DePIN

AND THE

PLATFORM ECONOMY

Today, we depend on centrally managed infrastructure for essential services such as internet, computing, utilities, and ride-hailing. These services are centralized because of the difficulty of creating and maintaining them, with high upfront costs and complex coordination. By leveraging blockchain's transparency and smart contract automation, it is possible to offer these services in a decentralized way. This trend is called Decentralized Physical Infrastructure Networks (DePIN) and we believe it is set to challenge centrally managed incumbent businesses across industries like Telecommunication, Technology, Utilities, Services and more.

JASPER DE MAERE
Research Lead at Outlier Ventures

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Transforming the platform economy to pave the way for revolutionary Web3 products.

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DePIN has seen early success with digital infrastructure including storage and connectivity. We believe that through the decentralized coordination of physical infrastructure and resources more business models are about to be disrupted. The next wave of DePIN will revolve around data and services that are increasingly built on special purpose blockchains and tailored SDKs.

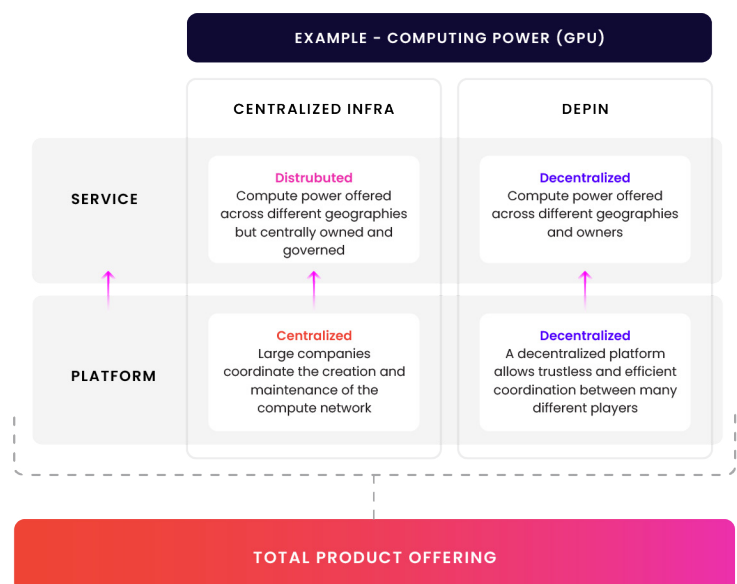## UNLOCKING THE DECENTRALIZED PLATFORM

Business models that operate physical infrastructure are made up of two parts.

First is "the platform", the infrastructure layer that coordinates the economic activity between the physical resources or nodes. **Second** is "the service", referring to the economic service or product as a result of coordinating these resources in a specific way.

Traditionally, the platform on which these businesses are built have been centrally organised due to the complexity of creating and maintaining these platforms. Blockchain technology changes this. Through technological innovation, the platform can become decentralized by leveraging the trustlessness and automated execution of the blockchain.

Replacing the centrally coordinated platforms with a decentralized alternative eliminates

costs and creates a more direct route from resource to users. All of this leads to the optimization of existing services and an entirely new category of services becoming economically viable, previously impossible due to high costs and inefficiencies related to centralized platform coordination. This breakthrough forms the basis for Web3 and when dealing with physical resources is called decentralized physical infrastructure (DePIN).

EXAMPLE - COMPUTING POWER (GPU)

	CENTRALIZED INFRA	DEPIN
SERVICE	**Distrubuted** Compute power offered across different geographies but centrally owned and governed	**Decentralized** Compute power offered across different geographies and owners
PLATFORM	**Centralized** Large companies coordinate the creation and maintenance of the compute network	**Decentralized** A decentralized platform allows trustless and efficient coordination between many different players

TOTAL PRODUCT OFFERING

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THE CATCH-ALL TERM

As the space grows, DePIN turns into a catch-all term.

DePIN is made up of physical and virtual infrastructure networks that serve as the framework supporting operations, distribution and management of services and resources. Irrespective of the network, we classify as DePIN when they do both of the following:

1. Use crypto-based, **decentralized coordination** to create and maintain infrastructure.

2. Rely or have an i**mpact on physical nodes** in the real world (for ex. Servers, sensors, drivers, housing, etc).

DePIN is maturing and so is the scope of where decentralized infrastructure networks can apply to.

DIGITAL INFRASTRUCTURE

The DePIN movement initially focused on hosting digital infrastructure (storage, compute, wireless communication...). Traditional digital infrastructure is centrally run and has high barriers of entry due to capital formation and upfront costs to enter the space. It is the perfect space to experiment and showcase the potential of decentralization driven by utility tokens. A necessary step setting the stage for broader applications addressing similar issues.

THE NEW FRONTIER

The applications built using DePIN are expanding outside of the scope of traditional physical infrastructure into verticals like data collection, AI infrastructure and the platform economy. We see two drivers behind this.

*   **The purpose of physical infrastructure is changing - Move to Data Networks**

    DePIN is transforming the purpose of physical infrastructure beyond traditional roles, shifting from digital services to data extraction. By creating a network of decentralized nodes, hosts can provide a way to extract valuable data. In doing so, DePIN is redefining infrastructure's value proposition, merging connectivity with data generation.

*   **The definition of physical infrastructure is changing - Move to Service Networks**

    The definition of (critical) physical infrastructure is extending beyond traditional physical constructs. Over past decade, society has increased its economic dependence on service networks (socials ie. Facebook etc, Services, ie. Uber etc.,...). These networks historically relied on centralized entities coordinating social economical activities. DePIN is moving from digital infrastructure into service networks.

WHY NOW?

Beside the obvious technical improvement in blockchain-based systems, we believe there are five key drivers, pushing DePIN adoption forward on both the demand and the supply side.

Cost curves - Cost curves of compute and hardware have come down drastically, making small scale node operation economically viable. (**Supply** & **Demand**)

Usability - AI-enabled front-ends are falling into the hands of consumers, improving decision making and management of DePIN networks and tokens. (**Demand**)

Privacy & Security - Since the diffusion Gen AI across billions of users globally, the concerns with privacy and security of data and services has drastically increased, leading to more user exploration for alternative solutions. (**Demand**)

Data Generation - There is an increase in data generation across network nodes propelled by the movements of AI and open-source. (**Demand**)

Utility tokens - tokenomics create the backbone of the incentive structure behind DePIN. After a few cycles, we believe that the expertise to create utility tokens structures is mature enough for many DePIN networks to successfully be bootstrapped. (**Supply**)

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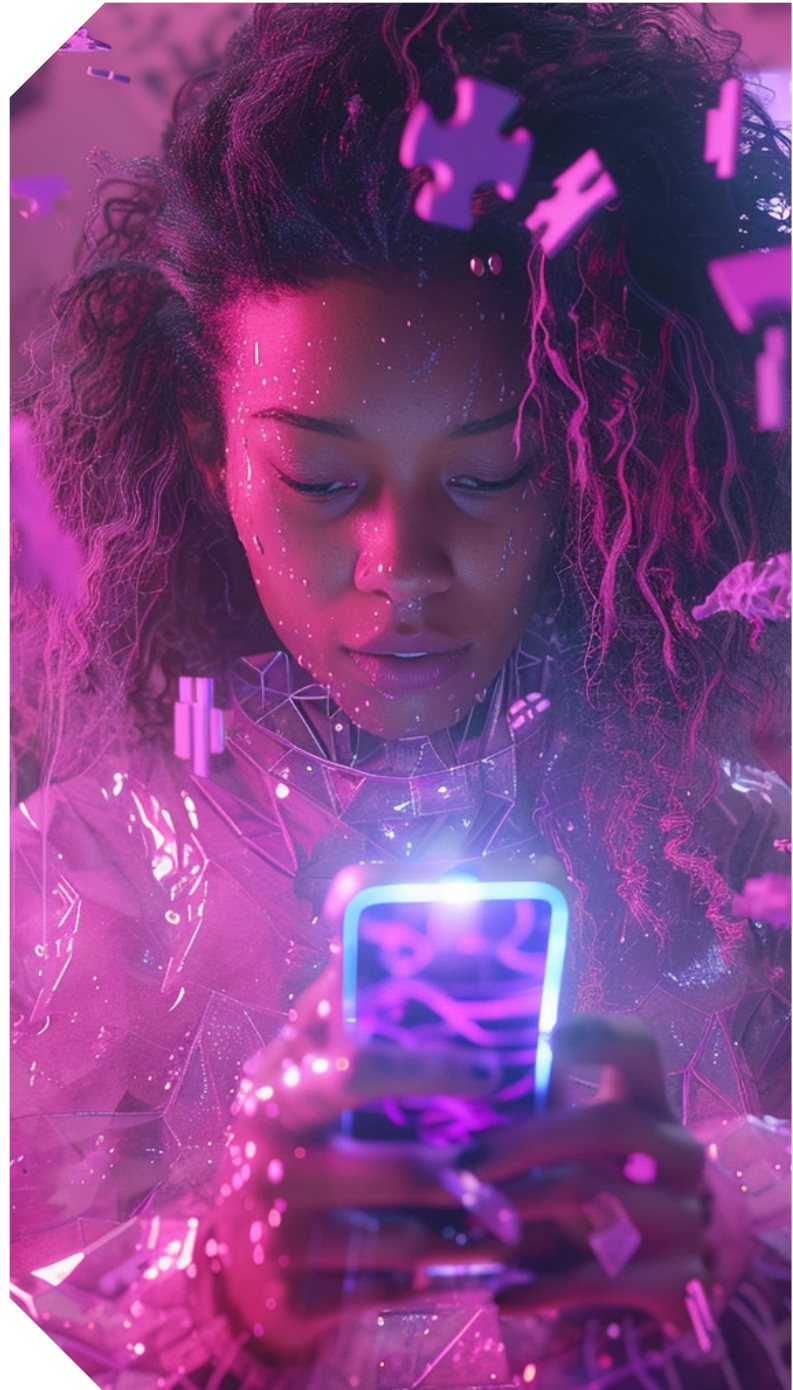
DePIN, a Combination of Platform and Service

"Decentralized Physical Infrastructure Network" is a very loaded term, so let's dissect:
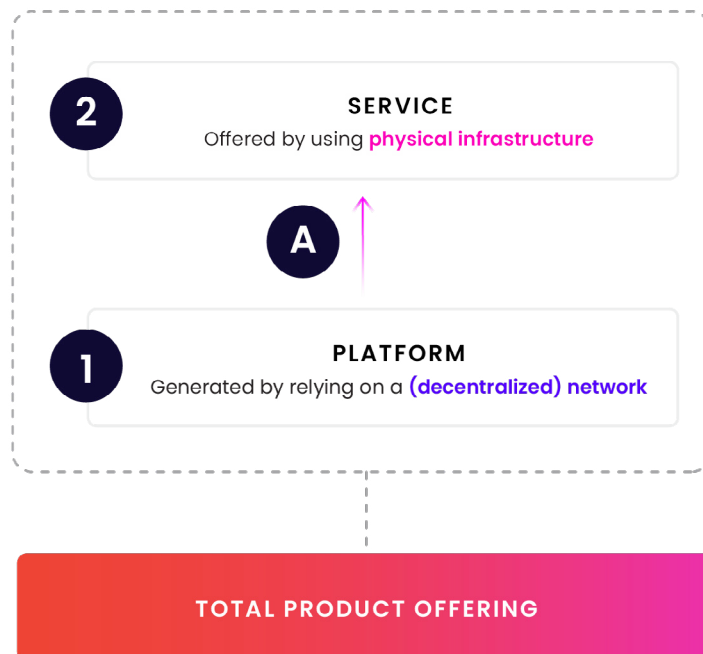
- **Decentralized Networks** - Refers to the platform used to coordinate interactions between service providers and users which is decentralized, underpinned by blockchain and thus relying on network effects.

- **Physical Infrastructure** - The resources or infrastructure that are used to provide the service or product are physical in nature, collectively making up the infrastructure.

DePIN has not been around for a while but the scope of what it means is already broadening. To understand the total potential scope of DePIN, one must start by understanding the type of business model DePIN is disrupting. In short, **DePIN disrupts business models that provide services generated by physical resources or infrastructure.**

DePIN platforms are by definition those that coordinate interactions between participants of different sides of the marketplace, allowing them to interact in a decentralized way (p2p). **Fundamentally, even before web3, the product offering consists of two components.**
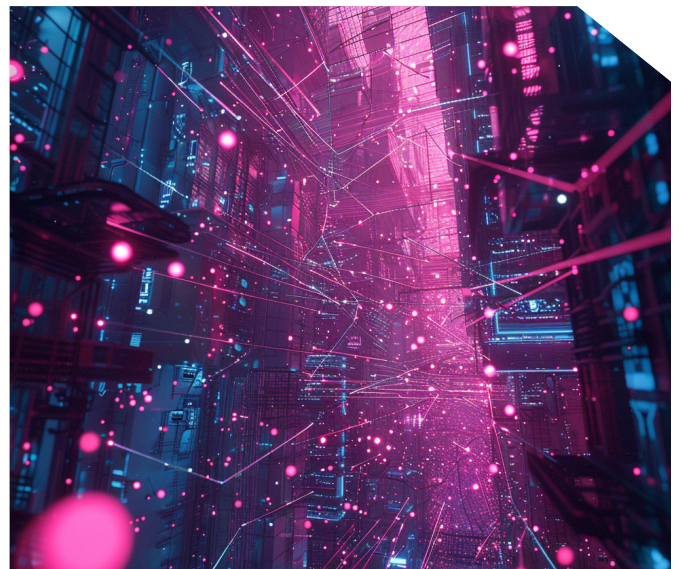
1. **The Platform** - It is the foundational infrastructure that enables coordination and interaction among users. It provides the necessary framework for the exchange of services, goods and information. It is used for coordination.

2. **The Service** - It encompasses the service made available through the platform. The scope of the service is defined by the nature of physical infrastructure or assets required to create these. It is used for distribution and consumption of the service.

A. **Note** - The way the platform allows coordination defines what types of services are offered. [More here](#).

2 **SERVICE**
Offered by using **physical infrastructure**

A

1 **PLATFORM**
Generated by relying on a **(decentralized) network**

TOTAL PRODUCT OFFERING
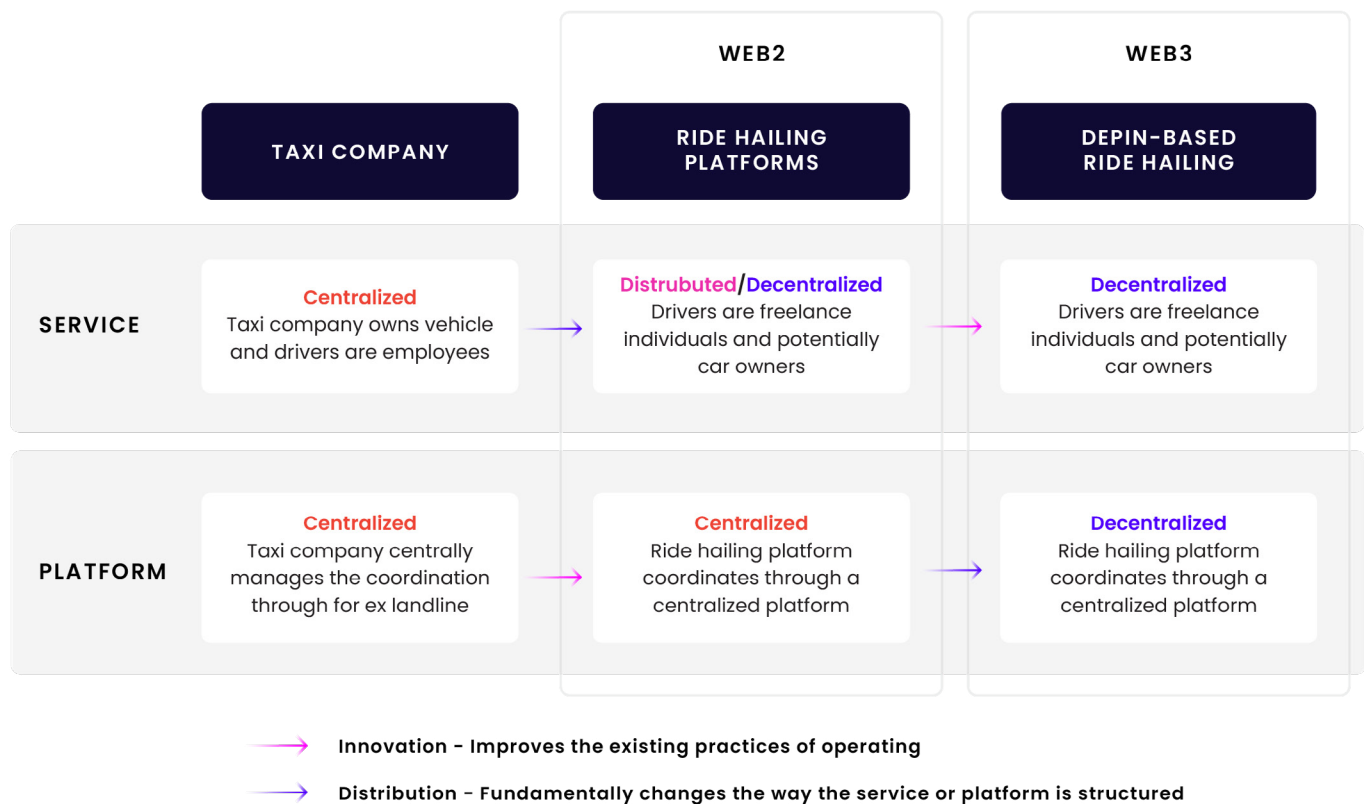
EXAMPLE – TAXIRIDE HAILING

We will elaborate on this framework using the age old example of ride hailing as shown below.

As seen in the example above, technology creates the ability to decentralize the platform or the service offered by physical resources which in this case are cars and other mobility devices.

We see the ride hailing platforms (Web2) as an intermediary state in which the

communication (the internet) technology was powerful enough for centralized platforms to coordinate a decentralized service like the individual drivers together making up a cluster of drivers in a geographical area. The limitation of web2 lies in the inability to do this in a trustless way, therefore still requiring a centralized entity to oversee fairness of the decentralized services.

Having a centralized platform coordinating decentralized services causes inefficiency and leads to sometimes unnecessary value extraction from the centralized platform.

		WEB2	**WEB3**
	TAXI COMPANY	**RIDE HAILING PLATFORMS**	**DEPIN-BASED RIDE HAILING**
SERVICE	**Centralized** Taxi company owns vehicle and drivers are employees	**Distrubuted/Decentralized** Drivers are freelance individuals and potentially car owners	**Decentralized** Drivers are freelance individuals and potentially car owners
PLATFORM	**Centralized** Taxi company centrally manages the coordination through for ex landline	**Centralized** Ride hailing platform coordinates through a centralized platform	**Decentralized** Ride hailing platform coordinates through a centralized platform

→ **Innovation - Improves the existing practices of operating**

→ **Distribution - Fundamentally changes the way the service or platform is structured**

# THE PLATFORM IMPACTING THE SERVICE

Not all products can achieve a distributed or decentralized service while relying on a centralized platform. Sometimes the coordination required to organise the service is so complex that it just is not economically viable. An example is wireless networks. Before blockchain, it was too complex and cost inefficient to decentralize the service.

Bringing smart contract execution, trustlessness and transparency to the platform creates the possibility for more complex and cost efficient coordination of the platform in a decentralized way. At times, the complexity of coordination requires such a large centralized platform that it becomes excessively value-extractive, rendering the use case economically unsustainable.

Below are some examples of physical infrastructure and how they can be run:

• **Decentralized services that can be coordinated through centralized platforms:** Food delivery, ride hailing, cloud computing...

• **Decentralized services that can only be coordinated between smart contract based decentralized systems:** Data, AI models, Wifi, 5G...
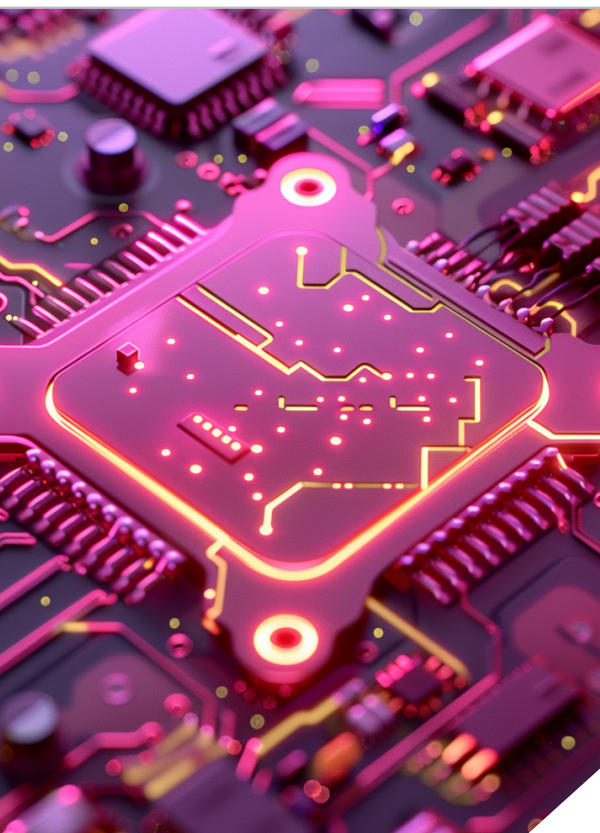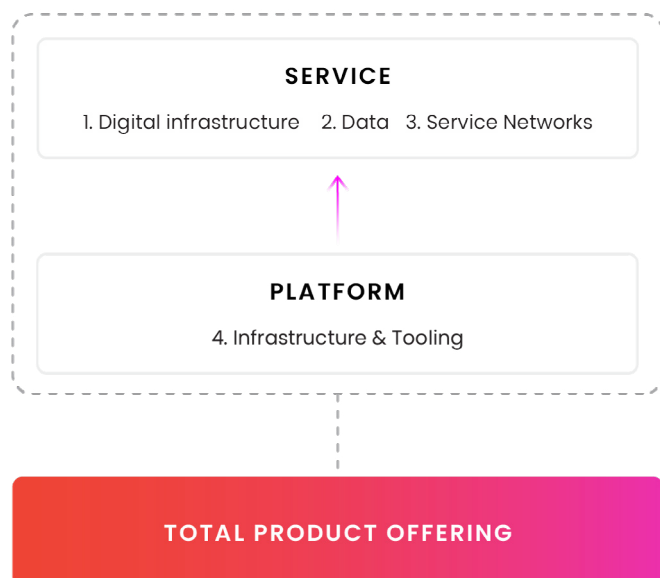
In short, we see centralized platforms running distributed or decentralized service as transitory. Blockchain based systems allow for new decentralized services to come online in the form of DePIN as the coordination mechanisms of the platform drastically increase, becoming trustless and highly automated.

The Categories of DePIN

It is still early days for DePIN networks and we expect quite a few new narratives to spawn from DePIN over the next few years.

Many of the current categorization looks at the type of infrastructure being decentralized and the sectors to which they apply. **We take a different approach and categorize DePIN based on the service or product they provide to the users of the networks. Below the four pockets of DePIN.**

SERVICE

1. Digital infrastructure   2. Data   3. Service Networks

↑

PLATFORM

4. Infrastructure & Tooling

TOTAL PRODUCT OFFERING

1. **Digital Infrastructure Networks** - Form the foundational hardware and software systems that enable the creation, storage and communication of digital data and assets across various platforms and services.

2. **Data Networks** - Designed to facilitate the collection, dissemination and analysis of data.

3. **Service Networks** - Created to connect individuals and organizations and facilitate social and economic coordination around services involving physical nodes.

4. **Infrastructure & Tooling** - Blockchain infrastructure supporting the platform and all the tooling to lower the barrier of entry to DePIN business models.

WHAT ABOUT AI?

We don't classify AI yet as a separate category, but expect that to become the case once we have decentralized AI models and market places that democratize access. We expect this to be a very large potential area for DePIN to explore once the underlying technology is mature enough. As discussed in other work, we are at the early innings of AI x Crypto.

GEOGRAPHICALLY DEPENDANT VS AGNOSTIC NODES

Another perspective to consider when looking at DePIN is the nature of the nodes that make up the network and whether or not they are geographically dependent.

- **Geographically dependent nodes** –

  Proximity to the end-user or environment from which they extract data is crucial for performance. Examples here are weather data and taxi ride hailing platforms.

- **Geographically agnostic nodes** –

  Proximity to the end-user or environment from which they collect data is more fluid. Examples include compute and storage.

The Marketplace

DePIN reinvents the way the supply side of infrastructure services are generated and maintained. At the same time it reinvents how the supply and demand side are coming together in a marketplace.

The supply and demand side of DePIN together make up the marketplace.

Supply side

Individuals, corporates and other participants who provide decentralized infrastructure. Participation requires infrastructure that either already sits idle or requires financial investments. More about this below.

Demand Side

Individuals, corporates or other participants that want access to the service offered by the decentralized infrastructure. More about this below.

MARKETPLACE DESIGN

With the decentralization of the platform come the ability to increase complexity of what services can be created with existing physical infrastructure. A well-designed marketplace allows for efficient coordination and dynamic interaction between the demand and supply side.

A well designed marketplace creates an environment of security and predictability for both sides, allowing demand and supply to rely on the infrastructure without any concerns. **Predictability and functionality are key in turning the marketplace into a critical piece of infrastructure for society, rivaling centralized competitors.** Just like many other business models in Web3, market places fundamentally rely on network effects.
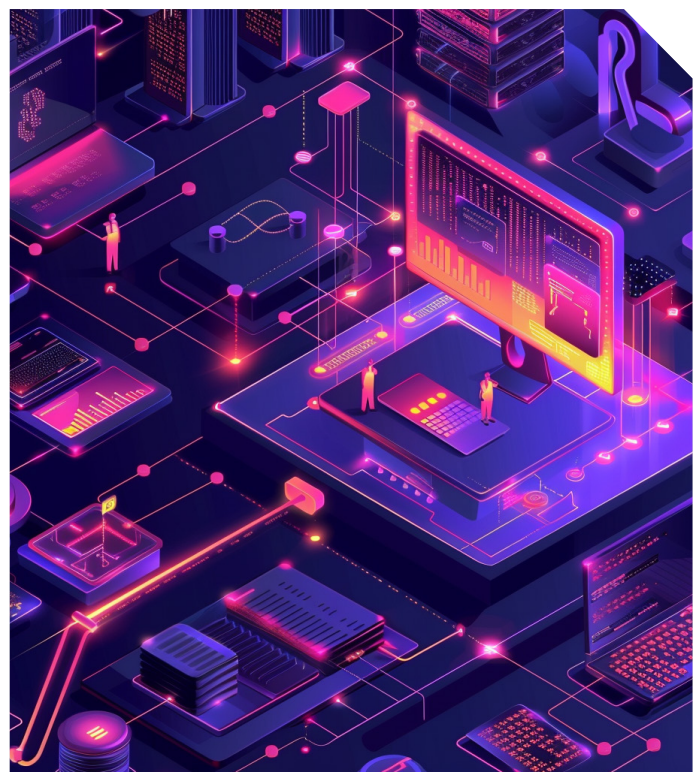
THE NETWORK EFFECT

Network effects occur where the value or utility a user derives from a product, service or platform depends on the number of users already using the service. The more users, the higher the value offered to each user by the service. The utility token incentives participate in the network.

Kickstarting a network effect of a new marketplace is notoriously difficult. The utility offered by the platform is a combination of the **positive value (+)** the product or service offers to the user and the **negative friction (−)** it causes due to poor UX and low usability.

Bootstrapping network effects often involved subsidizing the platform's utility for early adopters to the level where the total platform utility is high enough for them to stick around. In Web2 this is mainly done by financial incentives. Evidence has shown that this is a blunt tool. Web3 has the ability to incentivize through utility tokens, which lead to a more tailored solution. Utility tokens can attract early users that add value to the network effect until the platform gains critical mass, solving the critical-mass problem.
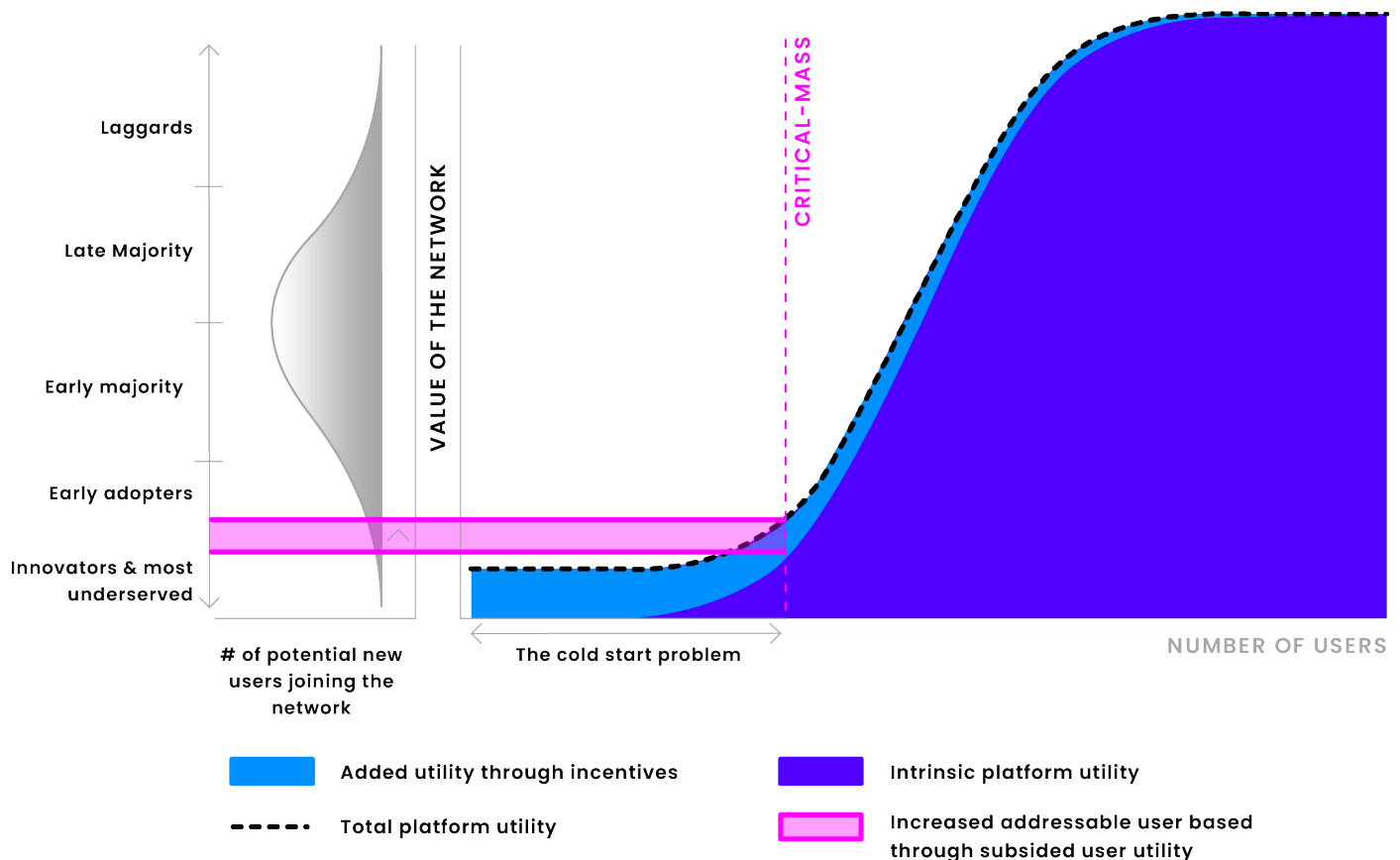
Besides being a new tool to solve the cold start problem, blockchain based systems also improve social and economic coordination, which is needed when dealing with decentralized nodes.

In short, utility tokens are a more precise tool to bootstrap network effects and coordinate social and economic activities between **decentralized participants, financially rewarding early adopters for taking risk and adding value to the network early on.**

Once the network reaches maturity, the utility token is used to create game theory based incentives for network participants to continue to participate and maintain the decentralized network.

The Benefits of DePIN

There are benefits for the entire network as well as supply and demand specific benefits tied to creating, maintaining and governing infrastructure in a decentralized way.
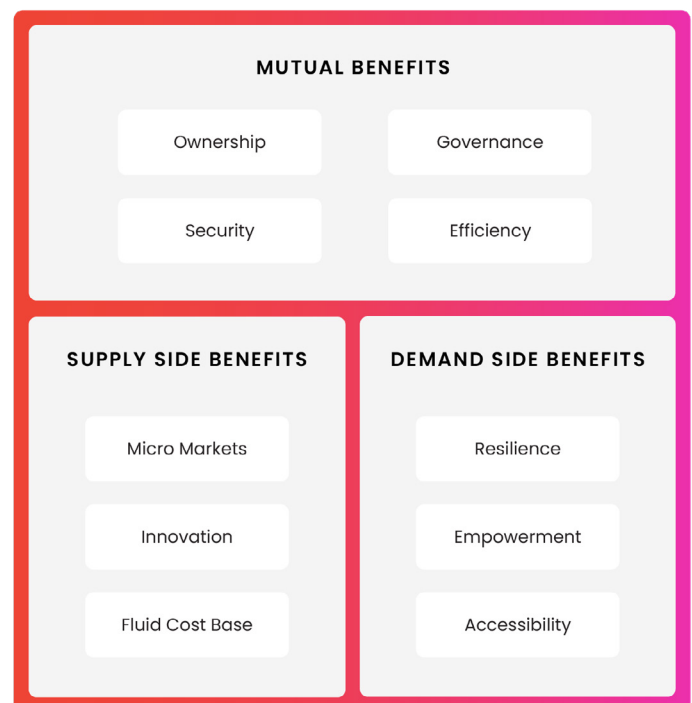
MUTUAL BENEFITS FOR BOTH SUPPLY AND DEMAND SIDE

Ownership - stakeholders across the network participate in the success and growth of the network through an equity-like ownership structure offered through utility tokens.

Security - improved security against systemic risk, increasing the integrity of the product.

Governance - participation of all stakeholders in decision making around development and maintenance of the product'.

Efficiency - allowing to deploy resources that are sitting idle in a decentralized way, generate strong efficiencies in cost and asset utilization.

MUTUAL BENEFITS	
Ownership	Governance
Security	Efficiency

SUPPLY SIDE BENEFITS	DEMAND SIDE BENEFITS
Micro Markets	Resilience
Innovation	Empowerment
Fluid Cost Base	Accessibility

DEMAND SIDE BENEFITS

Resilience - consumers enjoy more reliable access to services due to lower centralization and systemic risk of the platform.

Empowerment - infrastructure is less generic and caters better to local needs and preferences, resulting in better service quality.

Accessibility - services become more accessible as barriers to entering the service go down.

SUPPLY SIDE BENEFITS

Micro market - providers can cater to niche or local demands, unlocking new revenue opportunities.

Innovation - competitive and dynamic market fosters innovation of technology, service and business model.

Fluid cost base - suppliers benefit from a more fluid cost base of infrastructure provision without large upfront capital expenditures.

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The Supply Side

The supply of decentralized infrastructure assets and services necessary to build, maintain, and operate virtual or physical decentralized networks.

On the supply side of DePIN, there are three networks (as discussed) that together form the foundational infrastructure critical to society. Collectively they facilitate the creation and maintenance of infrastructure systems that govern and facilitate value creation in society.

The value proposition DePIN offer depends on the type of network. The innovation that comes with blockchain implementation also depends on their existing role, however in all cases, blockchain enables decentralized

coordination, removing the reliance on centralized entities to create and maintain the different types of networks. This leads to, as discussed in the benefits, to an increased efficiency and competition as a result of lower barriers to entry.

Out of the three main networks, digital infrastructure is currently most successfully adopted by DePIN. **A big driver behind the viability of digital infrastructure networks has been the declining cost curves of digital infrastructure over the past decade.**

COST CURVES COMING DOWN

Over the past two decades, the cost of computer memory and storage has drastically fallen. We believe this is a driver for DePIN business models to become viable as the economic moat from centralized players like cloud is fading as costs are becoming less of a factor.

Cost curves coming down of computational resources is a key enabler for the supply side

of DePIN to come online. The reduction in costs makes it economically viable for individuals and smaller organizations to contribute resources to the DePIN network without having to rely heavily on economies of scale.

Smaller players providing supply does not only increase the robustness and resilience of the network, but also increases the performance of the network by having a wider geographical distribution of services pushing down latency for virtual networks and increasing coverage for physical networks.

Historical cost ($/TB) of computer memory and storage since 2000
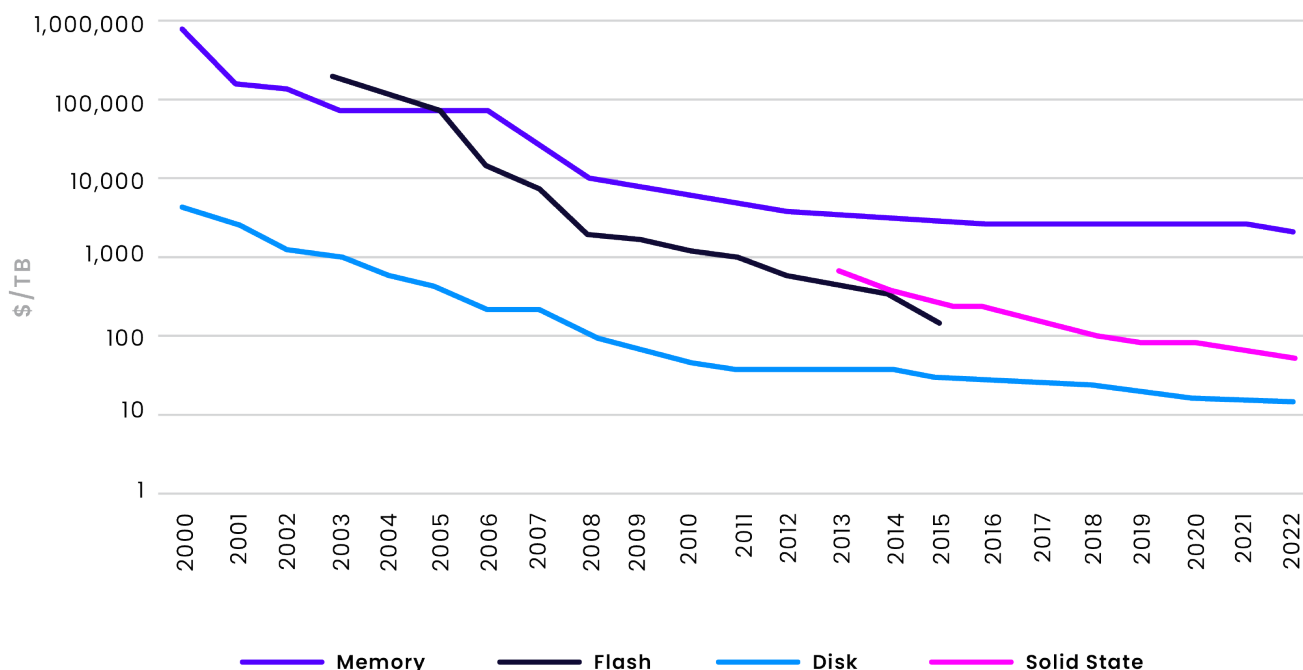
Source: Our World In Data

The Demand Side

The demand of decentralized infrastructure assets and services to users seeking these in an effort to solve new and existing challenges.

AI-ENABLED UX

Manually managing utility tokens across different DePIN platforms creates significant challenges for users such as complexity, learning curves and market making. It is time consuming, prone to errors and just creates a high degree of friction for the average user.

We believe AI-enhanced front-ends and AI agents will play a pivotal role in transforming the DePIN user experience, opening the floodgates to broad based adoption. AI and its ability to revamp the UX of DePIN by automating complex processes of utility token management making it user friendly.

CHANGING PURPOSE OF PHYSICAL INFRASTRUCTURE

What is the purpose of physical infrastructure? Is it mainly to provide services? Not exclusively. The narrative of infrastructure is changing in two directions.

1. **What is the definition of infrastructure?**
   The definition of infrastructure is changing. Service networks are increasingly considered a collective good and critical infrastructure that supports society. We explore how DePIN changes the social coordination of these platforms. More here.

1. **What is infrastructure used for?**
   The value proposition of infrastructure is changing. Because of the demand and value of data, infrastructure is now being used to extract valuable data points and insights from its surroundings. We explore how DePIN is now used to extract data and democratize participation in the data economy. More here.

Data Networks

The DePIN movement originally started seeing success in projects providing digital infrastructure (Filecoin, Golem, Helium, etc.). The recent wave of DePIN initiatives is less focused on providing tangible services and more on extracting valuable data points from its environment by creating physical networks relying on geographically distributed nodes.

We see evidence of the data narrative coming up when looking at maps like IoTeX's

DePIN explorer. Measuring the average social followers per vertical, we see servers, compute, wireless and storage being the largest verticals with quite a few projects. Sensors and especially data focused projects coming in with fewer projects and drastically lower average followers.

Below is a scatterplot looking at the number of projects and social following tracked on the IoTeX DePIN tracker.
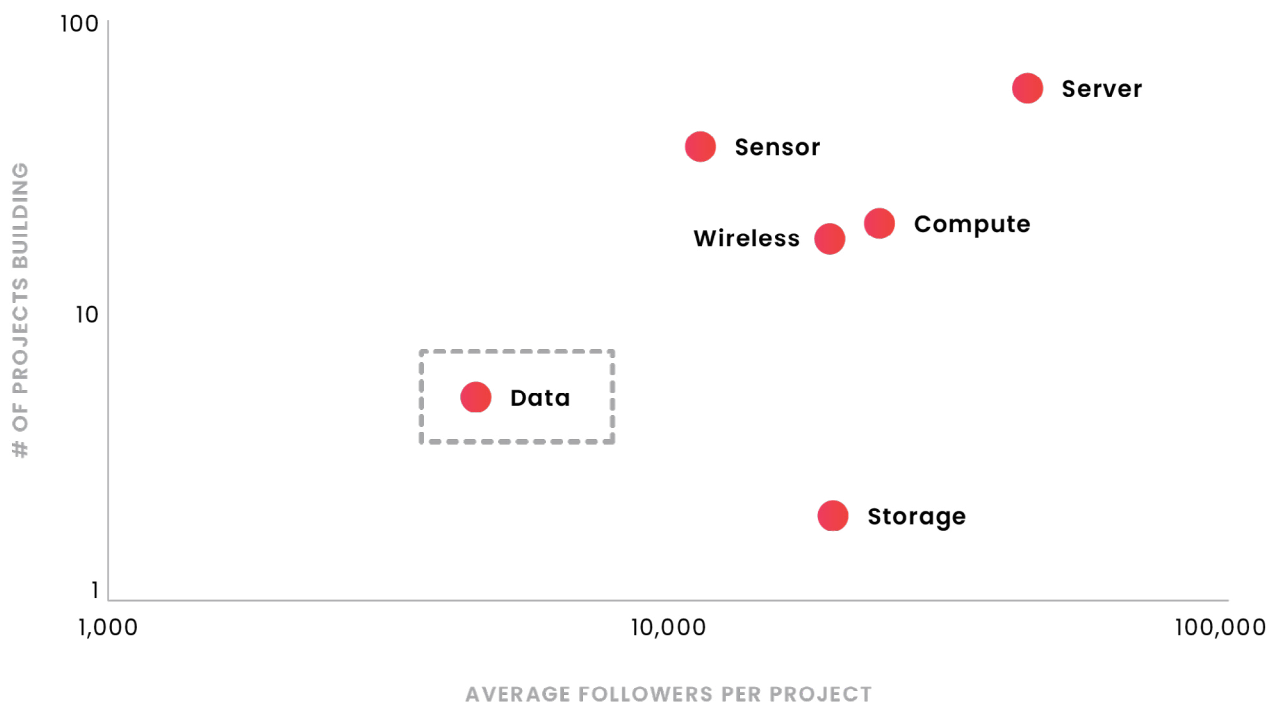

Source: DePINscan

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Over the past decade, data has emerged as an economically important asset. Driven by digital transformation allowing more value extraction from data. Data has become a key asset for driving business decisions, optimizing operations, understanding consumer behavior,... Next to capital and labor, data is becoming such an important economic input that it is creating new markets, industries and models of value creation.

We believe that as data becomes more important, the desire for data focused DePIN will go up. The first wave of data driven DePIN will focus on creating and generating existing

data points in a decentralized way. Projects like DIMO in the automotive industry are prime examples of how DePIN can aggregate in a decentralized way.

As the data economy matures, we believe new types of data focused DePIN will become economically viable. There are a lot of data points today that are collected but not yet valued by economic actors. As data value extraction tools like Gen AI mature, we believe new types of data requirements will become the driver for new types of data focused DePIN models.

Below you can see the change in data generated each year since 2010. 70% of all data stored has been generated over the past 3 years.
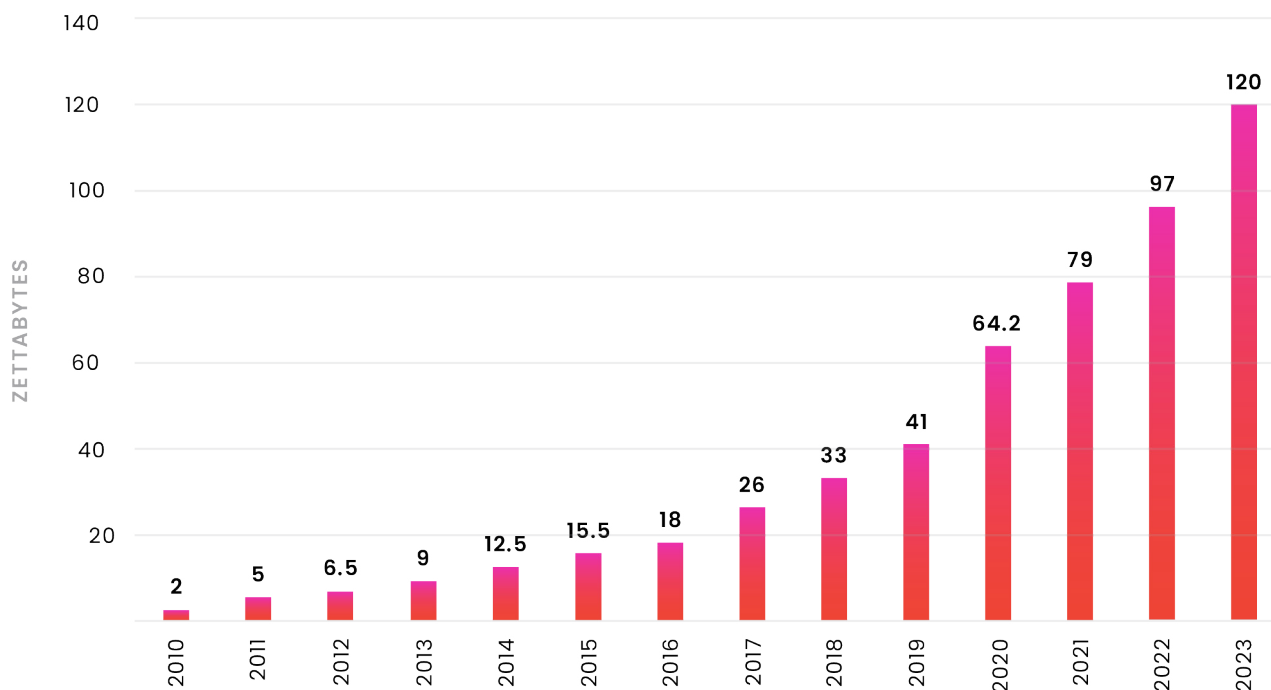
Source: Statista

TYPE OF DATA EXTRACTION

Despite decentralization being the direction of travel, given the high demand for data, we think that centralized and decentralized data providers will be complementary in the short to medium term.

The way DePIN extracts data is fundamentally different from current centralized data providers like big tech companies like social media and marketplaces. We compare horizontal vs vertical data extraction.

Horizontal Data Extraction -

Range of generic data points across **multiple industries or applications.**

Vertical Data Extraction -

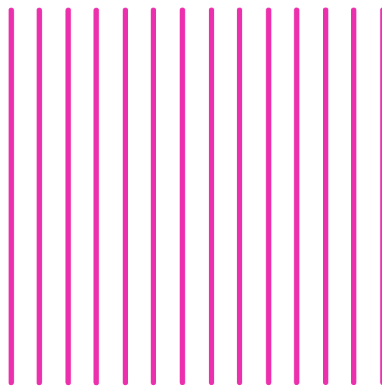**A few structured data** points across a **specific industry or application.**

We see them as complementary, together creating breath and depth in data sets across industries, applications and types of data. **Below the visualization of that process.**
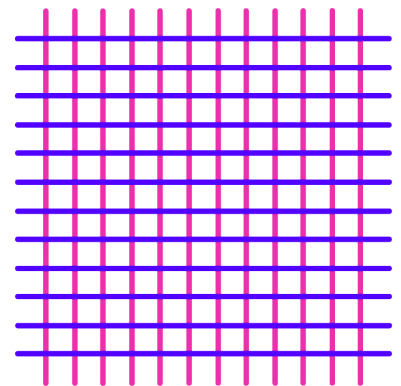
HORIZONTAL/CENTRALIZED
DATA COLLECTION
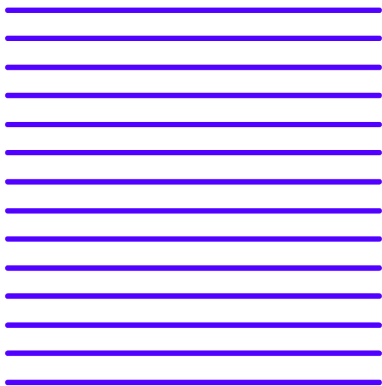
VERTICAL/DECENTRALIZED
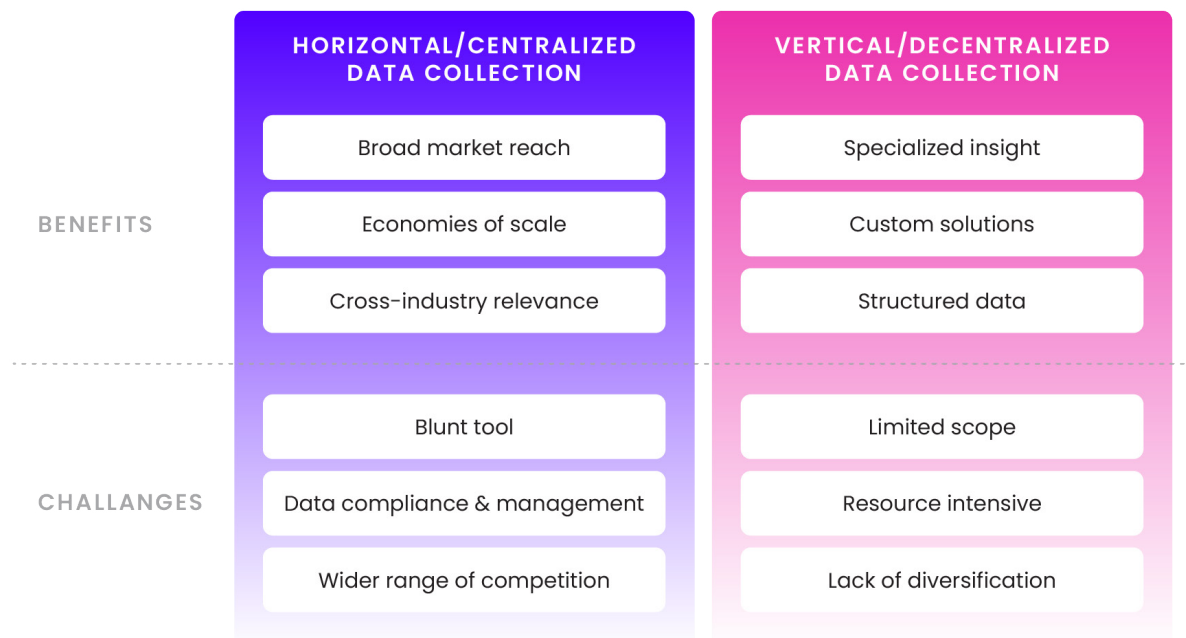DATA COLLECTION

COMBINED DATA
COLLECTION

While we strongly believe that decentralization is the direction of travel, we don't see a possibility of vertical/decentralized data extraction completely displacing horizontal/centralized data extraction in the short to medium term. As society moves deeper into the information era, the demand for data will only grow. **We need both centralized and decentralized data collection operators to**

meet the demand from the upcoming data glut driven by mainstream adoption of AI. In their current state, both approaches are actually complementary.

Below is a breakdown of the benefits and challenges related to horizontal and vertical data collection.

	HORIZONTAL/CENTRALIZED DATA COLLECTION	VERTICAL/DECENTRALIZED DATA COLLECTION
BENEFITS	Broad market reach	Specialized insight
	Economies of scale	Custom solutions
	Cross-industry relevance	Structured data
CHALLANGES	Blunt tool	Limited scope
	Data compliance & management	Resource intensive
	Wider range of competition	Lack of diversification

We are still at a point where the demand for quality data is higher than the supply. Until that dynamic is balanced out, we expect to see a blend of centralized and decentralized data providers. However, this is a strong tailwind for DePIN data providers to find product market fit as their offering is complementary to the existing products.
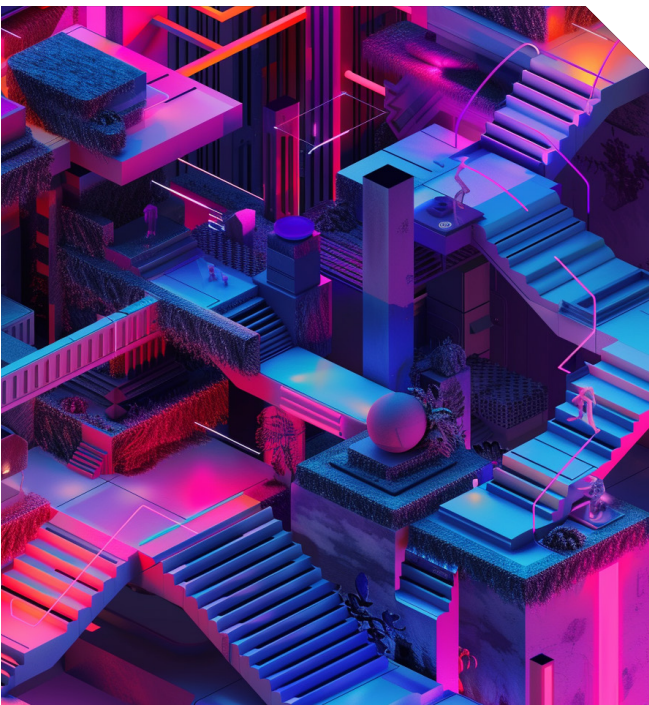
Service Platforms

They can be so value extractive because they have the ability to socially coordinate through data monopoly.

PROBLEMS WITH SERVICE PLATFORMS

Service platforms, because of their economic significance, have become collective goods. Despite this, there are still structural issues plaguing these platforms, causing issues for the users who have grown dependent on the services they facilitate.

We believe there are four key issues with existing centralized service platform.

1. **Value Extractive:** Centralized platforms concentrate wealth at the top, eroding local economies by funneling profits away from service providers and communities.

2. **Data Privacy and Security Concerns:** They monopolize sensitive user data, creating privacy risks and becoming prime targets for data breaches.

3. **Single Point of Failure Risk:** Centralization creates a single point of failure, risking service disruption and loss of data from cyberattacks or operational failures.

4. **Lack of Transparency and Accountability:** These platforms operate with opaque decision-making and provide limited recourse for user grievances, leading to a sense of powerlessness among participants.

THE DEPIN SOLUTION

DePIN can potentially address the structural issues of today's Web2 service platforms in the following ways:

1. **Value Extractive:** Fosters wealth distribution by unlocking community-driven business models and user participation.

2. **Data Privacy and Security Concerns:** Ensures user-controlled data privacy by leveraging blockchain for decentralized and secure data management.

3. **Single Point of Failure Risk:** Mitigates disruption through a distributed network.

4. **Lack of Transparency and Accountability:** Facilitates transparent decision-making and governance via collective oversight.

In summary, the decentralization of service networks via DePIN can address key issues by democratizing economic benefits, enhancing privacy and security, increasing network resilience and improving transparency and accountability.

There are still a lot of hurdles to overcome like navigating utility token complexity and economically incentivizing participation, however DePIN can change the paradigm of service networks to become more user-centric.

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Limitations to DePIN

There are still some developments holding DePIN back from reaching widespread adoption. There are some challenges tied to the type of network. There are also some more generic hurdles to overcome. **Below some of the key challenges that need to be addressed:**

1. **UX/UI** - from a UX/UI perspective, utility tokens, smart contract interaction and web3 wallets are adding complexity which needs to be overcome.

2. **Interoperability** - DePIN adoption will be a gradual process. During its transition, centralized and decentralized infrastructure will coexist. For many use cases it is still unclear how they will be compatible.

3. **Switching cost** - For the user there is a high switching cost associated with moving from centralized to decentralized services. DePIN's value proposition needs to improve so that users are willing to soak up these switching costs. Another possibility is for DePIN to become more backwards compatible so that the switching costs for the user go down.

There are quite a few other hurdles like technology and regulation that we won't discuss here.
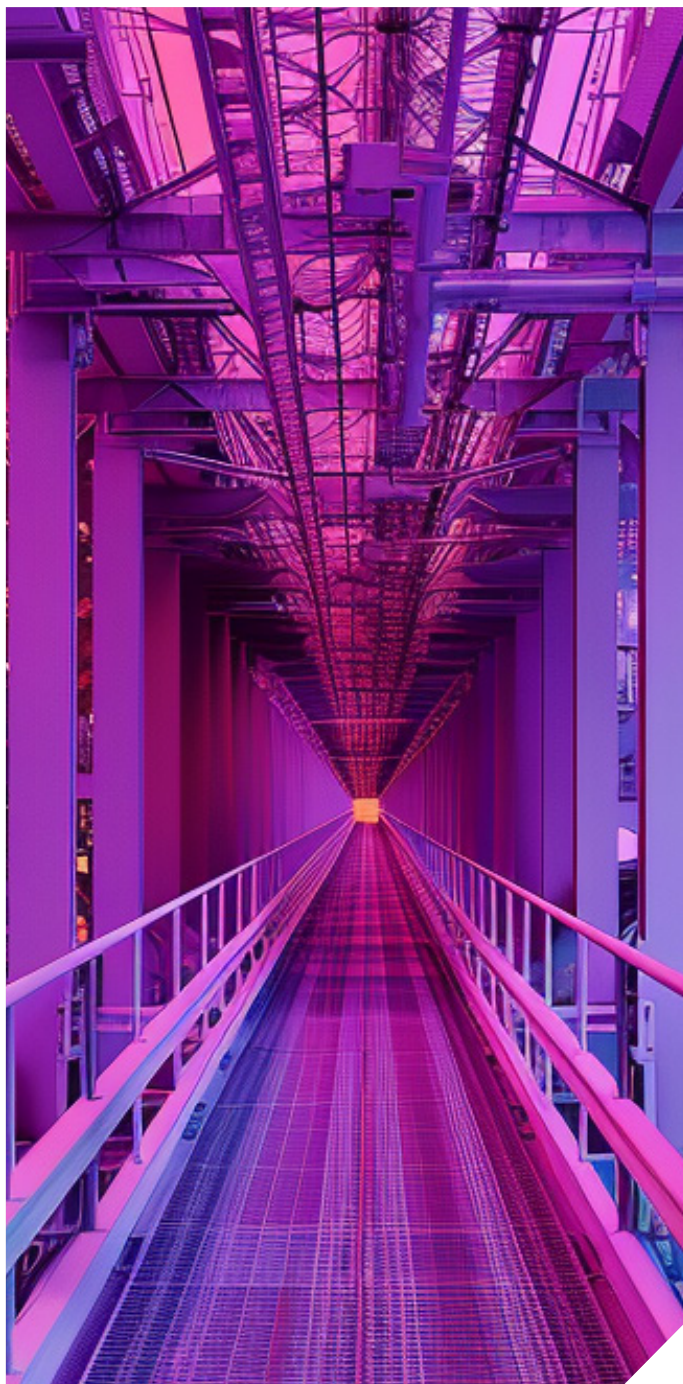
Conclusion

We believe DePIN will be a big narrative in the upcoming bull market and is set to become the key driver behind mainstream adoption of Web3 technology. Distributed ledgers, smart contracts and utility tokens are building blocks that allow for a decentralized yet coordinated approach to provide critical infrastructure. DePIN is no longer confined to digital resources. We expect that space to rapidly expand into data/IoT and service platforms as it goes mainstream.

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