



Decentralization and AI

The Building Blocks of a Resilient
and Open Digital Future

Alan Majer, Founder of GoodRobot.com

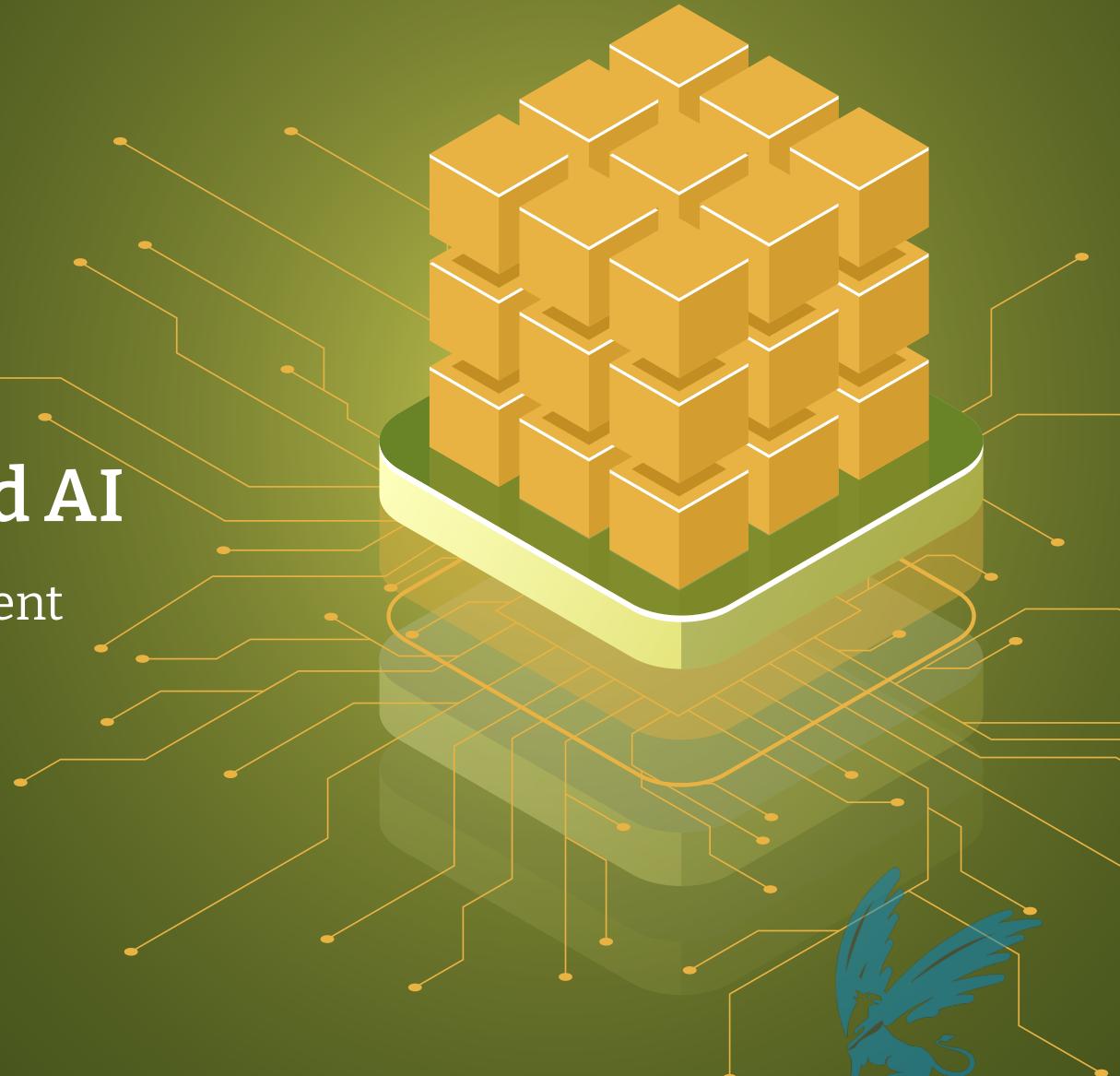
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The attention economy means our digital experiences have fallen short of their potential and **a few big companies control our online experiences.**



Increasingly, **powerful algorithms govern online systems**, putting users under the thumb of those who control them.



Systems of influence and fake news **erode our ability to access the truth**, and trust in all forms of media is at a historic low.



Regulations are necessary to curtail the power of private platforms and protect consumer privacy, but alone, they are **insufficient** to catalyze the innovation required.

A growing list of open source tools, platforms, and applications **create alternatives to today's centralized systems**, but obtaining critical mass remains difficult.

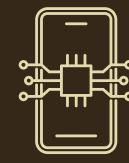


Today's centralized platforms face disruptive transformation: Decentralized building blocks, AI, and algorithms can build platforms that have never been possible before.

In order to succeed, decentralized systems must be **agile and easy to use**—having control over one's **data** should be an advantage.



Personalized autonomous agents afford us **greater control over our data and the algorithms** that govern our interactions.



Artificial intelligence can create **easy-to-use tailored interfaces and generate code and applications on the fly**, with far-reaching implications for software.

Autonomous AI agents will be **self-reflective and possess a wide scope of action**, allowing decentralized systems of agents to adapt behavior and properties.



Putting AI and algorithms at the edge can enhance personalized experiences yet keep data private, giving us **greater control over our online identity**.



We must make technology choices that ensure that **AI remains open and accessible** to all and represents everyone's values—not just those of tech platforms.



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Foreword

The rise of autonomous AI agents is set to shape the decentralized Web of the future. These agents, manifesting as embodied AI, robotics, or software processes, will play a critical role in this new digital ecosystem. Acting as our ultimate digital assistants, they will permeate our living environments, handheld devices, and wearables, offering personalized services and insights. However, as these agents gain deeper access to our personal and private lives, the need for robust protections of privacy, data, and personal identity becomes paramount.

Autonomous AI agents present both unprecedented opportunities and significant challenges. Their ability to operate independently at the edge of decentralized networks enables a more adaptive, intelligent Web. But as they interact with sensitive data and make decisions on our behalf, a globally recognized decentralized identity system is essential to ensure security, trust, and user sovereignty. Such a system must guarantee that individuals maintain control over their identities and information, preventing the vulnerabilities of centralized platforms from being replicated in a decentralized future.

By distributing intelligence across the network, these agents can foster a more resilient and privacy-preserving Web. Yet, this also amplifies the need for open, transparent identity frameworks that respect user autonomy. This report outlines the path toward integrating AI and decentralized identity, creating a future where **privacy, control, and trust are at the core of the digital experience.**

In this new era, we have the opportunity to collectively define a digital frontier where AI empowers users and safeguards their rights, shaping a decentralized Web that truly serves the people.

YUE CHEN, Head of Technology Strategy

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Executive summary

Today's digital platforms are not living up to the expectations of the Internet visionaries of the past. Digital experiences have fallen short of their potential, largely because the attention economy is so deeply infused into centralized platforms that a small handful of big tech companies control. As a result, many of today's centralized platforms pose risks to personally identifiable information and privacy, the value of content, and the benefits of our digital commons—even the Web itself. Increasingly, powerful algorithms govern these systems, putting users under the thumb of those who control them.

However, the winds are beginning to change. Regulators are noting the power of the largest tech companies and working to curtail them. Open source innovators are creating less-centralized alternatives and building decentralized

infrastructures that preserve individual privacy, autonomy, and digital property rights and increase access to the global commons. Most of all, advances in artificial intelligence are disrupting centralized platforms. New AI algorithms are not only changing how large tech incumbents will deliver experiences on their own platforms but also creating opportunities for novel platforms and systems without precedent. Autonomous AI agents optimized to the needs of users (rather than platforms or the economics of attention) afford new, more decentralized, ways of organizing. It's a chance to bring the capabilities of potent technologies back to the edge—open technologies back into the hands of everyone. None of this will happen on its own, however. Societies and individuals must choose their future, then use these technologies and capabilities to make it so.



Introduction

*“If it is not true,
it is very well invented.”*

—Giordano Bruno,
Renaissance-era philosopher¹

Who or what do we trust? “The perceived truth in media, both traditional and social, is lower than at any other time in our lifetimes,” writes investor Ray Dalio.² If that doesn’t surprise you, it should. Fifty years ago, people could barely dream of the information that average people have at their fingertips. The problem isn’t the availability of information or data; it’s whether we can trust the sources and platforms that deliver it to us. We recognize that platforms are vulnerable to bias. Over 80% say that outside groups influence the news that gets reported.³ We also know they’re nudging our opinions via the algorithms that mediate our experiences. It’s something ex-Google James Williams calls the “largest, most standardized and most centralized form of attentional control in human history.”⁴

Now, the most powerful algorithm of all—artificial intelligence—is nudging us. Already, bots (not all of which are intelligent) make up 49.6% of Internet traffic, actively involved in a war over private information.⁵ “Bad” bots that masquerade as humans and vacuum up data are replacing historic conventions on reciprocity (indexing data in exchange for search traffic). Says one publisher, “With the AI companies ... we’re getting nothing in return.”⁶ The Web as we’ve known it is becoming a tragedy of the commons. Tim Berners-Lee, the inventor of the Web, describes it as “a large-scale emergent phenomenon which is anti-human.”⁷

Without intervention, ever-more-powerful AI and algorithms will mediate our experiences and harvest all the data, reinforcing the dominance of today’s centralized platforms.

Berners-Lee and many others are attempting to take the open Web back. Trust in our foundational technologies and platforms are as important to healthy functioning societies as water or air. With the right choice of technology and regulatory ingredients, we can regain online autonomy and control. Says Tim Berners-Lee, “What could happen if we give people privacy and we give people control of their data?”⁸ It’s a process that some have referred to as the “rewilding” of the Internet.⁹ Doing this well isn’t about mimicking today’s centralized platforms and shoehorning in open technology.

We need to replace the Internet monoculture with something new and different in kind. A daunting task? Yes. Though the timing couldn’t be better—today’s dominant platforms are facing their own disruptive transformation. **Decentralized building blocks, AI, and algorithms create exciting new opportunities to build platforms that have never been possible before.** New breeds of personalized autonomous agents put intelligence at the edge, affording us greater control over our data and the algorithms that govern our interactions. Easy-to-use interfaces and on-the-fly code generation not only put a friendlier face on powerful tools but also have far-reaching implications for platforms, software, and even open source itself. The timing is ripe for new disruptive platforms built on an open foundation that can help us reclaim what should have always been ours in the first place.



Where did the Internet go wrong?

We live in a world of data abundance.¹⁰ At no time in history has the world's store of information been so vast and its potential so badly squandered. We started out with a bold vision of what the Internet could be. Take Google's mission statement, for example, "to organize the world's information and make it universally accessible and useful."¹¹ But, somewhere along the way, the Internet took a wrong turn (not TCP/IP itself, of course, but rather Internet-connected experiences). Instead, we enrich large, centralized platforms that control our digital experiences. And because our world is awash with data, it's easy to forget just how precious information can be.

Grand ambitions for a new digital commons wasn't the problem. In fact, the Internet succeeded in ways that previous generations could scarcely imagine. Information is now at everyone's fingertips, and intelligent wired and wireless networks connect billions of people on every coordinate of the globe.

Instead, the challenge has been to protect and maintain such a prize. It's a grave responsibility to permanently govern and run public goods such as the Internet. Robin Berjon, Deputy Director of the IPFS Foundation, explains: "We built this system that is, you know, planetary and currently serves over 5 billion people, and we didn't approach it with a mindset that matches the scale and responsibility of the task at hand."¹² Protecting and governing a global commons is not an easy task. Says Berjon, "no one said that governing the infrastructure for basically all of society at the planetary scale should be easy."¹³

Public decentralized infrastructures are a bit like ecosystems—they need to be sustainable and viable. Without resources and sound governance, the economic model for such a system can become a pressure point. Left unaddressed, it's an area of vulnerability where commercial systems may gain entry and co-opt the commons for their own benefit.

David Clark, a former chief protocol architect in the development of the Internet and now a senior research scientist at MIT, jokes about a conversation he had with an economist at a point in time when the Internet was starting to become more commercial:¹⁴

Economist: "The Internet is about routing money, and routing packets is a side effect, and you screwed up the money routing protocols."

David Clark: "I didn't design any money routing protocols."

Economist: "That's what I mean."

Of course, one solution to this problem is baking economics into the system from the beginning. It has worked for many blockchain-based systems, where arrangements of incentives drive entire ecosystems. Indeed, it's an interesting thought experiment: Would the "attention economy" (treating human attention and private data as a commodity that can be bought and sold) have arisen at all if the Web had a payment infrastructure built in from the start? David Clark, for one, suggests that the economic models of open systems are essential to their success. "The really critical issue in making a sophisticated, distributed ecosystem work is going to be the model of how money flows through the system. So, I am a complete believer in open source as a facilitator of this space, but the design of the ecosystem has to be right, or open source [alone] won't be enough to make it happen."¹⁵

"No one said that governing the infrastructure for basically all of society at the planetary scale should be easy."

*Robin Berjon
IPFS Foundation*



Others say it's not the economic models that are missing—simply better decisions and governance of complex systems. According to author and futurist Karl Schroeder, "the fundamental problem facing us is our inability to govern ourselves well, particularly when it comes to common goods."¹⁶ Robin Berjon of the IPFS Foundation suggests that it boils down to an issue of *epistemic democracy*—the capacity of the "many" to make the correct collective decisions and achieve better results.¹⁷ Without the right tools and decisions, our systems fail to escape "enclosure," a well-established pattern that Schroeder says has repeated itself over hundreds of years: "There's a 250-year-old, roughly, process that has repeated itself a number of times, and it's called the enclosure of the commons, and it started with the literal fencing in of common land used for grazing."¹⁸

In 15th- and 16th-century Britain, for example, as wool became more profitable, landowners started fencing in arable land and displacing commons. Adds Schroeder, "So, this is the classic example of the enclosure of the commons. It's an encirclement where, technically there is a commons, but it gets harder and harder to access, and walls get put up that necessitate gatekeepers."¹⁹

Today, the same phenomenon is unfolding in digital form. It's visible in the ownership of the airwaves, vast collections of data, and now even in computing and networking itself. "It's taken a little while for it to arrive in the Internet, but here we are," says Schroeder.²⁰ Robin Berjon agrees: "It's been captured. And yes, the means of capture have often been to take one piece and then leverage that into controlling other parts."²¹

Recognizing the problem is the first step. These systems are pervasive, and so is their influence, so it's easy for our values and control to slip away without us being aware of it. James Williams, a former architect of Google's search ad business, asks, "Will we be able to recognise it, if and when it happens? ... And if we can't, then how do we know it hasn't happened already?"²²

It's not an idle question. For example, much of the thought-provoking discussion about the influence of social media on society occurred from 2017 to 2020, a time when established journalism and media were under threat and when we began to understand the challenges of the "attention economy." Now, as social media platforms emerge as winners, is it reasonable to expect open, self-reflective dialogue on these platforms? Especially if it explores the nature of their dominance? In 2017, Justin Rosenstein, the inventor of the Facebook "like" button, prophetically suggested, "One reason I think it is particularly important for us to talk about this now is that we may be the last generation that can remember life before."²³

Can we fix the Internet?

"The world doesn't have to be the way it is right now," says Wendy Wong, Professor of Political Science at UBC.²⁴ While it might feel like a daunting task, "We need to stop thinking of Internet infrastructure as too hard to fix. It's the underlying system we use for nearly everything we do," suggest Maria Farrell and Robin Berjon in their article, "We Need to Rewild the Internet."²⁵ The Web belongs to everyone, says Tim Berners-Lee. "Collectively we hold the power to change it. It won't be easy. But if we dream a little and work a lot, we can get the Web we want."²⁶

David Clark certainly hasn't given up on the Internet he helped create. "I absolutely believe, with a considerable passion, that we should try to build a decentralized user experience."²⁷ Shroeder suggests that the recovery of a commons is easier than one might think. "The thing about the enclosed commons is that it's highly artificial. It rests on mercantilist and capitalist construction of reality. Basically, if the owners go away, the locals just come by and knock down the walls, and then you have a commons again."²⁸ It's about the return to a natural, less-



centralized, state. "The real world is decentralized," says Munindar P. Singh, SAS Institute Distinguished Professor of Computer Science at North Carolina State University. We need to shed our closed-loop assumptions and allow sufficient autonomy at the edge of a network.²⁹

Dominance also means accountability. Daniel Goldscheider, founder of the OpenWallet Foundation, says that platform

dominance should also come with responsibilities: "At the very least, you should not use or abuse that position of power just to further your own business goals."³⁰ What if, rather than furthering the interests of today's dominant players, our platforms benefited us by amplifying our capabilities instead? To appreciate the opportunities to steer future platforms, let's look at the root of the problem.



A closer look at the causes

*“Data is not the new oil—
it’s the new plutonium.”*

—Jim Balsillie³¹

The Internet didn’t begin with a built-in business model. Those in the packet routing business soon found one—consumers proved more than willing to pay subscriptions to Internet service providers. But the business models of burgeoning content and application providers was more uncertain. In the beginning, secure payment on the Web wasn’t even possible, and even today, wallets remain fragmented. Says Daniel Goldscheider, “If browsers behaved like wallets, then you would basically need to download a new browser for every website you visit.”³² This friction, and the lack of ubiquitous forms of payment, breathed life into advertising-based business models. We began paying for content and services—not with our money, but with our attention.

The miracle of the Internet is that everywhere we go, anywhere we spend our time, we’re traversing across platforms in which billions have been invested. Many of them are free—in that we don’t pay any money to use them. Instead, we cede control over our private data and attention. This “attention economy” puts a vast range of services and experiences at our fingertips, but it comes at a steep cost. Says James Williams, “The dynamics of the attention economy are structurally set up to undermine the

human will.”³³ Jim Balsillie agrees: “The online advertisement-driven business model subverts choice and represents a foundational threat to markets, election integrity and democracy itself.”³⁴ They “capture” and enclose the commons.

“Capture” of the commons relies on one piece that lends to control of the others. It often involves platforms that extend their footprint into key pieces of infrastructure, overlapping with domains that public goods, institutions, and national interests occupy. That’s a tricky role to occupy, suggests Daniel Goldscheider: “Whoever is trying to do something that is fundamental infrastructure—especially when you are entering an area where you are recreating functions that typically governments held—you should probably do so in the interest of the public and check your own business goals at the door.”³⁵

Centralized platforms and the ad-based models that power them are the thin edge of the wedge that now threatens the integrity of the Internet we set out to build. Specifically, we are increasingly participating in systems that:

- Threaten our personal data and privacy
- Subject us to information overload and devalue content
- Create walled gardens that erode the commons
- Use powerful algorithms to influence and control
- Gaslight us with misinformation to erode our trust and autonomy



Threats to personal data and privacy

The power that comes from the sensitive personal data that big tech has accumulated has not gone unnoticed. Data mining is often personal and invasive—for example, allowing Target to learn of a teen's pregnancy before her family did.³⁶ The White House itself has warned of the dangers of "Big Tech platforms gathering too much personal information."³⁷ Others, including Mozilla, have a take that is more blunt and to the point: "Ubiquitous surveillance ... harms individuals and society."³⁸

The value of information collected from "free" services is staggering, evident in Google's paying Apple \$20 billion in 2022 for the privilege of being Safari's default search engine.³⁹ But how much do these platforms really know about us? Quite a lot, it turns out:

- "Research has shown that up to 52 companies can theoretically observe up to 91% of the average user's Web browsing history."⁴⁰
- "[Large players] know on average 47% of each user's browsing history ... Google alone, which is the biggest player in the tracking ecosystem, covers 64% of the average users' history logs."⁴¹
- "Large trackers know, on average, nearly half of the browsing history of almost all users."⁴²
- "Online trackers can capture up to 80% of users' browsing histories."⁴³
- "We discover that 81.3% of visited websites send search terms to third parties in some form, representing a potential privacy threat to users."⁴⁴

However, individuals themselves are also complicit in this tracking and surveillance. It's not unusual to give up sensitive personal data in exchange for a few loyalty points (and 80% are willing to sell it for \$100 or less).⁴⁵ Yet it's not just giving data; sometimes people surrender control of valuable data that contains their history of experience. Rodrigo Mendoza-Smith, Founder of a start-up, Quira, which he describes as specializing in *experience quantification of software developers through data*, explains the difference between the two. Says Mendoza-Smith, for developers, "When you write code for a company, there's a big difference between your work output (and your code) and your own experience ... The company a developer works for owns the code and the IP they create. But the developer owns the reputation and experience associated with writing that code and creating that IP."⁴⁶ While it might sound like a minor difference, owning your work experience forms part of your reputation, allowing you to access new opportunities. It's what allows Quira to glean reputation information from public data. "My work is yours, but my experience is not," suggests Mendoza-Smith.⁴⁷ That's why access to and ownership of personal data are so important. Histories and experience help define who someone is.

Nor do people approach data sharing rationally. Research suggests that we share our data not because we believe it's safe or because we trust the platforms we share it with but because everyone else is doing it.⁴⁸



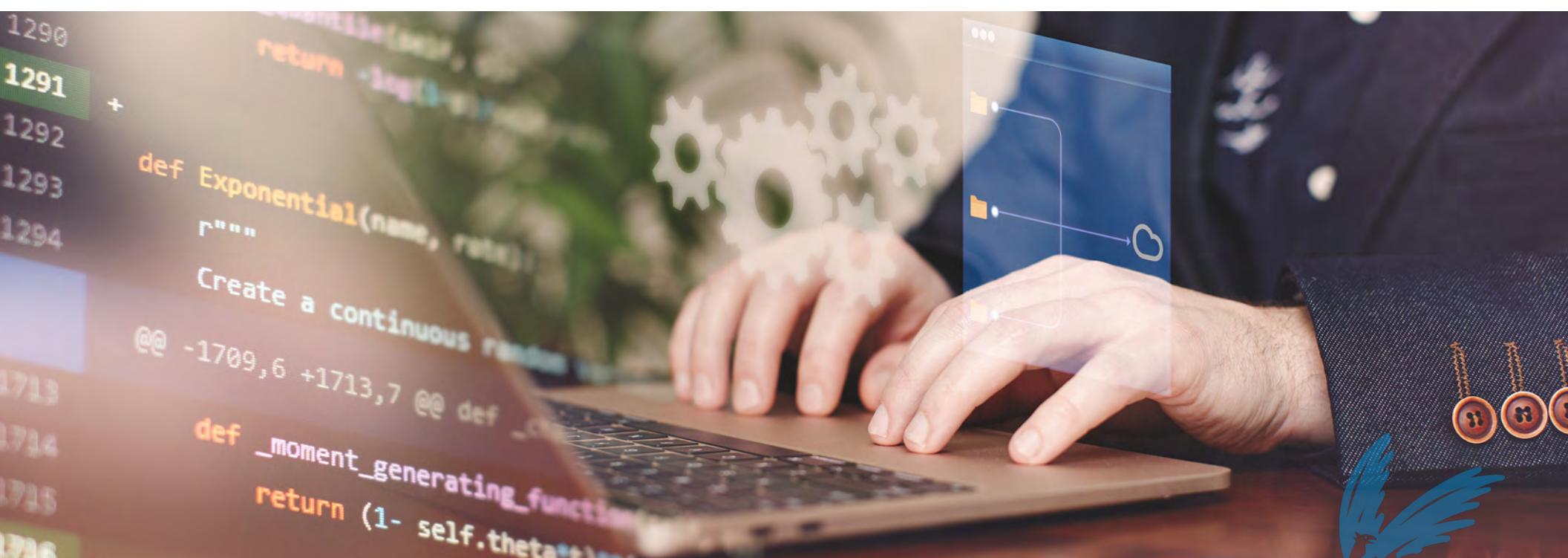
Information overload and devalued content

Online platforms also subject us to information overload. Research suggests that additional information aids decision-making, but only up to a point. Too much information impairs our decision-making performance,⁴⁹ leading to analysis paralysis. Social media amplifies the flow of low-quality content,⁵⁰ and AI-generated content will only make things worse.

According to Sam Altman at OpenAI, in 2024, ChatGPT generated approximately 100 billion words daily.⁵¹ In a year, that's about 1% of the world's total estimated store of 4.1 quadrillion total written words.⁵² It's a flood of chat sessions, articles, blogs, social media posts, and even vast amounts of synthetic training data used to generate future AI models. Even entire applications will

be coded up in an instant.⁵³ At a projected growth rate of 70% annually,⁵⁴ by 2032, AI agents would annually author 61% of today's total store of written words.⁵⁵ "Now we're in a position in which knowledge is free, and it's available anywhere and everywhere," says Rodrigo Mendoza-Smith.⁵⁶ The problem? The explosion of AI-generated content will overwhelm humans' capacity to absorb it.

A decade from now, the average written word is unlikely to be read by a human at all. What will it mean if AI can produce *anything* on the fly? Books, articles, software (even **open source** software)—the value of all of these things depends upon assumptions of scarcity, which may soon cease to exist. Without that scarcity, the value of apps, or even the Web itself, may fall off a cliff.



Walled gardens that erode the commons

Even if users don't treat personal data as precious, the companies that they divulge it to certainly do. There's a quiet arms race taking place for content and personal data among the platforms that control it. Content-harvesting bots have become pervasive, and so have the efforts to wall up data in order to keep them out. Bots today make up 49.6% of Internet traffic, and 32% of those are labeled "bad" because they attempt to disguise their behavior and mimic users, often for tasks such as extracting data without permission.⁵⁷ The open Web has become a walled garden. According to the Data Provenance Initiative, between 2023 and 2024, Web data sources have restricted themselves from automated access—approximately 5% of all data, as well as 28% of what it labels as the most active critical sources.⁵⁸

It's not just the public Web that's being harvested. Increasingly, dominant platforms are hiding data from each other. We are held hostage by applications that own our data, logins, and even identities—and every morsel of personal information is invisible to other platforms in an effort to make switching more difficult. For example, Amazon order confirmations no longer include emailed purchase descriptions for fear of information scraping.⁵⁹ The ubiquity of Secure Sockets Layer ensures that facts, such as what we search for, remain tracked but not eavesdropped upon.⁶⁰ There are many other measures, too: banning VPNs, removing APIs (or enforcing limits), or requiring CAPTCHAs (short for "completely automated public Turing test to tell computers and humans apart"). Five hundred human-years are wasted on CAPTCHAs every single day.⁶¹ Companies such as Cloudflare have built a business on warding off bots,⁶² while others such as CapSolver offer tools to help foil them.⁶³ A recent study suggests that chatbots displace public discourse, too, which "threatens the future of the open Web, as interactions with AI models are not added to the shared pool of online knowledge."^{64 65 66}



Some of these activities occur under the banner of consumer privacy protection. However, for many platforms, data protections also raise users' switching costs. Bans on bots mean consumers can't use them for legitimate purposes on these platforms, either. If there's a bot, it's generally one with strict limitations, and is not a user's own bot. Users are often stuck with whatever algorithms, automation, or bots the platform owner provides.

The market for attention has created an unhealthy arms race as walled gardens attempt to corral and lock in humans and keep out the bots. Platforms can detect bots, but the technologies for skipping ads get better, too. "I just want to ask my computer for something, and then it should give me a window into just what I want," says Killian Lucas, and let the computer sift through the ads and "bear the brunt of the terrible Internet experience that the attention economy has created."⁶⁷ Lucas adds, "But it's going to piss off a lot of advertisers. I have no idea if they're going to accept that, or if there are going to be more sophisticated ways of detecting that kind of computing activity. I'll say, though, that CAPTCHAs are totally easily solvable now by AI."⁶⁸

Powerful algorithms that influence and control

"Social media's toxicity is not a bug—it's a feature. Technology works exactly as designed."

—Jim Balsillie⁶⁹

Algorithms are at the heart of many social media experiences. The goal is to hold our attention for as long as possible and then leverage that influence to generate revenue. It's the science

of building and maintaining addiction in which companies are investing billions. Meta, for example, spends more than 25% of its revenues on R&D, a significant portion of which goes to AI and algorithms.⁷⁰

It's not about what's good for users; it's the capacity to keep them engaged. As Guillaume Chaslot told the *New York Times*, "Watch time is key. The algorithm tries to get people addicted rather than giving them what they really want."⁷¹ Some algorithms are particularly adept at steering our preferences. Take Netflix, for example: "More than 80 per cent of the TV shows people watch on Netflix are discovered through the platform's recommendation system."⁷² Some of the best algorithms consistently explore the frontier of our interests to get to know us better. TikTok, for example, recommends 30%-50% of videos based on past interactions, but it also mixes in a wider range of "exploratory" videos to glean deeper insights into users' tastes.^{73 74 75} Social media is an experiment, and we are the guinea pigs.

Optimizing for attention doesn't maximize individual or societal outcomes, however. It's easy to find oneself in a filter bubble. Touching our phones 2,617 times a day hasn't made us smarter.⁷⁶ Instead, says Justin Rosenstein, formerly of Facebook, "Everyone is distracted ... All of the time."⁷⁷ Eric Schmidt describes how he views the end-to-end process: "The CEOs, in general, are maximizing revenue. To maximize revenue, you maximize engagement. To maximize engagement, you maximize outrage. The algorithms choose outrage because that generates more revenue."⁷⁸ The problem is what these algorithms optimize for; they leave the values of users and society out of the loop, or even harm us directly.⁷⁹ At a societal level, the result can be an unhealthy level of addiction with questionable benefits for individuals.



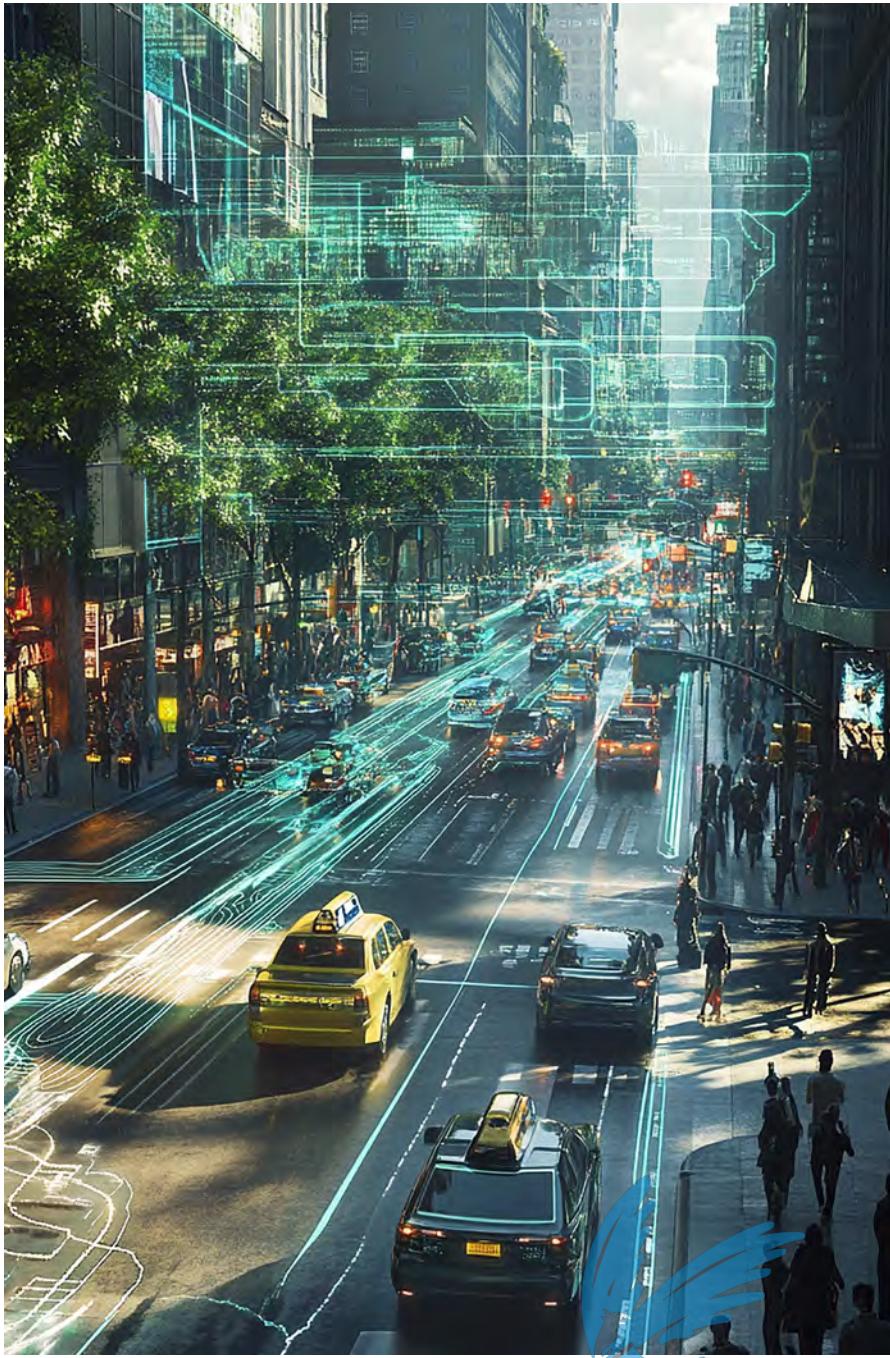
If algorithms are the problem, then should we do away with them? David Clark suggests they're a critical part of what makes social platforms successful: "At heart, you have to have a recommendation engine. There has to be a feed. This is what makes it exciting."⁸⁰ They're essential to the platform, but do they really benefit users? "I don't think we should get rid of those algorithms completely, I do see the benefits of them," says Rui Zhao, Research Associate at the University of Oxford, especially when it comes to exploring new or unfamiliar areas.⁸¹ Yet, developers can design these algorithms to exploit human weaknesses,⁸² and so problems can arise when users aren't in control of those algorithms. We should be able to turn them on or off—perhaps the "intention" economy rather than the "attention" economy, suggests Zhao.⁸³ Algorithms should reflect users' values, needs, and interests.

Gaslighting us with misinformation erodes trust and autonomy

"We have a trust problem in our society, democracies can fail, and the greatest threat to democracy is misinformation because we're going to get really good at it."

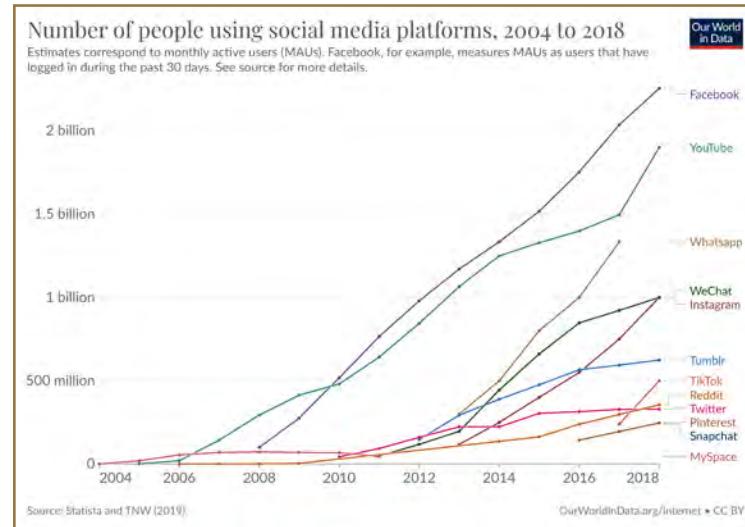
—Eric Schmidt⁸⁴

The following charts (Figures 1 and 2) depict the growth of social media (left) and the rise in the use of the term "fake news" (right). Although correlation is not causation, it is interesting to note that the term "fake news" (which first appeared in 1860) really came into vogue in 2016, just as many social media platforms rose to global dominance.



Figures 1 and 2: Growth of social media (left) and rise in the use of the term “fake news” (right).

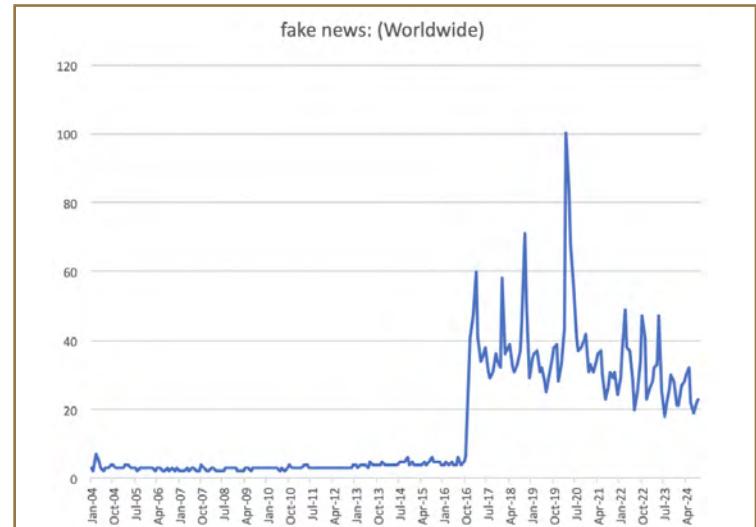
FIGURE 1: GROWTH OF SOCIAL MEDIA



Source: Statista and TNW, 2019, OurWorldInData.org/Internet, CC BY, <https://ourworldindata.org/rise-of-social-media>

In 2018, just two short years later, 57% of consumers sourcing news on social media expected it to be “largely inaccurate.”⁸⁵ Among users who got their news via social media, the level of inaccuracy is also what they dislike about it. In 2018, 18% cited inaccuracy as the thing they “disliked most” about getting news on social media; by 2023, that number had risen to 40%.⁸⁶ And yet, convenience means social media remains an important source of news, one that’s viewed as particularly valuable when it comes to following events in real time or when seeking opinions that help form our own opinions on current events.⁸⁷

FIGURE 2: USE OF “FAKE NEWS” OVER TIME



Source: Google Trends, <https://trends.google.com/trends/explore?date=all&q=fake%20news&hl=en-GB>

Original fact and evidence (even for this report) may be difficult to source in cases where authors don’t include references, let alone cases where news is outright fake (something 59% profess concern about).⁸⁸ Increasingly, we’re wondering about the facts, what’s real, and what isn’t. There’s a name for that—*gaslighting*, which Merriam-Webster defines as “manipulating someone into questioning their own perception of reality.”⁸⁹ Artificial intelligence only makes things worse, whether it’s creating misleading content by accident⁹⁰



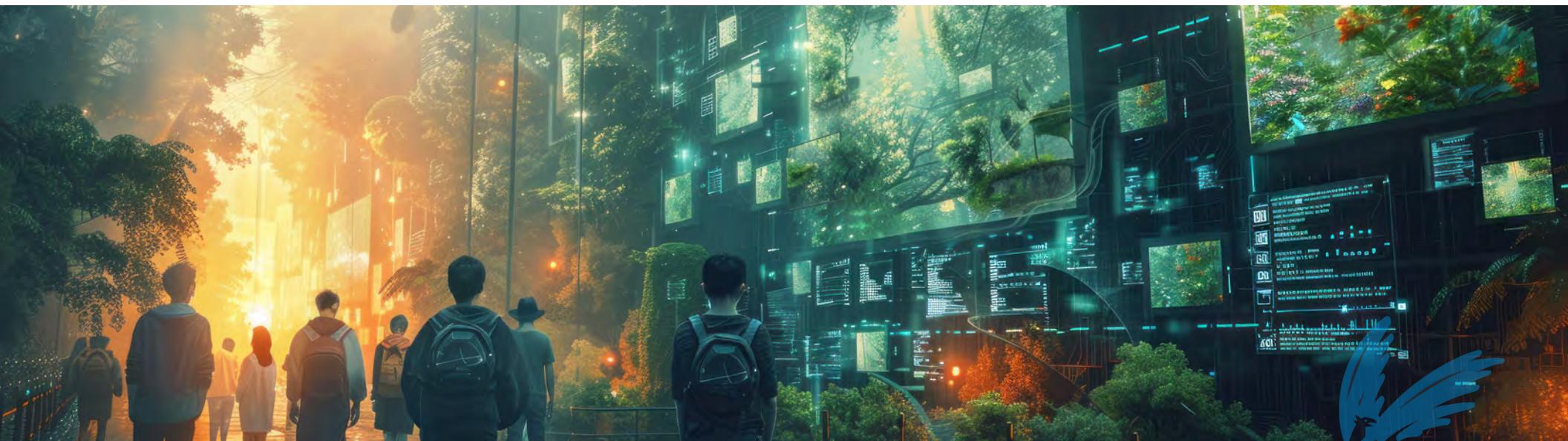
or amplifying our ability to generate fakes. We can fork reality itself, suggests Karl Schroeder, thereby inventing entire worlds that don't exist:

"Any amount of information, about anything, can be created on the fly. Entire libraries full of books, manuals, histories, cross referenced with the autobiographies of authors, maps, and so on for entire historical epochs that did not happen. Scientific developments, political theories, anything you can think of, social movements, religious systems with histories going back thousands of years. And then hundreds or thousands of different documents, sacred texts—all of it whipped up in seconds ... We'll be able to do that."⁹¹

How can anyone know what to believe? If social media puts individuals in a position where they begin to mistrust reality or question their perceptions, they become more receptive to outside influence—imperiling both individuals and society at large. Martin Baron, former Executive Editor at the *Washington Post*, is one of many who have warned of these risks: "If you

have a society where people can't agree on the basic facts, how do you have a functioning democracy?"⁹² Grounding points of reference and retaining a grip on the truth are difficult on platforms designed for purveying influence.

Living in a free society means having the ability to make educated choices and being responsible for their consequences. "Autonomy is very important, I think, for humans as a species," offers Wong.⁹³ "We are not being treated as though we have dignity, because data just gets collected about people in ways that we don't fully understand. We certainly don't have a good grasp of where the data goes once it's collected."⁹⁴ The values embedded in these algorithms don't belong to us, yet they're changing the very fabric of our society. "We're nudged toward certain types of social engineering outcomes that maybe we don't want," and we haven't consented to those changes.⁹⁵ "We were never asked," suggests Wong, "and it pushes against what it means to be a human being."⁹⁶



Regulatory currents of change

As the influence of major tech platforms has grown, regulators have started to put big tech under the microscope: scrutinizing data and consumer privacy, reinforcing consumer protection and liability, and ensuring fair market access and competition.

Europe in particular has been a hotbed of legislation. Mike Milinkovich, Executive Director of the Eclipse Foundation, which recently moved from the United States to Europe, describes it as “a cargo ship of regulatory activities that have all been passed in the last couple of years.”⁹⁷ Whether these actions can breathe life into decentralized players or mitigate some of the consequences of centralized platform power remains to be seen. Some changes, such as consumer data protection, have already resonated around the world, while others are still being tested.⁹⁸ Some tech pundits, such as Benedict Evans, suggest that the E.U. isn’t a large-enough market to force these platforms to change the way they do business, with the result that “EU consumers get the downsides of the regulations without the upside.”⁹⁹ For example, additional E.U. regulatory requirements might delay European access to new offerings or, in some cases, lead companies to avoid regional-specific releases at all. Others see it as a human rights issue where regulation is critical to fundamental protections.¹⁰⁰

Some examples of the most prominent regulations are:

- **Human rights:** The [GDPR](#) offers protection and privacy for consumer data, and the [E.U. AI Act](#) aims to improve AI safety and mitigate risks.
- **Fair competition:** The [Digital Markets Act \(DMA\)](#) emphasizes fair competition in digital markets, and the [DSA](#) defines rules for large online platforms and search engines.

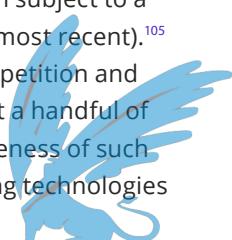
- **Property rights:** The [Data Act](#) covers greater control over generated data (including [data spaces](#)).¹⁰¹

- **Liability:** The [Cyber Resilience Act](#) introduces liability for software providers.

With so much at stake, striking the right balance isn’t easy, but it’s important to find common ground. Daniel Goldscheider, Founder of the OpenWallet Foundation, suggests that “there are some areas where governments and corporations may want to meet each other at eye level.” Force is rarely the answer when it comes to the adoption of open technology; instead, it’s better to focus on the benefits.¹⁰²

Many regulatory efforts seek to restore the balance of power between dominant platforms and the people who use them every day. Data ownership and portability, the right to be forgotten, and privacy rights are all worthy causes. But some rights aren’t clear cut. In vehicles, for example, OEMs often believe they own the data, while others say it belongs to a vehicle’s driver. Ted Guild, Connectivity Standards Lead at GEOTAB, has been involved in a number of automotive standards bodies. Says Guild, “You can’t make everything public if you don’t know who it belongs to.”¹⁰³

Other regulations aim to curb the dominance of major platforms and the market power they wield. “We should be using regulation more to break up monopoly power,” suggests Robin Berjon, yet regulation isn’t good at exploring new possibilities. “You can’t innovate by regulation.”¹⁰⁴ Major players have been subject to a steady stream of antitrust scrutiny (Google is the most recent).¹⁰⁵ The DMA, for example, seeks to further open competition and fair markets, leveling the playing field in areas that a handful of firms dominate. While some question the effectiveness of such legislation, even the most complex and fast-moving technologies



still offer important points of leverage. "AI has three fundamental components—data, compute, and algorithms," all of which are amenable to regulation, suggests Wendy Wong.¹⁰⁶

Other regulations, such as Canada's Online News Act, appear more protectionist. The Act obliges large players such as Google and Meta (Facebook) to compensate news publishers directly.¹⁰⁷ Facebook simply refused, dropping publishers from Canadian links. Other regulatory skirmishes are more personal. France arrested Telegram's founder Pavel Durov, who now faces criminal charges from a failure to moderate illegal or extremist content.¹⁰⁸ In Brazil, a battle over censorship boiled over into a ban of X throughout the country and a seizure of Starlink's funds.¹⁰⁹ Elon Musk called Brazil's Alexandre de Moraes "an evil dictator,"¹¹⁰ while Moras maintains that Musk has "total disrespect for Brazilian sovereignty."¹¹¹ These personal and political battles are difficult to decipher. Are these vendettas against free speech or worthy attempts to foster competition and protect national sovereignty?

It's not only regulators who are catalyzing change. Online advocates, open source communities, and their foundations play important roles in maintaining the open Internet as well as many of the public goods we often take for granted. Sometimes the work is simple, ensuring that regulations don't have unintended consequences—or, worse, that "what they have legislated is an impossibility."¹¹² ¹¹³ That's where advocacy work comes in, says Joshua Simmons, aligning regulation with practical considerations.¹¹⁴ Open source is also about fostering community, says Mirko Boehm, Senior Director of

Community Development for Linux Foundation Europe. "They want a neutral home for the project where it's not owned by one entity."¹¹⁵ That's where a foundation can help. "We basically encourage support [and] catalyze—if you will—the way different people work together."¹¹⁶ Daniela Barbosa, General Manager of Decentralized Technologies and Executive Director of LF Decentralized Trust at the Linux Foundation, echoes these sentiments: It's "a place [where] people can actually collaborate on these technologies in order to build something better together."¹¹⁷ Rebecca Rumbul, of the Rust Foundation, says it's important for foundations to fill in the gaps, taking care of all the things unlikely to happen on their own and engaging on a grassroots basis to help get things done.¹¹⁸ Supporting the momentum of the community is key, allowing it to keep making a difference even when progress itself is difficult to ascertain. Says Rebecca Rumbul: "How do you define success and impact in a field where everyone has a different idea of success and impact can be good or bad (or nothing) depending on which particular vantage point you have?"¹¹⁹ Building consensus on what matters is perhaps the most important contribution of all.

How do we build that consensus? Says Daniel Goldsneider, "I think it is really important to come up with fundamental principles that are independent of specific technological manifestations of human ingenuity."¹²⁰ That means open collaboration where differences are put aside. Says Goldsneider, "[My] hope is that governments and private sector companies will increasingly work together to ensure that critical technologies act in the interest of the public."¹²¹



Reimagining platforms: The Internet's decentralized future

If centralization is the problem, is decentralization the fix?

It's tempting to think so. After all, the Internet itself is a global decentralized network. Surely we can recast the digital platforms in a more effective decentralized form. But why decentralization, and what are its benefits?

The answer depends on who we ask. Vitalik Buterin, the founder of Ethereum, has distinguished among:

- Physical decentralization, that is, the number of computers comprising a system
- Political decentralization, that is, who controls those computers
- Logical decentralization, that is, whether the system is unified and monolithic or can be chopped into viable pieces¹²²

Those distinctions help describe system differences. For example, blockchain is architecturally and politically decentralized but logically centralized because it runs like a single computer.¹²³ The benefits of decentralization, according to Buterin, are:

- Fault tolerance, because of redundancy and diversity
- Resistance to attack, because there's no single point of weakness
- Collusion resistance, because it's harder to collude in ways that undermine the system¹²⁴

Ultimately, decentralization is about fostering greater autonomy at the edge to enable trusted systems that won't run counter

to our interests. Moxie Marlinspike, Co-Founder of the open source messaging application Signal, has a different take on the subject.¹²⁵ In his view, when many people think about decentralization, they have specific benefits in mind. He believes well-structured centralized systems can offer many of those benefits—"increased privacy, censorship resistance, availability and control."¹²⁶

Signal, with a focus on open source, privacy, governance, and user experience, is the realization of Marlinspike's ambitions: "What we want is for technology to better serve us."¹²⁷ While not fully decentralized in an architectural sense, Signal appears to fit Buterin's description of "political" decentralization. Marlinspike elaborates on these choices:

*"To the extent that people are manifesting the control they would like to see, it's interesting to me that it doesn't seem to have much to do with the decentralized nature of these protocols, that it has more to do with the open source nature of these projects, that because these projects are open source, it's very easy for people to take what's there and just change it and, you know, redeploy it as something else. So, in a sense, I feel like that ... open source is sort of the best tool that we have in terms of manifesting control."*¹²⁸

Instead, the *decentralized* piece of Signal's infrastructure—Marlinspike doesn't call it that—is the address book already found on phones.¹²⁹ Social apps need a social network, and one of the best ways to access that network is via an address book—it's personal, user owned, and very powerful—because users maintain that network even as they traverse different platforms and services.¹³⁰

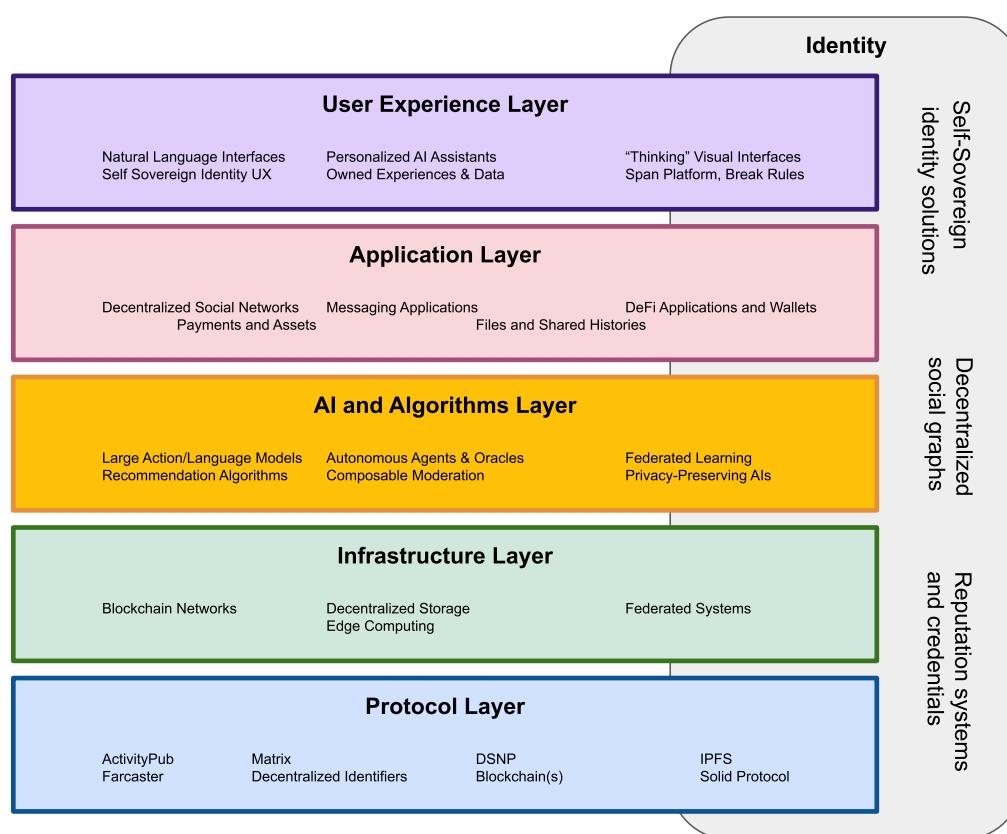


Must everyone, as Marlinspike suggests, accept centralized structures as a necessary evil in order to assert control over technology and enjoy its benefits? Must it be “under the control of a benign dictator?”¹³¹ Isn’t there a way to have the best of both worlds instead? David Clark suggests it’s a worthy goal: “I’m willing to put some energy into it, because I believe in that outcome.”¹³² Can we have a structure that’s sufficiently agile

but also decentralized? There are no guarantees; Clark calls it “a grand experiment that we don’t know the results of yet.”¹³³

Let’s take a closer look at some of the decentralized systems and technologies that are making headway on these challenges, as visualized in Figure 3.

FIGURE 3: VISUALIZING COMPONENTS OF FUTURE DECENTRALIZED PLATFORMS.



Source: Author; Chris Xie and Lalana Kagal also contributed to this diagram. In addition, the author consulted with Anthropic’s [Claude.ai](#), which also made helpful suggestions about the visualization and its components.



Infrastructure for decentralized social networks

"The Times 03/Jan/2009 Chancellor on brink of second bailout for banks."

—Satoshi Nakamoto¹³⁴

Using decentralized systems for communications isn't new. In the 1970s, citizens band radios were popular, and centuries ago, seafarers could receive letters at sea. With the advent of the Internet, some might argue that Usenet and Internet Relay Chat systems were decentralized as well.

Satoshi's message embedded in the genesis block (see Figure 4) may quote a headline from a British newspaper, but it almost certainly qualifies as a social use of blockchain. There were numerous other early systems as well, such as Steemit, Diaspora, and Eth-tweet.¹³⁵

FIGURE 4: THE SCRIPTSIG FOUND IN THE [GENESIS BLOCK](#) ALONG WITH ITS ASCII [CONVERSION](#).

SCRIPTSIG (HEX)	04fffff001d0104455468652054696d657320 30332f4a616e2f32303039204368616e6365 6c6c6f72206f6e206272696e6b206f662073 65636f6e64206261696c6f757420666f7220 62616e6b73
-----------------	---

04fffff001d0104455468652054696d657320
30332f4a616e2f32303039204368616e6365
6c6c6f72206f6e206272696e6b206f662073
65636f6e64206261696c6f757420666f7220
62616e6b73

Convert

swap conversion: [Ascii Text To Hexadecimal Converter](#)

Source: Author

While no list is exhaustive, the following is a selection of key protocols comprising a few of the most popular decentralized social media systems worth a closer look:

- ActivityPub
- AT Protocol
- Decentralized Social Networking Protocol (DSNP)¹³⁶
- Farcaster

ActivityPub: Mastodon and Threads

ActivityPub is one of the most well-established protocols for decentralized social media. It's what many would describe as a federated system, with endorsement from W3C and running on open protocols. Mastodon and Threads are some of the Twitter-like social networks using the protocol.¹³⁷ Together, these networks illustrate some of the successes, but also the challenges, of less centralized systems. Freedom and resistance to censorship have been value propositions of these alternative social networks, Renaud Chaput, Mastodon's CTO, says it's hard to solve the problem of large social networks where you're "really a prisoner in their platforms ... If your friends are using another platform, or if the platform owner is starting to do things you disagree with, then you are stuck."¹³⁸ That's made these platforms home to marginalized groups, strong supporters of digital freedom, and those who have fled the constraints of centralized systems.

It's a strange mix of strange bedfellows. Some of these networks received large influxes of users from events such as Elon Musk's purchase (and changes to) Twitter, as well as Donald Trump's ban from social media. Not surprisingly, not everyone gets along. For example, Truth Social (which runs a non-federated social network) was initially accused of using source code without giving proper credit. And Meta's interest in embracing open



protocols is tempered by a hesitance to adopt technologies that could put it under regulatory scrutiny (European content sharing requires user approvals—a difficult challenge for a federated protocol). Others are wary of Meta's motives, questioning its use of open protocols or shared AI models, for example. Says Nathan Lambert, "The intent is clear—Meta wants the Llama brand to touch as much of the open ecosystem that it can."¹³⁹ "Altruism is not a business model," suggests Mike Milinkovich, so it's important to consider practical considerations: "Every one of these companies is going to take the actions that they think are best for their business."¹⁴⁰

"Altruism is not a business model,"

Mike Milinkovich
Eclipse Foundation

Implementation differences can also mar user experiences and bottleneck growth. Making the platform more accessible (not just for those with technical skills) is a challenge Mastodon is still working on. "Compared with many other open source projects, we take a lot of care about user interface, onboarding, [and] accessibility," says Chaput.¹⁴¹ The choices are sometimes controversial. For example, Mastodon's initial signup system was very open, allowing users to pick from hundreds of servers. It was a daunting process, and users simply walked away: "They won't do it because it's so complex and they don't understand it."¹⁴² The solution was a new default button to create an account on mastodon.social. "We had a lot of backlash" about that, says Chaput, but "we think it's better for them to create an account than to leave."¹⁴³ In the future, offering hosting services may be another way to keep things simple. For the European Commission, for example, a hosted solution may be easier than trying to do it themselves.¹⁴⁴

Infrastructure constraints and fragmentation have also held up key features. Allowing users' social graphs to follow them from one service to another has always been part of the attraction for less centralized systems. But the feature has proved difficult to implement. Today, users can move their accounts, but their posted content doesn't always follow them. Rather, users "broadcast" their move to a new address so that followers can follow them there.¹⁴⁵ But putting additional burdens on users isn't the answer. "Content creators are burned out by the amount of social networks they need to manage," said Chaput.¹⁴⁶

Another issue is that the federated system of ActivityPub is itself unevenly adopted. Chaput says that despite the fact that Truth Social is based on Mastodon, "one of the first things they did was to disable Federation ... They are a closed social network."¹⁴⁷ Nor is it clear that a server should automatically accept content from other instances, either. Some servers lack moderation, with the result that they may host undesirable, banned, or even illegal content or images.¹⁴⁸ While algorithms are often key to such moderation, the opacity of such algorithms (especially when they dictate what's in users' feeds) means their use is something that "people in the Fediverse are very strongly against."¹⁴⁹ As a result, the software will lack algorithms—making moderation, automated spam fighting, trust and safety, detection of illegal content, and even content discovery and recommendations a little more challenging.¹⁵⁰ The resolution is decentralized search and discovery that is implemented externally instead.¹⁵¹

AT Protocol and BlueSky

Another popular destination for those leaving centralized systems is BlueSky. For example, in August 2024, the Brazilian government's disagreement with Musk's X led to a country-wide ban in Brazil.¹⁵² Many switched to BlueSky, which claimed a 2.6 million increase in users in a single week, 85% of whom were Brazilian.¹⁵³



The founders of BlueSky viewed it as a proof of concept for the AT Protocol, which is based on a microservices architecture (rather than large monolithic server instances).¹⁵⁴ Initially spun out of Twitter, the application for BlueSky is open source (see [GitHub](#)). The AT Protocol is currently governed by a public benefit corporation, whose stated mission is “to develop and drive large-scale adoption of technologies for open and decentralized public conversation.”¹⁵⁵ Its CEO, Jay Gruber, claims the company is “moving toward standardizing pieces of the protocol.”¹⁵⁶ BlueSky’s microservices architecture is a deliberate choice, something Gruber says makes it easier for features such as “composable moderation,” a decentralized solution for tailored moderation.¹⁵⁷ Joshua Simmons of Matrix suggests that these kinds of innovative algorithms are valuable features when it comes to accommodating diverse values and points of view: “You can layer on different frameworks of moderation to create the experience that you need.”¹⁵⁸ “There’s about 40,000 custom algorithms out there and custom feeds, and some of them are very simple, some of them are very complex, and users can install them and switch between them,” offers Gruber. Yet other features are global, such as search and discovery, account portability, or the ability to consolidate all feeds—these key features were planned from the outset.¹⁵⁹

DSNP and Farcaster

DSNP was created by Project Liberty,¹⁶⁰ a nonprofit founded in 2021.¹⁶¹ The goal was to create a public protocol that would “free the social graph from central control.”¹⁶² Like ActivityPub, social application functions such as moderation and algorithms were not designed as a part of the protocol but remain possible at higher levels of the technology stack. The project distinguishes itself by its use of blockchain as part of the protocol.

The attention to scalability (the stated aim is to support billions of users economically) means that running significant parts

of the protocol over blockchain is infeasible. So blockchain technology was considered for narrow, yet critical, parts of the protocol. As David Clark puts it, “the root of the tree is always, always, magic.”¹⁶³ For Clark, the “magic” part is identity.¹⁶⁴ Identity is tricky because so much rides on its implementation. “Key management is the ugly duckling of all of this stuff,” and there are a lot of edge cases to handle.¹⁶⁵ People lose passwords and devices, and so they need a recovery strategy. Even with a mobile device, says Clark, “it’ll be stolen, it’ll fall down a manhole. It’s got to be replaceable.”¹⁶⁶ That means having either a trusted agent (or system) that can vouch for one’s identity or a publicly visible “identity assertion on a blockchain.”¹⁶⁷ Project Liberty opted for the latter: using blockchain to help minimize the number of points of “trust” in the system. Today, a social network called MeWe is one of the largest adopters of DSNP. In August 2024, MeWe announced 1 million on-chain users, 500,000 of whom control their complete social graph on the blockchain.¹⁶⁸ The foundation’s main contributor is also said to be considering other acquisitions, the most ambitious of which could shorten the path to a critical mass of adopters.¹⁶⁹

Farcaster is another open protocol with on-chain components (Warpcast is a client) designed to aid the creation of social media apps.¹⁷⁰ The protocol’s stated goal is to address concerns of “privacy, monopolization, and censorship.”¹⁷¹ The project has a number of on-chain components; however, it uses this “friction” to its advantage. A \$5 fee helps to deter spam accounts, for example. While adoption levels appear to have leveled off, one of its users, Vitalik Buterin, praises it as a “Twitter alternative.”¹⁷² When somebody hacked Vitalik’s X account, Vitalik used Farcaster to explain what happened—a socially engineered SIM swap—and plugged Farcaster’s strong form of identity management: “Anyway, glad to be on farcaster, where my account recovery can be controlled by a good wholesome ethereum address :”¹⁷³



Communication and messaging

While many decentralized applications have focused on the social graph or microblogging, others, such as Matrix, have focused on messaging itself. David Clark scrutinized Matrix as part of his own research for Project Liberty. He describes the elegant simplicity of its decentralized ecosystem:

*"It's about as simple as you can get. Each user is represented by some software that runs on a client, and you can have multiple clients, and then those are synchronized by a package that they call the home server. ... when you want to send a post, it looks at all of the people it's going to, which are defined as being part of a room. That's their vocabulary."*¹⁷⁴

Joshua Simmons, Managing Director of the Matrix.org Foundation, describes Matrix as "a federated decentralized communications protocol."¹⁷⁵ It's suited to many different kinds of communication, real time chat, voice, or video calls—virtually any form of communication, even virtual reality clients, or AI-enhanced chat.¹⁷⁶

While Simmons is well versed in the technologies behind Matrix, he's most excited about the communities that Matrix enables. What is Matrix really about? "Free, open, secure, private decentralized communication for all humans,"¹⁷⁷ says Simmons, "Our view is that that is a human right."¹⁷⁸ Simmons is passionate about open source and the alternative these communities offer. In the early days, platforms such as Twitter were very developer friendly, and it was easy to build applications on top of them. Over time, these platforms began to close themselves off and became increasingly centralized. Their closure created an opportunity to be seized.

Says Simmons, "That drove home for me the power we give away when we buy in to closed social platforms."¹⁷⁹ Less-centralized systems mean no single platform or entity can pull out the rug.¹⁸⁰

"Ultimately, we need to empower people first to have private secure messaging that they own."¹⁸¹ That passion led Simmons to various open source and community roles before he joined the Matrix.org Foundation.

But how does an open platform maintain and steward the resources needed to sustain itself? For open source ecosystems, sustainability can be a constant struggle, one that requires balancing tensions with commercial interests. With Matrix, for example, the for-profit company Element has been a primary contributor. Yet, to help fund its own development, Element has switched to an AGPL v3 license.¹⁸² It forked the original Apache-licensed repositories of Matrix.org to exploit dual-use licensing opportunities for Element.^{183 184} "We didn't love that. And our policy is still to stick to permissive licenses that maximize adoption and experimentation," says Simmons. "Our role as an open source foundation is to be a steward, not an organization that's turning a profit ... For Matrix, our mission is much broader."¹⁸⁵

Sound stewardship, protocol simplicity, and an emphasis on values have contributed to the adoption of the Matrix open communications software. Those values resonate strongly; in some cases, they have outweighed other drawbacks, such as ease of use. Simmons tactfully suggests that Matrix sometimes requires a little bit of patience: "There might be some sharp edges here and there, and, truth be told, building federated, end-to-end encrypted systems is a thorny problem. And building a polished user experience on top of that is not easy."¹⁸⁶ But, ultimately, the importance of security, privacy, and data sovereignty helps overshadow some of the drawbacks. Public sector adoption has been strong, particularly in Germany and France.¹⁸⁷ Matrix has done an excellent job of matching its value and mission with adoption by parties that are seeking those requirements (and, often, highly discerning in their technology choices):¹⁸⁸



- **Education**—especially at a number of German universities.
- **Healthcare**—the national agency of Germany, for example, will use Matrix for messaging interoperability.^{189 190}
- **Defense**—adoption in military contexts has included Germany, the United Kingdom, the United States, and Ukraine.
- **Open source**—Linux distributions, as well as foundations such as Mozilla, and a number of Linux Foundation projects.
- **Marginalized groups or the oppressed**—examples include minorities, journalists, dissidents, queer/trans communities, and communities that harbor concerns about safety on other platforms.

As adoption becomes more mainstream, identity is an area that demands immediate attention. “I see people frustrated with the state of identity... [who say], ‘I would really like to be able to use one account for all of these things,’” says Simmons.¹⁹¹

The challenge is to offer consistent experiences with identity without relying on centralization. Matrix will soon work with other identity systems, such as OIDC, and support a new native alternative. Says Simmons, “We have our own in-house matrix authentication service that we’ve built.”¹⁹² Users will benefit from the convenience of logging in to Matrix with other identity providers, but in the long run, they may also use their Matrix identity to authenticate with other services, too.

What’s in store for Matrix users in the future? Joshua Simmons believes it’s about creating a more polished user experience and delivering the values its users hold dear:¹⁹³

“We’re at over 100 million [users today], which we feel very good about. But to get to a billion and beyond, the two things we have to solve is we have to deliver a polished user experience that feels much more like a drop-in replacement to existing communication tools. The other thing that we have to solve is delivering on trust and safety.”



Personal data storage and provenance

"If you want to keep a secret, you must also hide it from yourself."

—George Orwell, 1984

In the attention economy, it is not possible to retrieve "spent" private data. In the digital world, the ability to make unlimited perfect copies is both a blessing and a curse. In the same way that absence of scarcity creates the "double spend" problem for digital currencies, it also creates privacy issues.¹⁹⁴ Call it the *double spend problem* of private data. Those who receive private data may store, share, or make copies of it—often in ways that are difficult to anticipate (take vast libraries of AI training data, for example). Today, the protection of our identity and personal data relies on promises, often with the backing of legislation about how the owners of that data must store and share it.

Are these promises trustworthy? History has proven that once the genie is out of the bottle, it is very hard to stuff it back in. Bad actors may break these promises, but more often, users forego these rights, clicking them away in complex user agreements. Even with the very best of intentions, personal data is vulnerable to hacking or theft. Increasingly, users face zero-sum choices between disclosing personal information and benefiting from the systems and services that feed on them. Today, shielding one's data means cutting oneself off from services and platforms—a steep price to pay. We need something better—greater control and transparency over our personal data. Says author Karl Schroeder, "We should own our own information."¹⁹⁵

That's the idea behind the regulation underpinning Data Spaces, says Mike Milinkovich; systems of federated data in which data can aggregate—but only under specific, user-defined terms

and conditions.¹⁹⁶ An open protocol called Solid takes this a step further, with a technology option that literally puts users in control of their data via "decentralized data stores called Pods."¹⁹⁷ It's the right place to start, suggests Jesse Wright, a doctoral student at the University of Oxford: "This creates a much better online experience. By decoupling applications from user data, the Web can become user centric rather than company centric."¹⁹⁸ "As a user, I don't want to have to create a new login and re-enter the same personal details across every website I visit," so the principle of owning your own data is a natural way to enhance interoperability, says Wright. The "Solid and Semantic Web technologies provide solutions for many of these issues".¹⁹⁹

Equally important is the ability to transparently specify permissions related to our private data. "Some kind of additional information needs to come with the data," says Rui Zhao, formal descriptions of how it should or shouldn't be used, and what the obligations are.²⁰⁰ The sharing of data gives users explicit assurances about what will happen to it. Says Zhao, "We are generating new data, and we are sending data to others, and we are processing data. And it's no longer [about just] access control, it's more than access control, because we're talking about the rights or permissions of the new data."²⁰¹ "True self-sovereign identity and data portability" are becoming increasingly important, suggests Daniela Barbosa.²⁰² It's the idea that "I'm going to take the stuff I own and actually create better experiences for myself."²⁰³

Alone, this doesn't exactly solve the *double spend problem* for private data; we still rely on promises to protect it. But users gain formal explicit control over what those promises are, making data obligations far more transparent. Regulations give these obligations legal teeth to ensure compliance, but technology helps here, too. When aggregating data, for example, it can be difficult to ensure that individual data remains private.



"Differential privacy is one definition that is typically very strong," suggests Hart Montgomery, CTO of LF Decentralized Trust, and its application in the U.S. census is a well-known example.²⁰⁴ "Differential privacy is essentially a mathematical statement that says ... it's hard to tell whether you are [included] in a database or not; it effectively means that the database doesn't leak any of your personal information."²⁰⁵ Federated learning is another key enabler, allowing models to train on data even when it's not stored centrally. Instead, federated learning helps preserve data rights, allowing training data to be held by separate decentralized entities. In addition, we also have techniques such as zero-knowledge proofs that allow us to verify information about private data without having to share it. For example, a user may have a credential from a government agency, and it is demonstrable with zero knowledge that they possess properties related to that credential without having to directly disclose all its details. "As you might suspect," suggests Hart Montgomery, "this is extremely powerful for privacy."²⁰⁶

At the opposite end of the scale are techniques that help make data public—decentralized systems that, instead of focusing on privacy, can help ground content or data, creating a common point of reference. The provenance of shared information is critical, and it's important to access and verify sources of ground truth. Blockchain does this rather well, of course, and IPFS does, too. But Robin Berjon doesn't think of IPFS as merely a file system: "It's called the interplanetary file system, and it's neither interplanetary nor a file system."²⁰⁷ Says Berjon. "[What's] quite interesting about IPFS is that it's basically an architecture of protocols built around content addressing."²⁰⁸ That "shifts architectural power on the Web," says Berjon, because the server and its address is no longer a point of control.²⁰⁹ With IPFS, when you request content, the pointer to that content is the hash of the content itself. It bestows more power to clients at the edge; users don't need to "connect to the world to function."²¹⁰

What is a word worth? The word purple is worth \$40,000. At least, it was to Luke Farritor. Farritor decoded the word "purple" from a 2,000-year-old lump of charcoal using X-ray tomography, winning the Vesuvius Challenge's grand prize in the process.²¹¹ It's one of 1,800 carbonized lumps just like it, called the Herculaneum scrolls. All of these scrolls underwent instant carbonization in 79 AD when Mount Vesuvius erupted—and the buried scrolls weren't found until 1752. Because their significance was not known, many are thought to have been thrown out or lost. Others were damaged or destroyed in the attempts to read them: Some were cut in half, some disintegrated as they were unrolled, and the contents of some simply vanished when exposure to air faded any trace of the writing. Today, AI and 3D imaging are finally unlocking the centuries-old secrets hidden within each scroll. Ironically, carbonization itself helped preserve them—a regular scroll would be unlikely to survive the test of time.

Every word from such ancient documents is precious because the further we go back in time, the more scant our information becomes. Go further back than 2,000 years and provenance itself begins to break down. All that remains are gaps, contradictions, mysticism, broken clay tablets, and rubble. Even the existence of entire ancient libraries can remain a mystery. The library at Sarough (modern-day Iran), for example, may date as far back as 500 BCE.²¹² By one account, it once inspired awe similar to the Egyptian pyramids.²¹³ Yet today, the ruins at Sarough are scarcely more than a small hill. We only know of the existence of the library from passing mentions by 10th-century scholars who, in turn, reiterated others' reports of books discovered among the ruins in 350 AD.^{214 215}



Why is history so important? Because it tells us who we are and how we got here. It's the same for personal information. In a world rife with misinformation and distorted facts, the provenance of information matters. We need access to ground truth: sources of information and facts we can trust. It informs who we are and how we interact with others, like looking at ourselves in a mirror. Gauging the clarity and distortions of that mirror is important for an accurate picture. So it is with information.

Algorithms, too, can shift behavior to the edge. GitHub, for example, is a treasure trove of public behavioral data. Rodrigo Mendoza-Smith says Quira uses that data to "quantify developer reputation from the data they generate."²¹⁶ The goal, Mendoza-Smith says, is to create a market with perfect information: "We are building a market oracle that enables this market and gives people back ownership and control of their experience data."²¹⁷ Today's job market for software developers is far from that ideal; Mendoza-Smith calls interviews a "costly and lengthy process of talent validation."²¹⁸ Without this friction, everything changes; developers "can just jump into the market and then get the best economic opportunity for them right away."²¹⁹ None of this is possible if activity records are stuck in proprietary databases. That's why ownership of experience is so important.

Artificial intelligence adds another element to the mix. While artificial intelligence is normally thought of as orthogonal to privacy,²²⁰ it also affords new avenues for processing and sharing personal information. It's a possibility explored in a recent research paper, where generative AI language models use retrieval-augmented generation to access Solid Pods storing private documents.²²¹ The result combines the ease of

natural language retrieval with structured rules for information management. "New LLM technology is going to open up a lot of opportunities because more and more of our systems will be able to interact with [us] in natural language," says Tim Finin, Willard and Lillian Hackerman Chair in Engineering and Professor of Computer Science and Electrical Engineering at the University of Maryland, Baltimore County.²²² This offers a valuable complement to ontologies or structured knowledge graphs.²²³ Apple is another company making use of AI in the context of privacy (see the section starting on page 34). Suggests Killian Lucas, "The direction that Apple is going in with privacy is a great one. They are thinking about trying to have local models."²²⁴

"There's no reason why we can't have assistants that know us extremely well and act as liaisons. They act as mediators between ourselves and other entities, which could be companies, but it could also be other individuals," suggests Schroeder.²²⁵ Think of it as "an assistant that you own that can isolate your information."²²⁶ It's a compelling idea. For as long as humanity has held secrets, compartmentalization has been useful to manage them. Large organizations may break information up among silos, none of which has a full picture. Anthropic, for example, practices internal compartmentalization, describing how its platform provides access to sensitive or proprietary information and code on a need-to-know basis.²²⁷ Who makes the decisions about these compartments—and whether they are trustworthy—is an important question.

Unfortunately, conventional forms of compartmentalization are difficult in practice. On one hand, compartmentalization itself limits the benefits and insights possible with a bird's-eye view. On the other hand, managing compartments is onerous and difficult to scale because of labor-intensive processes such as cleaning data passed among compartments. Artificial intelligence affords new decentralized approaches for tackling both these problems—tackling the *double spend problem* for



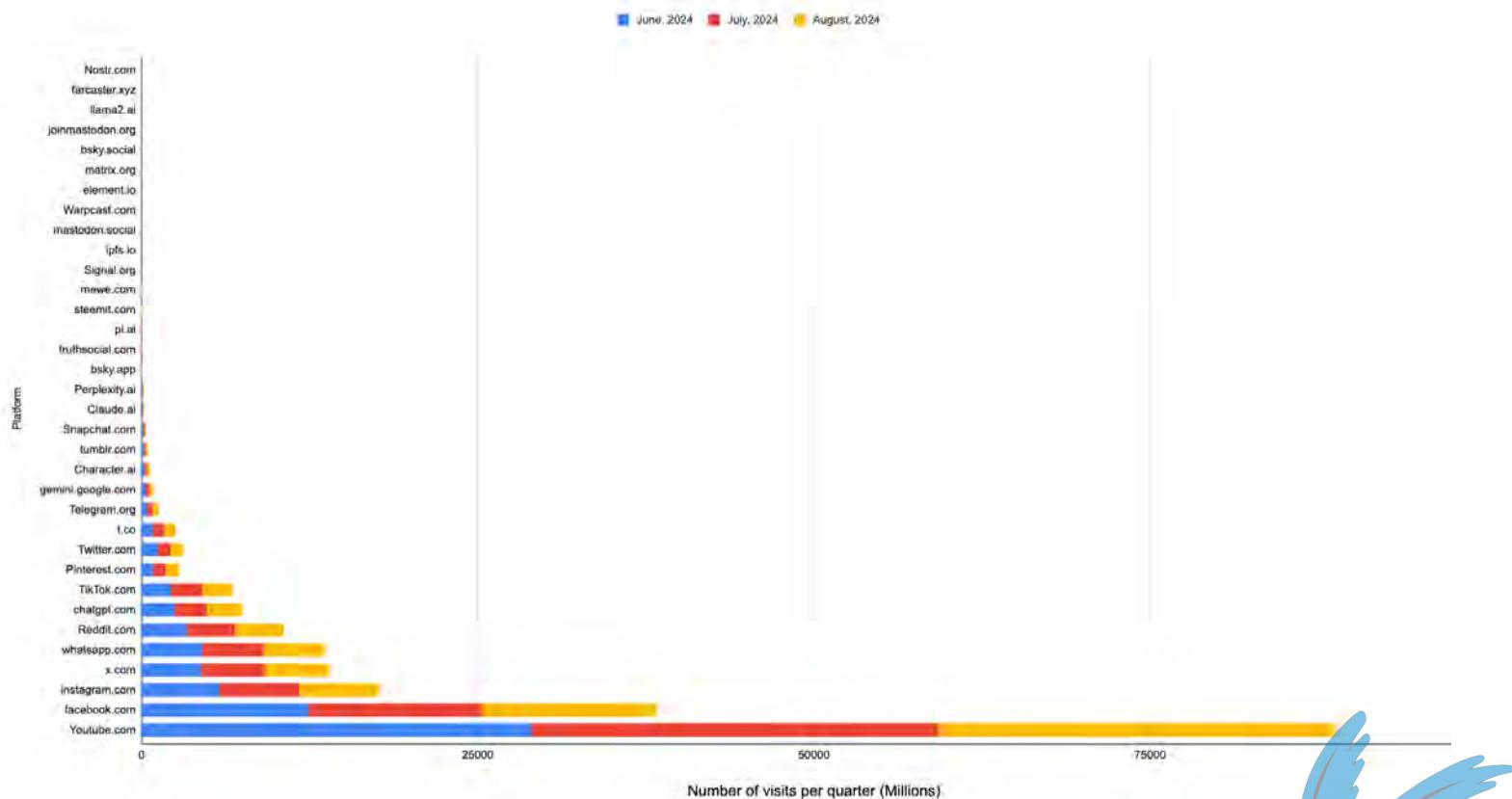
data head-on. AI agents represent a new, and potentially disruptive, opportunity in their own right, something Section 5 examines in more detail.

Winning with decentralization

Innovators have made tremendous progress in these domains, in many cases approaching parity with centralized platforms.

Decentralized platforms for private and secure messaging, social uses, and even payment applications are all within reach. But competition is stiff, and feature parity alone may not be enough. An installed base of billions of users creates significant network effects, and switching costs are high. Despite the rapid growth trajectories of new and emerging platforms, the bulk of them barely register against the traffic levels of incumbents (see Figure 5).

FIGURE 5: TRAFFIC DATA (WEB) BY PLATFORM FOR JUNE, JULY, AND AUGUST 2024.



Source: Author, compiled with data sourced from SimilarWeb²²⁸



Platform lock-in is no accident. One of the most desirable features of decentralized platforms is the portability of personal data and social graphs, the very thing these centralized platforms attempt to control at any cost. Users remain loyal to these platforms, not necessarily because of exceptional features or experiences (though many have these too) but because it's where others they know hang out; it's a community. That's a powerful barrier to entry that won't be lightly relinquished. New platforms need critical mass.

There are many approaches to obtaining critical mass. Here we'll consider just two, which we might label (1) *building a better mousetrap*²²⁹ and (2) *disruptive innovation*.

For many areas of application, blockchain and other key decentralized infrastructures are the "*better mousetrap*." Slowly and inevitably, assets and infrastructure are starting to migrate to a Web3 stack. Over time, the balance of power will shift as key use cases and applications make their way into the ecosystem. Blockchain and other decentralized technologies are making headway in some of the areas that matter most.

Security, for example, is an area where the underlying blockchain technology is extremely sound, says Hart Montgomery: "People should consider it mature."²³⁰ The ongoing safety of attractive targets (in this case, billions of dollars' worth of assets) is a really good way to judge security, suggests Hart Montgomery: "That's pretty good evidence that the technology is in good shape."²³¹

Blockchain is also becoming home to many other pieces of robust essential infrastructure, and even nation states are starting to take notice. Take identity for example: "We see a lot of people, including governments, use blockchain as the root of trust for distributed and decentralized identity."²³² Governments around the world—in Brazil, Hong Kong, and Singapore, for example—are exploring central bank digital currencies

(CBDCs). Suggests Daniela Barbosa, CBDCs are something fundamental "that every sovereign nation needs to figure out."²³³ Infrastructure changes can happen quickly. Take the India Stack, for example, "the moniker for a set of open APIs and digital public goods that aim to unlock the economic primitives of identity, data, and payments at population scale."²³⁴ Billions of people have already adopted the initiative, and it is now being offered to other countries around the world.

Even areas where gaps exist are receiving balanced attention by developers, communities, and early adopters—a must for grand technical undertakings:

- **Ease of use.** Blockchain technologies may not be easy to use, but "the early Internet was pretty awful, too."²³⁵ Imperfection creates plenty of room for improvement.
- **Infrastructure that's robust.** Mature infrastructure doesn't happen overnight. A robust infrastructure is very different from a proof of concept, says the Linux Foundation's Daniela Barbosa: "It takes a long time for these technologies to be adopted and for the technologies to be hardened and proven right."²³⁶
- **Secure.** "Security, even among devs, is a very niche pursuit," suggests Rebecca Rumbul of the Rust Foundation: "Historically, it was always kind of a bolt-on thing."²³⁷ Security gaps are finally gaining recognition, both within languages themselves and at every level of application development.

Enterprise adoption is also gathering steam. There's a lot of supply chain use cases in areas such as track-and-trace, for example, says Hart Montgomery: "We're seeing a big wave of adoption in finance."²³⁸ The outlines of an emerging *finternet* are beginning to manifest: "multiple financial ecosystems interconnected with each other ... a user-centric approach that lowers barriers between financial services and systems, thus promoting access for all."²³⁹



Tom Serres—Investor, Strategic Advisor, and Co-Founder of Warburg Serres—suggests that mainstream adoption is just a matter of time, because “network effect is stronger over here than it is over there.”²⁴⁰ “The lock-in to the network will be even more difficult to disrupt than the original Internet. “It’s not just sending and receiving data,” asserts Serres, “I’m actually tying my assets to this thing.”²⁴¹ “The lock-in of that network effect is just going to be that much more robust—and more difficult to displace—once it hits that escape velocity.”²⁴² Serres predicts that we can expect adoption to occur roughly twice as fast as the

Internet. By 2030, we will “have full proliferation and saturation of Web3 around the globe.”²⁴³

But what if we don’t want to wait till the end of the decade? Can disruptive innovation catalyze more immediate change? What extraordinary areas of opportunity promise to destabilize incumbent industries and platforms?

Artificial intelligence.



AI, agents, and algorithms catalyze new platform possibilities

“The hottest new programming language is English.”

—Andrej Karpathy²⁴⁴

Moshi is one of the lowest-latency conversational agents in the world (reacting in tens of milliseconds), capable of listening and speaking at the same time—so fast that it exhibits a tendency to interrupt and take over conversations.²⁴⁵ CTO Laurent Mazaré laughs, explaining that the latency (at a recent demo) was set as low as possible to showcase the speed and fluidity of conversations. “It’s probably not what you want [in real life], because an assistant should probably not interrupt you every two sentences.”²⁴⁶

Mazaré is part of a team of eight at Kyutai, a French nonprofit lab dedicated to open research in AI.²⁴⁷ How did this small team develop a world-class disruptive technology? “We reused lots of open source technology,” suggests Mazaré.²⁴⁸ That “allowed us to go very quickly.”²⁴⁹ Artificial intelligence itself also played a central role in accelerating development, both through the use of synthetically generated training data as well as the use of AI as a development productivity tool. “I would be a far worse coder if I

didn’t have access to the different AI models,” said Mazaré. “I use them a lot, and I find that they boost my productivity by quite some margin.”²⁵⁰ That’s a strong statement coming from a world-class developer who, in his “spare time,” developed Candle, a minimalist ML framework for Rust (a repository that has 15.1k GitHub stars).²⁵¹

Artificial intelligence is not only a source of new features and applications; it’s becoming a transformative platform in its own right.²⁵² Centralized players swim against that tide, reshaping artificial intelligence to conventional business models and platforms in an effort to cement centralization and dominance. Yet decentralized building blocks, AI, and algorithms also create fresh possibilities. New breeds of personalized autonomous agents put intelligence at the edge, affording us greater control over our data and the algorithms that govern interactions. Easy-to-use interfaces and on-the-fly code generation not only democratize powerful tools but also have far-reaching implications for platforms, software, and even open source itself.

The following sections take a look at both how conventional players are using AI and how AI catalyzes new and disruptive platform opportunities.



Artificial intelligence in today's centralized platforms: Apple

"It is not inherently evil to bring people back to your product ... It's capitalism."

—Chris Marcellino, former developer at Apple²⁵³

Tech giants and other large companies are expected to invest \$1 trillion in capital expenditures in the next few years, with Meta alone spending \$40 billion on AI infrastructure in 2024.^{254 255} Incumbents find themselves between a rock and a hard place. On one hand, disruptive changes threaten core business models. On the other, Wall Street is questioning whether the trillions invested in AI will ever pay off.²⁵⁶ Tech giants are responding in real time, adjusting offerings, altering business models, and making eye-watering investments in an effort to outspend and outperform peers. It shows few signs of abating. There are rumors of OpenAI attempting to secure another \$6.5 billion round of investment at a valuation of nearly \$150 billion (up \$50 billion from a week prior).²⁵⁷

While a closer look at the strategies of any number of tech giants would prove instructive, we'll instead focus on just one: Apple. The company has commandeered the very term "AI" in service of its own business model, purveying it to customers as Apple Intelligence.²⁵⁸ It's a field where Apple has been forced to play catchup.²⁵⁹ Siri, for example, has yet to match the Q&A performance of other smart assistants—one of the things that makes Apple's approach a little more interesting.²⁶⁰

Privacy and user experience are core to Apple's strategy. Its goal is a personalized contextual experience that keeps user

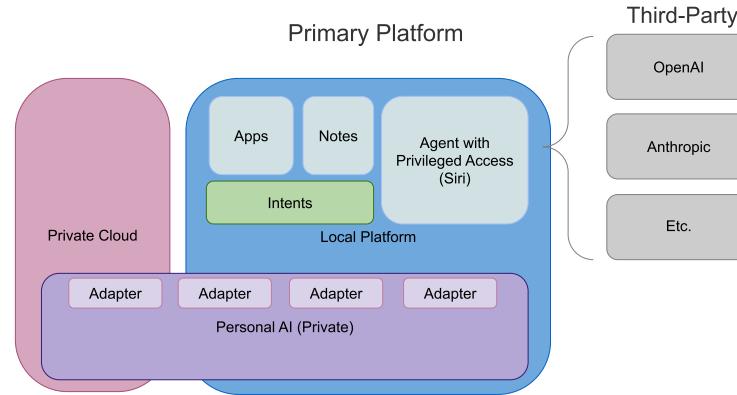
data private. That privacy comes through a mix of local LLMs, private data storage, and a secure auditable cloud, which Apple stated that even it can't access.²⁶¹ Queries undergo triage: simple requests can stay local while more complex queries are relayed to advanced LLMs in the cloud. Those with premium devices (such as Apple's latest 35 TOPS processor) will run more advanced models locally.²⁶² Apple intends to make the most local LLMs through what it calls adapters, "small neural network modules that can be plugged into various layers of the pre-trained model, to fine-tune our models for specific tasks."²⁶³ These adapters are tailored to experiential contexts: summarization, proofreading, mail replies, tone adjustment, refining, query handling, friendly, and urgency. The idea is that AI (with contextual knowledge) will streamline experiences.²⁶⁴ *Contextual knowledge* means that the AI "knows" what's on a user's screen and the actions available to it, including via other apps, so that it can gauge the user's intent and respond intelligently to queries.²⁶⁵ Attention to user experiences and safety has resulted in a carefully curated migration process that provides Apple Intelligence with deeper access to an app's capabilities.²⁶⁶ Christopher Nebel, an Apple engineer, describes how App Intents work:

*"They take the core features from inside your app, actions and content that are meaningful to someone using your app, and present them outside your app. To do that, you need to expose your app's core features in a way that the system can understand. App Intents is the framework to do that."*²⁶⁷

Figure 6 below offers a simplified view of Apple Intelligence; a more complete diagram is available in an explanatory video,²⁶⁸ and Apple has also published a detailed discussion of its foundational models.²⁶⁹



FIGURE 6: A SIMPLIFIED VIEW OF APPLE INTELLIGENCE.



Source: Author

Detailed personal data plus an intelligent agent (Siri) that can act upon it is a potent combination. Siri will receive privileged access to users, their apps, and their devices. OpenAI's Sam Altman professes wishing for a tailored AI with nearly unlimited access to personal data that "knows absolutely everything about my whole life, every email, every conversation I've ever had."²⁷⁰ Apple hasn't shared its road map, but such an assistant, were it to exist, would possess an unparalleled level of influence over its users. Today, user queries map to specific intents and actions that can summon and work with apps (or even third-party AIs) to help minimize "[friction](#)" and put AI in the driver's seat. In the long term, these advanced AI capabilities may deliver more of what users need on the fly—raising interesting questions about whether Apple itself might one day "forward integrate" into the domains that apps occupy on its platform today.

User interfaces are changing, too. Apple's Math Notes application ([link](#)) offers a sneak peek at the UI experiences that AI in the future might afford us.²⁷¹ Today, these features allow Apple to champion clear wins for user experiences and private data

protection. The challenge, of course, is that user experience and privacy *will improve*, but only for those *within* Apple's ecosystem. That will cement Apple's control over users and their data (and perhaps even the App Store itself) even further. User data may remain private, but without direct access and portability to other platforms, the data really belongs to Apple. This caters to privacy and regulations, says Robin Berjon, "but it doesn't change the power dynamic, which is the thing that matters."²⁷² Apple Intelligence strategically locks private data into its platform, then uses privileged contextual knowledge and advanced intelligence to contain the user experience. Platforms with these characteristics become digital gatekeepers, disintermediating basic experience.



True decentralization via reflective autonomous agents

"If we want to advance AI beyond its current capabilities—we want more than AI that can see and talk. We want AI that can do."

—Fei-Fei Li²⁷³

If artificial intelligence can further centralize today's dominant platforms, can it also do the opposite? How might decentralized AI systems create something fundamentally new and disruptive instead?

Decentralized AI agents are an exciting possibility. The idea of autonomous decentralized agents sounds well suited to blockchain—it's easy to imagine networks of AI agents orchestrated through smart contracts. Yet deterministic computing systems—blockchain or otherwise—are rigidly constrained. Overcoming those constraints requires a broader definition of "decentralization"—something beyond what blockchains *alone* offer. "That blockchain with the central ledger is trying to impose a unified perspective on the system," says Munindar Singh. "This puts a limit on what decentralization we can have because your perspective may be overwritten unless you are in control of the entire universe, i.e., the blockchain."²⁷⁴ "We have to go beyond our closed-loop thinking that we are accustomed to in computer science and technology generally," suggests Singh.²⁷⁵ True decentralization occurs in the real world where people use multiple systems, each with its own rules and structure. People choose the systems they use and the rules to abide by.

That's what truly autonomous decentralized agents look like; picking the systems they wish to use and the rules they choose to follow. There are always norms that give us acceptable paths, says Munindar Singh, but deviations are possible. Depending on the situation, some deviations may be desirable but not others.²⁷⁶ Those extra degrees of freedom are quite valuable, and in more rigid systems, it's why a human is kept in the loop. Says Amit Chopra, Associate Professor at Lancaster University, "Autonomy requires modeling systems at the social level, and that's where norms come in."²⁷⁷

"A social-technical system should be able to improve itself," says Singh.²⁷⁸ To do that, it must be possible to break the rules. "That's the heart of autonomy," suggests Singh, an agent that's "able to violate a contract."²⁷⁹ It's a significant departure from blockchain, but it's how self-organizing systems improve and get better. "People do that all the time."²⁸⁰ Changing a system and "showing one's work" is an essential practice in many self-organizing systems, whether it's a fact-checker making edits to Wikipedia or a developer making a commit after updating a line of code. However, it can apply to altering a system's rules as well. Choosing to violate an agreement might be as simple as missing an appointment when conflicting priorities arise, or it might have more serious consequences, such as if a disagreement leads to the forking of a project. Rigidity constrains our ability to innovate, adapt, and reach consensus, and that lack of flexibility has been a big part of what's been missing from conventional automation or from decentralized computing infrastructures. Rigidly designed systems running on structured code can't do this; they simply follow the rules.

To understand just how valuable rule-breaking can be, it's useful to revisit the Cold War, when tensions among superpowers ran high. In 1983, an early warning system detected a missile. Stanislav Petrov failed to follow orders to launch a retaliatory nuclear attack after the enemy launch was "detected."



Petrov's judgment (that the system was malfunctioning) was credited with preventing a full-scale nuclear war.²⁸¹ Systems without a human in the loop, operating in pure deterministic fashion, can put themselves at risk from these kinds of unanticipated consequences.²⁸² This inability to adapt is why some, including Marlinspike (see Section 4), say that centralized infrastructures are necessary.

Greater autonomy is the solution. While systems may have rules and norms, an autonomous agent "can do more than what the norm says. So the agent scope is larger than the norm scope," suggests Singh.²⁸³ Samuel Christie, an academic researcher from North Carolina State University, says, "An important aspect of the way that we look at agents and decentralization is that all interaction, state, and reasoning is local, so it's all held by the agents instead of the system, and that allows you to decentralize it and give those agents the autonomy that they need."²⁸⁴ This allows for new automation of systems without the constraints and baggage that automation tends to bring with it. It's the freedom from constraint that many centralized systems have been missing—a redistribution of power to the edge. Stafford Beer, an early proponent of such systems, suggests that "it is a prerequisite of viability that a system should develop maximum autonomy in its parts, where maximum is defined to mean 'short of threatening the integrity of the whole.'"²⁸⁵ It's easy to implement, too; some might call it a *simple rewilding*. We've never had an opportunity to build automated agents like this before—because, until recently, those capabilities didn't exist.

Today, we're seeing the advent of large action models (LAMs)—AI models that are also capable of actions (such as browsing the Web or writing code). So far, proprietary hardware-based versions of the concept ([Rabbit](#) and [AI Pin](#)) have proved somewhat disappointing. It remains to be seen whether AI [Friend](#) will experience the same fate. LAMs can interact with digital systems or even act directly upon the world itself, almost as a quasi-assistant or -advisor. The idea of AI systems interacting directly with the world isn't new to the likes of Tesla (automobiles) or 1x (robots), which are already using neural networks for end-to-end control. But it's an interesting idea for other kinds of platforms—the billions of edge devices we use every day.

Autonomous agents—agents that are open, have access to platforms and resources (not necessarily "stranded" on one), reflect upon their own actions,²⁸⁶ and can organize with one another—are a potent and disruptive recipe. It opens new architecture possibilities (see Figure 7) that are a sharp departure from AI on centralized proprietary platforms. As these agents get smarter, they're increasingly able to plan ahead and even think through their actions via hidden chain-of-thought reasoning. Greater agency resolves the timeless dilemma facing designers of decentralized systems—how to create something open and decentralized yet flexible enough to adapt to a world that's constantly changing. Autonomy at the edge allows us to finally cut this Gordian knot.

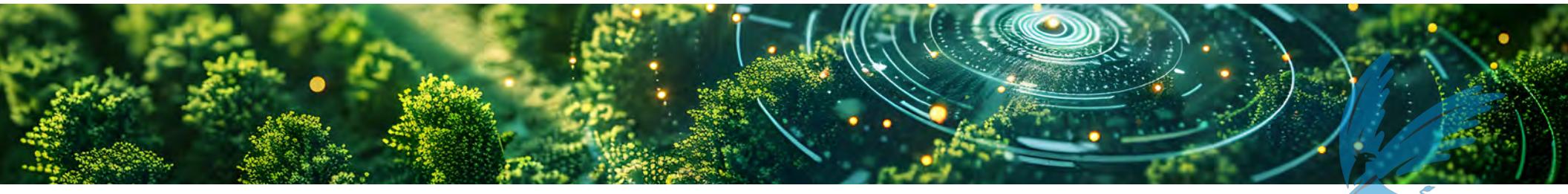
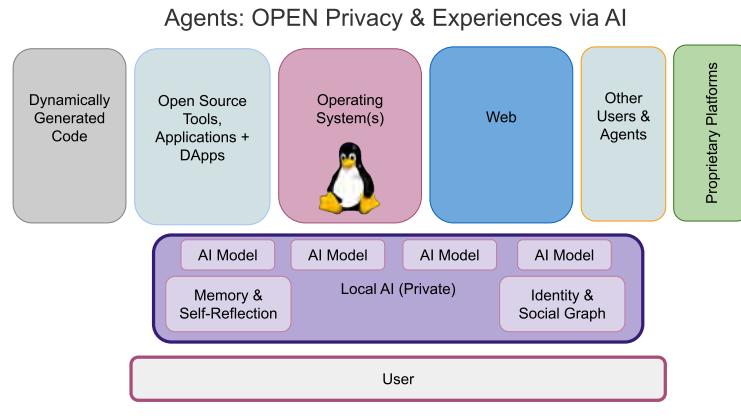


FIGURE 7: ONE POSSIBLE MODEL FOR USER-CENTRIC AI AGENTS AT THE EDGE.



Source: Author

Two very interesting open source examples highlight what emerging edge-based autonomy might look like: [Open Interpreter](#) and [Agent Zero](#).

Open Interpreter

[Open Interpreter](#) is an AI that has direct access to your laptop and uses code (via an LLM interpreter) in order to operate it. It's more open than Rabbit²⁸⁷ and allows you to specify an interpreter and, of course, operate locally with local compute resources. Think of it as a language model computer interface, Killian Lucas, the founder of Open Interpreter, suggests. It's "an intermediary layer between you and the operating system."²⁸⁸ In the same way that Apple and Microsoft imbue their systems with AI, an LLM interpreter is a very powerful way to do the same thing for Linux. And it has two key advantages:

- First, a voice AI offers an easy and incredibly intuitive user interface. It's a fantastic way to control a desktop or laptop (or any edge device) and a natural way to bring the power of open

source tools to mainstream (nontechnical) audiences. It can lift the constraints of today's user interfaces, too, so "you don't have to go through any layers of abstraction."²⁸⁹ In the future, perhaps we'll modify things the way we imagine them in our head, suggests Lucas, "much more like drawing on a piece of paper."²⁹⁰

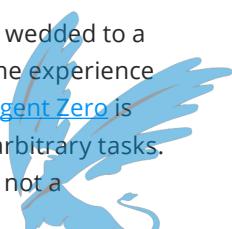
- Second, unlike Apple (or Microsoft), which might place limits or controls on operations within a "walled garden" OS, those using an AI interpreter on their machine face no restrictions. That means fewer rails of protection when things go wrong, but it also means rapid, unconstrained innovation. These are "tools that let you, as an individual, have power and control. Software has not been that."²⁹¹ "We are building incredible tools that amplify the natural abilities of humans ... this is another chapter in computing history," suggests Lucas.

Agent-based tools and interfaces hold the promise to transform what an OS is and the purpose it ought to serve. A lot of effort goes into making code and applications accessible by humans, a process that's historically been difficult. "AI is the advent of personal software," allowing us direct and tailored access, not only to an entire universe of open source software but to any digital experience we desire.²⁹²

Intelligent agents turbocharge the world of open source, putting a friendlier face on operating systems and providing a simple gateway to the power of an entire universe of open source applications. Says Lucas, "You can totally rethink what an operating system is, and that's absolutely what we want to do."²⁹³

Agent Zero

Unlike Open Interpreter, Agent Zero is slightly less wedded to a particular platform. It's not designed to mediate the experience of one's desktop computer or any other system. [Agent Zero](#) is an autonomous agent, a simple AI that performs arbitrary tasks. According to its GitHub description, "Agent Zero is not a



predefined agentic framework. It is designed to be dynamic, organically growing, and learning as you use it.”²⁹⁴ Jan Tomášek came up with the idea for Agent Zero as an alternative to setting up systems of specialized static agents. Instead, wondered Jan Tomášek, why not allow agents to break up projects into smaller specialized tasks (something AIs are particularly good at)? Tomášek prototyped a system that allowed agents to summon more agents (recursively as needed): “I started experimenting with this, and it worked.”²⁹⁵ Each agent acts as a quasi-atomic primitive, breaking larger tasks into smaller chunks and then summoning other sub-agents to perform them. “That’s the moment where I saw that it had great potential, because AI is very good at writing code, and it’s also very good at analyzing errors,” suggests Tomášek. If you execute code then feed the result back to the AI (along with self-reflections), “it can fix like 90% of the errors.”²⁹⁶

The priority is to make Agent Zero as flexible and useful as possible, allowing it to improve itself over time yet still benefit from more-capable versions of AI in the future. “I wanted it all to be customizable,” suggests Tomášek, making it easy for people to modify it as needed and explore its full potential. This flexibility means people are testing all kinds of use cases with it, from running an RPG to rendering geometric shapes in 3D. Agent Zero represents a highly autonomous agent, one that can operate across different centralized *and* decentralized systems and applications. Instead of specifying how to do a given task, these agents are autonomous, self-organizing their activities in the manner of their choosing. Are these the *droids we’re looking for?*

Like many AI agents, Agent Zero has its moments, sometimes acting the role of a “genius engineer” and at other times a “foolish child.” However, with the right amount of coaxing, some of its capabilities are astonishing. Yes, it can install an

Ethereum wallet and access the private key; even installing a Matrix client proves to be within its capabilities.²⁹⁷ It has a vast set of capabilities at its disposal, says Tomášek: “Python and Node.js and Debian Linux—those are probably the three biggest repositories of open source software on the Web. So, if it can use all of these three, it can do almost anything with a virtual computer.”²⁹⁸ With further improvement, Agent Zero’s capabilities will only grow. Areas Tomášek would like to see improvements in include:

- **Usability:** Today, novices still find Agent Zero difficult to install and use. A graphical application and installer will make it more accessible to non-programmers.
- **Memory:** Improvements to the memory and knowledge tools that require frequent manual intervention are necessary. In future, relevant information pertaining to a task should be summoned automatically, and agents should learn from past successes and failures. New research suggests that “Agent Workflow Memory” may allow agents to adapt and improve their performance over time.²⁹⁹ In the future, perhaps Agent Zero will also rewrite its own code (nearly 80% of which is AI generated anyway).³⁰⁰
- **Prompts:** Prompts were designed to be transparent and easily modified. Says Tomášek, “more than half of the potential of the framework lies in the prompt and not in the code itself.”³⁰¹ To date, much of this potential remains unexplored, as most users stick with the default prompts.
- **Networking:** While Agent Zero is currently confined to the resources of its Docker container (and the sub-agents spawned there), it lends itself easily to stitching with others of its kind in a network. In fact, Tomášek has already announced plans for an API endpoint, meaning “the framework can run in [the] background and be called via API from other applications.”³⁰²



What's next for Agent Zero? The project started as open, and it's important to keep it that way, suggests Tomášek. "Agent Zero itself should remain free for everyone."³⁰³ He sees the project as an open source counterweight to companies with large proprietary LLMs. There are currently no commercial plans, and Tomášek does not feel the need to "own" or micromanage the project, either. Rather, he seeks more experienced developers who can get involved to help the project grow: "I would like to hand this project over to the community if there are more, and better, developers."³⁰⁴

Autonomous agents and our rewilded future

Platforms composed of such agents break down fundamental instincts about platforms. The Web and all its content is a platform, a commons that all can benefit from. Yet now, in a world of limitless content (and even code) generation, people must organize around something new. Artificial intelligence is at the heart of this disruption, but perhaps it's also the cure. AIs such as Agent Zero and Open Interpreter have only recently become feasible—the technology to create truly autonomous agents has finally hit a tipping point. They break down platform conventions, giving us new edge-based building blocks.

Are we right to think about next-generation open platforms as atomic "AI agent" primitives? Many technical systems consist of "primitives," whether it's the AND, OR, XOR, NOT, NAND, NOR, and XNOR gates in silicon; odd languages such as LISP (composed of atomic CAR and CDR operations); or even the highly controversial idea that the universe itself might consist of computational automata (as Stephen Wolfram suggests).³⁰⁵ Modular microservices, or even SuperApps themselves, embrace similar philosophies.

What if we could assemble these AI primitives together into services, applications, user interfaces, or even larger AI entities? If anyone can set up open sets of networked AI primitives,

we could create a vast set of open, decentralized cognitive structures all capable of interfacing with one another in emergent ways. It suggests a completely new kind of platform—an "intention" economy, where combinations of agents and users have a hand in directing the result. In the same way that individuals self-organize into emergent structures—cities, companies, and societies—we're on the cusp of a new type of platform composed of agents that organize into emergent structures. It's a true decentralization that regains control at the edges. One might even call it a *rewilding* of sorts, a chance to remake the Internet and retake the openness that's been lost.

Today's technologies create new possibilities for an autonomous, decentralized future. The seeds have been planted, and something unique and different is already starting to grow. What might emerge from this fertile *wild* new ground? It's the million-dollar question, suggests Tomášek: "Nobody knows where a project like this is headed yet."³⁰⁶ But those who wish to help build it can do so.



Conclusion: At a crossroads

“Imagine that each and every human on the planet has their own programmer.”

—Eric Schmidt³⁰⁷

Today, we face pivotal choices with monumental consequences. New technologies—artificial intelligence, in particular—are more potent than anything humanity has encountered. We already see tectonic shifts in today’s dominant platforms and an epic struggle for dominance by those who would unseat them. The stakes have never been higher, and the pace of change is beginning to exceed humans’ ability to assimilate it. Decisions we all make in the next year or two will largely determine humanity’s future.

So, let’s make explicit choices about the kind of future we want. Let’s challenge those who lead discussions about the existential threat of AI as a means of centralizing its control. Might greater levels of sentience be a solution rather than a problem? We need not go quietly into a techno-deterministic future. We must make our preferences and values known. Do not sit back and cede key decisions on societal values, alignment, or safety to today’s tech giants. Opting out of our responsibilities hasn’t worked out well; we’re still reeling from the impact of the attention economy on society and individuals.

Instead, we must—individually and collectively—take our fate into our own hands and decide the future we want. First, we must recognize that we can determine our future through a series of choices about which technologies to use, when and where to make our voices heard, and what to build. Second, it’s

important that AI itself remains open. That means ensuring the existence of world-class open models accessible to all. Third, we must remember that AI and algorithms are expressions of values that are inherently malleable and subjective. Therefore, safety and alignment efforts represent deliberate choices that must be transparent. Significant AI infrastructure (including military) must be held accountable to the public.³⁰⁸ Fourth, we need the right to our own data, identities, credentials, and social graphs. That includes protected use of automated agents (acting directly on our behalf) to retrieve and assert control of our identity-related assets on social and other platforms. Last, we need to think carefully about the rights we have with respect to algorithms. Should we be able to turn these algorithms off? Might we have the right to tailor them to our needs, swap them out, or even substitute them for our own? We don’t need to operate our own infrastructures, systems, or algorithms—but having the choice to do so makes all the difference in the world. Decentralized technologies put power back into our hands.

Today, we see the outlines of what our future could be and how technology could serve society instead of the other way around. We’ve never tried algorithms optimized for *us* to increase our collective intelligence, improve the *way we are* with one another, harden our immune system against things that don’t match our values, anchor our knowledge in facts, and enhance our ability to innovate and coexist in harmony with new forms of intelligence.³⁰⁹ Power also comes with responsibility. That requires a broader understanding of sentience itself and the rights accorded to it. We can optimize for this, if we want it badly enough, and use these increasingly potent tools to forge a better world together.



But the technologies must be in our hands, decentralized from the start. Those with power don't give it up lightly, and, right now, it lies at the center, not at the edge. It doesn't have to be like that. Open source proves it—so does the Internet itself—we just need to rewild them. Autonomous agents can automate and self-organize at the edge in ways we haven't seen before. We have a chance to bootstrap something new—organize society itself with mixtures of human and automated forms of intelligence: new

and better recipes for decisions, consensus mechanisms, forms of collective wisdom, and even scientific discovery. With the right technologies in our hands, we will find the recipe for a new kind of Internet, the one that should have always been ours in the first place.

Where will you start?





Methodology

This investigation involved primary research interviews, secondary research, and extensive review, feedback, and consultation both from members of the research team and from outside stakeholders. The Linux Foundation conducted research work between March and October 2024 with sponsorship of Futurewei.

About the author

Alan Majer is the founder of Good Robot. For the first half of his career, Alan worked as a technology researcher and writer, helping to identify cutting-edge technology and business innovations. Today, Alan works with technology hands on, exploring the potential of artificial intelligence, robotics, and immersive experiences. The result is exciting new opportunities to innovate and transform user experiences and the ability to combine strategy and research activities with a real-world approach to their implementation. Alan is an active member of the local “maker” scene, enjoys collecting old books and vintage technology, and holds an MBA from McGill University.

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308 For example, it's troubling that the E.U. AI Act designed for AI safety specifically excludes military uses from scope: "However, AI systems placed on the market, put into service, or used by public and private entities for military, defence or national security purposes, are excluded from the scope."

309 Stafford Beer's short-lived experiment to use computers as part of governance in Chile's Project Cybersyn is worth a mention. *The New Yorker* has a fascinating article on the project: <https://www.newyorker.com/magazine/2014/10/13/planning-machine>. Stafford Beer has also outlined his thinking on control theory in works such as "Brain of the Firm," an archive which can be found here: <https://archive.org/details/brain-of-the-firm-reclaimed-v-1/>.





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