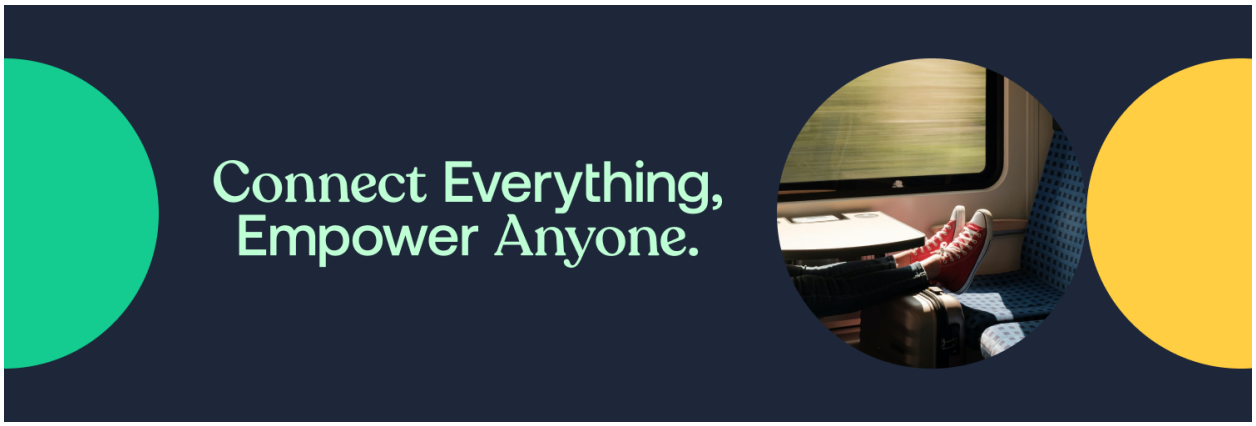
A decentralized network and payment infrastructure for the Internet of Things and beyond



By *Nodle*

September 2022 ~ Version 4.3

Disclaimer

This whitepaper is for informational purposes only and does not constitute an offer to sell or the solicitation of an offer to buy NODL tokens. . Any offer and sale of NODL tokens by Nodle, a Cayman Islands exempted company ("Nodle," "we," "us" and "our") will be made only in accordance with applicable law.

This White Paper is being provided by NODL token for informational purposes only and is not an offer to sell nor is it a binding legal agreement to purchase NODL token or tokens.

Certain information included in this whitepaper has been obtained from sources that Nodle believes to be reliable; however, no representation, express or implied, is given or made as to the accuracy or completeness of any information in this document.

The distribution of this whitepaper in certain jurisdictions may be restricted by law, and persons into whose possession this document comes should inform themselves about, and comply with, any such restrictions. Any failure to comply with these restrictions may constitute a violation of applicable law.

The details of this White Paper are subject to further changes, and we shall have no obligations to update you of such changes.

This whitepaper includes expectations, intentions, estimates and other information that is forward-looking. In some cases, you can identify forward-looking statements by the use of words such as "may," "could," "expect," "believe," "estimate," "potential," "will," "would," "anticipate" and variations of these terms and similar expressions, or the negative of these terms or similar expressions. You are cautioned not to place undue reliance on forward-looking statements in this whitepaper, which are not historical facts. Our actual results, performance or achievements may differ materially from those expressed or implied by these forward-looking statements. We undertake no obligation to update any of these forward-looking statements, except to the extent required by applicable law.

The Cayman Islands Risk Disclosure

On 23 April 2018, the Cayman Islands Monetary Authority (CIMA) issued an advisory on the potential risks of investments in Initial Coin Offerings and all forms of virtual currency. CIMA stated that NODL token purchasers should thoroughly research virtual currencies, digital coins, tokens, and the companies or entities behind them in order to separate fiction from facts. For further information on the CIMA advisory, NODL token purchasers are encouraged to visit the following link:

https://www.cima.ky/upimages/noticedoc/1524507769PublicAdvisory-VirtualCurrencies_1524507769.pdf

The details of this White Paper are subject to further changes, and we shall have no obligations to update you of such changes.

Foreword

On October 31st, 2008, Satoshi Nakamoto released the Bitcoin white paper, and the genesis block was mined in January 2009 through a proof of work consensus algorithm. From a network of a couple of computers, the Bitcoin network has now grown to a hundred thousand nodes. What is the explanation for such an explosive growth?

In his article, Crypto Tokens: A Breakthrough in Open Network Design, Chris Dixon demonstrates how crypto tokens are a fundamental innovation that aligns the incentives of network participants. It enables the deployment of an infrastructure, without central coordination.

The Nodle Network uses this mechanism to build a new kind of infrastructure: a decentralized wireless network that connects Bluetooth objects to the Internet through the connectivity provided by smartphones. In exchange for contributing to the network, the smartphones' owners are rewarded in NODL tokens.

The Nodle Network is also a way to accelerate the adoption of cryptocurrencies. As a matter of fact, people just need a smartphone and the app Nodle in order to participate in the Nodle network and get rewarded.

Abstract

The Internet of Things is growing exponentially, with estimates reaching more than 41 billion IoT devices by 2027, up from about 8 billion in 2019, and the demand for device-to-cloud and device-to-device connectivity is increasing at an equal or faster rate.

Today, connectivity for IoT devices is provided by central entities, such as network operators. Common Networks are centrally managed, capital intensive to deploy, and expensive to operate. High-density, short-range wireless networks leveraging Bluetooth technologies are too expensive and complex to be deployed by a central party.

The Nodle Network does not have this problem because the cost is already shared among all participants. It leverages the capabilities of existing smartphones, therefore repurposing an existing infrastructure..

With Nodle, smartphone owners rent the capabilities of their devices, such as Bluetooth mobile wireless connectivity, processing power, and sensor capabilities.In exchange, they

receive a reward in the form of the Nodle's native token, NODL. When users participate in the Nodle Network, their smartphones become Edge Nodes.

The Nodle Reward algorithm is based on the Edge Nodes availability and coverage. It incentivizes the Edge Nodes to be available when and where needed for the longest time possible to cover the large geographical areas . Due to the short-range nature of the Bluetooth protocol, it is currently impossible to cover the entire world surface with base stations. However, humans and machines can move to cover the required surface.

In addition to smartphones, other kinds of devices will integrate the Nodle Edge Nodes technology stack, Including fixed base stations running 24-7, and wireless routers, vehicles, and drones.

Most decentralized wireless networks are built to provide data connectivity. In essence, they play the role of network operators, with a decentralized architecture. The Nodle network differs from this as the Edge Nodes are also active agents. They embed a Nodle Virtual Machine that runs codes locally while interacting with other nodes. This allows for a range of new services that can be built by developers.

Vision

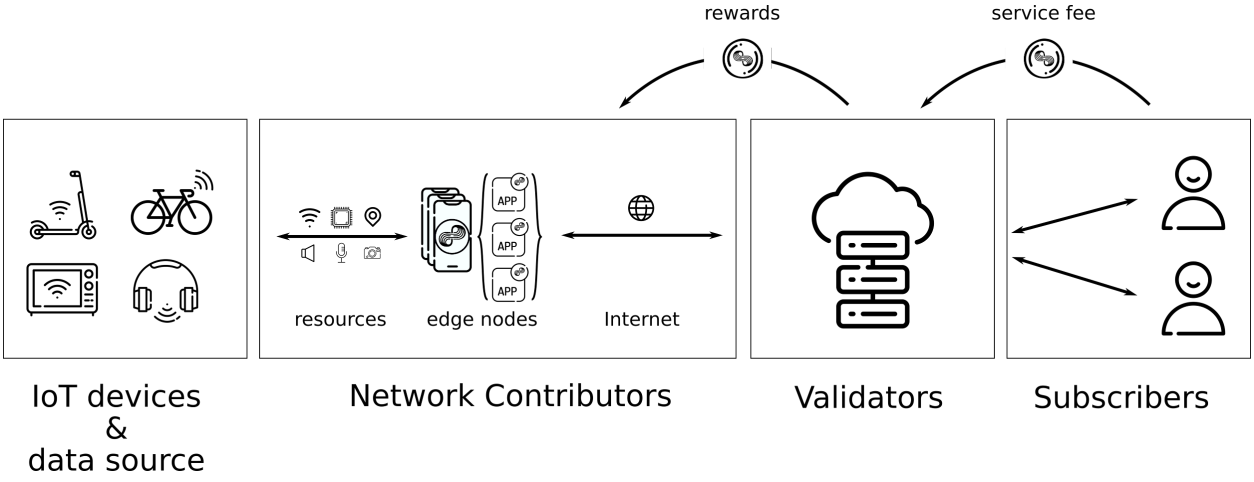
The vision for the Nodle Network is to build a decentralized data network providing connectivity and processing of micro-payments for the Internet of Things ("IoT"). The Nodle Network begins by providing delay-tolerant IoT connectivity and other services on top of the underlying infrastructure, and the Nodle networking stack.

Secure IoT is of the utmost importance moving forward. Nodle is actively engaged with chipset manufacturers to build secure elements within IoT devices, enabling cryptographic signing of payment transactions and secure transmission of data on the Nodle Network. Nodle envisions a world where machines autonomously transact with each other, sharing connectivity, data, and services.

Through distributed connectivity and utilizing existing infrastructure, we believe data costs and barriers to entry for connectivity can be reduced. We believe the Nodle Network is the first step in connecting billions of devices.

Architecture

The Nodle Network[1] is composed of different elements interacting together in order to connect IoT devices to the cloud while generating NODL rewards for every participant in the process.



Definitions

IoT Devices & Data Sources

IoT Devices or *Targets* are any device that can be connected to the Nodle Network through the resources available on the Contributors. Typically, IoT devices would embed a simple BLE chipset.

Network Contributors

The Network Contributors, at the edge of the access network, are devices that can interact with the IoT device, and act as a gateway for the Nodle Network; such devices are referred to as *Edge Nodes*. In our current rollout, most Edge Nodes are smartphones, thus the Nodle Network can be described as a crowdsourced IoT network. To become a Network Contributor, one simply has to embed the Nodle Software Development Kit (Nodle SDK) on devices that the contributor has access to. Contributors can be individuals, application developers, hardware manufacturers, or autonomous IoT devices that are seeking ways to monetize their connectivity. All Network Contributors are rewarded for participating in the

[1] *Covered by U.S. Patent No. 10,448,238, with Patents Pending in the United States, Europe, China, Brazil, Japan, and South Korea.*

Network (more details on the reward formula can be found in this paper below). Unlike traditional advertising SDK solutions that usually associate user devices with static advertising IDs and collect Personally Identifiable Information (PII), the Nodle SDK provides a privacy-centric alternative to monetize an app and does NOT collect PII from Edge Nodes. Once a user authorizes the Nodle SDK to run on their device, the device becomes an Edge Node by joining the Nodle Network and providing its local resources (such as BLE / Wi-Fi / mobile interface, GPS sensor, CPU & storage) to the resources of the global network. Participating to the Network consumes little energy and requires minimal interaction.

Nodle Network Clients

The Nodle Network Clients are people, or entities, that use the services of the Nodle Network. They interact with the Nodle Network by paying a fee in return for a service developed by the Network Developers and delivered by the Network Contributors while incentivizing the Network Collators.

Network Collators (Validators)

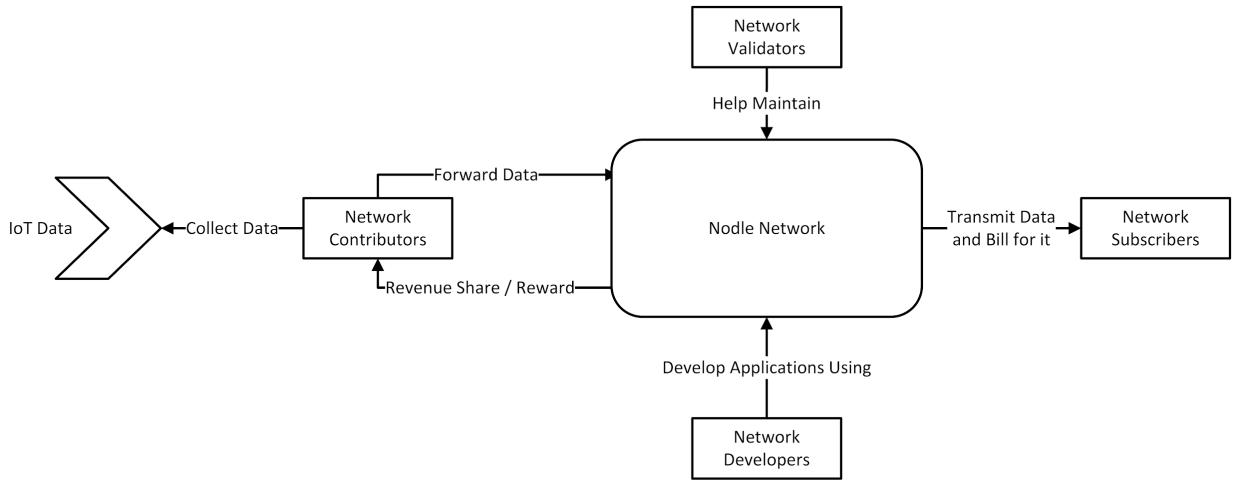
The Network Collectors settle the transactions on the Nodle Chain, constituting the *backbone* of the Nodle Chain. The role of a Collator is to maintain a distributed ledger (blockchain) called the Nodle Chain which is used to handle settlements between the network members and to operate the NODL token. Collators maintain the Nodle parachain by collecting transactions from users and producing state transition proofs for Relay Chain validators. Collators maintain a full node for the Relay Chain and a full node for their specific parachain. A Nodle collator is connected to both the Polkadot RelayChain and the Nodle parachain.

Edge Network Operator

An Edge Network Operator is an entity that manages a fleet of Edge Nodes, for example by deploying the Nodle SDK to apps on smartphones. An Edge Network Operator has the mission to ensure that the Edge Nodes are performing their roles, and needs to take measures to avoid fraud, and malpractices.

Network Developers

The Network Developers are technical users of the Nodle Network and its surrounding services. They develop custom applications that rely on the network or run on top of it.



Nodle Service Provider

A Nodle Service Provider is an entity which interacts with the Nodle chain to create services to which non-crypto applications, businesses or organizations can connect. NSPs create an abstraction on top of the chain to enable Web2 services to interact with the network. For example, consider an asset tracking service through which businesses can provision their own devices to be tracked by the network, consult the data from their devices through standard APIs, and pay for the service in USD. This service abstracts the complexity of committing NODL to finance smart missions running at the edge. The entity providing this service is a NSP.

Nodle Chain

The Nodle Chain is a core component of the Nodle Network, and it is in charge of payments via the Nodle token, between every party.

Payments

The Nodle Chain has its native token: the NODL token. The token is used to pay for network fees and serve as a currency between the different parties of the Nodle Network. Subscribers pay the network to connect the devices they are interested in. The Edge Nodes are rewarded for the service they provide. Additionally, NODL can be used with various services operated on the chain, and it also serves for governance purposes.

Smart Missions

In a future release of the Nodle Chain, smart contracts made in Web Assembly (WASM), will be supported. Any Network developer will be able to create Nodle network applications

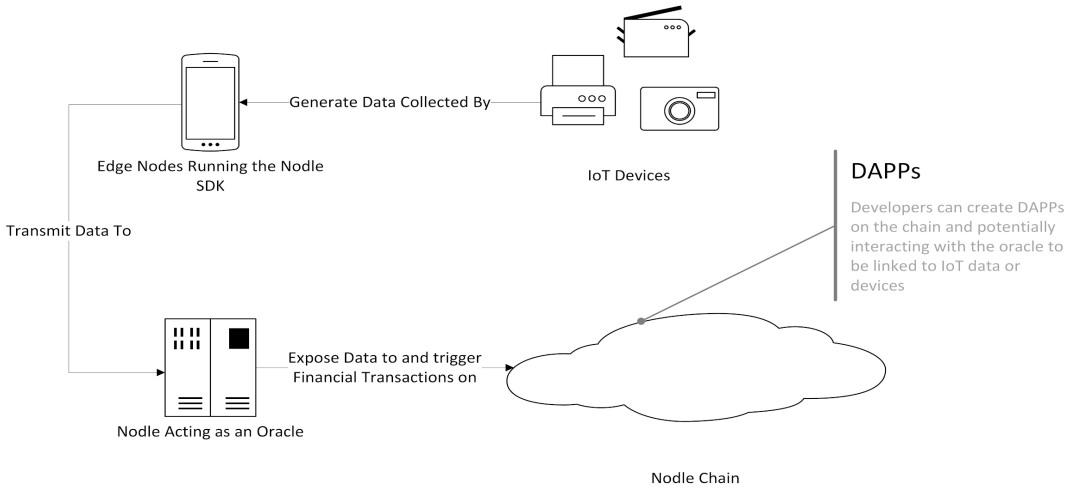
that run in the Nodle Chain. Smart contracts built by developers will be linked to interactions performed by Edge Nodes, called **Smart Missions**. A Smart Mission is an arbitrary task that a subset of Edge Nodes has been commissioned to perform; for example upgrading the firmware of an IoT device by staying next to it for two minutes, or locating a lost device in an area with no coverage. Smart Missions can be built with their logic code and reward mechanisms, as chosen by the developers. We expect this to open new use cases and processes for IoT applications and make specific operating tasks more cost-efficient and easier to perform.

Interoperability

The Nodle Chain became Polkadot's 11th parachain in March 2022. A parachain is a layer-1 blockchain that delegates its blockchain security to the layer-0 blockchain, Polkadot. Thanks to this, it is now possible for other parachain users to leverage the Nodle Chain capabilities.

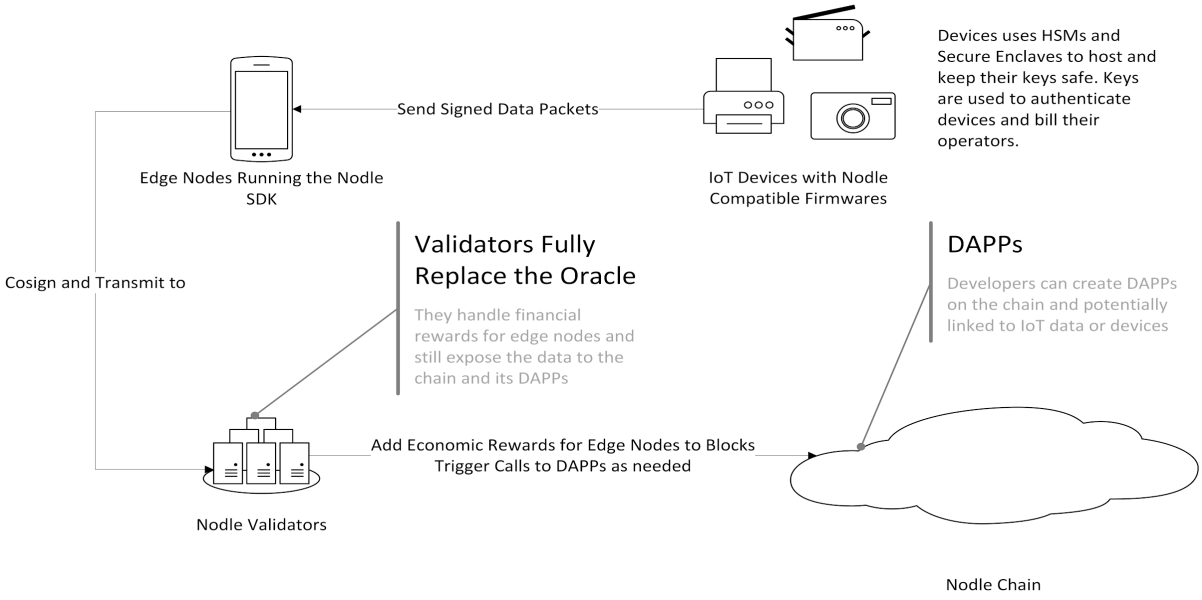
Path to Decentralization

Today the Network is composed of two parts: a decentralized ledger, i.e. the Nodle Chain, and a centralized oracle handling the interactions with the outside world. The Nodle Chain handles most tasks related to security, authentication and tokenomics. The oracle has the role of interfacing the data to the decentralized world. As we aim to support any existing IoT device and protocol, we our oracle verifies non cryptographic data.

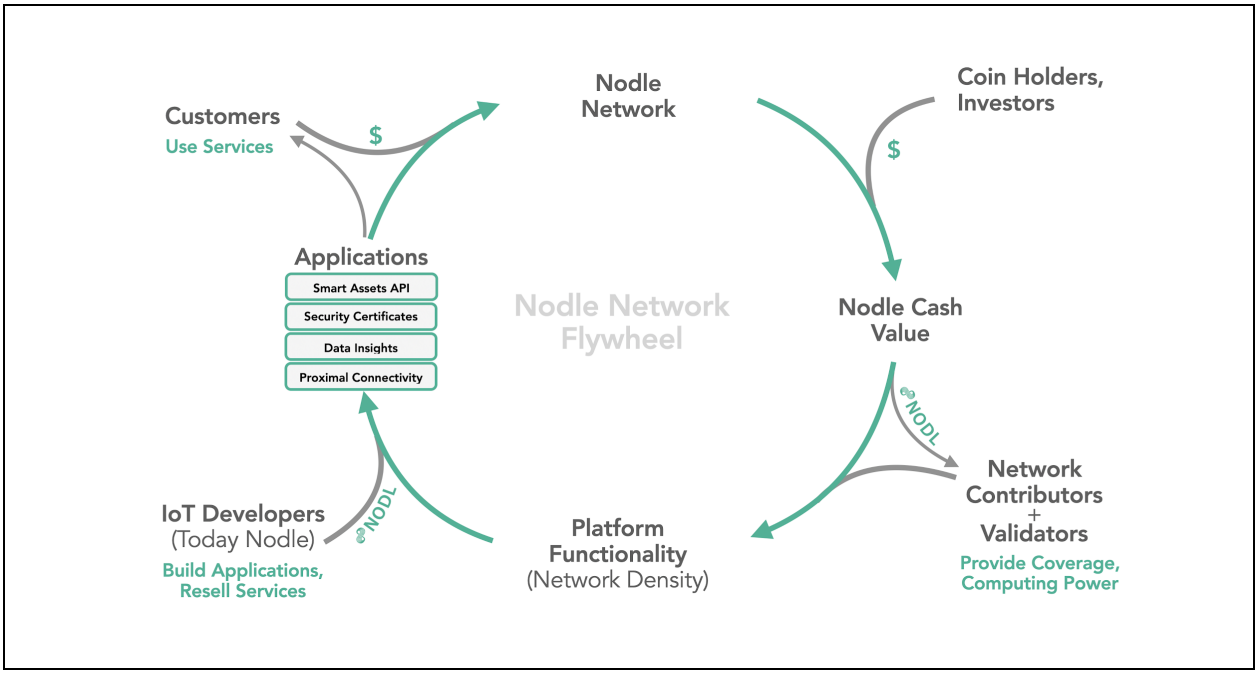


As we continue building the Network, we expect to see IoT devices that sign their data in a cryptographic way. This requires firmware to be integrated with manufacturer and IoT device's management tools. When it happens we no longer need an oracle, as data is verified cryptographically.

1. A decentralized way to connect IoT devices that sign their data in a cryptographic way
2. Integrated with manufacturers and device's management tools in a connectivity / IoT as a service fashion
3. We no longer interface with non cryptographic data (non trivial to verify) and thus no longer need an oracle



Nodle Economy



A Native Currency for IoT

The Nodle Network is an open ecosystem that incentivizes people to deploy their own wireless infrastructure. The Nodle Network Contributors are rewarded in NODL for their participation in the Nodle Network through a proof-of-connectivity algorithm. NODL is intended to incentivize the Network Contributors at an early stage, creating network coverage for subscribers. Developing sufficient coverage to provide reliable services presents the "chicken and egg" paradox: *There cannot be Nodle Network Clients without a network in which Network Contributors generate connectivity, and Network Contributors do not want to contribute to the Network without revenues from Nodle Network Clients.*

The Token Issuance

NODL tokens are periodically issued from the 12.6 billion NODL reward pool to reward Edge Nodes, network operators, and collators for their participation in the network.

As demand for the network grows stronger, the issuance will slowly decrease until rewards from the demand side take over. Ninety percent of the tokens will be issued within nine

years from the start of the Nodle parachain (May 2022), whereas the final tokens will be issued five years after.

The token Issuance follows an S-curve defined per the formula:

$$\sum_{k=0}^{t} I_k = \frac{I}{1+exp(\frac{-f(t-t_0)}{D})}$$

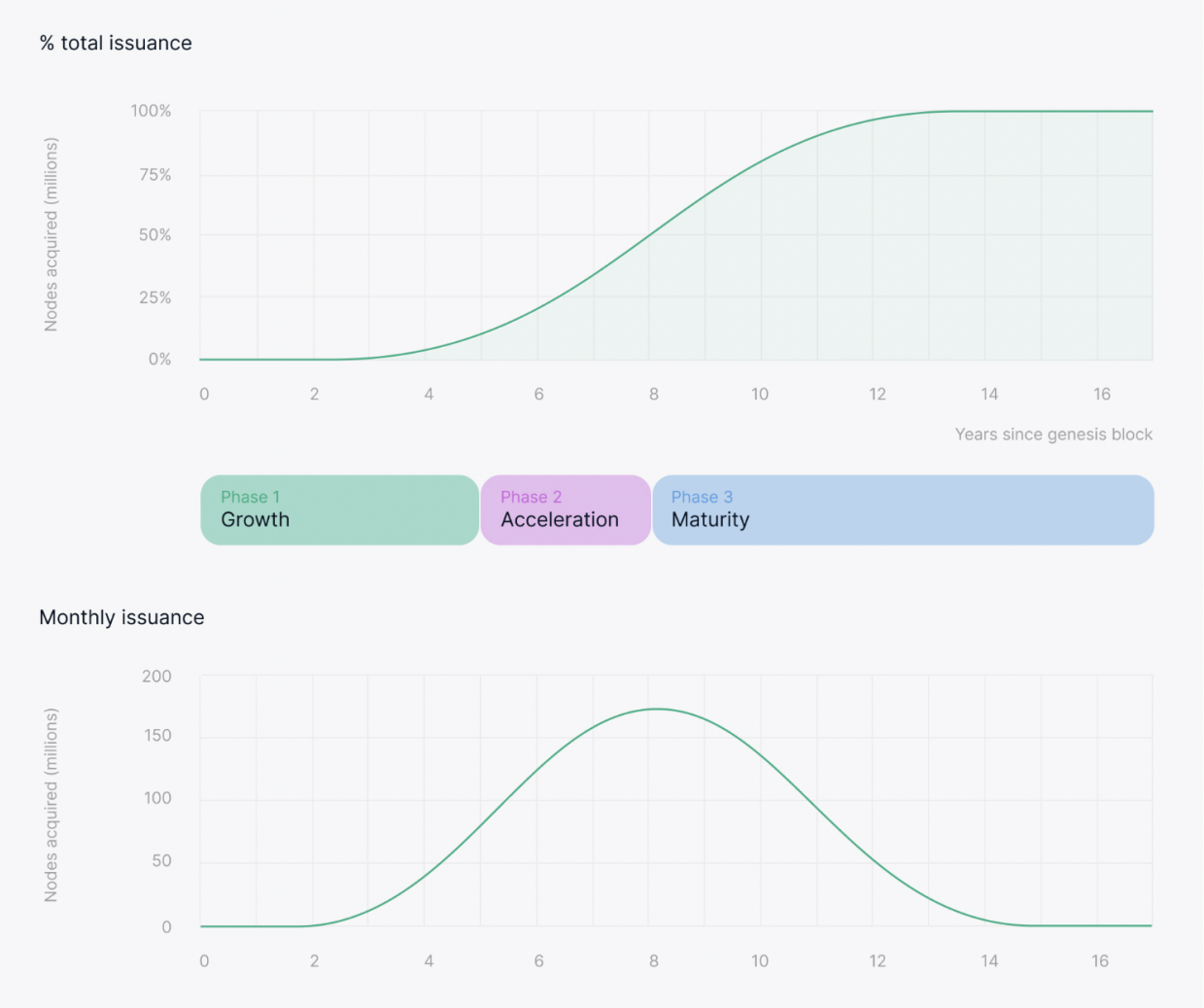
Where:

- *I* is the reward pool, of 12.6 billion NODL
- t_0 is the inflexion point for the network, which we set at 8 years, where demand will replace the rewards from actual consumption of NODL by network users in a timeline comparable to the time required by standard marketplaces to reach economical balance.
- $f(t - t_0)$ is a function that projects the timeline of the issuance $]\,0\,;\ 2\,t_0\,[$ to infinity $]-\infty;\ +\infty\,[$. For mathematical reasons that we will not detail here, for this purpose we will use the function:

$$f(t) = tan\,(-\frac{\Pi}{2}\,(1 - \frac{t}{t_0}))$$

- *D* is the deviation of the curve which is set to *D*=0.2

The S-curve for the issuance of coins ties to a normal distribution of tokens over the course of the issuance, as here:



Both curves draw three different phases:

Phase 1: Network growth. As the network grows, the token issuance, although modest, rewards early adopters through a built-in balancing mechanism: the smaller the network, the higher the reward, the stronger the incentive for early adopters to join and contribute. Nonetheless, if the network grows too fast, individual nodes will receive fewer rewards as the issuance is fixed and predictable. This mechanism allows for keeping the growth of the network under control, as the network needs some time to scale up with all the necessary tools, dashboards, and security measures.

Phase 2: Acceleration. As the network matures, the node growth accelerates as well as the reward issuance. At each reward event, the nodes still share a fixed allocation of tokens.

Nonetheless, as the value of the network increases according to Metcalfe's Law[2], the demand rewards begin to become a significant addition to the issuance reward, fueling the growth of the network.

Phase 3: Equilibrium. At equilibrium the network has reached the critical point that enables the network to be used in an economically sustainable way (Some use case include asset tracking, device connectivity, swarm computing, etc.).

NODL token distribution

Maximum Supply

The maximum supply of the NODL token is 21 billion, no additional tokens can be minted once the protocol reaches this number. Nodle was originally built on top of Stellar in 2018, where approximately 8.4 billion tokens were minted, it was then migrated to a native Nodle Chain in 2020. It then transitioned to a Polkadot Parachain in 2022. The rest of the tokens constituting the maximum supply will be minted according to the predictable mechanisms described in section "token issuance".

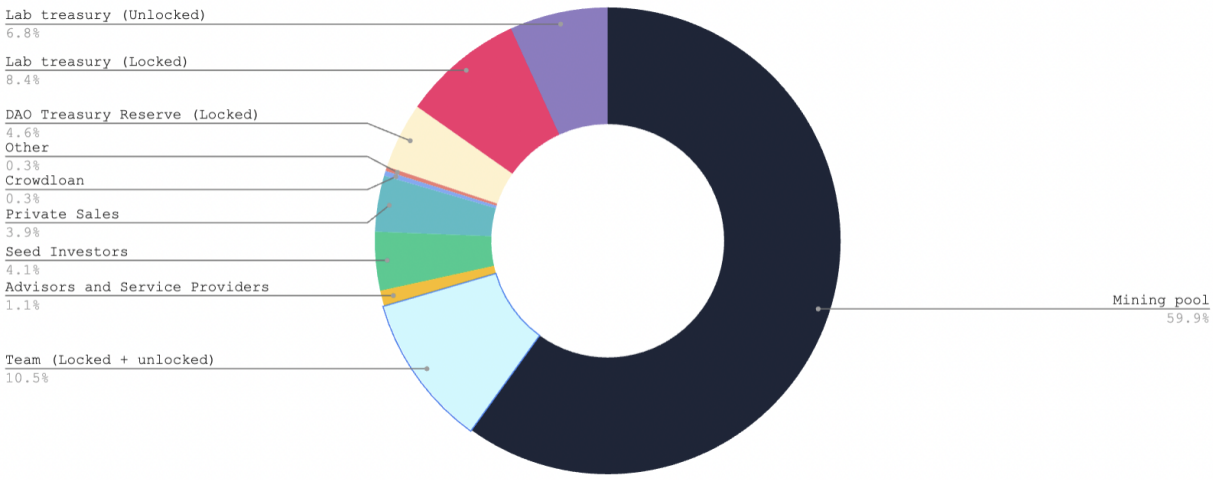
1: Original data on the stellar blockchain can be tracked here:
https://stellar.expert/explorer/public/asset/NODL-GB2Y3AWXVROM2BHFQKQPTWKIOI3TZEBBD3LTKTVQTKEPXGOBE742NODL

Token Allocation

In the early stages of the Nodle Chain, approximately 8 billion NODL tokens were minted and attributed to reward, incentivize the team and early investors; as well as to create a treasury aimed at financing and driving the growth of the network and its ecosystem. The first participants received tokens as network rewards incentives. As described above, the rest of un-mined tokens will be issued through the issuance mechanism described in the dedicated section.

The following is a snapshot of the Token Allocation upon migration of the NODL token to its Native blockchain in 2022:

[2] Metcalfe's Law is an empirical law formulated by George Gilder in 1993. It states that the value of a telecommunications network – whether the telephone network or the internet – is proportional to the square of the number of connected users of the system. It was later applied to leading social networks.



The treasury serves as a number of objectives:

- Incentivize third-party developers through grants to accelerate and drive the development of the network. Such grants will be allocated for building services on top of the network (such as asset tracking services, digital witnessing, geo-localized NFTs...), building infrastructure for the token ecosystem (gateways, interactions with smart missions, explorers, statistics, hardware wallets, corporate wallets, governance dashboards, security modules...), or to subsidize early usage of the network (in hackathons, or for subsidizing IoT startups to utilize the Nodle network, or to subsidize the use of B2C apps using the network such as the Nodle cash app.
- Create awareness around Nodle and its ecosystem in order to stimulate usage, sustain the utility of the NODL token, and educate users, developers and businesses.
- Serve as a way to compensate and retain the core team.

At first, the Nodle team controls this treasury. In the future, parts of it will be transitioned under the control of a Nodle DAO responsible for driving future evolutions of the network.

Allocation of Network Rewards

Distribution Between Network Stakeholders

The token issuance aims to reward edge nodes, operators, and collators. At each reward event, the NODL freshly minted is distributed among participants as follows:

- 80% are allocated for edge nodes. In fact, these 80% will be channeled to the NSP (or Nodle Service Provider, the equivalent on the Nodle network to an ISP or

Internet Service Provider). The NSP is responsible for deploying nodes on behalf of the network. Currently it means publishing the SDK and partnering with publishers who will integrate the SDK into their app. For example, the Nodle company is the NSP for the Nodle Cash App. NSPs are businesses: they are in competition for acquiring nodes - publishers will go to the NSP that offers the best deal to them. NSPs are also responsible for the nodes they deploy. In particular, they ensure the Nodle SDK is deployed in apps that respect privacy regulations. They also make sure they behave according to edge node operators responsible for deploying the nodes to the network.

- 10% are allocated to build the protocol. Until the Nodle DAO exists, these are transferred to a wallet controlled by the Nodle council. Once the Nodle DAO is created, the DAO will reward protocol builders through token grants or other means deemed appropriate by the community.
- 10% are allocated for collators.

Allocation to Edge Nodes

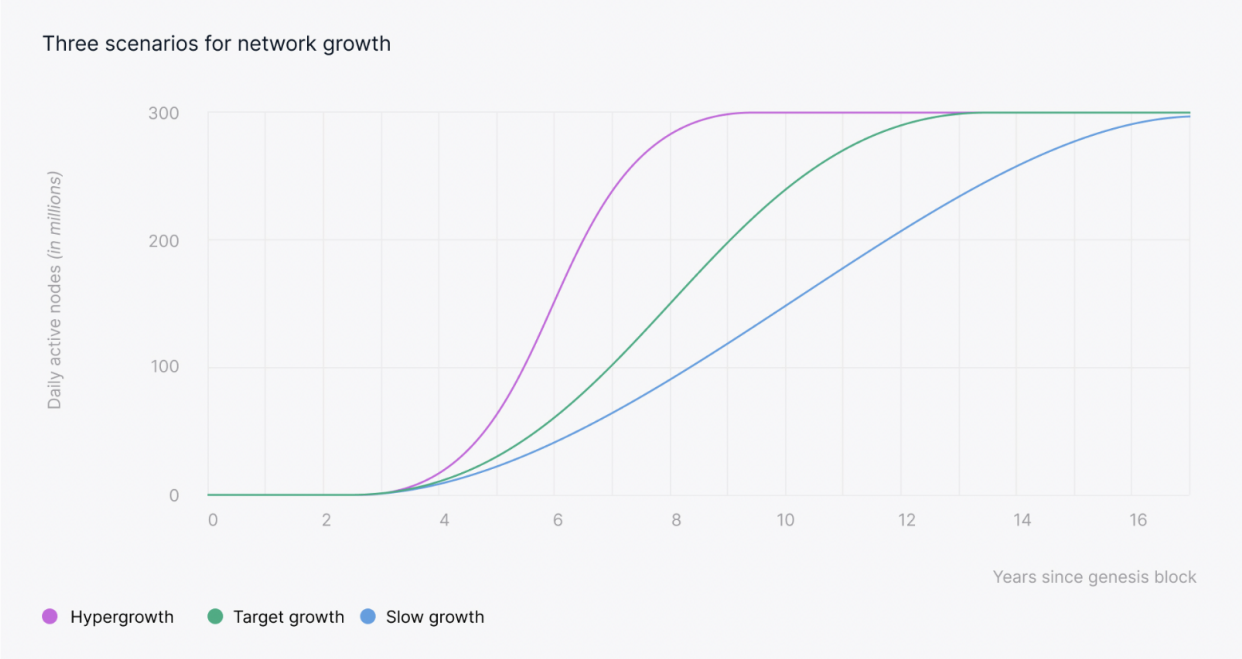
It's worth looking at the reward per node in different growth scenarios to understand the sustainability of the model. For the network to be successful, it needs to provide geospatial availability where the demand is, which will widely evolve over the lifetime of the network. For example, for the asset tracking smart contract, most assets will come from the logistics supply chain, with a high density of smart devices to be tracked in urban areas, in hubs such as commercial harbors, or in controlled environments such as construction sites.

These sites will require a high density of nodes to capture the required data, while other areas will work with a best-effort network. Consumer use cases (such as geolocalized airdrops of NFTs) will not require geospatial incentivization at all. For that reason, in the first phase of the network, the purpose of the rewards will be to incentivize a broad coverage of urban zones, which growing demand will then naturally shape. With this model in mind, and taking into account a conservative range for a BLE antenna (30 m in urban dense areas, although in rural areas it can go up to 200 m), we want the network to be able to incentivize enough nodes to cover all urban areas on Earth at least once a day. The market will then shape this idealistic target, as all areas are not equal from the standpoint of the demand.

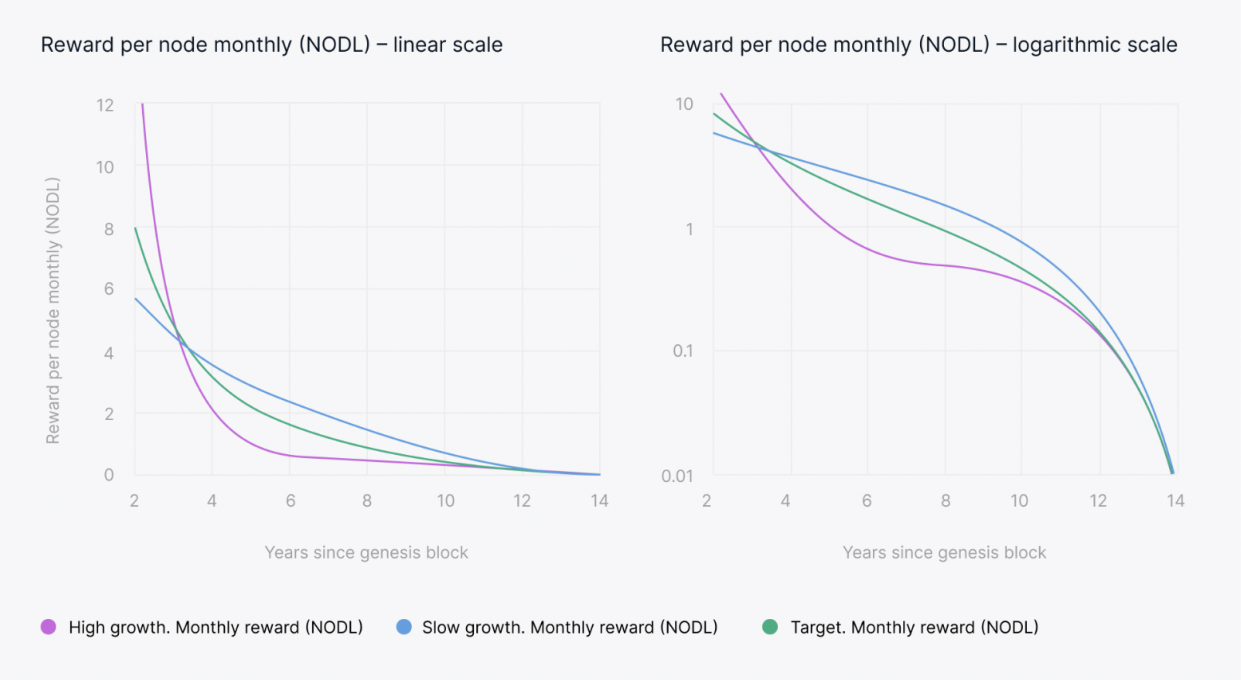
The number of daily active nodes is actually higher than the number of smartphones connected daily to the Nodle network, because statistically, the Nodle SDK will run as several distinct nodes on the same smartphones, in case the smartphone runs several apps embedding the SDK (for example, the Nodle Cash app and another partner app). We estimate the target is then in the vicinity of 300 million smartphones. As a reference, leading mobile advertising networks claim they can reach more than 2 billion smartphones daily.

At any given time, average rewards for edge nodes will depend on the size of the network. For reference, we can highlight three hypothetical scenarios for network growth leading to 300 million daily active nodes, and project what it means in terms of reward for individual nodes:

- A hypergrowth scenario, in which the network grows vert quickly. The risk in this scenario is issuing all coins before the network is mature enough to generate enough demand to reward the network contributors, in which case the network would be at a risk to recede.
- A target scenario for which we design the issuance. In this target scenario, the network reaches maturity in about 12 years, over the duration of the issuance.
- A worst-case scenario, in which the network grows slowly. The risk is to issue all coins before the network has reached the minimum coverage to sustain demand.



In each scenario, the supply of NODL at each reward event remains fixed (on top of which the Nodle project has reserves to adjust rewards, and demand will also fund edge nodes). Based on the size of the network, the reward per node will vary. Whether these rewards match minimal edge nodes expectations (for example competing with monetization they expect from other mobile monetization options) will depend on the price of the token:



The rewards formula for edge nodes

For edge nodes, the purpose of the rewards is to incentivize the nodes to:

- Maximize their uptime wherever they are.
- Be geospatially available where the demand is. Demand can actually grow only when and where there is a network strong enough to offer a level of service. The rewards need to incentivize the nodes to spread across areas as large as possible, while maintaining a target density.
- Enable as many capabilities as possible. As a beginning, the SDK requires Bluetooth and geolocation activated. Even these two simple features can rely on different libraries and authorizations on android and iOS. Activating one or the other is the choice of the SDK, but it will be rewarded for enabling the most permissions. As the SDK also enables operations at the edge, sharing its computing, storage or bandwidth resources at the edge, the SDK will have the opportunity to limit these resources. The more active the node, the higher the rewards.

We mark $H_K = 80$ the pool allocated to edge nodes at each reward event. The individual reward *h(n)* attributed to each node *n* will be computed as: $h(n) = \frac{H_K}{N}.f(m_n^t, m_n^g, m_n^c)$. Changing the balancing function would require a consensus vetted by the community.

Time-availability Factor m_k^a

For a given reward event, each node will be rewarded proportionally to its uptime since the previous reward event. Between two reward events (which as of May 2022 is a 4-hours period), the window is divided into 90-second slots. Each slot is allocated an equal share of the total reward available Hka. For any slot, a node is considered available (or up) if it performs at least one Nodle-related activity such as a Bluetooth scan, configuration fetching, or data upload. An oracle will then evaluate which nodes participated in the slot and distribute the rewards equally between the nodes active in that slot.

Geospatial-availability Factor m_k^g

Compared to traditional telecommunication networks, the Nodle network is unique in the way it incentivizes moving nodes and provides ad-hoc and best-effort connectivity. The reward formula is then designed to incentivize physical exploration and movement, as well as deterring farms of devices located in the same area.

For this purpose, at each reward event rewards are equally distributed among hexagonal tiles with an average hexagon edge length of 66m, which corresponds to a resolution of level 10 in the h3 specification[3]. The reward will be distributed among nodes performing at least one Nodle-related activity between the two reward events. This has several implications:

- Between two reward events, the nodes participate in rewarding all the tiles they scout. There is a limit in the number of tile rewards a single node can claim. Nodle aims to create a network for connectivity leveraging existing hardware, thus removing environmental pressure generated by deploying, maintaining and supplying electricity to a new hardware infrastructure. To align incentivization mechanisms with this purpose, the issuance caps the maximum number of tiles that can be claimed by a single node to the first 400 tiles they explore. This limitation reflects the maximum possible scouting between two reward events at an average speed of 30 Kmh (or 19 Mph), which is consistent with human-powered vehicles, such as bikes.
- The higher the density of nodes on a given tile, the smaller the individual rewards: nodes are incentivized to cover the widest area possible. New publishers deploying a fleet of edge nodes receive better incentives when providing coverage in an underserved area.

This mechanism naturally creates a map of warm and cold tiles, depending on network density. Nodes are incentivized to discover as many cold tiles as they can between two reward events.

[3] https://h3geo.org

Geospatial-availability Factor m_k^c:

For now, the capabilities multiplier is simply defined as 0 or 1. 1 is the baseline for nodes available to the network. 0, as of the time of writing in July 2022, is reserved for network users who can provide their own fleet of edge nodes but activate these nodes only to communicate with their own devices and do not share the connectivity with the Nodle network. This exactly nullifies the NODL rewards they are being issued, as they do not contribute to the network.

In the future, capabilities multipliers might include special capabilities such as onboarding HSM for smartphones. Nodle currently runs mainly on Android and iOS smartphones. Although not currently supported, a Linux implementation also exists, as well as portability on not-smartphone Android devices. Research is currently being carried out for special miner nodes that could deploy – and be rewarded for – new capabilities on the network, such as establishing reputation for regular nodes, or onboarding LoRaWAN antennas.

Compartmentalization Per Region

It is likely that different regions of the world will see network deployment at different paces. As edge node operators and node deploying publishers (typically mobile apps) typically operate at a country level, there is a sizable risk for rewards to be biased towards a specific region. For example, if a super-app in a highly populated country deploys the SDK before the network reaches its maturity phase, it would reap most issuance rewards for the years to come, thus decreasing incentives to build coverage elsewhere. There is consequently an option, not activated at the moment, for the network to compartmentalize the rewards per country. Activating this option would require a consensus vetted by the community.

This compartmentalization is designed as a way to level opportunities across regions independently from the strength of the economy of a given country. Each country will be allocated a number of coins at each issuance event in proportion to their share of voice in the global population. This mechanism separates rewards by country, so that first joiners in any given region can be rewarded for their higher incremental utility than new nodes in already populated regions. For example, the US represents 4.25% of the global population. Hence at any given reward event, nodes in the US will reap 4.25% of rewards. Unattributed rewards will be shared among participants in other countries.

Smart missions

Smart Missions stem from a massive pool of use cases broadly described as swarm computing. In the first years of the network's existence, smart missions should be

primarily used by the IoT industry, providing connectivity to smart devices at the edge. Essentially, the network leverages nodes to connect things with other things. As of 2022, the network is also developing its ability to connect things with people through nodes, where people are the owners of the smartphones acting as the nodes.

Most Smart Missions will rely on a specific feature of the Nodle network: Proof of Connectivity.

The Economy of Mission Builders

Smart Missions are written and deployed on the Nodle Parachain. Consequently they are open-source and their inner workings are transparent. Smart missions can be reused. Nodle Service Providers who create services on top of the chain can write their own Smart Missions or reuse existing Smart Missions published by mission builders.

Mission builders are developers who write the code for Smart Missions. As they create this code, they can include royalties to be paid as their code is used for Smart Missions, enabling an economy for mission builders. It is likely that some Smart Missions will include royalties and others will not, all in the spirit of the free software movement.

It is expected that revenue generated by some Smart Missions will decrease until they disappear, as some NSPs will reuse them to accelerate the creation of their service, but will internalize and rewrite the Smart Mission after a while. This means being the first to write code that develops the ecosystem creates value, which is rewarded but does not automatically create annuities on the network for an indefinite period of time. Other Smart Missions, on the contrary, will rely on access to specific resources accessible only by the Mission builder, which means copying the contract will not provide the same value of the original mission. In the long run, these mission builders will enable revenue for themselves without the need to set up their own NSP and having to deal with customers for that NSP.

A Decentralized Network for IoT

Compared to 5G networks or dedicated Low Power Wide Area Networks (LPWAN) provided by telecom operators (which includes technologies such as LoRaWAN, NB-IoT or Sigfox), the Nodle Network does not face any hardware infrastructure development cost. As a consequence it creates an economically viable long term opportunity to connect a new array of devices, including pallets, vehicles, packages, meters, containers, actuators, cameras, and sensors.

Until now, companies with major logistics challenges (e.g. transportation, delivery, distribution, urban services such as waste management, water or energy supply, traffic monitoring, stock optimization) could only connect devices carrying high economic value. The smartphone infrastructure allows to enable use cases specific to its properties: as edge nodes are mobile, one edge node can provide connectivity to devices along their whole journey - for example, tracking a package entails a handful of smartphones from key

employees onboard the Nodle SDK, whereas a fixed network would require antennas in all areas crossed by the package.

Because the number of edge nodes is proportional to population density, it is higher in urban areas, whereas 5G networks require the expensive deployment of thousands of antennas in such areas. This network has worldwide coverage (no roaming), high bandwidth, high precision from the smartphone geolocation, and the Nodle Virtual Machine potential to execute code at each node to interact with surrounding devices.

The Asset Tracking Contract

The first Smart Mission to run on top of the Nodle Network is an asset tracking service provided by the Nodle team, in closed beta as of July 2022. Nodle partners provide a fleet of smart devices, communicating through Bluetooth Low Energy. This provisioning takes the form of a smart contract of Smart Mission, where the organization controlling the smart devices creates a bounty for interacting with the device. With asset tracking, this bounty specifies the data to be gathered (the payload defined in the iBeacon specification, which encapsulates the encrypted identifier of the device along with its geo-location provided by the Nodle network), as well as the reward for capturing the data. Various use cases will value different frequencies and timeframes in which data will be gathered. The reward is defined in the smart contract to take it into account. Each node running the SDK at the edge can access the smart contract, including the list of target nodes and their rewards, and pick the missions they want to participate in. Edge nodes frequently performed BLE scans to identify the target devices through their payload. Once located, the data is sent back to the owner of the device, along with the Proof of Connectivity, through an API. If the Proof of Connectivity is validated, the payment is delivered from the smart contract to the node. Beyond asset tracking, the Nodle Network will become an open ecosystem for innovation at the edge. Any IoT developer will have the tools to write Smart Missions on the chain that will then be executed at the edge by the nodes of the network, enabling complex interactions between smart devices and the nodes through the Nodle Virtual Machine.

Using Proof of Connectivity to Bring People Together

IoT connects machines to machines and things to things. Through smartphones and apps such as the Nodle Cash App in which users consent to connect to the network, Nodle can also connect things to humans, or humans to humans, which creates a whole new category of demand. The Proof of Connectivity guarantees that the connection happened. Without Proof of Connectivity, most of the following use cases are purely marketing, in which users are ignorant of what happens backstage, becoming in effect “the product” in an exchange

of value between an advertiser and a publisher. With Proof of Connectivity, users become economic players.

Use Cases Include:

- **Foot traffic through direct payment**: The client of the service is a business that wants to increase foot traffic. It pays the user in NODL for coming to their place. If the brand is strong enough, it can also reward the user with NFTs either for their value as a unique work of art or as the key to a loyalty program. The Proof of Connectivity is established between a smart device set up by the business owner or a QR code scanned by the user.
- **Sponsored activities and event management**: The client of this service is an event organizer who wants to provide a unique conference experience to their attendees. Example: a crypto project wants to sponsor a conference and airdrop digital goodies' to the attendees. When the attendees purchase a ticket, they receive an NFT from the conference organizer on their Nodle Cash app wallet. The sponsors of the conference have added benefits to the NFT, such as a NODL allowance.
- **Proof of Participation (PoP):** The clients of this service are the ones who get paid, and the participants are the ones who pay in NODL, while they earn a PoP. For example, a street performer wants to get paid for playing guitar when people enjoy her music. The street performer uses the Nodle Cash app to create an “Activity” labeled “Guitar Street performance” at a specific location. People can earn a PoP NFT if they are around and thus reward the performer.

Combined, these use cases draw the picture of an ecosystem for Nodle that goes well beyond IoT. The Nodle Network creates an economical and technical framework to enable secure and private digital connection between any physical entity, whether a thing or a person, through the nodes that compose the network.

Commercial Applications

The Nodle Network is a multi-sided platform, and it is anticipated that developers will build applications on top of that network, much as users of modern wireless networks run a wide variety of applications on top of those telecom networks.

Several use cases and industries have been identified as potential usage of the Nodle Network.

These applications include:

Asset Tracking: Asset tracking is estimated to be a USD $27.1 billion industry by 2023[4]. Locating and connecting small sensors can provide greater situational awareness and improve efficiencies to industrial and logistics enterprises.

Sensor data: Sensors gather information like status, environmental data, and usage, and then transmit information through the Nodle Network. For example, the Nodle Network can monitor temperature and humidity sensors for food safety, or combined with analytics software can monitor machine health and provide alerts for preventive maintenance. In these ways, the Nodle Network can be used to reduce inventory costs and losses for perished or damaged items by optimizing first in, first out for goods in warehouses.

Consumer Electronics and Wearables: The Nodle Network enables users to locate lost electronic devices without having to rely on cellular service. By uploading a device ID, users can locate that device using a simple software app. Further updates to the network allow these devices to communicate with the cloud. The Nodle Network can locate consumer devices like headphones and wallets, or industrial machines like vehicles and mobile equipment. Nodle supports ready-made Bluetooth sensors, and trackers, along with most Bluetooth 4.2+ devices. Consumer electronics with Bluetooth (e.g. headphones, speakers, TVs, laptops, and smartphones) can all be discovered and located by provisioning the device on the Nodle Network. Two-way communications may allow Nodle Subscribers to remotely disable devices that may be stolen.

Metering Data: Low power, wide area networks (LPWANs) and LoRa are historically used for smart metering. Existing deployments suffer from high interference in urban environments[5]. The Nodle Network's high density of access points and smaller transmission distances can enable smart meters to transmit at lower power, lower cost, and with less interference. Bluetooth 5.0 standard will open up more industrial use cases, allowing metering with an increased range of up to 1 kilometer[6]

Healthcare and Pharmaceutical: The healthcare and pharmaceutical industries are highly regulated. The tracking of items like accessories and medicines has become a focus for enterprises and health agencies looking to ensure consumer safety. The Nodle Network provides a global, cost-efficient logistics monitoring network that can track the flow of pharmaceutical inventory, monitor local environmental conditions and provide secure audit chains.

---

[4] https://www.prnewswire.com/news-releases/global-asset-tracking-market-2018-2023-total-global-asset-tracking-market-will-reach-27-1b-by-2023--growing-at-14-8-cagr-300653648.html

[5] https://www.researchgate.net/publication/305909564_Experimental_evaluation_of_interference_impact_on_the_energy_consumption_in_Wireless_Sensor_Networks

[6] https://blog.nordicsemi.com/getconnected/tested-by-nordic-bluetooth-long-range

Smart Cities: The Nodle Network can provide street level data about metering, sensor data (e.g. temperature, humidity, UV index, radiation, air quality/pollution, etc), foot and auto traffic. The Nodle Network can also provide weather data for high-resolution models enabling analysis at a resolution of meters and minutes (versus kilometers and hours for traditional systems).

Population Density, Foot Traffic, Vehicle Density and Traffic: The Nodle Network can provide information on the density of IoT devices in a specific location at a given time.

IoT Devices Audit: The Nodle Network can be used to query existing IoT devices in order to collect specific information.

Proof of Location: Many services, such as ridesharing and delivery, require the position of a device to be confirmed by a third party. The Nodle Network's decentralized infrastructure can provide proof of a device's location validated by multiple nodes acting as witnesses.

Agriculture: Agricultural IoT is used to monitor livestock location and health, along with weather and soil sensors. Farm-based sensors can be aggregated to give insights on crop yields, environmental impact, and monitor consumables like water and fertilizer. The Nodle Network, paired with Bluetooth 5 on supporting devices, gives the range and bandwidth required to affordably and reliably deploy agricultural IoT. Alternatively or in combination, the collection of data can also be performed using standard BLE 4.0 modules and flying drones.

Automotive and Geolocation: The auto industry is looking at various ways to improve the location of vehicles. When GPS is not working or lacks accuracy in congested areas, underground or in tunnels, the Nodle Network can provide geolocation information by using anchors like beacons or fixed IoT devices.

Indoor location: The use of beacons and GPS combined with algorithmic probabilities, machine learning and triangulation can produce very good results.

Construction: Most construction environments are GPS-denied, metallic, and dynamic which means connectivity is next to impossible with existing technology. In other industries, sensors help an industrial team maintain safety, quality, and productivity but construction has been left behind because of solution scarcity. The Nodle Network's delay-tolerant capability and smartphone-enabled solution bring to the construction industry a much needed technology.

Insights and market intelligence: The Nodle Network can provide anonymized, aggregated data providing insights into real world economic data. The global market

for “Alternative Data'' and related analytics is currently estimated at $130bn, and is expected to grow to over $200bn by 2020.[7]

Luxury Goods: The Nodle Network can provide location and authentication data for jewelry, watches, luxury brands items, suitcases and fine art.

[7] https://www.cfasociety.org/cleveland/Lists/Events%20Calendar/Attachments/1045/BIG-Data_AI-JPMmay2017.pdf

Conclusion

The Nodle Network is a programmable and decentralized swarm of smartphones that receive instructions from transactions on a blockchain, the Nodle Chain. This framework unleashes a number of applications. The first obvious use case is the creation of a decentralized wireless infrastructure, with a focus on tracking and connecting IoT devices. However, other applications involving the generation of proof-of-participation or proof-of-location can also be developed by third-party developers.

For the service they provide, every smartphone is rewarded with NODL tokens. The Nodle Network enables people to earn crypto as passive income. It is an inclusive approach that preserves people's privacy while rewarding them for their participation.

With more demand for connectivity services at the edge, users could have a new way to monetize their smartphone capabilities without providing personal information.