Web 4.0: A New Paradigm for a Composable, AI-Powered Internet

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Abstract

This vision paper outlines the trajectory of internet evolution and introduces Web 4.0, a new paradigm that aims to fulfill the promises of a semantic, decentralized, and economically sustainable web. Building on the advancements and lessons from Web 1.0, Web 2.0, and Web 3.0, we propose a new architecture that integrates artificial intelligence, microservices and micropayments into a cohesive, user-centric framework. This paper addresses the technological components and economic challenges necessary for the realization of this vision.

1 Introduction

The internet has evolved through three distinct stages, each reflecting a shift in technological capability and societal need: from static information repositories in Web 1.0 to user-generated, social content in Web 2.0, and to the decentralized, trustless visions of Web 3.0. However, while each iteration improved on its predecessor, challenges remain. These include issues with data privacy, content monetization, and the unrealized potential of the "semantic web". As we face the next leap in web technology—powered by breakthroughs in artificial intelligence (AI)—we propose Web 4.0: a dynamic, composable, and AI-driven internet that promises a more accessible, efficient, and inclusive digital world.

To understand Web 4.0, we must trace the journey of the internet's development [2]:

- *Web 1.0 – Read-Only Era:* Web 1.0 was characterized by static pages linked through hyperlinks. It functioned as an extensive, interconnected library of information accessible to anyone but limited to information consumption, akin to an online encyclopedia.
- *Web 2.0 – Read-Write Era:* In Web 2.0, the internet became participatory. People could create and share content on platforms like blogs and social media, fostering a culture of collaboration and creativity. However, this iteration of the web introduced data silos, as tech companies aggregated and controlled user-generated data to power targeted advertising models.

- *Web 3.0 – Read-Write-Own Era:* The advent of Bitcoin marked the rise of decentralized currency on the blockchain, introducing a financial system independent of centralized control. Ethereum expanded this foundation with programmable smart contracts, enabling the creation of decentralized applications (dApps) and unlocking the potential for Web 3.0—a web of composable, decentralized services. However, in practice, Web 3.0 has largely evolved into an "online casino", where digital assets like cryptocurrencies and NFTs are primarily traded as speculative investments, overshadowing the broader vision of a functional, decentralized internet.

The Unrealized Potential of the Semantic Web. Tim Berners-Lee, the father of the web, envisioned the Semantic Web as an evolution of Web 1.0 [1]. The Semantic Web would enable algorithms to process and reason about web content. The aim was to create a web of data that machines could understand and interact with intelligently.

To implement this idea, Markup languages like OWL (Web Ontology Language) were developed to annotate content semantically, but these approaches did ultimately not gain widespread adoption. The primary hurdle to realizing the Semantic Web has been the difficulty of implementing reasoning algorithms capable of handling unstructured and dynamic data. Existing tools could not scale efficiently and required immense annotation efforts. This lack of practical implementation left the Semantic Web an unfulfilled vision.

Advances in Artificial Intelligence. The explosion of AI, driven by the development of large language models (LLMs) such as OpenAI's GPT series and Meta's Llama models, has redefined how we interact with data. These models demonstrate capabilities in processing unstructured information in a way that mimics human understanding.

This development opens up new opportunities. The availability of a rich ecosystem of online, composable microservices, together with the new semantic processing capabilities of LLMs allow us to revisit and expand on the idea of the Semantic Web.

2 Goals and Challenges

The goal is to terraform the current internet into an intelligent, user-centric ecosystem where natural language requests are seamlessly interpreted and autonomously executed by dynamically composing online services. Realizing this vision involves addressing three key challenges:

- *Building Distributed Orchestration AI.* Web 4.0 requires advanced AI capable of dynamically orchestrating online services. This system must interpret user intent expressed in natural language, identify and compose appropriate services, and execute tasks while adapting to real-time con-

ditions. Achieving this necessitates breakthroughs in distributed AI reasoning, interoperability standards, and distributed computing.

- *Sustainable Monetization Models.* Current internet monetization methods—advertising and subscriptions—fail to support a diverse and equitable service ecosystem. Advertisement-driven models commodify user data, raising privacy concerns, while subscription models create high entry barriers and reinforce monopolies. Micropayments emerge as a promising alternative that works well with a composable ecosystem, enabling users to pay small fees per interaction, directly rewarding service providers without reliance on intrusive data collection. However, scalability and usability issues with current payment infrastructures, including blockchain technology, hinder broad adoption. Advancements in low-cost, high-throughput transaction systems, such as Layer-2 solutions, are essential for enabling a viable micropayment economy.

- *Ensuring Trust and Safety.* Composable services introduce complex security risks. Users need assurance that orchestrated workflows are safe, ethical, and reliable. Traditional ex-ante safeguards (e.g., static rules) are insufficient for dynamic systems where unforeseen scenarios arise. A hybrid approach leveraging ex-post evaluations—real-time feedback loops from users—combined with AI moderation and adaptive regulatory frameworks, ensures dynamic safety. User-generated ratings, reviews, and ethical assessments become integral to fostering trust and accountability. This system incentivizes service providers to maintain high-quality offerings while adapting to emerging risks.

By overcoming these challenges, the new web has the potential to redefine the internet as a truly intelligent and equitable ecosystem, empowering users with unprecedented access to services while fostering innovation and inclusivity.

3 Web 4.0: An AI-Driven, Composable Web

We propose Web 4.0, a web that envisions a convergence of ideas where AI and micropayment-enabled services create a user-driven internet. Here, users can request web-based services in natural language, which an AI orchestrates on-the-fly by dynamically composing services. The architecture of Web 4.0 can be broken down into several interdependent components.

Composable Online Services. Web 4.0 leverages the existing repository of modular services, each representing a business process or data source. These services range from simple data queries to complex workflows involving AI-generated content, IoT device management, and interactions with other users. An AI system then dynamically composes these services to solve user queries. For instance, imagine a task that requires ordering supplies, managing invoices, and providing customer support. Instead of navigating separate services, Web

4.0 could integrate APIs from different providers to automate this process as a unified experience. This approach would enable solutions to be tailored specifically to user needs, covering unformalized, one-off use-cases.

AI-Driven Orchestration. A defining innovation of Web 4.0 is a distributed orchestration AI capable of dynamically creating workflows by selecting, arranging, and executing services to fulfill user requests—something which today's monolithic, generative-pretrained AI models cannot reliably do [3, 4]. This orchestration AI leverages online human feedback and a modular ecosystem of specialized APIs to achieve agility and generality while robustly handling the web's non-stationary environment, where new data and services emerge and vanish regularly, and ensuring that Web 4.0 remains up-to-date in a constantly evolving landscape.

Human feedback. The orchestration AI in Web 4.0 must efficiently integrate human feedback across multiple dimensions to refine service outputs and evaluate trust, fairness, and safety. This "human-in-the-loop" approach is essential, as the value of many Web 4.0 services lies in their real-world side effects, which cannot be fully monitored by automated systems.

Through this feedback mechanism, users can filter and rank services based on various criteria. Beyond expressing preferences, this approach doubles as a vetting mechanism, enabling new services to be initially accessible to early adopters, who assess their quality and safety before broader release, fostering a community-driven layer of evaluation and refinement.

Micropayment Integration. A high-bandwidth, low-fee micropayment-based marketplace will reward service providers for the usage of their APIs. This incentive structure could attract talent and investment, allowing individual creators and small businesses to participate in the Web 4.0 economy. For instance, an independent AI developer could deploy a specialized image recognition service that earns revenue each time it is used in a larger workflow.

4 Discussion

Privacy. Building on the tenets of Web 3.0, Web 4.0 marks a shift to a more secure, user-centered internet by reducing reliance on data-driven revenue models. With market dynamics directly controlled by user feedback, users only access and pay for relevant services, reducing incentives for data harvesting. AI-driven orchestration can further protect privacy by controlling access to personal data, enabling services to operate independently, and reducing centralized data silos and associated risks. This architecture empowers users to control their data, choose their interactions, and provide feedback, ensuring a degree of privacy and transparency by design. In Web 4.0, data autonomy becomes the standard, creating a safer, more private internet experience.

A Path Toward Safe AGI. Web 4.0 paves the way for an inclusive approach to Artificial General Intelligence (AGI) by orchestrating a network of specialized AIs, each focused on a unique task. Rather than relying on a single monolithic AI model, this modular system enables a distributed intelligence that learns, adapts, and self-improves with real user feedback. By coordinating these expert AIs, Web 4.0 approximates AGI—a system capable of tackling diverse tasks, contextualizing information, and managing complex workflows. This collaborative model fosters a safe, ethical, and human-centered path toward general intelligence.

Future Proof. Web 4.0's adaptable architecture enables continuous integration of new data, services, and technologies, ensuring resilience in a changing digital landscape. Its composable framework readily incorporates emerging AI models, IoT devices, and protocols, keeping the system relevant, scalable, and responsive to evolving user needs and regulations. By prioritizing a distributed, community-driven approach, Web 4.0 remains robust and adaptable as technology and society progress.

These foundational principles—privacy by design, a distributed path to AGI, and future-proofing through adaptability—make Web 4.0 a transformative platform for a fairer, more intelligent, and sustainable internet.

5 Conclusion

Web 4.0 aims to create a composable, AI-powered internet where users seamlessly request and orchestrate services. By integrating micropayments, modular AI, and collaborative tools, Web 4.0 realizes the long-envisioned Semantic Web. This ecosystem offers personalized, real-time solutions while empowering individual creators within a distributed economy. Emphasizing AI democratization, Web 4.0 makes advanced AI accessible to all, fostering a fair, inclusive internet economy. Its success depends on collaboration from developers, AI researchers, and innovators committed to building a responsive, equitable, and intelligent web for everyone.

References

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