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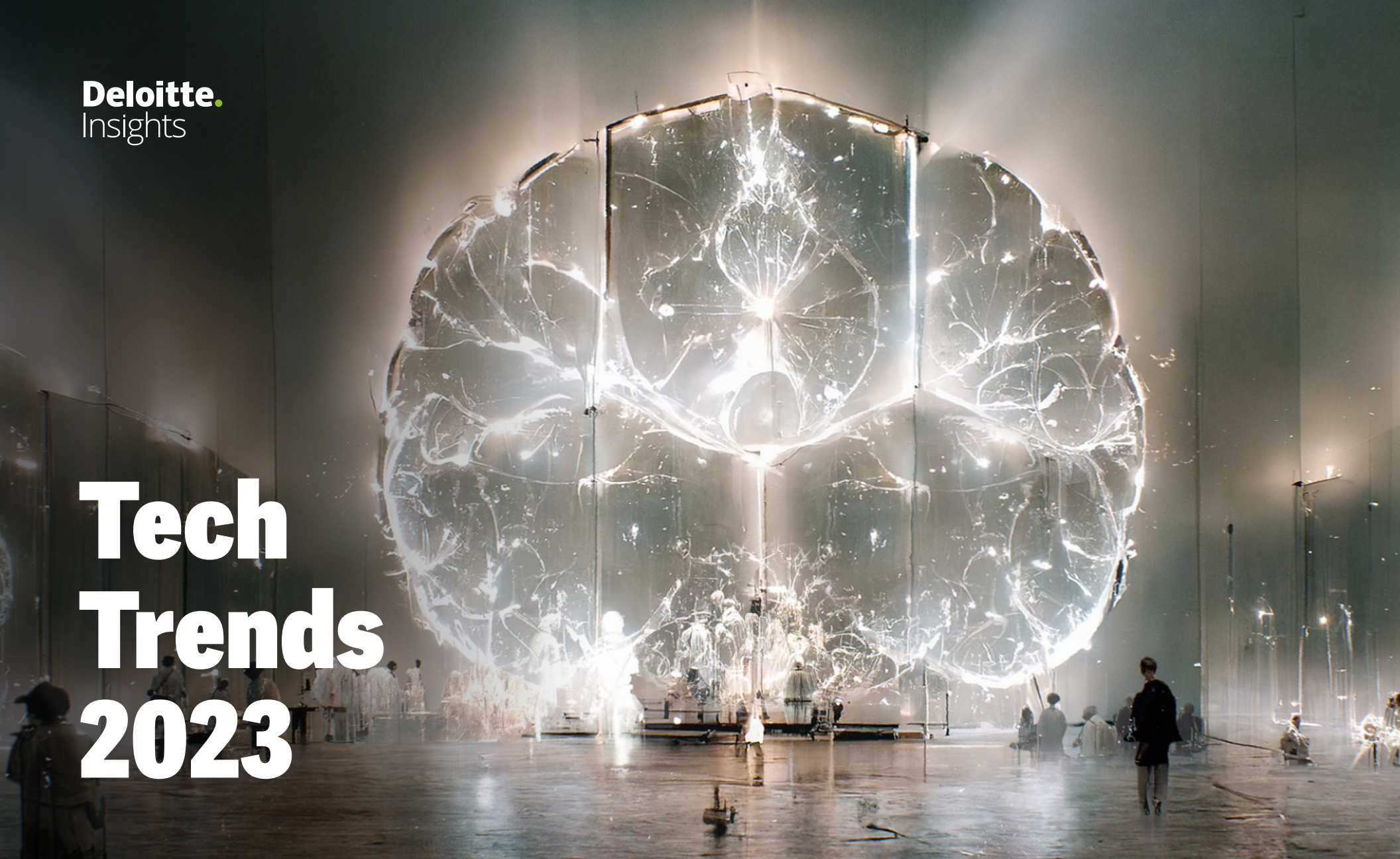
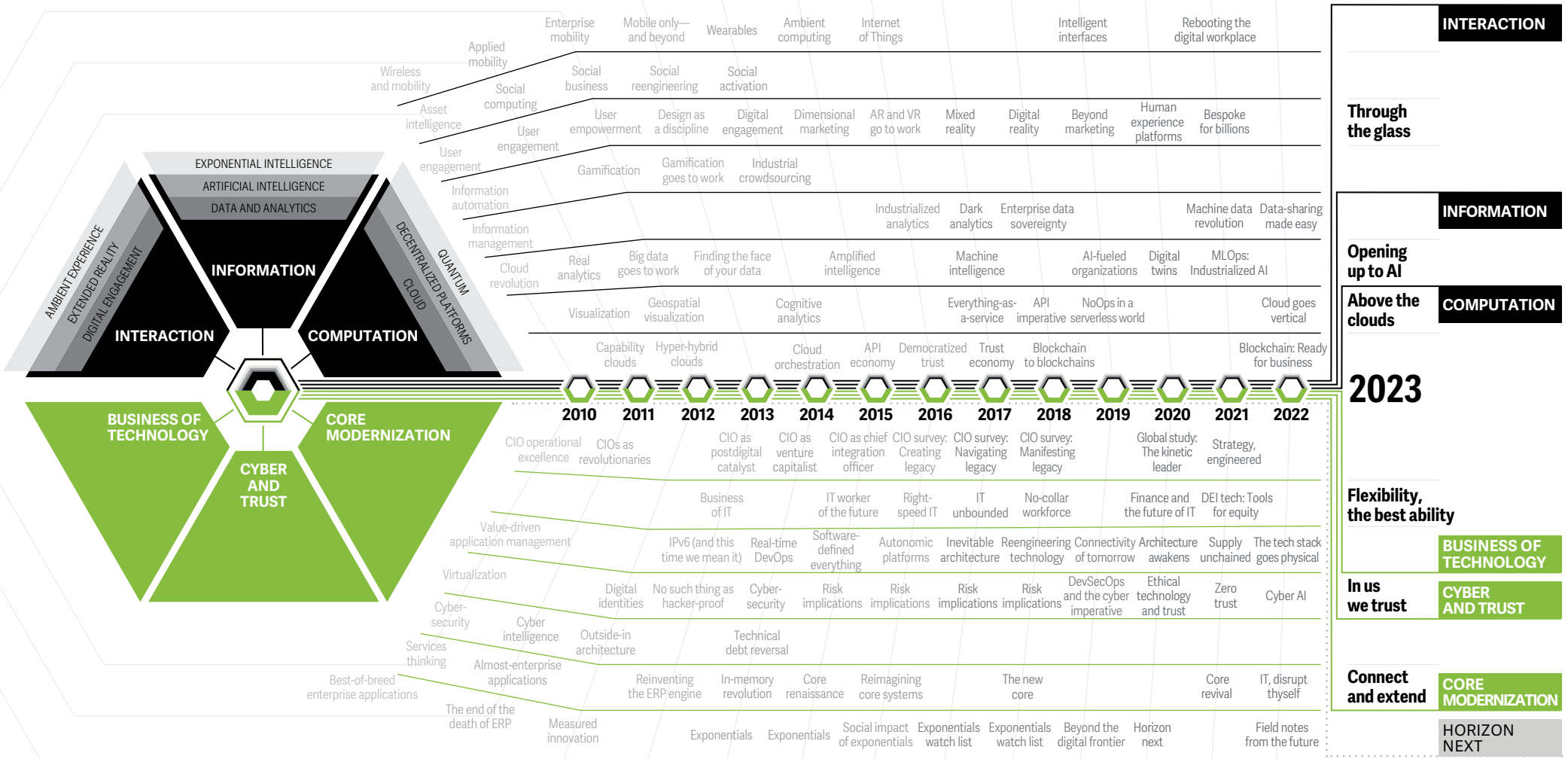
Tech Trends 2023



Trending the trends: Fourteen years of research



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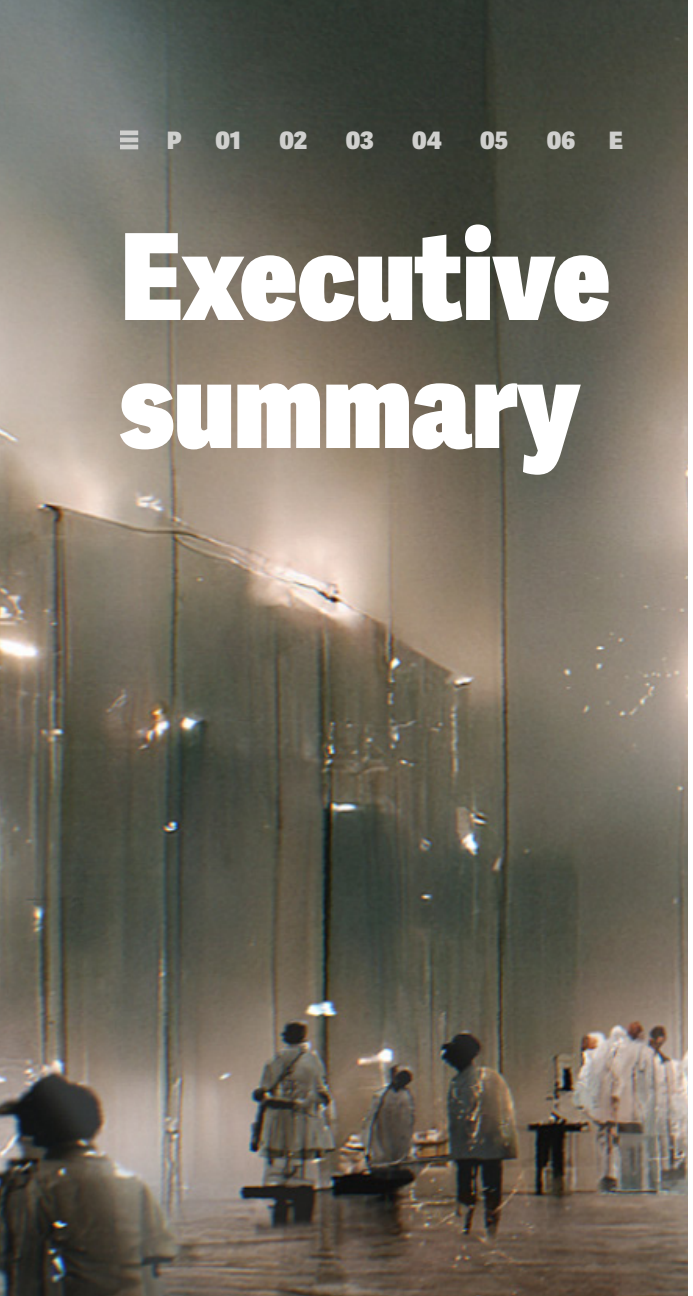


Deloitte's 14th annual *Tech Trends* report explores the impact of emerging technology opportunities in the innovation areas of interaction, information, and computation, and the foundational areas of business of technology, cyber and trust, and core modernization. Through the stories of pioneering organizations, we note what's happening now across sectors and geographies, highlight new technologies and approaches that stand to become the norm within 18 to 24 months, and project where the trends could be headed next during the coming decade.

Prologue: A brief history of the future

The entire history of IT has been a steady evolution of the same three enduring eternities: interaction, information, and computation. The future of IT will continue to march along these same three tracks toward specific, convergent endgames: simplicity, intelligence, and abundance. Three additional categories—the business of technology, cyber and trust, and core modernization—acknowledge the reality that business drives technology, not the other way around, and that extant systems and investments need to play nicely with pioneering innovations so that businesses can seamlessly operate while they grow. Taken together, these six macro technology forces are the backbone of information technology.

Eyes to the sky: Three enduring eternities

The history of IT has been a steady evolution of pioneering innovations in interaction, information, and computation, the three enduring eternities of modern computing.

Trend 1

Through the glass: Immersive internet for the enterprise

For a generation, the connection to the digital world has been mediated through an ever-shrinking series of rectangular screens. Now, as technologists recognize that screens can't keep shrinking forever, the paradigm is shifting again, toward interfaces that take users through the glass and into immersive virtual experiences, including the digital world known as the metaverse. Over the next few years, tangible, conversational, and virtual interfaces will likely continue to graduate from tech to toy to enterprise tool. While some companies build lucrative business models around the unique capabilities afforded by an "unlimited reality," others provide immersive environments for employees to streamline operations or collaborate and learn. As technology advances further over the next decade, organizations should be ready for reality to move online through expanded ways of interacting with mixed reality.

Trend 2

Opening up to AI: Learning to trust our AI colleagues

With AI tools increasingly standardized and commoditized, few businesses may realize true competitive gains from crafting a better algorithm. Instead, what will likely differentiate the truly AI-fueled enterprise from its competition will be how robustly it uses AI throughout its processes. The key element here, which has developed much slower than machine learning technology, is trust. As machines encroach on humanlike tasks that go beyond basic number crunching and enter the realm of discernment and decision-making via AI, the business world is having to develop a new understanding of what it means to trust machines.

Trend 3

Above the clouds: Taming multicloud chaos

To simplify multicloud management, some enterprises are beginning to turn to a layer of abstraction and automation that sits above the burgeoning multicloud. Known alternately as metacloud or supercloud, this family of tools and techniques can help cut through the complexity of multicloud environments by providing access to common services such as storage and computation, AI, data, security, operations, governance, and application development and deployment. Metacloud offers a single pane of control for organizations feeling overwhelmed by multicloud complexity.

Feet firmly on the ground: Three foundational forces

Existing systems and investments—represented by the business of technology, cyber and trust, and core modernization—should integrate well with pioneering innovations so that businesses can seamlessly operate while they grow.

Trend 4

Flexibility, the best ability: Reimagining the tech workforce

In the last year, many organizations have been engaged in a heated competition for a limited supply of technology talent. Yet with technical skills becoming outdated every few years, hiring for current needs is not a winning long-term strategy. Rather than competing in scarcity, savvy leaders consider an abundance frame, wherein technology talent can be curated, created, and cultivated. Companies should be prepared to eschew IT orthodoxies and prize flexibility as the best ability. By building a skills-based organization, tapping into creative sources for finding talent, and providing a compelling talent experience, companies can meet their talent goals. In the longer term, organizations should plan to brush up on their humanities, as AI technology advances enough to carry out many of the lower-order tasks that IT teams are burdened with today.

Trend 5

In us we trust: Decentralized architectures and ecosystems

Blockchain-powered ecosystems are becoming key not only to developing and monetizing digital assets but also to creating digital trust. As organizations begin to understand blockchain's utility, they're realizing that building stakeholder trust could be one of its primary benefits. From everyday enterprise applications to blockchain-native business models, decentralized architectures and ecosystems disintermediate trust, placing it not in a single person or organization but distributing it across the community of users. Organizations may be able to cement their credibility by helping reinvent a more decentralized internet—Web3—in which a single, immutable version of the truth is based on public blockchains. In this world, digital natives are increasingly likely to demand higher-quality proof and higher-order truth. Digital ledger technologies and decentralized business models that achieve consensus through code, cryptography, and technology protocols are demonstrating that none of us is as trustworthy as all of us.

Trend 6

Connect and extend: Mainframe modernization hits its stride

Rather than rip and replace legacy core systems, enterprises are increasingly looking to bring them into the modern era by connecting and extending them to emerging technologies. Through tried-and-true approaches to legacy system modernization, businesses are leveraging mainframes—and their precious data—to drive digital transformation.

Epilogue: Widening the aperture—From infoTech to xTech

Historically, to enterprise audiences, "technology" has served as shorthand for *information* technology. But separate and distinct from enterprise IT, an extended set of technologies—or xTech—are on the horizon. Rooted in the formal, natural, and social sciences, these academic and research areas are brimming with patent and startup activity, technology maturity and advancements, academic and grant investments, and venture capital funding. And they're attracting the best and brightest talent. We anticipate six emerging technology disciplines to eventually rival IT in their impact on business innovation: space and aeronautical engineering; cellular and biomolecular engineering; brain and nervous systems applications and interfaces; climate, sustainability, and the environment; autonomous and precision robotics; and power, energy, and battery technologies.

Prologue

A brief history of the future

Several years ago, at a demo day at Silicon Valley's Computer History Museum, I came face to face with the history of the future. At the time, I was a venture capitalist on the hunt for the next big thing. During a break from startup pitches from the best and brightest entrepreneurs, I wandered among the museum exhibits, where I stumbled upon a modern recreation of the first computer, designed in the 1840s by English polymath Charles Babbage.

I was fascinated to read about Babbage's Victorian-era designs, particularly his Analytical Engine, a mechanical general-purpose computer that he worked on with fellow mathematician Ada Lovelace. The Analytical Engine shared many features with modern digital computers, including three key components: the reader, the mill, and the store. The reader took in punch cards, permitting user interaction with the machine. The store held information—numbers and interim results—until they could be acted upon by the mill, which performed mathematical computations.

Babbage couldn't have known then that these three fundamental functions would still exist today, serving as the enduring foundation of modern computing. In fact, as we demonstrated in a joint research report with the World Economic Forum, the entire history of IT has been a steady evolution of these same three eternities: interaction, information, and computation.[1] In turn, it stands to reason that the *future* of IT will continue to march along these same three tracks toward specific, convergent endgames: simplicity, intelligence, and abundance (figure 1).

Interaction: Toward simplicity

Electronic, digital general-purpose computers appeared about 100 years after Babbage's design. Room-sized computers weighed tons and were programmed with punch cards, but within three decades, users interacted with desk-sized computers using the command-line interface.

By the 1990s, desktop-sized computers boasted graphical user interfaces, and simple iconography replaced arcane computer syntax. Later, point-and-click evolved to touch-and-swipe on portable computers carried in pockets and worn on wrists, and to virtual assistants that can understand voice commands. Today, extended reality can take us to immersive 3D universes where our digital doppelgangers interact and engage in virtual experiences.

FIGURE 1: A brief history of the future

TIME (years) ←	t–175	t–75	t–50	t–25	t–10	t	t+10	t+n	t=∞ →
Eternities	**Babbage's design**	**First digital computer**	**Mid-20th century**	**Late-20th century**	**Early 21st century**	**2023** *Today*	**Horizon next**	**Furthest stars**	**Endgames**
Interaction	Reader	Punched cards	Command-line	Graphical user interface (GUI)	Mobile devices	Extended reality	Ambient experiences	Neural interfaces	**Simplicity**
Information	Store	Arithmetic calculation	Relational databases	Descriptive analytics	Predictive analytics	Cognitive automation	Exponential intelligence	General-purpose AI	**Intelligence**
Computation	Mill	Mainframe	Mini-computer	Client server	Cloud architectures	Decentralized platforms	Spatial web	Quantum computing	**Abundance**

Source: Deloitte, Technology Futures Report 2021, accessed October 2022.

What's next for interaction?

The technologies that power human-computer interaction get more complex, but user experiences get *simpler*.

So what's simpler still? Ambient experiences, in which ubiquitous digital assistants monitor the environment, awaiting a voice, gesture, or glance, reacting to (or proactively anticipating) and fulfilling our requests. And beyond that? Neural interfaces that afford direct communication between biological thought and digital response. Today's smart thermostats accept voice control; tomorrow's will know you feel chilly and proactively adjust to ensure your comfort. Researchers are already exploring how neural interfaces might help people with certain disabilities use brain signals to control external devices.

Information: Toward intelligence

When Babbage designed his Analytical Engine, information meant numbers and, later, mathematical operations. Over time, arithmetical calculations gave way to relational databases of clearly defined and structured data. By the aughts, databases became advanced enough to manage unstructured data such as text, audio, and video. This structured and unstructured data could, in turn, be mined for patterns and trends. So began the era of descriptive analytics.

The last decade or so saw the rise of predictive analytics: what we can expect to happen based on observed patterns and trends. Today, cognitive automation systems combine predictive analytics with algorithms and AI to make useful data-driven decisions in real time.

What's next for information?

As our information systems continue to advance, machine intelligence itself will become increasingly well rounded.

Computer scientist Larry Tesler once quipped, "Artificial intelligence is whatever hasn't been done yet."[2] The future of AI, then, might be broadly defined as exponential intelligence: a progression up the curve of capabilities that have, to date, seemed "uniquely human."

Affective AI—empathic emotional intelligence—will result in machines with personality and charm. We'll eventually be able to train mechanical minds with uniquely human data—the smile on a face, the twinkle in an eye, the pause in a voice—and teach them to discern and emulate human emotions. Or consider generative AI: creative intelligence that can write poetry, paint a picture, or score a soundtrack.

After that, we may see the rise of general purpose AI: intelligence that has evolved from simple math to polymath. Today's AI is capable of single-tasking, good at playing chess or driving cars but unable to do both. General purpose AI stands to deliver versatile systems that can learn and imitate a collection of previously uniquely human traits.

Computation: Toward abundance

Computation turns inputs into outputs. From mill to mainframe to minicomputer to client server, advances in computation were a story of miniaturization: Moore's law and the relentless march towards better, faster, cheaper, and stronger. In practice, that changed over the decades with advances in virtualization, culminating in modern cloud architectures. Computing became a distributed utility, promising elasticity, flexibility, and possibility to those embracing it.

Today, the shift to the cloud has, in turn, given further rise to decentralization—technologies and platforms rooted in the cryptographically secure blockchain. Decentralization recognizes that millions of processors, disks, and resources sit idle for much of the time, and that they can be marshaled as resources. Decentralized storage, compute, domain name system (DNS)—and yes, currencies—spread the work and the trust across a community of network participants, demonstrating that none of us is as capable, or as trustworthy, as all of us.

What's next for computation?

As computers continue to miniaturize, virtualize, and decentralize, our capacity to process data, create and curate content, develop and code, and solve problems is on an unstoppable march toward abundance.

Fueled by decentralized networks, edge computing, and advanced connectivity, the spatial web is likely to blur the lines between physical and virtual environments. As reality itself increasingly comes online, digital content will be seamlessly woven into our physical spaces, inseparable from our shared personal and professional experiences. And waiting in the wings? Quantum computing—going beyond bits entirely, and harnessing the quirky laws of quantum mechanics to speedily solve previously intractable problems with physics rather than mathematics.

Tech Trends 2023: Eyes to the skies, feet firmly on the ground

Futurists don't have crystal balls. Instead, we subscribe to the notion that "the future is already here, albeit unevenly distributed." Our *Tech Trends* team has spent the better part of 14 years looking across all sectors and geographies for glimpses of pioneering leaders building distinct facets of the future, today. Fully half of the trends that we've chronicled fit into the three enduring categories of interaction, information, and computation described above.

But why only half?

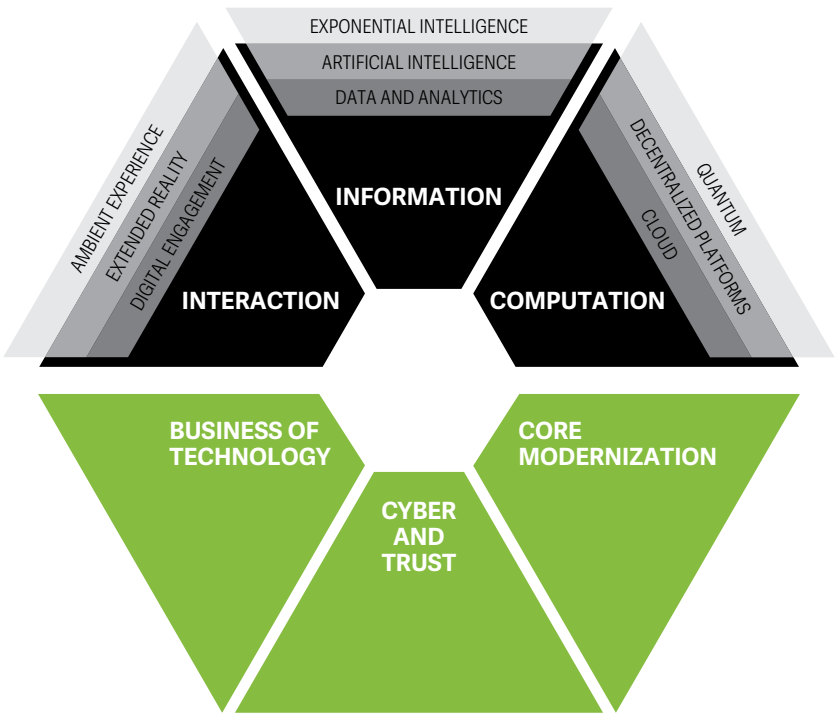
Startups often embrace the mantra "move fast and break things." It's easier for them to be disruptive because they're definitionally starting from zero and don't yet have a legacy to protect. Established organizations, on the other hand, very much do. Successful businesses realize they can't risk breaking "now" in pursuit of "new." Our responsibility is to balance our pioneering inclinations with the solemn duty of stewardship; to do no harm, the Hippocratic oath of IT. Responsible enterprise professionals must nurture what they have now as they seek to navigate to what's next.

To this end, we further chronicle emerging trends in three *additional* categories—the business of technology, cyber and trust, and core modernization—to acknowledge the reality that business drives technology, not the other way around, and that extant systems and investments need to play nicely with pioneering innovations so that businesses can seamlessly operate while they grow.

Taken together, we call these the six macro technology forces of information technology (figure 2).

We've arrived at this year's trends through both primary research and lived experience, interviewing both industry and public sector leaders who have developed innovations in everything from resilient manufacturing and data repatriation to digital and biometric credentialing. Their input helped us shape the six trends chronicled in *Tech Trends 2023*.

FIGURE 2: Six macro forces of information technology



Source: Deloitte analysis.

As we prepare for launch, I'd encourage a moment of perspective-cum-humility. Futurists are secretly historians. And as Mark Twain reportedly said, "History doesn't repeat itself, but it often rhymes."[3] Having worked in all things newfangled for 25 years, I've seen literally thousands of self-styled "world-changing technologies," but *none* that have marked "the end of history." It's a sobering thought to realize that today's white-hot innovations will indeed become tomorrow's legacy applications—that our pioneering advances might one day be dismissed by the new generation as "the old way." This is not meant to depress, but to embolden. It might be said that success for us as makers is building something significant and sustainable enough that our successors take notice and flag it for further modernization. Our job, dear reader and fellow leader, is not to hubristically chase "future-proof," but to humbly target "future-friendly."

Onward,
~!mb

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Spoiler alert: What if I told you that information technology is just the tip of the proverbial iceberg? We're witnessing the rise of many additional technology areas that will have an equally significant impact on business innovation. We'll spill the tea in our epilogue. In the meantime, enjoy *Tech Trends 2023*.

Endnotes

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Trend 1
Through the glass: Immersive internet for the enterprise

Technologies such as augmented and virtual reality are transforming the metaverse from specialized tech to enterprise tool—potentially paving the way to new business models.

Since the first computer was built, businesses and consumers have enjoyed a progression toward simpler and more intimate interactions with technology. Professors wielding punch cards gradually gave way to business people brandishing PCs and, more recently, mobile and wearable devices. In a sense, the connection to the digital world has been mediated through a series of ever-shrinking rectangular screens. Networking and computational advancements have led users to constantly switch back and forth between their devices and physical reality. Now, as technologists recognize that screens can't keep shrinking forever, the paradigm is shifting again, toward interfaces that take us through the glass and into immersive virtual experiences, including the digital world known as the metaverse.

While the term *metaverse* was coined in 1992, and virtual worlds have been popular in online games over the past two decades, a marked shift has occurred in recent years. The proliferation of affordable augmented and virtual reality (AR/VR) technology and the cultural shift brought on by the COVID-19 pandemic have catalyzed the acceptance and importance of digital worlds as viable places for human connection. In addition, architectural challenges that slowed previous incarnations of immersive spaces, such as *Second Life*, have since been partially mitigated by the elasticity of cloud computing.[1]

Businesses have also doubled down on **virtual worlds**, with tens of billions in venture capital investment in the past year, and analysts estimating a US$800 billion market by 2024.[2] Despite the hyperbole around the metaverse, leaders should consider it *not* as a diminished proxy for in-person experiences but instead as an enriched alternative to email, text chat, and heads in square boxes. In other words, the metaverse is best thought of as a more immersive incarnation of the internet itself: "internet plus" as opposed to "reality minus."

Over the next couple of years, virtual interfaces will likely continue to graduate from tech to toy to tool as companies build business models around the capabilities afforded by an "**unlimited reality**."[3] Innovative companies are likely to reduce costs, increase customer engagement, and pioneer entirely new offerings for a piece of the budding market. Investing in technologies such as edge computing and AR/VR devices may become table stakes, so intentional, strategic adoption will be crucial.

Now

The metaverse has graduated from tech to (lucrative) toy on its path to enterprise tool

Consider the metaverse use case that has defined the market up to now: gaming. The entire digital gaming industry is expected to surpass US$220 billion in revenue in 2023, more than streaming video, digital music, and e-books *combined*.[4] Specifically, the online gaming industry is poised to exceed US$26 billion in 2023,[5] boasting an audience of 1.1 billion gamers.[6] Crucially, these gamers often gather online not just for gameplay but for the social and commercial possibilities offered by the immersive internet.

About a quarter of US gamers have attended an in-game event in the last year: The Fortnite concerts of Ariana Grande and Charlie Puth attracted millions of players.[7] A striking 82% of those attending live in-game events also made a purchase because of the event, either in the form of digital goods or physical merchandise.[8] In fact, luxury brand Gucci made news for selling a virtual handbag in the game Roblox for US$800 more than its real-world price.[9] Such figures are emphatic proof that the economy of the immersive internet mirrors the physical world: Brands can charge a premium for providing a unique experience or signaling value to other consumers. Considering these market opportunities in existing digital worlds, brands across industries can invest now to meet today's customers where they *already are*.

Whether through gaming or other means, 25% of consumers could be spending at least one hour in the metaverse each day by 2026, while 30% of businesses are estimated to have products and services ready.[10] By the time the metaverse becomes a full-blown enterprise norm, a sound strategy could make the difference between winners and losers in the burgeoning market.

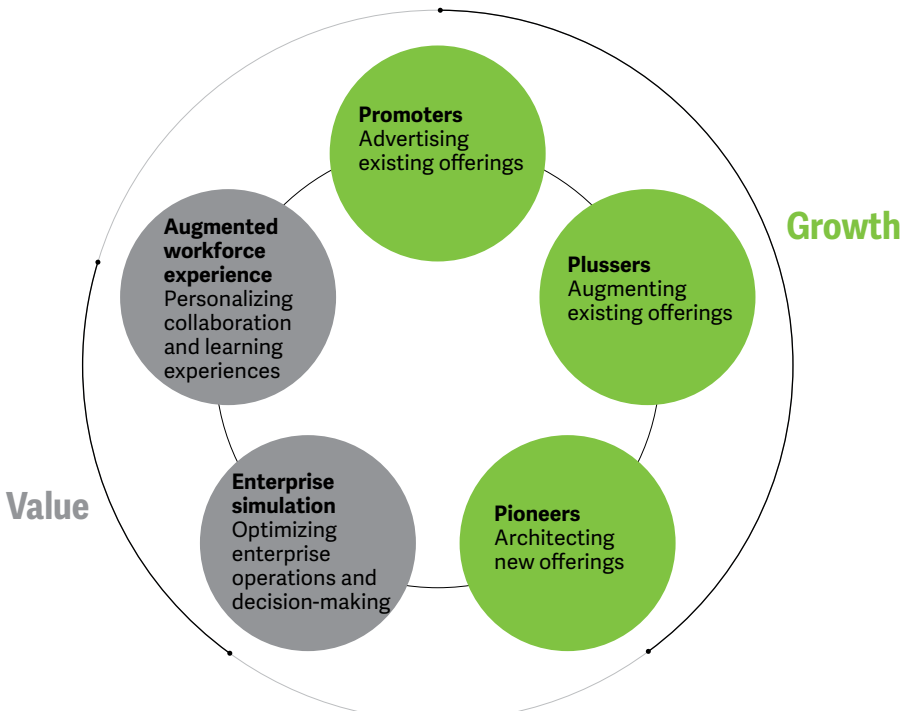
The entire digital gaming industry is expected to surpass US$220 billion in revenue in 2023, more than streaming video, digital music, and e-books *combined*.

New

To turn the metaverse from toy to enterprise tool, start with strategy

As enterprise use cases for immersive experiences emerge, those looking to create an adoption plan should consider history as their guide. By studying the adoption of the internet during the dot-com boom, businesses might better predict how to move forward into the metaverse. While some will seek to grow new streams of revenue through mixed-reality experiences and engagement for consumers, others may focus on optimizing operations through enterprise simulations and augmented workforce experiences (figure 1).

FIGURE 1: Choose your metaverse strategy and tactics



Source: Deloitte analysis.

Growth: Mixed reality experience and engagement

Promoters

Companies that have used the existing internet primarily to promote their products and services will likely continue to be promoters in the metaverse. Instead of a banner ad in the middle of the article they're reading, consumers may see interactive billboards while taking a stroll in the metaverse or enter a virtual storefront like those set up by Ralph Lauren.[11] Companies in this category may not consider the metaverse a core part of their product model but a way to engage consumers as the technology becomes more prevalent.

Plussers

For another set of companies, new AR/VR technologies present an avenue to augment, or "plus," their products and services in ways that are specific to the immersive internet. Like restaurants that used the web to fulfill delivery orders during the pandemic, "plussers" can cash in on today's metaverse interest without reinventing their business model. For example, the United Kingdom's **Lawn Tennis Association** (LTA), which organizes Wimbledon each year, recently augmented its brand by embedding AR messages into tennis ball canisters. Upon scanning a QR code, players see a tailored AR message from a prominent tennis figure, inviting them to an event or encouraging them to continue practicing.[12]

Through limited and strategic additions, even organizations that are not digital natives can attract younger consumers and update their offerings for a more immersive internet. For example, governments as diverse as the city of Santa Monica, South Korea, and **Saudi Arabia** are exploring how the metaverse can improve public services.[13]

Pioneers

The last category of revenue generation is reserved for companies aiming to take higher risks on the metaverse's potential—just as some companies created online-only business models in the early 2000s. Such companies are already developing key foundational metaverse technologies, platforms, products, services, content, and other enabling components. A prime example is Niantic, the maker of the mobile game Pokémon Go, which popularized the possibilities of an AR metaverse for tens of millions of users and grew in valuation from US$150 million to US$9 billion.[14] Companies that want to replicate this success are already investing in metaverse designers and creators who can envision exciting digital futures. Before the economic landscape of the metaverse changes from fluid to concrete, pioneers will need to make their moves.

Value: Optimization and process improvement

Enterprise simulation

The metaverse need not be entirely about top-line growth. Indeed, many may look to immersive digital experiences to preserve, protect, and optimize their existing business models. Virtual testing grounds can reduce the cost of designing, building, and operating complex machinery in capital-intensive industries such as aviation. For example, both Airbus and Boeing are creating digital twins of new airplanes and outfitting their mechanics with AR headsets, leading to quality improvements above 70%.[15] Similarly, **NVIDIA** has developed an Omniverse platform, where manufacturers like BMW can simulate entire factories. The automaker expects to see a 30% gain in efficiency by applying AI to optimize floor movements.[16]

Importantly, not all enterprise simulations require headsets to engage with advanced scenario and strategic planning. Many impactful deployments are still using more traditional "glass"—tablets, laptops, kiosks, etc.—to allow a wide range of stakeholders to engage with tools to better understand, predict, and optimize their businesses. For instance, Stora Enso, a leading provider of renewable products in packaging, biomaterials, wooden construction, and paper, and one of the largest private forest owners in the world, aims to develop a digital twin of a forest to provide decision support for its forestry practitioners and protection of biodiversity through sustainable forest management.[17]

Augmented workforce experience

Other enterprises are looking to immersive technologies such as AR/VR to provide personalized experiences for learning and collaboration that are intuitive, streamlined, and scalable. These solutions have the ability to provide better data on participation rates, how long trainees are spending on lessons, and the steps they are struggling with—leading to improved training effectiveness. Case in point: **Exelon**, the largest electric utility in the United States, has seen significant benefits from rolling out VR trainings. Since electrical substations can be dangerous to the uninitiated, the virtual environment allows Exelon's staff to build muscle memory for donning protective gear and solving electrical issues, without risking their safety.[18]

Despite the media focus on revenue potential, some of the best uses of the immersive internet may be in creating equitable access to company processes and developmental opportunities, just as some of the best enterprise uses of the internet have been in storing and accessing internal data online.

Next

Reality moves online

Regardless of how enterprises adopt the immersive internet in their business models in the next two years, these technologies are still nascent. Going forward, the simultaneous advance of computing, connectivity, and context (location-based data and more) should create an array of exciting possibilities for the metaverse and immersive technologies. Potential paths for the next decade of progress include:

- **Sensory expansion.** Until now, immersive technologies have focused on visual and auditory stimulation, but consider the possibility of one day smelling a cake baking in the metaverse or, if you're willing to lick a screen, tasting it.[19] Startups such as OVR Technology are developing scent packs to connect to VR headsets,[20] while others such as HaptX are building haptic gloves to deliver a sense of touch.[21]

- **Thought-based control.** Brain-computer interfaces (BCIs) represent an extreme in simplifying user interactions with technology. While chips in brains may sound like science fiction, noninvasive BCI technology is already finding its way into AR/VR headsets,[22] which should eventually allow users to control digital avatars and environments using thoughts.

- **All-in-one devices.** The next generation of devices may connect users to the metaverse without requiring additional headsets or handheld devices. Imagine stepping into a media room that displays the metaverse as a hologram across the walls. Or imagine a laptop that uses cameras to translate an employee's real-life gestures into an avatar's movement in the virtual workplace.

- **Spatial interaction.** AR tools such as smart glasses and motion sensors can enable spatial interaction, allowing users to interact directly with physical data without creating a digital copy. For example, patrons can walk up to a restaurant wearing smart glasses and be treated to a display of hours, current promotions, and reviews. Or, by suppressing images in their glasses, a group of friends can attend a concert without seeing any of the city billboards in view.[23]

As we suggested in our **prologue**, technology interaction is poised to progress from separate digital realities toward ambient computing, where users can move beyond the glass and look up from their devices at a world that synchronizes effortlessly with technology.[24] In each path previewed above, the common denominator is simplicity, the ultimate end game of technology interaction.

Yet as leaders prepare for this future, they should know that the risks, including cybersecurity, privacy, safety, regulation, and ethics, are anything but simple. Given immersive technologies' potentially profound impact on the economy, enterprises' highest-level leaders and boards should dedicate their time to shaping the technology in a way that protects trust and creates value.

If history continues to be a guide for future-ready leaders, then moving through the glass and beyond will likely require moving beyond established orthodoxies. Preparing now could help propel enterprises from the current internet age to the next.

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Trend 2
Opening up to AI: Learning to trust our AI colleagues

While the value of artificial intelligence is now undoubtable, the question has become how to best use it—and that often boils down to how much workers and end users trust AI tools.

Computers were once seen as more or less infallible machines that simply processed discrete inputs into discrete outputs, whose calculations were never wrong. If a problem ever arose in a calculation or business process, it was definitionally caused by human error, not the computer.

But as machines encroach on ever-more humanlike tasks that go beyond basic number crunching and enter the realm of discernment and decision-making via artificial intelligence (AI), the business world is developing a new understanding of what it means to trust machines.

The degree to which businesses and workers learn to trust their AI "colleagues" could play an important role in their business success. Most organizations today say they're data-driven. Many even call themselves AI-fueled companies.[1] There's plenty of evidence suggesting businesses that use AI pervasively throughout their operations perform at a higher level than those that don't: Enterprises that have an AI strategy are 1.7 times more likely to achieve their goals than those that lack such a vision.[2]

Yet the underlying AI tool implemented in a given workflow matters less.[3] With cloud vendors increasingly offering prebuilt models, any business can access world-class AI functionality with a few clicks. The top-performing facial recognition vendors ranked by the National Institute of Standards and Technology deliver comparable performance, and they're all easily accessed through cloud-based services.[4] It's what you do with the tool that's important—and whether your people, customers, and business trust the results.

So what may matter in the future is not who can craft the best algorithm, but rather who can use AI most effectively. As algorithms increasingly shoulder *probabilistic* tasks such as object detection, speech recognition, and image and text generation, the real impact of AI applications may depend on how much their human colleagues understand and agree with what they're doing.

People don't embrace what they don't understand. We spent the last 10 years trying to get machines to understand us better. Now it looks like the next 10 years might be more about innovations that help us understand machines.

Developing processes that leverage AI in transparent and explainable ways will be key to spurring adoption.

"What we're designing is an interface of trust between a human and a machine," says Jason Lim, identity management capability manager at the **Transportation Security Administration**. "Now you're taking an input from a machine and feeding it into your decision-making. If humans don't trust machines or think they're making the right call, it won't be used."[5]

Think of deploying AI like onboarding a new team member. We know generally what makes for effective teams: openness, rapport, the ability to have honest discussions, and a willingness to accept feedback to improve performance. Implementing AI with this framework in mind may help the team view AI as a trusted copilot rather than a brilliant but taciturn critic. When applications are transparent, resilient, and dependable, they can become a natural part of the workstream.

Now

Business-critical but inscrutable

When recruiting new team members, managers often look for the right mix of skills and fit. Few leaders doubt AI's abilities to contribute to the team. According to one survey, 73% of businesses say AI is critical to their success.[6]

But they're less sold on fit. Currently, enterprises have a hard time trusting AI with mission-critical tasks. The same report found that 41% of technologists are concerned about the ethics of the AI tools their company uses, and 47% of business leaders have concerns about transparency,[7] the ability for users to understand the data that went into a model.

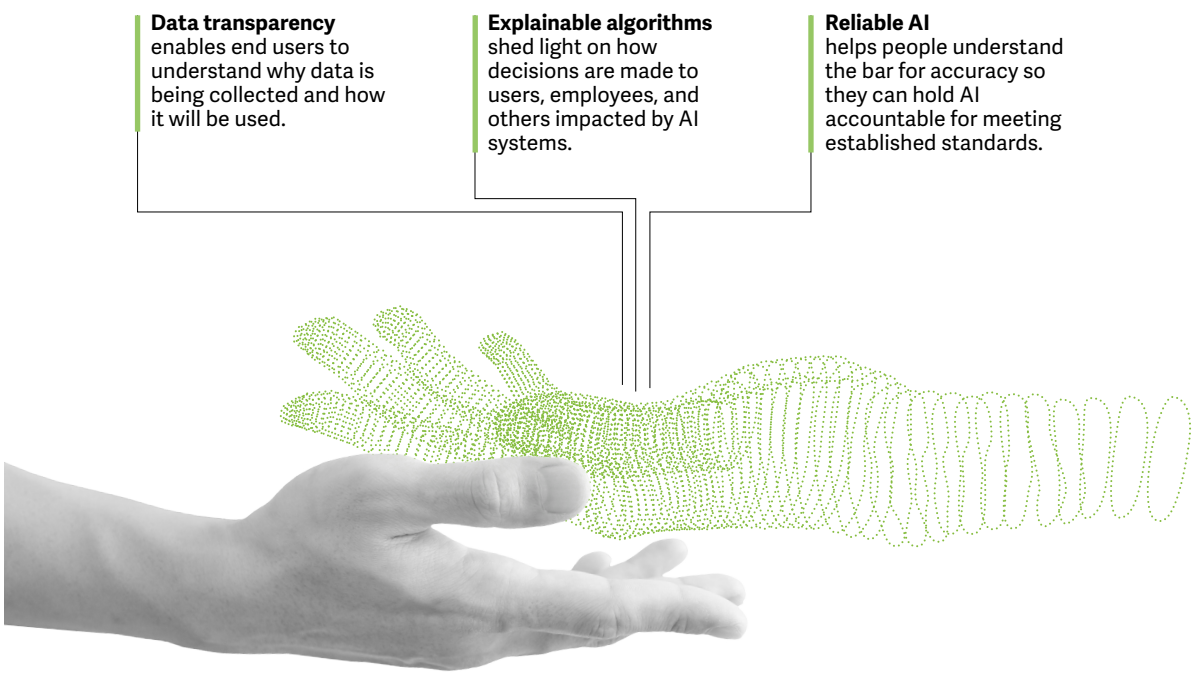
Enterprises are also grappling with a related concept, explainability, the ability of a model to give an explicit justification for its decision or recommendation. Explainability in AI systems is necessary when it is required by regulations, but it's also becoming expected functionality in situations where it helps make clear to end users how to use a tool, improve the system generally, and assess fairness.[8] Explainability is one of the biggest differentiators between the successful use of AI at scale and failure to reap returns on AI investment, yet many businesses haven't figured out how to achieve it.

New

From black box to glass box

Mistrust of AI can come from business leaders, front-line workers, and consumers. Regardless of its origin, it can dampen enterprises' AI enthusiasm and, in turn, adoption. But leading organizations are working on solving issues that diminish trust in AI implementations. Some of the most effective approaches treat AI not so much as a point technology but rather as a piece in a larger process, considering the various stages where humans interact with the AI system and working to identify and address areas of potential mistrust. Acknowledging that AI tools are techniques to be woven into the larger tapestry of processes within an organization can make it easier to fix trust issues proactively. For more trusted AI, forward-thinking enterprises are leaning on data transparency, algorithmic explainability, and AI reliability (figure 1).

FIGURE 1: How to make AI more trusted



Source: Deloitte analysis

Data transparency

Transparent data-collection methods enable the end user to understand why certain pieces of information are being collected and how they're going to be used. When users have this control, they can make informed decisions about whether the AI tool represents a fair value exchange.[9]

The Saudi Tourism Authority used this approach when developing a new application for travelers. The app uses AI to guide tourists through their stay in the country, recommending restaurants, attractions, and other activities based on location and preferences. But importantly, the user is in control of the data they provide to the app. Visitors can determine how much or how little data they hand over, or can opt out completely, with the understanding that giving the app less data access may mean less-tailored recommendations.[10] This stands in contrast to many apps that have all-or-nothing data access requirements that generally serve as a poor foundation for trust.[11]

Algorithmic explainability

One of the biggest clouds hanging over AI today is its black-box problem. Because of how certain algorithms train, it can be very difficult, if not impossible, to understand how they arrive at a recommendation. Asking workers to do something simply because the great and powerful algorithm behind the curtain says to is likely to lead to low levels of buy-in.

One automaker in the United Kingdom is tackling this problem by bringing front-line workers into the process of developing AI tools. The manufacturer wanted to bring more AI into the vehicle-assembly process by enabling machine learning to control assembly robots and identify potentially misaligned parts before the vehicle gets too far into the assembly process. At the start of the development process, engineers bring in frontline assembly workers to gauge their perception of problems and use that to inform development. Rather than dropping AI into an arbitrary point in the production process, they use it where the assemblers say they most need help.

The tools ultimately built are interpretable because the workers' input forms the basis of alerts and recommendations. In other words, it's easy for assemblers to see how the AI platform's recommendations map to the problems they themselves helped define. By bringing in

workers at the start and helping them understand how the AI functions, developers are able to support the assembly team with trusted cobot coworkers rather than a silicon overlord dictating opaque instructions.

AI reliability

People have grown accustomed to a certain level of reliability from work applications. When you open an internet browser or word-processing application, it typically simply "behaves." More specialized business applications such as customer relationship management platforms and enterprise resource management tools may be a bit more finicky, but their challenges are fairly well established, and good developers know how to troubleshoot them.

With AI, the question isn't whether it will work but rather how accurate the result will be or how precisely the model will assess a situation. AI is generally neither right nor wrong in the traditional sense. AI outputs are probabilistic, expressing the likelihood of certain outcomes or conditions as percentages—like a weather forecast predicting a 60% chance of rain—which can make assessing reliability a challenge. But workers need to know how accurate and precise AI is, particularly in critical scenarios such as health care applications.[12]

AI is sometimes viewed as much as an art as a science, but that may need to change for robust adoption. Organizations that take a rigorous approach to ensuring AI reliability consistently see better results. Those that document and enforce **MLOps processes**—a set of procedures designed to ensure machine learning tools are deployed in a consistent and reliable manner—are twice as likely as those that don't to achieve their goals and to deploy AI in a trustworthy way.[13] Taking an operations-minded approach puts guardrails around AI and helps build confidence that it is subject to the same standards of reliability as any other business application.

But reliable doesn't necessarily mean perfect. Just as human coworkers will never deliver perfect results every time, AI too will make mistakes. So the bar for reliability is not perfection, but rather how often it meets or exceeds an existing performance standard.

We spent the last 10 years trying to get machines to understand us better. Now it looks like the next 10 years might be more about innovations that help us understand machines.

Next

Creative machines

As enterprises deploy AI in traditional operational systems, a new trend is taking shape on the horizon: generative AI. We're already seeing the emergence of tools such as OpenAI's Dall-E 2 image generator and GPT-3 text generator. There's a generative model for music called Jukebox that lets users automatically create songs that mimic specific artists' styles.[14] AI is increasingly being used to automatically caption live audio and video.[15] These types of content generators are getting more sophisticated by the day and are reaching the point where people have a hard time telling the difference between artificially rendered works and those created by humans.

Concern over automation's impact on jobs is nothing new, but it is growing ever more pronounced as we head toward this automatically generated future. In many cases, generative AI is proving itself in areas that were once thought to be automation-proof: Even poets, painters, and priests are finding no job will be untouched by machines.

That does not mean, however, that these jobs are going away. Even the most sophisticated AI applications today can't match humans when it comes to purely creative tasks such as conceptualization, and we're still a long way off from AI tools that can unseat humans in jobs in these areas. A smart approach to bringing in new AI tools is to position them as assistants, not competitors.

Companies still need designers to develop concepts and choose the best output, even if designers aren't doing as much of the manipulating of images directly. They need writers to understand topics and connect them to readers' interests. In these cases, content generators are just another tool. As OpenAI's CEO Sam Altman writes in a blog on DALLE-2, "It's an example of a world in which good ideas are the limit for what we can do, not specific skills."[16]

Workers and companies that learn to team with AI and leverage the unique strengths of both AI and humans may find that we're all better together. Think about the creative, connective capabilities of the human mind combined with AI's talent for production work. We're seeing this approach come to life in the emerging role of the prompt engineer.[17] This teaming approach may lead to better job security for workers and better employee experience for businesses.

AI continues to push into new use cases through emerging capabilities that most people thought would remain the exclusive domain of humans. As enterprises consider adopting these capabilities, they could benefit from thinking about how users will interact with them and how that will impact trust. For some businesses, the functionality offered by emerging AI tools could be game-changing. But a lack of trust could ultimately derail these ambitions.

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Trend 3
Above the clouds: Taming multicloud chaos

To simplify multicloud management, enterprises are beginning to turn to a layer of abstraction and automation that offers a single pane of control.

The early days of cloud computing felt boundless. Freed from the limitations of on-premises servers, developers could build exciting new products and services tethered only by their imagination. Unconstrained by bureaucratic processes governing resource utilization, software engineers enjoyed an infinitely scalable palette that could seemingly manifest exactly what they needed at the push of a button. And as vendors began adding more and more capabilities providing advanced functionality like machine learning to their platforms, the cloud quickly became a one-stop-shop for all needs, everywhere.

But enterprises are awakening to the gray lining of the cloud. As developers' enthusiasm for the latest cloud services and tools grew, so too did the number of platforms businesses were supporting. This has created a tangled web of cloud tools that are sometimes interconnected but just as often redundant.

Enterprise adoption of multicloud strategies—using a mix of cloud environments and providers—continues to grow. But while a multicloud strategy can at least in theory provide specialized capabilities and optimized pricing, applications and workloads can be challenging to design and operate due to the complexity of working with a heterogeneous mix of proprietary platforms, services, and interfaces. And that means many companies struggle to fully realize all the benefits of their cloud investments, which, when done right, can include on-demand self-servicing, broad network access, rapid elasticity, resource pooling, and measured service. To simplify this management, some enterprises are beginning to turn to a layer of abstraction and automation that sits above the burgeoning multicloud. Alternately known as metacloud, supercloud, or sky computing, the concept of putting a compatibility layer on top of multiple clouds is gaining steam, even though it still carries some important caveats that businesses should consider.

Now

Multicloud is a tangled web

Today, the vast majority of enterprises are living with multiple platform-as-a-service tools, whether they want to or not. As much as 85% of businesses are using two or more cloud platforms, and 25% are using at least five. This situation is unlikely to change anytime soon. Solution teams want to use what they perceive to be the best tool for the job, regardless of what cloud it's in.[1] They do not want to be subject to the availability of tools within a single vendor's walled garden. Also, they're using vendors' competitors as leverage to obtain better terms for services.[2] Consolidating operations within a single cloud vendor is unlikely to be a tenable solution for most businesses, and multicloud will likely be a dominant thread for the foreseeable future.

However, many companies that are now in a multicloud environment find they got there inadvertently. They brought in new services ad hoc without a higher-level strategy for dealing with things like redundancy and security.[3] Complexities in multicloud environments come from maintaining multiple security configurations and data repositories. Technology leaders would like to eliminate these complexities because their organizations are unlikely to realize the cost savings or operational efficiency gains that can come with cloud adoption.[4] Their experience with multicloud complexity has led to problems such as paying for redundant services, holes in security, and difficulty finding workers to tame all the mess.

New

Simplicity as a service

Savvy business leaders aren't simply living with the convolution created by multicloud and the growing technology footprint. Instead, they're looking for ways to harness the operational gains that

come from managing multiple cloud instances while slaying the dragon of multicloud complexity.

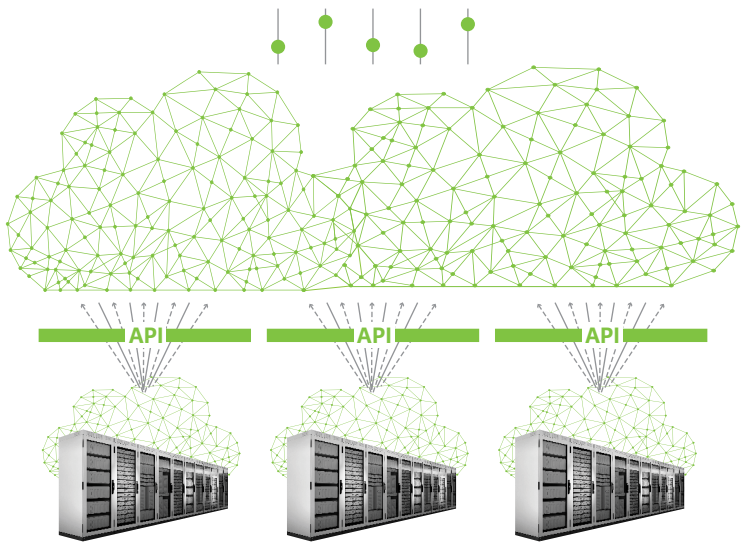
The approach known as metacloud involves building a compatibility layer that provides access to common services such as storage and compute, AI, data, security, operations, governance, and application development and deployment. This compatibility layer logically sits above a business' various cloud platforms and leverages their native technical standards through APIs—with the result that applications still enjoy the strong security of the cloud provider, but in a consistent manner with centralized control. Metacloud does this through a common interface, giving administrators centralized control over their multiple cloud instances. In a paper presented at the Association of Computing Machines' HotOS conference, computing luminaries Ion Stoica and Scott Shenker explain that the compatibility layer in the metacloud can be centered around APIs (figure 1). This is how the compatibility layer

FIGURE 1: What is a metacloud?

Sits above an organization's various cloud platforms, leveraging native technical standards through APIs

Provides access to common services such as storage and compute, artificial intelligence, data, security, operations, governance, and application development and deployment

Provides consistent, centralized control over multiple cloud instances through a common interface



Source: Deloitte analysis.

sends instructions to each of the separate cloud interfaces. They compare the cloud compatibility layer with a computer's operating system, managing a computer's resources and exposing APIs to applications.[5]

Benefits of metacloud

With an extra layer of abstraction and automation between the various cloud platforms, organizations don't need as much specialization in their workforce. Instead of specializing in specific cloud platforms, cloud developers can build more general skills.

Metacloud may also elevate security. Each cloud platform generally has good security standards and, in a silo, performs well. Problems arise when enterprises start mixing and matching. With multiple platforms to manage, the task of configuring necessary security settings becomes more daunting. "Hackers can leverage multiple clouds against each other," says David Linthicum, chief cloud strategy officer at Deloitte. "They're not breaching technology; they're breaching humans."[6] Metacloud can eliminate this problem by allowing developers to set one security configuration from the compatibility layer that is executed across each cloud platform through its native interface.

By eliminating unnecessary cloud services, enterprises can reduce their security exposure, enhance user privacy, lower costs, and do more with less. Teams may become less specialized in their abilities, and thus more capable of tackling whatever higher-level, generalized problem comes along.[7]

Challenges of metacloud

From a technical perspective, Stoica and Shenker believe metacloud makes perfect sense. From a business perspective, things get more complicated.

"We think achieving a widely usable compatibility layer is, on purely technical grounds, easily achievable," they write. "The problem is whether the market will support such an effort because, while the compatibility layer has clear benefits for users, it naturally leads to the commoditization of the cloud providers, which may not be in their interests."[8]

The other potential pitfall of this approach is that enterprises are on the hook for building it themselves. Right now, there are few vendors offering metacloud as a service. Instead, development teams will need to take the lead building each of the connections and the ultimate interface themselves. It's a complex solution to dealing with complexity, but the ultimate outcome should be greater simplicity.[9]

Next

Consolidation and centralization

History suggests, however, that metacloud may only be an interim solution. Past efforts to reign in sprawling data centers, databases, and operating systems have ultimately resulted in consolidation, centralization, standardization, and rationalization—not via middleware or orchestration engines, but with refactoring and simplicity. Improving license utilization has always been a focus of consolidation, and most enterprises have policies in place that control utilization of cloud resources.

Further, cloud services are often sold to various teams within IT. This could mean that as soon as IT centralizes cloud services under a metacloud, it may discover additional platforms that need to be reined in. At this point it becomes a game of whack-a-mole.

What could end up taking the place of metacloud is a more tactical approach, one that borrows the centralization and control of metacloud but leaves in place the freedom developers currently have to choose the right tool for the job. This tactical metacloud could govern provisioning of cloud credentials and allocate resources only to users that have a valid business case and the technical knowhow to make use of cloud resources without creating complexities.[10]

Self-service has been the ultimate game-changer in IT. Any approach to centralizing cloud resources will have to respect the end users' desire for agility.

Self-service has been the ultimate game-changer in IT. Any approach to centralizing cloud resources will have to respect the end users' desire for agility. In the past, centralization generally meant bureaucracy. Line-of-business users went around IT to get out from under burdensome processes that slowed their ability to solve business problems. But automation tools are making it easier for IT to deliver functionality without slowing down business initiatives and could play an important role in any effort to rein in multicloud complexity.[11]

Multicloud may feel messy, but it's the world we're living in, and likely will be for the foreseeable future. Smart business and technology leaders should look for areas to reduce complexity wherever possible—potentially through approaches like metacloud—and eliminate security and redundancy problems created by maintaining multiple cloud instances.

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Trend 4
Flexibility, the best ability: Reimagining the tech workforce

Organizations have been competing for a limited supply of tech talent. A winning long-term strategy instead creates, curates, and cultivates new talent.

The history of technology conjures images of lab coat–wearing PhDs wrangling information out of room-size mainframes. Previously synonymous with advanced scientific knowledge, the use of technology is now ubiquitous and becoming more democratized, and recently, more decentralized. Technologists have exchanged lab coats for crewnecks and black jeans; yet, when it comes to technology talent, organizations are still on the lookout for advanced scientific knowledge, in the form of advanced degrees and years of engineering experience.

In the last year, workers with this type of knowledge have been at an all-time shortage: More than half of IT executives were unsuccessful in filling a position.[1] Headlines about the Great Resignation abound, and companies often appear to be engaged in a heated competition for tech talent. But with technical skills becoming outdated every 2.5 years on average,[2] hiring for current needs is not a winning long-term strategy. Rather than competing for scarce tech talent, leaders would be wise to consider an abundance strategy, wherein technology talent can be curated, created, and cultivated. In other words, don't compete when you can create.

"My strategy is to create an environment that unleashes the potential of my staff. They should be getting poached by the best companies and yet not leaving because they love the work."

—Sathish Muthukrishnan, chief information, data, and digital officer, Ally Financial[3]

Since 2015, *Tech Trends* and the *Global Technology Leadership Study* have predicted the emergence of a new breed of IT worker, capable of infusing creativity, design, and emotional intelligence into the expanded definition of a technology team. Today, low-code/no-code technologies are increasingly common[4], modernization has been accelerated by the pandemic, and code repositories are abundant. As a result, respondents across industries in our forthcoming *2023 Global Technology Leadership Study* identified creativity, problem-solving, and other human skills as greater differentiators for tech talent than ever before.[5]

Over the next 18–24 months, technology leaders can reimagine the workforce and workplace to focus on the skills (both human and technical) needed to deliver IT products and services. Leading companies are likely to get creative and tap into new sources for finding talent, while providing a compelling talent experience to retain top performers. To win the battle for talent in the long-term and prepare for further changes to come, organizations should be prepared to eschew IT orthodoxies and prize flexibility as the best ability.

Now

Zero-sum blues

The COVID-19 pandemic catalyzed many technology workforce shifts that have persisted longer than anticipated. Many technology workers have opted to stay remote, creating a more fluid workforce. In fact, 85% of IT divisions plan to be hybrid or fully remote going forward.[6] At the same time, given the rate of digital transformation, enterprises are demanding more from their technology teams and are sourcing talent globally. It's therefore no surprise that in April 2022, the unemployment rate for tech talent was 1.3%, about one-third of the US unemployment rate.[7] It's also no surprise that 72% of US tech employees are considering leaving their jobs for greener pastures.[8]

To attract talent, organizations are often relying on a single approach, such as increasing compensation, providing flexible work arrangements, and reskilling or upskilling. However, as the talent shortage continues, choosing just one of these solutions is unsustainable. As other companies match or improve their job offers, tech talent may keep leaving for new opportunities, leaving organizations to play a zero-sum game to attract talent. For instance, in the last year, 82% of US enterprises were prevented from pursuing digital transformation projects due to a lack of resources and skills.[9]

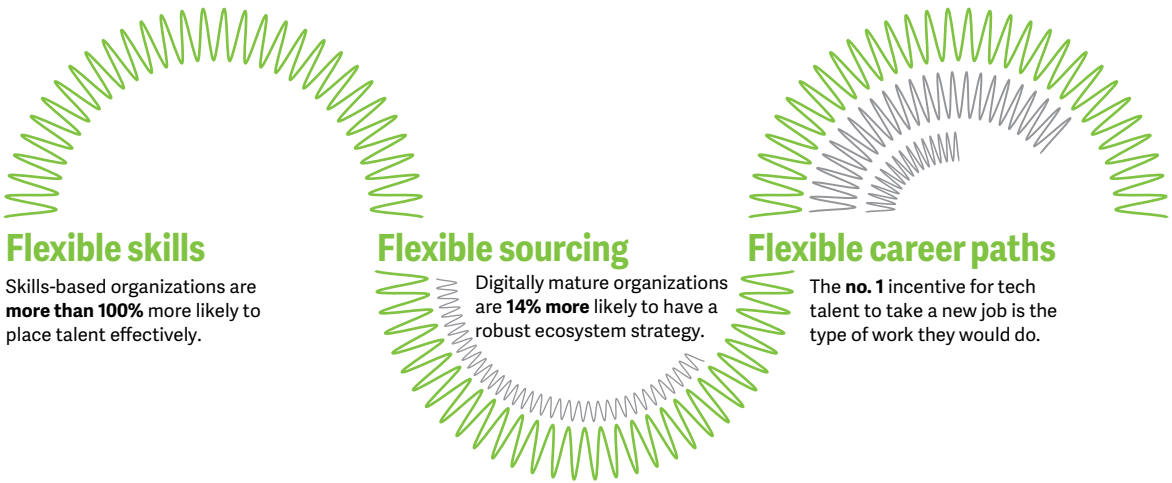
Rather than competing for the same talent using the same methods as others, technology leaders should recognize there is no one-size-fits-all strategy for talent. For instance, Joe Weider, chief technology officer (CTO) of Lincoln Financial Group, says he couldn't match the salaries offered by large tech companies, but he retained his talent in other ways. "We're taking employees out of the market by doubling down on our flexibility and our company culture, including bringing in staff for engaging offsites and creating opportunities for peer recognition," says Weider.[10] By expanding how they think about the tech talent problem beyond a single approach, enterprises can expand the scope of their solutions over the coming months.

New

Flexibility is the best ability

Over the next two years, the tech talent crunch may continue to impact the bottom line. Organizations that want to protect and pursue their transformation projects require a strategy-driven, differentiated approach to finding staff. Those who meet their talent goals will likely expand their conception of how technology work is planned and executed, instead of over-fitting for current technical needs (figure 1).

FIGURE 1: Prioritize flexibility to curate tech talent



Source: Deloitte analysis.

Flexible skills

Deloitte research has shown that the traditional concept of a job is one of the key hindrances to meeting targets for growth, agility, and diversity, equity, and inclusion (DEI). Many organizations are pivoting toward talent models that center on skills rather than jobs. For instance, Mercedes-Benz has organized some of its IT talent into "capability sets" to improve flexibility for assigning staff to new roles or new products.[11] The results speak for themselves: Skills-based organizations are more than 100% more likely to place talent effectively and 98% more likely to retain high performers.[12] In fact, recent shifts have made a skills-based approach more attainable, according to Patrick Noon, Bechtel's chief information and digital officer: "Recruiting for critical skills is easier because I can recruit from anywhere for jobs for remote work."[13]

Technology leaders looking to adopt this model should start with their business requirements and determine which human and technical skills are needed to fulfill those requirements. Then they can segment their needs into hard technical (e.g., data science), tech-related skills (e.g., Agile QA or customer success), and human skills (e.g., resilience), based on a forward-looking strategy. Crucially, a skills-based approach can enable organizations to be more creative in addressing their talent shortages. For instance, the SecureAmerica Institute, a public-private research collaborative focused on US manufacturing resilience, has helped manufacturers train talent accustomed to manual labor to be advanced machine operators.[14]

Flexible sourcing

Organizations that develop a flexible approach to skills may find it easier to adopt an abundance strategy when it comes to sourcing talent for those skills. Instead of only hiring, they can plan to outsource, offshore, train, or retrain talent, or leverage other components of their ecosystem to fill their needs.

Enterprises ahead of the curve are already crowd-sourcing talent, through gig workers or contractors, to fill gaps and free up their internal resources to focus on the most challenging and interesting work.[15] Debbie Browning, CTO of Workwear Group in Australia, did just that when she had trouble hiring talent. "We're a lean organization," she says. "It's more effective for us to scale with managed services than internal hiring."[16] Moreover, Deloitte research shows that digitally mature organizations are more likely to have a robust ecosystem strategy that can expand their access to skills (54% vs 40% of average organizations).[17]

At a time when 78% of technology talent said DEI initiatives are an important factor when accepting job offers, leaders should consider that a skills-based approach can make it easier to promote equity.[18] For example, some CIOs have partnered with organizations to offer a nine-month training program from which underrepresented

candidates graduate to work in cybersecurity and programming.[19] Such initiatives, coupled with the right development opportunities (e.g., mentoring, rotational programs, externships) can even empower organizations to create fresh talent instead of fighting over a limited supply.

Flexible career paths

Employees are looking for interesting work and flexible career paths—and companies should adapt to meet these needs. This shift in mindset is perhaps best represented by a move from "10X"[20] engineers to "10-job engineers": serial specialists who can build depth in multiple areas over the course of a career. Businesses can explore some of the following methods to create careers and experiences that retain employees:

- **Lateral moves.** Contrary to conventional vertical pathways, organizations should design career paths that allow for lateral progression between different technologies. Seventy-four percent of workers believe they need to update their skills at least once every six months to do their job effectively in a digital environment.[21]

- **Talent marketplaces.** An internal talent marketplace where employees can find short-term projects or new teams can promote internal mobility and allows them to discover purposeful and meaningful work. For tech talent, the No. 1 incentive in a new job (chosen by 54% of respondents) was the work they would do. Or, as Diogo Rau, chief information and data officer of Eli Lilly and Company, says, "You can't pay good engineers enough to do boring work. Offer a purpose that excites people."[22]

- **New operating models.** IT divisions are not known for their flexibility. To create experiences that allow for employees to work at the right pace with the right partnerships, organizations should consider instituting a few different modes of operations for technology work, as we'll discuss in our forthcoming *2023 Global Technology Leadership Study.*

"Today, the flexibility of talent to perform work is dependent on creating a culture of mobility that facilitates workers taking on new roles and learning new skills."

—*Fortune* 100 CIO

Modern training for modern engineering

Foundational training is critical to developing a flexible and capable technology workforce. New technical hires should receive dedicated training time, through a rigorous boot camp for instance, which exposes them to the full technology stack, the interplay of business and tech, and the internal culture of engineering. The ideal training not only provides a skills foundation, but also trains new hires to adapt quickly and develop a continuous learning mindset.

At many companies, that involves simulation-based practice and an apprenticeship model where new hires can learn the ropes from experienced engineers in a "two-pizza" team (as discussed in *Tech Trends 2022*). Especially when it comes to learning the intersection of business and technology, technical staff should have the space to learn detailed concepts and interaction skills during the natural flow of real work. At the same time, experienced engineers need regular upskilling on the latest technologies as well, through a combination of e-learning, vendor-led classes, and certification programs.

Moreover, flexible career paths require understanding different functions of the business.[23] Whether through rotational programs, lunch and learns, or on-the-job shadowing, tech talent should be exposed to a variety of disciplines, including product management and customer experience. Then, if they want to pursue lateral moves later in their career, the learning curve may be less steep.

Crucially, once training and upskilling have been delivered, engineers should be encouraged to get creative and write custom apps that better serve the business, instead of being limited to application maintenance. Curating a developer experience that reduces friction (from outdated systems and inefficient processes) can allow technologists to focus on their craft and drive business innovation and outcomes. As all companies increasingly become technology companies, modern engineering becomes the fulcrum upon which strategy rests. Developer, architect, and engineer training and experience may soon make the difference between winners and losers in the market.

Next

Brush up on your humanities

Businesses are at an inflection point in terms of talent. Over the next decade, technology will likely continue to get better at executing given tasks, freeing up tech talent to focus on higher-order problems: how to adapt to business needs, best partner with their digital colleagues, and innovate.

Just as the workforce of today would groan at the prospect of having to write code in an outdated language, the workforce of tomorrow may balk at not having AI assistants. In the Age of With™—an era defined by human *with* machine collaboration—if time-consuming computations are delegated to AI, human coworkers can focus on the tasks that need the human touch. For instance, American Airlines recently reduced a laborious four-hour gate assignment process, which once required a team of people working late into the night to assign flights to gates and account for the day's cancellations, to a 2.5-minute procedure using AI. This freed up their team members while providing an improved experience for their customers.[24] Similarly, the **Virginia Department of Health** is developing a chatbot to handle the nearly 2,000 basic customer inquiries received each week, allowing administrative staff to focus instead on higher-level problems.[25]

As we discuss in ***Opening up to AI: Learning to trust our AI colleagues***, tech talent is multiplying productivity by partnering with digital colleagues. Product Manager Mike Geyer at **NVIDIA** believes future engineers "are going to learn about how to set up problems for AI, so it can do the grunt work, instead of solving the equation themselves."[26] As AI automates problem-solving, enterprises may soon be on the hunt for humanities majors who can guide a set of accessible and capable AI technologies toward business results. Despite a steep decline in such degrees,[27] the big-picture thinking, ethics, and problem-framing of the humanities may soon be in demand again. The upside? Geyer's team of AI specialists forecasts 30% efficiency gains for the clients it serves.

"We're a global company with a diverse workforce, which means we also actively recruit globally. With the shortage of skilled cybersecurity professionals, it has become essential to rely and invest in AI technology to continue our drive for innovation."

—Peter Oggel,
chief technology officer, Irdeto BV[28]

Finally, the rising prevalence of technology innovation officers promises a future where technology teams are shaping the business instead of working to keep the lights on. Sixteen percent of organizations now have this position, which was rare just three years ago, and technology budgets dedicated to innovation have increased by 8% since 2020.[29] As discussed in our recent ***Innovation Study 2021: Beyond the buzzword***, innovation is concretizing as a discipline.[30] Some companies have already started innovation divisions, while others have invested in developing a series of internal "mini startups" to provide the innovative work tech talent craves.

As automation frees up precious human time to navigate what's next, the battleground of the next decade may not be in finding tech talent, but in pioneering technology for the future.

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Trend 5
In us we trust: Decentralized architectures and ecosystems

In an environment of ever-increasing mistrust, blockchain and Web3 could power "trustless" systems that decentralize data to rebuild trust.

We noted last year in ***Blockchain: Ready for business*** that exciting and creative enterprise use cases built on blockchain-powered systems are driving real productivity and value at scale.[1] As organizations begin to understand blockchain's utility and promise, they're realizing that stakeholder trust-building could be one of its primary benefits. In fact, blockchain-enabled "trustless" systems—so-called because trust is not placed in a single person or organization but in the community of users—could be an antidote to diminishing faith in government, media, money, businesses, and other civic and private institutions.

From cybercrimes to data misuse, digital trust issues undermine confidence in traditional institutions and the technology that powers them. With digital ledger technologies and decentralized business models that achieve consensus through code, cryptography, and technology protocols, decentralized architectures disintermediate trust and distribute it across network participants.

As decentralized platforms and protocols mature, many organizations are beginning to invest responsibly and explore at their own pace. From everyday enterprise applications to blockchain-native business models, these organizations are demonstrating that none of us is as trustworthy as all of us.

Moving forward, we anticipate further opportunities for organizations to cement their credibility with their key stakeholders by helping reinvent a more decentralized and transparent internet. Web3, what many call this next iteration of the internet, posits a future in which the loudest voices can't overshadow a single, immutable version of the truth, based on public blockchains. In this world, forward-thinking digital natives are increasingly likely to demand higher-quality proof of truth. Indeed, we anticipate tomorrow's leaders to assert "chain or it didn't happen."

Now

The digital trust gap

Numerous surveys highlight the erosion of the public's belief in civic and private institutions.[2] Social media and other Web2[3] ventures have made it easy to rouse negative emotions against individuals, businesses, and other organizations and institutions, says Nate Rackiewicz, chief data officer of Gannett. "At a prior research company I founded, Meteor Now, we discovered that hatred is the most impactful emotion for driving lift in consumer engagement across media verticals," he says. "We need to be mindful of this risk and on alert for bad actors that may be weaponizing this emotion against us in a quest for clicks."[4]

Disorganized business processes and systems can also lower stakeholder trust. For example, trust is paramount to participants in capital markets, but capital markets infrastructure is typically bloated and inefficient. It often takes six weeks to issue a bond and 25 days for a dividend to pass from the issuer to the end investor.[5] Settlement costs increase by 14% year over year, and 27% of settlement systems are more than 20 years old.[6] Perhaps it's inevitable that the tokenization of assets in capital markets is one of the top enterprise blockchain use cases, with organizations such as Broadridge, Clearstream, and Goldman Sachs using blockchain-based transaction platforms to help eliminate system and process inefficiencies and help increase participants' trust in capital markets.[7]

"We discovered that hatred is the most impactful emotion for driving lift in consumer engagement across media verticals."

—Nate Rackiewicz, chief data officer, Gannett

Businesses that lose the faith of stakeholders can pay a stiff price. Deloitte researchers studied three large global companies, each with a market cap of at least US$10 billion, that had been embroiled in scandals. The analysis found that the companies lost 20% to 56% of their value—a total US$70 billion loss—after losing their stakeholders' confidence.[8]

Many organizations build credibility with stakeholders by going beyond traditional business objectives such as product quality, profit, and growth to include environmental, social, and governance (ESG) efforts and diversity, equity, and inclusion (DEI) commitments. Blockchain can help bridge another credibility gap: digital trust.

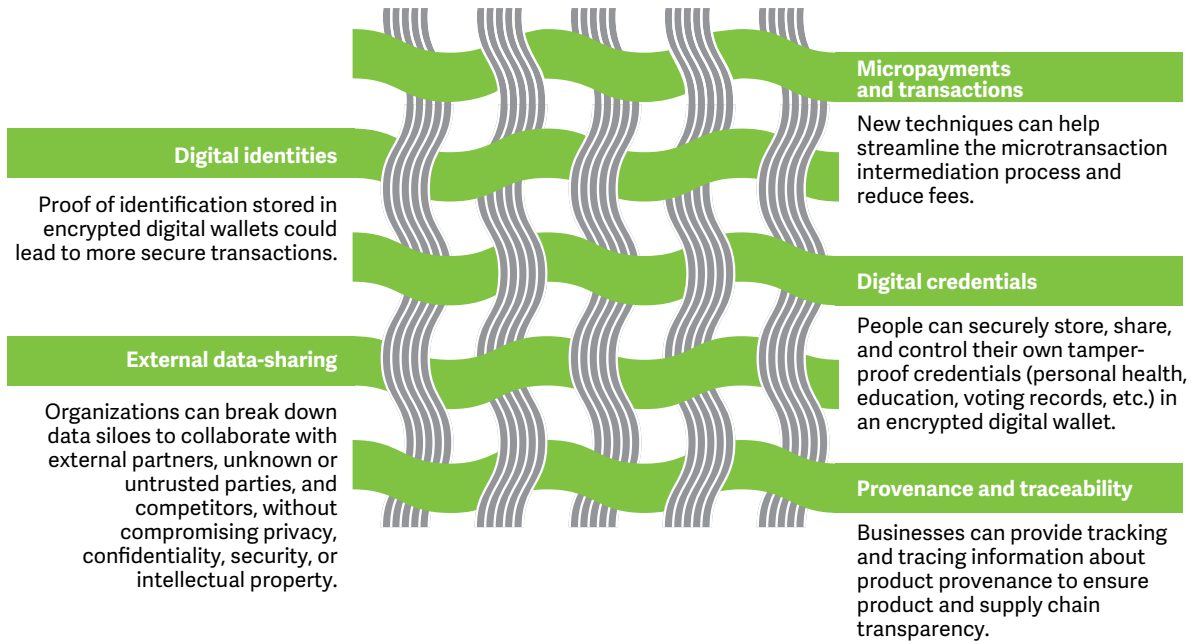
New

Minding the gap

Decentralized systems, applications, and business models add a protective layer to the existing transaction infrastructure, enabling organizations to close the digital trust gap by helping them create a single version of irrefutable truth. They rely on cryptography- and code-driven consensus of systemwide users, rather than moderation by third-party intermediaries—without sacrificing data privacy. The resulting shared, trusted record can be inspected by selected third parties but cannot be controlled by any single, central superuser. A consortium of participants keeps the information up to date so that each participant maintains a copy of the updated, immutable database.[9]

Trust-related use cases include digital credentials and identities, data-sharing with third parties, provenance and traceability, and micropayments and transactions (figure 1).

FIGURE 1: Blockchain-based trust use cases



Source: Deloitte analysis.

Digital credentials

Individuals can own and manage their own tamper-proof credentials for applications such as personal health, education, and voting records in an encrypted digital wallet on their personal devices. Organizations such as **New York State** are using blockchain to verify identity and credentials: The Excelsior Pass digital health credential allows New Yorkers to securely store and verify negative COVID-19 test results and vaccination records on their mobile phones without sharing other personal health data.[10]

According to Sandra Beattie, the state's first deputy budget director, credibility with citizens was crucial: "We centered on the belief that the citizen owned their data and transactions, and that our responsibility was to maintain the privacy and security of that data. Citizens had such a positive response to the app because they had trust in us to do that."[11]

Digital identities

Similarly, people can leverage blockchain to create, manage, and store their identities in digital wallets, potentially leading to more secure transactions between sellers and buyers, landlords and prospective tenants, and even users of dating apps.

Businesses can verify or issue credentials, identities, and licenses. For example, the BMW Group partnered with the German government on blockchain-based driver's licenses that help prevent identity fraud and reduce friction in transactions such as renting or purchasing a car and getting insurance.[12]

External data-sharing

Blockchain systems are useful for applications in which multiple external business partners, unknown or untrusted parties, or even competitors need to achieve consensus, and an intermediary isn't wanted, needed, or feasible. By breaking down the data siloes between such groups, blockchain allows data to flow among organizations without compromising privacy, security, or intellectual property.

For instance, fashion brand LVMH launched the Aura Blockchain consortium to track the provenance of products to prove product authenticity; founding members include fellow luxury brands Prada, Cartier, and Mercedes-Benz.[13] Members develop their own unique experiences and maintain their own data according to the strictest privacy standards.[14]

Provenance and traceability

Like LVMH and its founding partners, organizations in nearly every industry and sector are experimenting with blockchain to help them, their customers, and other stakeholders track and trace information about the provenance of their products.

For example, the Japan International Cooperation Agency (JICA) used a blockchain-based system to monitor child labor on cocoa farms in Côte d'Ivoire. The project aims to make all aspects of the cocoa production process transparent, using blockchain to ensure traceability. Says Yushi Nagano, an economist at JICA, "The beauty of utilizing blockchain is in making an emotional connection from farmers in Côte d'Ivoire to consumers in Japan. Data technology is not cold; it can be warm and emotional, too."[15]

Micropayments and transactions

When made in cryptocurrencies, online microtransactions—small payments ranging from a few dollars to even fractions of a penny, as in the case of in-game purchases—can carry transaction fees that are often greater than the transaction cost. New techniques can help make microtransactions more equitable by streamlining the intermediation process and reducing microtransaction fees.

"Data technology is not cold; it can be warm and emotional, too."

—Yushi Nagano, economist, JICA

Next

Chain or it didn't happen

To paraphrase Herbert Simon, theorizer of the concept of attention economics, a wealth of information means a dearth of attention.[16] In Web2's attention economy, truth is devalued in favor of clicks. Social media's balkanization threatens to splinter the internet and intensify outrage and fake news. The increasing use of data and artificial intelligence (AI) leads to charges of bias and the rise of deepfakes, and concerns about the privacy and use of data continue to grow.

Integrating blockchain into new aspects of their technology architectures could help organizations regain the confidence of key stakeholders. In an era of deepfakes, AI-generated imagery, and alternative facts, seeing something with your own two eyes is not necessarily sufficient proof of the truth. But if an entire community sees it on a public blockchain? Trustless, decentralized platforms could become an arbiter of truth: Chain or it didn't happen.

Here are a few of the possibilities:

Web3

Blockchain, decentralization, and tokens are at the heart of the next iteration of the internet, Web3. "Web3 makes the most passive consumer into a community member," says Ridhima Khan, vice president of business development at **Dapper Labs**, which uses blockchain technology to bring nonfungible tokens and new forms of digital engagement to consumers. "It's here to stay, and it's going to hit every sector and industry."[17]

By changing how content is made, managed, protected, and monetized, Web3 could rescue us from its predecessor's obsession with clicks and likes. A disintermediated web has the potential to transfer power from intermediaries to producers and consumers.

- **Producers.** In a Web2 world, "digital" is synonymous with "abundant." Nearly all digital content is infinitely shareable, legally or not. The infinite supply of content drives demand (prices and consumer attention) toward zero. By introducing the notion of "digital scarcity," Web3 architectures offer creators an opportunity to reassert some ownership and control of their content, data, profiles, and identities, with the ability to manage and monetize them across multiple websites and platforms rather than creating multiple copies. Creators could lock access to a song, video, or other intellectual property so it's only accessible via smart contract and programmable money, with the potential for revenue to be shared in real time.

- **Consumers.** The decentralized web could transfer ownership and control of identifying information and other personal data from intermediaries to individual consumers. End users could store their identifying information in a blockchain-based digital wallet and use it across multiple platforms, applications, and websites instead of creating a new identity for each one. This could give consumers more authority over data privacy and access, provide more protection from hackers, and allow them to monetize their data. With more control over their browsing and buying data, consumers could reduce email spam and unwanted advertising, or be compensated for providing their information or accepting email advertisements.[18]

Digital advertising

With consumers in charge of their own buying and browsing data, blockchain could significantly disrupt digital advertising. In addition to giving consumers control over their data and who uses it—in itself a massive disruption—it could also help eliminate advertising fraud caused by internet bots and domain spoofing, which fraudulently create traffic, clicks, impressions, conversions, or other data events that one research firm estimates will cost global advertisers US$68 billion by the end of 2022.[19] Adding a trust layer to the digital advertising process could help advertisers receive more representative data about the consumers reached by their ads.[20]

Artificial intelligence

As we discuss in ***Opening up to AI: Learning to trust our AI colleagues***, enterprises understand the power of AI to transform their operations, but they often doubt AI's ability to complete mission-critical tasks.[21] Consumers, too, are wary of AI,[22] with critical issues being the lack of transparency, interpretability, and explainability. In both cases, people don't have confidence in AI because they don't understand its decision-making process, and they're leery of the data used to train it.[23]

Blockchain's transparency and immutability could provide insight into the origin, integrity, and authenticity of the data used by AI, improve the security of the data by preventing it from being altered, and provide an audit trail.

Cybersecurity

Many of the attributes of decentralized architectures could lead to better cybersecurity in the long term. For example, transferring control of digital identity from the platform to the user could help reduce the amount of sensitive data stored by third parties and eliminate single, data-rich attack points. It would be difficult for hackers to compromise enough network nodes to control the consensus mechanism used to validate data blocks. And encrypting the entire blockchain can help ensure that the data stored within it is not accessed or changed wrongfully and provides an audit trail.[24]

While many public blockchains lack complete privacy and security, more trusted, secure options that reduce cyber risk are available. In non-public networks, only select, verified members can participate; in permissioned networks, those with a verified identity can join, and activities are controlled via permission-based roles.

Organizations are beginning to discover how trustless business models and operations could help them solve data-related credibility issues and win much-needed confidence across employee and customer groups, business ecosystems, and industries. And there are positive societal implications to consider as well.

Amid a crisis of faith in which seeing isn't believing, and people can't tell the truth from a lie, many of us have been waiting on a superhero: a person, company, or technology that might somehow serve as an unimpeachable arbitrator to help us settle quarrels and distinguish fact from fiction. Decentralized, trustless architectures are beginning to teach us that we are the heroes we've been looking for; and that none of us, in fact, is as trustworthy as all of us.

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Trend 6
Connect and extend: Mainframe modernization hits its stride

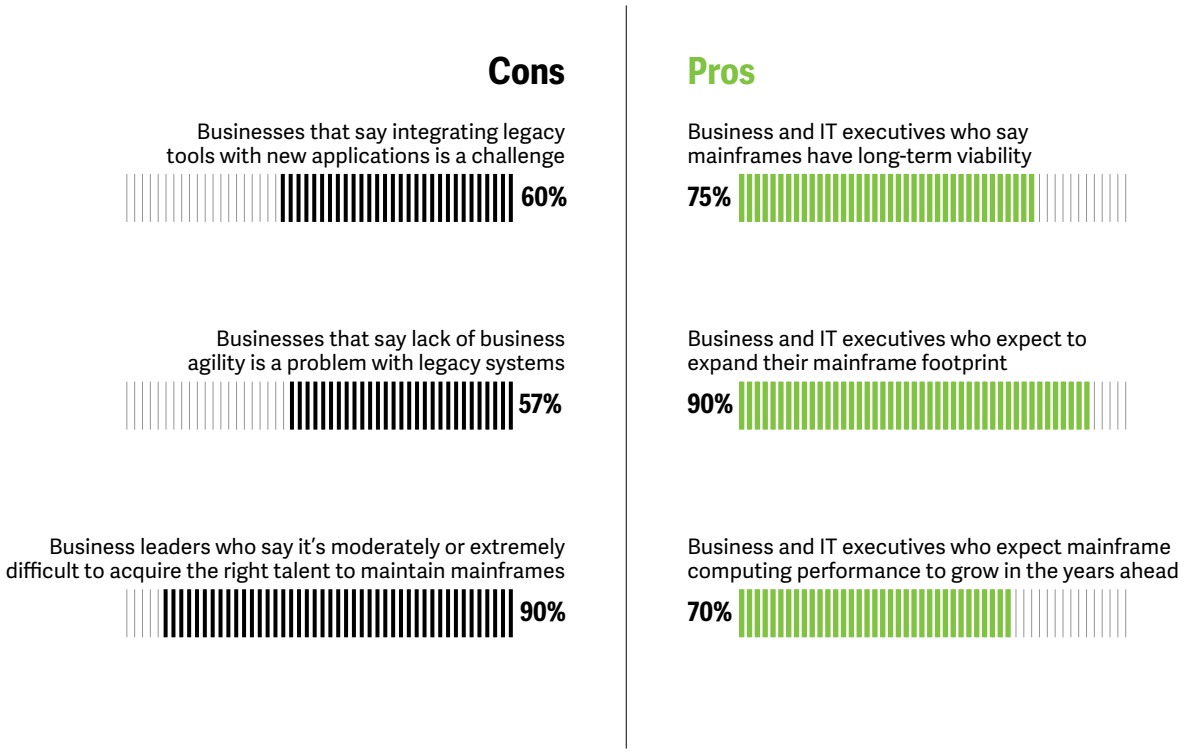
Instead of completely replacing mainframe systems, businesses have begun looking for ways to extend the functionality of mainframe systems by linking them to emerging technologies.

The trusty old mainframe may seem synonymous with a bygone era of computing. Left behind by cloud computing and walled off from next-gen functionalities such as artificial intelligence and business process as a service,[1] it once seemed destined for the dustbin of IT history.

But a funny thing happened on the road to obsolescence. People kept using mainframes. No matter how attractive cloud platforms become or how imperative modern features are to leading businesses, the mainframe continues to offer a compelling value proposition. Mainframes often host applications that can't be moved to the cloud because it would be either too cost-prohibitive due to the substantial work needed to refactor applications or too risky due to the possibility of breaking system dependencies.

The trick is getting the mainframe to communicate with modern applications, and this is where leading enterprises are getting creative. To be sure, enterprises have been working on this problem for years, but they're giving it a fresh look as they see the costly and potentially risky work associated with cloud migration. Rather than rip and replace legacy core systems, businesses are increasingly looking to link them to emerging technologies using innovative new connectors so that each family of systems can do what it does best (figure 1).

FIGURE 1: Mainframe pros and cons



Source: Deloitte analysis; BMC, "2020 BMC Mainframe Survey Results, October 1, 2020"; Tata Consultancy Services, "70% of Global CXOs See Mainframe and Legacy Modernization as Top Business Priority," February 11, 2021.

That's the approach taken by **Meuhedet**, an Israeli health insurance and care provider, whose mainframe-based electronic medical record system continues to serve as an effective store of patient data. "The vision is not to move on from legacy systems—because they work," says Katy Bar-Shalom, the organization's chief information officer. "The things they do are good, just not good enough. But with layers, web services, and applications, we can enlarge and bring new data and insights to our medical staff."[2]

Business users today expect to rely on modern applications such as CRM, data dashboards, and machine learning—and reconciling the business logic between mainframes and modern applications can be a technical challenge. This is partly because most mainframe code is written in COBOL, a language few computer science majors learn today. Modern applications are typically at the heart of enterprise's digital transformation efforts, and legacy systems are often seen as a hurdle.

Traditional efforts to link mainframes to modern applications have focused on APIs, which can work perfectly fine but have some limitations. Applications need to have prebuilt connections, or engineers need to build these connectors, which isn't always realistic for each piece of software. Building and deploying APIs can be a complex, time-consuming process.

Organizations are meeting this challenge by redoubling their efforts on tried-and-true approaches to core system modernization that allow them to connect legacy applications to even the most modern of tools. This includes things like AI-powered middleware solutions, advanced microservices applications, and refreshed user interfaces that harness the power of data-as-fuel. The result is a powerful pairing: the trusted functionality of core legacy systems with the expansive capabilities of emerging technologies.

In this way, legacy systems don't have to be roadblocks on the path to digital transformation, but rather, engines that drive the business forward.

"The vision is not to move on from legacy systems—because they work. But with layers, web services, and applications, we can enlarge and bring new data and insights to our medical staff."

—Katy Bar-Shalom, chief information officer, Meuhedet

Now

Mainframe remains business critical

Mainframes aren't just hanging around. Nearly three-quarters of business and IT executives believe mainframes have long-term viability in their organization, and more than 90% expect to expand their mainframe footprint.[3] Mainframes are still commonly used in tasks such as payroll processing, transaction recording, insurance underwriting, and much more. Mainframes do what they were intended to do, and they do it well.

The problem is people aren't getting what they want from them in terms of modern functionality. More than 60% of businesses say integrating legacy tools with new applications is a challenge, and 57% say lack of business agility—an inability to respond to emerging business challenges and opportunities—is a problem with legacy systems.[4]

New

Innovative takes on established approaches extend legacy system capabilities

For years, enterprises have been reinvigorating their legacy systems with the five Rs of core modernization: replatform, remediate, revitalize, replace, and retrench.[5] Those approaches are still bearing fruit. Some of the emergent faces of these approaches touch on new-to-world extensions that are breathing fresh life into core systems and extending their functionality for the modern, digital enterprise.

For example, the **US Air Force** recently began using a tool originally developed by the Defense Advanced Research Projects Agency called STITCHES, which is essentially a library of technical standards and translations that allow various applications to pass data back and forth, regardless of their underlying code.[6] In practice, one application sends data or instructions into STITCHES' library, which processes it into the standards of the next system. Various tools can connect to each other without requiring a common interface language.

Colonel William "Dollar" Young, the first commander of the 350th Spectrum Warfare Wing in the Air Force, says developing and deploying bespoke APIs to connect various pieces of software is time-consuming and complex. Each connection must be planned ahead of time, which limits the ability of people in the field to make connections between programs on the fly. But with STITCHES, anyone can link two or more pieces of software as soon as they need to, enhancing agility while improving connectivity between applications. "STITCHES allows humans to do what they do best, which is dream up a concept, and then the tool assembles the capabilities," Young says.[7]

Others are putting fresh integration layers on top of legacy systems that incorporate more advanced capabilities. Far more than the tried-and-true APIs of old, these applications have flexible file systems that can work with data in many formats and translate them to the standards of other applications. They help bring data from legacy systems to life in new ways.

This was the approach BMW took when it used **NVIDIA's** Omniverse platform to help make its UK manufacturing facility more efficient.[8] BMW wanted to transform its assembly line to be more responsive to customization requests and support the production of more electric vehicles. But its software infrastructure was geared mostly toward producing traditional vehicles.

Rather than retool its whole software infrastructure, BMW was able to connect and extend its existing tools. NVIDIA's Omniverse software utilizes an open-source file format that allows users to create scenes composed of many different file types. To enable multiple software systems to work in conjunction, it supports different client applications and microservices. In practice, this means that legacy data stores, ERP systems, computer-aided design software, and purchasing tools, to name just a few, can all sync up, connecting the tried-and-true functionality of legacy systems with the value-adding capabilities of emerging software.

As NVIDIA's industry product manager, Mike Geyer, says: "You've spent 15 years putting data into a software system. You can keep using it. Now you can just do more with it."

In another example, a commercial airline built a new app for customers to manage their membership, loyalty, and points program. The app itself is hosted in a cloud environment. A rules engine references data in the airline's mainframe without changing any of the mainframe data. The rules engine and cloud platform allow the airline to change offerings and functionality as needed without forcing it to completely revamp its data platform, which would have been a heavy lift given that the airline industry is particularly dependent on mainframes.[9]

Next

Mainframe levels up to meet emerging needs

Thanks to emerging technologies, the mainframe might actually become *more* relevant in the years ahead. A recent report from Allied Market Research found that the market for mainframe systems is expanding, in part thanks to increased adoption of Internet of Things (IoT) systems that produce massive reams of data that would be cost-prohibitive to move to the cloud.[10]

Economies of scale may continue to favor mainframes. Indeed, nearly 70% of business and technology executives expect mainframe computing performance to grow in the years ahead, making mainframe systems even better at these types of workloads.[11]

There is a class of problems that is deep and needs to be executed through world-class capability. For these types of problems, mainframes may share some characteristics with supercomputers, particularly as mainframe processing power continues to increase. For jobs that require high volume and precision—such as checking account balances at large, international banks—mainframes are likely to grow even more capable and continue as the choice for enterprises. When processes get more complex and require shifting data between applications—training machine learning algorithms, for example—cloud may offer better functionality.

Whether to keep applications in mainframes or move them to the cloud will continue to be a complex question. While refactored applications can work more seamlessly with modern, cloud-native applications, the process of refactoring takes a lot of work. Many businesses instead choose to lift and shift,[12] but that approach simply replicates existing roadblocks in the cloud. Then there's the cost to consider. Legacy applications running on on-premises hardware may already be paid for and shifting those applications to the cloud could constitute new costs.

This doesn't mean there's no cost to keeping applications in a mainframe, however. Especially given the lack of skilled workers available, finding people to maintain these systems—or worse, respond in the case of an outage—could become very expensive. More than 90% of business leaders say it's moderately or extremely difficult to acquire the right talent to maintain mainframes.[13] And maintaining applications in an on-premises environment could carry the opportunity cost of causing businesses to miss out on the broader gains that come with digital transformation enabled by cloud technologies.

More than 90% of business leaders say it's moderately or extremely difficult to acquire the right talent to maintain mainframes.

Dave Linthicum, chief cloud strategy officer at Deloitte Consulting LLP, says the pull of the cloud is strong today because it's trendy and mainframes are generally seen as passé. And while cloud platforms are likely to offer advanced capabilities that are difficult to replicate in a mainframe environment, businesses should still carefully ex- amine the business rather than jumping into the cloud to be on the cutting edge.

"People manage by what they read in magazines," Linthicum says. "They aren't necessarily making decisions based on business requirements. They're making emotional decisions based on where they think they should go. It may work if you spend a lot of money, but you may incur a million dollars more in operational costs because you move to a platform that is difficult to adjust to the needs of the business."[14]

Enterprises will have to weigh the costs and benefits of moving applications from mainframes to the cloud. They should evaluate what business needs have changed, and what opportunities exist in cloud versus mainframes to meet those needs. With more and more modern applications emerging that extend the functionality of the mainframe, it may not always make sense to throw out processes that are working simply in the name of modernization.

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Epilogue

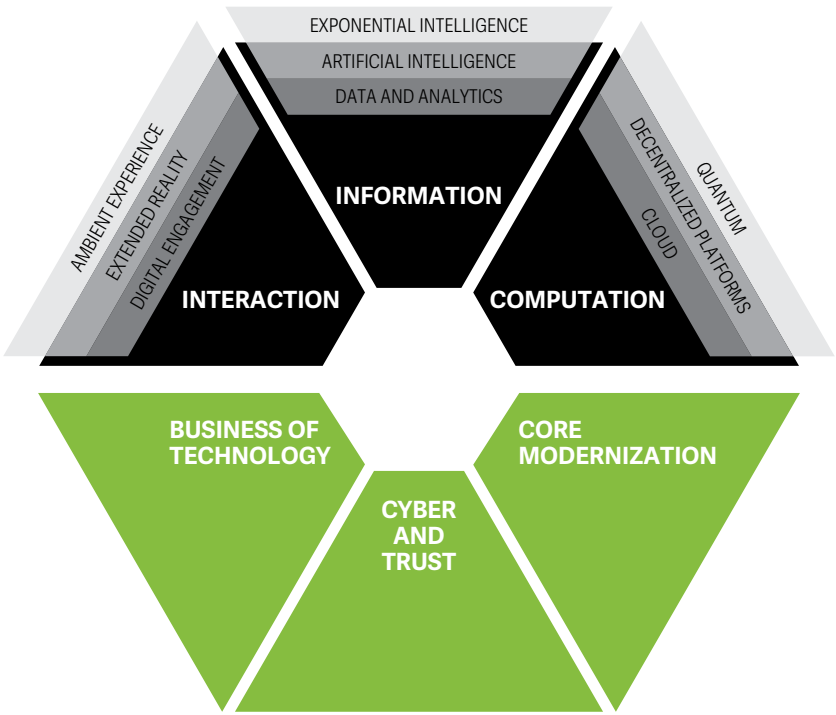
Widening the aperture: From infoTech to xTech

Since 2010, when our *Tech Trends* team began researching how emerging technologies are transforming and disrupting business in exciting and unpredictable ways, we've talked with hundreds of business and technology leaders. Through our conversations with these innovators, we developed—and continue to fine-tune—our macro forces framework, as we discussed in the **prologue** (figure 1).

These same conversations are also teaching us the limits of the macro forces framework. Historically, to enterprise audiences, "technology" has served as shorthand for *information* technology. Increasingly, however, pioneering leaders are drawing our attention to an extended set of technologies—or *xTech*—that, to date, have been separate and distinct from enterprise IT. Spurred by our clients' experiences, we sought to define *x*.

Our team of futurists went prospecting for potential futures. We drink our own champagne here at Deloitte, so we embarked on a principled exploration of emerging tech horizons, as described in the *Tech Trends 2020* chapter **Horizon next**.[1] For inspiration, we turned to the sciences. After all, information technology is rooted in the formal sciences (figure 2).

FIGURE 1: Six macro forces of information technology



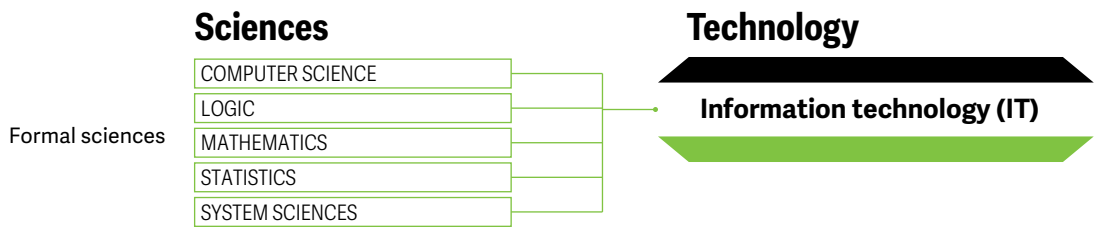
Source: Deloitte analysis.

Through a process of sensing, scouting, and scanning[2], we widened the aperture by surveying natural and social sciences, the scientific disciplines adjacent to the formal sciences. In search of xTech, we explored trends in R&D in these academic and research areas, and found some signals among the noise (figure 3).

We monitored patent and startup activity, technology maturity and advancements, academic and grant investments, and venture capital funding. We also looked at talent trends to identify the industries and sectors attracting the best and brightest professionals and grads.

In dissecting the data, we found that a handful of distinct IT-adjacent categories are snagging the lion's share of talent and treasure. The technologies in each of these categories look to solve fundamental quality-of-life challenges and constraints. We expect these six emerging technology disciplines to eventually rival IT in their impact on business innovation (figure 4).

FIGURE 2: The scientific roots of IT



Source: Deloitte analysis.

SpaceTech: Space and aeronautical engineering

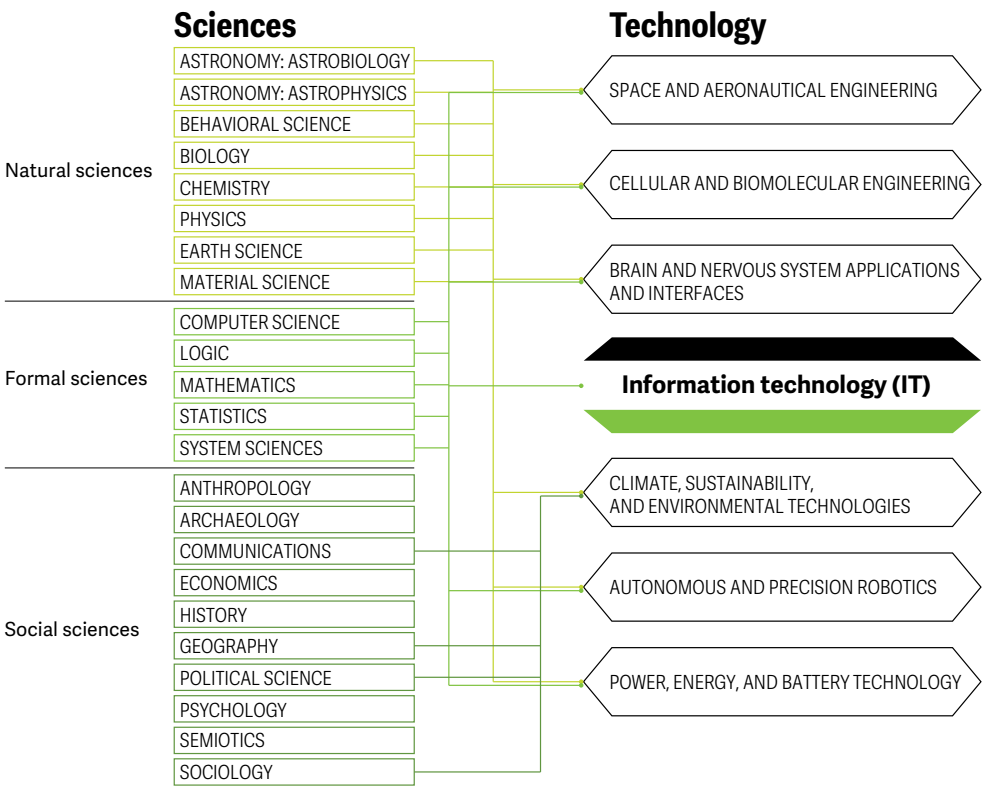
Once the exclusive province of government entities, space and aeronautical engineering has quickly become a vibrant enterprise opportunity, with government space agencies turning over many aspects of space flights, launches, and operations to private companies over the last couple of decades. Private industry investment in transportation and applications in low-Earth orbit (LEO)—Earth-centered orbits with an altitude of 2,000 kilometers (1,200 miles) or less—is flourishing, particularly as NASA's focus has evolved to deep space exploration,[3] launch costs have decreased, and companies begin to understand the benefit of space technologies and discoveries to life here on Earth.

The commercialization and industrialization of LEO, where the International Space Station is located, includes the so-called space-for-Earth economy—goods and services produced in space for use on Earth, such as communications infrastructure, earth observation capabilities, and national security satellites[4]—as well as in-orbit servicing, assembly, and manufacturing; commercial launch services and ground systems; scientific research and development; and commercial human spaceflight.

BioTech: Cellular and biomolecular engineering

Sitting at the convergence of biology and engineering, the field of cellular and biomolecular engineering provides the ability to deconstruct and architect cells, tissues, and molecules, rather than relying on natural selection to produce optimal outcomes. Insight into complex biological systems—plants, animals, and even people—at the molecular scale has already resulted in the complete sequencing of the human genome as well as

FIGURE 3: Toward xTech



Source: Deloitte analysis.

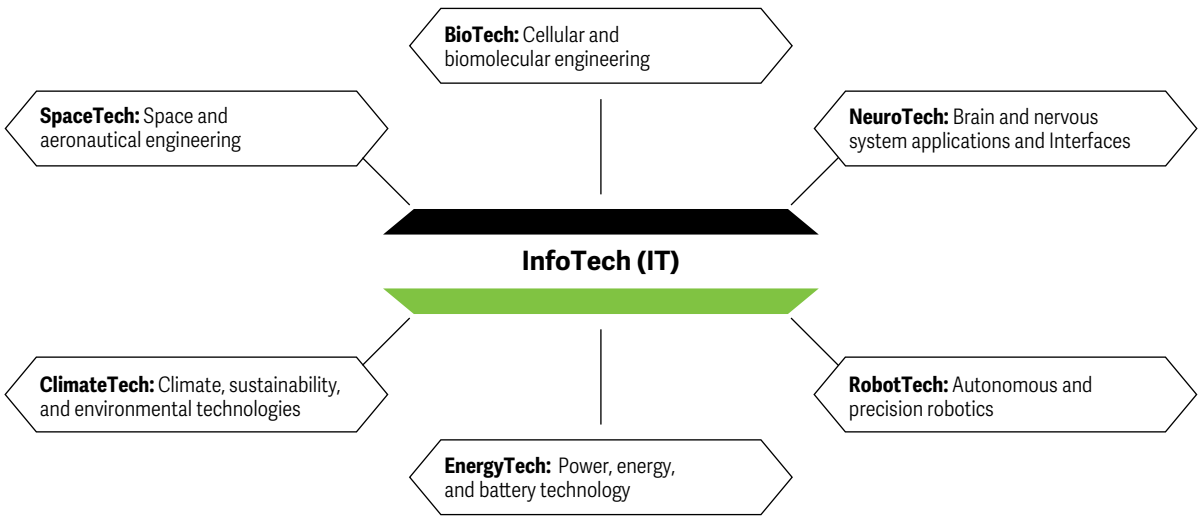
tissue-engineered products used for therapeutic purposes.[5]

The introduction of nanotechnologies, precision manufacturing robotics, and DNA modularity have fueled recent advancements and applications in biosensing, therapeutics, biofuels, pharmaceuticals, vaccines, synthetic food, pollutant-cleaning microbes, and biological data storage. Technology areas ripe for commercialization include synthetic biology, the process of creating or redesigning biological parts and systems and developing synthetic life forms; genomics, the function and editing of genomes; and cellular agriculture, the production of synthetic food using cell cultures and new ways of generating proteins, fats, and tissues.

NeuroTech: Brain and nervous system applications and interfaces

Brain and nervous system applications and interfaces, also known as brain-computer interfaces (BCIs) can help remove the friction between humans

FIGURE 4: From infoTech to xTech



Source: Deloitte analysis.

and technology by translating brain signals (thoughts) into commands and enabling humans to perform physical actions. BCIs measure the activity of the brain and central nervous system and translate it into commands that can control external software or hardware systems. They have the potential to make controlling computers as natural as thinking.

In the near term, BCIs will be used for assistive technologies; in the long term, for revolutions in human-computer interaction. Today's state-of-the-art technology features noninvasive EEG electrodes that relay brain signals to AI-trained algorithms, which predict the meaning of the signal and transmit commands to control a device. R&D is primarily focused on restorative, therapeutic, and assistive applications for people with paralysis or other disabilities. Future applications could include elective placement of BCIs that could help humans enhance their thinking, capabilities, and skills.

RobotTech: Autonomous and precision robotics

Autonomous and precision robots extend the value of AI applications from software-based decision-making systems to physical robots and machines that can make decisions and complete movement-based actions. An autonomous robot can scan and understand its surroundings and figure out where to go and what to do, without any special physical infrastructure. This includes autonomous cars and trucks and micromobility options, such as bikes, scooters, and small delivery vehicles. Precision robots are dexterous, multifunctional, and intelligent robots used to complete highly specific and exacting actions in industrial, agricultural, marine and space exploration, and medical and surgical applications.

Autonomous and precision robotics advancements include those in traditional manufacturing, cobot automation, autonomous transportation, logistics, process virtualization, and optimization. This domain will be supported by adjacent advancements in AI, interconnectivity of Internet of Things smart devices, edge computing, digital twins, remote operation, satellite and 5G communications, and advanced materials.

ClimateTech: Climate, sustainability, and environmental technology

Climate change is proving to be one of the most intractable issues of our time. In response to the climate crisis, many businesses are prioritizing net-zero policies and business models. Technology could be the most powerful weapon in the net-zero arsenal. "Technology is part of the [climate] solution, not part of the problem," says Inger Andersen, executive director of the United Nations Environment Program."[6]

Relevant climate technology areas include renewable energy, decarbonization, sustainable material development, heat abatement technologies, and supply chain optimization. Digital technologies,

too, can play a viable role. For example, solutions leveraging IoT, AI, and big data can help organizations measure, analyze, and track carbon emissions. And advances in sensors, robotics, and AI are helping businesses (and consumers) manage energy use more efficiently.

EnergyTech: Power, energy, and battery technology

Many power, energy, and battery technologies can help lessen the impact of climate change, but we categorize them separately from climate technologies because others simply help make energy more abundant, safer, or less expensive.

For example, advancements in nanotechnology and materials are helping to improve battery life for vehicles and phones and to reduce dependence on infamously scarce and hard-to-obtain materials such as cobalt and lithium. And energy storage solutions such as pumped storage hydropower and flywheel energy storage can help stabilize energy grids, make them more efficient, and ensure that energy isn't wasted.

What's next?

Given the emergence—and the importance—of these IT-adjacent technology domains, to continue to focus solely on IT would be to ignore a broad spectrum of potentially transformational business applications on the next technological horizon. What does all of this mean for *Tech Trends*? Our flagship report will remain focused on IT, but it will be joined shortly by a series of *Tech Futures* reports that will consider these exciting emerging technological frontiers. In our first issue, we'll take a look at the "what," "so what," and "now what" stemming from pioneering advancements in space systems and aeronautical engineering.

Coming soon: *Deloitte Technology Futures: SpaceTech*. Scheduled for launch in mid-2023.

See you in the future.

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Acknowledgments

Our insights can help you take advantage of emerging trends.

If you're looking for fresh ideas to address your challenges, let's talk.

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The NExT team

The Novel and Exponential Technologies (NExT) team is a team of futurists and researchers that senses—and makes sense of—emerging technologies that have the potential for widespread business impact. With our pragmatic approach to futurism, we help organizations shape strategic business agendas and set an intentional course toward tomorrow.

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As chief futurist with Deloitte Consulting LLP, Mike Bechtel helps clients develop strategies to thrive in the face of discontinuity and disruption. His team researches the novel and exponential technologies most likely to impact the future of business, and builds relationships with the startups, incumbents, and academic institutions creating them.

Prior to joining Deloitte, Bechtel led Ringleader Ventures, an early stage venture capital firm he cofounded in 2013. Before Ringleader, he served as CTO of Start Early, a national not-for-profit focused on early childhood education for at-risk youth. Bechtel began his career in technology R&D at a global professional services firm, where his dozen US patents helped result in him being named that firm's global innovation director. He currently serves as professor of corporate innovation at the University of Notre Dame.

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