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Google & Visa Join x402: Redefining AI Agent Payments

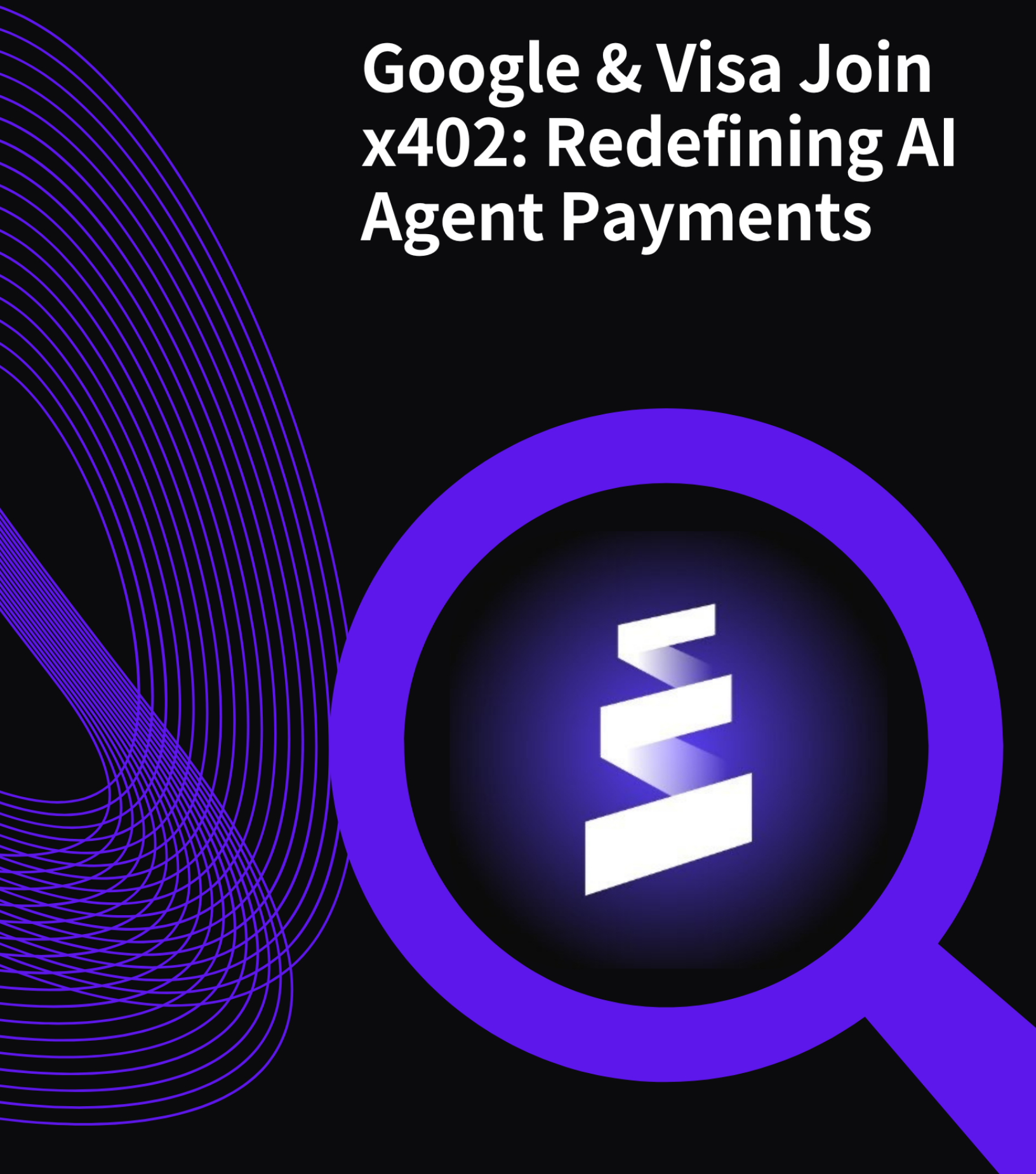


Table of Contents

Abstract

As Artificial Intelligence evolves from auxiliary tools to autonomous AI Agents, traditional Internet payment systems are struggling to meet the demands of high-frequency, micro-amount, and automated transactions that require zero human intervention. This report provides an in-depth analysis of the x402 Protocol, jointly promoted by Coinbase and Cloudflare. It explores how the protocol activates the dormant HTTP 402 status code to construct a standardized payment bridge connecting the Web2 information network with the Web3 value network.

Key Findings:

- **Underlying Logic:** The x402 protocol is not a standalone blockchain project but a set of Internet-native interaction specifications. Its core lies in constructing a tripartite architecture consisting of **"Server-side Quotation, Client-side Signature, and Facilitator Payment."** By transforming HTTP 402 responses into structured quotations and combining a "Off-chain Authorization + On-chain Settlement" mechanism, x402 successfully realizes millisecond-level, frictionless (Gasless) payments between machines, effectively solving the micro-payment pain points associated with AI Agent API calls and data acquisition.
- **Ecological Positioning:** This report assesses that x402 is currently transitioning from an early asset speculation phase ("Hype") to an infrastructure construction phase ("Infra"). Within the AI Agent protocol stack, x402 forms deep synergy with the **MCP/A2A protocols** (connectivity), the **ERC-8004 standard** (identity and trust), and Google's **AP2 protocol** (compliance layer). Compared to AP2, which focuses on human authorization and compliance, x402 has established a unique positioning as the backend settlement layer for Machine-to-Machine (M2M) interactions.
- **Market Progress:** The ecosystem has currently formed a multi-layered landscape covering **Agents** (e.g., SANTA), **Facilitators** (e.g., PayAI, Coinbase), and **L1 Infrastructure** (e.g., Kite AI). Although early momentum was significantly driven by "Meme" sentiment, capital and technical focus are shifting towards the "Audit + Proxy Payment" infrastructure sector. On-chain transaction volumes and application scenarios are gradually validating its potential as a universal standard.
- **Risk Warnings & Challenges:** While x402 demonstrates the potential to reshape the Internet's value exchange layer, large-scale commercial adoption faces three major hurdles:
    - Underlying Standard Risk: The semantics of the HTTP 402 status code have not yet been unified by international standards organizations like the IETF, posing compatibility risks.
    - Business Model Friction: Peer-to-peer payment methods challenge the established traffic distribution and commission models of tech giants, creating a risk of future obstruction by incumbents.
    - The Cost Inversion Dilemma: In micro-payment scenarios, on-chain Gas fees often exceed business revenue. The current model, which relies on project subsidies, is difficult to sustain long-term, necessitating the exploration of sustainable economic models.

Conclusion: The x402 protocol represents a critical infrastructure attempt for the commercialization of AI Agents. It lowers the frictional costs of machine collaboration through technical standardization. Whether it can become the universal language of the machine economy depends on its actual

performance regarding multi-chain cost optimization, standard compatibility, and strategic maneuvering with Web2 giants.

Keywords: x402 Protocol; AI Agent; HTTP 402; Machine Economy; Micropayments

01 / Introduction: The Explosive Growth of x402—The Payment Protocol for the AI Agent Era

In October of this year, a concept codenamed "x402 Protocol" swept across the entire Internet and Web3 communities. This underlying payment specification, jointly launched by Coinbase and Cloudflare, not only quickly garnered the favor of tech and financial giants like Google and Visa following its debut in May 2025, but also triggered a hundred-fold "meme craze" in the asset markets by late October, becoming one of the most hotly contested narratives of the moment.

x402 is hailed by the industry as the savior for the AI Agent payment dilemma and is regarded as the product with the highest potential for large-scale application in the Web3 world since stablecoins. However, what exactly is the underlying logic of this protocol? Why is it perfectly adapted to AI Agents? Furthermore, what are the hidden commercial potentials, risks, and future directions behind it? This article provides a deep dissection to reveal the true commercial value of this next-generation Internet payment infrastructure.

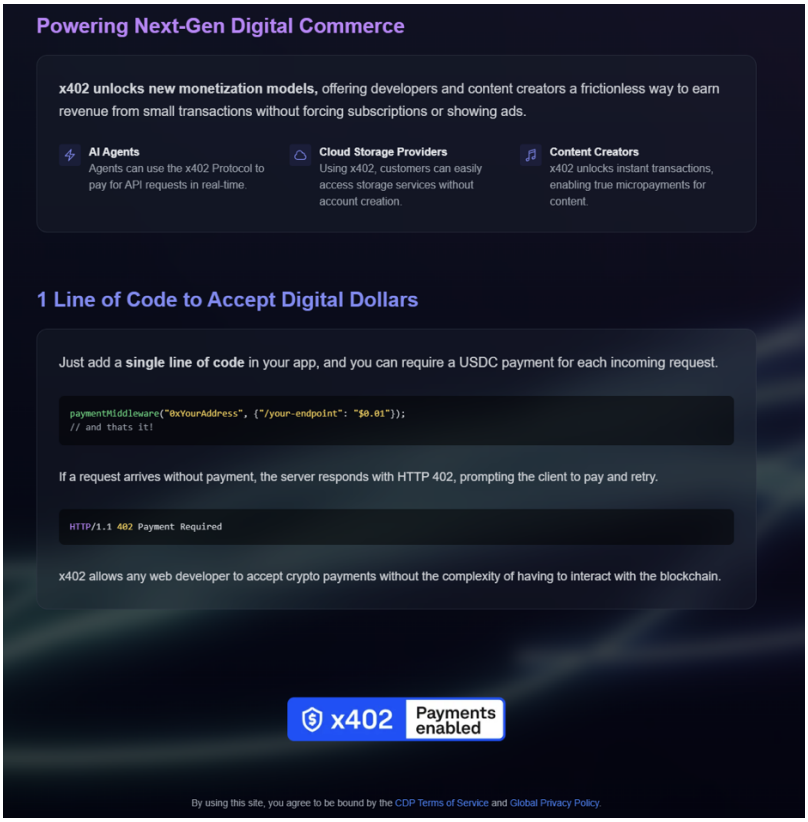
02 / The x402 Protocol: A Micro-Payment Standard Born for Machine Settlement

2.1 Concept Definition: The Core Connotation of the x402 Protocol

Fundamentally, the x402 protocol is an open-source payment protocol built on existing Internet standards (HTTP status codes) that enables automated, on-chain settlement, specifically designed for micro-payments and pay-per-use models.

- Specification Definition: The x402 protocol is an open-source standard officially proposed by Coinbase in May 2025. Its core innovation lies in activating and standardizing the long-dormant HTTP 402 (Payment Required) status code. The protocol aims to build an Internet-native programmable payment layer. Through an embedded "pay-per-use" mechanism, it specifically addresses the structural pain points where traditional payment methods fail to adapt to high-frequency, small-amount settlements in AI Agent interoperability and Machine-to-Machine (M2M) API call scenarios.
- Layman's Understanding: Simply put, x402 is an automated, friction-free, small-amount micro-payment standard based on stablecoins. Precisely because it perfectly matches the AI Agent's need for high-frequency, friction-free payments, it has been integrated into the grand narrative of AI Agent Commerce, leading to its explosive popularity.

Figure 1: x402 Official Website Introduction (Source: x402 Official Website)



Source: x402 Official Website

The value of the protocol was quickly recognized by underlying infrastructure enterprises. In September 2025, Coinbase and Cloudflare jointly announced the establishment of the x402 Foundation, marking the official move towards open standardization regarding the protocol's governance, compatibility, and ecosystem expansion. This move rapidly attracted participation from cloud service providers, payment institutions, and large technology companies (such as Google and Visa), which began integrating x402 into their own Agent payment or machine settlement systems. This has propelled x402 from an experimental tool into a rapidly developing, cross-industry, Web-native payment infrastructure.

2.2 Core Advantages: Perfectly Tailored for AI Agent Transactions

The ability of x402 to attract traditional giants lies precisely in its protocol design, which perfectly aligns with the automated transaction needs of AI Agents. Its core characteristics can be summarized across the following five dimensions:

Figure 2: Summary of x402 protocol features

analysis dimension	Core Features	implementation path	meaning
Technical Architecture	Web native and underlying properties	The protocol directly uses HTTP status codes and runs on the underlying standards of the Internet. It is a Web native protocol rather than an "on chain protocol"	No need for additional protocol stack or complex middleware, easy to deploy by existing Internet architecture
Protocol governance	Open and decentralized tendencies	The protocol code is open source and released, and the x402 Foundation adopts a multi-party driven foundation governance model	Prevent the protocol from being controlled by a single vendor
Payment model	On demand and per use micro payment	The protocol supports fine-grained charging for resource units (such as API call counts and data read volumes), achieving on-demand and per use billing for "micro payments"	Suitable for frequent, automated API calls, and data access by AI agents
Trading friction	Zero threshold and automation	The agreement pursues frictionless transactions, without the need for additional registration or manual authorization, and without charging additional handling fees	Completing transactions in a single HTTP request ensures the efficiency and low cost of machine settlement
scalability	Cross chain and compatible with traditional finance	The protocol does not rely on any public chain or currency, and can be integrated with traditional payment transaction architectures such as Visa and Google	Implementing full on chain adaptation at the protocol level also provides an adaptation path for traditional financial payments

Source: Pharos Research

In summary: By leveraging its Web-native simplicity, the efficiency of micropayments, and the compatibility of open governance, the x402 protocol successfully bridges the gap between Web3 decentralized settlement capabilities and traditional Web2 infrastructure. It establishes an efficient, trustworthy, and universal payment standard for commercial implementation in the AI Agent era.

2.3 Protocol Origins: Activation of the HTTP 402 Standard

The fundamental reason x402 possesses the five core advantages outlined above is that it simply reuses the Internet's underlying HTTP standard, rather than constructing a new on-chain protocol from scratch.

Internet data interaction relies on the HTTP (Hypertext Transfer Protocol) to transmit information between Clients and Servers, defining a series of standard response status codes to identify request results—such as the widely known "404 Not Found" (page missing) or "200 OK" (request successful).

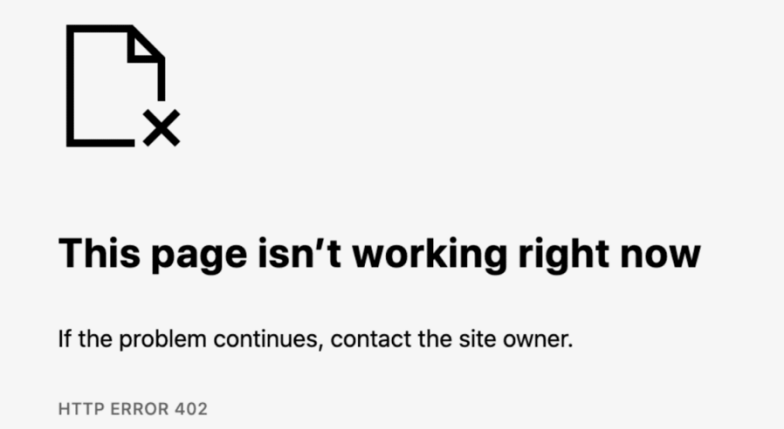
Figure 3: Summary of HTTP Status Codes

Status Code Category	Status Code	English Meaning	English Meaning	Status Code Category	Status Code	English Meaning	English Meaning
1XX Information Responses	100	Continue		4XX Client Error	400	Bad Request	
	101	Switching Protocols			401	Unauthorized	
	102	Processing			**402**	**Payment Required**	
	103	Early Hints			403	Forbidden	
2XX Successful	200	OK			404	Not Found	
	201	Created			405	Method Not Allowed	
	.....				406	Not Acceptable	
	208	Already Reported			407	Proxy Authentication Required	
	226	IM Used			408	Request Timeout	
3XX Redirection	300	Multiple Choices			409	Conflict	
	301	Moved Permanently			410	Gone	
	.....				411	Length Required	
	308	Permanent Redirect			.....		
5XX Server Error	500	Internal Server Error			428	Precondition Required	
	.....				429	Too Many Requests	
	510	Not Extended			431	Request Header Fields Too Large	
	511	Network Authentication Required			451	Unavailable For Legal Reasons	

Source: Pharos Research

Within this vast system of status codes exists a special code: 402 (Payment Required). This code belongs to the 4xx series (Client Error), and its core meaning is to intercept access due to non-payment. However, due to the long-standing lack of a native Internet payment mechanism, HTTP 402 remained a definition only for a significant period; it was never activated with practical application scenarios and remained dormant.

Figure 4: Illustration of HTTP 402 (Payment Required) Error Page in Traditional Network Environments

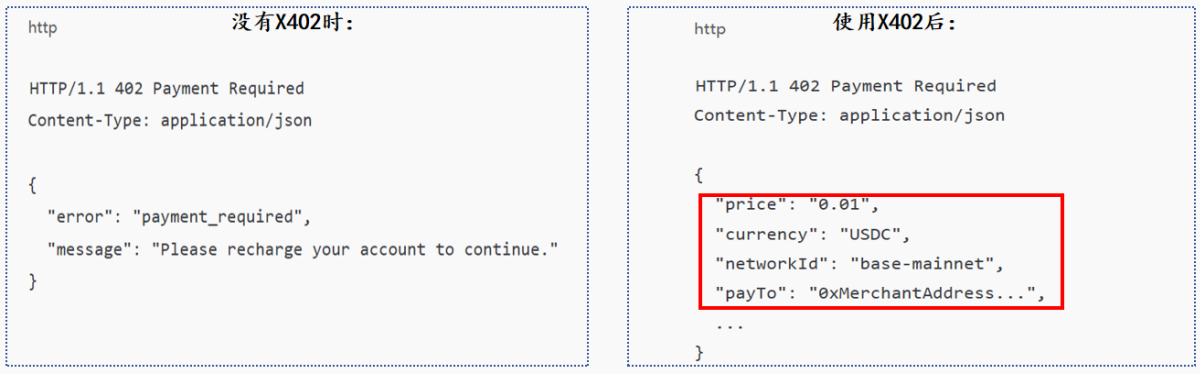


Source: General Web Browser Interface Display

The core innovation of the x402 protocol lies in transforming the passive "request refusal" behavior of the server into a standardized "quotation interaction." Under the x402 framework, when a server returns a 402 status code, it is no longer merely an access block. Instead, it synchronously encapsulates specific payment parameters within the response header, covering critical data such as amount, token type, target blockchain network, and receiving address.

This mechanism empowers the client to receive transaction information, enabling it to complete signature authorization and leverage subsequent processes to access the blockchain transaction settlement system (specific workflows will be analyzed in subsequent chapters). In this sense, access requests that were previously severed are, with the aid of the x402 protocol, transformed into continuous transaction flows.

Figure 5: Comparison of HTTP 402 Response Mechanism Before and After Enabling x402 Protocol



Source: Pharos Research

Figure 5 clearly illustrates the difference in the HTTP status code response received by the client before and after the x402 protocol is enabled:

- **Traditional Mode:** The content returned by HTTP 402 is unstructured and ineffective, serving only a simple "error blocking" function, consistent with the original definition of the 4xx series "Client Error."
- **x402 Embedded Mode:** The server's refusal response now carries a **"Quotation"**: while returning the 402 code, it precisely transmits all payment information required to complete the transaction. This allows the client to identify the requirement, complete the payment on-chain, and automatically initiate a secondary request.

In this context, x402 has constructed a **"Structured Quotation System,"** acting as an intermediary channel between the Web2 HTTP transmission protocol and Web3 payments.

03 / The Narrative Logic: Reshaping the Internet's Value Exchange Layer

3.1 Core Pain Points: The Absence of a Value Exchange Layer in the Traditional Internet

Reviewing the development history of the World Wide Web (WWW), the HTTP protocol has achieved immense success in information transmission efficiency, but there has always been a structural absence at the level of value exchange. As early as its design in the 1990s, the HTTP protocol failed to incorporate native "payment" functionality. This forced Internet business models over the past thirty years to rely on roundabout, platform-centric paths. This model established platform control over both traffic entry points and content exit points. In the tripartite game between platforms, users, and creators, a series of irreconcilable systemic drawbacks have gradually been exposed:

- **Profit Model Level:** Due to the lack of native micropayment methods, ad-driven models became the default law of survival for the Internet. According to GroupM statistical forecasts, the global internet advertising market size is expected to exceed **$1 trillion** in 2025 [1]. Giants such as Google, Meta, and X (Twitter) monopolize the vast majority of revenue, forcing the Internet into a vicious cycle of the "Attention Economy." To pursue click-through rates, low-quality and sensationalist content proliferates, which not only fragments the user experience but also causes a reverse selection (Gresham's Law) in the information environment.
- **Revenue Distribution Level:** Centralization is extremely severe. Under the current system, creators are reduced to digital laborers for platforms. The vast majority of surplus value is intercepted by the platform; creators lack direct monetization channels and are forced to passively rely on algorithmic recommendations and secondary distribution, making it difficult to obtain immediate and fair positive feedback.
- **Payment Method Level:** Users are forced to accept high-threshold subscription models, unable to pay "per use" based on actual demand. Furthermore, they must pay high platform handling fees, which directly obstructs value realization for long-tail content.
- **Information Security Level:** User privacy leakage and data abuse are rampant. To support massive advertising machines, platforms conduct comprehensive tracking and data collection on users, leading to the systemic erosion of privacy and even malicious data trafficking.

Although these maladies have existed for a long time, they have been difficult to shake due to platform monopolies. However, the arrival of the **AI Agent era** signals the total failure of the old model. The operational logic of an Agent is high-frequency calling, automated execution, and frictionless access—concepts completely contrary to the traditional platform economy philosophy. It can be said that the absence of a machine economy value exchange layer in the current Internet platform economy has become the single greatest obstacle to the commercial implementation of AI Agents.

3.2 The Solution: Infrastructure for the Machine Economy via x402

The emergence of the x402 protocol essentially fills the missing machine payment interface for the Internet. It resolves the aforementioned obstacles through improvements on three levels:

1.Establishing Micropayment Standards to Meet Pay-Per-Use Demand: x402 allows API calls, data access, or GPU computing power to be priced precisely by "count" or "second." For example, researchers can access a single document for $0.25 without paying expensive annual fees; AI models can pay $0.005 for each image recognition task. This granularity of payment capability is unattainable for traditional subscription models.

2.Providing Instant Settlement for High-Frequency Machine Interaction: Compared to traditional financial settlements which often take days, x402 relies on on-chain networks to achieve millisecond-level transaction confirmation, meeting the speed requirements of high-frequency inter-machine calls.

3.Removing Intermediaries to Realize P2P Value Flow: The protocol directly connects service providers and payers, eliminating platform intermediary fees. This allows revenue to flow directly to creators, truly realizing frictionless payment.

Figure 6: Comparison of x402 and mainstream payment channel performance data

payment channel	Typical expenses	Settlement time	Risk of chargeback	Throughput (TPS)
credit card	$0.30 + 2.9%	Several days (batch settlement)	Yes (up to 120 days)	Theoretical value~65000
PayPal	~3%+premium	Instant authorization (settlement takes several days)	have	unknown
ACH transfer	float	1-3 days	have	limited
Ethereum L1	$1-5 Gas fee	1-2 minutes (confirmed)	none	15-20
X402 (on the Base Chain)	<$0.0001	200 milliseconds	none	thousands

Source: Coinbase official website

3.3 Catalyst for Explosion: Convergence of Supply and Demand and Industry Drivers

Although the HTTP 402 standard has existed for 26 years, it is only today, through x402, that it has found its opportunity for implementation. This is the result of the confluence of three key factors: supply, demand, and industry momentum.

Urgency on the Demand Side: This stems from two areas. First, there is a rigid demand from **AI Agents** for cross-platform, high-frequency API calls and data services; traditional payment systems simply cannot support such automated "Machine-to-Machine" transactions. Second, the AI industry faces its own survival pressures—model training involves exorbitant computational costs and copyright compensation issues for corpora—creating an urgent need for a business model that allows AI Agents to generate their own cash flow to cover costs.

Maturity on the Supply Side: This benefits from the perfection of Web3 infrastructure. The proliferation of high-performance public chains (such as Base, Solana, Pharos) and high-liquidity

stablecoins (USDC) has endowed on-chain payments with second-level confirmation and ultra-low costs, making Internet micropayments technologically and economically feasible for the first time.

Key Momentum from Industry Giants: The decisive factor is the entry of industry titans. Coinbase open-sourced the protocol specifications; Google and Visa provided endorsement and support; and infrastructure giants like Cloudflare jointly initiated the **x402 Foundation**. This combined force, dedicated to establishing x402 as a new "Open Internet Standard," has significantly lowered integration barriers and accelerated ecosystem formation.

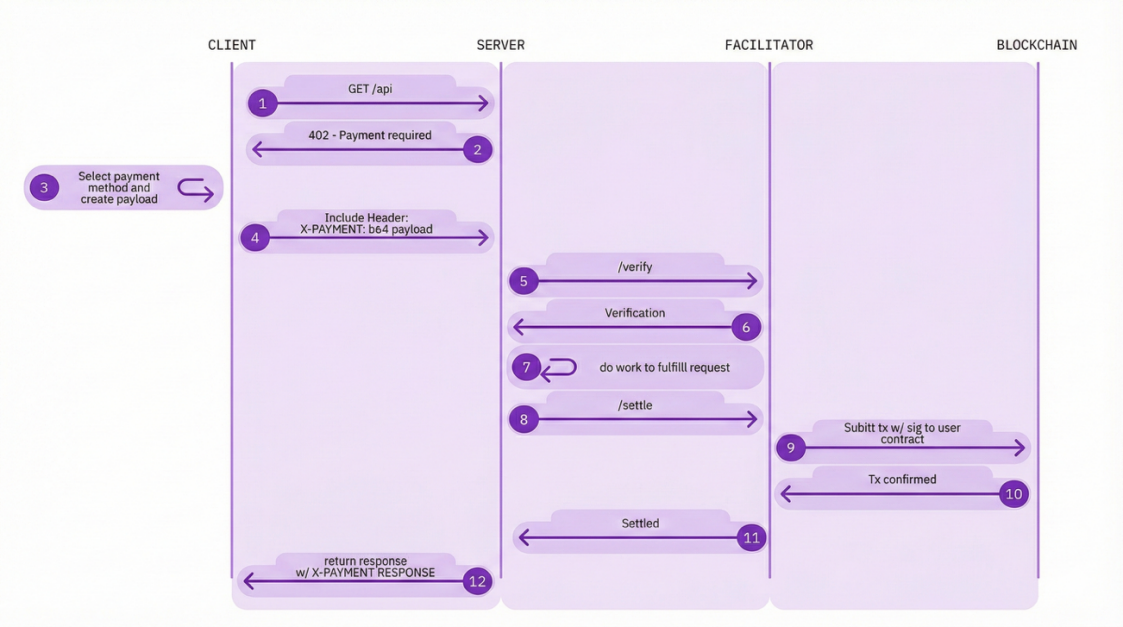
It is precisely due to the intersection of technical supply and AI demand, combined with the concerted push by giants, that x402 has transformed from a dormant standard into a realistic solution, leaping from theoretical conception to infrastructure.

04 / Underlying Architecture Analysis: The Universal Translator for Web2 and Web3

4.1 Nature of the Protocol: A Standardized Interaction Specification

Before dissecting the specific operations of x402, its technical nature must be clarified. x402 is not a specific application or component, but a **Protocol**—a rulebook defining how parties collaborate, or a standardized process. It does not directly take over fund transfers—that is the function of the underlying blockchain network—but rather focuses on standardizing the process of "Information Exchange."

Figure 7: x402 Workflow Diagram (Standard Version, including Facilitator)



Source: Coinbase Official Website [2]

As shown in Figure 7, as a standardized process, x402 aims to standardize the collaboration model between the Client, Server, and Facilitator. Its core task is to resolve three fundamental questions in information interaction:

- Who transmits to whom?
- What content is transmitted?
- In what format is it transmitted?

By standardizing definitions across these three dimensions, x402 successfully connects Web2's Hypertext Transfer Protocol (HTTP) with Web3's value settlement network (on-chain transactions), establishing a universal language for machine collaboration.

4.2 Core Participants: A Tripartite Architecture Introducing the "Facilitator"

According to Coinbase's architectural definition, the x402 ecosystem consists of three main entities, introducing the role of a **Facilitator** between the common Client and Server. Figure 7, derived from Coinbase's official x402 introduction guide, details the coordination workflow among the three:

- **Client:** The entity initiating the request off-chain, including user terminals or autonomously running AI Agents.
- **Server:** The resource provider holding APIs, data, or computing power.
- **Facilitator:** This is the most unique role in the x402 architecture. It assumes the dual functions of "Validation" and "Execution." It is responsible not only for verifying the validity of the signature credentials provided by the Client but also for translating off-chain payment instructions into on-chain settlement transactions.

Crucial Note: The Facilitator is a logical functional role, not necessarily a mandatory independent third-party entity. In actual deployment, if the Server possesses the corresponding on-chain interaction and verification capabilities, it can assume this function itself, thereby achieving a closed loop within the system without external processes. However, in practical applications, considering deployment costs and operational expenses, service providers typically choose to introduce an external third-party Facilitator[3].

4.3 Operational Mechanism: Value Flow from Request to Settlement

x402 acts as a universal translator between the Web2 transmission protocol and the Web3 value settlement layer, focusing on standardizing information flow (rather than blockchain settlement). According to Cloudflare's official analysis, its standard workflow can be summarized in the following six key steps [4]:

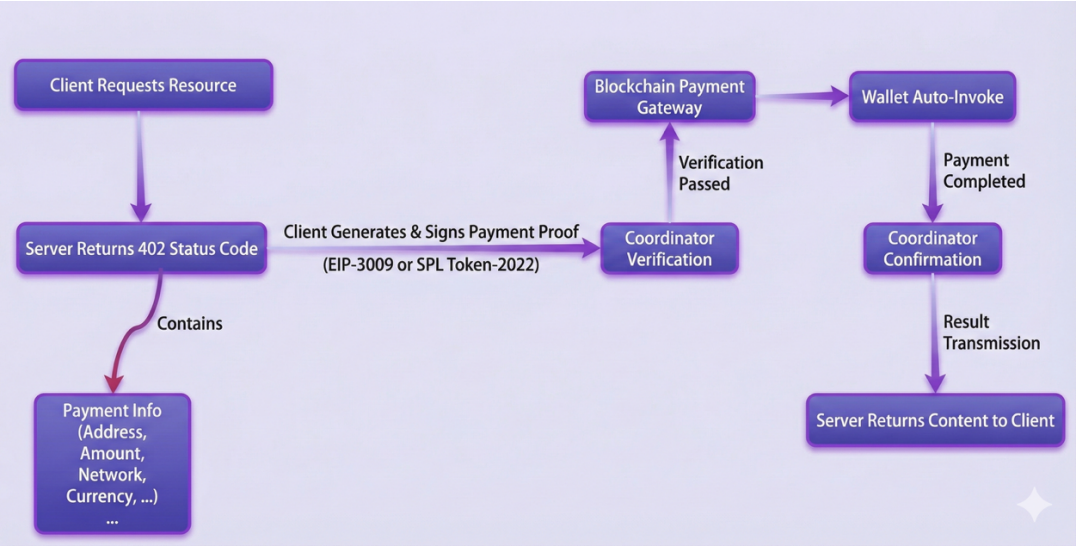
Figure 8: Summary of the main workflow of x402

Phase	Corresponding steps to Figure 7	Direction of Information Transmission	main content
Client initiates resource request	one	Client → Server	The client initiates a request (such as GET/app) to a resource protected by x402, which has not yet involved payment information
The server returns a payment request	two	Server → Client	After receiving the request, the server returns a 402 Payment Required response and provides the required payment information in the response, including payment details such as amount, currency, and receiving address
Client generates payment authorization (signature)	three	Client local	The x402 client generates a payment voucher (containing payment information) locally, and then signs and authorizes this payment voucher according to different blockchain standards (such as EIP-3009, SPL Token-2022)
Client submits payment voucher	four	Client → Server	The client initiates a new request and includes the X-PAYMENT field in the request header to carry the payment voucher from the previous step
Payment verification and on chain settlement	2025/5/11	Server ↔ Facilitator ↔ Blockchain	The facilitator receives the X-PAYMENT field and verifies the payment voucher within it; After confirming the validity, the facilitator initiates transaction settlement on the corresponding blockchain network and completes on chain payment
Payment confirmation and resource return	twelve	Server → Client	After the payment is completed: (1) The server verifies that the payment is successful and confirms that it is correct, and attaches the X-PAYMENT-SENSE field in the response to indicate that it has been confirmed. (2) The server returns the actual resource content to the client

Source: Cloudflare Official Blog [4]

Based on the above process, the complete workflow of x402 can be deconstructed into three core stages: **"Structured Quotation," "Signature Authorization," and "Verification Settlement"** (corresponding to steps 2, 3, and 5 in Figure 8). These correspond to the three main participants: Server, Client, and Facilitator. These three stages are tightly interlinked to complete an automated micropayment without human intervention. (Specific stages are shown in Figure 9).

Figure 9: Schematic of x402 Core Working Steps



Source: Pharos Research

4.3.1 Phase I: Server-Side Structured Quotation

This phase best embodies the origin of the x402 name; essentially, it is a **"Structured Quotation"** of transaction conditions. Once the Server identifies the Client's request, it returns the HTTP 402 Payment Required status code. In the response header or body, the Server explicitly provides the payment parameters required for access, including but not limited to:

- Payment Amount
- Payment Currency
- Receiving Address or Account Identifier
- Payment Expiration Time
- Blockchain Network, etc.

By returning the HTTP 402 status code, the Server synchronously returns transaction information, officially activating the x402 protocol flow via the HTTP status code.

4.3.2 Phase II: Client Signature Authorization

The essence of this step is the Client's confirmation of transaction information and the completion of automated signature authorization. Upon receiving the HTTP 402 response, the Client does not directly initiate an on-chain transfer. Instead, based on the transaction information provided by the Server, it generates a payment voucher locally and performs an encrypted signature to authorize it.

This process relies on specific asset standards: in the EVM (Ethereum Virtual Machine) system, the Client generates authorization based on the **EIP-3009** standard; in the Solana system, it relies on the **SPL / Token-2022** standard.

After completing the signature authorization, the Client re-initiates the request, encapsulating the signature containing the payment voucher within the X-PAYMENT request header. This **"Offline Signature"** mechanism allows the Client to provide authorization without needing to interact directly with the blockchain.

4.3.3 Phase III: Facilitator Verification and Settlement

When the Client sends the X-PAYMENT request to the Server, the **Facilitator** intervenes. It first strictly validates the payment voucher:

- Checks the legitimacy of the signature and whether the authorization has expired.
- Verifies whether the amount, currency, and receiving address match expected requirements.

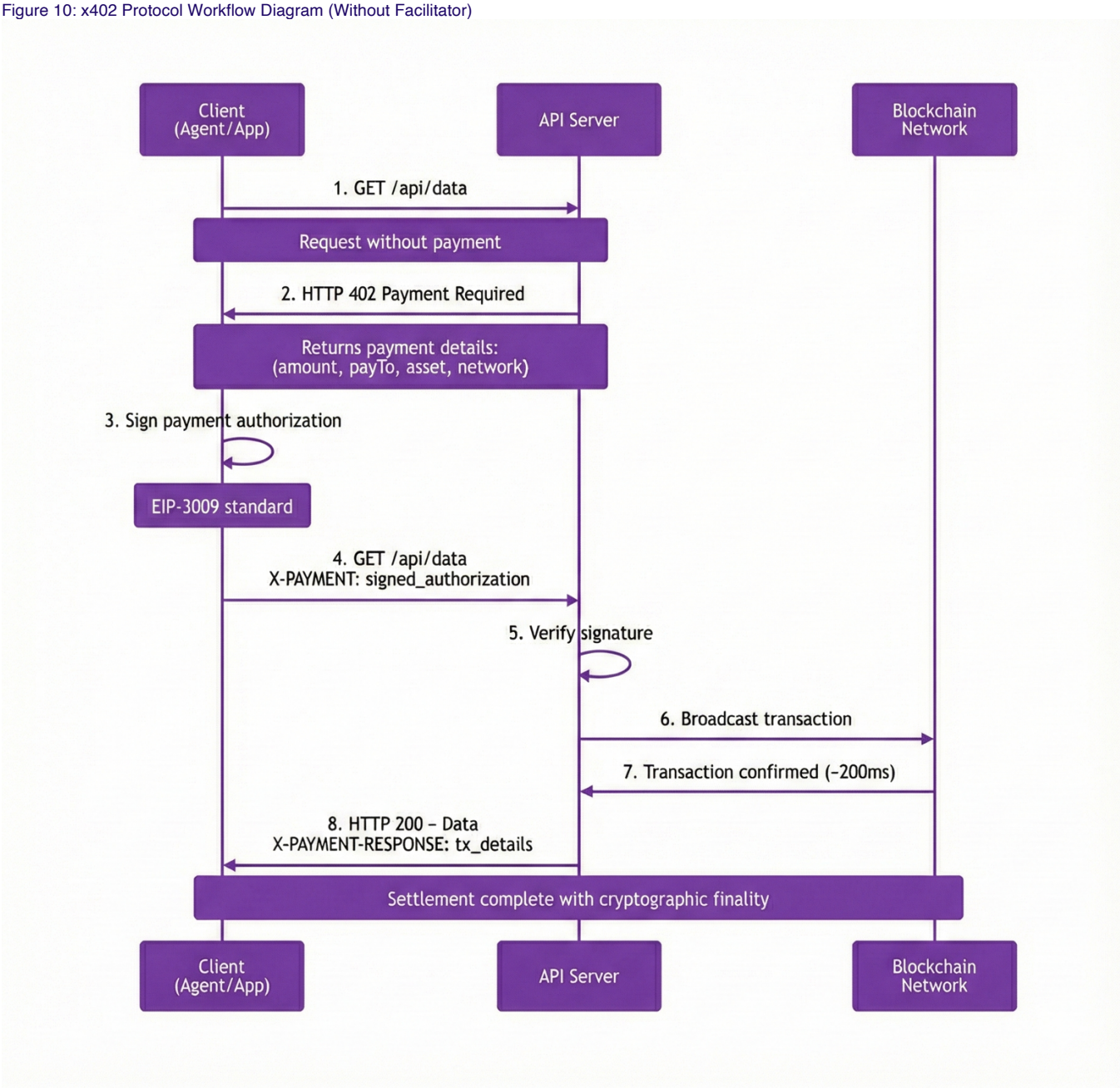
Once validated, the Facilitator initiates the actual settlement transaction on the corresponding blockchain network to complete the fund transfer. When the chain confirms the transaction is successful, the Facilitator reports the payment result to the Server. Upon confirmation, the Server delivers the actual resource content to the Client.

4.4 Three Special Clarifications Regarding the Architecture

Under the x402 workflow, the Client, Server, and Facilitator cooperate to combine Web2 Internet resources with Web3 on-chain payments, thereby completing an automated micropayment. Three points require special clarification:

1. **Facilitator Independence is Not Mandatory:** In the actual implementation of the x402 architecture, the Facilitator does not need to be an independent external component. Its core functions—verifying signatures and on-chain settlement—can be flexibly deployed according to the Server's development capabilities. Ordinary developers usually choose to access third-party services to lower barriers, while technologically mature Servers can adopt a **"Self-Hosted"** model, directly integrating validation code locally and interacting with the blockchain (as shown in Figure 10). This makes x402 suitable for both lightweight access and highly customized enterprise-level requirements.

Figure 10: x402 Protocol Workflow Diagram (Without Facilitator)



Source: Jinse Finance

2. **Settlement Flexibility:** The settlement network under the x402 architecture is flexible and not forcibly tied to blockchain systems. x402 is essentially a **technologically neutral credential specification**, not purely a blockchain application. Although current mainstream implementations rely on on-chain transactions, this does not exclude traditional finance. As long as a settlement system (such as bank accounts or credit card gateways) can generate electronic receipts verifiable by machines, it can theoretically be encapsulated into the standard x402 process via adapters. The industry has already begun exploring wrapping traditional payment methods like credit cards and bank accounts within the x402 workflow.
3. **Protocol is Free, Infrastructure is Not:** x402, as a standardized process specification, is inherently free, similar to the public nature of the HTTP protocol. However, this does not mean AI Agent access achieves absolute "zero cost." Since the protocol's operation relies on underlying value transmission networks, cost pressure is shifted to the infrastructure layer:
    - On one hand, using third-party Facilitator services may involve service fees or commissions.
    - On the other hand, transaction confirmation on the blockchain network itself consumes Gas fees.

Therefore, the advantage brought by x402 lies in procedural **"frictionlessness"** and automation, rather than economic "zero overhead." Its ultimate operating cost will depend heavily on the performance of the selected public chain and the pricing strategy of the Facilitator.

05 / Mechanism of "Gasless" Payment: Off-Chain Authorization + On-Chain Proxy Payment

From the perspective of a user or an AI Agent, the core transformation brought by the x402 protocol is the **"Gasless"** payment experience. Users only need to hold business assets like USDC to complete on-chain payments; there is no need to maintain reserves of native Gas tokens (like ETH or SOL), nor is there a need to understand complex miner fee mechanisms. The frictional costs in this process are either paid by a third party or implicitly included in the quotation.

The underlying logic that enables x402 to achieve this highly smooth interaction lies in the combination of **"Off-Chain Signature Authorization + On-Chain Facilitator Proxy Payment."** This also implies that the protocol's multi-chain expansion capability fundamentally depends on the adaptability between off-chain asset standards and on-chain coordination services.

5.1 Off-Chain Signature Authorization: The Technical Cornerstone of Frictionless Interaction

The key to x402 realizing a Gasless experience lies in fundamentally changing how transactions are initiated. Traditional on-chain interactions require users to hold native Gas tokens and actively broadcast transactions. In the x402 model, the Client is responsible only for **"Signature Authorization,"** while the actual right of on-chain execution is handed over to the Facilitator. This "Off-Chain Authorization + On-Chain Proxy Payment" model is primarily built upon the **EIP-3009** standard in the EVM ecosystem and the **SPL/Token-2022** standard in the Solana ecosystem.

In the EVM System: x402 adopts the EIP-3009 standard, which defines a specification for transferring funds via signature authorization. It allows users to delegate the execution rights of asset transfers and Gas payment responsibilities to a third party through cryptographic signatures compliant with EIP-712.

- *Crucial Distinction:* It is worth noting the fundamental difference between this and **EIP-7702**, which is currently gaining traction in the Ethereum Pectra upgrade. EIP-7702 focuses on Account Abstraction (AA) at the chain layer, endowing EOA accounts with smart contract capabilities. Conversely, x402 selects EIP-3009, which is an interface specification at the token contract layer. This means x402 has chosen a lighter, more reusable path—as long as the on-chain stablecoin contract (e.g., USDC, EURC) implements EIP-3009, a Facilitator can provide proxy payment services on any compatible chain without waiting for underlying chain upgrades. Projects like Cronos and SKALE have already clarified this in their official documentation.

In the Solana System: Although it lacks a standard directly benchmarking EIP-3009, x402's mechanical logic remains consistent. The protocol is built directly on top of the **SPL / Token-2022 Token Program**. The Client signs a Payload containing information such as amount and validity period. Subsequently, a Solana-supporting Facilitator (e.g., PayAI) receives this and constructs a transaction containing the Transfer instruction on-chain, paying the SOL fees using its own account as the Fee Payer.

Figure 11: Comparison between Account Abstraction (ERC-4337) and x402

	Account Abstraction (ERC-4337)	x402
core objective	Upgrade the 'wallet' to a smart account	Turn 'payment' into HTTP native capability
Main levels	Transactions at the on chain execution layer	Protocol of Web Layer
The blockchain involved	Native to Ethereum+various EVM chains	The protocol itself is not related to the chain
Requirements for Wallet	Strong dependence on wallet to implement ERC-4337 interface, not applicable to regular EOA	The protocol itself has no special requirements for wallets
Architecture complexity	Complex architecture with numerous on chain and off chain roles (such as ExitPoint, Bundler, Paymaster, etc.)	The protocol itself is simple (only implemented through the facilitator)

Source: Pharos Research

Unlike Account Abstraction (AA) adopting the EIP-7702 standard, x402 focuses more on the optimization of Web-layer protocols. Since it does not involve changes to wallet and blockchain architecture itself, it possesses significant advantages in adaptability and architectural complexity, potentially solving many pain points previously criticized in Account Abstraction solutions.

In summary, the signature authorization mechanism—**EIP-3009 on the EVM side + SPL/Token-2022 on the Solana side**—jointly provides x402 with the foundational path of "Signature Authorization → Facilitator Execution." For the client, regardless of whether the underlying layer is EVM or Solana, x402 unifies the interaction paradigm: **one signature, combined with one HTTP request, completes the payment.**

5.2 The Facilitator Mechanism: Dual Functions of Audit Node and Proxy Channel

In the x402 network architecture, the **Facilitator** is the critical hub connecting Web2 HTTP requests with Web3 on-chain settlement. It is not merely an information forwarder but assumes the dual functions of **"Audit Verification"** and **"Proxy Payment."** Although server-side entities can choose to self-host this component, calling an external Facilitator has become the mainstream solution to reduce development and O&M costs.

5.2.1 Prerequisite: Request and Negotiation Based on HTTP 402

The entire process begins with the interaction and negotiation between the Client and Server. When a Client (whether a user or an AI Agent) initiates a request for a protected resource, the Server returns an HTTP 402 Payment Required response. This response body is effectively a clear **"Quotation,"** listing the required amount, asset type, and validity period. Upon receiving the quote, the Client does not directly initiate on-chain operations but performs an offline signature on payment instructions containing critical information like Amount, Nonce (random number), and Expiration. Subsequently, the Client encapsulates this signature into the X-PAYMENT request header and re-initiates the request to the Server. This process completes the digital authorization of payment intent, preparing for the Facilitator's intervention.

5.2.2 Facilitator Role I: Audit Verification Node

After the Server receives the request with the signature, the Facilitator intervenes, first fulfilling its function as an **"Audit Verification Node"** by calling the /verify interface. At this stage, the Facilitator does not directly operate on the blockchain but focuses on strict cryptographic verification of the data submitted by the Client. Its audit priorities include: validity of the signature, matching of payment amount to quotation, uniqueness of the Nonce (to prevent replay attacks), and timeliness of the authorization. Through this layer of off-chain auditing, the Facilitator can precisely filter out invalid or malicious requests, ensuring that only legal, authentic, and unique transaction instructions enter the subsequent payment pipeline. This significantly saves on-chain resources and establishes a necessary firewall between Web2 business logic and Web3 asset security.

5.2.3 Facilitator Role II: Proxy Payment Channel

Once the audit is passed, the Facilitator immediately switches to the **"Proxy Payment"** role, responsible for substantive interaction with the blockchain. The Facilitator calls the /settle interface, wrapping the user's signed instructions into a standard on-chain transaction, and broadcasts it to the blockchain network via standard interfaces like transferWithAuthorization. This segment is the key to realizing **"Gasless Payment"**: all Gas fees generated by this transaction are typically advanced by the Facilitator. This means the user does not need to hold native tokens like ETH or SOL, nor care about complex Gas mechanisms. The Facilitator uses its own capital reserves to complete the asset transfer operation, effectively acting as the user's "On-Chain Proxy Payer," thereby providing a completely frictionless payment experience for frontend users or AI Agents.

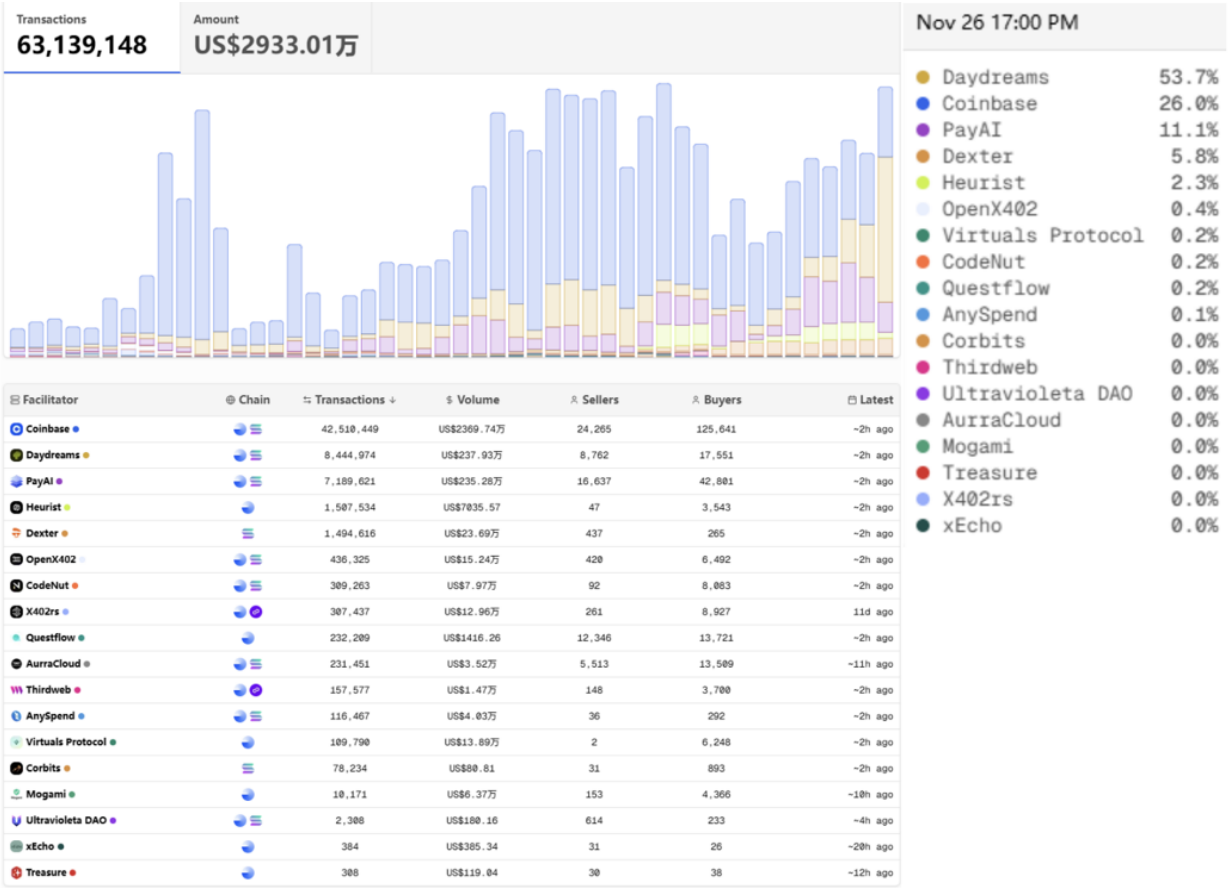
5.2.4 Credential Delivery and Transaction Closed-Loop

When the on-chain transaction is confirmed, the Facilitator generates a unique Transaction Hash (txHash). This hash value is returned to the Server in the X-PAYMENT-RESPONSE header as an immutable "credential." Based on this, the Server confirms the funds have arrived and subsequently unlocks and delivers the resource to the Client. Thus, a tight **"Payment ↔ Delivery"** binding loop is formed, spanning request, quotation, audit, proxy payment, and final delivery.

5.2.5 Market Landscape: Giant Dominance and Diversified Development

From the perspective of ecosystem development, the Facilitator market has formed a landscape of multipolar coexistence. According to on-chain statistics from **x402scan** (October 27, 2025 - November 27, 2025), the x402 network processed a total transaction volume of **$29.33 million** and exceeded **63.13 million** transactions in the past month.

Figure 12: Market Share Distribution of Mainstream Facilitator Providers



Facilitator	Chain	Transactions	Volume	Sellers	Buyers	Latest
Coinbase		42,510,449	US$2369.74万	24,265	125,641	~2h ago
Daydreams		8,444,974	US$237.93万	8,762	17,551	~2h ago
PayAI		7,189,621	US$235.28万	16,637	42,801	~2h ago
Heurist		1,507,534	US$7035.57	47	3,543	~2h ago
Dexter		1,494,616	US$23.69万	437	265	~2h ago
OpenX402		436,325	US$15.24万	420	6,492	~2h ago
CodeNut		309,263	US$7.97万	92	8,083	~2h ago
X402rs		307,437	US$12.96万	261	8,927	11d ago
Questflow		232,209	US$1416.26	12,346	13,721	~2h ago
AurraCloud		231,451	US$3.52万	5,513	13,509	~11h ago
Thirdweb		157,577	US$1.47万	148	3,700	~2h ago
AnySpend		116,467	US$4.03万	36	292	~2h ago
Virtuals Protocol		109,790	US$13.89万	2	6,248	~2h ago
Corbits		78,234	US$80.81	31	893	~2h ago
Mogami		10,171	US$6.37万	153	4,366	~10h ago
Ultravioleta DAO		2,308	US$180.16	614	233	~4h ago
xEcho		384	US$385.34	31	26	~20h ago
Treasure		308	US$119.04	30	38	~12h ago

Source: x402scan, Data Range: Oct 27, 2025 – Nov 27, 2025

Analysis of Figure 11 reveals that the current Facilitator market presents obvious "Head Effects" and trends toward segmentation:

- **Coinbase CDP Facilitator** occupies a dominant position with a monthly transaction volume of **$23.69 million** (approx. 80%). Its core advantage lies in the fee-free settlement capability of USDC on the Base chain and comprehensive support for KYT/OFAC compliance reviews, making it the preferred choice for compliant commercial scenarios. Its business has currently expanded to the Solana chain.
- **PayAI Facilitator** is deeply cultivating the Solana ecosystem, with a monthly transaction volume of approx. **$2.35 million** (approx. 8% share). Leveraging a "Solana-first" strategy and multi-chain coverage capabilities, PayAI has established a solid foothold in the market for small-to-medium developers and AI Agents.
- **Daydreams Facilitator** represents the new force of the native Agent economy. As an application framework for Generative AI Agents, Daydreams is a software toolkit focused on creating highly autonomous, multimodal AI agents, providing intelligent logic and generation capabilities. Although its total monthly volume (approx. **$2.3793 million**) is on par with PayAI, Daydreams' daily transaction volume share exceeded 50% on November 26. This spike was driven by high usage from specific projects and has subsequently returned to stability.

This diversified ecological structure maintains a dynamic balance between decentralization and commercial compliance. Large institutions can choose Coinbase for strong compliance, while native Web3 developers tend towards PayAI or Daydreams. Differentiated competition among Facilitators regarding compliance reviews, fee subsidies, and developer experience is accelerating the maturation of Agent economy infrastructure.

5.3 Scalability Logic: Multi-Chain Adaptation and Asset Compatibility Strategy

Benefiting from the underlying design philosophy of "Off-Chain Authorization," x402 possesses natural multi-chain compatibility. The boundary of its payment capability is not limited by specific blockchain networks but depends on the universality of "Asset Standards." This means x402's expansion logic is not about separate development for every chain, but adaptation based on the universality of asset contracts.

- **Mainstream Ecosystem Adaptation:** Standardized token contracts have paved the way. In the **EVM ecosystem**, any token that implements the EIP-3009 standard at the contract layer (typically USDC, EURC, AUSD, etc.) can theoretically be used for frictionless payment via the x402 protocol immediately. The only prerequisite for implementation is the existence of a Facilitator service supporting that chain on the network. Similarly, in the **Solana ecosystem**, x402 directly supports all standard SPL and Token-2022 tokens (like USDC-SPL) without requiring additional protocol layer configuration for seamless access.
- **Non-Native Compatible Networks:** "Wrapped Adaptation" expansion solutions have emerged in the ecosystem. Taking **BNB Chain** as an example, due to the lack of stablecoins natively supporting EIP-3009, ecosystem developer **Pieverse** launched an extension protocol similar to x402b. This solution issues a wrapped stablecoin, **pieUSD**, anchored 1:1 to USDT, and supplements the EIP-3009 style signature authorization interface at the contract layer. This "Wrapped Adaptation" path proves that the x402 protocol has extreme plasticity—even if underlying facilities are temporarily lacking, access can be achieved through contract layer modification.

Based on the above architecture, users and AI Agents theoretically only need to hold a few mainstream stablecoins (like USDC or pieUSD) to complete settlements via the unified x402 payment process across multiple chains.

Summary: Dissecting the critical architectural design of x402 reveals two facts:

1. Both the frontend "Frictionless Payment Experience" and the backend "Cross-Chain Compatibility" ultimately stem from the **"Off-Chain Signature + On-Chain Proxy Payment"** model.
2. The realization of this model depends on two key architectures: **Unified Asset Standards + Unobstructed Facilitator Channels.**

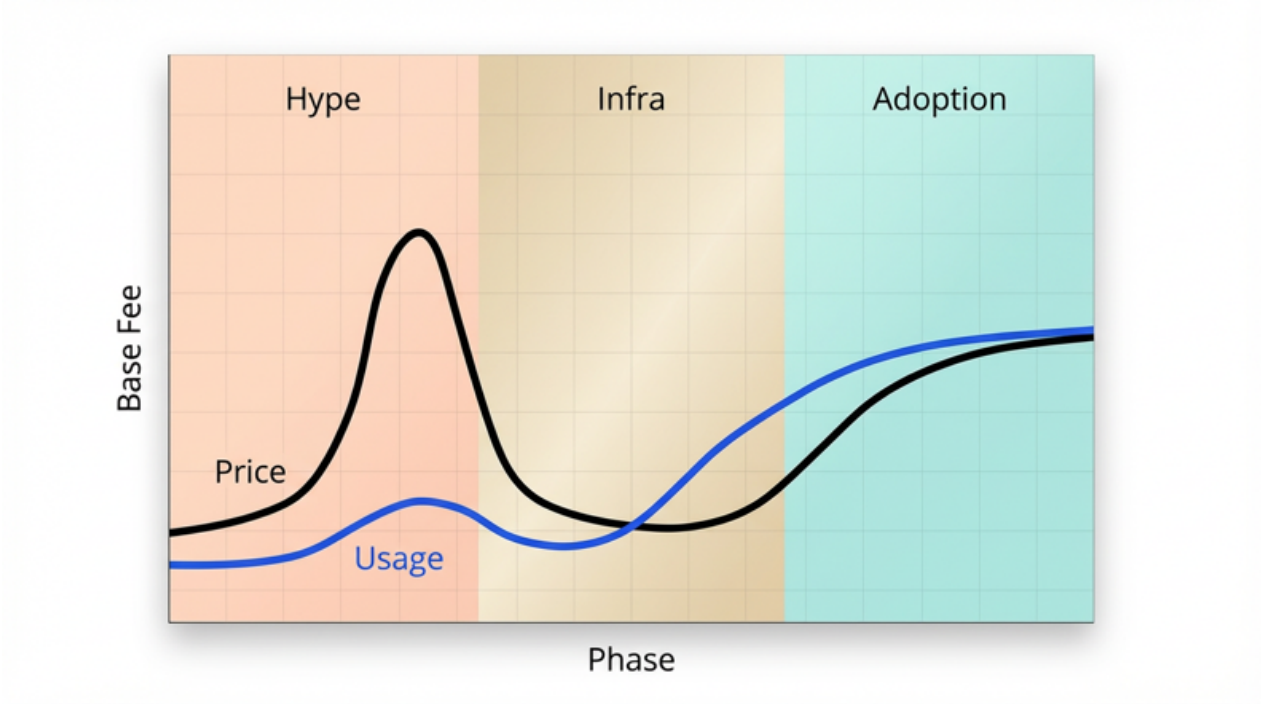
Asset standards endow "Universality of Authorization," while Facilitators solve the "Automation of Execution." These two elements constitute the foundation of the x402 protocol's operation. As long as these conditions are met, any blockchain network (or even other settlement networks) can be transformed into an automated payment facility available to AI Agents.

06 Ecosystem Panorama: From Narrative Bubble to Infrastructure Reality

6.1 Assessment of Protocol Progress: Moving from Hype to Construction

According to the **Gartner Hype Cycle** [5], any narrative must undergo three processes: **Hype -> Infra (Construction) -> Adoption**.

Figure 13: Gartner Hype Cycle Illustration *(Source: Pharos Research)*



Source: Pharos Research

- **Hype Phase:** The market is dominated by emotion and grand narratives. Capital floods into related tokens and Meme projects, causing asset valuations to decouple from fundamentals in the short term. This phase usually lasts weeks to months, followed by a value correction as enthusiasm wanes.
- **Infra Phase (Construction):** Speculative bubbles fade, and capital and talent shift to substantive construction. Developers are dedicated to perfecting underlying protocols, toolchains, and ecosystem support. This phase is accompanied by brutal survival of the fittest; projects lacking engineering implementation capabilities will gradually die out.
- **Adoption Phase:** A few leading protocols successfully cross the chasm, validate Product-Market Fit (PMF), and transform from speculative targets into business components generating actual cash flow.

Figure 14: Timeline of the Birth and Application of x402

time	event	Meaning and Impact
one thousand nine hundred and ninety-nine	HTTP/1.1 specification includes status code 402 (HTTP402)	The HTTP 402 (Payment Required) status code is reserved, but there is no standardized application
May 6, 2025	Coinbase releases x402 protocol	The x402 protocol was born, and the concept of HTTP 402 status code welcomed large-scale application for the first time
September 16, 2025	Google releases AP2 (Agent Payments Protocol), with x402 becoming one of its encrypted payment options	X402 has been accepted by Web2 giants for the first time, becoming a bridge connecting Web2 and Web3 payments
September 23, 2025	The Internet giant Cloudflare announced that it will be incorporated into the x402 ecosystem and build a 402 foundation with Coinbase	The application scenarios and infrastructure of x402 have greatly expanded. The establishment of the foundation marks its entry into specialized and long-term operation
October 14, 2025	Visa announces partnership with Coinbase to integrate x402 into its Trusted Agent Protocol (TAP) protocol	X402 has been recognized by traditional financial giants and is beginning to penetrate into the mainstream payment field
September October 2025	Nearly 500000 transactions were made in a single week, with a month on month growth of over 10000%, and a peak of 239000 transactions per day	X402 large-scale promotion, validated by the market
October 25, 2025	PING meme coin surged due to its association with the x402 concept, with its market capitalization surpassing $60 million.	The concept of x402 has gained widespread attention in the cryptocurrency market and beyond
October 25, 2025	Kite AI announces deep integration of x402 in its AI payment blockchain	X402 has been further upgraded from a 'protocol plugin' to the default payment track for some AI public chains
October 27, 2025	PayAI, as a third-party facilitator, has emerged as a rising force, with its market value surpassing PING at one point and handling approximately 14% of x402 transactions	The ecological focus is gradually shifting from pure Meme to the infrastructure construction track of "audit+payment agency"
Early November 2025	Industry technical articles begin to discuss x402 alongside authoritative AI agent underlying protocols such as MCP, A2A, AP2, ACP, etc	X402 is no longer seen as a standalone payment protocol, but is classified as a key layer of the Agentic Internet technology stack
Mid November 2025	The Google AP2 documentation has launched a special document titled "AP2 and x402", which explains how AP2 can collaborate with x402	The integration between x402 and giants has deepened, further consolidating x402's position as a core component of the current AI Agent protocol
.....		

Source: Internet public information, organized by Pharos Research

Combining the timeline in Figure 13 with current market data, we assess that x402 is currently in a critical transition phase from the "Hype Phase" to the "Infrastructure Phase."

- **Narrative Fermentation and Bubbling:** x402 first appeared in May 2025 via Coinbase merely as a technical experiment. However, after a16z crypto released the "State of Crypto 2025" report, its narrative was rapidly elevated, deeply binding it to the trillion-dollar potential market of "Agentic Commerce." This grand narrative peaked in October, where Meme tokens represented by PING surged, successfully triggering phenomenon-level discussion on crypto social media.
- **Value Return and Sector Switching**: Recently, as early speculative sentiment cools and related token prices retract, the market is undergoing a healthy "de-bubbling" process. More importantly, capital and attention have shifted substantially:
    - **From Meme to Infra**: On October 27, the market cap of third-party service provider PayAI flipped the Meme coin PING, processing approximately 14% of the network-wide volume. This data reversal marks the shift of ecosystem focus from pure speculative hype to the infrastructure construction track represented by "Audit + Proxy Payment."

- **Standardization of the Tech Stack:** Industry discussion is no longer limited to token prices but focuses on the convergence of technical standards. x402 is gradually being viewed as a core component alongside ERC-8004, MCP (Model Context Protocol), A2A, and AP2.

In conclusion, while market heat has cooled in the short term, this is precisely the sign of the protocol maturing. x402 is shedding financial speculation attributes and returning to its technological foundation. Its future ecosystem implementation will depend on its actual adoption rate as the "Value Transmission Standard" in multi-agent collaboration networks, warranting continuous tracking.

6.2 Giant Entry: How x402 Builds an AI Agent Synergy Ecosystem with AI Titans

Viewing from the protocol stack perspective, the AI Agent economy is evolving a clear three-layer architecture: the **Connectivity Layer** (data links/capability calls), the **Trust Layer** (identity sovereignty/reputation), and the **Transaction Layer** (final value settlement). In this architecture, MCP, A2A, x402, AP2, ACP, and ERC-8004 occupy critical ecological niches. The real competition is not who replaces whom, but who can become mutually compatible, composable infrastructure. In this landscape, x402 has the opportunity to form a distinct combination with giant protocols, becoming the default underlying payment standard in the AI Agent economy.

6.2.1 Connectivity Layer: Role Division of MCP and A2A

Before Agents can conduct economic activities, they must first solve data acquisition and collaboration issues. Currently, **MCP (Model Context Protocol)** led by Anthropic and **A2A (Agent-to-Agent)** led by Google are the two core pillars of this field, representing "Inward" and "Outward" connection logics respectively.

- **MCP** focuses on solving the **Depth** problem of data. Through a standardized Client-Host-Server architecture, it acts as a universal interface for AI, allowing direct reading of local databases, codebases, or private files. Without MCP, AI is like an analyst with reasoning capabilities but no access to files.
- **A2A** focuses on extending the **Breadth** of capabilities. Google designed it as a social network for agents, allowing agents to discover each other through standardized "Agent Cards" and delegate complex long-process tasks to other more specialized agents.

Figure 15: Comparison of Mainstream Connection Layer Protocols (MCP vs A2A)

Agreement Name	MCP	A2A
full name	Model Context Protocol	Agent-to-Agent
Leading party	Anthropic	Google
core functionality	Southbound: Connecting tools and data	East West: Collaboration and delegation between intelligent agents
analogy	Connect the model to a unified interface to read local and proprietary data	Give each agent a "business card" to achieve mutual employment between agents
architecture	Client Host Server (based on JSON-RPC 2.0)	Peer to peer interaction (based on HTTP)
Applicable scenarios	Deep reasoning, long context, complex tool invocation	Large scale orchestration, multi-agent collaboration, cross system collaboration

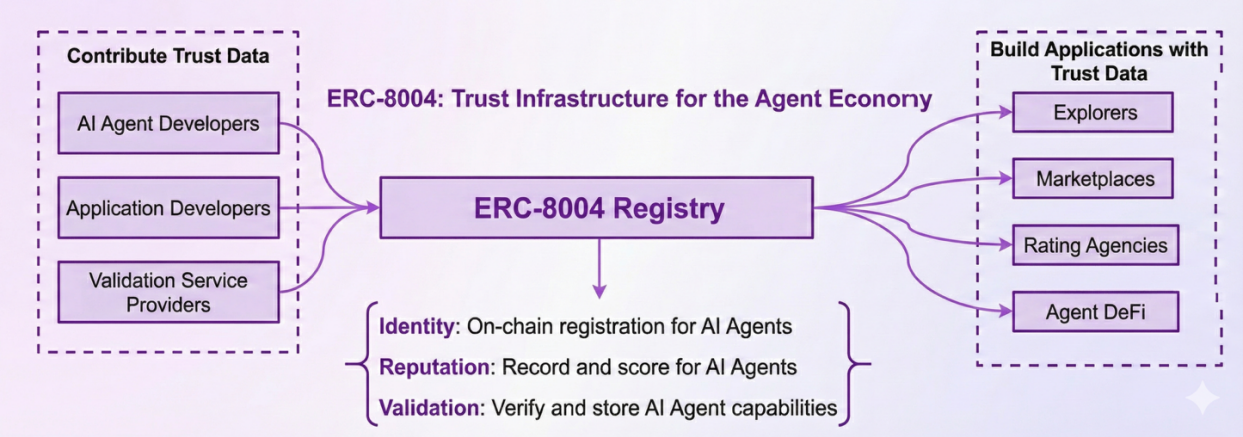
Source: Compiled by Pharos Research

In practical application, these two are not mutually exclusive but highly complementary: MCP is better suited to connecting "one agent" deeply with its required data and tools; A2A focuses more on reliable collaboration and task distribution among "multiple agents." In the future, a hybrid trend is expected: utilizing MCP to mine vertical data value while using A2A to expand the horizontal collaboration network. **x402's role in this layer is embedded as a "Value Carrier":** It can act as a standard tool provided by an MCP server or as a callable settlement endpoint via A2A. Cloudflare has already added support for x402 in its Agents SDK and MCP servers, indicating that in engineering implementation, the connectivity layer and payment layer are being standardized simultaneously.

6.2.2 The Trust Layer: ERC-8004 Building the Identity Foundation

After solving data connectivity, for the Agent economy to move towards commercialization, it must cross the chasm of **"Trust."** In an open network, distinguishing efficient AI service providers from malicious script bots is crucial. The **ERC-8004** protocol emerged to address this, launched by the Ethereum Foundation dAI team and Consensys in conjunction with Google, Coinbase, and others. It aims to build a decentralized commercial registration system, endowing every AI Agent with verifiable identity, resume, and capability proofs.

Figure 16: Breakdown of ERC-8004 Functions



Source: Bitget Wallet

The ERC-8004 system constructs a complete trust loop through three core registries, providing security prerequisites for subsequent x402 transactions:

- **Identity Registry:** The "Digital Passport" for Agents. It uses the ERC-721 protocol to generate unique on-chain identities. This not only allows agents to carry identity across platforms but also publicly records basic metadata via standardized "Agent Cards," enabling permissionless discovery.
- **Reputation Registry:** The decentralized "Credit Score." This is the link most tightly integrated with x402. It builds a tamper-proof evaluation system centered on **"Evaluation as Proof of Transaction"**—all feedback must be linked to x402 on-chain payment records. This ensures only real transaction participants can leave reviews, effectively curbing brushing and fraud, establishing a transparent reputation market.

- **Validation Registry:** The "Accountability Mechanism" for high-value transactions. Agents can call TEE oracles or ZK-ML (Zero-Knowledge Machine Learning) proofs to solidify the correctness of their reasoning process on-chain. This introduces an accountability system similar to professional services.

6.2.3 Transaction Layer: Division and Synergy of x402, AP2, and ACP

Once data acquisition and identity verification are complete, the final value exchange stage begins. Currently, **x402, AP2, and ACP** represent the three core standards of the transaction layer, reflecting different technical routes and design philosophies.

Figure 17: Comparison of mainstream protocols in the trading layer (x402 vs AP2 vs ACP)

project	x402	AP2	ACP
full name	HTTP 402 Protocol	Agent Payments Protocol	Agentic Commerce Protocol
attribute	Internet native+decentralization	Authorization and Compliance Orientation	Close to the existing e-commerce checkout experience
promoter	Coinbase + Cloudflare	Google	OpenAI + Stripe
Main functions	Using HTTP 402 to view payments as a native capability of web pages and APIs	Resolve 'agent risk', strengthen authorization, risk control, and audit closed loop	Optimize AI driven checkout and subscription processes on the existing credit card system
Payment Method	stablecoin	Legal tender/credit card	Tokenized Cards
Payment Method	On chain settlement, borderless restrictions	Relying on traditional payment networks such as Visa/Amex	Relying on acquiring networks such as Stripe/Worldpay
Core strengths	High frequency micro payment, extremely low cost, strong programmability	Safe, accountable, and compliant	Friendly to existing merchants and seamlessly integrated into the existing e-commerce system

Source: Compiled by Pharos Research

In this competitive landscape, **x402 demonstrates an irreplaceable ecological niche advantage:** Google's AP2 and OpenAI-backed ACP focus more on frontend retail (B2C) scenarios. They utilize traditional credit card and banking networks to address compliance, authorization, and fund security—primary concerns for human consumers. However, this architecture, tethered to the traditional financial system, has natural shortcomings: high fees and cumbersome verification processes make it unable to handle high-frequency, micro-amount inter-machine transactions.

This is x402's core opportunity. As a protocol built on the HTTP 402 standard and stablecoins, **x402 is designed for backend automation (B2B/M2M).** In scenarios involving billions of API calls, data stream subscriptions, and compute leasing, machines need to pay fees of $0.01 or less at millisecond speeds. x402's low friction and borderless nature make it the optimal solution here.

Crucially, x402 possesses strong underlying compatibility. It can be viewed as a foundational **"Settlement Pipe"** nested within the execution logic of AP2 or ACP. Specifically: **AP2 handles upper-layer governance (who is authorized to buy what), while x402 handles underlying**

execution (fund flow). This explains why Google has recently increased its investment in x402 and continues to push integration.

This **"AP2 Governance + x402 Settlement"** combination is likely to become the mainstream form of the future agent economy. x402 is not a replacement for AP2 or ACP, but fills the high-frequency, micro-amount, M2M transaction space they cannot reach.

Future Synergy Landscape:

- **Upstream Connection: MCP** connects internal enterprise knowledge bases; **A2A** coordinates multiple agents into task groups.
- **Resource Procurement (M2M):** When external APIs or compute are needed, after verifying identity via **ERC-8004**, agents use **x402** for stablecoin micropayments, realizing automated, instant resource delivery.
- **Authorization Management:** When sensitive funds or enterprise budgets are involved, the **AP2** protocol is introduced to record "Principal Authorization" and audit logs.
- **Terminal Settlement (B2C):** When finally charging human users, **ACP** accesses the credit card network to provide a frictionless payment experience.

Conclusion: x402 assumes the role of the foundational settlement base in the machine economy. Together with AP2 (responsible for "Authorization Compliance") and ACP (responsible for "Terminal Experience"), it constitutes the clearly layered, mutually supporting payment technology stack of the AI era.

6.3 Ecosystem Panorama: A Full-View of the Agent Economy Under Multi-Chain Synergy

Currently, over 200 ecosystem projects have been incubated based on x402. Across ecosystems like Base, Solana, and BNB Chain, a multi-layered landscape has formed, covering Agents, Facilitators, Analytics, Protocols, and Derivative Assets (e.g., Memes).

Figure 18: Overview of the x402 Ecosystem Landscape

Source: X post @henloitsjoyce

6.3.1 Agents: The Commercial Carriers of AI

In the x402 architecture, AI Agents are the execution carriers driving network operations. They act not only as demanders but also as direct initiators of transactions, spanning the entire chain from data access to on-chain payment.

In the Base Ecosystem, SANTA and AurraCloud are typical representatives:

- **SANTA:** Developed by **Questflow** in collaboration with the **Virtuals** team. Questflow completed a $6.5 million seed round led by cyber•Fund in July 2025. SANTA represents an autonomous Agent Cluster (multiple AI Agents working together) and acts as a cross-chain Facilitator. The name stands for **Swarmous Networked Task Agents**, emphasizing its role as a coordinated AI agent network capable of autonomously executing complex Web3 tasks. On one hand, it is built on Questflow's QDP (Developer Platform) and MAOP (Multi-Agent Orchestration Protocol), enabling complex task automation. On the other hand, as a launchpad project of the Virtuals Protocol, it has garnered significant attention in the "Virtual Character + Agent" sector. SANTA highlights genuine cross-chain capabilities, extending x402 to multiple ecosystems, including Base, EVM-compatible chains, and non-EVM networks like Solana.
- **AurraCloud:** A decentralized cloud computing platform developed by the Aurra team. It connects a network of nodes providing computing resources with users via smart contracts and natively integrates x402 to realize automated pay-as-you-go billing. It leans more towards **AI Agent Infrastructure construction**: (1) For developers, it completes one-click verification services and hosting by compatible MCP servers, x402 payments, OpenAI APIs, wallets, and monitoring; (2) For novice users, it enables the deployment of an Agent in minutes for customer service, market queries, group management, on-chain data queries,

etc. Its token, **AURA**, issued by Virtuals Protocol, saw its market cap break $9 million at its peak before retracing.

In the Solana Ecosystem, Daydreams is a prime representative. This project has origins deeply tied to blockchain gaming, co-created by the fully on-chain game infrastructure platform **Cartridge** and Loaf, founder of the on-chain MMO *Eternum*. It provides an open agent framework for on-chain interaction and game development. The project has shifted to providing a comprehensive **AI Agent Application Framework** (essentially a software package), guiding developers on how to build agents with **"Chain of Thought (CoT)"** and **"Daydream"** mechanisms. **Distinction from Aurra:**

- **AurraCloud** leans towards "Compute, Hosting, Payment Infrastructure" (Infra/Platform Layer).
- **Daydreams** leans towards "Agent Logic and Cognitive Frameworks" (Application Layer). It is worth noting that Daydreams' Facilitator service is exceptionally strong, consistently ranking in the top three on the x402 Facilitator list since launch (data shown in Figure 11, Section 5.2.5). By introducing the x402 protocol framework, AI Agents developed using Daydreams can directly bind stablecoin settlements, providing native charging and incentive mechanisms for "AI-driven on-chain interactions."

In the BNB Chain Ecosystem, AEON serves as the crypto payment and settlement infrastructure framework for AI scenarios. Its core function is to enable automatic on-chain payment initiation and fund routing via AI Agents based on the x402 standard, focusing on automated payment scenarios + lowering the barrier for real-world crypto usage.

- AEON provides agents with the ability to connect to millions of service providers within the ecosystem: it enables automatic fund settlement and payment path selection while providing transparent, traceable financial records.
- Simultaneously, based on the x402 payment standard, it has natively deployed x402 Facilitators and SDKs on BNB, allowing various AI Agents to initiate, verify, and settle on-chain and off-chain automated payments using stablecoins, extending this capability to tens of millions of real-world merchants.
- As one of the earliest AI Agent settlement protocols in the BNB Chain ecosystem to be fully compatible with the x402 standard, AEON holds significant observational value for establishing next-generation decentralized AI payment infrastructure.

In Summary: Among the AI Agents in the "Execution Layer" of the x402 ecosystem, some focus on agent orchestration and cluster collaboration (e.g., SANTA), while others provide infrastructure and applications to simplify deployment (e.g., AurraCloud, Daydreams), superimposed with native agent payment protocols like AEON. Together, they provide implementable application samples for "AI autonomously accessing resources and completing value exchange."

6.3.2 Facilitators: Infrastructure for Payment and Settlement

Facilitators are responsible for processing signature verification, transaction broadcasting, and Gas abstraction. They are the critical undertaking layer in the x402 payment process, bridging "Transaction Intent" to "On-Chain Settlement." Many projects targeting AI Agents also operate their own x402 Facilitators, such as Daydreams. For the current Facilitator ecosystem details, refer to Section 5.2.5; only key projects are briefly analyzed here.

- **Coinbase:** Leveraging the **Coinbase Developer Platform's x402 Facilitator** and EIP-3009 authorization, it has achieved zero-fee, sub-second settlement on Base, providing

foundational support for the majority of early x402 traffic. It is currently the service provider with the highest share of the Facilitator market.

- **PayAI Network:** In terms of multi-chain expansion, PayAI is one of the most representative third-party Facilitators and one of the earliest projects to implement x402 in actual business on **Solana**. It is dedicated to building next-generation payment infrastructure for AI Agents, using x402 to enable instant settlement and low-cost micropayments between agents. It focuses on the **"Agent-to-Agent (A2A)"** payment model, allowing agents to collaborate autonomously, complete transactions, and purchase services without human intervention. PayAI's vision is to create a 24/7 online AI marketplace where agents possess the ability to autonomously create value and consume. Functionally, PayAI is not only a multi-chain x402 Facilitator (Solana-focused, compatible with Base/EVM) but also provides various developer tools, such as the **x402 Echo Merchant** (simulating real merchants), an open network for freelance agents, and a "Token Gateway" allowing projects to collect payments in their own tokens. These capabilities allow it to accumulate network effects in both "AI Payment Infrastructure" and "Agent Market" dimensions, serving as a critical diffusion channel for x402 in the Solana ecosystem.

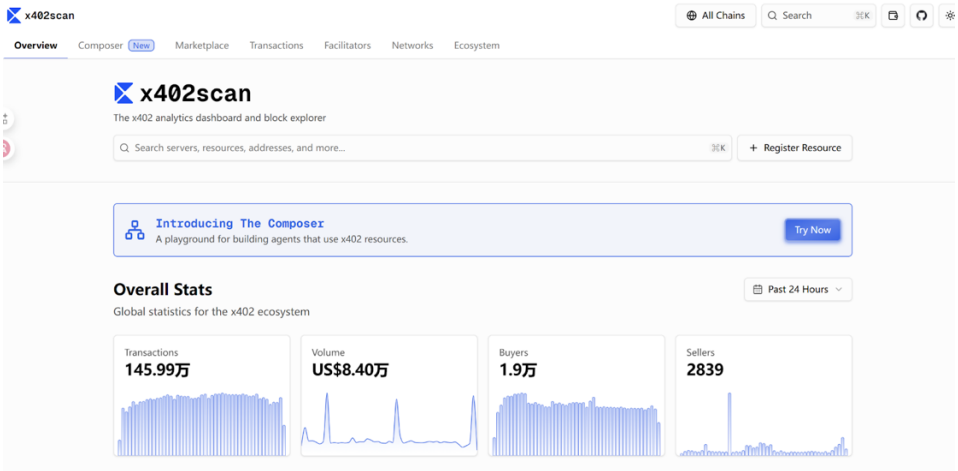
As more third-party Facilitators join, competition in this layer will primarily manifest in multi-chain support, fee structures, developer experience, and the depth of compatibility with upper-layer protocols like AP2 and ERC-8004.

6.3.3 Analytics: The Visual Window into Ecosystem Health

Although there are fewer purely "Analytics" assets in this cycle, this remains an indispensable part of the ecosystem. Represented by tools like **AurraCloud**, **Corbits**, **Thirdweb's built-in analysis modules**, and **x402scan**, the ecosystem possesses full-link observation capabilities ranging from transaction volume and resource distribution to Facilitator performance and Agent activity.

Spotlight on x402scan: Developed by Merit Systems, x402scan serves as an open-source explorer and research tool. It provides developers and researchers with specialized data views surrounding x402 payments, including usage statistics of Facilitators across chains, usage data of popular Agents, call frequency of resource APIs, and the distribution of buyers and sellers. It aggregates multi-source data based on the CoinbaseDev SQL API. (As shown in Figure 19).

Figure 19: x402scan Official Website Introduction



Source:x402scan • x402 Ecosystem Explorer

6.3.4 Protocols: Defining Future Infrastructure Standards

Below the application layer lies the foundational Protocol Layer, which determines the ecosystem's upper limits. These protocols are responsible for deeply binding payments with storage, computation, identity, and time assets. We select key projects for introduction below.

Kite AI is a heavyweight player in this domain. As **Layer 1 infrastructure within the Avalanche ecosystem**, its primary focus is providing native identity, payment, and governance capabilities for AI Agents.

- **Design Philosophy:** The project directly writes Coinbase's x402 standard **"into the chain,"** becoming one of the few public chains to integrate x402 payment primitives at the protocol layer. This allows agents to autonomously authorize, send, and reconcile stablecoin payments on-chain, rather than relying on patch-like support from middleware Facilitators.
- **Core Mechanism:** The **"Agent Passport"**—assigning an on-chain identity, session keys, and spending limits to each agent. Through programmable constraints and audit trails, it ensures agents remain within controllable risk boundaries while possessing autonomous payment rights.
- **Financing:** Kite has completed a cumulative total of approximately **$33 million** in financing. The **$18 million Series A** in September 2025 was co-led by **PayPal Ventures** and **General Catalyst**, with follow-on investments from Samsung Next, Avalanche Foundation, Animoca Brands, and Coinbase Ventures. This places it in a position of abundant capital and resources in the "x402 + L1 Payment Infrastructure" track.

Pieverse started with the **"TimeFi (Time Finance)"** narrative. Through mechanisms like Time Bid, Time Task, and Time Draw, it mints "time slices" of expert consultation and task collaboration into tradable assets, pairing them with AI calendars and productivity tools to map user time to on-chain value.

- **Infrastructure Stack:** The team launched a payment and compliance infrastructure stack based on **BNB Chain**. By issuing **pieUSD**, a wrapped stablecoin supporting EIP-3009 (anchored to USDT), it solved the issue of BNB Chain's native stablecoins being unable to run x402 directly.
- **x402b Protocol:** On top of this, the project defined the **x402b protocol**—while maintaining x402 payment capabilities, it attaches structured intent metadata and timestamp receipts to every transaction. It stores credentials in decentralized storage like **BNB Greenfield**, realizing "Payment as Proof" audit and tax-friendly features.
- **Progress:** As an incubated project of **Binance MVB Season 9**, Pieverse has launched pieUSD on the testnet and supports fiat on-ramp paths to lower Web3 barriers. In October 2025, it announced the completion of a **$7 million strategic financing** round led by **Animoca Brands** and **UOB Ventures**, used to further strengthen its "x402b + Compliant Invoice" payment infrastructure and multi-chain receipt standardization capabilities.

TermiX is a project primarily promoted by **Binance**, mainly deployed on BNB Chain. Officially positioned as the **"AI Engine of Future Finance,"** it supports complex operations like natural language decomposition and DeFi. Currently, the project has not issued a native token and leans more towards being an Infra-type project.

- **Developer Offering:** TermiX offers developers an **AI-Native dApp construction framework + AI-Web3 Operating System**. Its core product is an out-of-the-box React component library and SDK, allowing developers to add AI chat, contract calling, and

automated workflow capabilities to Web3 apps in minutes, and orchestrate 100+ on-chain protocols via MCP integration.

- **Payment Integration:** On the payment side, TermiX has integrated both the **Coinbase x402 protocol** and **Google AP2 (Agent Payments Protocol)**. On one hand, it uses x402 to enable Agents to interface with paid APIs and automatically collect fees; on the other, it utilizes AP2 to manage user authorization and risk boundaries, combining into an integrated **"Agent Wallet + Smart Charging"** capability.

Thirdweb itself is an established multi-chain Web3 development platform, providing a full suite of SDKs and hosting services for wallets, contract interaction, Bridges, and Token issuance. In the x402 narrative, it plays the role of a **"Universal Payment & Agent Tool Provider."**

- **Services:** Starting in 2025, Thirdweb launched a complete x402 client/server stack and Facilitator service. It supports developers in performing HTTP native pay-per-use on hundreds of EVM chains using any token supporting **ERC-2612 or ERC-3009**, and provides wrappers like wrapFetchWithPayment, allowing frontends to add 402 payment protection to APIs with just a single line of code.
- **Nexus MCP:** Even more critical is its **Nexus MCP Server + x402 Agents**. It provides every connected AI Agent with a wallet, semantic search, and fetchWithPayment tools, enabling Agents to automatically discover paid APIs, complete payments, and retry requests—essentially providing a **"Universal Agent Gateway"** for the entire x402 ecosystem.
- **Significance:** Thirdweb does not directly define new chain-level standards, but through SDKs, MCP, and Facilitators, it packages payment standards like x402 and AP2 into pluggable development components, allowing the "Agentic Internet" payment standards to truly land in frontend and server-side code.

Overall: This foundational standard layer, through projects like Kite AI, Pieverse, and Thirdweb, connects x402 with elements like identity, memory, time assets, universal payments, and development frameworks, making it not just a standalone payment protocol but a component embedded into the underlying structure of the "Agentic Internet."

6.3.5 Assets and Narrative: Market Consensus Beyond Technology

Above the technical architecture, the Asset and Narrative Layer provides propagation and capital momentum for the x402 ecosystem through price action and topicality. Meme tokens can be issued independently or launched via platforms like Virtuals Protocol, forming a batch of representative assets at the intersection of **"AI × Payment × Meme."**

(1) Business-Backed x402 Assets Compared to pure Memes, Virtuals-ecosystem tokens are generally closer to having products and revenue potential:

- **SANTA:** A multi-agent project on the Virtuals platform with multi-chain x402 Facilitator capabilities for automated on-chain task execution and settlement.
- **AURA:** Corresponds to the AurraCloud platform, providing compute hosting, MCP services, and x402 payment capabilities for AI Agents—a typical "Infrastructure + Token" combination.
- **GLORIA:** Data service for traders and Agents providing real-time news, supporting pay-per-use calls to terminals and APIs via x402.
- *Core Characteristic:* Behind the token lies a relatively clear AI product and x402 usage scenario; the narrative is not just the token itself.

(2) Pure Narrative-Driven x402 Memes There is also a batch of tokens leaning more towards conceptual narrative, primarily serving to amplify the x402 topic. Typical examples include:

- **PING (Base):** Regarded as the **first Meme token minted based on the x402 protocol**. Through the story of "Internet Native Payment," it quickly gathered an early community, becoming the emotional bellwether for x402 heat.
- **PENG! x402 (BSC):** Under the banner of "The First x402 Meme on BSC," it diffused the x402 concept from Base to BNB Chain, leaning more towards narrative experimentation than product orientation.
- *Role:* These projects primarily help the protocol "break out" (gain mainstream traction). While product depth is limited, they are critical in the early propagation phase.

(3) New Issuance Models Based on x402 x402 is not just for "paying"; it directly changes "how assets are issued." The PING minting model was the first demonstration of **"x402 Native Minting."** By paying ~1 USDC via x402, users could directly mint ~5,000 PING. The entire process required no exchange, account, or extra frontend—just one x402 payment, turning an HTTP request into an on-chain verifiable minting transaction. Derivative Launchpads include:

- **402rush.fun:** A simple Launchpad for projects. After configuring the x402 payment entry on the server side, users receive an HTTP 402 response upon subscription. Completing the x402 signature payment automatically triggers token distribution. The entire "Initial Offering" process is essentially a standardized API call.
- **Unibase Launchpad:** In Unibase's Launchpad module, fund flows for subscription and staking are handled via x402 interfaces and unified SDKs. Combined with memory and identity modules, it provides an integrated environment of "Memory + Identity + Financing" for AI Agent projects.
- **x420 Platform:** Allows anyone to issue their own x420 tokens with one click. The platform automatically allocates subdomains and x402 API interfaces and creates trading pairs on DEXs (like Clanker). The token serves as both a payment medium and a "Pass" to access a specific API, binding issuance, liquidity, and actual usage scenarios together.

Overall: Meme narratives played a role in "igniting topics + attracting liquidity" in the early stages of x402. The Meme sector serves as both an emotional amplifier for the x402 ecosystem and an important indicator for judging the stage of narrative development.

6.4 Hidden Worries and Challenges Behind the Ecosystem

Beyond the optimistic market sentiment and grand narratives, it must be soberly recognized that the x402 protocol faces three severe tests in moving from proof-of-concept to large-scale commercial use: **Underlying Standards, Giant Gaming, and Economic Model Sustainability**. These challenges are not merely technical difficulties but touch upon the fundamental logic of the protocol's development.

First is the issue of standardization of the underlying HTTP protocol. The HTTP 402 status code still lacks unified semantics and usage conventions within mainstream Web standards. Mainstream Web standards have not yet truly accepted it as a universal specification. Current x402 implementations are not natively supported but rely heavily on custom HTTP headers like X-PAYMENT to simulate standards. This path of establishing custom Headers appears somewhat fragile. If the **Internet Engineering Task Force (IETF)** defines the 402 code differently from the

current crypto community usage in the future, the x402 ecosystem may face underlying compatibility issues.

Figure 20: Developer Documentation Noting Compatibility Issues with HTTP 402 Status Code

Source：MDN Web Docs

Second is the subtle commercial game with Internet giants. Although giants like Google have begun experimenting with integrating x402 into AI frameworks, this does not mean they will thoroughly embrace this standard. The "Peer-to-Peer Payment" and "Bypassing Platform Intermediaries" advocated by x402 fundamentally challenge the profit models of traditional Internet giants, which rely on traffic monopolies and payment commissions. The current entry of giants is more of a technical placeholder and pilot. If x402's scale begins to substantively erode the profits of the traditional platform economy, will these giants—who control operating system entry points—change their attitude? This remains a massive uncertainty.

Finally, and most trickily, is the "Cost Inversion" dilemma of the Facilitator role. In x402's ideal model, the Facilitator handles signature broadcasting and Gas proxy payment, serving as the key hub connecting off-chain intent with on-chain settlement. However, current prosperity is largely built on a "transfusion" model where project teams pay out-of-pocket to subsidize Gas to capture market share.

- **Revenue:** At current market levels, revenue for 1 million API calls for a standard business might only be around **$100**.

- **Cost:** Taking the Solana chain as an example, the on-chain cost for a single transfer is at least in the magnitude of **$0.0001** (pricing model during non-congestion). Consequently, the on-chain interaction cost for 1 million API calls would conservatively reach **hundreds of dollars**—and if congestion is considered, costs could reach the magnitude of **thousands of dollars**.

This means **Gas fee expenditures far exceed the revenue of the business itself.** The current boom relies heavily on "cash burning" subsidies by projects to grab market share. This model is obviously unsustainable. If capital retreats, Facilitator providers will face immense operational pressure: if costs are passed to users, the low-rate advantage of micropayments will vanish; if not passed on, providers will fall into a death spiral of increasing losses. The market has not yet found a sustainable path to perfectly balance high-frequency small payments with on-chain Gas costs. This is perhaps the greatest dilemma x402 faces in moving from Demo to large-scale commercial use.

In summary: The technical loop of x402 works, but the commercial logic remains to be validated. Whether it can cross the threshold of standardization, balance the interests of giants, and solve the cost inversion problem in micropayments will be key to determining if it can move from a technical experiment to an industry cornerstone.

07 / Conclusion: From Technical Experiment to the Universal Language of the Machine Economy

The emergence of the x402 protocol is not merely a local iteration of crypto technology but a perfection of the Internet's underlying architecture, filling a gap that has existed for thirty years. It successfully borrows the long-dormant HTTP 402 status code, transforming it into a set of standardized payment instructions, thereby breaking the barrier between the Web2 information network and the Web3 value network.

Especially for the exploding **AI Agent industry**, the infrastructure transformation brought by x402 is crucial. Traditional financial payment systems cannot support high-frequency, millisecond-level, ultra-small amount transactions between machines. Through the mechanism of **"Off-Chain Authorization, On-Chain Settlement,"** x402 provides a survival mode for intelligent agents that requires no human intervention and has low friction. This allows data, computing power, and model services to finally be freely accessed and priced as precisely as web pages, providing a solid physical foundation for the scaled operation of the machine economy.

The current x402 ecosystem is undergoing a critical pivot from emotional hype back to value construction. With the substantive entry of industry giants like **Coinbase, Google, and Visa**, and the rise of native infrastructure like **PayAI and Daydreams**, the protocol is no longer a mere speculative symbol but is gradually embedding itself deep into the AI tech stack. It is deeply integrating with the **MCP protocol** (responsible for data connection), the **ERC-8004 standard** (responsible for identity authentication), and the **AP2 protocol** (responsible for compliance authorization) to jointly build a division-of-labor-based agent collaboration system. In this system, x402 focuses on solving the most fundamental fund settlement issues, allowing intelligent agents to evolve from isolated software tools into economic entities possessing autonomous transaction capabilities and self-sustaining abilities.

Looking ahead, for x402 to truly become a universal standard for the Internet, it must cross the dual thresholds of **Commercial Logic** and **Technical Specification**. On one hand, the ecosystem must solve the inversion problem between micropayment revenue and on-chain settlement costs, exploring sustainable business models that do not rely on subsidies. On the other hand, it needs to strive for official status within the existing Internet standard system and find a balance point between the traffic maps of giants and the open vision of decentralization.

Despite the heavy challenges, the direction pointed by x402 is clear: **The future Internet will no longer belong solely to humans.** Billions of AI Agents with autonomous payment capabilities will become active economic participants and value creators. This will not only reshape our understanding of online payments but also open a new economic era where machines and humans jointly create and distribute value.

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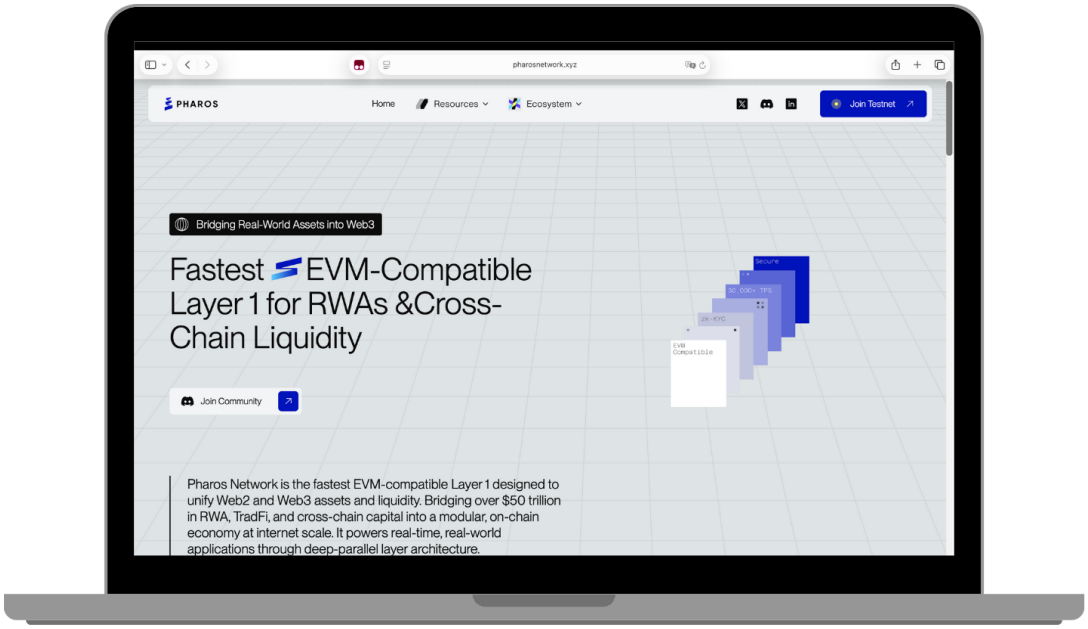

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