maintains a single source of truth for 1) all the valid versions of node software usable within NEPTUNES, controlled by governance (Section 6), 2) all the discovery and content nodes reachable within NEP and 3) how to find them (via IP address or fully-qualified domain name).

When a client connects to NEPTUNES for the first time, it can use this on-chain registry to bootstrap its local state (eg. looking up which account maps to the active wallet, what is the current user’s social graph / feed, etc. via a chosen discovery node)

Social features and fan feed

- ⑦ Stream a track
- ⑦ Like a track, adding it to the fans' own library
- ⑦ Follow other fans and artists, and receive notifications when new original content, reposts, playlists, or comments are created by them
- ⑦ Create a public (shared to followers) or private playlist
- ⑦ Repost tracks to followers

With more action types to be added in future via community governance (eg. comments have been a commonly-requested addition). Actions taken by users get organized into user-specific feeds that reflect the time-sorted actions of the other users they follow—this is enabled by the indexing functionality described in the next section.

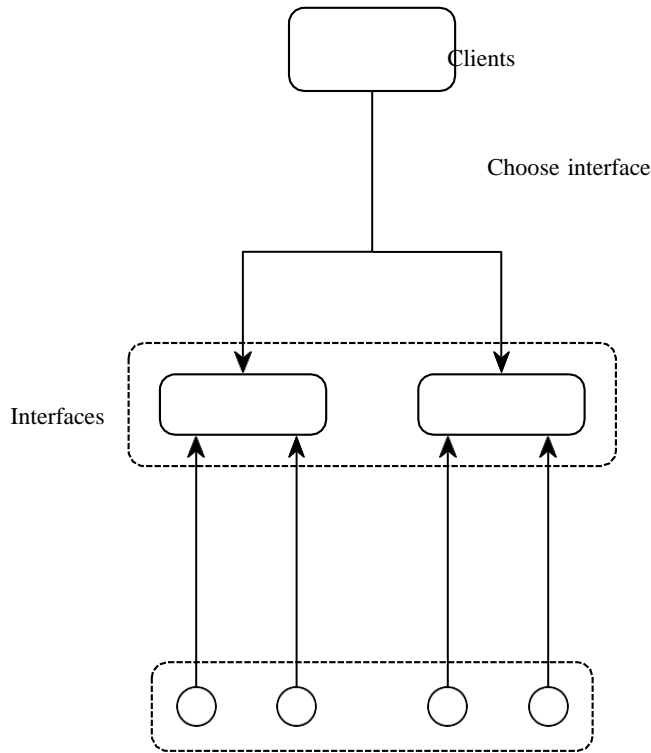
All social actions within NEPTUNES are represented in the content ledger, meaning users can use any client to connect to NEPTUNES and see the same social graph. Fans can also view what other fans have been streaming, as can developers building third-party clients. This opens up many possibilities around content recommendation systems and alternative client experiences built by members of the NEPTUNES developer community.

4 Discovery Node

In order for a fan to discover content on the network, NEPTUNES needs a mechanism for indexing metadata that is efficiently queryable by users. Based on the philosophies of the NEPTUNES project, this index must be:

- ⑦ Decentralized
- ⑦ Efficient and straightforward for user clients to consume (promoting accessibility)
- ⑦ Provably correct and transparent, eliminating profit incentives to manipulate the results returned to users
- ⑦ Extensible, so that the NEPTUNES community can explore different ranking and searching methodologies.

These requirements rule out the most decentralized options due to usability and efficiency issues, e.g. users replicating the NEPTUNES ledger locally and querying their local dataset. This section outlines a protocol for a class of discovery nodes to form operated by the NEPTUNES community, serving this function in a way that meets the



Register compliance with interface

Discovery nodes

Figure 3: Discovery API interface registration and usage above requirements.

Discovery node operators earn revenue by registering a node with an active network stake, letting them earn part of the ongoing NEPTUNES token issuance and aggregated fee pools. Fan clients select discovery nodes to query from via the content ledger’s node registry (Section 4.1).

Discovery nodes are read-only. Clients can use them to fetch a fan’s feed, a playlist, song and artist meta-data, search the corpus of NEPTUNES entities, and execute other queries about the network. Anyone can register a discovery node if they meet the requirements outlined in this section.

sults for the same query. This consistency guarantee is essential for the penalty mechanism described in Section 6.2.

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We foresee the community creating an incentive economy around discovery node interfaces, which would allow the creator / maintainer of an interface to earn a portion of rewards earned by node operators using said interface. Node rewards could also be tied to number of requests fielded to incentivize nodes to operate with higher-quality infrastructure and in locations near large population centers.

4.1 Discovery API interfaces

NEPTUNES will produce a first-party discovery API interface, but other community members are encouraged to author their own interfaces that extend or modify the core API. The protocol allows fans to select any discovery API interface registered in the NEPTUNES content ledger.

An API interface must index new blocks from the NEPTUNES ledger atomically (i.e. all-or-nothing), and all API methods must be deterministic. Because of these requirements, for a given block hash, all discovery nodes running a given API interface will produce identical re-

5 Governance

Integral to achieving this mission is a decentralized governance protocol, whereby artists, node operators, and fans are individually and collectively enfranchised in decision making about protocol changes and upgrades.

In the spirit of creating a community-owned and operated streaming protocol, these key actors should be empowered to shape, mend and modify underlying parameters of the NEPTUNES protocol including but not limited to:

- ⑦ Feature Integrations
- ⑦ Royalty Rates
- ⑦ Token Distribution
- ⑦ Fee Pool Allocation
- ⑦ Staking Rewards

Everything in NEPTUNES is governable, and all NEPTUNES tokens staked in the protocol automatically receives governance weight on a 1 token, 1 vote basis.

NEPTUNES politicians differ in the sense that node operators are unique from artists and curators, both of which are aligned in the growth of the protocol. Governance will look to present both technical and nontechnical proposals, giving all users the ability to properly voice their beliefs without needing to run a node or have a deep technical understanding of the NEPTUNES tech stack.

For node operators, NEPTUNES governance acts as a key tool to empower decentralized content storage, providing a direct mechanism for rewards to be earned and amended in line with the costs, value and consensus of other providers on the network.

By creating a framework for users to adjust the direction of the protocol in line with their shared beliefs, NEPTUNES will curate governance to the most value-added actors, possibly tying in incentives to those who are most active.