

A Primer On Account Abstraction

August 2023



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Key Takeaways

- Account abstraction (“AA”) has witnessed significant developments with new features and innovations that seek to simplify the user experience.
- Part of the Ethereum roadmap initiative, AA aims to replace externally owned accounts (EOA) with smart accounts by incorporating programmable logic. With the introduction of ERC-4337, AA is now supported on the Ethereum Mainnet without making changes to the core consensus level.
- Zk-rollup solutions StarkNet and zkSync have already launched native AA solutions with the emergence of wallet providers such as Argent and Bravos that seek to offer these solutions.
- Many use cases have been identified with traditional institutions, such as Visa, which is trailblazing with its exploration and experiments in this space. Wallet service providers and protocols such as Lens Protocol and CyberConnect have also adopted AA. These have been revealed to exhibit realized and potential benefits to encourage user onboarding into the Web3 environment.

Overview

2023 has heralded the emergence of new innovations. For example, the BRC-20 token standard unlocked new possibilities for the Bitcoin network. **In the world of Ethereum, the blockchain formally introduced a feature known as “account abstraction” (“AA”) through the ERC-4337 standard.** This was a key enhancement to simplify and create new functionalities for users by modifying the base account structures.

Account Abstraction

To begin with, we highlight key points about the existing Ethereum account structure in this section and provide an overview of this sector.

Types of Account Structures

As the term suggests, AA introduces the programmable logic that allows users to interact with their existing accounts. Previously, wallet solutions adopted an externally owned account (“EOA”), where users have a pair of private and public keys.

“Not your keys, Not your coins.” While EOAs conferred users complete custody over their funds with their private key, this also means that once they lost it, it became impossible to restore. Furthermore, traditional EOAs had limited functionalities; users could only send and receive transactions from another EOA.

Figure 1: Types of account structures in Ethereum

Externally Owned Account (EOA)	Contract Account (CA)
Signing accounts	Smart accounts
Controlled by private keys	Controlled by code
Unable to contain programmable logic	Contains programmable logic for execution

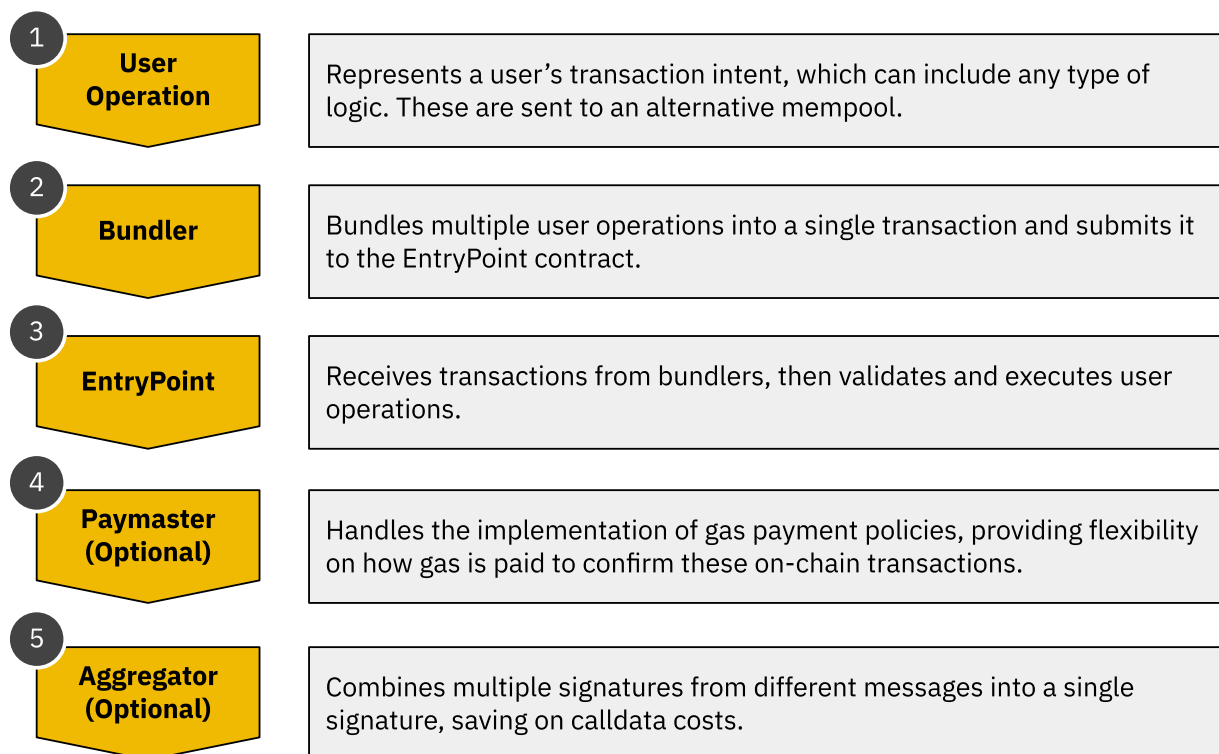
Source: Binance Research

Therefore, AA seeks to merge an EOA with a contract account (“CA”). This enables them to flexibly program their wallets with logic, coining the term **“smart contract wallets.”**

Technical Overview

To understand how the process works, the general mechanism in Figure 2 below describes the key components of AA. These features interact to allow developers to build smart contract wallets that are compatible with on-chain dApps.

Figure 2: Overview of AA

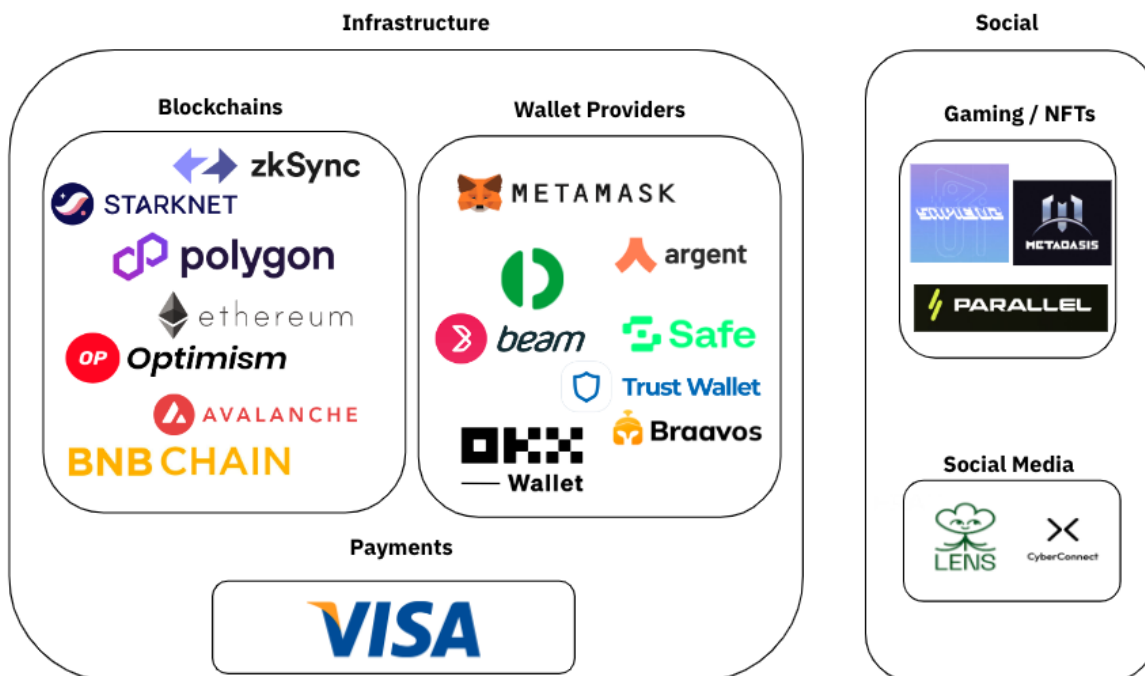


Source: Ethereum Foundation, Binance Research

2.2 The AA Ecosystem

The AA ecosystem has continued to expand rapidly over the past year as developers recognize the need for cleaner UX and user-friendly interactions between wallets, applications, and end users. By implementing AA, this aims to enhance the existing infrastructure and expand possibilities for users to engage in on-chain activities in an intuitive manner to encourage wider adoption. Advancements in this area can be broadly classified into the “infrastructure” and “social” sectors.

Figure 3: Current AA ecosystem map



Note: The diagram is not an exhaustive list of projects in the industry. Projects showcased are mapped according to their primary use cases. The mention of specific projects does not constitute endorsement or recommendation by Binance.
 Source: Binance Research

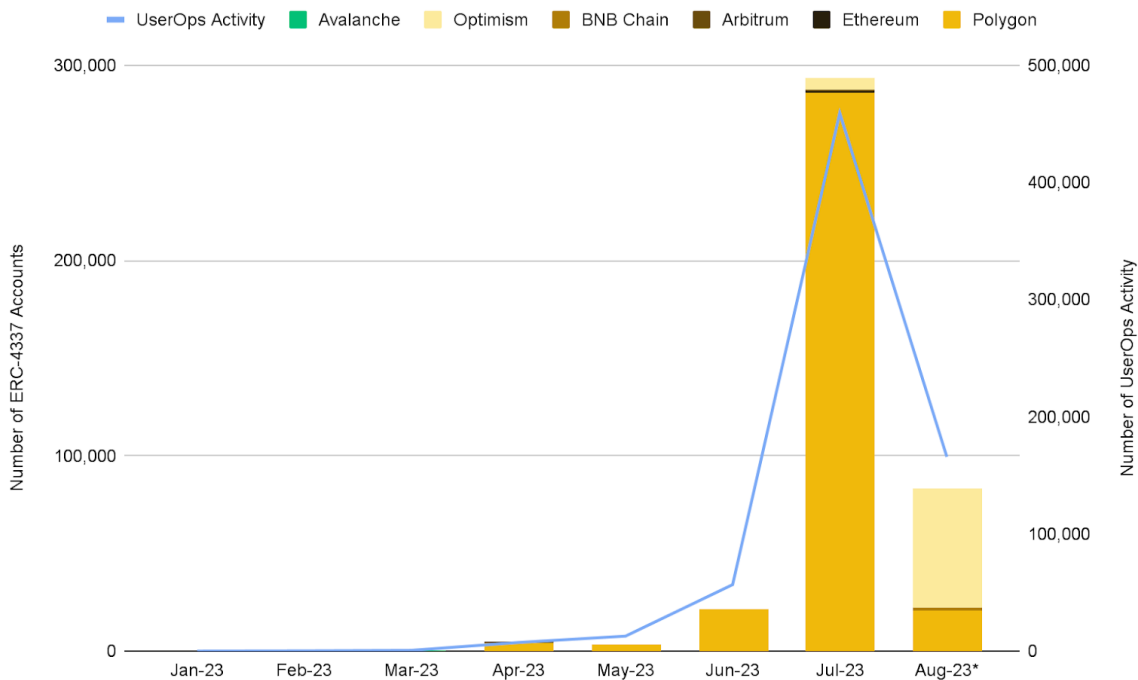
- ◆ **Blockchains:** EVM-compatible blockchains and scaling solutions such as zk-rollups that support AA.
- ◆ **Wallet Providers:** Wallets that leverage AA to provide user-specific functionalities.
- ◆ **Payments:** Provides fee abstraction capabilities through Paymaster contracts, where users do not need to own the blockchain’s native tokens and can still execute digital transactions.
- ◆ **Gaming/NFTs:** Adopts AA with token standards such as ERC-4337 and ERC-6551 to improve the on-chain gaming experience and extend the utility of NFTs.
- ◆ **Social Media:** Incorporates forms of AA such as signature abstraction to enable users to continuously interact with the social network with their Web3 wallets.

3 AA Growth and Adoption

3.1 On-Chain Adoption

Although the AA market is still in the infant stages of development, there are clear signs of increasing adoption and enthusiasm within the developer community. In particular, the ERC-4337 [EntryPoint contract was deployed](#) on March 1 this year⁽¹⁾. The feature can be used on EVM-compatible blockchains such as BNB Chain, Polygon, and Avalanche. Since then, transaction activity and the total number of ERC-4337 smart accounts have surged, especially in July⁽²⁾.

Figure 4: Monthly active ERC-4337 smart accounts and UserOps activity spiked



“UserOps activity” refers to transactions made by the ERC-4337 smart account
Source: Dune Analytics (@niftytable), Binance Research, as of August 11, 2023

Based on Figure 4, we observe a steady increase in the number of smart accounts, with nearly 300,000 accounts created in July, as UserOps activity drastically increased. Interestingly, the majority of AA activities were driven by Polygon. This is attributed to the launch of CyberConnect⁽³⁾, a social network where all accounts are ERC-4337 wallets.

3.2 Exploring Use Cases

To understand the use cases for AA, we highlight key infrastructure projects that have implemented new features using token standards such as ERC-4337 and ERC-6551. With the underlying goal of improving the UX for end users, these projects aim to drive real-world adoption of blockchain technologies.

Please note that the mention of specific projects does not constitute an endorsement or recommendation by Binance. Instead, the projects cited are merely used for the purposes of illustrating the adoption of AA. Additional due diligence should be taken to better understand the projects and their associated risks.

Paymaster

Adapting the concept of **fee abstraction**, the **Paymaster** component of ERC-4337 refers to smart accounts that enable third-party entities to sponsor and pay for transactions. Known as **'gasless transactions,'** users will not need to own the blockchain's native token to pay for transactions, improving accessibility. The owner of this contract can further define the rules under which user operations can be sponsored.

Visa

Digital payments giant Visa experimented with Paymaster contracts⁽⁴⁾ to abstract away the basic blockchain interactions and improve the on-chain user payments experience through a self-custodial smart contract wallet. The [proof of concept](#) aimed to reduce friction for users to transact through their wallets and explore the “untapped potential” of digital transactions for consumers.

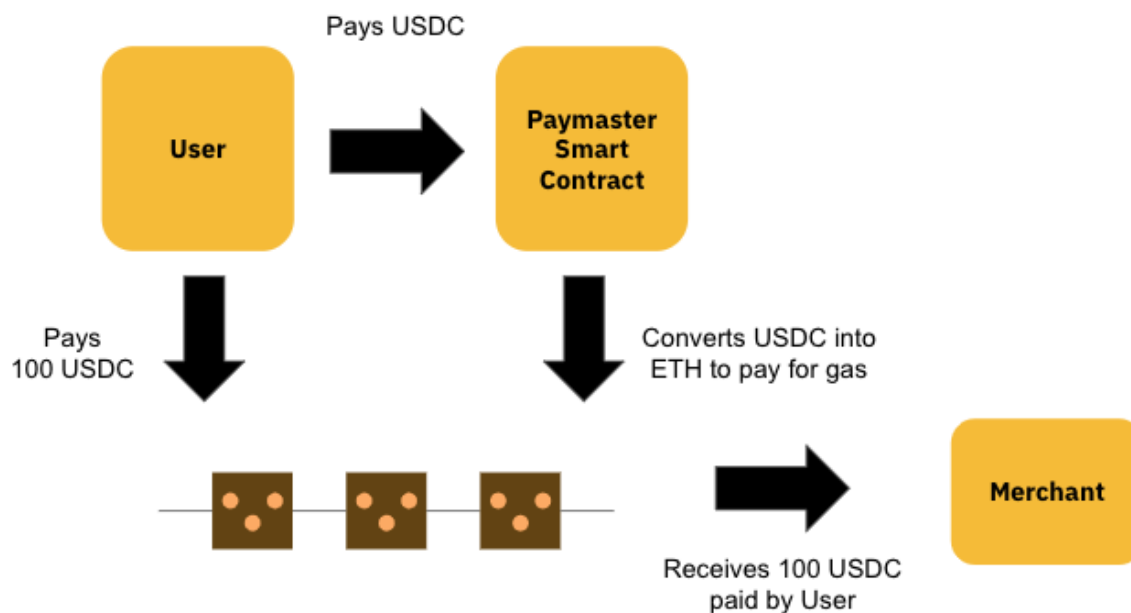
Figure 5: Visa's Paymaster proof of concept addresses today's challenges

Today's Challenges		Paymaster Solution
Users are required to hold the blockchain native token.	→	Users can pay the Paymaster in any of the supported tokens, which get auto-converted to the native token.
Users need to pay for transactions when interacting in the on-chain space.	→	The Paymaster can sponsor the transaction entirely instead.
Daunting experience for non-native crypto users who are new to blockchain.	→	Creates a secure channel and interface to interact in the on-chain environment.

Source: Visa, Binance Research

In this case, the contract acts as an **intermediary currency conversion service**, where it can receive digital currencies from the user and convert them into the blockchain’s native token to pay for gas fees. Alternatively, the Paymaster contract can also **cover the gas fees for users and make it free** for them to transact through their wallet platform.

Figure 6: Schematic representation of Visa’s Paymaster contract design



Experiment 1	Experiment 2
Enables users to pay transaction fees with alternative tokens (e.g., stablecoins or CBDCs).	Sponsors transaction fees for users entirely without the need to pay.

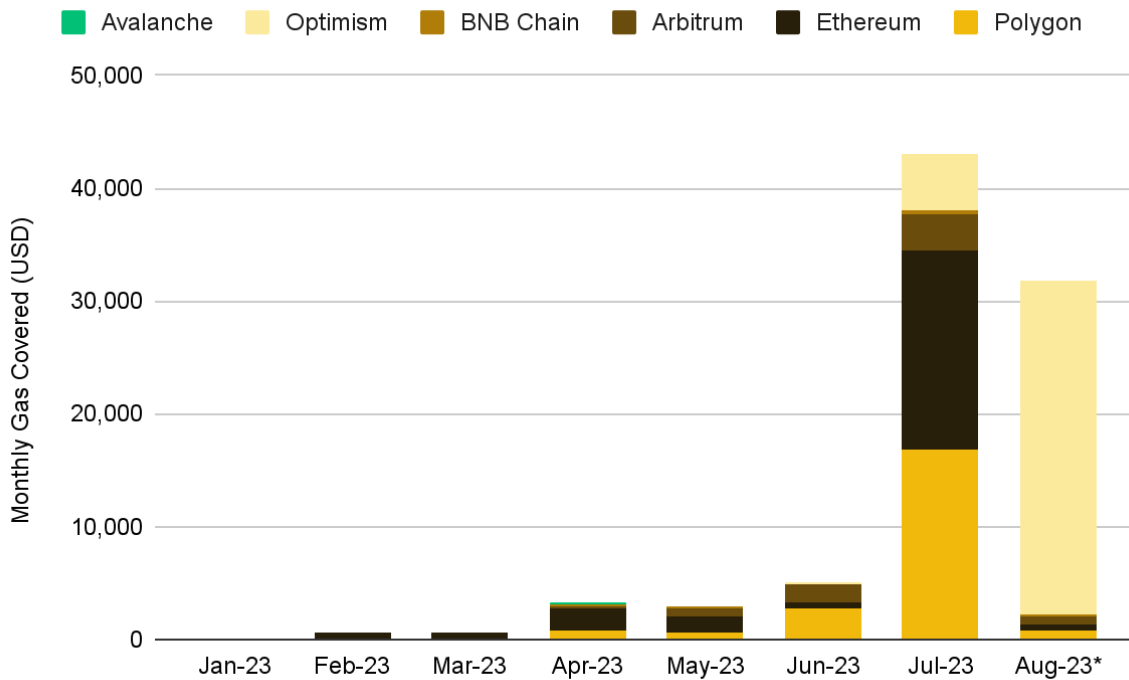
Source: Visa, Binance Research

More recently, the company has further [refined this approach](#), where users can now pay for transaction gas fees directly with a Visa card⁽⁵⁾. These experiments bring the “ease and convenience of traditional payments” to provide a seamless and secure channel for users to interact with blockchain technologies.

Usage of Paymaster Contracts

In fact, on-chain adoption of Paymaster contracts has **steadily grown** across the space, with Optimism leading the pack. This comes as new projects such as the [Beam wallet were launched on Optimism](#) in late July. Similarly, it uses Paymasters, enabling users to pay for gas fees with the coin used in the transfer instead of the blockchain’s native token.

Figure 7: Monthly gas covered by Paymaster contracts has drastically risen this year



Source: Dune Analytics (@niftytable), Binance Research, as of August 11, 2023

The amount of gas covered by these solutions has substantially increased, suggesting a growing demand for these intermediary services to simplify the user experience. Therefore, by abstracting away the complexities of blockchain transactions, users no longer need to hold the blockchain's native tokens solely to pay for gas fees. This **improves the existing payment infrastructure** and creates a more **accessible and user-friendly environment** for digital transactions.

Wallet Management

AA also abstracts away the friction associated with using Web3 wallets to interact with on-chain dApps. Following the high-profile implosions across the space in 2022, self-custody of assets has emerged as a top priority for users. However, users experience notoriously difficult challenges in securing their accounts. These include the following:

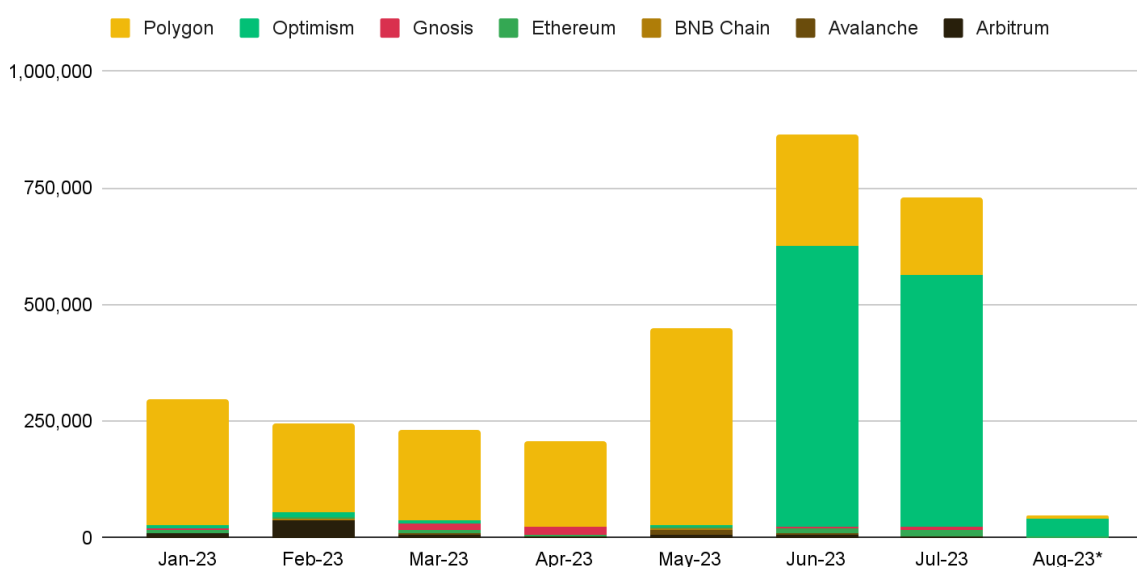
- Private keys in existing wallet solutions are **single points of failure**. Users cannot recover their wallet if they lose their seed phrase or private key.
- Users are **susceptible to social engineering attacks** as malicious actors can devise new means to compromise their private keys.

By incorporating AA into existing wallet solutions, this turbo-charges these accounts into **smart contract wallets with programmable logic**, granting new functionalities such as batch transactions and social recovery.

Safe

Previously known as Gnosis Safe, Safe is an industry player within the wallet management sector. The decentralized custody protocol is available on the Ethereum and EVM-compatible blockchains, with a huge number of wallets created on a weekly basis⁽⁶⁾.

Figure 8: Number of Safe wallets created on a weekly basis



Source: Dune Analytics (@safe), Binance Research, as of August 11, 2023

Safe stands out in the space for its multi-signature scheme, which requires multiple authorized entities to sign transactions on the same account instead of a single private key. This reduces the risk of malicious attacks that siphon funds from the account.

The platform has most recently integrated the ERC-4337 standard through a **plug-and-play** interface, which offers developers the flexibility to build and create their wallets using the modules offered. By implementing signature abstraction, users are permitted to customize the rules for authorizing wallets to initiate transactions. For instance, to protect against suspicious activities, the user can specify spending limits to reject transactions of a certain size for enhanced security.

Social logins through Google or Apple ID have also been introduced as an [experimental feature](#)⁽⁷⁾, removing the need for users to remember their seed phrases. This opens up possibilities and provides a frictionless Web3 experience.

Argent

As the leading wallet provider on Starknet, Argent introduced the idea of “**social recovery**,” allowing users to recover lost or forgotten private keys⁽⁸⁾. According to [Chainalysis](#), about 20% of the bitcoins in circulation as of 2021 were lost because the owner did not remember their private key.

As such, users of Argent can nominate “**guardians**,” which are other wallets or accounts they trust. Guardians will each need to sign a transaction to help the user access the wallet if the user forgets the seed phrase.

Alternatively, the user can also use their **email address and phone number for off-chain recovery**, introducing the familiar two-factor authentication mechanism. This adds another layer of protection to their account and eliminates the need for users to remember complicated passwords and secure their private keys. However, this may compromise the anonymity of users since their personal information is revealed.

Braavos

Wallet provider Braavos, also available on Starknet, has unveiled its smart wallet, which adopts a form of **signature abstraction**. This means that users can customize the way they sign and verify transactions. In this case, a user can use their **mobile phone’s biometric identity feature**⁽⁹⁾ (e.g., facial or fingerprint recognition) to access their wallet. The authentication method provides a secure and user-friendly onboarding experience.

These AA innovations seek to simplify the user experience and unlock new possibilities for developers and users to interact with blockchains. Through different abstraction schemes, we posit that these positive developments will empower existing wallet solutions to provide the familiar Web2 interface for mainstream adoption.

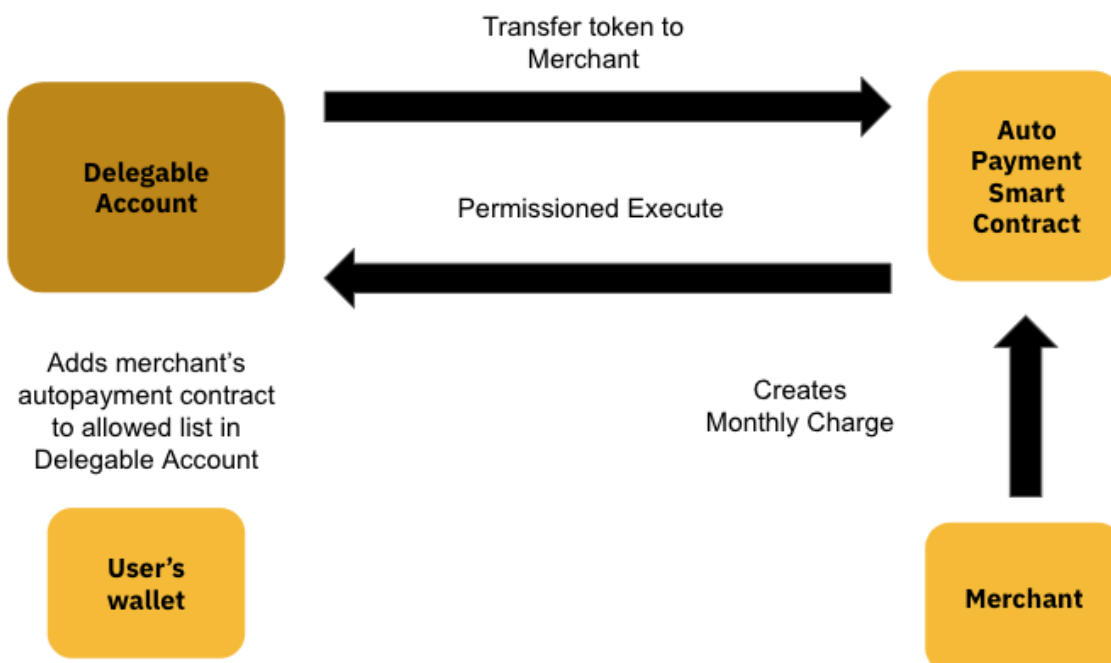
Delegation

A new type of account contract, “**delegable accounts**,” leverages AA for users to delegate signing privileges to an approved external contract. This account contains the relevant rules, which are coded in a customizable manner based on the user’s preferences. They can then interact with these applications in a seamless manner without having to manually approve every transaction.

Automatic Payments

Visa demonstrated a solution towards “real-world application of auto payments for self-custodial wallets.” Instead of having to request payments each time on a blockchain, the wallet can be set up to **enable recurring payments**⁽¹⁰⁾ based on predetermined conditions. While still enjoying full control over the wallet, the user can approve automated, programmable payments for utility and subscription bills.

Figure 9: Schematic representation of Visa’s delegable account design



Source: Visa, Binance Research

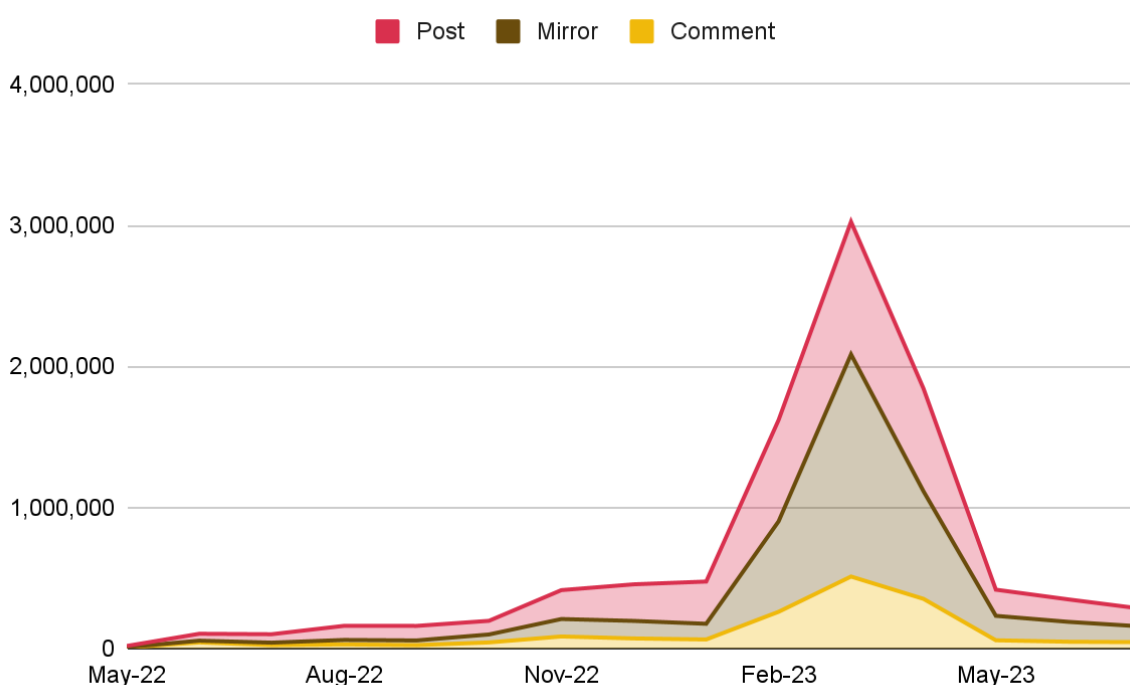
1. The merchant deploys an auto-payment smart contract.
2. The user’s wallet, with a delegable account, approves auto payments and will add the smart contract to its list of permitted contracts.
3. Every month, when the merchant creates a bill for the user’s subscription charges, the auto payment contract automatically causes the user’s delegable account to pay based on the required amount.

As a result, the user does not need to manually approve these transactions and can easily schedule recurring payments. This application enables a user to conveniently set up programmable payment instructions, highlighting the potential for real-world applications.

Social Media

Decentralized social media network Lens Protocol has implemented AA via the **dispatcher**. It provides a tool for users to delegate signing privileges to this dispatcher wallet for functions such as **posting, commenting, and changing profile metadata**⁽¹⁴⁾. This enables users to **continuously interact with dApps without needing to constantly approve each time**. Simultaneously, the dispatcher also **pays the gas fees** for these transactions, removing the need for users to hold the native tokens for in-app interactions. Over the past year, the protocol has enjoyed a rise in adoption.

Figure 10: Daily social media activity on Lens Protocol



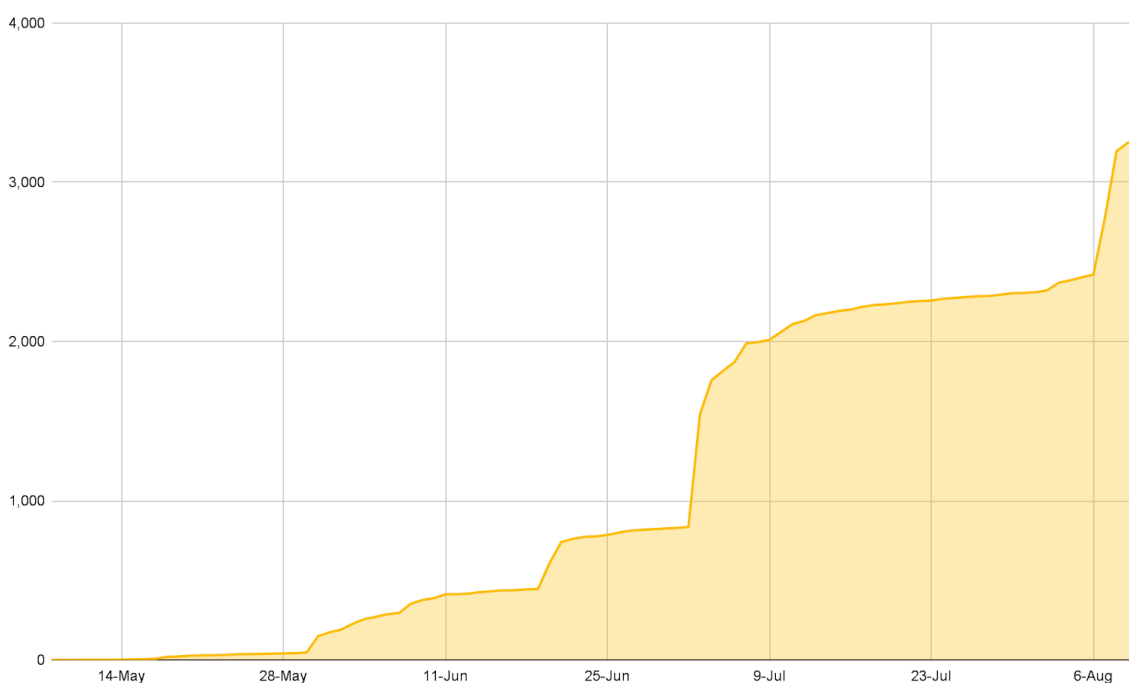
Source: Dune Analytics (@sixdegree), Binance Research, as of August 11, 2023

Delegation effectively abstracts the signature verification away and changes in-app user interactions for a more user-friendly experience.

Token-Bound Accounts

ERC-6551 introduced the Ethereum standard for token-bound accounts (“TBAs”) and was officially deployed in May 2023. The new standard empowers NFTs to function as **“smart contract accounts”** and be their own wallets using a permissionless registry. This enables an integrated mechanism for owners to **custody NFTs within the TBA**.

Figure 11: Number of token-bound wallets created daily has risen



Source: Dune Analytics (@sixdegree), Binance Research, as of August 11, 2023

Figure 12: ERC-6551 supercharges existing NFTs through abstraction

	Features of ERC-6551	Potential Benefits
Multi-Layer Asset Ownership	Enables players to easily manage their individual assets (ERC-721 NFTs) under a TBA.	Game developers can create “inventories” for players and sophisticated in-game UIs.
Interoperable NFTs	TBAs enable NFTs to be used across ecosystems as they are compatible with most existing on-chain infrastructures.	Enables the creation of “network playable characters” for cross-game interactions.
More Economical	NFTs can be grouped under one parent TBA. Rather than transacting	Reduce gas fees and makes transactions more affordable

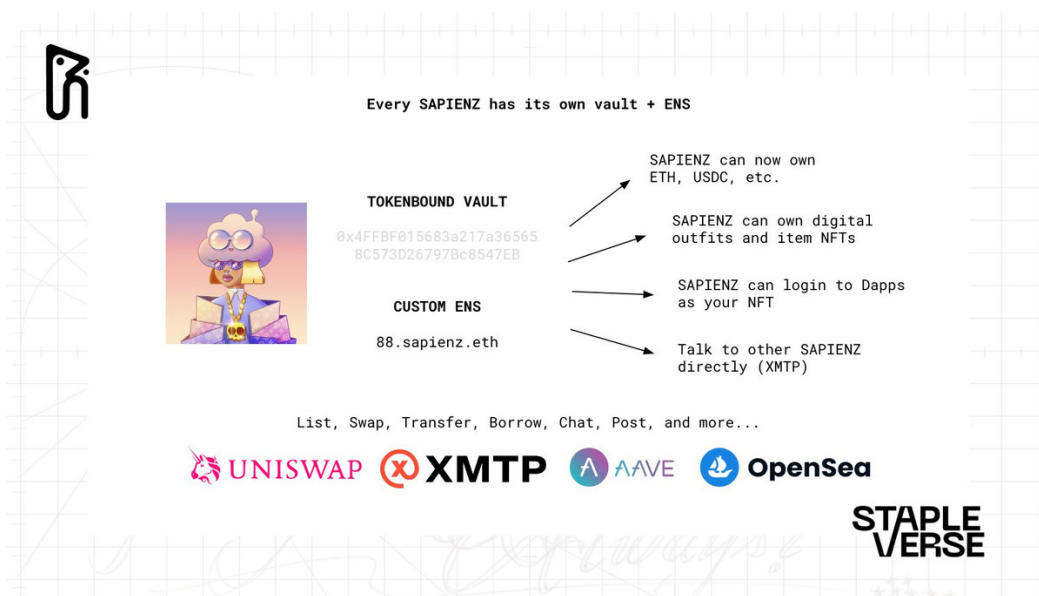
	with each individual NFT, only the TBA needs to be sent.	(e.g., buying a collection of merchandise).
On-chain Identity Management	TBAs enable NFTs to interact with dApps directly.	NFTs have their own digital identity for on-chain interactions.

Source: Binance Research

Sapienz

Stapelverse unveiled the Sapienz project, which introduced a paradigm shift to digital street culture by incorporating the ERC-6551 standard. Users receive a customizable character that is unlocked based on the NFTs they own. They can outfit the character with different cosmetics and personalize it based on their preferences. These cosmetics are attached to the TBA of the characters and can be located in a common inventory for each user.

Figure 13: ERC-6551 functionalities of Sapienz



Source: @stapleverse

Through a different variation of abstraction, ERC-6551 has upgraded every NFT to now have its own smart account. Historically, ERC-721 NFTs have remained **largely static and stateless**, as they are unable to have any added functionalities beyond the non-fungibility of their metadata. As such, ERC-6551 significantly enhances the utility of NFTs, enabling them to hold assets, manage an identity, and participate in the on-chain landscape.

Notable Developments

Smart contract wallets already exist today but remain a challenge to implement as Ethereum is unable to natively support them. Instead, it relies on ‘relayers’ run by intermediaries to translate messages signed by the user into typical Ethereum transactions. In fact, the chain faces existing limitations:

1. Given the maturity of Ethereum and the need to coordinate among many nodes to implement these changes, the **technical debt on the blockchain introduces inertia** for these new changes.
2. Due to the complex processing logic embedded within these accounts, wallets are likely to also incur additional **overhead gas costs**.

As such, **newer L2 chains have surfaced as viable alternatives** for developers to experiment with AA. These include the following:

- ❖ zkSync was the first EVM-compatible chain to implement native AA at the protocol level⁽¹⁴⁾. This means that all accounts are required to implement the IAccount interface, which is fully programmable and allows for various customizations.
- ❖ Similarly, the zk-rollup solution, StarkNet, has also implemented AA. Examples include Argent, which is used by 80% of StarkNet users⁽¹⁵⁾. Visa’s delegable accounts and auto-payment experiments were also done on the chain.
- ❖ Optimistic rollups such as Optimism and Coinbase’s Base have also implemented forms of AA. They provide APIs for developers to create new solutions with supported features such as Social Onboarding and gasless transactions. Most recently, the Base, Safe, and Gelato teams have provided bounties at ETHDenver to encourage projects that incorporate AA in their projects⁽¹⁶⁾.

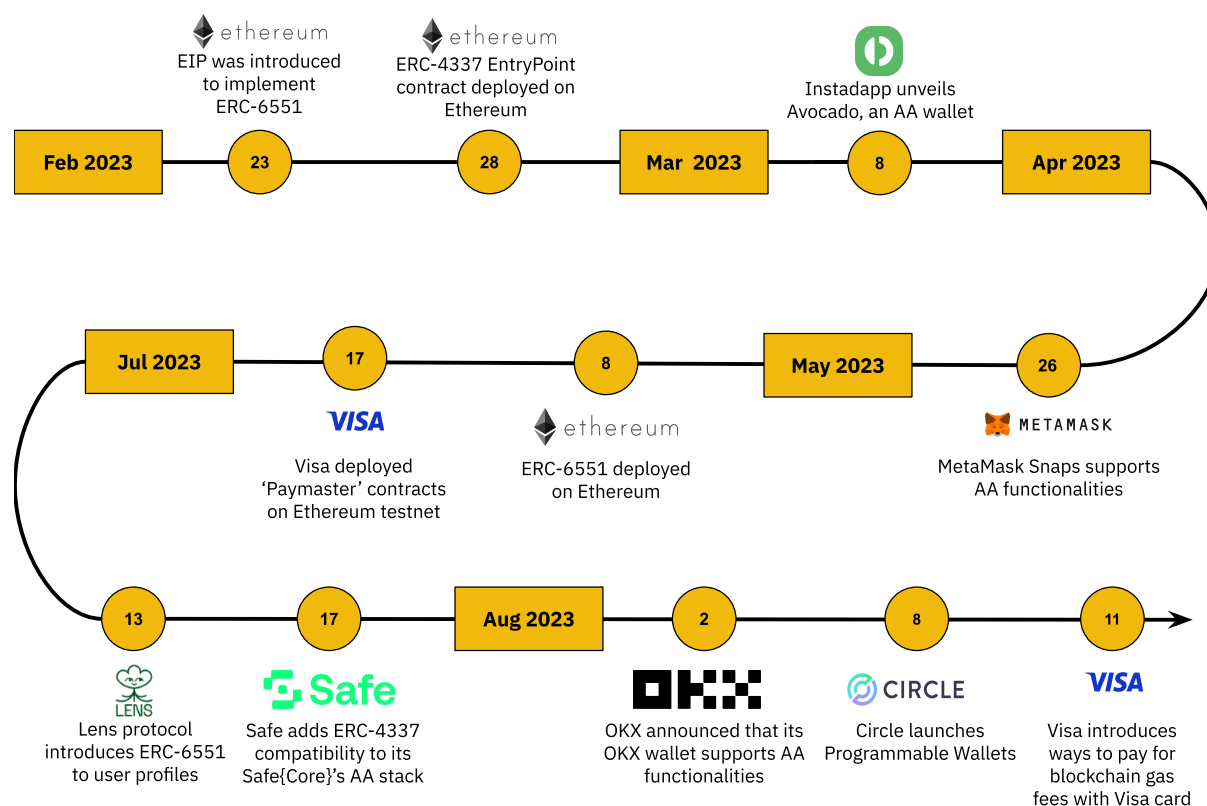
Looking ahead, we recap the improvement proposals and highlight the ongoing developments in the space.

Figure 14: AA-related Ethereum Improvement Proposals⁽¹⁷⁾

	Features	Status
EIP-2771	AA-using meta transactions that allow third parties to pay for a user’s gas costs without making changes to the Ethereum protocol	Active Implemented by Biconomy
EIP-2938	Update the Ethereum protocol by introducing a new transaction type to support AA	Inactive Inertia for fundamental changes to the protocol’s consensus
EIP-3074	Upgrade EOA to incorporate smart contract logic into the account	
EIP-4337	AA without requiring changes to the Ethereum protocol. Adds a new system and introduces user operations	Active
EIP-6551	Introduces non-fungible TBA, an interface for smart contract accounts owned by NFTs	Active

Source: Ethereum Foundation, Binance Research

Figure 15: Timeline of AA adoption and market developments



Source: Binance Research, as of August 11, 2023. This is not an exhaustive list of all ongoing AA developments.

- ◆ **Feb. 23, 2023:** An Ethereum Improvement Proposal (EIP) was introduced to implement ERC-6551. This would enable NFTs (ERC-721 tokens) to have their own smart contract accounts (TBAs)¹⁾.
- ◆ **Feb. 28, 2023:** The ERC-4337 EntryPoint contract was officially deployed on Ethereum.
- ◆ **Mar. 8, 2023:** Instadapp introduces the smart contract wallet Avocado⁽¹⁸⁾. It comes with in-built AA functionality, allowing users to pay for gas on any supported chain in USDC. Other features include network abstractions, where a user who is connected to one network can also transact on any other network.
- ◆ **Apr. 26, 2023:** Metamask announced that it supports the adoption of AA through MetaMask Snaps, an open-source system where developers can extend the functionality of MetaMask wallets and incorporate features into a “Snap.”
- ◆ **May 8, 2023:** ERC-6551 was officially deployed on Ethereum⁽¹⁹⁾.
- ◆ **May 17, 2023:** Visa deployed Paymaster contracts on the Ethereum testnet to experiment with frictionless and gasless transactions.
- ◆ **Jul. 13, 2023:** Safe adds ERC-4337 compatibility to its Safe{Core}'s AA stack.
- ◆ **Jul. 17, 2023:** Lens Protocol introduces the ERC-6551-powered profile as a wallet, “giving NFTs their own social relationships, voice, and monetization opportunity.”
- ◆ **Aug. 2, 2023:** OKX announces that its OKX Wallet⁽²⁰⁾ supports AA, where users can now create smart accounts in their mobile application. It is supported on networks

such as Ethereum, BNB Chain, and other EVM-compatible chains, enabling users to manage assets across networks.

- ◆ **Aug. 8, 2023:** Circle launches Programmable Wallets⁽²¹⁾ under its Web3 Services product line. It provides an all-in-one platform with tools for developers to build and deploy their wallets.
- ◆ **Aug. 11, 2023:** Visa introduces a way for users to pay for gas fees on Ethereum using the Visa card.

Closing Thoughts

The idea of abstraction aims to remove the complexities of wallets and blockchains and provide a familiar interface for Web3 dApps. By focusing on the user experience, AA is a strong enabler for user adoption and provides an attractive opportunity for developers to curate a frictionless and familiar experience. We have seen signs of institutional adoption with Visa's innovative crypto-leadership, which has revealed ways in which AA can be used to bridge the chasm between Web2 and Web3 interactions.

Indeed, providing programmable logic into wallets opens endless possibilities for developers to extend the functionalities that these contracts can provide users. It is heartening to witness the surge in interest within this research area as on-chain figures reveal the growing adoption and preference amongst users to use these technologies. Despite it being natively available on scaling solutions such as StarkNet and zkSync, we note the progress underway to integrate AA into the broader ecosystem.

Looking ahead, ERC-4337 has already laid the foundation to improve the underlying account structures on Ethereum. This has paved the way for more innovations, such as ERC-6551, which infuses the power of AA to further the utility of NFTs. Once again, advancements in blockchain technology have proven their relevance with their real-world use cases, and we eagerly await these new innovations that will drive wider adoption.

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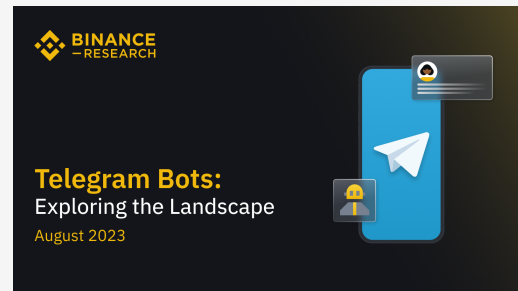
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