



Looking Glass

Bringing tech-led business
changes into focus

Introduction	3
Platforms as products Delivering value through customer focus	4
Hostile tech Confronting challenges in security, ethics and privacy	9
Partnering with AI Making machine intelligence mainstream	15
Making the metaverse Exploring the frontiers of digital interaction	20
Evaluating Web3 Navigating the internet's possible futures	25
Accelerating sustainability Responding to the climate crisis with technology	32
Glossary	37



Introduction

For many businesses around the world, keeping up with technology can be a significant challenge given the rapid pace of change in the industry. That's why Thoughtworks created the Looking Glass — it's designed to help businesses navigate industry shifts and identify new opportunities.

As a digital transformation consultancy, staying ahead of technology trends is a fundamental part of the work we do. It allows us to help clients unlock strategic advantages and remain one step ahead of their competition. Thoughtworks' global network of consultants and clients not only provides us with a broad picture of what's coming, it also helps us dig into the details of how soon and what the impacts are likely to be. In this report we share our insights to help businesses transform through leading-edge technology.

Key trends to help you explore technology's impact

The Looking Glass is built around six "lenses." Each one reveals a major industry storyline, along with dozens of underlying technology trends which drive changes in business. The lenses help you focus on what specific technologies could mean for your enterprise and how you need to react.

- **Platforms as products: Delivering value through customer focus.** To be truly effective and transformative, platforms must be designed and delivered with a relentless commitment to end-user value.
- **Hostile tech: Confronting challenges in security, ethics and privacy.** Successful innovation requires a strong commitment to mitigating the potential risks of new technologies.
- **Partnering with AI: Making machine intelligence mainstream.** Businesses must consider where and how to embed machine learning capabilities, ensuring a tangible impact.
- **Making the metaverse: Exploring the frontiers of digital interaction.** Emerging technologies, such as extended and augmented reality, are enabling new forms of connection inside organizations and across the wider economy.
- **Evaluating Web3: Navigating the internet's possible futures.** The future of the internet is still taking shape; leaders must make smart and informed choices about their participation.
- **Accelerating sustainability: Responding to the climate crisis with technology.** Technology is not only an important area for sustainable transformation, but it can also help drive it.

In each lens, we present opportunities for implementing technology in your business and signals to gauge how fast something is approaching. We categorize each of the 100+ trends in two dimensions: the prevalence across enterprises — **seeing now, beginning to see, or on the horizon** — and our recommended strategic response — **adopt, analyze, or anticipate**.

This report will help you to identify the most important trends impacting your business today and in the future. In times of economic uncertainty, it's critical that you make informed decisions about how to act and what to prioritize. Doing so will position you to emerge stronger on the other side.



Platforms as products

Delivering value through customer focus

As more organizations migrate to the cloud and seize the opportunity to build their own customized platforms on top of cloud infrastructure, different stages of platform performance or fluency are becoming clearer.

As we noted last year, determining what kind of platform is fit for purpose and defining the value you expect it to deliver, are critical initial steps. But then comes the drive to get the most out of your investments and maximize the value platforms provide — to do this, understanding the platform as a product is essential.

Many of the disappointments that organizations experience with platforms stem from the failure to treat them as products. For example, many platforms intended for developer infrastructure lack the initial research into user needs and contextual analysis we've come to expect in other types of products. This leads to problems with user experience and adoption, and can ultimately even drive developers to take their sought-after skills elsewhere.

The challenge can be addressed by seeing platforms as products that have customers who must be won over, with a value proposition, a clear roadmap and dedicated resources to help those customers create value for the organization. Like any good product, a platform needs ongoing attention, and to evolve and adapt in response to developer feedback and the changing business landscape.

Signals include

- The rise of Backstage and other **platforms emphasizing developer experience**, which can play a powerful role in engaging and retaining tech talent
- **Industry luminaries** and **vendors talking about engineering-focused platforms**, which shows the view of developers as platform 'customers' is entering the mainstream
- There is a move beyond data lakes towards **federated data stores and data products**, allowing a division of responsibility and smooth flow of value across an organization. The popularity of data mesh demonstrates the value of this approach
- Team Topologies, an increasingly popular approach to structuring business and technology teams for peak efficiency, **highlighting the need for platform teams to offer platforms as an internal product** to enable and accelerate other teams

The opportunities



Empower developers, data scientists and others to deliver exceptional value. Platforms with a product mindset provide fundamental building blocks so that a ‘higher’ level team can spend less time on ‘lower’ level concerns, such as infrastructure, and instead focus on delivering what matters to their customers and the business.

The value being delivered may differ depending on the type of platform (see table below for examples). It may be direct or indirect, and the latter may not always be apparent or appreciated by the business — such as a platform replacing an old system that performs the same functions in a more resilient, adaptable way. But even indirect value can ultimately be linked directly to positive business outcomes.

Type of platform	Customer	Value proposition
Developer-focused infrastructure platform	Internal development teams	<ul style="list-style-type: none"> • Enable teams to spend more time on delivering business value • Guardrails for security & compliance • Ease of deployment
Data science and ML platforms	Data practitioners	<ul style="list-style-type: none"> • Find, access and understand data • Ability to experiment, analyze • Train and deploy models
Business capability platform	‘Line of business’ teams providing value to external or downstream customers	<ul style="list-style-type: none"> • Easily access capabilities through APIs • Quickly remix existing services to create new customer value



Good platforms **can also offer value to consumers** and **democratize access to data**, but with problem- or use-case specific acceleration. A bank might create one platform with strong compliance and security characteristics, and another amenable to fast experimentation.



Critically in a highly competitive market for talent, **effective platforms can be a key differentiator and a way to attract and retain skilled technologists**. It’s no exaggeration to say that ML experts, in particular, can work just about wherever they like. They will inevitably gravitate towards organizations where they’re not wrestling with infrastructure problems, but using platforms that provide a foundation to apply their skills to meaningful projects.





What we've seen

The HSE24 Group located in Germany, Austria, Switzerland and Russia, initially launched on TV in 1995. Since then, HSE24 has evolved from being a primarily television-based business into an omnichannel retailer, present on four TV stations and further digital channels, including an online shop, a shopping app and social media.

HSE24 partnered with Thoughtworks to expand their digital platform into an engagement platform. The journey included replacing the old shop system and with it, decreasing technical complexity, increasing resiliency, and shortening the development process.

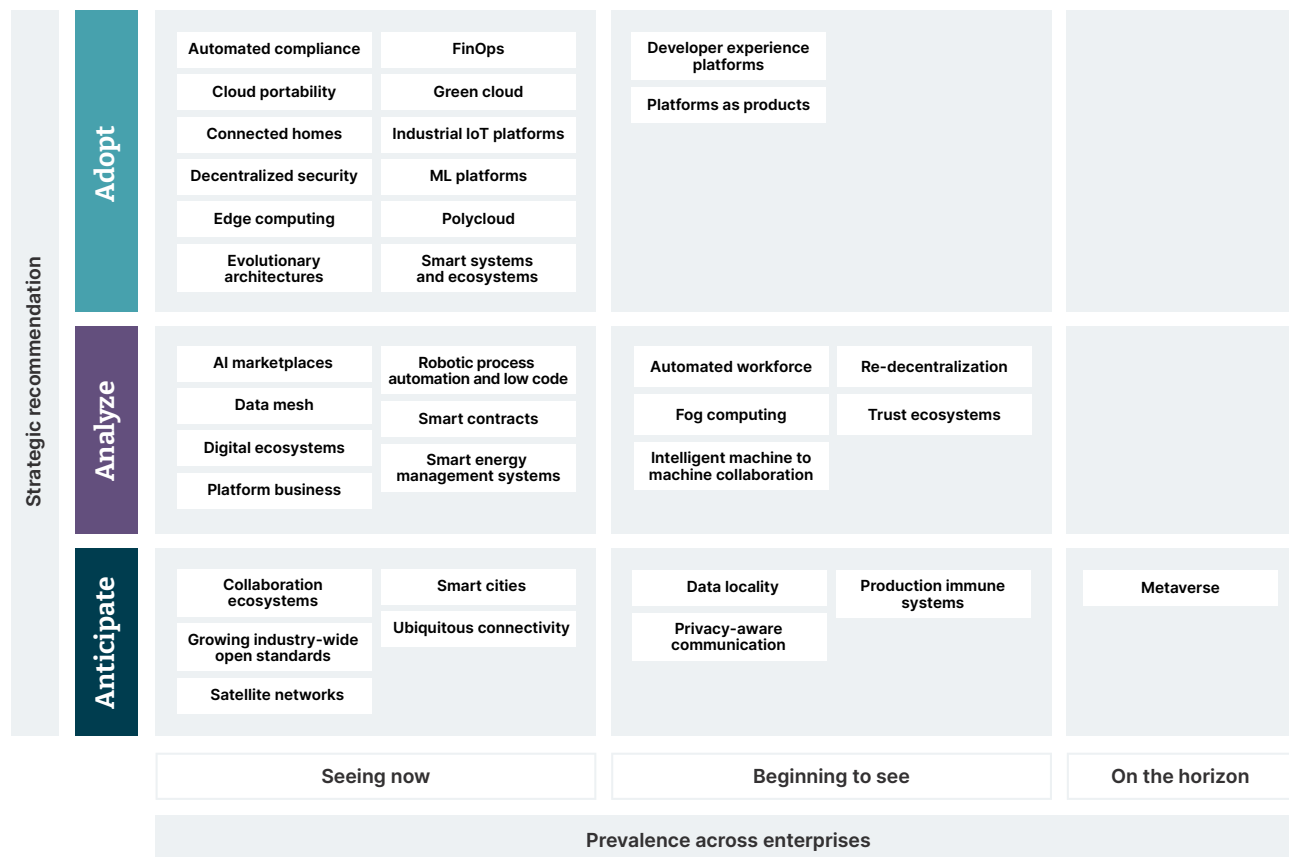
With this new platform and process, features are rolled out to customers in a manner that is staggered and prioritized according to what will be most valuable to customers. Teams first release a microsite with minimal features to a small test audience via a targeted social media campaign. Subsequently, this is rolled out to a wider audience, while the impact on the KPIs — such as customer-feedback or floor sales — is monitored. Finally, this full feature set can be pushed to all customers.



“Platform investments must be linked to tangible business value, and then measured. Indirect value such as speed to market or the ability to innovate can be as important as delivering new products, increasing revenue and decreasing costs. You should pursue and measure both direct and indirect value.”

Rachel Laycock
Global Managing Director - Enterprise Modernization,
Platforms and Cloud, Thoughtworks

Trends to watch



Adopt: Developer experience platforms

In our experience, what developers want — above all else — from their employers is the ability, freedom and empowerment to do the best job, in the smoothest and most logical way. And at its heart, that's what developer experience (DX) is concerned with. DX platforms provide tooling to make it as easy as possible for developers to create, test and deploy software, collaborate with their peers and build upon common services to quickly add value.

Analyze: Re-decentralization

The adoption of public cloud services such as Amazon Web Services, Google Cloud and Microsoft Azure represent a move to centralized systems. While they appear to be decentralized — disparate teams and organizations use and control their own portions of the cloud — the underlying infrastructure is often shared. As a response, companies are considering strategies that spread risk across multiple providers, availability zones or regions.

Anticipate: Ubiquitous connectivity

Edge and on-device computing will bring experiences even closer to the end user, while 5G and satellite internet bring data to more places across the planet. This opens up opportunities to process massive quantities of data cheaply, improve privacy, reduce cloud costs and shorten response times to create unique experiences for customers.

Advice for adopters



Treat platforms as products and staff your teams with the right skill sets. Product management is a skill that is a culmination of experience and education, not something that anyone can just pick up. Do not expect this to come for free just because you have skilled infrastructure specialists.



Be clear about the 'core mission' of people building platforms, and of their users. Platform builders should focus on making it faster for consumers of the platform to create business value. Ensure that business platform teams themselves are also using underlying cloud capabilities to create platforms quickly where possible.



Invest in internal marketing of platforms and APIs. At one of our large energy clients, teams doggedly did 14 months of promotion on what they had built with little apparent traction, then suddenly found they had 25 teams building on their API. Those teams saved upwards of US\$5 million by not building APIs from scratch.



Embrace having multiple platforms. Especially given computing trends, this is to be expected, because each platform will have different characteristics and cater to different sets of customers. As long as it remains under control, a certain amount of duplication may be desirable as it can foster competition and force platform teams to be more attuned to their customers. Platforms should be a 'paved road' rather than mandatory. Make it so teams want to use a platform, not that they have to.



Ensure platform product owners can articulate the value in terms of business outcomes. Platforms are not short-term cost savers, but they are accelerators; this means they need to provide demonstrable long-term ROI.



Measure platform success. You can't manage what you can't measure, and measurement is the only real way to confirm value is being created and delivered. Success metrics will differ depending on the platform goal but are likely to include:

- adoption (number of customers, consumption by customer, consumption by product)
- service (issues raised, time to close issues)
- customer satisfaction (NPS, customer feedback)
- performance (uptime, throughput, response time)
- delivery efficiency (velocity, cycle time, roadmap delivery)



Adopt FinOps principles. Associate cloud costs with the products and teams generating customer value, rather than burying them inside a platform or infrastructure organization. Focus on unit economics so that you can optimize your spend for impact.



Budget to run it, not just build it. For a successful platform, the first release is the first draft. You should anticipate needing new features, for instance, as adoption increases or as cloud platforms release new services. Increasing scale will demand feats of engineering that the platform's users will never notice (hopefully). Active and thoughtful maintenance will be required to keep your platform functioning as a value multiplier.



Hostile tech

Confronting challenges in security, ethics and privacy

As we noted in last year's *Looking Glass*, technology's rapid advance has been accompanied by negative impacts, whether deliberate or unintended. 'Hostile' technology continues to manifest in multiple ways, including bias in AI, addictive technology and certain synthetic media. This year we are focusing on threats to security and consumer privacy, because we see those threats — and the subsequent response — ramping up in the year ahead.

Balancing evolving regulations, changing expectations, the need to get closer to consumers and simply doing the right thing will be critical to remaining competitive and fostering customer loyalty. The speed at which regulation is changing means it won't always be realistic to keep up — our data privacy specialists use an automated service to keep up to date, and, operating in 18 countries, get an email detailing adjustments nearly every day.

What's more, simply complying with regulation won't always fix the problem. Standards like the European Union's (EU) General Data Protection Regulation (GDPR) mean that consumers are warned about the privacy implications of websites or applications, and invited to 'opt in' or 'accept' as a matter of course — yet few would claim to actually understand what they're signing up for. The way things are developing means that rather than reactive measures, enterprises should proactively create ethical frameworks to guide the use of technology and data. These can create a firm baseline of respect and security for their customers and minimize the chances of consumer or societal harm.

In the short time since publishing this edition of *Looking Glass*, tools like ChatGPT have taken the world by storm. While full of promise, we believe organizations should approach with caution. The outputs tend to be trusted or accepted at face value, but in fact they are often incorrect or include 'hallucinated' answers that seem plausible but are actually made up. For more information about our views into balance between this new experiment and responsible technology see this interview with our CTO, Rebecca Parsons: [Society urged to hold companies to account on tech use](#).

Rather than reactive measures, enterprises should proactively create ethical frameworks to guide the use of technology and data.



Signals include

- **Debate around the concept of 'informed consent.'** While virtually all companies now offer consumers the chance to agree to terms and conditions with privacy implications, whether that agreement is genuine is an open question. The New York Times pointed out that understanding standard privacy policies and terms — which can be up to 20,000 words long — requires far more time than the average consumer is likely to have. The result is that consumers are often left unaware of the extent of the data collected about them, while companies are collecting more data than they really need, or storing it for longer than is reasonable. In some cases, this behavior ventures into the illegal.
- **An extended wave of privacy regulation and enforcement.** Companies like Google are facing punitive action and being forced to change their practices with the EU's 'cookie law' coming into effect. In the US, a number of data privacy regulations are emerging at the state level, with the California Consumer Privacy Act (CCPA) and Virginia's Consumer Data Protection Act (CDPA) to be followed next year by the Colorado Privacy Act and Utah Consumer Privacy Act.
- **Privacy concerns changing marketing and business models.** Companies like Apple have positioned themselves as staunch defenders of data privacy, enabling consumers to declare a screeching halt to the sharing of information and taking steps to protect users from targeted spyware. This is making it harder for companies to directly track users — roughly 70–80% of Apple users have opted out of tracking for apps they use, which has in turn hit revenues from advertising that relied on this information.
- **More companies putting physical marketing back into their strategies,** possibly as a result of having less specific data about customers. Amazon, Bass Pro Shops, and others are direct-mailing physical catalogs and advertising to customers, complete with embedded QR codes.
- **The rising discovery of, and trade in, 'zero-day' vulnerabilities** — previously unknown flaws in software or systems that leave organizations open to data theft or manipulation. The marketplace for zero-day problems is developing rapidly, with the emergence of brokers who engineer deals between those who identify them and the companies impacted (often the likes of Google or Microsoft), governments, or, less happily, criminal or other bad actors, all of which are often prepared to pay a high price for this knowledge. On the one hand it's encouraging that more of these issues are being flagged; on the other, risks could rise as the entire marketplace becomes more lucrative.
- **Higher risks of cyber attacks** with Russia's war on Ukraine increasing both state-sponsored and volunteer cyber-warfare. The US government has explicitly warned that the victims of these attacks could include 'regular' businesses (and by extension their customers) as well as 'legitimate' military targets.



The opportunities



Enhancing security to protect the bottom line. Target incurred more than \$200 million in costs related to a breach of credit card numbers and personal information. The average cost of a data breach continues to mount, now topping \$9 million in the US according to IBM, underlining the urgency of developing and investing in a comprehensive security strategy that's based not just on technology, but culture. Similarly, strong, transparent standards and ethical data practices can help organizations avoid the hefty fines being handed out by regulators, which spiked sevenfold to \$1.2 billion in 2021 for the GDPR alone.



Beyond the money, solid data protection and security practices help companies **avoid lasting brand damage**. Consider the online backlash to recent changes to Samsung's privacy policies. The actual motivations became almost moot, demonstrating that even just a perceived invasion of privacy can have a negative impact on brand reputation. On the other hand, companies like Apple and now Google are benefiting by presenting themselves as privacy and security champions.



Healthier and more open customer relationships. There's emerging evidence that consumers will be more inclined to share information with companies that are seen as stewards or examples of good data governance. Research has pointed to the number of users opting into app tracking growing since Apple made this a choice. The organizations that do the most to convince consumers they respect privacy and are taking proactive steps to protect customer data will very likely be entrusted with more of that data to use as a basis for developing insights.



A "privacy-first" stance can help brands win business against their laggard competitors. Research shows that consumers want strong privacy protections and as a result, some of the world's biggest brands are taking an ethics-led approach, especially to digital marketing and advertising. Ensuring that your business cares about privacy as much as your customers do can help you stay ahead of this trend.



What we've seen

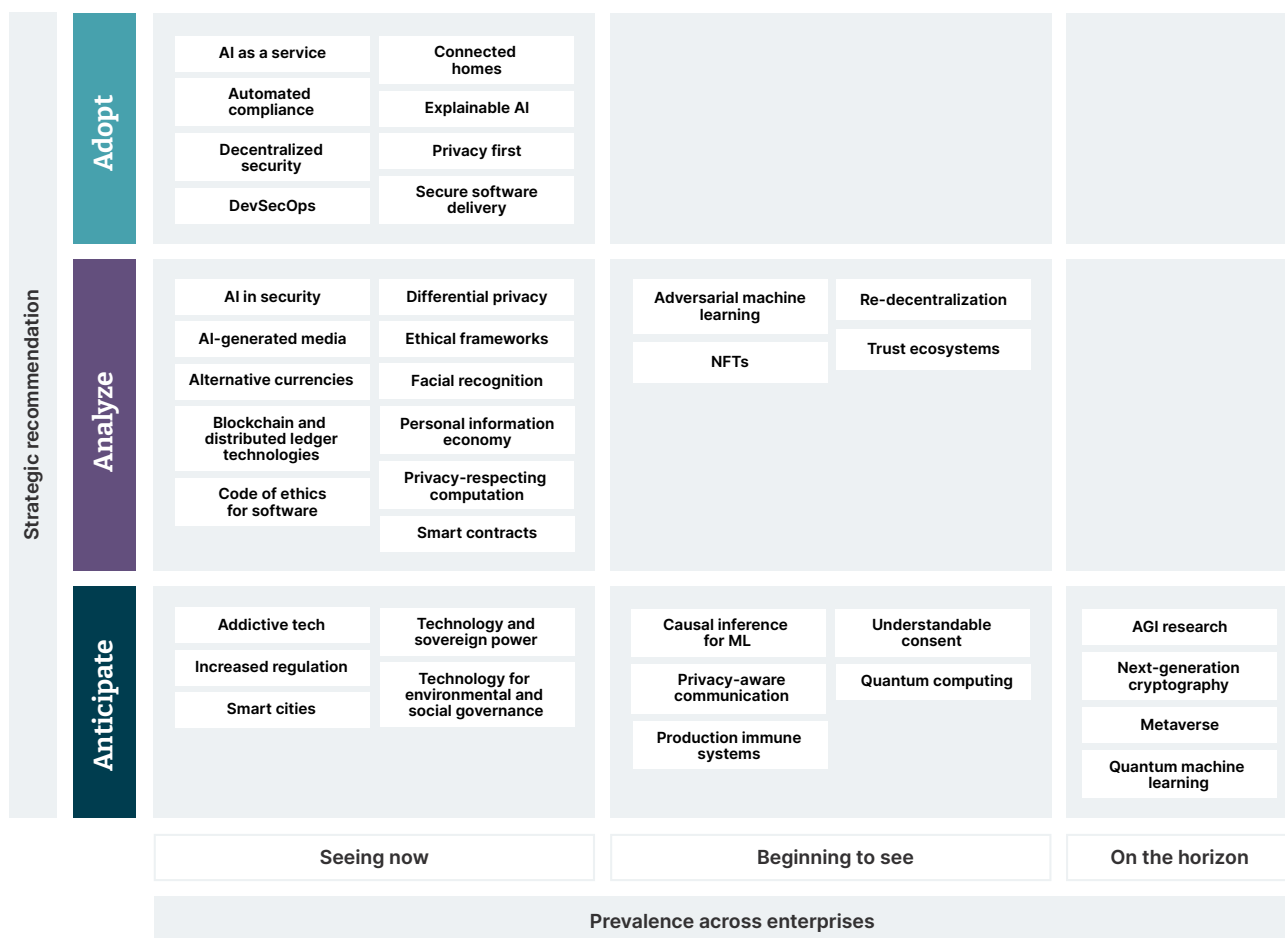
To properly address privacy, we urge organizations to think differently about their data. Specifically, adopting a [data mesh](#) paradigm enables stronger governance, because instead of simply slurping data from anyone, anywhere, knowledgeable data owners are appointed for a given domain; they're able to make decisions about what data is needed, what is not and how it should be ultimately used. When we work with clients to implement data mesh, we find it is particularly valuable in helping us to architect systems that incorporate [Privacy by Design](#).

“Privacy must be part of your company culture. Instead of slurping data from anyone, anywhere, and creating a massive data swamp with toxic leaks of unknown provenance, you need to carefully curate data. This is an opportunity to take a pro-privacy stance and build a trusted brand.”

Katharine Jarmul
Principal Data Scientist, Thoughtworks Germany



Trends to watch



Adopt: Decentralized security

As the nature of cyber threats changes, previous methods to prevent attacks are routinely failing. There is no longer a safe boundary or perimeter. System design needs to allow for risk management and security enforcement throughout the entire architecture, with increasing use of security-in-depth practices that embed protection across multiple layers to make it more holistic. These include the use of encrypted communications, segmented regions and authentication and authorization at a more granular level, as well as more intelligent intrusion detection systems.

Analyze: AI in security

AI capabilities are becoming increasingly important in everyday software applications. Organizations should leverage work in this area to help security professionals identify and react to security threats, and predict attack vectors wherever possible. While we don't believe automation is a viable replacement for well-trained security professionals, it provides a tool set that can automate some basic defensive processes, and allow people to focus on the most critical threats.

Anticipate: Increased regulation

While we've flagged some of the most recent regulations to emerge in the privacy space, organizations should be prepared for more. Worldwide, there are a **significant number of data protection laws** already on the books with more to come. Challenges will emerge as compliance potentially grows more complex, especially for firms operating in multiple jurisdictions. When GDPR came into effect, for example, **many US-based news sites** simply blocked people in Europe from accessing their websites because they were concerned about falling foul of a law they didn't understand.

Advice for adopters



Remember that when it comes to data, what you *don't* do is also important. Since the 'big data' trend started firms down a path of gluttony, many companies collect data almost by default and store it for long periods, without critically examining how necessary it is to the business. Today's machine learning algorithms also encourage a degree of data hoarding. But data has to be recognized as a liability as well as an asset. Hackers can't steal what you don't collect, and a security snafu can't leak customer information that's not in your database. Think selectively about the data you need and the possible fallout if it is stolen or leaked, and remember, the less customer data you're dealing with, the easier it will be to manage.



Recognize personalization is not always necessary, and can be counterproductive. The reality is consumers do not necessarily expect or even want a one-to-one, personalized experience from every brand or product. Privacy-friendly web analytics is an emerging practice that enables brands to still get a 'pulse check' and understand high level flow and consumption trends to get a reading of target audience engagement. Given privacy trends and concerns, our recommendation is to invest heavily in customer research to understand key segments rather than individual behaviors, identifying how these interact with your brand online and offline to create flows and content that work for a broader group, while keeping individual privacy intact.



Work with your legal and marketing teams to create easy to understand privacy policies.

Not only will these help engage and benefit consumers; internal teams can also use such policies as an effective reference to design their solutions, data retention policies and compliance approaches. Berkeley's [Information Security Office](#) and [this research paper](#) provide some good advice on how to start.



Enable your teams to focus on creating value by automating security, privacy and compliance testing. When creating security policies, make sure they can be effective as guard rails for teams, then automate and treat them as code wherever possible so teams can get immediate benefits. One way of doing this is by using [dependabot](#) to ensure dependencies are secure, patched and up-to-date, or AI tools that help people to identify and respond to incidents by zeroing in on unusual patterns.



Make security education a priority. Hackers only need to find one vulnerability to get in and inflict damage, but defenders need to secure their entire organization — a highly asymmetric reality. Security is much more effective when everyone in the organization does their part. Learning about good security practices is not easy, but creating a layered strategy where experts help improve the overall security stance of the organization, and giving people the tools to make good decisions, will leave the enterprise significantly safer. By extending education to customers, taking steps to bring them up to speed on the importance of data privacy and what can go wrong when data is shared, enterprises can enlist their help in the battle.



Build products with robust security and privacy practices. This requires deep commitment and strong leadership; security and privacy are not just technical concerns, but should be seen as an outcome of the culture of the entire organization. Leaders must make it clear that the team should not consider these aspects 'nice to have,' something they can delay until later, or somewhere investment can be trimmed to save costs. Products need to embed robust security and respect user privacy from day one.



Partnering with AI

Making machine intelligence mainstream

The AI achievements appearing across the industry are nothing short of astonishing: just look at Google Deep Mind's projects to predict **3D protein structures** and **control fusion reactors**, or NVIDIA's system to **instantly create 3D photos based on 2D objects**. But what's really interesting is how AI and ML innovation is 'trickling down' and is now in the reach of the rest of us. Never before have these fields exhibited so much potential or mainstream applicability. Businesses are using AI solutions to scan physical receipts, detect fraud, recommend products to customers and even turn interactions over to **synthetic spokespeople**.

We see AI and ML becoming even more accessible, more embedded in the business — and more productive. Cloud vendors such as AWS are now offering data management tools and pre-trained ML models that can feasibly provide any company a head start in creating value through ML. Some vendors even offer AI services where businesses can simply feed data into a ready-to-use model to get an answer or outcome.

The growing emergence of 'off the shelf' solutions has the capacity to level the playing field, and make more and more solutions AI or ML-enabled. Nonetheless, the companies that do AI/ML best, and with the highest-quality data, will retain an advantage. That makes it important to continue to strive to develop AI/ML knowledge, capabilities and talent.

In the short time since publishing this edition of Looking Glass, tools like ChatGPT have taken the world by storm, providing further evidence that AI is becoming more mainstream. Its conversational style and back-and-forth between humans and the AI also showcase the 'partnership' approach for AI. ChatGPT and related technologies are deeply nuanced, and throw up many as-of-yet unresolved questions. See [here](#), for an in-depth exploration of these issues.

Signals include

- **A rapidly expanding enterprise AI market.** Gartner predicts the market for AI software will approach **US\$135 billion by 2025**, with growth more than doubling to 31% — a considerably faster pace than the software market as a whole.

- **Consumer products incorporating AI as a matter of course** and without much fanfare. AI-powered features that might have generated significant excitement just a few years ago are now standard issue in devices like Apple's iPhone, which uses AI to detect, sort and enhance images — often without users appreciating the clever underlying technology.
- **More organizations appointing chief data officers**, and in some cases chief analytics officers (or chief data analytics officers). According to recruitment specialist Korn Ferry, only a decade ago barely 10% of big firms had such roles; the rate now among “data-intensive” companies is closer to three-quarters.
- **AI leaders like Meta** disbanding dedicated AI groups in favor of embedding AI experts in product teams or other parts of the enterprise. This points to AI becoming an integrated part of everyday business operations, rather than a specialized, stand-alone practice.
- **Creative professionals are taking AI tools much more seriously** and using them as time-saving helpers to create illustrations, art, articles, blogs and emails, and even program code.

The opportunities



Using AI to generate real business value. With AI and ML now in easier reach for many organizations, and more companies able to embed AI/ML capabilities in operations or products, there are a multitude of paths to explore. There are different ways to get value from AI and ML. For example, companies are applying AI to improve efficiency, ultimately reducing costs. In some cases AI is even being harnessed to create entirely new, award-winning products, by augmenting human creativity and decision-making. In other cases, ML is being used in much less dramatic ways to remove friction from user experiences.



Unlocking untapped innovation capacity by freeing up people to focus on the big picture. There's an unfortunate but still common perception that adopting AI/ML inevitably means automating away jobs. But when applied in the right way, AI/ML reduces the amount of time people need to devote to mundane tasks, giving them room to focus on higher-value functions. By contributing to business and customer knowledge, AI can provide additional insights that pave the way for productive decisions and greater customer delight. The real goal of an AI/ML implementation should be to support and augment human intelligence, not render it obsolete.



Answering the big questions — everywhere. The sheer computational power and algorithmic understanding being offered to organizations today means they can solve problems that were previously insurmountable. Critically, these algorithms can be run in more and more places. Cellphones with embedded AI hardware can be as powerful as a desktop computer. Edge devices with constrained processors can use TinyML techniques to run AI almost anywhere, without even needing network connectivity. All this creates unprecedented potential to draw and analyze data from different sources to generate insights and inform decision-making, wherever that needs to happen.



Answering the small questions — at scale. For some decisions, it's possible to take humans out of the execution loop and provide fast responses at scale. For example, using dynamic pricing to boost hotel room occupancy. With this style of AI, humans are still involved in monitoring the results to ensure the system remains within intended parameters.



What we've seen

Marimekko is a beloved Finnish lifestyle design company renowned for its original prints and colors. In celebration of 70 years of success, [Marimekko launched Maripedia](#), an interactive print library.

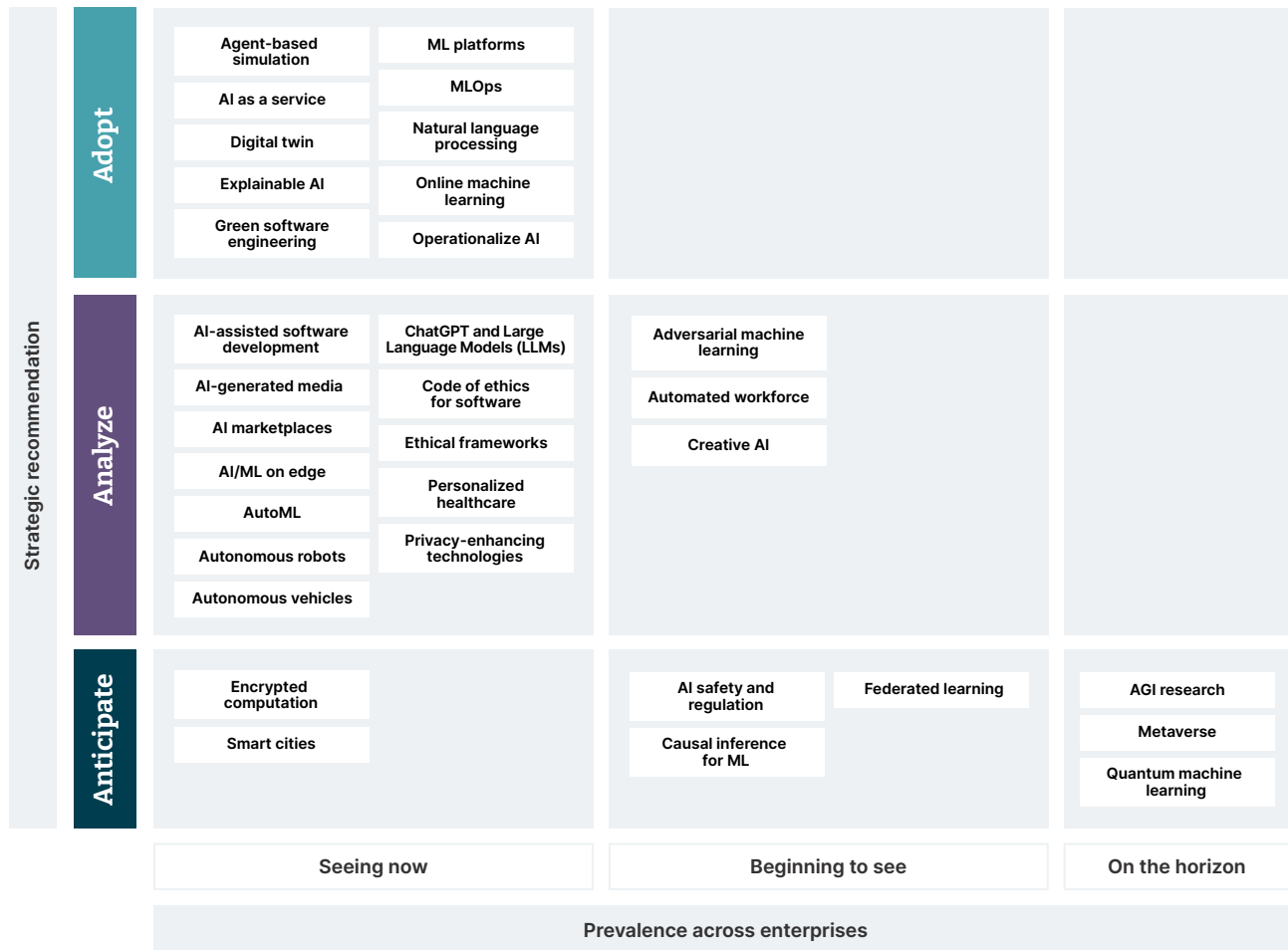
Maripedia enables users to upload photos of patterns with special meanings to them, such as prints cherished by a parent or grandparent. Then AI-powered image search analyzes the photo, compares it to digitized samples of thousands of Marimekko's patterns, and finds the closest match. Maripedia reveals the stories behind each historical design but also allows customers to find current products featuring similar fabrics. The experience provides a fascinating peek behind the scenes of Marimekko's art of printmaking from the early 1950s to the 2020s, and gives the company new insight into what customers are interested in today. When customers are attracted to a particular historical print, Marimekko can act on this insight to create new products and stay ahead of trends and fashions.

“The rise of machine learning and AI continues to impress me. AI can now solve hard problems like protein folding, controlling plasma within fusion reactors, and creating art from text. But don't let these fancy use cases distract you – AI and ML usage is becoming more mainstream, providing value across all sectors and industries.”

Danilo Sato
Head of Data & AI, Thoughtworks Europe



Trends to watch



Adopt: ML platforms

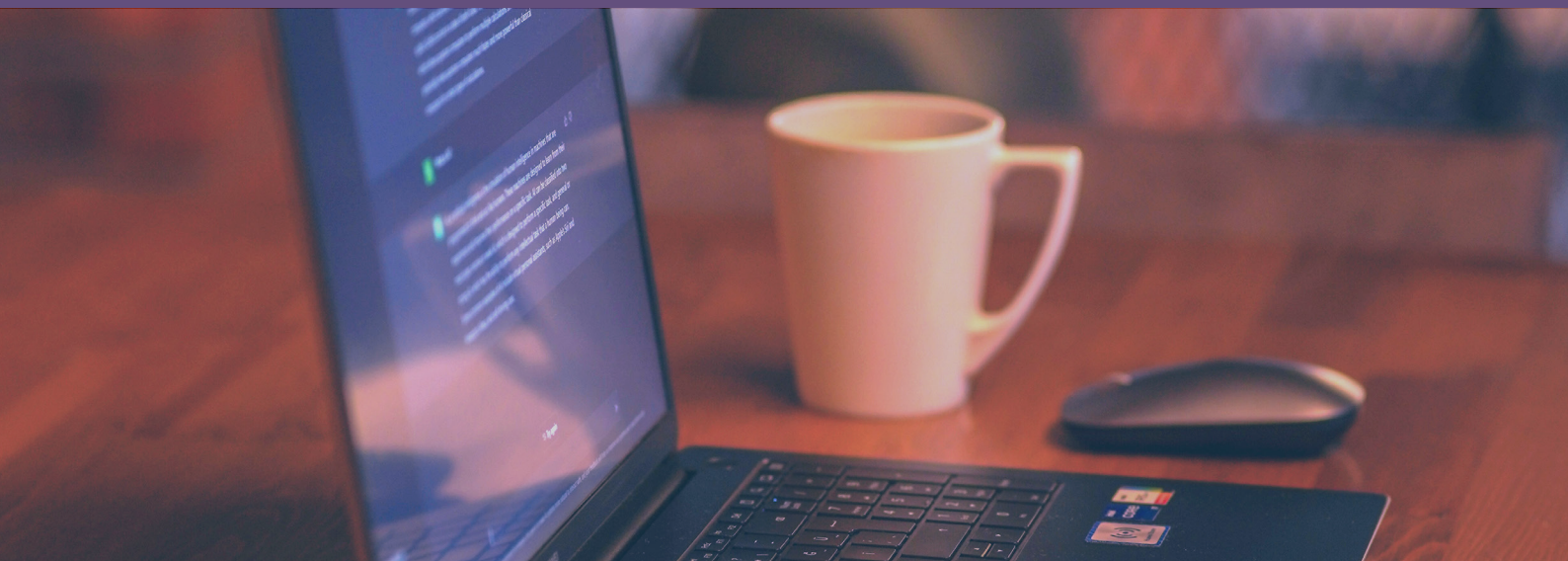
A solid ML platform provides a sound base for the entire ML lifecycle, from ingesting data to readying it for use in models and monitoring the results. This can substantially enhance the productivity (and satisfaction) of data analysts, who no longer have to be concerned about the more mundane aspects of making data fit for purpose. ML platforms also pave the way for more consistent, effective ML software, enabling the organization to put its best foot forward with automation.

Analyze: ChatGPT and Large Language Models (LLMs)

There's intense interest in these technologies, which at first glance seem to have made remarkable advances in the capabilities and 'intelligence' of AI chat bots. But looking deeper, the technology has problems: an information cut-off date after which the bot knows nothing about current events or technologies, biased responses driven by skewed training data, and a propensity to confidently give wrong answers about just about every topic. While experimentation is appropriate, companies should fully investigate when and how ChatGPT and related technologies can be used within their organization and provide staff with clear guidance.

Anticipate: AI safety and regulation

As the ethical challenges created by AI [become more apparent](#), governments and regulators are taking steps to develop rulebooks and codes of conduct that enterprises looking to apply AI/ML will have to take into account. Early examples include a roadmap for an [AI assurance ecosystem](#) that will form part of the UK's National AI Strategy, the [AI Bill of Rights](#) unveiled by the White House's Office of Science and Technology Policy, and the [EU's AI Act](#).



Advice for adopters



Understand that most of the AI technologies you hear about in the press – especially ChatGPT – are tools for experts. ChatGPT has a tendency to fabricate plausible sounding answers that are factually incorrect, so is best used by someone who already knows what a ‘good’ output looks like. We expect this to improve as the technology is developed and better training data is fed to the bot, but the point remains: organizations should carefully monitor and verify the outputs before relying on them. We’ve written about this in more detail in our article [ChatGPT: A useful tool buried beneath the hype](#).



Ensure AI and ML are part of your enterprise toolbox. DeepMind has people looking at the world’s most complex algorithmic problems — protein folding, controlling fusion reactor plasma with magnetic fields — and asking “could we solve this with AI?” The business world needs to adopt a similar approach when confronting more mundane challenges. Take steps to raise awareness of the range of AI/ML tools and services becoming available, so when your people face a problem they consider bringing these solutions to bear. In general ‘off the shelf’ AI services can address undifferentiated problems, such as image recognition or speech-to-text, whereas customized models are more appropriate in cases where your data will be very different from that of competitors, such as customer churn and sales forecasting.



Support your ML efforts with an underlying data platform or data mesh. Even if you have the same model or AI product as your competitor, good data, and the ability to harness it effectively, can be a massive differentiator. For example, if you use an AI service to predict customer demand for your products, providing higher-quality historical data over a wider range of data points will give you more precise answers, even if a competitor is using the same cloud AI service. Better data can be the difference between effective or ineffective use even of packaged models, and good data platforms will enhance the productivity of your people.



Avoid establishing AI ‘centers of excellence’ or simply telling your team to ‘go do AI.’ All this does is give the impression of AI as something that stands apart, when what’s really needed is guidance on the right model for infusing AI across the organization. Much like security or DevOps, AI works best when practitioners are working directly with people across the enterprise, helping others learn.



Recognize that AI/ML systems will face an adoption curve and possible lack of trust, beyond the challenges of operationalizing AI from a technical level. Slicing implementation into small experiments on impactful projects can minimize the chances of massive disruption while helping build comfort and buy-in. Advances in explainable AI and privacy enhancing technologies can help increase trust over time.



Strive to measure the impact of AI/ML-infused products and services. Measuring value is always difficult, but it's important to at least try to demonstrate there's a clear business case for change. Estimate the extra value created by using AI and ML over simpler software with if/then/else logic, or the value created by freeing up people from manual tasks and allowing them to think about more complex problems.



Remember AI also has negative manifestations, and consequences. Along with the justifiable concerns about the rise of AI-powered surveillance and inherent bias in algorithms, there are growing concerns about AI solutions facilitating digital addiction. Training large models can also consume large amounts of energy, running counter to sustainability efforts. It's advisable to remain sensitive to these concerns, and think through the possible unintended consequences of applying AI to a process or business goal, not just for reputational and regulatory reasons, but because it's the right thing to do.



Be open-minded. Be prepared for AI to lead you to learn things you weren't expecting to learn, or towards an approach that you didn't necessarily consider originally. At the same time, because people sometimes call things AI that aren't in fact AI, and claims are made about AI that are hard to verify, maintain a degree of skepticism and recognize AI/ML is not the answer to every business problem.



Making the metaverse

Exploring the frontiers of digital interaction

There's no denying the hype surrounding the metaverse right now — or that the hype is driving real business investments. Meta alone **has invested more than \$10 billion** in the metaverse over the past year, and although that has been treated with skepticism by some investors, many other companies are following suit.

Some investments in the metaverse will prove useful. Yet in our view the metaverse is often a distraction from a larger shift: an evolving new frontier of interaction. This evolution incorporates a multitude of other fast-advancing technologies including virtual, augmented and extended reality (VR / AR / XR) as well as voice, gesture and facial recognition. What's more, these technologies are already 'here' and likely to be immediately relevant to businesses in a way the metaverse — at least for now — isn't.

There's clearly a degree of **brand 'FOMO'** going on as marketers rush to experiment with things like NFTs or concerts in virtual worlds. This may be a result of so many missing out on the social media wave, or the metaverse being lumped into the Web3 craze. In reality, metaverse technology stands apart. The metaverse could well succeed without cryptocurrencies, distributed identity or the other trappings of Web3 tech.

Signals include

- **The affordability and ergonomics of hardware bringing evolving forms of interaction further into the mainstream.** **Quest Pro's full-color AR** and deliberately open peripheral vision headset is one example. Rumors also continue about an **Apple headset**, though no official announcement has been forthcoming. Apple has a history of making sure content has reached a certain critical mass before announcing hardware to access it.
- **More cynicism around the metaverse itself.** Meta, the most prominent advocate of the space, has been **urged by shareholders to cut staff and slash spending on the metaverse**. And while many research firms trumpet the metaverse's potential for growth, not all are in agreement. Canalys has predicted most metaverse efforts will **have met their demise by 2025**.
- **'Digital twins' giving rise to the industrial metaverse.** For all the focus on the 'retail' metaverse where brands interact directly with consumers, it's actually the enterprise version that may gain traction first. Organizations like **GE Formula One** and **Ford Motor** are employing digital twins — virtual models of a process, product or service that allows both simulation and data analysis — to

monitor, optimize and experiment with complex creations. Digital twins increasingly incorporate AR, VR and AI to further narrow the gap between physical assets and their virtual counterparts. McKinsey sees a network of virtual twins laying the foundations for a **massive industrial metaverse** that transforms development processes and paves the way for better decision-making, and companies such as NVIDIA and Siemens are already **stepping up to provide the infrastructure**.

- **Advances in haptics allow users to ‘feel’ virtual interactions.** XR can be incredibly immersive audio-visually, but the illusion is broken as soon as you try to touch something. Until recently, all XR input has relied on handheld controllers or touchscreens. As hand tracking and gesture recognition replaces buttons and joysticks, people will increasingly want to reach out and touch virtual objects. High resolution **haptic gloves** — as well as **watches** and **bodysuits** — could take the experience to the next level.
- **Advances in gaming technology deliver immersive, high-fidelity experiences.** There’s a lot of progress in the games industry that is likely foundational for a consumer-oriented metaverse. Foundational tech includes **photorealistic graphics**, the ability to have **large crowds of player avatars** in the same virtual world, and **easy to use tools** allowing more people to build virtual worlds.

The opportunities



Developing digital twins to test, learn, and enhance certainty. In environments like factories or with machines in the field, there’s significant potential to use 3D visualization and live data to better understand what’s happening to pieces of equipment you can’t actually see and identify maintenance problems before they result in failures. Digital twins also enable enterprises to test or prototype with a higher degree of precision before building or deploying a product in earnest, and provide physically dispersed teams a new platform for collaboration.



The opportunity to find and connect with audiences in new ways. The metaverse and other emerging technologies create room for marketing or brand exposure to customer groups that your business might otherwise struggle to reach. They can be applied to make interactions more accessible, multimodal and seamless, with far fewer restrictions around real estate or location, giving the notion of ‘meeting customers where they are’ a whole new meaning. The possibilities range from billboards in the metaverse to immersive AR or VR experiences that build anticipation for an event or product.



Making training more effective, and impactful. By employing virtual or augmented reality, manufacturers can demonstrate and teach skills such as material finishing with higher exactitude, reducing the likelihood of errors later as well as the amount of material waste generated in a given process. Such technologies also provide a means to prepare staff for high-pressure events like Black Friday in the US, or to accurately reproduce and rehearse for potential emergency situations to build readiness.



Empowering customers to use products more effectively by tapping into new means of interaction to ‘show’ rather than tell, and bring instruction manuals or directions for assembly to life. As well as potentially reducing support costs and return rates, this has the potential to contribute to customer satisfaction and ultimately loyalty, as more people use products safely and in the way they were intended.



What we've seen

Research commissioned by Reece, Australia's leading supplier of bathroom, plumbing, waterworks and HVAC-R products, found that more than a third of bathroom renovators agreed that one of their biggest pain points was not being able to visualize the end result.

Reece partnered with Thoughtworks for their integrated tech, design and digital innovation experience, to develop a modern 3D bathroom planner tool. Imagin3D lets customers lay out a floor plan, choose products, and bring their designs to life before committing to a purchase. Reece's showroom consultants and independent contractors also use the tool to close renovation contracts and proposals.

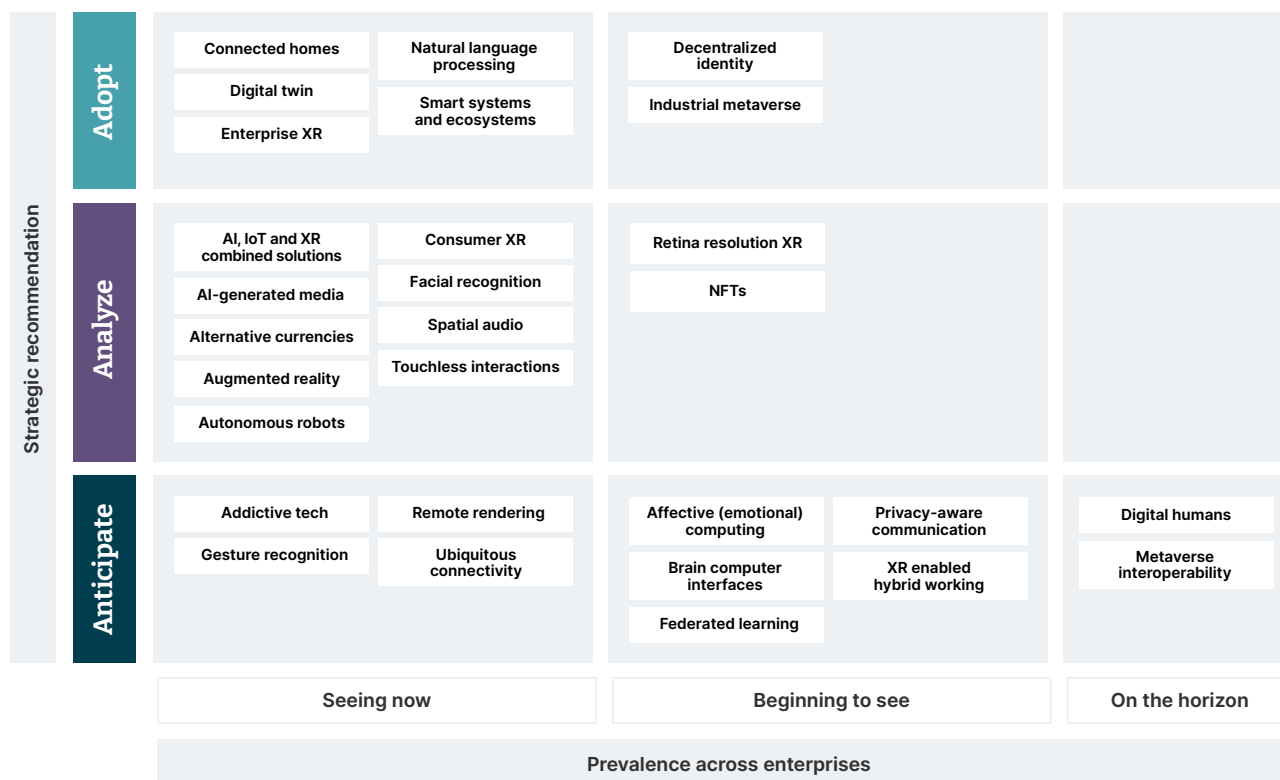
While Imagin3D doesn't use XR — it can be accessed using an everyday web browser — it is an excellent example of how to engage consumers in new ways with an experience that goes way beyond a flat 2D website. In the first three months, the tool helped over 30,000 customers bring their dream bathrooms to life. Reece will continue to meet their customers where they are, with proactive testing and feedback to inform how the visualization tool can solve their customers' challenges in other parts of the home.

“Without a functioning crystal ball, it's impossible to predict the future of the metaverse. What we can do is try to understand where the metaverse is today, the different directions that it could go, and the opportunities that exist for early adopters.”

Cam Jackson
Lead XR Researcher, Thoughtworks Australia



Trends to watch



Adopt: Digital twin

Digital models of physical processes, assets or services make it possible to see what's happening to pieces of equipment or processes in real time, and even simulate what would happen if circumstances or configuration were changed. As just one example, [GE builds digital twins for its jet engines](#), taking real-time data from dozens of sensors in each. Using machine learning, data is extrapolated from dozens of real sensors into hundreds of virtual sensors and used to improve reliability and perform preventative maintenance.

Analyze: AI-generated media

It's become much easier to generate lifelike interactions using AI and image processing technologies, for better and for worse. This could be used for things as simple as short advertisements on video streaming services, to creating complex fakes that spread disinformation. AI-generated art has become fashionable, [unnerving some human artists in the process](#), though it's unfortunately often associated with the NFT schemes that sell access to it.

Anticipate: Metaverse interoperability

Meta founder Mark Zuckerberg has claimed to value the ability [for metaverse implementations to work with each other](#). In practice, we are unconvinced companies like Meta will allow users to gain access to their content without subscribing to their services. So far, certain metaverse implementations, such as Horizon Worlds, only function on the vendor's hardware. But there are initiatives such as OpenXR — backed by Qualcomm, Lenovo, and Microsoft — that could eventually mean XR applications work easily across devices. Open standards for key capabilities like gesture tracking, digital twins, haptics and identity could have positive implications for adoption.

Advice for adopters



In the rush to the metaverse, don't overlook other evolving interactions. The true extent of business relevance and consumer appetite for the metaverse has yet to be fully grasped. Yet it's **already possible to apply technologies like XR** to create new interfaces, channels of communication and immersive experiences for customers or employees, often with direct near-term benefits in terms of brand engagement or productivity.



That said, **watch the development of the metaverse closely** and look for advancements, even possible investments, that might benefit your business. There may not be a clear business case to participate in Horizon Worlds, but research there will almost certainly lead to XR advances such as digital twins that could prove invaluable in an industrial setting.



Be prepared to go where your customers are. Pioneering brands constantly adapt, meeting their digital native customers through whichever app or experience is most relevant. If customers begin to flock to new metaverse platforms or adopt AR on a significant scale, enterprises should be ready to be there.



Remember there will be many metaverses, at least at first, despite the inclination of vendors to pitch theirs as the only one that matters. Companies that can afford to spread their bets among more than one promising platform for digital experiences should certainly do so where there's a likely business case.



Think carefully about how you want your company to be perceived through emerging interaction technologies. For example, if you're implementing a voice bot, is it authoritative or sympathetic? If you're building a 3D experience, does it convey your brand values? Almost every company puts significant effort into shaping how their physical space 'feels' to their customers and invests heavily in ensuring this space offers a quality experience. A similar process and resources should accompany the creation of virtual spaces.



Don't skimp on interaction tech. Things like voice interfaces and gesture recognition have advanced significantly and have clear potential to improve customer relationships, but consumer expectations have evolved in tandem. Any solutions that don't support high-quality, near-human and near-instantaneous interactions — with great visuals to match — can do more harm than good to perceptions of your brand.



Have an interaction talent development strategy. New forms of interaction will require skills to match that may not currently exist in your team. Companies that decide to participate in a metaverse, for example, will either need to teach existing developers about metaverse technology, or hire people from the gaming industry who have designed and built virtual worlds and train them in enterprise tech. In almost every scenario, exploring new interactions will require an organizational learning curve.



Evaluating Web3

Navigating the internet's possible futures

Few tech-related topics are in as much focus, or as prone to causing confusion, as Web3. While the term 'Web 2.0' was invented to describe an already apparent shift to dynamic web pages and user-generated content, Web3 is closer to a manifesto, coined by people and organizations with specific agendas referring to what they want the internet to be.

Web3 proponents — each with their own different vision of what Web3 actually is — claim they will create a more decentralized internet. From a technical perspective, this will be done largely through peer-to-peer protocols, where users control their own data and value is realized more by users and content creators than by owners of infrastructure. But so far, Web3's most widely adopted components are cryptocurrencies and related tech such as NFTs. This means that for some, Web3 is synonymous with crypto, volatility, 'get rich quick' schemes and out-and-out-scams.

Web3 is closer to a manifesto, coined by people and organizations with specific agendas referring to what they want the internet to be.



We think Web3 is best understood as a collection of building blocks focused on decentralization that could combine with existing technology to create the next major phase of the internet. It's important to note there are competing definitions — Tim Berners-Lee, creator of the web, recently talked about his vision of "web 3.0," which shares some of the characteristics of decentralization but is much more focused on people controlling access to their own data and does not require an underlying blockchain.

For businesses and consumers, it's important to note Web3-related developments may have positive or negative implications. Decentralization can counter monopolies and democratize access to services. Yet centralization and regulatory oversight provide protection and legal recourse — and the crypto space provides plenty of cautionary tales about what happens when there are no guardrails in place.

As Web3 develops, it remains to be seen how wedded it will remain to its ideals. For businesses, the main thing is to avoid getting dazzled by the hype that accompanies some innovations adopting the 'Web3' tag as it edges into mainstream legitimacy, and to zero in on what it offers that's directly relevant.

Signals include

- **Increased regulation to protect consumers and businesses**, especially around crypto tokens and whether they constitute securities.
- Large **financial institutions participating in the crypto ecosystem**, such as Schwab **creating an ETF based on the crypto economy**. Banks and wealth management firms are also **becoming custodians** for more types of digital assets.
- **Blockchain-based technology being applied to good causes** such as **supply chain verification**, **vaccine tracking**, or **sustainability auditing**.
- **Big brands** such as **Starbucks** and **Nike** **experimenting with things like NFT technology**, though the value of these efforts beyond marketing is still very much up for debate.
- **Central bank digital currencies (CBDCs)**. Policymakers worldwide have set out to identify what effect the rise of cryptocurrencies may have on traditional currencies, and to determine a response. The White House recently **published a report** on CBDCs, their policy implications and the "responsible" development of digital assets. It's important to note that, depending on their implementation, **CBDCs may or may not require blockchain-style technology**.
- **Players in the Web3 space acknowledging the environmental impact of technologies** like crypto and working to reduce it. Old-style GPU miners **are quickly going out of business** after Ethereum, one of the leading cryptocurrencies, moved to 'proof-of-stake' by phasing out the practice. The Ethereum inventor claims this resulted in a 0.2% reduction to global energy usage.
- **Federated systems, which are decentralized rather than controlled by a single entity, are gaining traction**. **Mastodon**, a decentralized social network, has seen rapid growth in response to Elon Musk's turbulent first weeks of owning Twitter. **Millions of people** are now taking their first steps in the 'fediverse' — a federated universe of content. It remains to be seen how federated content moderation will handle the challenges of today's social media platforms.





The opportunities



Getting ahead of the adoption curve — with caution. Keep a keen eye on how Web3 is evolving and potential use cases for your organization — without getting swept up in the general excitement. If “blockchain verified” becomes a positive in terms of public opinion, being close to Web3 technologies can be both a brand and commercial opportunity. At the same time, some Web3 ‘innovations’ may prove more style than substance, or even carry regulatory or reputational consequences, so caution is warranted.



For many businesses, the biggest opportunities are likely to emerge around **reducing friction** in contexts without a trusted central authority. Blockchain, for example, is already demonstrating the ability to smooth and accelerate cross-border transactions. By preventing tampering it could also have positive implications for documentation or processes such as contracts or escrow.



Leveraging trust to unlock new opportunities. Provided Web3 manages to shake off some of its more negative associations and the security and privacy aspects of things like blockchain come to the fore, qualities like decentralized identity and greater end-user control could convince more consumers to share or parcel out their data for commercial purposes. This will give companies much richer resources to work with.



New industry alliances. Beyond consumers, there are already examples of governments and companies launching special ‘permissioned’ chains that promote digital interaction and information-sharing among members, potentially providing a secure basis for cooperation where none previously existed. These include China’s government-backed Blockchain-based Service Network, and The Energy Web Chain created for energy companies.



What we've seen

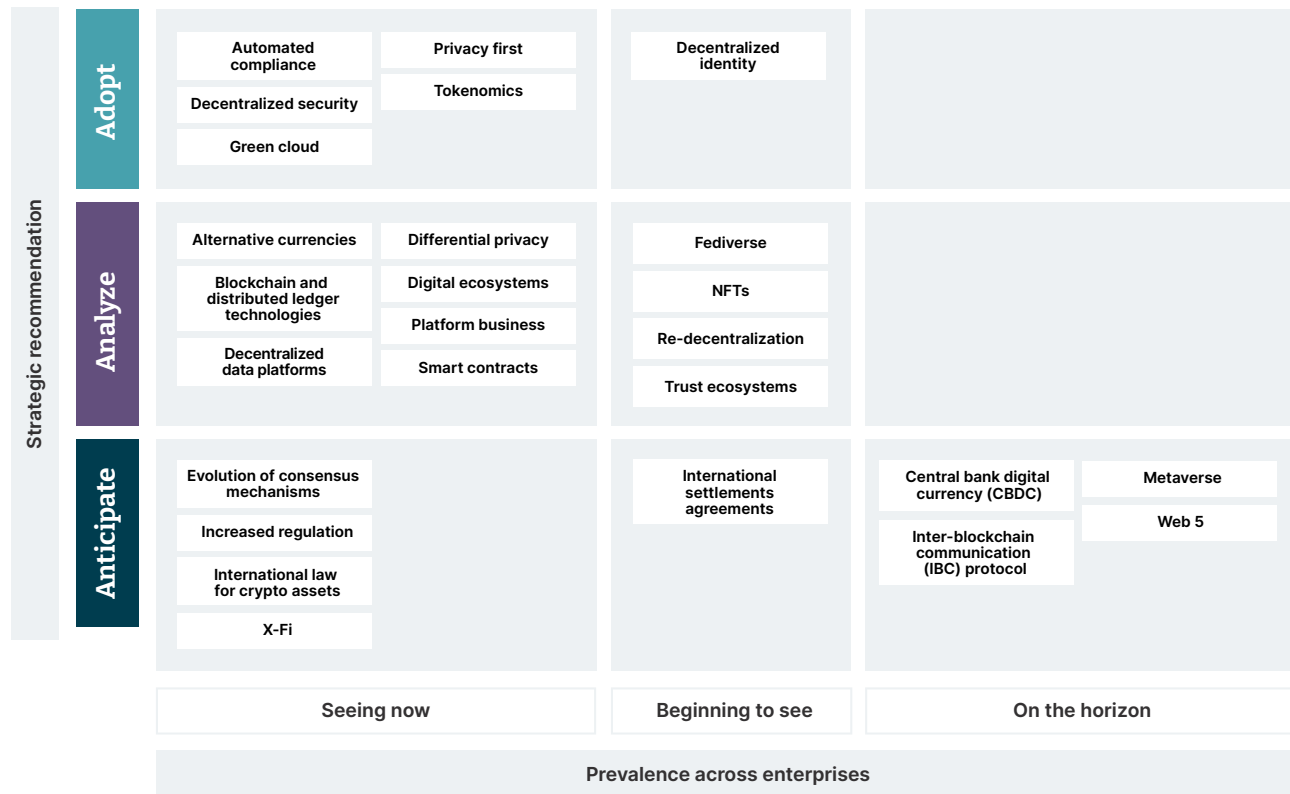
We're working with one national government to create a decentralized identity system for its citizens. This system will give citizens more leeway to choose the appropriate type and amount of personal information to share with authorities or businesses based on the individual use case. For example, the information required for a credit application would be very different from the information required to book a doctor's appointment.

"Billion-dollar sums, the rise and fall of crypto empires, and uncanny algorithmic art are driving the headlines, but we need to look beyond that. The technologies underlying Web3 may be new building blocks for a future decentralized web. But the future is far from clear. Many people are still asking, is there a 'there', there?"

Chad Wathington
Chief Strategy Officer, Thoughtworks



Trends to watch



Adopt: Decentralized Identity

Tim Berners-Lee calls this [“single sign on for the web,”](#) allowing users to control their own identity without relying on a provider. Some version of this is one of the few trends people with different visions for the next version of the web agree on. In practice, this could range from the [Solid Project’s pods](#), developed by Berners-Lee, to standards being promoted by organizations such as the [World Wide Web Consortium](#), the [EU](#) and [Microsoft](#). These standards are not yet mainstream, which makes the trend hard to “adopt,” but we believe organizations should be working towards a better understanding of these concepts and how they might affect their business.

Analyze: Smart contracts

Unfortunately named, these ‘contracts’ are not legal documents but actually software programs that execute as part of a blockchain. They automate multiple steps into a single transaction and in theory eliminate [counterparty risk](#). [Use cases include](#) supply chain tracking, land title custody, complex financial instruments such as derivatives, and can include concepts such as escrow or [flash loans](#). Since they are programs, smart contracts have all the problems of regular code, including bugs. This leads to a dilemma: if smart contracts can be changed after implementation (to fix bugs) one party might get a [different ‘contract’](#) than they thought they had signed up for. Given these issues, it’s good practice to closely scrutinize smart contracts and to enlist expert help in doing so.

Anticipate: Increased regulation

Regulation in this area, especially when associated with cryptocurrencies, is fast moving. Regulations also vary wildly from country to country and affect the acceptance and adoption of Web3-based technologies. For example, some more speculative use cases in western countries are simply not legal in China. Sites such as [Cryptocurrency Regulations Around the World](#) can be used to track developments where you do business.



Advice for adopters



Create an overall Web3 decision-making framework for your company. The strength of feeling around Web3 — positive and negative — can make it difficult for organizations to assess it with confidence and clarity. What's important is that you should approach it with the same degree of due diligence you would with any other new product or technology trend. A decision-making framework can help here, giving you a set of questions and considerations to formulate your approach to Web3. Take time to ask yourself the following questions:

- What specific benefit do you hope to achieve from using Web3 technology? Will it achieve something you couldn't do with traditional technology, or a way to participate in the energy, excitement and innovation surrounding Web3?
- What return on investment do you expect? If the benefit is largely brand recognition, what's that worth to you? What are the reputational risks, given the volatility of the sector?
- If the opportunity involves anything crypto, ask some questions: Do the founders have a track record? How much funding has the project attracted? How many participants are there? And what is the trading volume and total value?
- How will you know your exploration of Web3 is successful? If it is not, how will you know when to stop? If it is a success, will you increase your investment?



Stay informed about this fast-moving space. There is no shortage of reports providing guidance about Web3. Make a point of keeping an eye on developments in Web3, crypto, blockchain and distributed technologies. Take steps to become informed, but be careful about buying in. Large (and at times speculative) amounts of capital are being deployed in this space, and the stakes are high enough that you can never take someone's opinion at face value. You need to understand their interests and motivations.



Along with developing your understanding, **decide whether you as a company need to participate in Web3**, and what form that participation might take. Will you need to join a public blockchain to credibly audit your sustainability or supply chain data? Is there a real argument for creating a presence in the commercial metaverse, or launching an NFT, to engage consumers? Whatever you're doing or building, make sure it has real business or customer value.



Look for ways to experiment beyond the public blockchain, for example by participating in the development of private/permissioned chains with industry peers, which are more likely to have immediate business benefits and long-term potential.



Acknowledge that the path to the future of the internet looks different depending on where you are in the world. A lack of trust in local authorities or banks drives many to look towards decentralization for security and guarantees. For others, local regulations curtail what they can do with digital assets, as seen in [China](#) — arguably a good thing, given how many investors have lost money in crypto. Web3 approaches may therefore have to be tailored (or abandoned) depending on the market or customer group.



Related to that, **be sensitive to the regulatory trajectory** in different jurisdictions. Regulatory agencies move slowly, and don't have the expertise of companies or commercial interests who are lobbying for changes in regulation. Nonetheless, it's safe to say some aspects of Web3 are now firmly in regulators' sights, and care needs to be taken to stay on the right side of a shifting compliance line.



Take real, demonstrable steps to establish trust with customers now to prepare for the possibility that a move to decentralized identity management and regulation may make it more difficult for you to collect and store their data later. Provided some kind of critical mass is reached, greater customer or user control could actually result in richer data for those businesses that build a sufficient foundation of trust and/or incentives for customers to part with their data willingly.



Accelerating sustainability

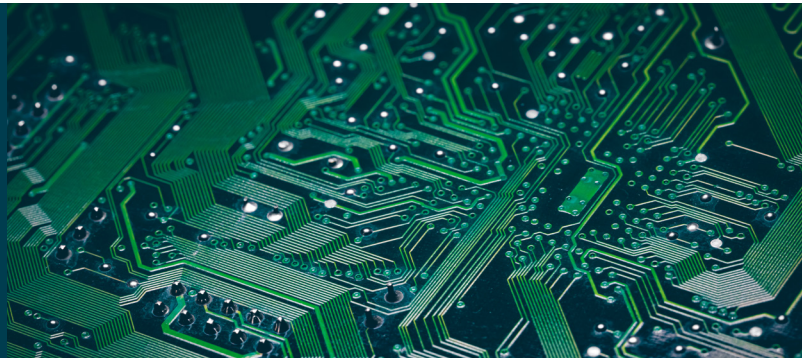
Responding to the climate crisis with technology

The effects of climate change are accelerating and momentum is shifting. Significant climate-related disasters are occurring. **Things are getting worse** and **faster than scientists previously predicted**.

Despite the urgency, sustainability is not yet 'business as usual' for many organizations. Business remains unprepared to fully reckon with the impact of trends like carbon accounting and will soon be expected to hit targets that can no longer be pushed back because of the real global consequences.

The good news is that organizations that were already taking action in response are doing more — and more organizations are at least doing something. Technology is emerging as a powerful accelerant and enabler of sustainability in two main ways: by reducing the direct carbon emissions from things like data centers and cloud servers, and by providing new tools and techniques to help organizations understand, categorize and optimize their emissions and progress towards environmental targets.

Technology is emerging as a powerful accelerant and enabler of sustainability



Signals include

- **Governments reacting to public opinion and their peers by increasing both 'carrots' and 'sticks'** to encourage companies to act, such as **funding for firms** that invest in sustainable technology or **tougher fines for polluters**
- **Geopolitical tensions are driving a short-term reliance on fossil fuels** but are accelerating countries towards an overall shift to sustainable energy policies. In some cases, the policy goals include energy independence

- **A surge in production of clean energy components** such as lithium ion batteries, combined with concerns about the long-term financial health of traditional energy companies as they face a wave of divestment
- **Sustainability metrics being factored into annual reports and executive targets**, and in some cases tied to directly to bonuses
- **Cloud providers improving their sustainability performance** through strategies such as power purchase agreements, transparency of emissions data, adopting solid state storage or making compute instances more energy efficient — and helping their clients do the same
- **Growing momentum** in organizations such as the Green Software Foundation and the FinOps Foundation's Sustainability Working Group, to create standards, tooling and recommended practices

The opportunities



Enhance IT's strategic role by driving sustainability improvement. Beyond simply looking at the carbon costs of its own operations, by applying practices like AI and decision science to better measure and understand a broader range of potential outcomes. IT can help the rest of the organization adopt a stronger sustainability stance, decrease their carbon footprint and directly boost the bottom line.



Better align with customer values. Increasingly, consumers have demonstrated that they **are choosing vendors** based on their environmental stance and actions. One study found consumers see reducing harm to the environment as important for businesses as meeting tax obligations and that a significant majority buy from brands that reflect their personal beliefs



Stand out in the race for talent. Hiring will remain one of the biggest challenges for technology and other companies for years to come. With employees, and particularly younger workers, also gravitating to organizations that share their environmental principles, companies that can demonstrate real commitment to sustainability will have an edge to attract, retain and motivate skilled workers



Gain competitive advantage. Organizations that chart real progress towards sustainability goals with credible data will differentiate themselves from those that spout vague principles or make unsubstantiated claims





What we've seen

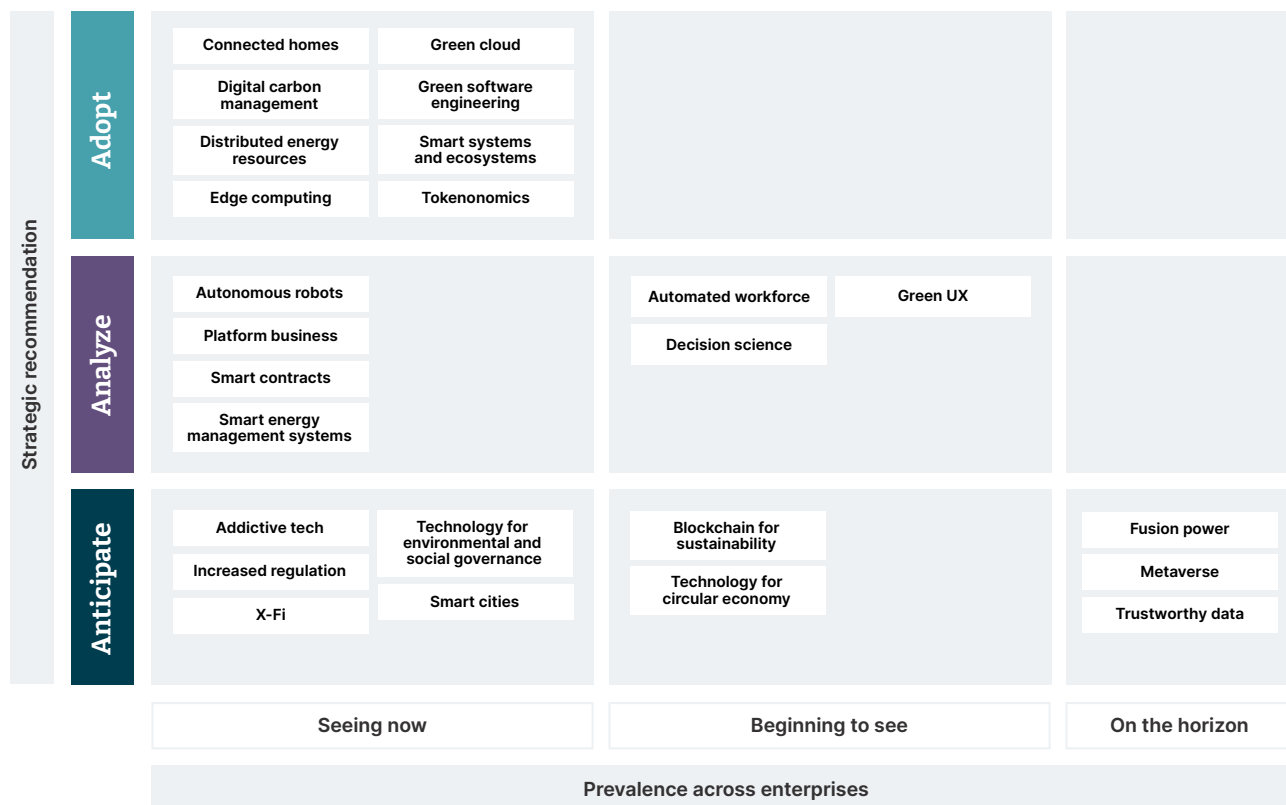
We worked with one of the UK's largest and oldest banks to help them identify how they can make real and lasting changes to the energy they use and the carbon they create. Like many financial institutions, they became a primarily digital business over the last couple of decades, and also like many other banks, their infrastructure is 95% on-premises. While they recognized that migrating to the cloud could be effective in reducing emissions, they needed help upskilling their software engineers to integrate green cloud fundamentals into their operations.

“While technology may not be the magic bullet that will solve climate change, it can make a powerful difference to the way organizations plan, set targets, execute, optimize, measure and report on sustainability initiatives.”

Andy Nolan
Director of Emerging Technologies, Thoughtworks Australia



Trends to watch



Adopt: Green cloud

The shift to cloud computing is often seen as a ‘silver bullet’ for improving IT sustainability, since cloud providers are investing significant resources to improve their carbon footprints. Some providers even advertise that they are carbon neutral. But simply relying on cloud platforms to advance sustainability is too simplistic. It’s still important to avoid cloud sprawl and to understand the energy usage of cloud environments and services. Fortunately, large cloud platforms now provide [detailed carbon accounting](#) to help with this, and there is a growing set of “cloud management” companies that include sustainability in their offering.

Analyze: Decision science

Artificial intelligence tools and techniques previously used to assist in complex scientific and academic choices can now be applied to corporate decision making. Combining human expertise and insight with data-driven modeling and simulation can allow decision makers to sift through countless possible combinations of strategic choices and pick the best path forward with unprecedented speed and clarity. These practices could help organizations understand the bigger picture of their energy usage, and make important decisions at a level higher than simply improving the numbers.

Anticipate: Trustworthy data

To make sound decisions around sustainability, especially for complex organization-wide elements such as the impact of supply chains, complete and accurate data is a must. If a department or supplier provides inaccurate (or worse, outright fabricated) data, an organization can no longer be sure decisions will drive the desired results. Trustworthy data is an emerging set of techniques to [certify the provenance](#) of data and to govern its use across an organization that could prove transformative in the effort to track and enhance progress towards sustainability targets.

Advice for adopters



Foster 'carbon awareness' in your employees and customers. There is a huge potential for carbon savings by empowering your end-users with the information they need to make carbon-efficient decisions. Airlines now list flights with CO2 emission data, and GPS mapmakers flag routes as being the most carbon efficient. Consider an explicitly labeled 'eco mode' for your products and services, which will contribute towards your own goals and demonstrate your commitment to sustainability.



Get ahead of oncoming regulation. Accelerating sustainability is no longer just about doing the right thing — there are specific, mandatory targets coming in the decades ahead and more will likely emerge. With both scientific evidence and public opinion building momentum, there is a commercial imperative to **understand your carbon footprint**, and to get serious about making reductions. Organizations that are proactive and do more than the regulatory minimum will be the best positioned to meet future government and customer demands.



Take advantage of the 'carrots' on offer, such as the **clean energy tax incentives** recently signed into law by US President Joe Biden. Unfortunately these sweeteners typically have a shelf life; subsidies today may become penalties tomorrow as governments adopt more aggressive tactics to get results.



Measure, don't guess, and try to properly model all variables when targeting environmental improvements. As with any optimization, the interplay of components can make the journey very complex.



Ensure sustainability becomes a cultural trait for your organization. It's hard to do sustainability without being sustainable. Some organizations are tying executive compensation to green outcomes, while others, including Thoughtworks, have signed up to achieve **science-based targets**. It's only when sustainability is a clear priority at all levels of the organization and reflected in KPIs that it becomes truly embedded.



'Shift left' on sustainability. Encourage teams to consider sustainable practices and goals earlier in the process of designing and building systems, rather than viewing them through a sustainability lens after most of the work has been done. As with security, you can achieve more significant outcomes and better respond to regulatory and market pressures if you 'build sustainability in' from the beginning, rather than trying to tack it on later.



Understand the tradeoffs and be prepared to make hard choices. For businesses and governments alike, sustainability inevitably involves sacrifice of one kind or another, whether time, resources, efficiency or even competitive edge. Doing the right thing typically costs more, and may not be the most convenient option — just think of electric vehicles, which can be very efficient when charged daily and driven shorter distances but offer reduced range and flexibility over their gas-powered counterparts.



Efforts to be sustainable may have initial negative consequences — for example, cutting corporate travel will reduce carbon emissions but can also leave staff and customers feeling disconnected — and positive impacts may not be apparent for decades. However, the key is to **be flexible**, constantly pushing progress where possible while remaining realistic about what the organization (and its people) have the capacity to adopt and embrace.



Glossary

A

Addictive tech: Some applications are specifically designed to be addictive, driven by fierce competition for eyeballs and engagement. While this might be good for companies in the business of selling advertisements to audiences, there is an increasing awareness of the societal and environmental harms of addictive tech.

Adversarial machine learning: These are attacks on (or using) machine learning systems. Attackers may tamper with training data or identify specific inputs that a model classifies poorly, to deliberately create undesired outcomes.

Affective (emotional) computing: A collective terms for systems and devices that can recognize, interpret, process, simulate and respond to human emotions.

Agent-based simulation: The use of simulated independent agents, each working towards their own goals, to model a real world situation. Such simulations can help us understand complex phenomena such as the spread of diseases or protein folding.

AGI research: An Artificial General Intelligence (AGI) has broad capabilities across a range of intellectual tasks, and is often compared to human-level intelligence. This contrasts with

today's "narrow" AI which can be remarkable, but only for very specific tasks.

AI as a service: "Ready-to-go" AI solutions offered as a service on cloud platforms. They often don't require specialized AI or ML skills to be used.

AI in security: AI is increasingly being deployed both defensively, to respond to threats more dynamically, and offensively, to probe for weaknesses in a system.

AI marketplaces: Marketplaces such as AWS Marketplace, Google TensorFlow Hub and MS Azure Marketplace enable independent developers and companies to sell their models to a global market. They also allow consumers to quickly leverage those models to create value quickly.

AI safety and regulation: Government regulation and guidance on the use of AI, intended to ensure responsible use and consequences of AI systems. This includes monitoring, compliance and good practices.

AI-assisted software development: The use of AI to speed up or improve software development. Examples include code completion in IDEs, AI-created automated tests, AI that can detect bugs or even AI code generation tools.

AI-generated media: Images, audio or video that have been manipulated by AI. Also known as synthetic media.

AI, IoT and XR combined solutions:

A new breed of solutions in which multiple technologies are combined and act together. Drones, robotics and autonomous vehicles are all examples of devices that require machine learning, processing streams of data and layers of intelligence to solve problems.

AI/ML on edge: The ability to run AI and machine learning algorithms at the edge of a network, often on resource-constrained devices.

Alternative currencies: Currencies other than money, such as cryptocurrencies or reputation-based currency. Increasingly, this includes vendor-specific reward-based currencies such as Starbucks Stars or Amazon Coins.

Augmented reality: Where the physical world is combined with the digital. A limited form of AR is now ubiquitous, delivered via Apple and Android cell phones, capable of overlaying virtual objects to a camera view of the world. More advanced AR is delivered via a dedicated headset such as Microsoft's HoloLens or Google Glass.

Automated compliance: The use of technology to make all the data required to satisfy compliance reports, checks and balances readily available. In many cases, the automation simplifies reporting by sifting through data; however, AI is now beginning to replace manual decision making.

Automated workforce: The use of technology to perform repeatable or predictable workflows. Automation doesn't necessarily mean completely replacing humans; in some cases human-machine "teaming" may produce better results than either working alone.

AutoML: An approach to partly automate the work of data scientists and machine learning engineers by automatically selecting and training machine learning models for specific tasks.

Autonomous robots: Smaller and cheaper than their industrial counterparts, robots with on-

board AI are able to sense their environment, navigate, learn to complete tasks and even fix themselves and other things.

Autonomous vehicles: Self-driving cars, trucks and public transport. While the headline focus may be on self-driving cars, autonomous vehicles also have high potential for specialized industrial and business applications.

B

Blockchain and distributed ledger

technologies: Blockchain is the technology underpinning the Bitcoin and Ethereum networks. Distributed ledger technology (DLT) allows us to create a worldwide, indelible database for which everyone agrees on the contents.

Blockchain for sustainability: Blockchain is beginning to provide unique sustainability opportunities. It can foster transparent collaborations between consumers and producers by assisting people to adopt more sustainable lifestyles and helping companies improve their sourcing and recycling practices.

Brain computer interfaces: A device that reads and analyzes signals from the brain and turns them into an input mechanism for a computer. The human and the device, both after a period of training, work together to encode and decode human intentions.

C

Causal inference for ML: Techniques to draw cause and effect relationships between the input data and the outcomes of a machine learning model, which allows a model to be more generalizable and require less training data to perform well.

Central bank digital currency (CBDC): A form of digital money or monetary value, denominated in the national unit of account, that is a direct liability of a government-run central bank.

ChatGPT and Large Language Models (LLMs):

A machine learning model designed to process and understand human language at a high level of complexity. Typically trained on vast amounts of text data, using deep learning techniques to generate human-like text based on a given input prompt.

Cloud portability: The ease with which it's possible to move an application from one cloud to another or to leverage more than one cloud solution at once.

Code of ethics for software: A set of guidelines organizations can use to manage risk and mitigate the potential negative consequences of given technologies (such as AI bias).

Collaboration ecosystems: When individuals or organizations share common goals, they will probably want to work together. To do so, they need a set of tools and resources they can use to unlock value effectively — a good example is a remote environment for development teams. It allows people to solve problems together.

Connected homes: Featuring smart hubs, voice activation, the ability to control lights, temperature and even cooking via an app, homes are now becoming 'smart'. Analytics can even guide or manage heat and energy supply and learn from individual habits or those in a neighbourhood.

Consumer XR: Extended reality intended for consumers rather than professional or enterprise users.

Creative AI: AI that creates text, image, audio and video from very simple human language prompts. It's also known as "generative learning" or "diffusion models."

D

Data locality: The process of moving computation to the node where that data resides, instead of vice versa — helping to minimize network congestion and improve computation throughput.

Data mesh: A data platform organized around business domains where data is treated as a product, with each data product owned by a team. To enable speed and drive standardization, infrastructure teams provide tools that allow data product teams to self-serve.

Decentralized data platforms: Use of multiple data stores instead of singular, monolithic centralized stores. A good example is the "data mesh" (see above).

Decentralized identity: Also known as self-sovereign identity, decentralized identity (DiD) is an open-standards-based identity architecture that uses self-owned and independent digital IDs and verifiable credentials to transmit trusted data. Although not dependent on blockchains, many current examples are deployed on them as well as other forms of distributed ledger technology, and private/public key cryptography, it seeks to protect the privacy of and secure online interactions.

Decentralized security: Rather than using traditional security perimeters that are a single point of failure, techniques such as zero-trust networks instead decentralize security checks across the network.

Decision science: Combines AI tools and techniques with behavioral and management sciences for the purpose of upskilling and amplifying decision making and decision makers across a variety of complex problems from scenario planning to operations research.

Developer experience platforms: Platforms which provide the tooling to make it as easy as possible for developers to create, test and deploy software.

DevSecOps: An abbreviated portmanteau for development, security and operations. This is an approach that includes security as a first-class concern, together with development and operations.

Differential privacy: A privacy technique that introduces noise in a dataset in such a way as to provide individual privacy while still allowing insights to be drawn or machine learning models to be built on top of the data.

Digital carbon management: Measuring organizational green house gas (GHG) emissions and efforts to mitigate those emissions. Establishing a carbon footprint and a program to determine it is an essential component on the journey towards net zero and is the first building block towards any sustainability strategy.

Digital ecosystems: Disparate participants, systems and even organizations that cooperate, collaborate and compete to create an emergent ecosystem where the whole is greater than the sum of the parts. Examples include the travel industry, online marketplaces and new “super apps” such as Gojek and WeChat.

Digital humans: AI-powered virtual assistants and non-playable characters that recreate human interaction within the metaverse.

Digital twin: A virtual model of a process, product or service that allows both simulation and data analysis. 3D visualization can be used together with live data, so you can understand what is happening to pieces of equipment you can’t actually see.

Digitally enabled energy components: Digitally enabled energy components and products, such as electrified transport, are completely different from non-electrified alternatives, for example, petrol-powered vehicles. The software architecture of new and advanced electric vehicles surpasses petrol vehicles due to opportunities found when the whole vehicle is electric.

Distributed energy resources: A category of electrical power generation that are “behind-the-meter.” DERs generate power for the grid, and reward energy credits to the DER owner. An example is solar panels installed on a home.

E

Edge computing: Bringing data storage and processing closer to the devices where it is stored, rather than relying on a central location that may be thousands of miles away. Benefits include reduced latency for real-time systems, and improved data privacy.

Encrypted computation: The ability to perform calculations on encrypted data, without first decrypting it. Useful to maintain data privacy while allowing data storage and manipulation to be outsourced.

Enterprise XR: An umbrella term for virtual and augmented reality and related technologies which are now being used in the enterprise. Advantages can include cost reductions or efficiency or safety improvements.

Ethical frameworks: Decision-making frameworks that attempt to bring transparency and clarity into the decision-making process, especially around the use of AI and potential bias in data.

Evolution of consensus mechanisms: The change in consensus mechanisms at the heart of Bitcoin, Ethereum, and other crypto platforms. Consensus mechanisms include the energy hungry proof of work and the efficient but unfair proof of stake.

Evolutionary architectures: In contrast to traditional up-front, heavyweight enterprise architectural designs, evolutionary architecture accepts that we cannot predict the future and instead provides a mechanism for guided, incremental change to systems architecture.

Explainable AI: A set of tools and approaches to understand the rationale used by an ML model in reaching a conclusion. These tools generally apply to models that are otherwise opaque in their reasoning.

F

Facial recognition: Detection of a human face, matching against a database of faces for identification purposes, and even recognition of a person's emotional state.

Federated learning: An approach that downloads a machine learning model and then computes or trains a specific, modified model using local data on some other device. The approach helps multiple organizations to collaborate on model creation without explicitly exchanging protected data.

Fediverse: An ensemble of interconnected servers that are used for web publishing (i.e. social networking, microblogging, blogging, or websites) and file hosting, but which, while independently hosted, can communicate with each other.

FinOps: An evolving cultural practice where everyone takes ownership of their cloud usage and uses this knowledge to optimize and manage cloud costs.

Fog computing: A decentralized computing infrastructure where data, computation, storage, and applications are somewhere between the data source and the cloud.

Fusion power: The use of nuclear fusion to generate electrical power. Nuclear fusion is the process used by the sun to create energy, and is far more efficient and cleaner than the nuclear fission process we use in today's nuclear reactors.

G

Gesture recognition: Machine understanding and interpretation of human gestures such as waving, making an "up" or "down" motion, hand positioning, and so on.

Green cloud: Data centers fed by renewable energy, running software and systems designed and optimized for efficient processing while also minimizing energy consumption.

Green software engineering: Choosing technologies, programming languages, algorithms and software architectures that are efficient and use less energy resources.

Green UX: Design of user interfaces and prompts that help people understand the environmental consequences of the choices they make. Examples include an airline website displaying carbon emissions for flights or a mapping tool showing the carbon output for driving a particular route.

Growing industry-wide open standards: Industry-specific standards that can help drive better interoperability between companies. Examples include GTIN for product IDs, FHIR for the healthcare industry and the Open Banking initiative in the UK.

I

Increased regulation: The steady increase of regulation, especially around data, privacy, security and greenhouse gas emissions.

Industrial IoT platforms: Services and capabilities that connect, monitor and manage IoT assets in a scalable way. These platforms tend to be cloud based and provide services that cover end-to-device installation, data collection, analytics and intelligence.

Industrial metaverse: Using virtual environments to test and model desired physical outcomes in an industrial context.

Intelligent machine to machine collaboration: Technologies enabling direct interaction of devices and information sharing between them, usually in an autonomous fashion. This enables to decision making and action with little or no human intervention.

Inter-Blockchain Communication (IBC) Protocol: Given that there are over a thousand blockchain protocols and at some point they may need to access information from one another. [Inter-Blockchain Communication protocols](#) establish connections and transfer data between blockchains.

International law for crypto assets: Crypto assets are traded across the world. Similar to the move for international laws for AI, crypto assets also need international law for cross border trading. This might include costs, categories of assets and what constitutes legal trading.

International settlements agreements: For physical assets traded through a blockchain, a **bank for settlements** provides a platform for cooperation and core policy guidance for transacting parties.

M

Metaverse: A version of the internet experienced as a 3-D virtual world. Large companies, content providers and governments are all making investments to construct or participate in the metaverse.

Metaverse interoperability: The ability for multiple different metaverse platforms to interoperate and share data, including avatars, digital assets, and potentially even metaverse apps and experiences.

ML platforms: Platforms designed specifically for machine learning, providing end-to-end capabilities such as data management, feature engineering, model training, model evaluation, model governance, explainability, AutoML, model versioning, promotion between environments, model serving, model deployment and model monitoring.

MLOps: A movement to bring DevOps practices to the field of machine learning. MLOps fosters a culture where people, regardless of title or background, work together to imagine, develop, deploy, operate, monitor and improve machine learning systems in a continuous way. Continuous Delivery for Machine Learning (CD4ML) is Thoughtworks' approach to implement MLOps end-to-end.

N

Natural language processing: Artificial intelligence and other modern technologies

that help computers understand the intent and meaning of spoken or written language. Used for everything from dictation software to analyzing documents for meaning.

Next-generation cryptography: Forms of cryptography created in response to technological or societal challenges. Examples include quantum-resistant encryption algorithms, confidential computing with specialised hardware secure enclaves, homomorphic encryption allowing computation to occur on the data while it is still encrypted, and energy efficient cryptography.

NFTs: A crypto token, usually part of the ethereum blockchain, that represents a digital asset such as art, text or audio, that can be bought and sold. Ownership of an NFT can confer benefits, such as membership of a club or access to events.

O

Online machine learning: A technique where algorithms continuously learn based on the sequential arrival of data, and can explore a problem space in real time. Contrasts with traditional machine learning where model training uses only historical data and cannot respond to dynamic or previously-unseen situations.

Operationalize AI: The work done by organizations to integrate AI and ML into their core processes, products, and IT environments, in order to truly operationalize it and reap the benefits.

P

Personal information economy: A business model that aims to extracting business value from the possession and use of large amounts of personal information. Examples range from the primitive use of cookies to targeted profiling of people via their online usage patterns. This has historically been the domain of companies or intermediate ad-based services trying to retain and target customers, but since GDPR

and similar privacy laws, we are seeing a shift towards people controlling what data they wish to expose in exchange for a service.

Personalized healthcare: Understanding an individual patient's genetic profile to identify potential issues before they happen and provide more effective treatments in response to existing conditions.

Platform business: A business model based on facilitating transactions between an ecosystem of participants, usually consumers and producers, and that creates value through these interactions.

Platforms as products: A way of creating and supporting platforms with a focus on providing customer (user) value instead of treating platform building as a time-boxed project.

Polycloud: Passing different types of workloads to different cloud providers based on their relative strengths, in contrast to a "one cloud fits all" approach.

Privacy first: Respect for an individual's privacy should be top priority and proactive rather than reactive. This is achieved by building security in from the beginning, and must be embedded into all aspects of the product creation lifecycle.

Privacy-aware communication: Communications software that directly advertises its security stance and features, such as end-to-end encryption.

Privacy-enhancing technologies: A collection of technologies and techniques to preserve user privacy, such as anonymization, encrypted computing and differential privacy.

Privacy-respecting computation: New techniques that allow stronger guarantees for privacy, even when personal data is used in computations. Part of the broader category of privacy-enhancing technologies (PETs).

Production immune systems: Systems that monitor metrics and take corrective action if a problem is detected. They are often used for security, but increasingly also for resilience and recovery in the face of an outage.

Q

Quantum computing: Use of probabilistic states of photons, rather than binary ones and zeros, to run algorithms. Although proven to work in the small, quantum computing has yet to scale to broadly useful applications.

Quantum machine learning: Machine learning algorithms adapted and executed on a quantum computing engine, generally used to analyze classical (non-quantum) data.

R

Re-decentralization: Systems, both human and machine, originally designed to be decentralized have become more centralized over time. Re-decentralization refers to the conscious effort of moving those systems back to a decentralized model.

Remote rendering: The practice of rendering interactive 3D scenes on remote servers, instead of rendering them on the user's device. The frames are then streamed to the user as a movie. This enables high quality 3D on smaller devices, if the network connection is sufficiently high bandwidth and low latency.

Retina resolution XR: Ultra-high resolution XR with photorealistic rendering over a wide field of view. Currently only available via extremely expensive headsets. An example is [Varjo XR-3](#).

Robotic process automation and low code: Robotic process automation (RPA) aims to allow scripts or bots to interact with UIs instead of needing a human operator. Low-code seeks to democratize programming, by allowing non-programmers to create software systems.

S

Satellite networks: High-speed, low-latency broadband for places where traditional fiber or wireless network providers won't spend the money to connect. Examples include Starlink from SpaceX, Kuiper from Amazon, OneWeb and Telesat.

Secure software delivery: Security applied to the entire process of software creation, which in modern architectures includes the delivery pipeline used to build, test and deploy applications and infrastructure.

Smart cities: An urban area that uses different types of IoT sensors to collect data coupled with platforms to integrate and act on the data, advising or commanding digitally enabled systems to perform some response. Insights gained from the data are used to manage assets, resources and services efficiently; in return, that data is used to improve the operations across the city.

Smart contracts: A programmable business agreement that allows for automatic execution of actions according to agreed terms.

Smart energy management systems: Ubiquitous availability of energy usage data via measurement equipment, APIs and tools gives a range of energy players (generators, distributors, suppliers, vendors) and customers more ability to understand and analyze their energy usage.

Smart systems and ecosystems: Networks of networks that use AI and ML to enhance a system to become more than the sum of its parts. For example, in a smart city, networks of cars and roadside sensors help speed the flow and safety of traffic.

Spatial audio: Advanced signal processing, originally from Apple, that allows sounds to be placed virtually in 3D space. Spatial audio also tracks headphones and screen position to allow for accurate sound placement.

T

Technology and sovereign power: Rising forces are leading to internet balkanization — the splintering of the internet — many led by nation states. Privacy legislation accelerates this process, as it enforces data rights, data sovereignty, and strongly impacts how companies deploy and distribute systems and data on the Internet.

Technology for circular economy: A closed economic system where raw materials and products are constantly shared so as to lose their value as little as possible. Technology that supports this includes reusable services, traceability, IoT and data mining.

Technology for environment and social governance: There is an increasing need for corporate transparency. If companies were open by default — with appropriate privacy built in — they would gain trust and increase brand strength.

Tokenomics: A system of incentives and behavior control methods, their production, distribution and consumption. This branch of study combines economics and blockchain technology.

Touchless interactions: The ability to interact with devices without touching, driven at least partially as a result of the COVID-19 pandemic. Specific technologies include hand tracking and voice and gesture recognition.

Trust ecosystems: A model where new decentralized ecosystems based on distributed ledgers allow trust to be suitably handled within the ecosystem in a mutually agreeable way to all parties. This includes emerging consortia-based systems focused on specific domains such as energy.

Trustworthy data: An emerging set of techniques to certify the provenance of data and to govern its use across an organization. This could prove transformative in the effort to track and enhance progress towards sustainability targets.

U

Ubiquitous connectivity: Providing connectivity to everyone and everything, everywhere, every time. Some predict ubiquitous connectivity will super-charge innovation in resource-limited parts of the planet, while critics see it as expensive and unnecessary.

Understandable consent: Most terms of service (TOS) or end-user license agreements (EULAs) are impenetrable legalese that make it difficult for people without a law background to understand. Understandable consent seeks to reverse this pattern, with easy-to-understand terms and clear descriptions of how customers' data will be used.

W

Web 3.0: The next version of the web envisioned by Tim Berners-Lee is based on user controlled decentralized data stores called Pods. Pods pick the apps that can access their personal data. This idea, a project called Solid, is not blockchain based.

Web5: A web based on decentralized data and identity based purely on Bitcoin is being proposed as the next version of the Web by Jack Dorsey's Square, now called Block.

X

X-Fi: The postfix "Fi" denotes anything that includes finance as an essential ingredient. TradFi refers to traditional finance, DeFi refers to decentralized finance, CeFi refers to a centrally controlled crypto currency, and GameFi refers to a financial ecosystem within a game world.

XR enabled hybrid working: A collaboration strategy where, using XR, everyone on a hybrid local/remote team interacts with the same shared artifacts, such as whiteboards and other information radiators. This brings the remote collaborators closer to the in-person team.

Thoughtworks is a global technology consultancy that integrates strategy, design and engineering to drive digital innovation. We are 12,000+ people strong across 50 offices in 18 countries.

Over the last 25+ years, we've delivered extraordinary impact together with our clients by helping them solve complex business problems with technology as the differentiator.