BRIDGING THE GAP: HOW AI AND BLOCKCHAIN ARE SHAPING THE DIGITAL ASSETS LANDSCAPE

BLOCKHEAD

BLOCKHEAD RESEARCH NETWORK

2024

www.thebrn.co

www.blockhead.co

Contents

Executive Summary

Jointly produced by Blockhead and its research arm, Blockhead Research Network, this report explores the convergence of Artificial Intelligence (AI) and blockchain technology, highlighting their transformative potential in modern digital ecosystems. As two of the most significant technological advancements of our time, AI and blockchain have historically developed independently but are now increasingly integrated to address each other's limitations. This convergence represents a significant shift in how digital ecosystems can be structured and governed. This paper covers the diversity of solutions, the technical challenges they try to overcome, and the still early stage of their development.

We also propose a framework to grasp the complexity of AI-blockchain technologies, with a taxonomy methodology that can help find the factors that differentiate the economic nature and potential of AI tokens. We found that price movements are still being mostly driven by general crypto and AI perceptions of value and potential, with more fundamental-driven behaviors to be expected with the growth in adoption and usage.

Key Highlights

- **Transformative Potential**: The intersection of AI and blockchain offers significant opportunities for enhancing data privacy, transparency, and operational efficiency across various sectors, including healthcare and finance.
- **Innovative Integrations**: The report discusses multiple applications, such as federated learning with blockchain, token incentives for decentralized AI systems, and AI-driven smart contract auditing, demonstrating practical implementations of these technologies.
- **Classification Framework**: A structured classification framework is introduced to systematically assess AI-blockchain projects, aiding stakeholders in evaluating market potential and associated risks.
- **Risks**: Despite the potential benefits, the integration of AI and blockchain faces challenges, including regulatory compliance, scalability issues, and ethical concerns. These risks necessitate a cautious approach to development and investment.

Introduction

Blockchain and artificial intelligence (AI) are two of the most transformative technologies of our time, with numerous intersections. These technologies, which were originally developed independently, are converging, addressing each other's limitations and enhancing their respective strengths.

Blockchain technology has emerged as a cornerstone for building trust in digital transactions, enhancing ownership rights, and improving efficiency across various industries by providing a decentralized and immutable ledger system. On the other hand, AI has extended the capabilities of human organizations by enabling sophisticated data analysis, decision-making, and automation that surpass human abilities in speed and scale.

The intersection of these two technologies has been theoretically explored for some time. However, the significant surge in interest occurred with the mass adoption of advanced AI models, such as ChatGPT. This marked a turning point, as the practical implications of combining AI's analytical prowess with blockchain's trust-building mechanisms became more apparent.

Growth in market capitalization of top AI & Big Data tokens (Data: CoinMarketCap)

These technologies, being complex stacks on their own, present numerous challenges. Yet, the unique strengths of each can be leveraged to address the other's limitations. In the following sections, we will delve into the various ways blockchain and AI intersect, examining how they can complement each other to solve some of the most pressing challenges in both fields.

How it Works

The integration of blockchain and AI represents a convergence of two transformative technologies, each addressing critical challenges and enhancing the other’s capabilities.

The integrations can generally be classified into two broad categories: AI improving blockchain functionalities, and blockchain enhancing AI functionalities. Within these categories, we can further distinguish between internal and external support—where internal support involves deep, foundational changes to the technology stack, and external support refers to enhancements that provide marginal improvements.(1)

In this section, we explore various blockchain-AI integrations through this classification framework. We will discuss the specific challenges addressed by each primary technology, the benefits brought by the complementary technology, and provide a concise explanation of how these integrations work in practice.

It's important to note that this overview does not cover all possible integrations of these technologies but highlights some of the most relevant and impactful ones to date.

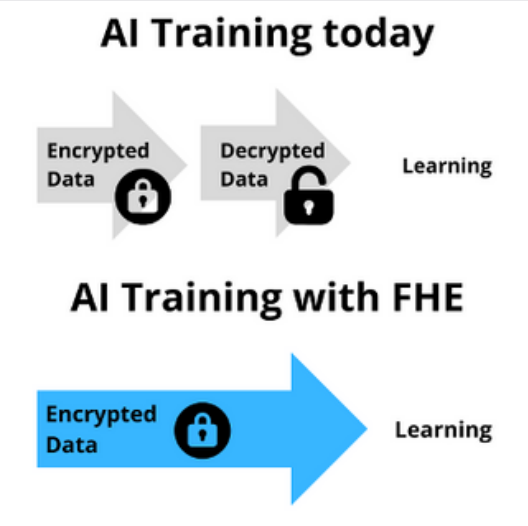
Crypto Applied to AI Services

1. Fully Homomorphic Encryption (FHE) and Blockchain

FHE is considered the “Holy Grail” of AI because it helps overcome one major privacy risk of AI: traditionally, algorithms cannot learn from encrypted datasets, so data must be decrypted beforehand – thus, legacy AI models cannot be trained on sensitive information such as health data without compromising data privacy.

FHE is the novel technology that allows models to process encrypted data itself, maintaining data privacy throughout the entire training process.

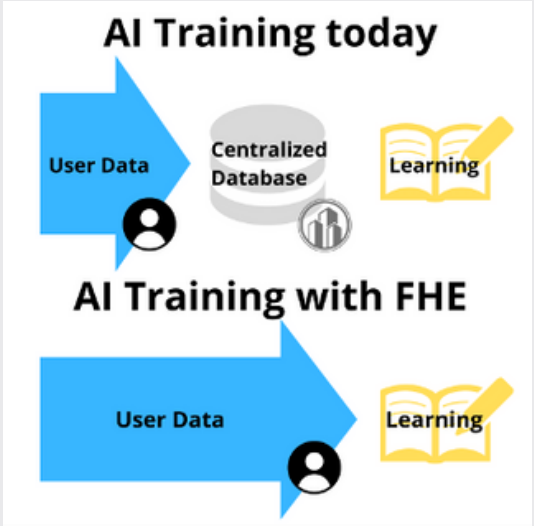
Blockchain-based systems ensure data ownership and integrity by recording every data transaction and modification on a distributed ledger.(2)



2. Federated Learning with Blockchain

AI models need access to vast amounts of data to improve their accuracy. Thus, training models on centralized databases can raise several privacy issues and regulatory challenges. Additionally, data owners typically lose control of their information and risks of data breaches may be amplified.

Federated learning, instead, allows AI models to be trained on decentralized data sources without the need to centralize or share the raw data. This preserves privacy while enabling collaborative AI model development. Blockchains can add security to the system with automated, trustless smart contracts acting as gatekeepers for data access and ownership, preventing data leaks and misuse by model owners.(3)



3. Token Incentives for AI Decentralized Systems

Training AI models requires large amounts of data and computational resources (such as GPU), which are often costly to obtain. Moreover, as there is limited incentive for individuals and organizations to contribute with these resources, developers might face market inefficiencies and resource scarcity.

That's why token-based incentive models are increasingly popular: they compensate contributors with protocol tokens that can be traded or used within the ecosystem, setting clear economic incentives for those who provide data, processing power, or AI models to the network.(4)

AI Applied to Blockchain

1. AI for Smart Contract Auditing

Smart contracts come with risks—code vulnerabilities can lead to serious security breaches and financial losses. Traditionally, audits rely on experts manually reviewing code, which, while thorough, is time-consuming and not foolproof.

Using machine learning models, particularly reinforcement learning and anomaly detection, AI can analyze vast datasets of existing smart contracts to learn about common vulnerabilities. This not only reduces the time and cost associated with manual audits but also increases accuracy, making blockchain applications more secure and trustworthy.(5)

2. AI-Powered On-Chain Data Analysis

Blockchain networks produce an enormous amount of data, with every transaction and smart contract interaction recorded. Traditional data analysis methods struggle to keep up with this scale and complexity, leading to missed opportunities and inefficiencies.
AI provides a scalable solution for analyzing on-chain data. Machine learning models can scan and interpret massive amounts of blockchain data, detect unusual patterns, predict trends, and provide real-time analytics, enabling users to make better-informed, data-driven decisions.

3. AI in Decentralized Autonomous Organizations (DAOs) Governance

Decentralized Autonomous Organizations (DAOs) rely on community-driven decision-making processes that, as they scale, can become inefficient and slow. Managing a growing number of participants while ensuring that decisions are data-driven and beneficial for most members is a significant challenge.

AI can change the governance framework within DAOs by automating and enhancing decision-making processes. With outcomes' prediction, offer recommendations, and routine governance tasks, such as proposal evaluation and voting, these models may help DAOs make more strategic and well-informed choices. Automating these processes also frees up human participants to focus on higher-level, strategic activities, ensuring that DAOs remain effective and transparent even as they grow.

Examples of AI-Blockchain Integrations

Application	Main technology	Internal / External	Cases
FHE for AI Training	AI	Internal	Privasea, Zama and Mind Network
Federated Learning with Blockchain	AI	Internal	Ocean Protocol, Fetch.ai
Token Incentives	AI	External	SingularityNET, Numerai
AI for Smart Contract Auditing	Blockchain	External	0x0 Auditor, ChainGPT AI Smart-Contract Auditor
AI-Powered On-Chain Data Analysis	Blockchain	External	ChainIntelGPT, Laika AI
AI in DAO Governance	Blockchain	Internal	– (6)

Table 1: Examples of AI-blockchain integrations

Classification Framework for AI-Blockchain Projects

The convergence of blockchain and AI may be a fundamental shift in how digital ecosystems can be structured and governed. By applying a structured classification framework, we can gain deeper insights into the market potential, operational risks, and strategic opportunities presented by AI-blockchain projects.

This section will explore how this framework can be utilized to systematically assess and compare projects, enabling more informed decision-making in this rapidly evolving landscape.

Table 2 can be used by investors, developers, and analysts to systematically assess and compare blockchain projects, enabling more informed decision-making based on the project's structure, market potential, and associated risks.

Understanding the **sector** in which a project operates provides valuable insights into its addressable market. For instance, projects in the "AI and machine learning" sector can be assessed using metrics related to AI adoption rates, investment trends, and technological advancements. By identifying the sector, investors and analysts can also select relevant indices and metrics as proxies to estimate the project's long-term growth potential and market penetration.

The **function** of a project sheds light on its role within the sector and the potential revenue streams. By comparing the project's function to that of incumbent solutions, one can gauge the revenue share the project might capture within the sector. For example, a project focused on "Decentralized AI Models" might aim to disrupt traditional AI service providers, allowing for an estimate of its potential revenue share in the AI economy.

Architecture classification is crucial for assessing the operational risks associated with a project. On-chain and hybrid solutions might face risks related to smart contract

vulnerabilities, which could lead to security breaches or loss of funds. Off-chain solutions, on the other hand, might be exposed to counterparty risks, where the reliability of external systems or partners becomes critical. Understanding the architecture helps stakeholders evaluate the robustness and scalability of the project.

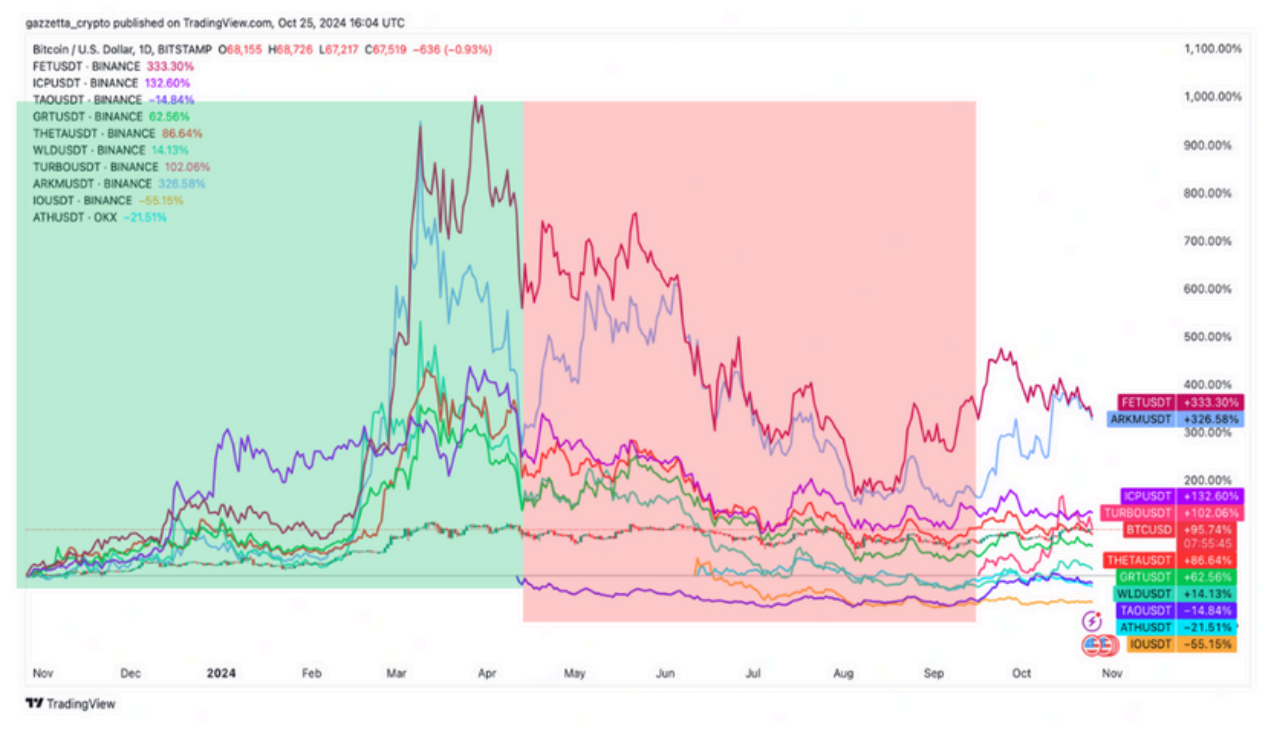
Governance models offer insights into how decisions are made within a project and the potential risks or benefits associated with them. Decentralized governance, while fostering inclusivity and resilience, may face challenges such as slower decision-making or conflicts among stakeholders. Centralized governance, though more streamlined, might raise concerns about transparency and control. This classification helps in evaluating the project's stability, responsiveness, and alignment with its community or investors.

Utility of the token directly influences its demand, liquidity, and overall market behavior. Tokens with multi-purpose utilities, such as those used for governance, transactions, and access, are likely to attract a broader user base, enhancing their value and adoption. Conversely, tokens with more specific uses might be subject to higher volatility or regulatory scrutiny. Understanding token utility is essential for assessing the token's role in the project's ecosystem and its potential impact on the token's value.

Token	Sector	Function	Architecture	Governance	Token Utility	Market Cap ($M)	12m Return
Internet Computer (ICP)	General	Decentralized Web Services	On-Chain	Decentralized	Multi-purpose	$3,900	134%
Bittensor (TAO)	AI and machine learning	Decentralized AI Models	On-Chain	Decentralized	Reward	$3,830	-14%
Artificial Superintelligence Alliance (FET)	AI and machine learning	Decentralized AI Models	On-Chain	Decentralized	Multi-purpose	$3,285	344%
The Graph (GRT)	General	Data Indexing	On-Chain	Decentralized	Access	$1,519	65%
Theta (THETA)	Media	Decentralized Content Distribution	On-Chain	Decentralized	Transactions	$1,234	90%
Worldcoin (WLD)	General	Identity Verification	Off-Chain with Integration	Decentralized	Governance	$1,181	18%
Turbo (TURBO)	Memecoin	Meme coin created with AI	On-Chain	Decentralized	Transactions	$616	108%
Arkham (ARKM)	Cybersecurity	Cybersecurity Analysis	On-Chain	Centralized	Access	$369	336%
io.net (IO)	AI and cloud computing	Decentralized Cloud Computing Services	On-Chain	Decentralized	Access	$215	-55%
Aethir (ATH)	AI, gaming, and cloud computing	Decentralized Cloud Computing Services	Hybrid	Decentralized	Multi-purpose	$193	-20%

Table 2: AI tokens categorized by sector, function, architecture, governance, and utility.

Final Considerations

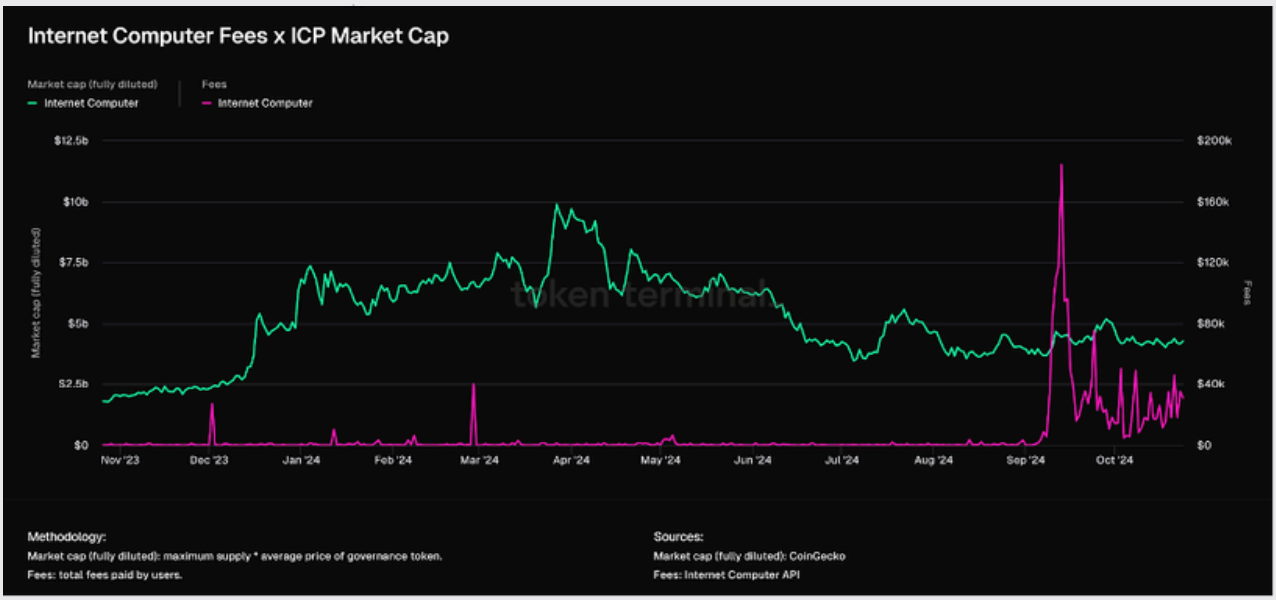


What's driving the price of AI tokens?

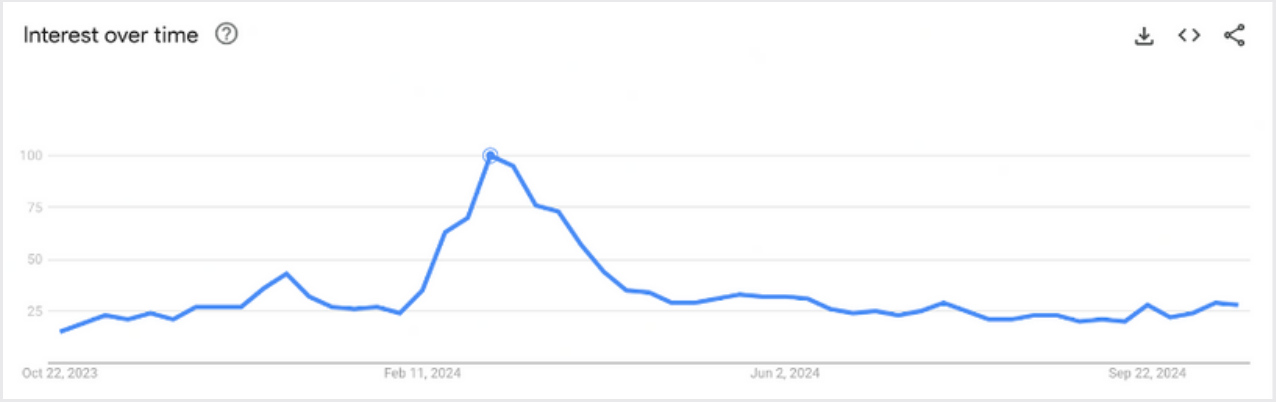
While a classification of AI tokens based on their underlying products allows us to have a grasp on how the inner economics of these platforms may affect token value, a look at recent price performance shows that the performance of these tokens are not merely based on fundamentals. This may be due to several factors.

First, the underlying technologies of all these tokens are at a very early stage, with almost negligible user adoption.

We can take Internet Computer as an example as it is the only one with some data on fundamentals available on Token Terminal. Internet Computer has had close-to-zero activity on its network until mid-September, when a spike anticipated higher base level of fees on the network. Even the highest value accrued in fees on a day (US$184,000) is still too low in contrast to ICP's daily volume, currently around US$30M, which means the on-chain activity has a limited impact on market demand and, thus, prices.



Taking a look at Bitcoin's price performance and Google searches for "AI crypto," we can say the price performance of ICP — and other AI tokens — is most likely influenced by crypto's overall performance and public perception towards the AI-blockchain narrative.



With that in mind, we understand the positive period from Q4 2023 to Q1 2024 was fueled by hype surrounding Bitcoin and the expectations that the US would approve spot Bitcoin ETsF; the following two quarters were still Bitcoin-driven, marked by macroeconomic uncertainty — with all tokens on the list showing negative performance.

Interestingly, the only assets with negative returns (TAO, ATH, and IO) in the 12 month period were launched during the negative months from April to September, when expectations about the rate cut by the Federal Reserve started driving price action. TURBO was launched in mid-September and benefited from the upward momentum in public interest and price.

But arguably the most important insight from the chart above comes from observing how the price movements are mostly correlated. This observation is perfectly compatible with the immature ecosystem of AI tokens, since the projects' tokens are more strongly affected by the public perception on AI and crypto than by their projects' intrinsic factors.

To have a clearer view of how closely connected these prices are, we can take a look at the correlation matrix below.(7)

	FET	ICP	GRT	TAO	THETA	WLD	ATH	ARKM	IO	BTC
FET	1	0.772	0.799	0.529	0.889	0.337	0.88	0.366	0.835	0.533
ICP	0.772	1	0.651	0.222	0.748	0.173	0.681	0.15	0.674	0.317
GRT	0.799	0.651	1	0.781	0.771	0.75	0.706	0.762	0.825	0.797
TAO	0.529	0.222	0.781	1	0.392	0.782	0.517	0.867	0.471	0.741
THETA	0.889	0.748	0.771	0.392	1	0.344	0.836	0.306	0.912	0.546
WLD	0.337	0.173	0.75	0.782	0.344	1	0.227	0.958	0.49	0.901
ATH	0.88	0.681	0.706	0.517	0.836	0.227	1	0.266	0.778	0.393
ARKM	0.366	0.15	0.762	0.867	0.306	0.958	0.266	1	0.452	0.873
IO	0.835	0.674	0.825	0.471	0.912	0.49	0.778	0.452	1	0.648
BTC	0.533	0.317	0.797	0.741	0.546	0.901	0.393	0.873	0.648	1

As the correlation matrix shows, half of the 10 tokens have +0.6 correlation with Bitcoin. FET (0.5), THETA (0.5), ATH (0.4), and ICP (0.3) are the exceptions, and, maybe not coincidentally: aligned with the observation above, FET, THETA and ICP are projects with longer price histories, relatively mature technologies and ecosystems, which justifies their prices being more independent.

Risks

Now that we have a clearer vision of what drives AI tokens' value and prices, we can finally discuss what are the risks involved and what the investor can expect from future market developments. It is important that expectations are tethered not only by the promises the new ecosystem brings, but also by a comprehensive overview of the risks involved in the segment. For that, we briefly discuss the main risks of AI-blockchain technologies.

From a technical perspective, **security** remains a concern, particularly as AI systems require large datasets that can be vulnerable to breaches or manipulation. Also, the **complexity** of both technologies creates additional risks as they are combined.

Scalability is another challenge that could hinder the broad adoption of blockchain-AI solutions. Both technologies demand substantial computational power and resources, which are expensive and difficult to manage. As we've seen scalability bottlenecks in Ethereum and Solana causing instability in the space, the new solutions will probably face similarly hard times during their evolution.

The evolving global **regulatory landscape** also poses significant concerns for AI-blockchain integrations. The need to navigate different regulatory standards while they're still under development could increase operational risks and costs, making compliance a significant hurdle for widespread adoption.

Furthermore, the **ethical implications** of AI and blockchain integration must be carefully considered. As decision-making processes become more automated, questions regarding accountability and transparency will arise, especially in applications where decisions impact the lives of large numbers of stakeholders, such as health care and finance.

Notes

(1) The classification framework used here is proposed in *AI x Crypto Primer* by Mohamed Baioumy, PhD, and Alex Cheema at Oxford University.

(2) A deep dive into FHE and blockchain can be found in the academic paper *Blockchain and Homomorphic Encryption for Data Security and Statistical Privacy*.

(3) The technology mix is implemented and evaluated by researchers in the paper *A Federated Learning Method Based on Blockchain and Cluster Training.*

(4) A specific application of token incentives is explored in the paper *Tokenized Incentives for Data Contribution in Federated Learning* by Pandey et al.

(5) A framework for intuitive smart contract auditing with fine-tuning and LLM-based agents is proposed in *Combining Fine-Tuning and LLM-based Agents for Intuitive Smart Contract Auditing with Justifications*.

(6) The use case is addressed by multiple players, but no functional case has been found at the time of writing.

(7) TURBO was only launched in September so it is excluded from the correlation study.