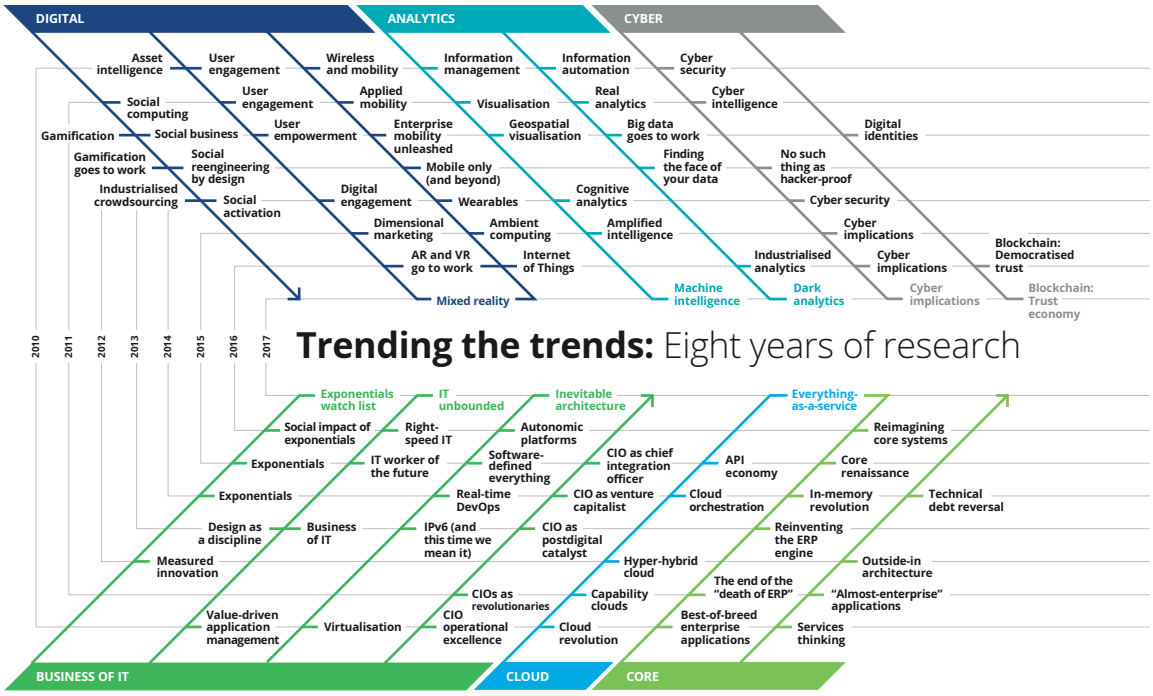
Deloitte.
University Press

UK edition

Tech Trends 2017

The kinetic enterprise



Deloitte Consulting LLP's Technology Consulting practice is dedicated to helping our clients build tomorrow by solving today's complex business problems involving strategy, procurement, design, delivery, and assurance of technology solutions. Our service areas include analytics and information management, delivery, cyber risk services, and technical strategy and architecture, as well as the spectrum of digital strategy, design, and development services offered by Deloitte Digital. Learn more about our Technology Consulting practice on www.deloitte.com.

COVER AND CHAPTER ARTWORK BY SHOTOPOP

CONTENTS

Introduction

LEGENDARY basketball coach John Wooden once said, “Failure itself is not fatal, but failure to change might be.” Any company competing in today’s rapidly mutating business climate should take Coach Wooden’s wisdom to heart. Seemingly without warning, powerful technology forces give rise to ripe opportunities while simultaneously rendering existing business models obsolete. Just as quickly, customers tailor their expectations to include new channels, products, and modes of engagement. Companies that don’t anticipate and embrace this change may find themselves sinking slowly in its wake.

The theme of this year’s *Tech Trends* report is the kinetic enterprise, an idea that describes companies that are developing the dexterity and vision required not only to overcome operational inertia but to thrive in a business environment that is, and will remain, in flux.

This is no small task. Though the technology advances we see today embody potential, only a select few may ultimately deliver real value. Indeed, some are more hype than substance. We need to do a better job of sifting through the noise to identify truly groundbreaking innovations that can deliver value. Then we need to act. Passively wondering and waiting are not options. As in Newtonian physics, the task before us is turning energy’s potential into reality.

This is our eighth *Tech Trends* report. The beauty of following a broad swath of technology advances over time is that amid the incredible pace of change, we can recognise familiar themes. For example, the five macro forces—digital, analytics, cloud, the reimagining of core systems, and the changing role of IT within the enterprise—have remained constant, year after year driving disruption and transformation. Despite the omnipresence of these five forces, enterprise adoption of them continues to vary widely. Some companies are only beginning to explore trends we wrote about in 2010, while others have advanced rapidly along the maturity curve. To the former, arriving late to the party doesn’t necessarily diminish the opportunities you are pursuing. You have the advantage of being able to leverage compounded years of evolution within, say, mobile or analytics without having to work sequentially through the incremental advances represented in our annual Trends reports.

Longtime readers occasionally ask about our hit rate: Of the trends we have examined over the years, how many have actually delivered on the potential we described? Looking back, with much humility, we’re proud that most of our analysis was right on target. For example, in 2014 we recognised cognitive analytics as a potentially powerful trend, which, with all the advances in machine learning and artificial intelligence, it turned out to be. We’ve emphasised security and privacy every year, evolving our coverage from examinations of individual trends to embedding cyber and now risk implications into every chapter. In 2010, we highlighted the need to embrace user engagement, and to make human-centred design both a mandate for technology solutions and a critical discipline for next-generation IT shops to nurture.

Yet there were instances in which we were overly ambitious. For example, in 2010 we predicted that asset intelligence—sensors and connected devices—was on the cusp of driving significant disruption. No question we were a few years premature, though we still believe that asset intelligence, aided by new Internet of Things

applications, will soon have a major impact. Similarly, in 2012 we recognised the important role digital identities could play in a new economy. The concept was generally there, but we had to wait for a protocol to emerge to set the trend in motion. With the emergence of blockchain, we believe the protocol has arrived and that digital identities may soon become foundational in an emerging trust economy.

Over the past eight years, the only constant has been change. We hope this latest edition of *Tech Trends* helps your organisation understand the changes under way more clearly. And, with a nod to Coach Wooden, we also hope it helps you respond to these changes by creating deliberate plans for turning business potential into kinetic energy.

When the rules of the game are changing, you can't afford to sit idly on the bench.

Stephen Mercer
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

Mark Lillie
Partner, CIO Programme lead
Deloitte MCS Limited
020 7007 2395
mlillie@deloitte.co.uk

Deloitte.
University Press

IT unbounded

The business potential of IT transformation

AS ORGANISATIONS MODERNISE THEIR IT OPERATING AND DELIVERY MODELS, SOME are creating multifunctional teams and breaking down silos across IT. They are also looking beyond organisational boundaries to explore the open talent market and to form new types of relationships with vendors, incubators, and academics. Finally, with technology dominating strategic business priorities, some companies are educating executives and staff to increase awareness and understanding of both core and emerging technologies. For many, embracing this multifaceted approach may require adjustments to org models, IT processes, and supporting systems. The good news is that irrespective of an organisation's legacy footprint, there are systematic approaches that can make the task more manageable. And the outcome may justify the effort: Services become "unbounded" and more efficient, transforming the IT organisation.

JUST as powerful technology forces such as cloud, analytics, and digital have profoundly disrupted business, so too have they disrupted IT's operations and, on a bigger scale, its very mission.

Over the last decade, leading CIOs have adopted dramatically different approaches to running their IT organisations. They have shifted IT's focus from maintenance and support of systems, to innovating and enabling business strategy. They've revitalised legacy systems to enable new technologies and eliminate complexity. Some have even borrowed from the venture capitalist playbook by managing IT as a "portfolio of assets." Looking back, the notion, circa early 2000s, that a CIO's job is simply to "keep the lights on" now seems quaint.

And while the evolution of IT and of the CIO's role has been both necessary and in many cases beneficial, it represents only one leg in a much longer IT transformational journey. The pace of technology innovation only accelerates, as does the disruption these innovations drive. Going forward, IT must be faster and more agile, be more responsive to the business, and, critically, work not just to enable but to help shape the organisation's broader strategy.

Over the next 18 to 24 months, we may see the next phase of IT transformation unfold—a phase focused on the way IT operates, how it collaborates with business and external partners, and how its development teams work smarter and more efficiently to deliver services. The ultimate goal of these efforts will be to reimagine IT development, delivery, and operating models, and to enhance IT's ability to collaborate effectively within the enterprise and beyond its traditional boundaries. In short, in the coming months, forward-looking CIOs will likely begin building IT organisations that are *unbounded*.

Creating an unbounded IT organisation will require that CIOs think beyond their own experiences and domain expertise and begin viewing IT through a different operational and strategic lens. For example, they can take a look at the efficiency and effectiveness of current budgeting, portfolio planning, and vendor selection processes and try to identify procedural, administrative, and

other constraints that can be eliminated. Or they can work with business partners, start-ups, academics, IT talent, and vendors to explore non-traditional innovation, collaboration, and investment opportunities.

Likewise, they can help streamline their development processes by coming up with fresh approaches to testing, releasing, and monitoring newly deployed solutions. Important to development, IT organisations can work to replace bloated, inefficient skillset silos with nimble, multiskill teams that work in tandem with the business to drive rapid development of products from ideation all the way through to deployment.[1]

Loosening the ties that bind

The traditional "bounded" IT organisation has for many years been structured around functional silos: infrastructure, application operations, information management, and others. IT's operating model emphasises service catalogs, service levels, and delivery commitments. Though business analysts may have occasionally teamed with applications developers on projects benefiting the business side, ongoing, fruitful collaboration between IT and business leaders has been rare. Finally, IT's traditional working and business relationships with vendors have been spelled out in rigidly detailed service contracts.

While the bounded IT organisational model served the enterprise well for many years, over the last decade powerful technology forces have begun diminishing its effectiveness. Cloud-based software-as-a-service (SaaS) offerings can now be procured and operated without any assistance from IT. Technology has become an integrated part of business processes, with CIOs assuming leadership roles in strategy development and execution. Importantly, automation is increasingly rendering some traditional IT roles and activities obsolete.

In the face of disruption at this scale, CIOs looking to transform IT operations and empower technology talent should consider taking one or more of the following steps:

Break down functional silos. In many IT organisations, workers are organised in silos by function or skillset. For example, the network engineering silo is distinct from the QA silo, which is, of course, different and distinct from database administrators. In this all-too-familiar construct, each skill group contributes its own expertise to different project phases. Frequently, projects become rigidly sequential and trapped in one speed (slow). This approach encourages "over the wall" engineering, a situation in which team members work locally on immediate tasks without knowing about downstream tasks, teams, or the ultimate objectives of the initiative.

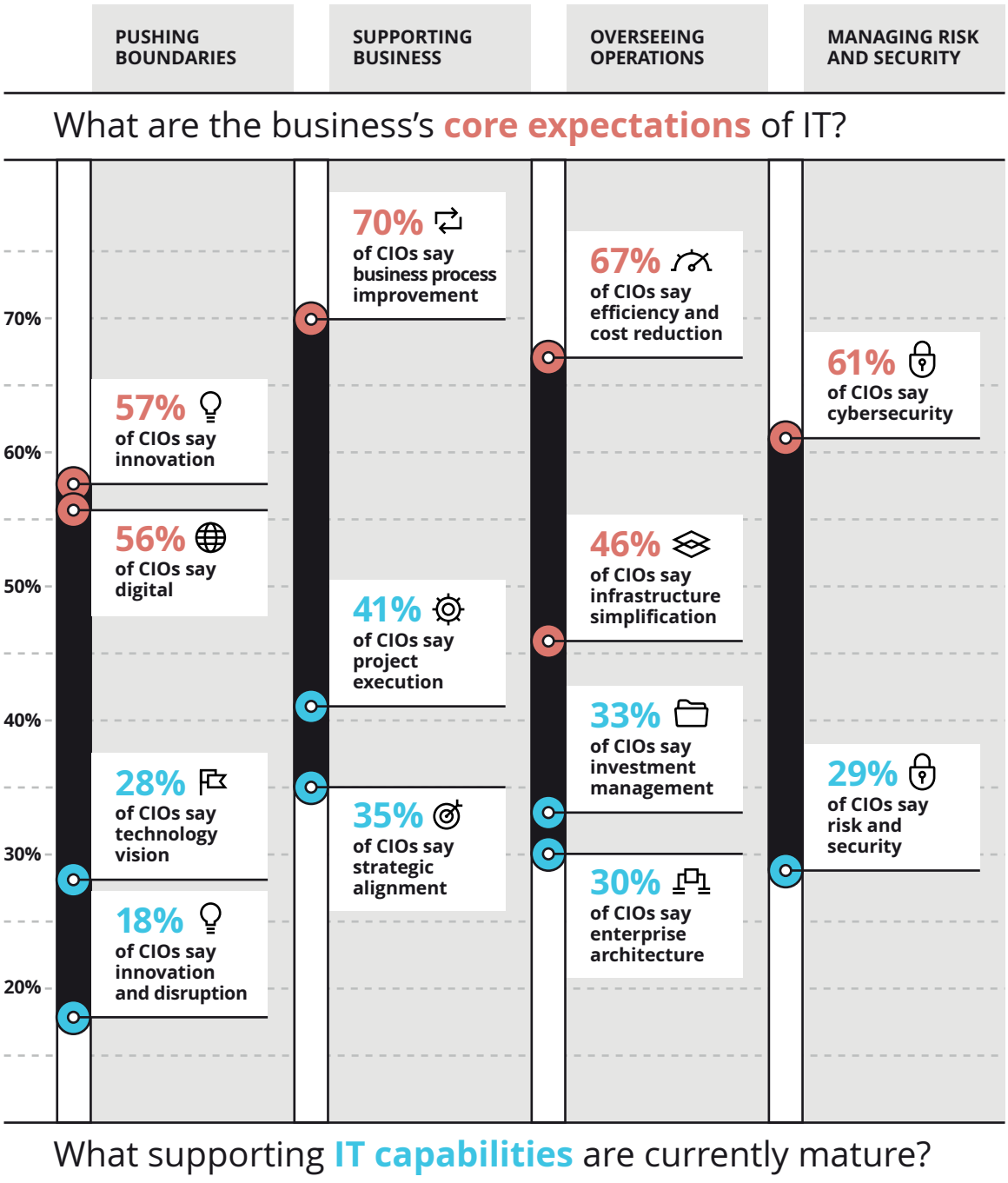
Transforming this model begins by breaking down skillset silos and reorganising IT workers into multiskill, results-oriented teams focused not on a specific development step—say, early-stage design or requirements—but more holistically on delivering desired outcomes. The team, working with product owners, becomes ultimately responsible for an initiative's vision, for its design, and for day-to-day decision making. This approach can effectively sidestep the layers of decision rights, council-based sign-offs, and other procedural requirements that routinely kill project momentum.

Embrace right-speed IT.[2] The speed at which IT operates should be as fast as possible, while balancing business value, risks, and technical feasibility. Organisations are recognising that they must be able to support a continuum of speeds in order to dial in the right approach for a specific initiative. These approaches frequently target release management, testing, requirements management, and deployment, all areas in which early wins can demonstrate meaningful impact.

Automate early and often. Increasingly, IT departments are leveraging DevOps and autonomic platforms to overcome traditional limitations of manual workloads and disjointed teams. DevOps utilises tools and processes to eliminate some of the waste embedded in legacy modes for operating IT. In a way, it also extends the software-defined-everything mission into the workforce by instilling abstractions and controls across the end-to-end life cycle of IT.

Figure 1. Aligning the gaps: Business expectations vs. IT capabilities

Deloitte's *2016 Global CIO Survey* revealed that there are gaps between the business's core expectations of IT and IT's current capabilities. Closing these gaps will likely allow CIOs to modernise their IT operating models and support business strategy more effectively. *Percentages represent survey respondents that selected each option.*



Source: Khalid Kark, Mark White, Bill Briggs, and Anjali Shaikh, *Navigating legacy: Charting the course to business value*, Deloitte University Press, November 10, 2016, https://dupress.deloitte.com/dup-us-en/topics/leadership/global-cio-survey.html; Survey question: What are the core expectations from the business of your IT organization/CIO?; Survey question: How would you evaluate your IT organization's current capability across the following areas? "Mature" denotes respondents that selected "Leading" or "Excellent."

Autonomic platforms[3] make it possible for IT to dynamically manage resources while integrating and orchestrating more of the end-to-end activities required to build and run IT solutions. Almost all traditional IT operations are candidates for autonomics, including anything that's workflow-driven, repetitive, or policy-based and requires reconciliation between systems. There are many approaches: robotic process automation, bots, cognitive automation, intelligent automation, and even cognitive agents. However, their underlying stories are similar—applying new technologies to automate tasks and help virtual workers handle increasingly complex workloads.

Erase boundaries between IT and the business. Deloitte's *2016 Global CIO Survey* of 1,200 IT executives found that 78 percent of respondents view strategic alignment as the organisational capability most critical to IT's success.[4] This statistic may come as no surprise to those CIOs who, over the last decade, have become key partners to C-suite leaders in the development and execution of technology-driven business strategy.

As CIOs begin the next phase of IT transformation, they should take their collaboration with and support of the business to the next level. In a business climate where emerging technologies and rapid-fire innovation can quickly render established strategies and business models obsolete and, at the same time, give rise to potentially transformative opportunities, there can be no disconnect between IT and the business. It's no longer sufficient to jot down a business team's functionality wish list for a new tool and come back six months later with a beta product. Indeed, product development teams must work without boundaries between the business and IT.

Making IT talent essential members of business teams represents a profoundly different collaborative approach for two enterprise groups that, historically, have not always spoken the same language. Consider the matter of "shadow IT." When the C-suite viewed IT as a commodity service provider, business initiatives often procured needed tools and solutions from sources other than IT. The root cause of these actions varied, but it was often either because IT's fixed budgeting and prioritisation process prevented its involvement or because top executives lacked confidence in IT's speed, cost, or ability to execute. From a business perspective, this may have seemed like an efficient way to acquire needed applications that IT couldn't or wouldn't provide. From IT's perspective, it was nothing short of rogue behavior. Not only did this risk the integrity and security of the IT landscape—it represented an existential threat to the future of the IT department. Conflict often followed.

The next phase of IT-business collaboration offers both groups an opportunity to dissolve the idea of shadow IT by fundamentally blurring the line between "business" and "IT." Going forward, they can be joint partners in the use of technology to operate a function or commercialise a product. With SaaS offerings, business analysts should be trusted to configure business rules and potentially enhance functionality that would have previously required IT to develop, test, and deploy code. IT should decide where it can relax its "ownership" of applications, while advancing platforms, reference architectures, guidance, and governance to balance the business's desire to move quickly with technology expertise to mitigate operational or security threats.[5]

Develop new approaches to driving innovation. Increasingly, IT finds itself competing against third-party IT service vendors to support internal customers. To help IT fulfill its core mission while pursuing new opportunities, CIOs can explore possibilities to work with business partners, vendors, academics, and start-ups in new ways. These organisations can be repositories of the kind of fresh ideas, unique perspectives, and untapped resources that can inform and inspire IT transformation efforts.

Is there a way to expand your network of partners to include venture capitalists, academics, and incubators? And what about investing directly in start-ups and other emerging technology players? Ford Motor Co. recently made a $182.2 million investment in Pivotal, a cloud-based software platform company, to further enhance its software development capabilities and deliver innovations to customers more quickly. The move is part of Ford's effort to redefine itself in the marketplace as

a company that delivers data and analytics as well as connectivity and mobility.[6]

With vendors, consider creating new categories of engagement that can be deployed against efforts beyond simple fixed-scope and traditional service-level agreements. Consider value-based arrangements in which vendors are compensated based on outcomes, potentially along with co-investment scenarios involving joint solution development and go-to-market arrangements beyond traditional supplier/vendor or contractor/consultant relationships.

Finally, few IT organisations have all the talent and expertise that they will need to meet ever-evolving demands for new systems, tools, and capabilities. Large companies may have the luxury of pursuing talent where it lives, which is what General Electric has done. The company recently announced it will be establishing small IT offices in Atlanta, Miami, and Providence to tap into talent pools in those areas.[7]

However, for IT organisations that need specialised skillsets for only short periods of time, it may not make financial sense to bring these skills on payroll permanently. To satisfy evolving skill and talent needs, CIOs may want to participate in external talent ecosystems. A crowdsourcing strategy can help guide the usage of crowd platforms to solve an organisation's short-term staffing problems. HR can also become a differentiating capability in the talent search by shifting its focus from people and policy administration to talent attraction and development.

To be clear, creating an unbounded IT organisation does not mean reinventing the IT wheel. Indeed, much of the transformative work CIOs have done during the past decade now serves as the bedrock upon which future initiatives can be grounded. Rather, it is more about evolving IT's focus, and expanding its reach in order to learn, grow, and pursue future opportunities.

Banking on a digital future

As digital innovation disrupted the banking sector and gave rise to a host of new channels and customer experiences, Capital One Financial Corp. recognised that to win in the future of banking it needed to reimagine its IT organisational model, development approaches, and delivery processes.

Capital One began with the assertion that if the winners in banking are going to master digital channels, machine learning, and real-time analytics, the company needed to invest and invent like the leading technology companies in those fields—it needed to operate like a bank that a technology company would build. This meant making a commitment to developing its own software, attracting and growing software engineering talent, and reimagining its IT operating model.

The effort, which began in 2010, commenced with a ceremonial rebranding of the tech organisation: IT's official name became Capital One Technology. "This was more than a name change," Capital One CIO Rob Alexander says. "It was a declaration that we would no longer be a traditional bank IT shop. From that day on, we would be an organisation working to transform Capital One into a technology company."

At the same time, Alexander and leaders across the bank's lines of business worked to develop a roadmap for building competitive advantage in digital banking. "It became clear to everyone that the future of banking would be different," he says, adding, "The stakes were high. The landscape is littered with companies that didn't understand that their industries were being disrupted."

The transformation initiative that followed embedded agile deeply in the business. Moving beyond the rhetoric of "business and IT alignment," Capital One business executives have agile teams dedicated to their products, services, and broader business strategies. Together, they work to deliver results on a much different time horizon than that of traditional waterfall development. They also actively manage priorities and the backlog of new services, features, enhancements, and user stories.

As the initiative progressed, it became clear that talent would be critical if the bank hoped to execute on its development goals. Capital One approached operational transformation with this question in mind: "How do we work in a way that allows great talent to do great work?"

The resulting operational vision features the following principles:

- **Agile:** True agile development focused on building Capital One's own customer-facing digital experiences, evolving products and services, and enabling solutions for reinventing how employees do their work.
- **Dev/Ops:** Capital One Technology moved operational team members upstream in

the software development lifecycle to work more collaboratively with developers, while investing in tools and processes to automate software delivery.

- **Business-agile development alignment:** Agile teams assigned to executives are responsible for developing solutions and services in the executives' business spaces.
- **Re-use:** The bank standardised on RESTful APIs, a microservices architecture, and containerisation in the cloud.
- **Open source:** Capital One takes advantage of open resources to expedite development. Moreover, it encourages its engineers to contribute back to open source projects. This approach has informed how Capital One manages shared platforms across lines of business—contributions from people across the organisation now help extend and improve core services.
- **Cloud:** The bank has adopted a cloud-first mind-set. According to Alexander, cloud makes it possible to keep up with the pace of innovation; as such, he has forged strategic relationships with leading cloud vendors.
- **Human-centred design principles:** Capital One views great design as central to every development project—a competency that should be appreciated and nurtured. To that end, in 2014, the bank acquired Adaptive Path, a design and user-experience consultancy.
- **Ecosystem:** Capital One has industrialised its sensing, scanning, and incubation function through engagement with venture capital firms and start-ups, prnt investments with academic institutions, and through an active acquisition strategy designed to add talent and differentiated technology to the bank's arsenal.
- **Tech college:** The bank has established a learning organisation to help employees from both the technology and business sides increase their understanding of existing and emerging technologies.

Since Capital One's IT transformation journey began seven years ago, many of the original operational and development goals have been met and surpassed. "We are a fundamentally different organism today," Alexander says. "We build our own products and release them on a regular basis. We have hundreds of applications in the cloud and are creating innovative products for the marketplace. We are a much larger and more capable operation."

But, he adds, the journey is far from over. Recognising that banking services will likely be integrated ever more closely into people's lives, Capital One Technology is now working to develop a branded yet personal customer experience. "We start with the way customers want to interact with their banks, and work backward from there," Alexander says. "By designing and delivering experiences that exceed customer expectations, we will be defining the digital bank of the future."[8]

Reinventing the IT wheelhouse

When Marcy Klevorn was appointed to the position of CIO at Ford Motor Co., the storied automaker was successfully harnessing the forces of technology disruption to become a pioneer in connectivity, mobility, and autonomous vehicles. Moreover, the company was developing new business and customer-engagement models along with new product design and engineering approaches, a process that continues unabated.

Klevorn recognised that to better support the kind of nimble, accelerated product exploration and development that Ford was embracing, the 11,000-person IT organisation would need to work differently. "We want IT to be Ford's unfair advantage," she says.

Her solution was to add a new development group to complement the existing core team. The "core" team focuses on critical capabilities like design, manufacturing, and service, areas where risk needs to be fiercely managed; and a new "emerging technologies" group supporting high-velocity development for projects such as FordPass,

connected vehicles, and autonomous cars, where there is greater tolerance for risk, experimentation, and learning.

"Since the emerging group was a separate, new team, it wasn't bound by all of the same rules that applied to the rest of IT because the things they were working on didn't exist yet," Klevorn says. "We encouraged them to take risks, fail in the process, and move on quickly to the next idea."

Klevorn leveraged the company's infinity symbol to describe the relationship between the core and emerging groups. "It is a symbol of synergy," she says. "These two groups have different approaches and priorities, but you can't have one without the other. The emerging group grew faster than anticipated. But what really surprised us was how much the demand for core initiatives grew as well, and we are now expanding these methods across IT."

The emerging team started with agile development, quickly adding operations staff and architects who helped the group become more self-sustaining. IT staffers can now rotate between the emerging and core groups so the benefits and opportunities are open to all. Now the lines between the groups are becoming increasingly blurred as many emerging products are grounded in core systems and are deployed in ways that augment core operations.

To further speed ideation and remove obstacles from the emerging team's path, a group of senior leaders held an hourlong "triage meeting" daily, in which team members presented problems and worked with senior management to find solutions before the meeting was over. Ford initially thought the process would primarily benefit emerging projects but found it benefited everyone: Emerging projects may have been surfacing items because of their rapid pace, but 90 percent of the improvements ended up affecting the core.

To nurture a culture of continuous improvement and unbounded innovation, Ford has implemented "Power Up" time, a weekly block of four hours during which all IT team members are encouraged to get creative, innovate, explore ideas, and fix problems. Employees have identified many innovations since Power Up time began and it has become so popular that other teams across the business are adopting the practice as well. This cultural shift has empowered employees to think creatively and play to their strengths.

"We have placed a lot of focus on communications and being transparent which has helped the employees with our transformation," Klevorn says. "It helps them cross silos and feel comfortable talking to anyone. The person in the room, who has the information, no matter what their level, is the most important person in the room."[9]

From "do it yourself" to "better together"

Faced with the challenges of shrinking budgets, retiring skills, and technical debt, Connecticut's individual state agencies banded together to share IT resources across organisational boundaries. The result is an enterprise operating model that delivers shared services across the government and automated capabilities to its citizens.

"Connecticut had a do-it-ourselves attitude; each agency had full authority and stood alone," says state CIO Mark Raymond. "We wanted to broaden our approach to support new systems and capabilities, but we knew we couldn't scale to meet demand, so we began rethinking what our delivery should look like."

To ensure strategic alignment of state organisations, the human services team established an executive steering committee composed of state agency leaders. This committee reviewed each agency's needs, defined a statewide IT strategy, and identified how individual organisations could share resources to both speed up and simplify delivery of services. Next, they designed an enterprise operating model that outlined shared resources and responsibilities across several organisations. These steps kickstarted IT's shift from being a trusted operator of agency IT assets to an agency-embedded co-creator of value.

The restructuring began three years ago when the state went live with ConneCT, a customer service modernisation initiative that provides the public with self-service and multiple online access points to the federal and state programs administered

through the Department of Social Services (DSS). While delivering the project, the multifunctional teams recognised that several of the project's baseline capabilities could be leveraged elsewhere. The new operating model and governance made it possible to expose and share capabilities that other agencies and projects could adopt or use.

In the first instance, Access Health CT, the state's health insurance martketplace, was built on the same foundational infrastructure as ConneCT. The DSS teamed with Access Health CT to revamp legacy systems in order to deliver single-point online access to the state's health care exchange.

Currently, the state is rolling out ImpaCT (Integrated Management Process and Accountability System for Connecticut), which will provide an automated eligibility determination process for citizens seeking DSS services. It replaces legacy systems and is designed to provide end-to-end fiscal management, improved operations and performance, and cost reduction by leveraging organisations' existing assets (both from within Connecticut as well as from other states).

"We recognised the do-it-yourself approach wasn't going to be sustainable," Raymond says. "The initial projects were run independently; as we reached the end of each project journey, we realised that components could be reused and shared, which meant the teams could be shared as well."

Formalising this strategy to create shared or cross-functional teams that have a stronger DevOps culture and embedded mind-set has helped Connecticut agencies better manage demand, prioritise next steps, and coordinate multiparty tasks. It provides visibility into operations and enables more efficient resolution of defects. While the state is looking at multivendor support to broaden its capabilities, the IT team is utilising agile disciplines throughout the enterprise to enable quick delivery of benefits and greater flexibility in response to changing business environments. There are still challenges in modernising at a speed that fits all the agencies' varying sizes, cultures, and priorities, but the embedded IT team is crucial to help manage change and expectations while focusing on the organisations' business needs. Bringing ideas, shared services, and opportunities for reuse and other accelerators to the table helps IT help the agencies aid Connecticut's citizens.

"The structure we put in place has allowed us to generate new opportunities," Raymond says. "We are maintaining a citizen-centric view of our services. A holistic approach is the most effective way to meet their needs."[10]

MY TAKE

ROSS MEYERCORD, CIO
SALESFORCE

At Salesforce, we have earned a leadership position in the customer relationship management market by delivering products and a philosophy that are relentlessly customer-focused. We believe that each of our customers should be treated as if they were our only customer, which means we put every customer's unique need at the centre of our innovation to deliver cutting-edge technology across the Customer Success Platform.

> "WE DON'T HAVE TWO-SPEED IT—WE HAVE ONE SPEED, AND IT IS FAST."

We take this same customer-centric approach to scaling and improving Salesforce's IT operations and strategies. By understanding the technology needs of our internal customers—Salesforce employees—and solving the operational and organisational problems identified, we have made significant progress in breaking down the boundaries that separate IT from employees.

The first step in our IT transformation journey was to build a culture of collaboration across the entire IT support team and better connect them with the employees they support. Tech Force bars were set up in break rooms and are manned by members of the IT support team, making IT troubleshooting and support more collaborative and real-time. Now, employees walk up to a tech bar and talk face-to-face with team members about their IT issues, versus logging a ticket and waiting for a response. We've already seen a decline in operational costs year to year, but more importantly, end-user satisfaction has gone from good to fantastic.

We have also built new apps and search tools to help employees get support not only from IT but also from HR, payroll, and facilities. We used our own technology to create a search engine called Concierge into which employees can type their questions in natural language and get answers immediately. The Concierge app helps direct employees to the appropriate knowledge source and log a ticket for additional assistance where needed with just a few clicks. This cross-functional application fields thousands of questions each day. As a result, IT case deflection has increased by 24 percent and overall cost of service has decreased.

As for our development process, 100 percent of our app development is SCRUM agile. We don't have two-speed IT—we have one speed, and it is fast. This has meant deep integration between "business" and "IT" teams, with dedicated product owner roles, business analysts, and multidisciplinary sprints working against a jointly maintained backlog. The organisation shifted from months of exhaustive requirements gathering to the idea of "MVP" (minimum viable product). This allows us to get prototypes out quickly, gather feedback to make improvements, and iterate over time as needs may change. This also means we provide ongoing support beyond initial deployment. In fact, I keep a budget for continuous support and improvement of existing and potentially mature products. This team is already in place, short-circuiting prioritisation and planning to deliver changes the business needs as quickly as possible.

Our strategy for building an IT organisation that is "unbounded" will inevitably evolve as new technologies, tactics, and business opportunities emerge. Yet our focus on customers—both internal and external—will remain constant. At the end of the day, Salesforce provides a service that helps people create value. As we transform IT to make it more efficient, flexible, and effective, this basic business philosophy will drive our efforts.

Efforts to maintain effective cyber controls can be undermined by two common challenges. First, in many organisations employees outside of IT view cyber as IT's exclusive problem. As such, they pay little mind to basic, commonsense security precautions. Secondly, in some IT operations, cyber considerations are an afterthought. IT leaders treat security and privacy as compliance tasks—required hoops to jump through to clear project stage gates. Security analysts are put in the difficult position of enforcing standards against hypothetical controls and policies, forcing an antagonistic relationship with developers and business sponsors trying to drive new solutions.

With these challenges in mind, the notion of erasing boundaries within IT and throughout the enterprise means that cyber risk should become everyone's concern. Likewise, efforts to create a flexible IT ecosystem that is "unbounded" include overhauling IT systems and processes, breaking down organisational siloes that separate business from IT, and reorganising operations around service delivery. Each of these initiatives offers companies an opportunity to design risk management capabilities into new systems and processes on the front end.

> "ERASING BOUNDARIES WITHIN IT AND THROUGHOUT THE ENTERPRISE MEANS THAT CYBER RISK SHOULD BECOME EVERYONE'S CONCERN."

IT organisations should take a proactive view of risk—particularly as it relates to strategic business initiatives. Potential benefits of taking this "risk first" approach include:

Acceleration: When risk and security capabilities are designed into systems and products up front, companies can avoid the expense and time-consuming effort required to retrofit these same systems and products down the road. The net result becomes an acceleration of the product development life cycle.

Completeness: By factoring in risk and compliance considerations during the earliest stages of project planning and design, engineers and designers can craft "complete" products that are effective and maintain security and compliance standards. Likewise, by taking a holistic design approach that balances risk, user experience, and performance considerations, systems will likely be more efficient. As CIOs work to blur the borders between the business and IT, as well as to integrate the development and operations teams within IT, they should make the chief information security officer and her team active participants throughout the project life cycle—from planning and design through implementation, testing, and deployment.

IT is in a rare position to orchestrate awareness of and appropriate responses to cyber threats. With an integrated view of project objectives and technology implications, conversations can be rooted in risk and return. Instead of taking extreme positions to protect against imaginable risk, organisations should aim for probable and acceptable risk—with IT helping business units, legal, finance, sales, marketing, and executive sponsors understand exposures, trade-offs, and impacts.

Organisational mind-sets may need to evolve, as risk tolerance is rooted in human judgment and perceptions about possible outcomes. Leadership should approach risk issues as overarching business concerns, not simply as project-level timeline and cost-and-benefit matters. CIOs can force the discussion and help champion the requisite integrated response.

This is a lofty goal, but it can be achieved by making "secure by design" a fundamental requirement through the unbounded IT operation.

Where do you start?

Given the lean state of many IT budgets, the term "IT transformation" may strike fear into the hearts of CIOs already struggling to do more with fewer resources. Yes, the ultimate goal of building an unbounded IT organisation is to reimagine IT development, delivery, and operating models, and to enhance IT's ability to collaborate effectively within the enterprise and beyond its traditional boundaries. But to be clear, this goal is often best served when pursued incrementally, in a phased approach tailored to a company's strategic and technology priorities as well as its available resources.

In the coming months, expect to see more organisations embrace the IT-unbounded trend by taking initial steps in what can and should be a manageable, deliberate journey toward a more efficient, flexible, and business-focused IT organisation.

As you begin your journey, consider how the following approaches could help you achieve longer-term transformation goals:

- **Earn business leaders' trust:** Business teams can be hesitant to engage IT in development projects because they may assume that IT will abandon them within five minutes of a new product going live. For your next development project, consider creating an integrated agile team with the idea that a subset of this team will stay in place after launch to provide support on an ongoing basis and to work with users to continually develop needed capabilities. If you are implementing a SaaS solution, consider taking a similar approach: Put together an independent team that includes staff from both IT and the service provider to operate and enable the supported business function. Make sure to set aside funds to support ongoing evolution and improvement.
- **De-emphasise IT's traditional focus as service provider to the business:** Convert IT SLAs to business KPIs, creating common objectives between business and IT. Instead of defining IT success by the operational and systems dimensions, try basing it in the function's ability to support the business's key objectives. This doesn't mean that IT is no longer responsible for responding to incidents, maintaining uptime, and hitting project deadlines. Nor does it absolve IT from being stewards of enterprise considerations applying to the technology stack: reliability, scalability, availability, maintainability, and security. But in today's kinetic enterprise, the "–ilities" are table stakes. IT should focus primarily on aligning with business objectives.
- **Liberate IT talent to focus on new tasks:** Refocusing IT talent on development or on innovative value-add tasks can help unleash creative thinking, boost worker morale, and break down inefficient skill silos. Yet augmenting talent in this way first requires freeing workers from the mundane care-and-feeding tasks that consume their workdays. Consider how moving to the cloud, automating back-end processes and workflows, and leveraging bots and cognitive systems to address user support can not only eliminate low-level work but also drive greater operational efficiencies.
- **Establish an innovation council:** While breaking down operational boundaries, it is also important to de-silo planning, particularly in the area of innovation. A cross-functional "skunk works" with membership representing IT, business, marketing, finance, and other enterprise groups can ideate and drive focused innovation. Though these groups often work exclusively with technology innovation, they don't necessarily have to report to IT.
- **Escape your echo chamber:** It's all too easy to get hamstrung by the status quo. When things operate the same way over a period of years, even the most creative IT leaders can struggle to come up with a new operational vision. A quick way to disrupt IT groupthink is to amplify voices of those outside the group. Consider involving your vendors more deeply as you develop new

goals, strategies, and processes. Or bring in non-IT experts from the world of academia, research, and business. Finally, try working with contract or crowdsourced talent with deep experience in a given area. These free agents can challenge your thinking and expand your horizons—without driving up talent costs long-term.

Bottom line

In the midst of historic technology and market disruption, only the fleet of foot will survive. The important work CIOs take on in the coming months to liberate IT from operational constraints and reimagine development and delivery models is, in the current climate, mission-critical. When approached methodically, the work of "unbinding IT" can help technology organisations develop the speed and agility needed for the race ahead.

CONTACTS

LUCINDA CLEMENTS
Director, Technology Strategy & Architecture
Deloitte MCS Limited
020 7007 9948
lclements@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AUTHORS

ATILLA TERZIOGLU
Technology Strategy & Architecture principal, Deloitte Consulting LLP

MARTIN KAMEN
Human Capital IT Transformation leader, Deloitte Consulting LLP

TIM BOEHM
Principal, Deloitte Consulting LLP

ANTHONY STEPHAN
US Technology Strategy and Architecture leader, Deloitte Consulting LLP

ENDNOTES

1. Mark White, Judy Pennington, Thomas Galizia, and Mike Habeck, *Right-speed IT: Living between black and white*, Deloitte University Press, February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/devops-it-optimisation-speed.html.
2. Ibid.
3. Ranjit Bawa, Jacques de Villiers, and George Collins, *Autonomic platforms: Building blocks for labor-less IT*, Deloitte University Press, February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/bi-model-it-on-autonomic-platforms.html.
4. Khalid Kark, Mark White, Bill Briggs, and Anjali Shaikh, *Navigating legacy: Charting the course to business value*, Deloitte University Press, November 10, 2016, https://dupress.deloitte.com/dup-us-en/topics/leadership/global-cio-survey.html.
5. Stephanie Overby, "How to embrace the benefits of shadow IT," *CIO Magazine*, June 22, 2016, www.cio.com/article/3078344/it-industry/how-to-embrace-the-benefits-of-shadow-it.html.
6. Ford Motor Co., "Ford invests in Pivotal to accelerate cloud-based software development," May 5, 2016, https://media.ford.com/content/fordmedia/fna/us/en/news/2016/05/05/ford-invests-in-pivotal.html.
7. Thor Olavsrud, "GE to open new locations to develop industrial Internet talent," *CIO Magazine*, June 9, 2016, www.cio.com/article/3081483/careers-staffing/ge-to-open-new-locations-to-develop-industrial-internet-talent.html.
8. Interview with Rob Alexander, CIO of Capital One Financial Corp., January 17, 2017.
9. Interview with Marcy Klevorn, vice president and CIO of Ford Motor Co., January 11, 2017.
10. Interview with Mark Raymond, CIO of the state of Connecticut, December 23, 2016.

Deloitte.
University Press

Dark analytics

Illuminating opportunities hidden within unstructured data

ACROSS ENTERPRISES, EVER-EXPANDING STORES OF DATA REMAIN UNSTRUCTURED and unanalysed. Few organisations have been able to explore nontraditional data sources such as image, audio, and video files; the torrent of machine and sensor information generated by the Internet of Things; and the enormous troves of raw data found in the unexplored recesses of the "deep web." However, recent advances in computer vision, pattern recognition, and cognitive analytics are making it possible for companies to shine a light on these untapped sources and derive insights that lead to better experiences and decision making across the business.

IN this age of technology-driven enlightenment, data is our competitive currency. Buried within raw information generated in mind-boggling volumes by transactional systems, social media, search engines, and countless other technologies are critical strategic, customer, and operational insights that, once illuminated by analytics, can validate or clarify assumptions, inform decision making, and help chart new paths to the future.

Until recently, taking a passive, backward-looking approach to data and analytics was standard practice. With the ultimate goal of "generating a report," organisations frequently applied analytics capabilities to limited samples of structured data siloed within a specific system or company function. Moreover, nagging quality issues with master data, lack of user sophistication, and the inability to bring together data from across enterprise systems often colluded to produce insights that were at best limited in scope and, at worst, misleading.

Today, CIOs harness distributed data architecture, in-memory processing, machine learning, visualisation, natural language processing, and cognitive analytics to answer questions and identify valuable patterns and insights that would have seemed unimaginable only a few years ago. Indeed, analytics now dominates IT agendas and spend. In Deloitte's *2016 Global CIO Survey* of 1,200 IT executives, respondents identified analytics as a top investment priority. Likewise, they identified hiring IT talent with analytics skills as their top recruiting priority for the next two years.[1]

Leveraging these advanced tools and skill sets, over the next 18 to 24 months an increasing number of CIOs, business leaders, and data scientists will begin experimenting with "dark analytics": focused explorations of the vast universe of unstructured and "dark" data with the goal of unearthing the kind of highly nuanced business, customer, and operational insights that structured data assets currently in their possession may not reveal.

In the context of business data, "dark" describes something that is hidden or undigested. Dark analytics focuses primarily on raw text-based data that has not been analysed—with an emphasis on unstructured data, which may include things such

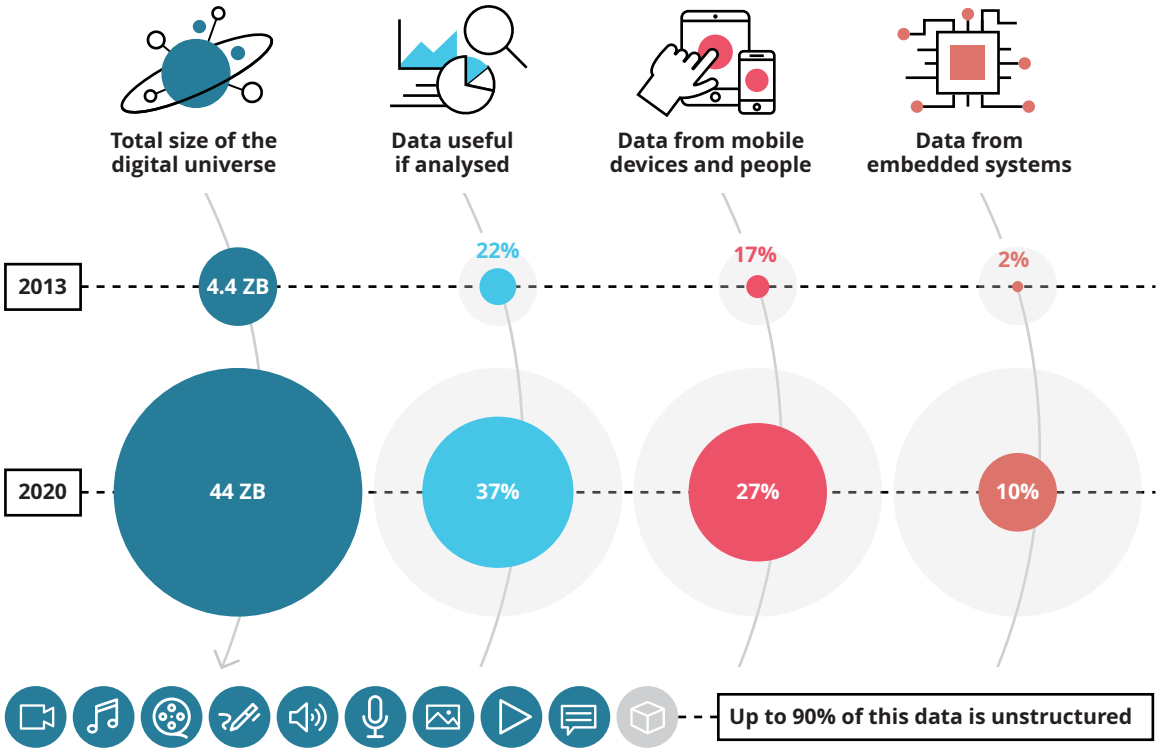
as text messages, documents, email, video and audio files, and still images. In some cases, dark analytics explorations could also target the deep web, which comprises everything online that is not indexed by search engines, including a small subset of anonymous, inaccessible sites known as the "dark web." It is impossible to accurately calculate the deep web's size, but by some estimates it is 500 times larger than the surface web that most people search daily.[2]

In a business climate where data is competitive currency, these three largely unexplored resources could prove to be something akin to a lottery jackpot. What's more, the data and insights contained therein are multiplying at a mind-boggling rate. An estimated 90 percent of all data in existence today was generated during the last five years.[3] The digital universe—comprising the data we create and copy annually—is doubling in size every 12 months. Indeed, it is expected to reach 44 zettabytes (that's 44 *trillion* gigabytes) in size by 2020 and will contain nearly as many digital bits as there are stars in the universe.[4]

What's more, these projections may actually be conservative. Gartner Inc. anticipates that the Internet of Things' (IoT) explosive growth will see 20.8 billion connected devices deployed by 2020.[5] As the IoT expands, so will the volumes of data the technology generates. By some estimates, the data that IoT devices will create globally in 2019—the bulk of which will be "dark"—will be 269 times greater than the amount of data being transmitted

Figure 1. The expanding digital universe, 2013–2020

In 2020, the digital universe is expected to reach 44 zettabytes. One zettabyte is equal to one billion terabytes. Data valuable for enterprises, especially unstructured data from the Internet of Things and nontraditional sources, is projected to increase in absolute and relative sizes.



Sources: EMC Digital Universe with research and analysis by IDC, "The digital universe of opportunities: Rich data and the increasing value of the Internet of Things," April 2014; International Data Corporation, "IDC iView: Extracting value from chaos," 2011, www.emc.com/collateral/analyst-reports/idc-extracting-value-from-chaos-ar.pdf, accessed December 29, 2016.

to data centres from end-user devices and 49 times higher than total data-centre traffic.[6] Against this statistical backdrop, big data, as a business imperative, might be more accurately described as "enormous data."

To date, companies have explored only a tiny fraction of the digital universe for analytic value. IDC estimates that by 2020, as much as 37 percent of the digital universe will contain information that might be valuable if analysed.[7]

But exactly how valuable? IDC also projects that organisations that analyse all relevant data and deliver actionable information will achieve an extra $430 billion in productivity gains over their less analytically oriented peers by 2020.[8]

Let there be light

When we think about analytics' potential, the possibilities we often envision are limited to the structured data that exists within the systems around us. Dark analytics seeks to remove those limits by casting a much wider data net that can capture a corpus of currently untapped signals.

Dark analytics efforts typically focus on three dimensions:

Untapped data already in your possession: In many organisations, large collections of both structured and unstructured data sit idle. On the structured side, it's typically because connections haven't been easy to make between disparate data sets that may have meaning—especially information that lives outside of a given system, function, or business unit. For example, a large insurance company mapped its employees' home addresses and parking pass assignments with their workplace satisfaction ratings and retention data. The effort revealed that one of the biggest factors fueling voluntary turnover was commute time—the combination of distance to the office, traffic patterns based on workers' shift schedule, degree of difficulty in finding a parking spot, and length of walk from car to their workspace.

Regarding "traditional" unstructured data, think emails, notes, messages, documents, logs, and notifications (including from IoT devices). These are text-based and sit within organisational boundaries but remain largely untapped, either because they don't live in a relational database or because until relatively recently, the tools and techniques needed to leverage them efficiently did not exist. Buried within these unstructured data assets could be valuable information on pricing, customer behavior, and competitors. Particularly in multinational companies, they may also contain potentially valuable yet untranslated data assets created for or generated in non-English-speaking markets.

What percentage of the data in existence today is unstructured? No one knows for sure. The generally accepted figure has long been 80 percent—known as "the 80 percent rule"—though recent estimates put the number closer to 90 percent.[9]

Nontraditional unstructured data: The second dark analytics dimension focuses on a different category of unstructured data that cannot be mined using traditional reporting and analytics techniques—audio and video files and still images, among others. Using computer vision, advanced pattern recognition, and video and sound analytics, companies can now mine data contained in nontraditional formats to better understand their customers, employees, operations, and markets. For example, a retailer may be able to gain a more nuanced understanding of customer mood or intent by analysing video images of shoppers' posture, facial expressions, or gestures. An oil and gas company could use acoustic sensors to monitor pipelines and algorithms to provide visibility into oil flow rates and composition. An amusement park could gain greater insight into customer demographics by analysing security-camera footage to determine how many customers arrive by car, by public transportation, or by foot, and at what times during the day.

Low-cost high-fidelity surround cameras, far-field microphone areas, and high-definition cameras make it possible to monitor all business activities taking place within an enterprise. The ability to apply analytics to audio and video feeds in real time opens up profound new opportunities for signal detection and response. Such digital cues offer new ways of answering existing questions and exploring

new opportunities. Moreover, in recent years data storage costs have declined by an estimated 15 to 20 percent, making the archiving of image and audio files a more realistic option for smaller organisations.[10]

Data in the deep web: As a dimension of dark analytics, the deep web offers what may contain the largest body of untapped information—data curated by academics, consortia, government agencies, communities, and other third-party domains. But the domain's sheer size and distinct lack of structure can make it difficult to search. For now, only data mining and analytics efforts that are bounded and focused on a defined target—for instance, licensable data owned by a private association—will likely yield relevant, useful insights. Just as the intelligence community monitors the volume and context of deep web activity to identify potential threats, businesses may soon be able to curate competitive intelligence using a variety of emerging search tools designed to help users target scientific research, activist data, or even hobbyist threads found in the deep web. For example, Deep Web Technologies builds search tools for retrieving and analysing data that would be inaccessible to standard search engines.[11] Its software is currently deployed by federal scientific agencies as well as several academic and corporate organisations. Stanford University has built a prototype engine called Hidden Web Exposer that scrapes the deep web for information using a task-specific, human-assisted approach. Other publicly accessible search engines include Infoplease, PubMed, and the University of California's Infomine.[12]

Flashlight, not interplanetary star

To be clear, the purpose of dark analytics is not to catalog vast volumes of unstructured data. Casting a broader data net without a specific purpose in mind will likely lead to failure. Indeed, dark analytics efforts that are surgically precise in both intent and scope often deliver the greatest value. Like every analytics journey, successful efforts begin with a series of specific questions. What problem are you solving? What would we do differently if we could solve that problem? Finally, what data sources and analytics capabilities will help us answer the first two questions?

Answering these questions makes it possible for dark analytics initiatives to illuminate specific insights that are relevant and valuable. Remember, most of the data universe is dark, and with its sheer size and variety, it should probably stay that way.

IU Health's Rx for mining dark data

As part of a new model of care, Indiana University Health (IU Health) is exploring ways to use nontraditional and unstructured data to personalise health care for individual patients and improve overall health outcomes for the broader population.

Traditional relationships between medical care providers and patients are often transactional in nature, focusing on individual visits and specific outcomes rather than providing holistic care services on an ongoing basis. IU Health has determined that incorporating insights from additional data will help build patient loyalty and provide more useful, seamless, and cost-efficient care.

"IU Health needs a 360-degree understanding of the patients it serves in order to create the kind of care and services that will keep them in the system," says Richard Chadderton, senior vice president, engagement and strategy, IU Health. "Our organisation is exploring ways to mine and analyse data—in much the same way consumer-oriented companies are approaching customer data—to develop this deeper understanding."[13]

For example, consider the voluminous free-form notes—both written and verbal—that physicians generate during patient consultations. Deploying voice recognition, deep learning, and text analysis capabilities to these in-hand but previously underutilised sources could potentially add more depth and detail to patient medical records. These same capabilities might also be used to analyse audio recordings of patient conversations with IU Health call centres to further enhance a patient's records. Such insights could help IU Health develop a more thorough understanding of the patient's needs, and better illuminate how those patients utilise the health system's services.

Another opportunity involves using dark data to help predict need and manage care across populations. IU Health is examining how cognitive computing, external data, and patient data could help identify patterns of illness, health care access, and historical outcomes in local populations. The approaches could make it possible to incorporate socioeconomic factors that may affect patients' engagement with health care providers.

"There may be a correlation between high density per living unit and disengagement from health," says Mark Lantzy, senior vice president and chief information officer, IU Health. "It is promising that we can augment patient data with external data to determine how to better engage with people about their health. We are creating the underlying platform to uncover those correlations and are trying to create something more systemic.

The destination for our journey is an improved patient experience," he continues. "Ultimately, we want it to drive better satisfaction and engagement.

More than deliver great health care to individual patients, we want to improve population health throughout Indiana as well. To be able to impact that in some way, even incrementally, would be hugely beneficial."[14]

Retailers make it personal

Retailers almost universally recognise that digital has reshaped customer behavior and shopping. In fact, $0.56 of every dollar spent in a store is influenced by a digital interaction.[15] Yet many retailers—particularly those with brick-and-mortar operations—still struggle to deliver the digital experiences customers expect. Some focus excessively on their competitors instead of their customers and rely on the same old key performance indicators and data.[16]

In recent years, however, growing numbers of retailers have begun exploring different approaches to developing digital experiences. Some are analysing previously dark data culled from customers' digital lives and using the resulting insights to develop merchandising, marketing, customer service, and even product development strategies that offer shoppers a targeted and individualised customer experience.

Stitch Fix, for example, is an online subscription shopping service that uses images from social media and other sources to track emerging fashion trends and evolving customer preferences. Its process begins with clients answering a detailed questionnaire about their tastes in clothing. Then, with client permission, the company's team of 60 data scientists augments that information by scanning images on customers' Pinterest boards and other social media sites, analysing them, and using the resulting insights to a develop a deeper understanding of each customer's sense of style. Company stylists and artificial intelligence algorithms use these profiles to select style-appropriate items of clothing to be shipped to individual customers at regular intervals.[17]

Meanwhile, grocery supermarket chain Kroger Co. is taking a different approach that leverages Internet of Things and advanced analytics techniques. As part of a pilot program, the company is embedding a network of sensors and analytics into store shelves that can interact with the Kroger app and a digital shopping list on a customer's phone. As the customer strolls down each aisle, the system—which contains a digital history of the customer's purchases and product preferences—can spotlight specially priced products the customer may want on 4-inch displays mounted in the aisles. This pilot, which began in late 2016 with initial testing in 14 stores, is expected to expand in 2017.[18]

Expect to see more pilots and full deployments such as these in the coming months as retailers begin executing customer engagement strategies that could, if successful, transform both the shopping experience and the role that nontraditional data plays in the retail industry.

MY TAKE

GREG POWERS, VICE PRESIDENT OF TECHNOLOGY
HALLIBURTON

As a leader in the oil field services industry, Halliburton has a long history of relying heavily on data to understand current and past operating conditions in the field and to measure in-well performance.

Yet the sheer volume of information that we can and do collect goes way beyond human cognitive bandwidth. Advances in sensor science are delivering enormous troves of both dark data and what I think of as really dark data. For example, we scan rocks electromagnetically to determine their consistency. We use nuclear magnetic resonance to perform what amounts to an MRI on oil wells. Neutron and gamma-ray analysis measures the electrical permittivity and conductivity of rock. Downhole spectroscopy measures fluids. Acoustic sensors collect 1–2 terabytes of data daily. All of this dark data helps us better understand in-well performance. In fact, there's so much potential value buried in this darkness that I flip the frame and refer to it as "bright data" that we have yet to tap.

We've done a good job of building a retrospective view of past performance. In the next phase of Halliburton's ongoing analytics program, we want to develop the capacity to capture, mine, and use bright data insights to become more predictive. Given the nature of our operations, this will be no small task. Identical events driven by common circumstances are rare in the oil and gas industry. We have 30 years of retrospective data, but there are an infinite number of combinations of rock, gas, oil, and other variables that affect outcomes. Unfortunately, there is no overarching constituent physics equation that can describe the right action to take for any situation encountered. Yet, even if we can't explain what we've seen historically, we can explore what has happened and let our refined appreciation of historic data serve as a road map to where we can go. In other words, we plan to correlate data to things that statistically seem to matter and, then, use this data to develop a confidence threshold to inform how we should approach these issues.

"THERE'S SO MUCH POTENTIAL VALUE BURIED IN THIS DARKNESS."

We believe that nontraditional data holds the key to creating advanced intelligent response capabilities to solve problems, potentially without human intervention, before they happen. However, the oil and gas industry is justifiably conservative when it comes to adopting new technology, and when it comes to automating our handling of critical infrastructure, the industry will likely be more conservative than usual. That's why we may see a tiered approach emerge for leveraging new product lines, tools, and offerings. At the lowest level, we'll take measurements and tell someone after the fact that something happened. At the next level, our goal will be to recognise that something has happened and, then, understand why it happened. The following step will use real-time monitoring to provide in-the-moment awareness of what is taking place and why. In the next tier, predictive tools will help us discern what's likely to happen next. The most extreme offering will involve automating the response—removing human intervention from the equation entirely.

Drilling is complicated work. To make it more autonomous and efficient, and to free humans from mundane decision making, we need to work smarter. Our industry is facing a looming generational change. Experienced employees will soon retire and take with them decades of hard-won expertise and knowledge. We can't just tell our new hires, "Hey, go read 300 terabytes of dark data to get up to speed." We're going to have to rely on new approaches for developing, managing, and sharing data-driven wisdom.

CYBER IMPLICATIONS

Deploying analytics technologies to help illuminate actionable insights not only within raw data already in your possession but also in derived data represents a potentially powerful business opportunity. Yet dialing up your data mining and analysis efforts and importing large stores of nontraditional data from external sources can lead to questions about data veracity, integrity, legality, and appropriateness of use. These are questions that few organisations can afford to ignore today.

On the flip side, deep analysis of more data from a variety of sources may also yield signals that could potentially boost your cyber and risk management efforts. Indeed, the dark analytics trend is not just about deploying increasingly powerful analytics tools against untapped data sources. From a cyber risk perspective, this trend is also about wielding these and other tools to inspect both the data in your possession and third-party data you purchase.

As you explore the dark analytics trend, consider the following risk-related issues and opportunities:

> "THE DARK WEB REPRESENTS ONLY ONE SMALL COMPONENT PART OF THE LARGER DEEP WEB."

Sourcing data: To what degree can you trust the data's integrity? If you can't confirm its accuracy, completeness, and consistency, you could be exposing your company to regulatory, financial, and even brand risks. The same goes for its authenticity. Is the source of the data who it says it is? If not, the data could be recycled from other dubious sources or, worse, stolen.

Respecting privacy: The specter of privacy law casts a long shadow over audio and video data sourced outside the enterprise. In many cases, the privacy laws that apply to audio or video clips are determined by the nationality of the individuals appearing in them. Likewise, in some countries, even recording an Internet protocol (IP) address is considered a violation of privacy. In developing a dark analytics cyber risk strategy, you should remain mindful of the vagaries of global privacy law. Finally, data that may appear to be benign could, in fact, carry potential privacy risk if it has been derived from analytics. For example, analysis of customer data might suggest a correlation between customer meal preferences and certain medical conditions or even their religion. As you begin to curate and analyse data, how do you put proper controls in place and manage the associated privacy and legal risks? What liability could you face if you archive data containing such correlative findings?

Building predictive risk models: As you apply analytics to nontraditional data sources, there may be opportunities to create predictive risk models that are based on geography, hiring practices, loans, or various factors in the marketplace. These models could potentially help companies develop a more nuanced understanding of employee, customer, or business partner sentiment that may, in turn, make it possible to develop proactive risk mitigation strategies to address each.

Spotlighting third-party risk landscape: Global companies may depend upon hundreds or even thousands of vendors to provide data and other services. By analysing data from nontraditional sources, companies may be able to create predictive risk models that provide more detailed risk profiles of their vendors. Some of the risks identified may likely be beyond your control—a point to keep in mind as you source third-party data.

Leveraging deep web signals: The data contained in those parts of the web that are currently accessible to search engines is too vast for organisations to harness. Expanding that already-infinite universe to include nontraditional data from the deep web may present data analysis opportunities, but from a cyber risk standpoint, it may also present considerable risks. The dark web represents only one small component part of the larger deep web, but it has, time and again, been at the root of cyber challenges and issues.

As such, it will likely amplify the risk challenges and complexities that companies face should they choose to explore it. Proceed with eyes wide open.

That said, by applying risk modeling to bounded data sets sourced from the larger deep web, organisations may be able to further expand their knowledge in the realms of cybersecurity, competitive intelligence, customer engagement, and other areas of strategic priority.

Where do you start?

Three years from now, your organisation may find itself overwhelmed by immeasurable volumes of unstructured data generated by Internet of Things devices. Working today to develop the discipline and tools you will need to manage and mine all of this dark data can help your organisation generate data-driven insights today while preparing for even greater opportunities in the years ahead.

This process begins with a series of practical steps:

- **Ask the right questions:** Rather than attempting to discover and inventory all of the dark data hidden within and outside your organisation, work with business teams to identify specific questions they want answered. Work to identify potential dark analytics sources and the untapped opportunities contained therein. Then focus your analytics efforts on those data streams and sources that are particularly relevant. For example, if marketing wants to boost sales of sports equipment in a certain region, analytics teams can focus their efforts on real-time sales transaction streams, inventory, and product pricing data at select stores within the target region. They could then supplement this data with historic unstructured data—in-store video analysis of customer foot traffic, social sentiment, influencer behavior, or even pictures of displays or product placement across sites—to generate more nuanced insights.
- **Look outside your organisation:** You can augment your own data with publicly available demographic, location, and statistical information. Not only can this help your analytics teams generate more expansive, detailed reports—it can put insights in a more useful context. For example, a physician makes recommendations to an asthma patient based on her known health history and a current examination. By reviewing local weather data, he can also provide short-term solutions to help her through a flare-up during pollen season. In another example, employers might analyse data from geospatial tools, traffic patterns, and employee turnover to determine the extent to which employee job satisfaction levels are being adversely impacted by commute times.
- **Augment data talent:** Data scientists are an increasingly valuable resource, especially those who can artfully combine deep modeling and statistical techniques with industry or function-specific insights and creative problem framing. Going forward, those with demonstrable expertise in a few areas will likely be in demand. For example, both machine learning and deep learning require programmatic expertise—the ability to build established patterns to determine the appropriate combination of data corpus and method to uncover reasonable, defensible insights. Likewise, visual and graphic design skills may be increasingly critical given that visually communicating results and explaining rationales are essential for broad organisational adoption. Finally, traditional skills such as master data management and data architecture will be as valuable as ever—particularly as more companies begin laying the foundations they'll need to meet the diverse, expansive, and exploding data needs of tomorrow.
- **Explore advanced visualisation tools:** Not everyone in your organisation will be able to digest a printout of advanced Bayesian statistics and apply them to business practices. Most people need to understand the "so what" and the "why" of complex analytical insights before they can turn insight into action. In many situations, information can be more easily digested when presented as an infographic, a dashboard, or another type of visual representation. Visual and design software packages can do more than generate eye-catching graphics such as bubble charts, word clouds, and heat maps—they can boost business intelligence by repackaging big data into smaller, more meaningful chunks, delivering value to users much faster. Additionally, the insights (and the tools) can be made accessible across the enterprise, beyond the IT department, and to business users at all levels, to create more agile, cross-functional teams.
- **View it as a business-driven effort:** It's time to recognise analytics as an overall business

strategy rather than as an IT function. To that end, work with C-suite colleagues to garner support for your dark analytics approach. Many CEOs are making data a cornerstone of overall business strategy, which mandates more sophisticated techniques and accountability for more deliberate handling of the underlying assets. By understanding your organisation's agenda and goals, you can determine the value that must be delivered, define the questions that should be asked, and decide how to harness available data to generate answers. Data analytics then becomes an insight-driven advantage in the marketplace. The best way to help ensure buy-in is to first pilot a project that will demonstrate the tangible ROI that can be realised by the organisation with a businesswide analytics strategy.

- **Think broadly:** As you develop new capabilities and strategies, think about how you can extend them across the organisation as well as to customers, vendors, and business partners. Your new data strategy becomes part of your reference architecture that others can use.

Bottom line

With ever-growing data troves still unexplored, aggregation, analysis, and storage are no longer end goals in the agile organisation's analytics strategy. Going forward, analytics efforts will focus on illuminating powerful strategic, customer, and operational insights hidden within untraditional and dark data sources. Be excited about the potential of unstructured and external data, but stay grounded in specific business questions with bounded scope and measurable, attributable value. Use these questions to focus your dark analytics efforts on areas that matter to your business—and to avoid getting lost in the increasingly vast unknown.

CONTACTS

HARVEY LEWIS
Director, AI and Cognitive Computing lead
Deloitte MCS Limited
020 7303 6805
harveylewis@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AUTHORS

TRACIE KAMBIES
US Retail Analytics & Information Management and IoT lead, Deloitte Consulting LLP

NITIN MITTAL
US Analytics & Information Management practice leader, Deloitte Consulting LLP

PAUL ROMA
Deloitte Analytics leader, Deloitte Consulting LLP

SANDEEP KUMAR SHARMA, PH.D.
Deputy chief technology officer, Deloitte Consulting LLP

ENDNOTES

1. Khalid Kark, Mark White, Bill Briggs, and Anjali Shaikh, *Navigating legacy: Charting the course to business value*, Deloitte University Press, November 10, 2016,
2. Marc Goodman, "Most of the web is invisible to Google. Here's what it contains," *Popular Science*, April 1, 2015, www.popsci.com/dark-web-revealed.
3. Åse Dragland, "Big data, for better or worse: 90% of world's data generated over last two years," *Science Daily*, May 22, 2013, www.sciencedaily.com/releases/2013/05/130522085217.htm.
4. EMC Digital Universe with research and analysis by IDC, "The digital universe of opportunities: Rich data and the increasing value of the Internet of Things," April 2014, www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm.
5. Gartner Inc., "Gartner says 6.4 billion connected 'things' will be in use in 2016, up 30 percent from 2015," press release, November 10, 2015, www.gartner.com/newsroom/id/3165317.
6. Cisco, "Cisco Global Cloud Index: Forecast and methodology, 2014–2019," October 28, 2015, www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/Cloud_Index_White_Paper.html.
7. Dan Vesset and David Schubmehl, "IDC FutureScape: Worldwide big data, business analytics, and cognitive software 2017 predictions," December 2016, International Data Corporation.
8. Ibid.
9. Seth Grymes, "Unstructured data and the 80 percent rule," *Breakthrough Analysis*, August 1, 2008, https://breakthroughanalysis.com/2008/08/01/unstructured-data-and-the-80-percent-rule/.
10. Cindy LaChapelle, "The cost of data management: Where is it headed in 2016?" *Datacenter Journal*, March 10, 2016, www.datacenterjournal.com/cost-data-storage-management-headed-2016/.
11. Microsoft, "Multi-lingual, federated search solution provides global access to scientific research," March 24, 2015, https://customers.microsoft.com/en-US/story/multilingual-federated-search-solution-provides-global.
12. David Barton, "Data mining in the deep web," *The Innovation Enterprise*, July 14, 2016, https://channels.theinnovationenterprise.com/articles/data-mining-in-the-deep-web.
13. Interview with Richard Chadderton, senior vice president of engagement and strategy, Indiana University Health, December 9, 2016.
14. Interview with Mark Lantzy, CIO of IU Health, November 21, 2016.
15. Jeff Simpson, Lokesh Ohri, and Kasey M. Lobaugh, *The new digital divide*, Deloitte University Press, September 12, 2016, https://dupress.deloitte.com/dup-us-en/industry/retail-distribution/digital-divide-changing-consumer-behavior.html.
16. Ibid.
17. Hilary Milnes, "How Stitch Fix's happy relationship with Pinterest helps customers," *Digiday*, March 16, 2016, http://digiday.com/brands/how-stitch-fix-depends-on-pinterest-to-make-its-customers-happy/.
18. Kim S. Nash, "Kroger tests sensors, analytics in interactive grocery shelves," *Wall Street Journal*, January 20, 2017, http://blogs.wsj.com/cio/2017/01/20/kroger-tests-sensors-analytics-in-interactive-grocery-shelves/.

Deloitte.
University Press

Machine intelligence

Technology mimics human cognition to create value

ARTIFICIAL INTELLIGENCE'S RAPID EVOLUTION HAS GIVEN RISE TO MYRIAD DISTINCT—yet often misunderstood—AI capabilities such as machine learning, deep learning, cognitive analytics, robotics process automation (RPA), and bots, among others. Collectively, these and other tools constitute machine intelligence: algorithmic capabilities that can augment employee performance, automate increasingly complex workloads, and develop "cognitive agents" that simulate both human thinking and engagement. Machine intelligence represents the next chapter in the advanced analytics journey.

DATA'S emergence as a critical business asset has been a persistent theme in every *Tech Trends* report, from the foundational capabilities needed to manage its exploding volumes and complexity to the increasingly sophisticated analytics tools techniques available to unearth business insights from data troves. By harnessing analytics to illuminate patterns, insights, and opportunities hidden within ever-growing data stores, companies have been able to develop new approaches to customer engagement; to amplify employee skills and intelligence; to cultivate new products, services, and offerings; and to explore new business models. Today, more and more CIOs are aggressively laying the foundations needed for their organisations to become more insight-driven.

Artificial intelligence (AI)—technologies capable of performing tasks normally requiring human intelligence—is becoming an important component of these analytics efforts. Yet AI is only one part of a larger, more compelling set of developments in the realm of cognitive computing. The bigger story is *machine intelligence* (MI), an umbrella term for a collection of advances representing a new cognitive era. We are talking here about a number of cognitive tools that have evolved rapidly in recent years: machine learning, deep learning, advanced cognitive analytics, robotics process automation, and bots, to name a few.

We are already seeing early use cases for machine intelligence emerge in various sectors. For example, a leading hospital that runs one of the largest medical research programs in the United States is "training" its machine intelligence systems to analyse the 10 billion phenotypic and genetic images stored in the organisation's database. In financial services, a cognitive sales agent uses machine intelligence to initiate contact with a promising sales lead and then qualify, follow up with, and sustain the lead. This cognitive assistant can parse natural language to understand customers' conversational questions, handling up to 27,000 conversations simultaneously and in dozens of spoken languages.

In the coming months, expect to read about similar use cases as more companies tap into the power of machine. Spending on various aspects of MI is already increasing and is projected to reach

nearly $31.3 billion in 2019.[1] It is also becoming a priority for CIOs. Deloitte's *2016 Global CIO Survey* asked 1,200 IT executives to identify the emerging technologies in which they plan to invest significantly in the next two years. Sixty-four percent included cognitive technologies.[2]

Data, now more than ever

What we think of today as cognitive computing actually debuted in the 1950s as a visionary effort to make technology simulate human intelligence. Though somewhat primitive AI technologies were commercially available by the 1980s, it wasn't until the 2000s that AI—and the cognitive computing capabilities that comprise the emerging machine intelligence trend—took off.[3]

A confluence of three powerful forces is driving the machine intelligence trend:

Exponential data growth: The digital universe—comprising the data we create and copy annually—is doubling in size every 12 months. Indeed, it is expected to reach 44 zettabytes in size by 2020.[4] We also know that data will grow more rapidly as new signals from the Internet of Things, dark analytics, and other sources proliferate. From a business perspective, this explosive growth translates into a greater variety of potentially valuable data sources than ever before. Beyond the potential to unlock new insights using traditional analytics techniques, these volumes of structured and unstructured data, as well as vast troves of unstructured data residing in the deep web,[5] are critical to the advancement of machine intelligence. The more data these systems consume, the "smarter" they become by discovering relationships, patterns, and potential implications.

Effectively managing rapidly growing data volumes requires advanced approaches to master data, storage, retention, access, context, and stewardship. From signals generated by connected devices to the line-level detail behind historical transactional data from systems across all businesses and functions, handling data assets becomes a crucial building block of machine intelligence ambitions.

Faster distributed systems: As data volumes have grown larger and analysis more sophisticated, the distributed networks that make data accessible to individual users have become exponentially more powerful. Today, we can quickly process, search, and manipulate data in volumes that would have been impossible only a few years ago. The current generation of microprocessors delivers 4 million times the performance of the first single-chip microprocessor introduced in 1971.[6] This power makes possible advanced system designs such as those supporting multi-core and parallel processing. Likewise, it enables advanced data storage techniques that support rapid retrieval and analysis of archived data. As we see with MapReduce, in-memory computing, and hardware optimised for MI techniques like Google's Tensor Processing Units, technology is advancing to optimise our ability to manage exponential data more effectively.

Beyond increases in sheer power and speed, distributed networks have grown in reach as well. They now interface seamlessly with infrastructure, platforms, and applications residing in the cloud and can digest and analyse ever-growing data volumes residing there. They also provide the power needed to analyse and actuate streamed data from "edge" capabilities such as the Internet of Things, sensors, and embedded intelligence devices.

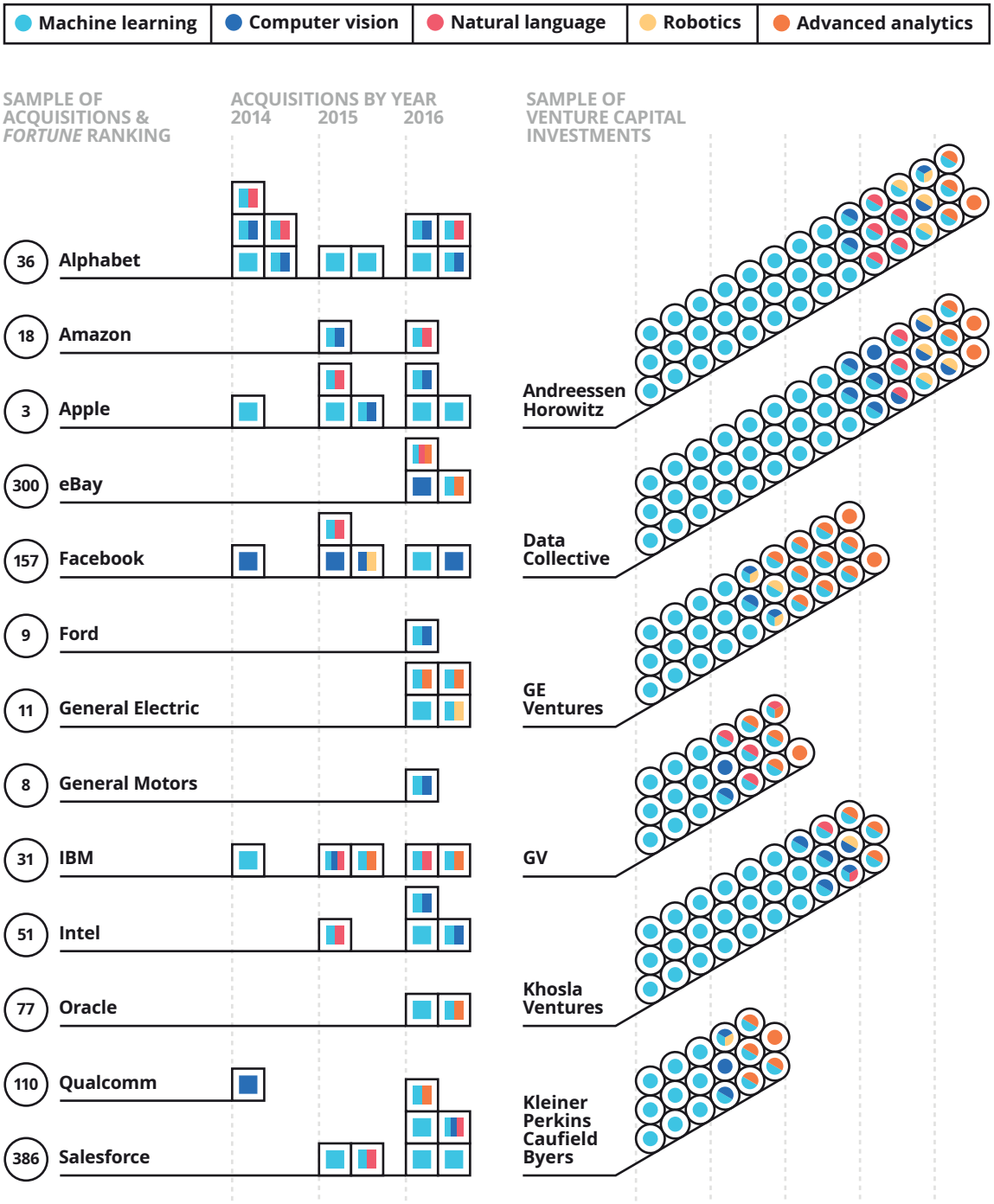
Smarter algorithms: In recent years, increasingly powerful MI algorithms have advanced steadily toward achieving cognitive computing's original goal of simulating human thought processes.

The following algorithmic capabilities will likely see broader adoption in the public and private sectors as machine intelligence use cases emerge over the next 18 to 24 months:[7]

- **Optimisation, planning, and scheduling:** Among the more mature cognitive algorithms, optimisation automates complex decisions and trade-offs about limited resources. Similarly, planning and scheduling algorithms devise a sequence of actions to meet processing goals and observe constraints.
- **Machine learning:** Computer systems are developing the ability to improve their performance by exposure to data without the need to follow explicitly programmed instructions. At its core, machine learning is the

Figure 1. Machine intelligence's impact: Sample acquisitions and investments, 2014–2016

A Deloitte analysis reveals that *Fortune* 500 companies and venture capital firms have recognised the potential of machine intelligence and are strategically investing to build new capabilities.



Sources: Publicly available information on all *Fortune* 50 companies and on technology companies in the *Fortune* 500; Erin Griffith, "Here are the 51 technology and telecommunications companies of the *Fortune* 500," *Fortune*, June 7, 2016, http://for.tn/22o9uUO; All investment information provided by cited companies, December 2016.

process of automatically discovering patterns in data. Once identified, a pattern can be used to make predictions.

- **Deep learning:** Developers are working on machine learning algorithms involving artificial neural networks that are inspired by the structure and function of the brain. Interconnected modules run mathematical models that are continuously tuned based on results from processing a large number of inputs. Deep learning can be supervised (requiring human intervention to train the evolution of the underlying models) or unsupervised (autonomously refining models based on self-evaluation).
- **Probabilistic inference:** New AI capabilities use graph analytics and Bayesian networks to identify the conditional dependencies of random variables.
- **Semantic computing:** This cognitive category includes computer vision (the ability to analyse images), voice recognition (the ability to analyse and interpret human speech), and various text analytics capabilities, among others, to understand naturally expressed intention and the semantics of computational content. It then uses this information to support data categorisation, mapping, and retrieval.
- **Natural language engines:** A natural language engine understands written text the way humans do, but it can manipulate that text in sophisticated ways, such as automatically identifying all of the people and places mentioned in a document; identifying the main topic of a document; or extracting and tabulating the terms and conditions in a stack of human-readable contracts. Two common categories are natural language processing for techniques focused on consuming human language and natural language generation for techniques focused on creating natural language outputs.
- **Robotic process automation (RPA):** Software robots, or "bots," can perform routine business processes by mimicking the ways in which people interact with software applications. Enterprises are beginning to employ RPA in tandem with cognitive technologies such as speech recognition, natural language processing, and machine learning to automate perceptual and judgment-based tasks once reserved for humans.[8]

How machine intelligence can create value

For CIOs, pivoting toward machine intelligence will require a new way of thinking about data analysis—not just as a means for creating a static report but as a way of leveraging a much larger, more varied data corpus to automate tasks and gain efficiencies.

Within machine intelligence, there is a spectrum of opportunities CIOs can consider:

Cognitive insights: Machine intelligence can provide deep, actionable visibility into not only what has already happened but what is happening now and what is likely to happen next. This can help business leaders develop prescribed actions to help workers augment their performances. For example, in call centres around the globe, service representatives use multifunction customer support programs to answer product questions, take orders, investigate billing problems, and address other customer concerns. In many such systems, workers must currently jump back and forth between screens to access the information they need to answer specific queries.

Cognitive engagement: At the next level on the machine intelligence value tree lie cognitive agents, systems that employ cognitive technology to engage with people. At present, the primary examples of this technology serve consumers rather than businesses. They respond to voice commands to lower the thermostat or turn the television channel. Yet there are business tasks and processes that could benefit from this kind of cognitive engagement, and a new field of applications is beginning to emerge. They will likely be able to provide access to complex information, perform digital tasks such as admitting patients to the hospital, or recommend products and services. They may offer even greater business potential in the area of customer service, where cognitive agents could potentially replace

some human agents by handling billing or account interactions, fielding tech support questions, and answering HR-related questions from employees.[9]

Cognitive automation: In the third—and potentially most disruptive—machine intelligence opportunity, machine learning, RPA, and other cognitive tools develop deep domain-specific expertise (for example, by industry, function, or region) and then automate related tasks. We're already seeing devices designed with baked-in machine intelligence automate jobs that have, traditionally, been performed by highly trained human workers. For example, one health care start-up is applying deep learning technology to analyse radiology images. In testing, its system has been up to 50 percent better than expert human radiologists at judging malignant tumors.

In the education field, machine intelligence capabilities embedded in online learning programs mimic the benefits of one-on-one tutoring by tracking the "mental steps" of the learner during problem-solving tasks to diagnose misconceptions. It then provides the learner with timely guidance, feedback, and explanations.[11]

"Co-bots," not robots

Facing cost pressures driven by prolonged low interest rates, increased competition, and evolving customer and market dynamics, global insurance provider American International Group Inc. (AIG) launched a strategic restructuring to simplify its organisation and boost operational efficiency. Part of this effort involved dealing with mounting technical debt and a distributed IT department struggling to maintain operational stability.

According to Mike Brady, AIG's global chief technology officer, by restructuring IT into a single organisation reporting to the CEO, AIG laid the foundation for creating a new enterprise technology paradigm. The first step in this transformational effort involved building foundational capabilities, for which the team laid out a three-part approach:

Stabilise: Overall network performance needed improvement, since users experienced high-severity outages almost daily and the virtual network went down once a week.

Optimise: The strategy focused on self-service provisioning, automation, and cost-efficiency.

Accelerate: To move forward quickly, the team implemented a DevOps strategy to create a continuous integration/continuous deployment tool chain and process flow to deploy software in real time.

AIG turned to machine learning to help with these directives. The company developed an advanced collaborative robot program that utilises built-in algorithmic capabilities, machine learning, and robotic process automation. These virtual workers have been dubbed "co-bots"— a nod to the company's desire for everyone on staff to treat the virtual workforce as an extension and assistant to employees.

In October 2015, AIG deployed "ARIES," the company's first machine learning virtual engineer, to resolve network incidents around the globe. During a 90-day pilot program, ARIES was trained in a "curate and supervise" mode in which the machine operated alongside, and learned from, its human counterparts. In this approach, ARIES learned through observation and experimentation how to assess outage sources and identify probable causes and responses. The co-bot was ready for full deployment on day 91. It's not that these machines are dramatically faster—in fact, AIG has found that humans take an average of eight to 10 minutes to resolve a typical issue, while co-bots take an average of eight minutes. The benefit lies in its scale: Co-bots can work around the clock without breaks or sleep, and they can resolve incidents so rapidly that queues and backlogs never develop.

Within six months of ARIES's deployment, automation identified and fixed more than 60 percent of outages. Within a year, ARIES's machine intelligence, coupled with the expansion of sensors

monitoring the health of AIG's environment, was making it possible to programmatically resolve an increasing number of alerts before they become business-impacting events. The virtual engineer can automatically identify unhealthy devices, perform diagnostic tests to determine the cause, and log in to implement restorative repairs or escalate to a technician with "advice." Additionally, the co-bot correlates network issues, so if data patterns show one device caused 50 incidents in a month, for example, the IT team knows it needs to be replaced. Those efforts have reduced the number of severity 1 and 2 problems by 50 percent during the last year. They have also increased technician job satisfaction. Instead of having to perform mundane and repetitive tasks, technicians can now focus on more challenging, interesting tasks—and benefit from the co-bots' advice as they begin their diagnosis.

Four additional co-bots, each operating with a manager responsible for governance, workloads, training and learning, and even performance management, have been deployed with consistent successful adoptions.

Following the success of the co-bot program in IT, AIG is exploring opportunities to use machine learning in business operations. "We want business to use machine learning instead of requesting more resources," Brady says. "We need to leverage big data and machine learning as new resources instead of thinking of them as new costs." Internal trials are getting under way to determine if co-bots can review injury claims and immediately authorise payment checks so customers need not delay treatment. Other opportunities will likely emerge in the areas of cognitive-enhanced self-service, augmented agent-assisted channels, and perhaps even using cognitive agents as their own customer-facing channels.

"The co-bot approach takes work," Brady adds. "If it's really complex, you don't want inconsistencies in how the team does it. That's where design thinking comes in. Since we started doing this a little over a year ago, we have resolved 145,000 incidents. It's working so incredibly well; it just makes sense to move it over to business process and, eventually, to cognitive customer interaction."[12]

Patients, please

As health care moves toward an outcomes-based model, patients are looking to health insurers to provide the same level of highly personalised customer service that many retailers and banks deliver. To meet this expectation, Anthem, one of the nation's largest health benefits companies, is exploring ways to harness the power of cognitive computing to streamline and enhance its engagement with customers and to make customer support services more efficient, responsive, and intuitive. Anthem's end goal is to change the way the company interacts with its affiliated health plan companies' members over the life of a policy, not just when a claim is filed.

Anthem's strategy grows across three dimensions of machine intelligence: insight, automation, and engagement. In the first phase, the company is applying cognitive insights to the claims adjudication process to provide claims reviewers with greater insight into each case. According to Ashok Chennuru, Anthem's staff vice-president of Provider/Clinical Analytics and Population Health Management, "We are integrating internal payer data—claims, member eligibility, provider demographics—with external data that includes socioeconomic, clinical/EMR, lifestyle and other data, to build a longitudinal view of health plan members," he says.[13]

Currently, reviewers start with a process of document review, patient history discovery, and forensics gathering to determine next steps. With cognitive insight, the new system is continuously reviewing available records in the background to provide reviewers with the full picture right from the start, including supplemental information such as a patient's repeat hospital stays to inform possible care plans or targeted intervention, as well as applying intelligence to flag any potential problems with the claim. By the time the claims representative receives the case, she has the information necessary for a comprehensive assessment.[14]

In its next phase, Anthem will start to add cognitive automation to claims processing, freeing up time for adjudicators to dedicate their attention to

patients requiring added levels of support. "By deploying predictive and prescriptive analytics and machine learning algorithms, we will be able to process both structured and unstructured data in a more cost-effective, efficient way," Chennuru says. At first, the system will identify any potential issues that need addressing and recommend a specific course of action. As the system matures, it can begin to resolve certain issues by itself, if its analysis reaches a certain threshold of certainty based on all signals and inputs. If the level of certainty falls below that threshold, then an adjudicator will still manually review and resolve the claim. As the system's continuous learning capabilities monitor how adjudicators successfully resolve issues over time, the system will correlate specific issues with proper courses of action to continuously improve its automated resolution accuracy and efficiency.

In the third phase, as Anthem goes deeper into cognitive engagement, the company will more broadly utilise its neural networks and deep learning to engage one-on-one with health care providers recommending individualised care plans for patients. In a shift from simply reacting to claims to proactive involvement in a customer's care, Anthem will be able to review a patient's medical history and reach out to providers with recommendations for future care plans.

Anthem's baseline of semi-supervised machine learning capabilities teach the system how to break down problems, organise them, and determine the best response. During test periods, observers will compare system behavior and performance to the traditional human-driven approach to gauge the system's efficiency and accuracy.

The company is currently collecting and crunching data, training systems, and streamlining its solutions architecture and technology, and it is seeing positive outcomes across the board as a result of the claims management cognitive insights. A prototype of the automated adjudication system is scheduled to launch in 2017, followed by a minimum viable product version a few months later.

Anthem has built a broad cognitive competency, with multiple teams mapping out use cases to achieve results, evaluating proof of value, and optimising how teams prepare data, tune algorithms, and deliver program availability. "Eventually," Chennuru says, "we will be able to leverage the platform in many areas such as value-based analytics, population health management, quality management, and to develop insights into gaps in care and cost of care." Anthem wants to enable as many enterprise cognitive engagements as possible to train its models, optimise its program, and grow its cognitive intelligence to help the company better serve members.

MY TAKE

MARIA RENZ, VICE PRESIDENT, TECHNICAL ADVISER TO THE CEO

TONI REID, DIRECTOR, AMAZON ALEXA

AMAZON

With 2017 ushering in the most exciting time in artificial and machine intelligence history, the Amazon team is empowered to think big and chart new territory.

At Amazon, we believe voice will—and in many ways already has—fundamentally improved the way people interact with technology. While we're a long way from being able to do things the way humans do, we're at a tipping point for many elements of AI and voice technology. Solving unbelievably complex problems every day, voice makes the complex as simple as the most natural and convenient user interface.

The original inspiration for the Amazon Echo was the Star Trek computer. We wanted to create a computer in the cloud that's controlled entirely by voice—you can ask it things, ask it to do things for you, find things for you, and it's easy to converse with in a natural way. We're not quite there yet, but that was our vision.

One of the key capabilities of Alexa, the voice and brain behind Echo, is that she's a cloud-based service that is always getting smarter, in both features and natural language understanding and with improved accuracy. Because her brain is in the cloud, she continually learns and adds more functionality, every hour, every day, which only makes it easier to innovate and add features on behalf of customers.

Since launching Echo in November 2014, we have added more than 7,000 skills to Alexa. Her footprint is expanding across the Echo family of devices and is now embedded within other Amazon hardware (Fire TV and Fire tablets) and in third-party devices such as the Nucleus intercom system, Lenovo Smart Assistant speaker, and the LG Smart InstaView Refrigerator, plus embedding Alexa into cars from companies such as Ford and Volkswagen.

In terms of the surface area she covers and her accuracy within search material, Alexa understands users effectively. Even so, voice technology presents ongoing challenges. When we started working on this, the technology didn't even exist—we had to invent it. We're fortunate to have the power of the AWS cloud to put behind it, and we have teams of incredibly smart speech experts, including talented speech scientists, working on solving these problems.

> "DON'T BE AFRAID TO INVENT ON THE CUSTOMER'S BEHALF."

We view the benefits to customers and opportunities with AI as nearly limitless. Right now, Alexa mainly operates through the Echo hardware, but in the future her brain will continue to expand through countless numbers of systems and applications. We've made the implementation process easier by making a series of free, self-service, public APIs available to developers with the Alexa Skills Kit (ASK), the Smart Home Skill API, and the Alexa Voice Service APIs.

Ultimately, our developments in machine intelligence, neural networks, and voice recognition advancements should offer our customers new capabilities that are helpful in meaningful ways.

At Amazon, we start any new product or service with a draft press release, imagining the core customer benefits that we would deliver when and if we launch the product. We focus on building the right experience first and solve the hard technical problems later.

With this in mind, we advise looking at your customer base, listening to them, and understanding their core needs and ways in which you can make their lives easier. From there, develop your product or service based off that feedback. That said, don't be afraid to invent on the customer's behalf—customers don't always know what to ask for. If you have the right focus on the customer experience, the rest should fall into place.

In the context of cybersecurity, machine intelligence (MI) offers both rewards and risks. On the rewards front, harnessing robotic process automation's speed and efficiency to automate certain aspects of risk management could make it possible to identify, ring-fence, and detonate (or, alternatively, scrub) potential threats more effectively and efficiently. Leveraging machine intelligence to support cyber systems could potentially help scale data analysis and processing and automate the means of acting in a deliberate manner on the risks these tools identify.

MI's efficacy in this area can be further enhanced by predictive risk and cyber models that extend its data mining net further into largely unexplored areas such as the deep web, and address nontraditional threats it may encounter.

Companies can also harness MI to drive channel activity, strategy, and product design. For example, using capabilities such as deep learning, sales teams can construct fairly detailed customer profiles based on information readily available on social media sites, in public records, and in other online sources. This information can help sales representatives identify promising leads as well as the specific products and services individual customers may want.

But there is a potential downside to MI's customer-profiling power: These same applications can create cyber vulnerabilities. MI might make inferences that introduce new risks, particularly if those inferences are flawed. By creating correlations, MI could also generate derived data that presents privacy concerns. Ultimately, companies should vet derived data based on inferences and correlations.

Indeed, as automation's full potential as a driver of efficiency and cost savings becomes clear, many are discussing broader ethical and moral issues. What impact will automating functions currently carried out by humans have on society, on the economy, and on the way individual organisations approach opportunity? How will your company manage the brand and reputation risk that could go hand-in-hand with aggressive automation initiatives? Likewise, will your organisation be able to thrive long-term in what some are already describing as "the post-work economy"?

> "WILL YOUR ORGANISATION BE ABLE TO THRIVE LONG-TERM IN WHAT SOME ARE ALREADY DESCRIBING AS "THE POST-WORK ECONOMY"?"

Finally, risk discussions should address the "black box" reality of many MI techniques. At this juncture, it may not be possible to clearly explain how or why some decisions and recommendations were made. While there is an ongoing push for algorithmic transparency that could eventually drive development of new means for auditing and understanding assumptions, observing patterns, and explaining how conclusions are justified, those means do not currently exist. Until they do, try to determine where a lack of visibility could be an issue (legal, reputational, or institutional) and adjust your plans accordingly.

As we sail into these uncharted waters, CIOs, CEOs, and other leaders should carefully balance the drive for shareholder value with a host of potential risks to reputation, security, finance, and others that will likely emerge in the years to come.

Where do you start?

Few organisations have been able to declare victory in and around data. Even when data was largely structured and limited to information housed within the company's four walls, managing and analysing could prove challenging. Today, sophisticated algorithms and analysis techniques enable us to solve complex scenarios; we can move from passively describing what happened to actively automating business responses. Yet even with rapidly advancing capabilities, some organisations still struggle with data.

The good news is that machine intelligence offers new approaches and technologies that may help us finally overcome some longstanding data challenges:

- **Curate data:** MI techniques can be applied in a largely automated fashion to data taxonomies and ontologies to define, rationalise, and maintain master data. MI can analyse every piece of data, its relationships, and create a derived approximation of data's quality. Likewise, it can potentially provide a means for remedying content or context issues that arise.
- **Bounded and purposeful:** Focus on gaining insight into business issues that, if resolved, could deliver meaningful value. Let the scope of the problem statement inform the required data inputs, appropriate MI techniques, and surrounding architectural and data management needs. By resolving a few of these issues, you may acquire greater license to apply MI to more complex questions.
- **Sherpas welcome:** MI is enjoying its own age of enlightenment, with academia, start-ups, and established vendors bolstering capabilities and adding new techniques. Consider partnering with vendors willing to co-invest in your efforts. Likewise, collaborate with academics and thought leaders who can provide unbounded access to valuable expertise.
- **Industrialised analytics:** Data has become a critical strategic corporate asset. Yet too few organisations have invested in a deliberate, holistic commitment to cultivate, curate, and harness this asset across the enterprise. Industrialising analytics means driving consistent and repeatable approaches, platforms, tools, and talent for all dimensions of data across the enterprise—including machine intelligence. Tactically, this will likely lead to services for data ingestion, integration, archiving, access, entitlement, encryption, and management.

Bottom line

Artificial intelligence may capture more headlines, but the bigger story is machine intelligence, a term describing a collection of advances in cognitive computing that can help organisation move from the legacy world of retrospective data analysis to one in which systems make inferences and predictions. The ability to take these insights, put them into action, and then use them to automate tasks and responses represents the beginning of a new cognitive era.

CONTACTS

WARWICK GOODALL
Director, Technology Consulting
Deloitte MCS Limited
020 7007 9825
wgoodall@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

DAVID ADAMS
Associate Director, Risk Advisory
Deloitte Consulting LLP
0161 455 6813
davadams@deloitte.co.uk

AUTHORS

NITIN MITTAL
US Analytics & Information Management practice leader, Deloitte Consulting LLP

PETER LOWES
Principal, Deloitte Consulting LLP

SANDEEP KUMAR SHARMA, PH.D.
Deputy chief technology officer, Deloitte Consulting LLP

RAJEEV RONANKI
Cognitive Computing and Health Care Innovation practice leader, Deloitte Consulting LLP

JERRY WEN
Managing Director, Technology Strategy and Architecture practice, Deloitte Consulting LLP

ENDNOTES

1. IDC, "Worldwide spending on cognitive systems forecast to soar to more than $31 billion in 2019, according to a new IDC spending guide," press release, March 8, 2016, www.idc.com/getdoc.jsp?containerId=prUS41072216.
2. Khalid Kark, Mark White, Bill Briggs, and Anjali Shaikh, *2016–2017 Global CIO Survey*, Deloitte University Press, November 10, 2016, https://dupress.deloitte.com/dup-us-en/topics/leadership/global-cio-survey.html.
3. David Schatsky, Craig Muraskin, and Ragu Gurumurthy, *Demystifying artificial intelligence*, Deloitte University Press, November 4, 2014, https://dupress.deloitte.com/dup-us-en/focus/cognitive-technologies/what-is-cognitive-technology.html.
4. Dan Vesset and David Schubmehl, "IDC FutureScape: Worldwide big data, business analytics, and cognitive software 2017 predictions," International Data Corp., December 2016.
5. Deloitte Consulting LLP, *Tech Trends 2017: Dark analytics*, 2017.
6. Andrew Danowitz et al., "CPU DB: Recording microprocessor history," *ACMQueue* 10(4), 2014, http://queue.acm.org/detail.cfm?id=2181798.
7. Schatsky, Muraskin, and Gurumurthy, *Demystifying artificial intelligence*.
8. David Schatsky, Craig Muraskin, and Kaushik Iyengar, *Robotic process automation*, Deloitte University Press, September, 14, 2016, https://dupress.deloitte.com/dup-us-en/focus/signals-for-strategists/cognitive-enterprise-robotic-process-automation.html.
9. Tom Davenport and Rajeev Ronanki, *The rise of cognitive agents*, Deloitte University Press, August 26, 2016, https://dupress.deloitte.com/dup-us-en/focus/cognitive-technologies/rise-of-cognitive-agents-artificial-intelligence-applications.html.
10. *Economist*, "Automation and anxiety," June 25, 2016, www.economist.com/news/special-report/21700758-will-smarter-machines-cause-mass-unemployment-automation-and-anxiety.
11. Barbara Kurshan, "The future of artificial intelligence in education," *Forbes*, March 10, 2016, www.forbes.com/sites/barbarakurshan/2016/03/10/the-future-of-artificial-intelligence-in-education/.
12. Interview with Mike Brady, global chief technology officer, American International Group Inc., November 22, 2016.
13. Ashok Chennuru, Anthem's staff vice president of Provider/Clinical Analytics and Population Health Management, email communication, January 24, 2017.
14. Deloitte Insights, "Health insurers embrace cognitive," *Wall Street Journal*, December 15, 2016, deloitte.wsj.com/cio/2016/12/15/health-insurers-embrace-cognitive-computing/.

Deloitte.
University Press

Mixed reality

Experiences get more intuitive, immersive, and empowering

THE ENTERPRISE POTENTIAL OF AUGMENTED REALITY AND VIRTUAL REALITY continues to grow as companies explore use cases and move beyond pilot applications. Increasingly, these efforts intersect with opportunities made possible by Internet of Things technology—sensors and connected devices that help build a more integrated and extended digital and physical landscape. Yet amid this flurry of activity, many overlook the larger implications of AR and VR's emergence. Design patterns are evolving dramatically, with 2D screens giving way to tools that use sensors, gestures, voice, context, and digital content to help humans interact more naturally with the increasingly intelligent world around us. Though it may be several years before mixed reality's ultimate end game materialises, the time to begin exploring this dynamic new world—and the digital assets it comprises—is now.

ADVANCES in augmented reality (AR) and virtual reality (VR) promise to change the way we interact with technology. Though consumer buzz surrounding devices designed for gaming and entertainment is growing, AR and VR's enterprise potential is proving to be the real cause for excitement. Across sectors, use cases and concepts are emerging, and pilot programs are ramping into production.[1]

Meanwhile, the Internet of Things (IoT) is attracting more business investment as attention begins shifting from underlying sensors and connected devices to real-world scenarios driven by advances in IoT technology. Pioneering applications are emerging in the areas of personal health and wellness, supply chain, and in the civic infrastructure of smart cities, among others.[2]

Mixed reality (MR) represents the controlled collision of the AR/VR and IoT trends. With MR, the virtual and real worlds come together to create new environments in which both digital and physical objects—and their data—can coexist and interact with one another. MR shifts engagement patterns, allowing more natural and behavioral interfaces. These interfaces make it possible for users to immerse themselves in virtual worlds or "sandboxes," while at the same time digesting and acting upon digital intelligence generated by sensors and connected assets. For example, as a worker wearing smart glasses examines a system in a remote location, diagnostic information appearing in his field of vision indicates the system is malfunctioning. If the worker can't fix the problem himself, skilled technicians in another location would be able to transmit detailed digital instructions for repairing the malfunction and, then, walk him through the repair process quickly and efficiently. In this and similar scenarios across industries and operating models, MR makes it possible to deliver actionable information to any location where work is done—on site, on the shop floor, or in the field.

The mixed-reality trend is being fueled by investments in platforms, devices, and software ecosystems. The ultimate goal of these investments is to replace keyboards and flat displays with entirely new paradigms for communication and collaboration. If successful, this would represent the

biggest fundamental shift in user engagement we have in seen in the modern technological era. Each successive improvement to user interface patterns—from function keys and typing, to point and click, to touch and swipe, and now to talk—offers a chance to move "beyond the glass" of static displays, and to reimagine engagement around gestures, grasps, and glances.

MR advances are already profoundly affecting how we relate emotionally to these novel ways of working. The ability to grab information from things around us—and for that information to respond to our visual

Figure 1. Mixed reality on the factory floor

Maintenance & operations

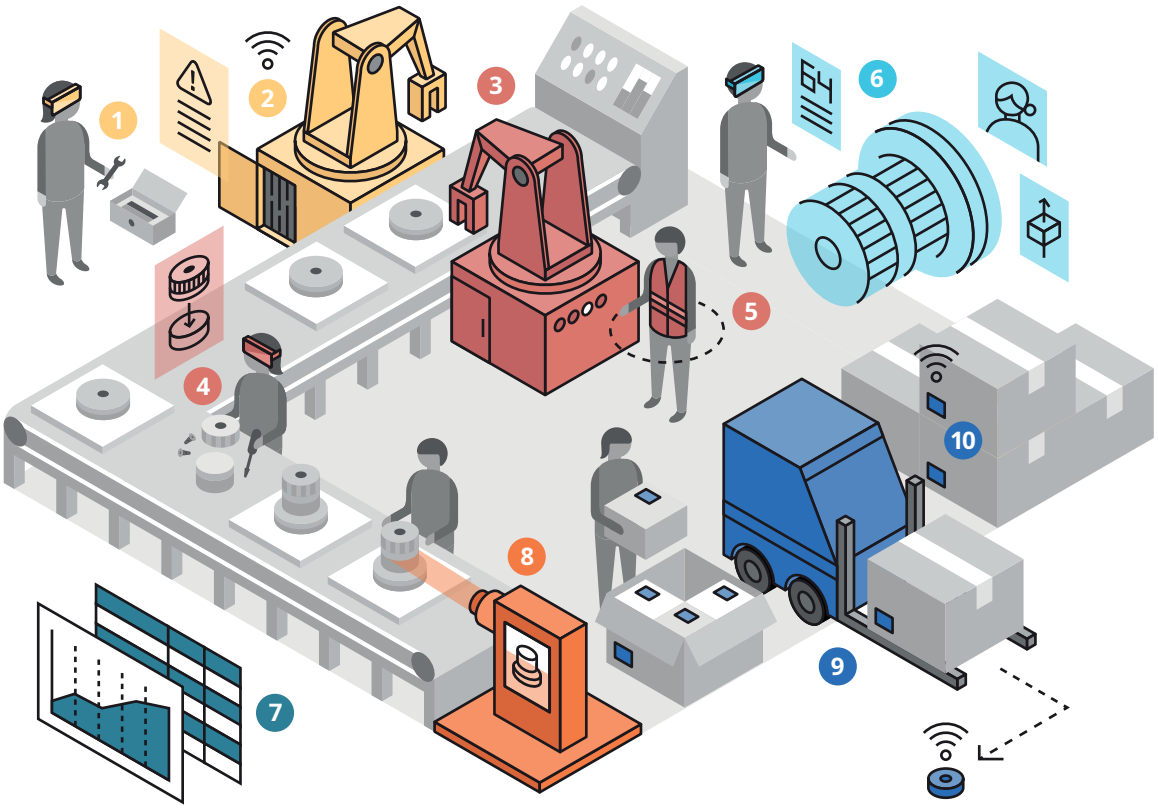
1 Smart goggles provide metrics, instruction, and remote support to maintenance workers. **2** Sensors on machines generate diagnostic data and machine learning helps predict failures and improve productivity.

Production

3 Smart robots automate production. **4** Smart goggles with cameras and motion sensors help train workers and overlay assembly instructions. **5** Smart equipment like safety vests and hard hats monitor surroundings.

Design & development

6 Virtual prototypes allow rapid iteration, assembly simulation, advanced testing, and remote collaboration. Full-body motion tracking informs ergonomic design of workspaces and assembly lines.



Reporting & analytics

7 All devices are connected to a data management system, which digitally documents each step of the process. Advanced analytics predict demand patterns to optimise production.

Quality control

8 Machines use sensors, computer vision, and photogrammetry to evaluate products against standards. 3D models give inspectors access to all product specs during production.

Distribution

9 Beacons and smart goggles guide operators through the warehouse. Autonomous vehicles manage inventory. **10** Product sensors provide visibility into the entire supply chain.

and physical feedback—changes the ways in which we consume and prioritise our work. By stripping away the intermediaries and barriers to cognitive recognition, processing, and understanding, the enterprise may be able to transform worker effectiveness and engagement.

The where is the what

Mixed-reality use cases and patterns have emerged around early investments. Though specific priorities differ by industry, many land somewhere within the following areas:

Training, education, and learning: AR and VR can be used to onboard new employees and develop existing talent by immersing them in highly realistic, virtual work environments that feature both educational information and interactive problem-solving challenges. Immersive environments offer a number of advantages over traditional teaching methods. For example, they provide trainees with safe (virtual) exposure to complex and potentially dangerous equipment and scenarios. They also make it possible for supervisors to review video recordings of training sessions to monitor progress and tailor lessons to specific employee needs.

Operations: By providing field service technicians, warehouse pickers, assembly-line workers, and others with IoT applications and digital system content tailored to their unique tasks, companies may be able to boost employee productivity and streamline work processes. On the production floor, for example, job aids can guide workers performing kitting tasks to locations of shelved items. In the field, engineers could access the service history of specific equipment, guidance on triage and repair steps, and any real-time information that intelligent devices may be generating from a site. They would review this information in a hands-free, heads-up manner that maintains their autonomy and supports worker safety.[3]

Communication and collaboration: As organisations become "unbounded" by eliminating functional siloes, multidisciplinary teams will be able to work seamlessly together within and across company walls. Mixed reality can support this kind of next-generation interaction by replacing shared productivity tools and videoconferencing with immersion and a sense of presence. Workers in disparate locations can interact with the same digital artifacts, just as if they were in one conference room manipulating the same physical objects. Automotive manufacturers are applying these methods to visualise design improvements of existing components—dramatically accelerating the concept-to-manufacturing process among globally distributed teams.[4] Likewise, research and development functions, construction and engineering firms, and even some services organisations are exploring this new style of collaboration, removing geo-temporal constraints from both creative processes and more tangible operations.[5]

Marketing and customer service: From high-tech experiential marketing to virtual branches, MR—specifically leveraging VR capabilities—can provide experiences that not only replicate aspects of the real world but build compelling engagement patterns predicated on the convergence of technologies. For example, you will be able to put a virtual product in your customer's hands and then guide her experience, gauge her responses, and personalise content based on this customer's transaction history and preferences.[6]

Shopping: Virtual reality stands poised to revolutionise the way we shop. Consider, for example, "walking" through a virtual cruise-ship cabin or hotel suite before booking it or immersing yourself in a virtual jewelry store where you try on necklaces that catch your eye. Mixed-reality capabilities could enhance these virtual experiences by providing pricing or descriptive information on the products or services you are considering, along with suggestions for similar offerings.[7]

MR technology: Enablers and obstacles

As it often does with emerging technologies, tremendous hype surrounds AR's and VR's promise—for good reason. These platforms offer new ways of framing and delivering content,

experiences, and interactions. They also bring with them opportunities to redefine the tools, models, and business processes that they could potentially replace. But as MR devices, software and standards evolve, enterprises are discovering hidden challenges beyond the management of technology.

AR, VR, and IoT represent new categories of devices that need to be managed and secured. Learning from the workplace adoption of smartphones and tablets, organisations can begin their MR journeys on the right foot by developing appropriate controls and policies to monitor and enforce enterprise needs. Security and privacy are important considerations—at the device level, the data and supporting content level, and the application level. Safety and regulatory compliance implications are paramount, especially since many potential scenarios involve critical infrastructure and sensitive operations.

To process event streams, render mixed-reality experiences, and capture and respond to the movements of an individual user, platforms will need several enabling environments. They must be immediately aware of that user's role, the context in which he works, and information he needs to complete his tasks. MR's ability to simultaneously track an environment and an individual's relationship to that environment is the key to allowing virtualised objects and information to respond realistically to what that individual is doing. This requires the kind of complex signal processing and response generation found in some advanced videogame designs. It's no surprise that early experiments have been built on top of popular gaming development engines such as Unreal.[8]

MR must also navigate interfaces that allow for the blend of voice, body, and object positioning to open up a world of business process opportunities in every industry. Recognising subtle expressions requires precise techniques, from eye tracking to interpreting a wink or a smile correctly. MR design patterns should make it possible for digital content to react intuitively to signals. New vocabularies for design patterns are required, along with solutions to manifest in both the AR/VR systems, as well as the surrounding connected devices and sensor-enabled environments.

MR should bring together relevant data to provide insightful interactions. That could mean integrating MR with the core in order to access information residing in ERP, CRM, HR, marketing, and other systems. Conversely, MR can be an important tool to digitise work—potentially automating underlying workload, updating data with supplemental supporting information, or allowing MR steps to be a part of a longer-running business process.

The context of content

Perhaps most importantly, natural interfaces make it possible to simultaneously process the meaning, intent, and implications of content in context of how the world works—and how we behave in it.

A digital object's weight, scale, angle, position, and relationships with other virtual and real-world objects allow designers to fashion truly visceral experiences. Sound and haptics (or sensory feedback) can replace graphical predecessors, allowing for the enterprise to rethink alerts, warnings, or the completion of tasks. Built-in object and facial recognition gives us the ability to map spaces and people to accurately render in the virtual or augmented experience, and to insert purely digital enhancements in a way that seems both natural and realistic.

MR requires an entirely new set of digital content and context. High-definition, 360-degree renderings of facilities and equipment are necessary to translate the real world into virtual environments or to marry augmented physical and digital experiences. Sensors and embedded beacons may also be required to track devices, equipment, goods, and people. Likewise, meta-data describes not just an asset's base specifications but also its composition, behavior, and usage—all necessary to simulate interactions.

All together now

Even as we elevate mixed reality above its piece-parts of AR, VR, and IoT, the underlying technologies themselves are continuing to advance. Individually they represent very different solutions, domains,

and potential applications. However, if companies pursue them in isolation, their full potential will likely never be realised. The goal should be evolving engagement—building more intuitive, immersive, and empowering experiences that augment and amplify individual users, leading to new levels of customer intimacy, and creating new solutions to reshape how employees think and feel about work. If done correctly, mixed reality may open floodgates for transforming how tomorrow's enterprises are built and operated.

Using immersive technologies to protect child welfare

Each year, newly graduated social workers enter child welfare agencies determined to make a difference. Unfortunately, many of them may be unprepared, both practically and emotionally, for what awaits. It can take years of on-site visits to homes and childcare centres to help a social worker develop the deep observational skills and attention to detail required to accurately assess a child's living situation and, then, to determine whether further investigation and action is necessary.

Immersive technologies may someday offer child welfare agencies an efficient way to accelerate that learning process. Using serious games—games designed specifically to teach skills—and 3D simulation, social workers would be able to practice real-time engagements designed to help develop sensitivities and nuanced evaluation skills previously achieved only after years on the job.

For example, one training module might place a trainee social worker in a virtual home setting and ask her to identify all potential risk factors in a few minutes. After the initial scan, the trainee returns to the virtual room, where risk factors she overlooked during the initial assessment are blinking. When the trainee points at a specific signal, a description of the specific risk factor and an explanation of its importance appear in her field of vision. As part of this same process, the trainee could also practice reacting to difficult situations and documenting what she sees.

3D training models could be customised and refined for use in any environment or scenario. Not only could this expand the breadth of training available for new recruits—it would likely help veteran social workers further their professional development. When used over time, these capabilities might also help agencies assess and improve their overall effectiveness and teach critical thinking and decision making. In this light, MR capabilities are not just technical game changers but behavioral solutions, creating experiences that potentially benefit social workers and—even more importantly—help those they serve.

AR meets the IoT on the shop floor

In 2016, two innovative companies introduced to each other at the MIT Media Lab, convened at Jabil Blue Sky, an innovation centre in Silicon Valley to kick the tires on a new digital manufacturing process technology. The companies involved were Jabil, a global provider of engineering, manufacturing, and intelligent supply chain solutions, and Tulip, which offers a cloud-based platform featuring shop-floor apps, industrial IoT, and real-time analytics.

The solution being tested? A new cloud-based operating system that feeds IoT production-line data in real time to workers on a shop floor through their smartphones and tablets. By monitoring this information stream as they perform their production tasks, workers can respond on the fly to process changes. Eventually, the system could also integrate the power of mixed reality into manufacturing environments. The goal is to improve manufacturing flow through the shop floor. With real-time information enabled by the latest improvements in digital technology, companies may be able to reduce worker pauses or idle machine cycles that typically accompany changes in production conditions.

After initial testing at the Blue Sky innovation centre, Jabil and Tulip deployed the system in a production environment used by workers executing highly specialised work processes. For a period of six months, engineers monitored cycle and step-times data to further optimise manufacturing processes through continuous time studies and root-cause analysis exercise aided by the new digital tools. The results? Production yield increased by more than 10 percent, and manual assembly quality issues were reduced by 60 percent in the initial four weeks of operation, which exceeded customer accepted yields and predictions for the current design.

According to Tulip co-founder Natan Linder, in the near future, augmented reality (AR) capabilities will likely amplify the power of IoT manufacturing solutions such as the one his company tested with Jabil. The delivery of contextual information to workers without requiring a screen is already providing significant benefits to global manufacturers, says Linder, citing increased product and service quality, increased worker productivity through reduced rework, and higher throughput, as well as reduced training time. "Increasingly, we're seeing deployment of light-based AR in manufacturing, which uses lasers and projectors to layer visual information onto physical objects. This approach doesn't have many of the disadvantages of other AR interfaces; most importantly, it doesn't require workers to wear headsets.

"The real power of augmented reality comes into play," he continues, "when it is combined with sensors, machines, and data from smart tools. These IoT data sources provide the real-time information that the hands-on workforce needs to get work done and optimise processes, with augmented reality delivering the information at the right time and in the right place."[9]

Yeah, but can you dance to it?

By adding production capabilities to data collected from sensors and multiple cameras in the field, mixed-reality solutions can transform how humans interact (visually and socially) with the world around them and the events they "attend."

In the last few years, we've seen VR broadcasts of sporting events as diverse as NASCAR, basketball, golf, and even surfing. Those initial broadcasts gave viewers a 360-degree view of the playing field and allowed them to choose their own vantage point throughout the game or race, supplemented with fully mixed 3D VR audio, announcer commentary, VR-like graphics, and real-time stats.

The use of sensors can enable broadcasters to provide additional value to remote viewers. Spanish start-up FirstV1sion, a wearables company that embeds video and radio transmission equipment in athletes' uniforms so VR viewers can watch a play or a game from a specific player's view point, outfitted players for European soccer matches and basketball games. In addition to the video feed, the electronics include a heart monitor and accelerometer so viewers can track players' biometric data as the game progresses. The hope is that fans will be more emotionally involved in the game if they can see a player's heart rate increase as the action heats up.[10]

Musical events are obvious settings for social interaction, and virtual streaming of concerts is becoming more common. For example, the Coachella festival provided a cardboard headset with each ticket sold last year in case concertgoers didn't want to leave the hospitality tent to watch a band. One VR company is taking it a step further to

let music fans be the performers: TheWaveVR has developed a virtual reality concert platform that not only allows users to watch musical performances—when paired with the HTC Vive, it enables them to DJ their own set in a virtual venue.[11] Viewers can listen and dance to the music in the "club" while talking to other attendees.

On the political front, NBC News used mixed reality to encourage dialogue between American voters during the recent presidential campaign. It virtually recreated the real-life "Democracy Plaza" it had erected at New York's Rockefeller Centre so viewers located anywhere could enter the plaza, view live programming, access real-time viewer opinion polls, interact with its newscasters and pundits, and, most importantly, engage with other audience members.[12]

It seems the dire predictions of virtual reality's isolationism have been much exaggerated. By adding sensors, voice recognition, and data overlays to create a mixed reality in which humans can interact more naturally, the future looks quite engaging for playtime as well as industry.

MY TAKE

BRIAN BALLARD, CEO AND FOUNDER

UPSKILL (FORMERLY APX LABS)

A longstanding technology gap separates employees on the shop floor, in the field, or on job sites—places where work actually gets done—from the data solutions that are driving the work. However, investments in wearables and mixed reality are finally providing a form factor that is bridging this divide. At Upskill, our mission is to provide workers with better information, more understanding, and more empowerment to help them to amplify their expertise. We started building software for smart glasses in 2010. Today, we provide our clients with a platform for extending the power of augmented and virtual reality into manufacturing, field services, and logistics.

"WITH DIGITAL INSTRUCTIONS, AEROSPACE WORKERS WORKED 32 PERCENT FASTER USING WEARABLES; LIKEWISE, THE ENERGY WORKERS WORKED 35 PERCENT FASTER WITH WEARABLES—AND THIS WAS THEIR FIRST TIME USING A NEW TECHNOLOGY. WHAT OTHER SOLUTIONS HAVE INSTANTLY DELIVERED A SKILL INCREASE TO THE WORKFORCE?"

When discussing mixed reality's business potential, we start with the problems people are trying to solve and then try to identify opportunities to drive real value through the technology strategies a given company can employ. For example, a company might need to solve a logistics responsiveness problem. It can do this by overlaying real-time information on inventory levels or the shelf location of products in the vision fields of warehouse handlers wearing smart glasses. Or deploy the same tactics in kitting processes in manufacturing—picking parts, adding to carts, and bringing to the proper workstations for just-in-time manufacturing orders. These are real-world challenges we have seen firsthand—in both scenarios, some of our clients have achieved up to 50 percent improvements in delivery times.

Broadly speaking, the results across industries are very exciting. We recently performed experiments with workers from several industrial customers. In each, we filmed these workers performing complex assembly tasks in two different circumstances: one in which task-related instructions were paper- or tablet-based, the other in which the same instructions were delivered via smart glasses. The results were dramatic: With digital instructions, aerospace workers worked 32 percent faster using wearables; likewise, the energy workers worked 35 percent faster with wearables—and this was their first time using a new technology. What other solutions have instantly delivered a skill increase to the workforce?

In both situations, neither the workers nor their job function changed. The transformative factor was the way the workers accessed the information they needed. Visualising a task at hand with an overlay of contextual or instructional information can be very powerful. It eliminates the need to stop working when reading instructions, and it can improve safety, letting workers stay hands-free and heads-up while completing tasks. At the same time, it enables workers to augment their own expertise, which can lead to better decision making. The confusion that can occur when dealing with complex information is significantly

reduced and the need to memorise training materials is virtually eliminated. It's like a GPS for your job. Never getting lost or having to memorise a map has certainly changed the way the world gets around. I think the parallel between mixed reality and GPS is strong. Can you imagine paper maps ever becoming the norm again?

Wearable solutions also make it possible for companies to digitise, analyse, and optimise organisational behavior. For example, in a complex assembly environment, a manufacturer may able to capture information about each of the 100,000 steps being performed—something impossible to track before mixed reality brought work data to the edge. By applying machine learning to the resulting data, the manufacturer could experiment with different ways to group and break down the work to enhance productivity and provide coaching and training to individual workers based on understanding at which tasks they excel, and where there are development opportunities. Pulling the GPS analogy forward, this is the equivalent to real-time traffic alerts.

People often ask me how their companies can get started with mixed reality. Whether framing pilot initiatives or full-blown rollouts, best practices start with specific ROI goals. For example, "I will onboard new employees 20 percent faster," or, "First-time quality on our assembly line will improve by 35 percent." Once a tangible use case focused on measurable impact is identified, avoid hypothetical integrations and simulated environments. Wherever possible, try to deploy to a production environment to understand real-world behavior, benefits, and opportunities to improve. Of course, safety, security, privacy, and operational continuity are essential and can be addressed while rolling out the pilot. I think process owners would be surprised by the number of deployment success stories the wearables industry can already tell.

Companies exploring mixed reality (MR) use cases and experimental applications should take into account several cybersecurity and risk considerations inherent to MR's components—virtual reality, augmented reality, and the Internet of Things (IoT). Consider these questions:

1. When you are immersed in an MR environment, can you trust the integrity of the digital data on display? Can you confirm its authenticity? Are you confident that it—particularly the data sourced through IoT technology—is not vulnerable to malicious hacking?
2. With mixed-reality environments, can you confirm that your view has not been manipulated? There may be distinct MR environments used for training purposes, and variations of these same environments deployed for live business purposes. Can you trust that you are immersed in the correct environment? Could the digital assets, experience, and supporting context be manipulated to mislead? Or worse, could they trick users into performing digital corporate sabotage by encouraging wasteful, brand-damaging, or even dangerous actions?
3. If you are engaged with another individual within an MR environment, how certain can you be that that person is actually who she says she is? How can that trust be maintained?

These and similar considerations highlight one of the major risk-related challenges surrounding MR environments: controlling and securing associated digital assets. Virtual reality, augmented reality, and IoT technology introduce new and different intellectual property that may contain sensitive information requiring controls for security and privacy, regulatory and compliance issues, and competitive advantage—for example, high-definition 3D renderings of facilities and detailed tracking of property and equipment location and controls. Associated beacons, sensors, and connected footprints need appropriate protection, from encryption and access controls to rights and asset management.

In an MR environment, this can be challenging because each technology presents its own cyber risk challenges. For example, AR requires many more data points than VR to drive content for GPS and positioning, tagging, shared metadata, and facial recognition. Moreover, to enhance and tailor an individual user's augmented experience, AR systems may also integrate data from a host of sensors tracking that person and from other personal sources such as health and fitness monitors. This raises a number of security and privacy concerns about the data sources to which individuals have access, and whether combinations of data being aggregated by AR may compromise personally identifiable information or payment card industry data.

> "EACH NEW DEVICE INTRODUCED IN AN IOT ECOSYSTEM ADDS A NEW ATTACK SURFACE."

Regarding IoT technology, each new device introduced in an IoT ecosystem adds a new attack surface or opportunity for malicious attack, thus adding threat vectors to a list that already includes protecting devices, data, and users. IoT ecosystem structures that organisations often deploy typically depend on the closely coordinated actions of multiple players, from vendors along the supply chain to clients, transport agencies, the showroom, and end-use customers. Vulnerabilities exist within each node and handoff seam between sensors, devices, or players. It should not be assumed that vendors or other third parties—much less customers—have broad mechanisms in place to maintain data confidentiality and guard against breaches.[13]

The flip side of the MR cyber risk coin is that VR, AR, and the IoT show promise as tools that may help organisations boost their overall security and privacy strategies. VR, for example, can be used in disaster recovery efforts and war-room simulations. Scenario planning around incident response can be taken to another level with experiences closely resembling real-life events. Likewise, AR may help companies better visualise the cyber threats they face.

Where do you start?

The promise of customer, partner, and employee engagement moving beyond the glass is powerful. The mixed-reality trend could usher in a new world of simulated experiences grounded in the ways business gets done and customers actually use products. Yet because MR's component parts are still proving their worth in an enterprise setting, pursuing their full promise could present challenges, at least for now. To short-circuit potential false starts, consider taking the following initial steps:

- **Do try this at home:** Words cannot describe how powerful virtual reality's immersion experience can be. Likewise, potential stakeholders should see augmented reality's many possibilities firsthand not only to build credibility for the journey MR journey ahead but to light a spark for ideation.
- **Anchors overboard:** MR exploration should start with how something *could* or *should* be done, rather than with existing processes or interactions. MR represents a sea change from static displays and clumsy user interface techniques. Don't waste time trying to improve today's realities incrementally—instead, begin with bold scenarios in mind.
- **Debunk the science fair:** Given that many associate MR with science fiction, some organisations' institutional inertia may naturally dismiss it as yet another shiny object. In reality, many companies and government agencies are actively piloting the technologies, with many aggressively moving into broad production investments. A wait-and-see attitude will only put you further behind others in your industry.
- **Avoid a device derby:** Recognise that existing devices will evolve and new categories will emerge. And while the broader consumer market will likely deliver an oligopoly of "winners," consider focusing your investments in areas that offer potential today, and design an architecture that is as loosely coupled as possible. Let the market shake out as it will. Don't let long-term uncertainty distract from immediate benefits, especially as the shelf life of any given device needs to be only long enough to support its original purpose.
- **OT meets IT:** For some industries, MR may force a new level of collaboration between operating technology and information technology. Especially as many of the best MR solutions will have deep hooks into core applications, there is a good possibility that integration with MEMS and machine-to-machine systems will be necessary. This may also require a new governance and architecture that enables orchestration between the broader OT and IT stacks—recognising IT's desire to innovate new services and solutions, while fiercely protecting OT's requirements around reliability, security, performance, and availability.

Bottom line

Mixed reality elevates the potential of AR, VR, and IoT technology by combining the best of our digital and physical realities. Instead of removing users completely from the real world, or simply layering flat content on top of our immediate view, MR adds intelligence—physics, gravity, dimension, even personality—to digital content relative to the space around us. As a result, we are able to blur the lines between what is real and what is imagined while stripping away the barriers that interfere with our ability to make decisions quickly, absorb and process critical information, visualise possible scenarios before acting, or share knowledge and tasks between individuals and groups. Science fiction no longer, the future of engagement is here, and enterprises will likely be the first to embrace it.

CONTACTS

PAUL LEE
Partner, Technology Consulting
Deloitte MCS Limited
020 7303 0197
paullee@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AUTHORS

NELSON KUNKEL
Deloitte Digital US creative director, Deloitte Consulting LLP

STEVE SOECHTIG
Deloitte Digital Experience practice leader, Deloitte Consulting LLP

ENDNOTES

1. Nelson Kunkel, Steve Soechtig, Jared Miniman, and Chris Stauch, *Tech Trends 2016: Augmented and virtual reality go to work*, Deloitte University Press, February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/augmented-and-virtual-reality.html.
2. John Greenough and Jonathan Camhi, "Here are IoT trends that will change the way businesses, governments, and consumers interact with the world," *Business Insider*, August 29, 2016, www.businessinsider.com/top-internet-of-things-trends-2016-1; also see Deloitte University Press's series of articles on the Internet of Things, https://dupress.deloitte.com/dup-us-en/focus/internet-of-things.html.
3. Interview with Brian Ballard, CEO and founder, Upskill, January 13, 2017.
4. Leo King, "Ford, where virtual reality is already manufacturing reality," *Forbes*, May 3, 2014, www.forbes.com/sites/leoking/2014/05/03/ford-where-virtual-reality-is-already-manufacturing-reality/.
5. Kunkel et al., *Tech Trends 2016: Augmented and virtual reality go to work*.
6. Alexa Matia, "What the rise of virtual reality means for marketers," *Convince & Convert*, www.convinceandconvert.com/digital-marketing/virtual-reality-for-marketers/, accessed January 22, 2017.
7. Jeff Booth, "How virtual reality will change the way you shop," *Time*, March 28, 2016, http://time.com/4273885/virtual-reality-shopping/.
8. Adi Robertson, "The Unreal engine now lets you build games inside virtual reality," *Verge*, February 4, 2016, www.theverge.com/2016/2/4/10908444/epic-unreal-engine-editor-vr-edition.
9. Interview with Natan Linder, Tulip co-founder, December 5, 2016.
10. Natasha Lomas, "Sports broadcast wearable FirstV1sion gets sweat-tested in EuroLeague basketball," *Tech Crunch*, April 8, 2015, https://techcrunch.com/2015/04/08/firstv1sion/.
11. Ezra Marcus, "'TheWaveVR' is the virtual reality concert platform of the future," *Thump*, September 29, 2016, https://thump.vice.com/en_us/article/wave-virtual-reality-future.
12. Adi Robertson, "Can virtual reality help us talk politics online?" *Verge*, September 26, 2016, www.theverge.com/2016/9/26/13023358/altspacevr-nbc-news-vr-democracy-plaza-launch.
13. Irfan Saif, Sean Peasley, and Arun Perinkolam, "Safeguarding the Internet of Things: Being secure, vigilant, and resilient in the connected age," *Deloitte Review* 17, July 27, 2015, https://dupress.deloitte.com/dup-us-en/deloitte-review/issue-17/internet-of-things-data-security-and-privacy.html.

Deloitte.
University Press

Inevitable architecture

Complexity gives way to simplicity and flexibility

ORGANISATIONS ARE OVERHAULING THEIR IT LANDSCAPES BY COMBINING OPEN source, open standards, virtualisation, and containerisation. Moreover, they are leveraging automation aggressively, taking steps to couple existing and new platforms more loosely, and often embracing a "cloud first" mind-set. These steps, taken individually or as part of larger transformation initiatives, are part of an emerging trend that some see as inevitable: the standardisation of a flexible architecture model that drives efficiency, reduces hardware and labor costs, and foundationally supports speed, flexibility, and rapid outcomes.

IN some companies, systems architecture is older than the freshman tech talent maintaining it. Sure, this legacy IT footprint may seem stable on a day-to-day basis. But in an era of rapid-fire innovation with cloud, mobile, analytics, and other forces implemented on the edge of the business fueling disruption and new opportunities, architectural maturity is becoming a persistent challenge—one directly linked to business problems.[1] Heavy customisation, complexity, security vulnerabilities, inadequate scalability, and technical debt throughout the IT environment have, directly or indirectly, begun to impact the bottom line. In Deloitte's *2016 Global CIO Survey*, 46 percent of 1,200 IT executives surveyed identified "simplifying IT infrastructure" as a top business priority. Likewise, almost a quarter deemed the performance, reliability, and functionality of their legacy systems "insufficient."[2]

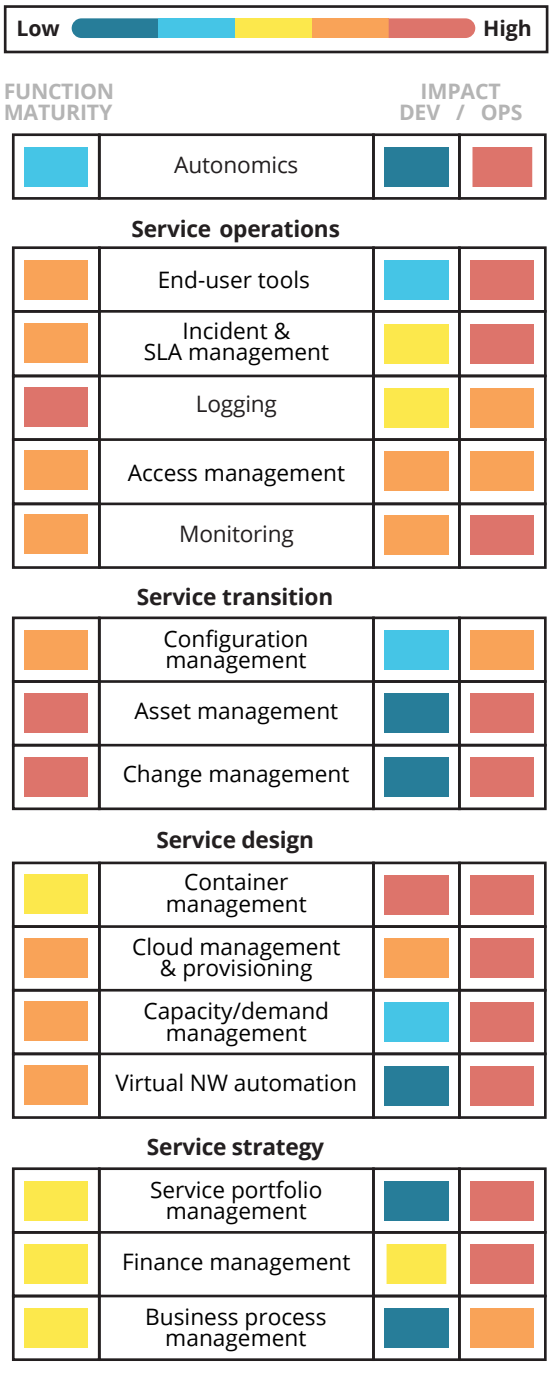
Previous editions of *Tech Trends* have examined strategies that CIOs are deploying to modernise and revitalise their legacy core systems, not only to extract more value from them but to make the entire IT footprint more agile, intuitive, and responsive. Likewise, *Tech Trends* has tracked IT's increasingly warm embrace of automation and the autonomic platforms that seamlessly move workloads among traditional on-premises stacks, private cloud platforms, and public cloud services.

While these and other modernisation strategies can be necessary and beneficial, they represent sprints in a longer modernisation marathon. Increasingly, CIOs are thinking bigger-picture about the technology stacks that drive revenue and enable strategy. As they assess the capacity of current systems to meet future needs, many are likely asking, "If I could start over with a new IT architecture, what would I do differently to lower costs and increase capabilities?"

In the next 18 to 24 months, CIOs and their partners in the C-suite may find an answer to this question in a flexible architecture model whose demonstrated efficiency and effectiveness in start-up IT environments suggest that its broader adoption in the marketplace may be *inevitable*. In this cloud-first model—and in the leading practices emerging around it—platforms are virtualised, containerised, and treated like malleable, reusable resources. Systems

Figure 1. Infrastructure management tools: Maturity and developer and operations impact

The infrastructure management tools landscape is heavily segmented and complex. While some capabilities such as cloud management and autonomics are at the origin of disruption for IT, technology leaders should also address adjacent capabilities to enable seamless IT.



Deloitte University Press | dupress.deloitte.com

are loosely coupled and, increasingly, automated to be self-learning and self-healing. Likewise, on-premises, private cloud, or public cloud capabilities can be deployed dynamically to deliver each workload at an optimum price and performance point. Taken together, these elements can make it possible to move broadly from managing instances to managing outcomes.

It's not difficult to recognise a causal relationship between architectural agility and any number of potential strategic and operational benefits. For example, inevitable architecture—which also embraces open-source/open-stack approaches—provides the foundation needed to support rapid development and deployment of flexible solutions that, in turn, enable innovation and growth. In a competitive landscape being redrawn continuously by technology disruption, time-to-market can be a competitive differentiator.

Moreover, architectural modernisation is about more than lowering capital expenses by transitioning to the cloud and eliminating on-premises servers. Indeed, its most promising opportunity for cost savings often lies in reducing the number of people required to maintain systems. This does not mean simply decreasing headcount, though in some cases that may become necessary. Rather, by automating mundane "care and feeding" tasks, companies can free critical IT talent to focus on higher-level activities such as developing new products and services, working hand-in-hand with the business to support emerging needs, and deploying a revitalised technology stack that enables rapid growth in an innovation environment.

Beyond start-ups

To date, much of the "tire-kicking" and experimentation done on the inevitable-architecture model has taken place in the IT ecosystems of start-ups and other small companies that are unburdened by legacy systems. However, recently some larger organisations have begun experimenting with one or more inevitable-architecture components. For example, Marriott Hotels, which runs VMware virtual machines on an IBM cloud, recently deployed a hybrid cloud co-developed by the two vendors.

This time-saving solution makes it possible to move virtual workloads created and stored on-premises to the cloud quickly, without having to rewrite or repackage them. Marriott reports that with the new solution, a process that could take up to a day can now be completed in an hour.[3]

And retail giant Walmart has embraced open-source with a new DevOps platform called OneOps that is designed to help developers write and launch apps more quickly. Walmart has made code for the OneOps project available on GitHub.[4]

In the coming months, expect to see other organisations follow suit by experimenting with one or more of the following inevitable-architecture elements:

Loosely coupled systems: Large enterprises often deploy thousands of applications to support and enable business. In established companies, many of the core applications are large, monolithic systems featuring layers of dependencies, workarounds, and rigidly defined batch interfaces. In such IT environments, quarterly or semiannual release schedules can create 24-month backlogs of updates and fixes. Moreover, making even minor changes to these core systems may require months of regression testing, adding to the backlog.[5]

Over the last several years, the emergence of microservices and the success of core revitalisation initiatives have given rise to a fundamentally different approach to infrastructure design in which core components are no longer interdependent and monolithic but, rather, "loosely coupled." In this structure, system components make little if any use of the definitions of other components. Though they may interface with other components via APIs or other means, their developmental and operational independence makes it possible to make upgrades and changes to them without months of regression testing and coordination. They can also be more easily "composed" than large monolithic systems.

Containers: Similar to loosely coupled systems, containers break down monolithic interdependent architectures into manageable, largely independent pieces. Simply put, a container is an entire runtime environment—an application plus its dependencies, libraries and other binaries, and configuration files—virtualised and bundled into one package. By containerising the application platform and its dependencies, differences in OS distributions and underlying infrastructure are abstracted away.[6] Containers are fully portable and can live on-premises or in the cloud, depending on which is more cost-effective.

Container management software vendors such as Docker, CoreOS, BlueData, and others are currently enjoying popularity in the software world, due in large part to their ability to help developers break services and applications into small, manageable pieces. (Current industry leader Docker reports that its software has been downloaded more than 1.8 billion times and has helped build more than 280,000 applications.)[7]

Though containers may be popular among developers and with tech companies such as Google, Amazon, and Facebook, to date corporate CIOs seem to be taking a wait-and-see approach.[8] That said, we are beginning to see a few companies outside the tech sector utilise containers as part of larger architecture revitalisation efforts. For example, financial services firm Goldman Sachs has launched a yearlong project that will shift about 90 percent of the company's computing to containers. This includes all of the firm's applications—nearly 5,000 in total—that run on an internal cloud, as well as much of its software infrastructure.[9]

Speed first, then efficiency: As business becomes increasingly reliant on technology for emerging products and services, it becomes more important than ever for IT to shrink time-to-market schedules. As such, inevitable architecture emphasises speed over efficiency—an approach that upends decades of processes and controls that, while well intentioned, often slow progress and discourage experimentation. Though it may be several years before many CIOs wholly (or even partially) embrace the "speed over efficiency" ethos, there are signs of momentum on this front. Acknowledging the gravitational pull that efficiency can have on development costs and velocity, streaming service Netflix has created an IT footprint that doesn't sacrifice speed for efficiency.[10]

Open source: Sun Microsystems co-founder Bill Joy once quipped, "No matter who you are, most of the smartest people work for somebody else. . . . It's better to create an ecology that gets most of the world's smartest people toiling in your garden for your goals. If you rely solely on you own employees, you'll never solve all your customers' needs." This idea, now referred to as Joy's Law, informs open-source software (OSS) and open-stack approaches to development, both core attributes of inevitable architecture.[11]

Many large companies still have old-world open-source policies featuring bureaucratic approval processes that ultimately defeat the entire purpose of OSS.[12] Yet, to quote reluctant Nobel laureate Bob Dylan, the times they are a-changin'. One recent study of open-source adoption estimates that 78 percent of companies are now using OSS. Even the generally risk-averse federal government is getting in on the act, having recently outlined a policy to support access to custom software code developed by or for the federal government.[13]

Fault expecting: For decades, developers focused on design patterns that make systems fault-tolerant. Inevitable architecture takes this tactic to the next level by becoming "fault expecting." Famously illustrated in Netflix's adventures using Chaos Monkey, fault expecting is like a fire drill involving real fire. It deliberately injects failure into a system component so that developers can understand 1) how the system will react, 2) how to repair the problem, and 3) how to make the system more resilient in the future. As CIOs work to make systems more component-driven and less monolithic, fault expecting will likely become one of the more beneficial inevitable-architecture attributes.

Autonomic platforms: Inevitable architecture demands automation throughout the IT lifecycle, including automated testing, building, deployment, and operation of applications as well as large-scale autonomic platforms that are largely self-monitoring, self-learning, and self-healing. As discussed in *Tech Trends 2016*, autonomic platforms build upon and bring together two important trends in IT: software-defined everything's climb up the tech stack, and the overhaul of IT operating and delivery models under the DevOps movement. With more and more of IT becoming expressible as code—from underlying infrastructure to IT department tasks—organisations now have a chance to apply new architecture patterns and disciplines. In doing so, they can remove dependencies between business outcomes and underlying solutions, while redeploying IT talent from rote low-value work to higher-order capabilities.

Remembrance of mainframes past

For many established companies, the inevitable-architecture trend represents the next phase in a familiar modernisation journey that began when they moved from mainframe to client-server and, then, a decade later, shifted to web-centric architecture. These transitions were not easy, often taking months or even years to complete. But in the end, they were worth the effort. Likewise, successfully deploying and leveraging inevitable architecture's elements will surely present challenges as the journey unfolds. Adoption will take time and will likely vary in scope according to an organisation's existing capabilities and the incremental benefits the adopting organisation achieves as it progresses.

Once again, the outcome will likely justify the effort. It is already becoming clear that taken together, inevitable architecture's elements represent a sea change across the IT enablement layer—a modern architecture up, down, and across the stack that can deliver immediate efficiency gains while simultaneously laying a foundation for agility, innovation, and growth. Its potential value is clear and attributable, as is the competitive threat from start-ups and nimble competitors that have already built solutions and operations with these concepts.

Future stack: Louisiana builds an IT architecture for tomorrow

With some legacy IT systems entering their third decade of service, in 2014 the state of Louisiana launched the Enterprise Architecture Project, an ambitious, multifaceted effort to break down operational silos, increase reusability of systems and services, and most important, create the foundation for the state's next-generation architecture. The end state was clear: Accelerate the delivery of flexible, secure building blocks and the capabilities to speed their use to produce value for Louisiana citizens. Changes to how IT procures, assembles, and delivers capabilities would be not only needed but inevitable.

"We deliver end-to-end IT services for 16 executive branch agencies," says Matthew Vince, the Office of Technology Services' chief design officer and director of project and portfolio management. "With a small IT staff and that much responsibility, we didn't see any way to take on a project like this without jumping into inevitable architecture."

Given the age and complexity of the state's legacy architecture—and that Louisiana's government takes a paced approach in adopting new technologies—it was important to define a clear strategy for achieving short- and longer-term goals. The team focused agencies on architecture principles and the "so what" of the inevitable modern capabilities it would supply: enabling components and reuse over specifying "microservices," how automation could help agencies over specifying a particular IT product, and the need for workload migration and hybrid cloud enablement over specifying a particular form of virtualisation.

"For example, think about containers," says Michael Allison, the state's chief technology officer. "Having the ability to jump into Docker or Kubernetes today is not as important as being able to adopt container orchestration solutions in the future. Our immediate goal, then, is to lay the foundation for achieving longer-term goals."

Laying that foundation began by aligning IT's goals and strategies with those of agency leaders and business partners. IT wanted to determine what tools these internal customers needed to be successful and what options were available from their suppliers and partners before planning, prototyping, and providing working solutions to meet those needs.

After careful consideration of business and IT priorities, budgets, and technical requirements, IT teams began developing a next-generation software-defined data centre (SDDC) to serve as the platform of choice for the enterprise architecture project and future line-of-business applications. This SDDC was put into production at the end of

2016 and now supports efforts in several EA project areas, including:

Security and risk management: Replaces network segregation with software-defined data security policies.

Cloud services: Uses both public and enterprise cloud services, including commercial infrastructure-as-a-service offerings.

Consolidation and optimisation: Consolidates and optimises data centre services, service-oriented architecture, and governance to increase efficiencies and lower costs.[14]

Progress in these areas is already having a net positive impact on operations, Vince says. "Traditionally we were siloed in service delivery. Suddenly, barriers between teams are disappearing as they begin working through the data centre. This has been one of the greatest benefits: Lines between traditionally segregated skill sets are becoming blurred and everyone is talking the same language.

We are seeing SDDC technology can be used across the enterprise rather than being confined to use by a single agency," he continues. "A priority in our move to the SDDC is integrating systems, maximising reusability, and—when legislation allows us to—sharing data across agencies. Going forward, everything we do will be to meet the needs of the entire state government, not just a single agency."[15]

The keys to Citi-as-a-service

Responding to a seismic shift in customer expectations that has taken place during the past decade, leading financial services company Citi is transforming its IT architecture into a flexible, services-based model that supports new strategies, products, and business models.

"The sophistication and generational change in customer expectation in our industry as well as the delivery requirements impacts everything we do now, from behind the scenes items such as how we run our data centres to the way we design branch offices, mobile and ATM capabilities, and the financial instruments we offer," says Motti Finkelstein, managing director, CTO-Americas and Global Strategy and Planning at Citi. "Due to the dynamic nature of this change, the whole design of IT architecture needs to be more agile. Infrastructure should be flexible—compute, network, storage, security, databases, etc.—with elastic real-time capabilities to meet business demands in a time-efficient manner."

Citi actually began working toward its ultimate architecture goal more than a decade ago, when the organisation took initial steps to virtualise its data centres. Other virtualisation projects soon followed, eventually leading to an effort to standardise and focus architectural transformation on building a broad everything-as-a-service (XaaS) environment. Finkelstein estimates that ongoing efforts to transform Citi's architecture have reduced infrastructure costs significantly in the last decade. "We are continuing on a trajectory of not only expediting time to market delivery but becoming more cost-efficient as we move our optimisation efforts up the stack with technologies such as containerisation paired with platform-as-a-service," he says. Container technologies are rapidly becoming enterprise ready, and may inevitability become the bank's target architecture. Barriers to adoption are diminishing with industry standards coming into place and the up-front investment required to re-architect applications onto these platforms steadily reducing.

Leaders also found that while these new technical building blocks drove cost and efficiency savings for IT, equally important were the new capabilities they enabled. "While we were investing in virtualisation, automation, and XaaS, we are also building our development capabilities," Finkelstein says. "Development will become much more efficient and productive as our engineers are designing and implementing XaaS environments, reducing time to market and improving adoption times for innovation in technology." Citi has engineered a PaaS environment with predefined microservices to facilitate rapid and parallel deployments; this enables the use of clear standards and templates to build and extend new services both internally and externally, which marks a significant change from only a few years ago.

Inevitably, speed to market and rapid outcomes are attracting the right kind of attention: "When we started working to create an XaaS environment, we thought it would be based on policy requirements," Finkelstein says. "Today, everyone—including the business—understands the need for this development process and the benefit of templates standardisation to build new products and services. This model being DevOps-operated needs to have a lot of visibility into the process; we are starting to see different organisations become more involved in building those templates for success. At this point, it becomes more about tweaking a template than about starting from scratch." (DevOps is the term used for agile collaboration, communications, and automation between the development and operations technology units.)[16]

Inventing the inevitable

Google has been passionate about the piece-parts of inevitable architecture—a cloud-based, distributed, elastic, standardised technology stack built for reliability, scalability, and speed—since its earliest days. They company's head of infrastructure, Urs Hölzle (Google's eighth badged employee), recognised the inherent need for scale if the company were going to succeed in building a truly global business allowing people to search anything, from everywhere, with content delivered anywhere. With seven of its products each having more than a billion active users, that early vision has not only been the foundation of Google's growth—it has driven the very products and solutions fueling the company's expansion.

According to Tariq Shaukat, president of customers at Google Cloud, "We recognised that our technology architecture and operations had to be built to fulfill a different kind of scale and availability. We invented many of the core technologies to support our needs . . . because we had to." That led to the development, deployment, and open sourcing of many technologies that help fuel the growth of inevitable architecture—including MapReduce, Kubernetes, TensorFlow, and others. These technologies have become a complement to Google's commercial product roadmap, including the Google Cloud Platform, across infrastructure, app, data, and other architectural layers.

At the heart of Google's technology landscape is a systems mind-set: deeply committed to loosely coupled but tightly aligned components that are built expecting to be reused while anticipating change. This requires that distributed teams around the globe embrace common services, platforms, architectural principles, and design patterns. As development teams design and build new products, they begin with an end-state vision of how their products will operate within this architecture and, then, engineer them accordingly. Not only does this approach provide a common set of parameters and tools for development—it also provides a consistent approach to security and reliability, and can prevent architectural silos from springing up around a new application that doesn't work with all of Google's global systems. Extensions and additions to the architecture happen frequently but go through rigorous vetting processes. The collaborative nature of capabilities such as design and engineering is coupled with tight governance around non-negotiables such as security, privacy, availability, and performance.

Google's architectural efforts are delivering tangible benefits to both employees and customers. The company's forays into machine learning are one example: In a period of 18 to 24 months, it went from an isolated research project to a broad toolkit embedded into almost every product and project. Adds Shaukat, "The reason it was possible? A common architecture and infrastructure that makes it possible to rapidly deploy modules to groups that naturally want to embrace them. It was absolutely a grassroots deployment, with each team figuring out how machine learning might impact their users or customers." By rooting agility in a systems approach, the company can make an impact on billions of users around the globe.[17]

MY TAKE

JOHN SEELY BROWN, INDEPENDENT CO-CHAIRMAN, CENTRE FOR THE EDGE

DELOITTE LLP

The exponential pace of technological advancement is, if anything, accelerating. Look back at the amazing changes that have taken place during the last 15 years. At the beginning of the naughts, the holy grail of competitive advantage was scalable efficiency—a goal that had remained mostly unchanged since the industrial revolution. Organisations and markets were predictable, hierarchical, and seemingly controllable. The fundamental assumption of stability informed not only corporate strategies and management practices but also the mission and presumed impact of technology. By extension, it also informed IT operating models and infrastructure design.

Then the Big Shift happened. Fueled in part by macro advances in cloud, mobile, and analytics, exponential advances across technology disciplines spawned new competitors, rewired industries, and made obsolete many institutional architectures. Rather than thinking of our business models as a 200,000-ton cargo ship sailing on calm open waters, we suddenly needed to mimic a skilled kayaker navigating white water. Today, we must read contextual currents and disturbances, divining what lies beneath the surface, and use these insights to drive accelerated action.

At a lower level, new principles have emerged in the world of computer science. Eventual consistency is now an acceptable alternative to the transactional integrity of two-phase commit. Tightly aligned but loosely coupled architectures are becoming dominant. Mobile-first mind-sets have evolved, giving way to "cloud first"—and in some cases "cloud only"—landscapes. Distributed, unstructured, and democratised data is now the norm. Moreover, deep learning and cognitive technologies are increasingly harnessing data. Open standards and systems are providing free capabilities in messaging, provisioning, monitoring, and other disciplines. The proliferation of sensors and connected devices has introduced a new breed of architecture that requires complex event correlation and processing.

Collectively, these advances form the underpinnings of inevitable architecture. They are redefining best practices for IT infrastructure and are providing new opportunities to use this infrastructure to empower the edge. This, in turn, makes it possible for companies to rapidly bring complex new ideas and products to market.

> "WE MUST DIVINE WHAT LIES BENEATH THE SURFACE."

Moreover, inevitable architecture supports experimentation at the pace of overarching technological advancements. Importantly, it also provides opportunities to automate environments and supporting operational workloads that can lead to efficiency gains and concrete cost savings while also enabling a new kind of agility. Companies can use these savings to fund more far-reaching inevitable architecture opportunities going forward.

In describing Amazon's relentless focus on new offerings and markets, Jeff Bezos once famously said, "Your margin is my opportunity." The gap between exponential technologies and any organisation's ability to execute against its potential is the new margin upon which efficiencies can be realised, new products and offerings can be forged, and industries can be reshaped. If every company is a technology company, bold new approaches for managing and reimagining an organisation's IT footprint become an essential part of any transformational journey. They can also help shrink the gap between technology's potential and operational reality—especially as the purpose of any given institution evolves beyond delivering transactions at scale for a minimum cost. Inevitable architecture can provide the wiring for scalable learning, the means for spanning ecosystem boundaries, and the fluidity and responsiveness we all now need to pursue tomorrow's opportunities.

Overhauling IT infrastructure by embracing open source, open standards, virtualisation, and cloud-first strategies means abandoning some long-held systems architecture design principles. Doing so may require rethinking your approach to security. For example, if you have been a network specialist for 30 years, you may consider some kind of perimeter defense or firewall foundational to be a good cyber defense strategy. In a virtualised, cloud-first world, such notions aren't necessarily taken as gospel anymore, as network environments become increasingly porous. Going forward, it will be important to focus on risks arising from new design philosophies. Open standards and cloud-first aren't just about network design—they also inform how you will design a flexible, adaptable, scalable cyber risk paradigm.

> "GOING FORWARD, IT WILL BE IMPORTANT TO FOCUS ON RISKS ARISING FROM NEW DESIGN PHILOSOPHIES."

Also, as companies begin overhauling their IT infrastructure, they may have opportunities to integrate many of the security, compliance, and resilience capabilities they need into the new platforms being deployed by embedding them in templates, profiles, and supporting services. Seizing this opportunity may go a long way toward mitigating many of the risk and cyber challenges often associated with a standardised, flexible architecture model. Moreover, designing needed cybersecurity and risk management capabilities into new systems and architectures up front can, when done correctly, provide other long-term benefits as well:

Speed: Retrofitting a new product or solution with cyber capabilities may slow down development initiatives and boost costs. By addressing cyber considerations proactively as they begin overhauling IT infrastructure, companies may be able to accelerate the product development lifecycle.

Product design as a discipline: When risk and compliance managers collaborate with designers and engineers from the earliest stages of product development and transformation initiatives, together they can design "complete" products that are usable and effective and maintain security and compliance standards.

Effectiveness: By establishing practices and methodologies that emphasise risk considerations—and by taking steps to confirm that employees understand the company's approach to managing different types of risk—organisations may be able to move more efficiently and effectively. Just as infrastructure transformation initiatives offer designers the opportunity to incorporate risk and cybersecurity into new products and services, they offer the same opportunity to instill greater technology and risk fluency in employees throughout the enterprise.

However, with these benefits come questions and challenges that CIOs may need to address as they and their teams build more flexible and efficient architecture. For example, they may have to create additional processes to accommodate new cyber and risk capabilities that their organisations have not previously deployed.

Likewise, new platforms often come with risk and security capabilities that can be deployed, customised, and integrated with existing solutions and business process. While companies should take advantage of these capabilities, their existence does not mean you are home free in terms of risk and cybersecurity considerations. Risk profiles vary, sometimes dramatically, by organisation and industry. Factory-embedded security and risk capabilities may not address the full spectrum of risks that your company faces.

Embracing open source and open standards also raises several risk considerations. Some may question the integrity and security of code to which anyone can contribute, and one challenge that organisations using open source code may face is mitigating whatever risk does come from using code written by anonymous strangers. CIOs should consider performing broad risk and capability assessments as part of an architecture transformation initiative. Likewise, they should evaluate what IT and legal support should be put in place to address potential issues.

Where do you start?

In organising systems and processes to support an inevitable architecture (IA) model, start-ups often have the advantage of being able to begin with a blank canvas. Larger companies with legacy architectures, on the other hand, will have to approach this effort as a transformation journey that beings with careful planning and preparatory work. As you begin exploring IA transformation possibilities, consider the following initial steps:

- **Establish your own principles:** Approaches to inevitable architecture will differ by company according to business and technology priorities, available resources, and current capabilities. Some will emphasise cloud-first while others focus on virtualisation and containers. To establish the principles and priorities that will guide your IA efforts, start by defining end-goal capabilities. Then, begin developing target architectures to turn this vision into reality. Remember that success requires more than putting IA components in place—business leaders and their teams must be able to use them to execute strategy and drive value.
- **Take stock of who is doing what—and why:** In many companies, various groups are already leveraging some IA components at project-specific, micro levels. As you craft your IA strategy, it will be important to know what technologies are being used, by whom, and to achieve what specific goals. For example, some teams may already be developing use cases in which containers figure prominently. Others may be independently sourcing cloud-based services or open standards to short-circuit delivery. With a baseline inventory of capabilities and activities in place, you can begin building a more accurate and detailed strategy for industrialising priority IA components, and for consolidating individual use case efforts into larger experiments. This, in turn, can help you develop a further-reaching roadmap and business case.
- **Move from silos to business enablement:** In the same way that CIOs and business teams are working together to erase boundaries between their two groups, development and infrastructure teams should break free of traditional skills silos and reorient as multidisciplinary, project-focused teams to help deliver on inevitable architecture's promise of business enablement. The beauty? Adopting virtualisation and autonomics across the stack can set up such a transition nicely, as lower-level specialisation and underlying tools and tasks are abstracted, elevated, or eliminated.
- **CIO, heal thyself:** Business leaders often view CIOs as change agents who are integral to business success. It's now time for CIOs to become change agents for their own departments. Step one? Shift your focus from short-term needs of individual business teams to medium or longer-term needs shared by multiple groups. For example, if as part of your IA strategy, seven of 10 internal business customers will transition to using containers, you will likely need to develop the means for moving code between these containers. You may also need to bring additional IT talent with server or container experience on staff. Unfortunately, some CIOs are so accustomed to reacting immediately to business requests that they may find it challenging to proactively anticipate and plan for business needs that appear slightly smaller on the horizon. The time to begin thinking longer-term is now.

Bottom line

In a business climate where time-to-market is becoming a competitive differentiator, large companies can no longer afford to ignore the impact that technical debt, heavy customisation, complexity, and inadequate scalability have on their bottom lines. By transforming their legacy architecture into one that emphasises cloud-first, containers, virtualised platforms, and reusability, they may be able to move broadly from managing instances to managing outcomes.

CONTACTS

JOHN STARLING

Partner, Technology Consulting
Deloitte MCS Limited
020 7303 7225
jstarling@deloitte.co.uk

STEPHEN MERCER

Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

RICHARD FORREST

Director, Technology Consulting
Deloitte MCS Limited
020 7303 8547
rforrest@deloitte.co.uk

AUTHORS

RANJIT BAWA

US Cloud and Infrastructure leader, Deloitte Consulting LLP

SCOTT BUCHHOLZ

Managing Director, Technology practice, Deloitte Consulting LLP

KEN CORLESS

Principal, Technology Strategy and Architecture practice, Deloitte Consulting LLP

JACQUES DE VILLIERS

Cloud Services director, Deloitte Consulting LLP

EVAN KALINER

Solutions Network practice leader, Deloitte Consulting LLP

ENDNOTES

1. Scott Buchholz, Ben Jones, and Pavel Krumkachev, *Reimagining core systems: Modernising the heart of the business*, Deloitte University Press, February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/reimagining-core-systems-strategy.html.
2. Khalid Kark, Mark White, Bill Briggs, and Anjali Shaikh, *Navigating legacy: Charting the course to business value*, Deloitte University Press, November 10, 2016, https://dupress.deloitte.com/dup-us-en/topics/leadership/global-cio-survey.html.
3. Alex Konrad, "IBM and VMware deepen hybrid cloud partnership for customers like Marriott," *Forbes*, August 29, 2016, www.forbes.com/sites/alexkonrad/2016/08/29/ibm-vmware-deepen-hybrid-cloud-partnership-for-customers-like-marriott/.
4. Frederic Lardinois, "Walmart launches OneOps, an open-source cloud and application lifecycle management platform, *TechCrunch*, January 26, 2016, https://techcrunch.com/2016/01/26/walmart-launches-oneops-an-open-source-cloud-and-application-lifecycle-management-platform/.
5. Buchholz et al., *Reimagining core systems*.
6. Paul Rubens, "What are containers and why do you need them?" *CIO Magazine*, May 20, 2015, www.cio.com/article/2924995/enterprise-software/what-are-containers-and-why-do-you-need-them.html.
7. "Ben Golub on what digital containers hold for the future," *Wall Street Journal*, February 10, 2016, www.wsj.com/articles/ben-golub-on-what-digital-containers-hold-for-the-future-1455103832.
8. Clint Boulton, "CIOs aren't ready for Docker and container technology," *CIO Magazine*, February 15, 2016, www.cio.com/article/3033167/virtualisation/cios-aren-t-ready-for-docker-and-container-technology.html.
9. Steven Rosenbush and Steven Norton, "Big changes in Goldman's software emerge from small containers," *Wall Street Journal*, February 24, 2016, http://blogs.wsj.com/cio/2016/02/24/big-changes-in-goldmans-software-emerge-from-small-containers/.
10. Patrick Nommensen, "Adopting microservices at Netflix: Lessons for team and process design," *Dzone*, April 13, 2015, https://dzone.com/articles/adopting-microservices-netflix-0.
11. Greg Satell, "Why open beats closed," *Forbes*, September 26, 2016, www.forbes.com/sites/gregsatell/2016/09/26/why-open-beats-closed/.
12. Black Duck Software, *The Tenth Annual Future of Open Source Survey*, 2016, www.blackducksoftware.com/2016-future-of-open-source, accessed November 20, 2016.
13. Tony Scott, "The people's code," White House Blog, August 8, 2016, www.whitehouse.gov/blog/2016/08/08/peoples-code.
14. State IT Recognition Awards, National Association of State Information Officers, Louisiana Department of Administration, Office of Technology Services, Enterprise Architecture and Software Defined Datacentre, 2016, www.nascio.org/portals/0/awards/nominations2016/2016/2016LA5-20160518%20LA%20EA%20NASCIO.pdf, accessed December 18, 2016.

15. Interview with Michael Allison, state chief technology officer, and Matthew Vince, chief design officer and director, project and portfolio management, Office of Technology Services for the state of Louisiana, December 5, 2016.

16. Interview with Motti Finkelstein, chief technology officer, Americas and Global Strategy Planning, Citi, December 7, 2016.

17. Interview with Tariq Shaukat, president of customers at Google Cloud, January 9, 2017.

Deloitte.
University Press

Everything-as-a-service

Modernising the core through a services lens

MANY ORGANISATIONS ARE REORIENTING THEIR BUSINESS CAPABILITIES AND approaching business products, offerings, and processes as a collection of services that can be used both inside and outside organisational boundaries. But doing so means IT may need to revitalise legacy core assets by upgrading to the latest ERP platforms or refactoring aging custom code. Though sometimes-daunting undertakings, these and other legacy remediation efforts can help achieve short-term efficiency gains and cost savings, while laying the foundation for broader strategic shifts.

DURING the last decade, the one-two punch of business imperatives and a rapidly evolving technology landscape has led many CIOs to revitalise their legacy core systems.

On the technical front, after years of customisations, workarounds, and deferred upgrades, many heart-of-the-business systems that run back-, mid-, and front-office processes has become hamstrung by accumulated technical debt and dependencies. For many CIOs, refactoring these assets and building new architectures and platforms around them have been essential steps in making IT systems not only more efficient and effective but fundamentally more reliable.[1]

As for the business imperatives that often drive core revitalisation efforts, the pace of technological innovation continues to accelerate, offering ripe opportunities to rewire the way companies work, engage their customers and business partners, and compete. Globalisation, increased M&A activity, and cyber threats are putting pressure on IT ecosystems and delivery models. New digital products and offerings, along with powerful forces such as analytics, social media, and mobile, are giving rise to business models built around intuitive experiences and grounded in underlying mission-critical data, transactions, and systems.

Among the questions CIOs must answer: Can legacy core systems support these innovations and the strategies they drive? And are core assets sufficiently flexible and scalable to meet business needs going forward? For those CIOs answering "no," core revitalisation has provided a roadmap for approaching the core not as an anchor but as a set of customer-focused, outcome-driven building blocks that can support the business well into the digital age and beyond.

Today, a new business imperative is gaining traction in boardrooms and IT shops alike. Everything-as-a-service (XaaS) is a strategic and operational blueprint that, within the next 18–24 months, will likely begin upending business and operational models, and redefining the fundamental goals of core modernisation.

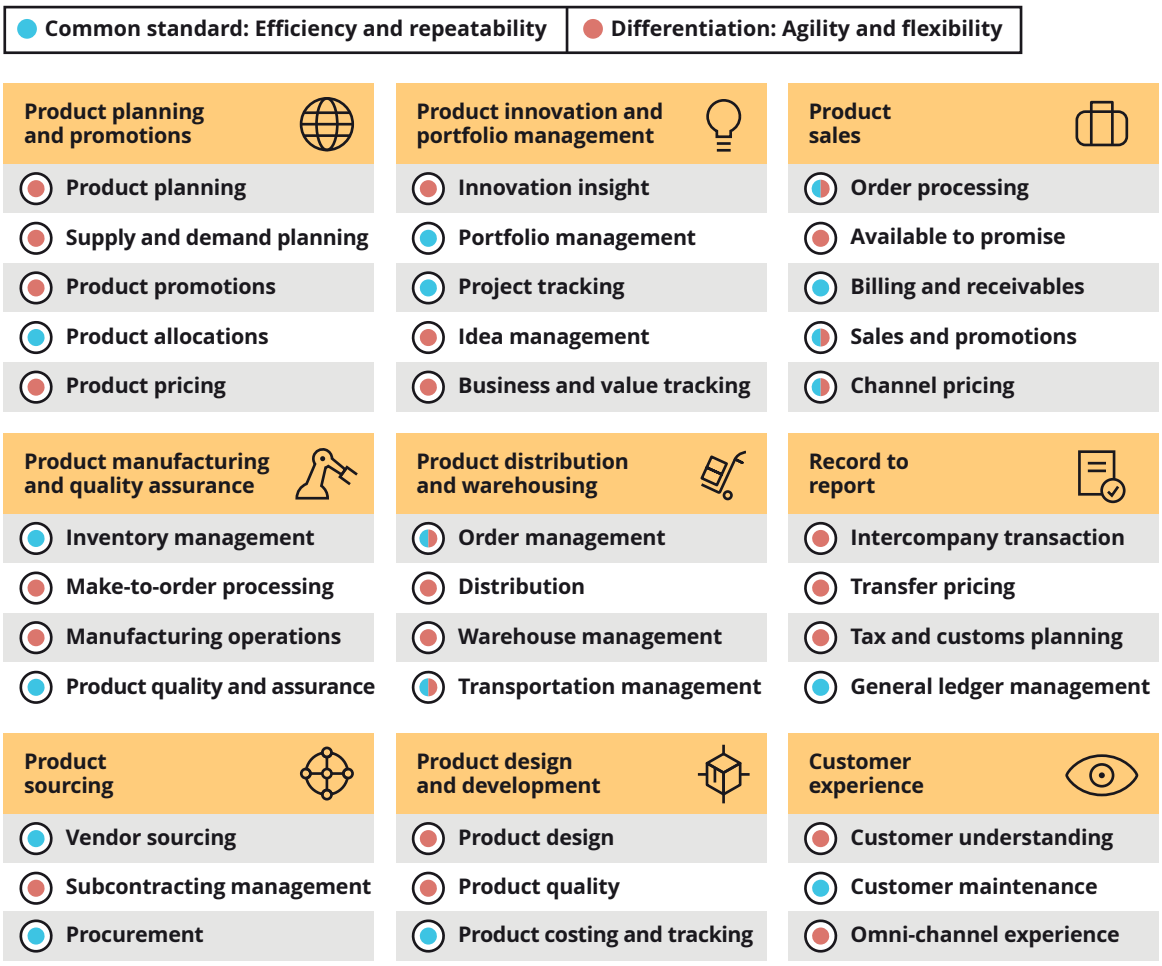
XaaS envisions business capabilities, products, and processes not as discreet vertical offerings operating

individually in silos but, rather, as a collection of horizontal services that can be accessed and leveraged across organisational boundaries. So with a few technical upgrades and strategically deployed APIs, the customer service module in your ERP system that is used exclusively to support external customers can now be leveraged by other departments as well: by IT for help-desk queries, by HR for internal customers, and by logistics for vendor support, for instance.

XaaS casts core modernisation in an entirely new light. What was primarily a technical process of overhauling legacy systems becomes a broader operational and business effort to create greater efficiencies and to engage customers, employees, and business partners in new ways. This effort also entails building a catalog of assets that embody existing IP and establishing platforms for ecosystem investments that can, in turn, lead to new products or even business models.

Figure 1. Redesigning business processes as services

In the high-value opportunities listed below, services defined as "common standard" represent compartmentalised, commodity business functions where repeatability and efficiency matter most. By treating these as services, organisations can expand sourcing options to include out-of-the-box ERP, legacy systems, BPO, or cloud offerings. Services defined as "differentiated" represent opportunities to drive competitive advantage by improving agility and operational flexibility.



For CIOs, XaaS may also offer a way to help justify essential if decidedly unglamorous investments to the board. In many companies, addressing reliability, security, and scalability challenges in legacy core systems is, from a technical perspective, essential. Unfortunately, those holding the purse strings often view core revitalisation as nothing more than plumbing upgrades that, at best, increase efficiency. However, when viewed through the lens of XaaS, core modernisation lies at the heart of business strategy: It involves shoring up the technical base to deliver efficiencies while rationalising complex redundant footprints, reducing licensing commitments, and most importantly, allowing redeployment of IT operations resources. Ideally, those cost savings would then be used to fund innovation and business growth initiatives.

XaaS and the customer

What's driving XaaS? And why now? In short, customer expectations of ownership, service, and access are evolving rapidly. In what some call the "Uberised economy," individual consumers and companies alike are embracing a new consumption model in which little or no friction exists between desire and the satisfaction of need. For example, ride-sharing services such as Uber and Lyft offer transportation-as-a-service, making it possible for individuals to get from point A to point B quickly, efficiently, and, perhaps most importantly, without the operational expense associated with owning a car. With ride-sharing, secondary and complementary activities are delegated to someone else.[2]

Now, apply this same model to enterprise IT. Like the individual who wants to get to a destination easily, affordably, and without having to buy a car, employees, business partners, vendors, and even customers all want easy, frictionless access to critical services that someone else supports and maintains.

For IT, that could mean sourcing some capabilities from cloud services vendors. Notably, it could also mean extending IT services to regional operations or newly acquired assets, or beyond organisational boundaries for use by customers, business partners, and even competitors. We're already seeing XaaS use cases—and success stories—emerge in various industries. Retail giant Amazon, for example, has taken the internal services it was using in its e-commerce operations and extended them to customers outside the Amazon organisation for use in their own businesses. Customer service, financial services, fulfillment, warehouse systems—the company has monetised commonly used business services by making them available, for a fee, for customers, competitors, or other third parties to use.[3] Recently, it was reported that the company is laying the groundwork for its own shipping business that would compete with UPS, FedEx, and the US Postal Service. Not only would this business deliver Amazon's parcels—it could be made available in a B2B model for other retailers to use as well, a strategy that CIOs could potentially use to help offset core revitalisation costs.[4]

Similarly, General Electric, a company synonymous with manufacturing, is pursuing multiple XaaS opportunities by wrapping data, analytics, and digital solutions around traditional offerings and making them available to customers as services. For example, building on its storied history as a lightbulb manufacturer, GE has created a cloud-based energy-as-a-service business that helps customers monitor and optimise their energy consumption using sensors embedded in LED bulbs.[5]

To be sure, these and similar early use cases are pioneering initiatives undertaken by companies with specific needs and well-defined, long-term business and IT strategies. For many companies, however, the process of transitioning to an XaaS model will likely begin around the organisational edges and progress incrementally over the coming years. In this more cautious approach, layering application programming interfaces (APIs) on top of complex legacy systems makes it possible for companies to reuse, share, and monetise core assets and data as they explore XaaS opportunities. Deploying APIs in this strategic way can help extend the reach of existing services and, potentially, enable new revenue streams. Such opportunities are currently driving API use.[6] According to Mulesoft's second annual *Connectivity Benchmark Report*, of 802 IT decision makers surveyed, 56 percent already

had an API strategy for accomplishing goals such as these.[7]

Of course, it's not enough just to build APIs. They introduce an entirely new set of capabilities not typically part of traditional middleware or integration scenarios, and CIOs need to consider deliberate approaches for designing, exposing, contracting, servicing, metering, and billing based on API usage. Fulfilling a function similar to that of OSS and BSS-esque supporting services in middleware scenarios, API management is a critical piece of the burgeoning API economy.[8]

The XaaS road ahead

CIOs and business leaders can begin their XaaS journeys by answering the following questions:

What can everything-as-a-service do for your business? Viewing business models, processes, and strategies through an XaaS lens may illuminate entirely new opportunities to grow revenue and drive efficiency. For Salesforce.com, those opportunities began with hosted CRM. For Amazon, it was subscription-based data storage in the cloud. Bringing these opportunities to fruition may require that you overhaul some legacy systems and reimagine your operations and the way you engage customers. The good news is that there are core modernisation techniques that can help you extract more value from legacy assets while laying the groundwork for a service-oriented future—from replatforming to remediating to revitalising.

How can XaaS transform the way your employees work? Think about how your employees currently do their jobs. What departmental or task-specific systems do they rely upon? What processes do they follow, and how does your operational model help or hinder them as they work? Then, imagine those same systems, processes, and operating models as services that are no longer siloed by task or department. Instead, they are horizontal, extending across organisational boundaries for use by internal and external customers, business partners, and suppliers, among others. What opportunities can you identify?

What new products and service offerings can XaaS enable? XaaS is as much a mind-set as it is a strategic and operational vision. It helped Amazon and GE identify and then pursue bold, new opportunities that lie outside of their traditional business models. Amazon monetised its own internal services by extending them to customers. GE is evolving from a manufacturer of goods to a purveyor of business outcomes. Clearly, the degree to which both of these organisations have transformed their core businesses will not be appropriate for every company. But even on a smaller, more focused scale, what products do you offer that could manifest as services? What operational verticals could take on new life as horizontals?

In the coming months, as more CIOs and business leaders find answers to these questions, they will have opportunities to redraw boundaries that have traditionally informed their strategies and goals. Indeed, through the lens of XaaS, entire marketplaces may begin to look less like crowded, hypercompetitive arenas and more like blank slates upon which imaginative new rules of competition can be written.

Reaching for the clouds

Global semiconductor company Broadcom Ltd. is transforming its core infrastructure by providing business offerings and processes as a collection of services to employees and, more recently, to customers.

During the last two decades, the Broadcom organisational structure and IT environment have grown and morphed due to a series of mergers and acquisitions. In response, vice president and chief information officer Andy Nallappan began exploring ways not only to mesh and optimise legacy systems, but to make the systems more efficient, user-friendly, and attuned to business needs. "I wanted to liberate the IT organisation from the mundane tasks that don't add much value so they can focus instead on projects that drive growth and profitability and make our company unique in the marketplace."

With these goals established, Broadcom—then called Avago Technologies—began its XaaS journey in 2009 by transitioning from a legacy on-premises email platform with limited storage capacity to a cloud-based productivity, collaboration, and storage solution. At that time, the solution vendor was only beginning to make its mark in the enterprise space. Consequently, as an early adopter, Broadcom enjoyed an unusual degree of access to the vendor's product roadmap and architectural plans for the tools being implemented. Likewise, Nallappan and his team were able to collaborate closely with the vendor's senior developers, project managers, and other product leaders during implementation. The end results were encouraging: Data storage capacity improved while overall management costs, in terms of budget and time, declined.

Since its initial XaaS foray, Broadcom has deployed:

- A single sign-on that crosses Broadcom's hybrid landscape—from on-premises ERP to its suite of cloud services
- A cloud-based security suite to ensure all employee devices are secure no matter where they are being used
- A cash management service that makes it possible for the CFO to view a complete picture of the company's transactions, revenue, and cash flow from a tablet device
- A cloud-based HR suite that consolidates HR services such as staffing, learning, and benefits and extends them, uniformly, across the enterprise
- An internal IT service desk platform that has recently been deployed as an external customer-facing service as well

These new systems and service-based approaches allow Broadcom to scale up quickly as the organisation grows. They also help the company

realise acquisition-related cost synergies more quickly, which supports overall acquisition goals.

Nallappan says he looks forward to a day when he won't need to operate any on-premises systems at all and can source everything externally. This day, he acknowledges, may not arrive in the near term. "I don't go to the cloud just because it's cool; it has to make financial sense," he notes. "Not all the pieces we need are available in the cloud yet, but when that time comes, we'll move."[9]

Java-based services transform IT architecture at the IRS

With its development and deployment of a new services-based data processing solution, the Internal Revenue Service is making early progress on its everything-as-a-service journey—one that is already delivering cost savings and operational efficiencies.

Processing an estimated 3 billion tax forms each year is no small task—one made more challenging by the sheer variety of forms the IRS uses. Traditionally, if the agency created a new family of forms, IT would develop and deploy a new solution to process them. "This was an inefficient way to enhance our processing capabilities," says IRS manager Irene Soter, who leads a team of Java developers and contractors currently working to modernise the agency's information return processing systems. "Very little was reusable."

With new forms being introduced as part of the Patient Protection and Affordable Care Act (ACA), agency IT leaders decided to take a different approach. From a data perspective, the ACA forms would be more complex than many existing IRS forms such as the 1099 or the W-2, with more questions to answer and fields to fill in. It became clear that to process ACA data, the IRS would need to create new scanning and data analysis capabilities that could determine: whether a submitted form had been filled out completely; if there was any evidence of fraud; or if the submitted information was ambiguous, and if so, what the submitter's intent actually had been.

IT leadership recognised that the capabilities needed for ACA form processing would be useful in other development projects and with future forms and decided to take a services-based approach to the ACA form design and development. The team charged with building what would become known as the Information Returns Processing system faced a hard deadline of January 2016 to stand up these new service capabilities. Using agile techniques, the team began developing reusable Java-based data processing services that would deliver validated data to a modernised information return database, which was also being developed.

The first release was slated to include three services but instead delivered nine, on time and within budget. These reusable services also started to accelerate other deliveries: "As we began making progress, other IT and business partners began reaching out and asking how they could access these services," Soter says.

Moving forward, the IRS will work to expand its service offerings and transform its IT architecture to be more flexible and services-based. This also includes an expanded focus on continuous service improvement: for instance, fine-tuning the Information Returns Processing platform as data volumes increase and more services are deployed. "Tuning to volume is always the issue when you are dealing with this much data," Soter says. "Managing the larger scale and providing visibility into individual service performance will be the trick. We will be relying on our team of highly talented developers with experience in how to handle the volume, how to tweak it, and how to step it up."[10]

Out with the old

Several years before changes in capabilities, products, and processes began coalescing into what is now recognised as the everything-as-a-service trend, Cisco Systems sensed a change in the operational winds and took action. The global technology products and services provider launched a multifaceted architectural and operational initiative to break down silos, deploy and leverage technology more effectively, and align IT services with both customers and the business.

"This is an ongoing transformation effort," says Will Tan, Cisco's senior director of operations. "We have 30 years of mind-set to overcome, but today, what we provide are services, and we need to create an organisational construct to support that."

Cisco's move to the as-a-service model began by examining the company's operations through a product and positioning lens, especially in the area of cloud offerings. "We realised that we needed to rethink the way we were working, how we thought about value streams, and the way we organised ourselves," Tan says. "Likewise, we began reviewing the relevance of our architecture to determine what kind of connectivity we need to meet our [XaaS] goals."

So, roughly six years ago, Cisco took a first—and fundamental—step in its transformation journey by creating a single, uniform taxonomy that would clearly define the company's services, the architectural components that support them, and, importantly, how these components fit together. Dubbed BOST (the business operations systems and technology stack), this working taxonomy has helped break down functional silos by ensuring that all groups approach services and services architecture consistently.

Following this initial step, Cisco identified two major goals that would drive its transformation efforts going forward:

Business alignment of IT capabilities: Cisco has worked aggressively to align IT with the business units' missions and operations—reorienting all IT operations so they "lead with a business view." IT now organises its priorities by the business's strategic and operational priorities, measuring success not just by isolated performance of IT disciplines but by business outcomes.

Anchor IT with a services mind-set: IT capabilities began to be defined by the value they were creating, decoupling the underlying technical skills, activities, and solutions from the overarching business services driving growth and demanding flexibility and agility. This meant the IT operating model and organisation had to evolve, along with the underlying technical architecture up, down, and across the stack.

Some companies view XaaS exclusively as a means for controlling costs and creating efficiencies. Cisco sees an equally compelling opportunity to rethink the way it engages and understands customers—and to shift its mind-set to how its ecosystem of supply chain and channel partners think about their customer outcomes.

Though Cisco's XaaS journey is ongoing, the company's efforts are delivering tangible benefits, with IT costs coming down and processes becoming more streamlined. And Tan cites other welcome outcomes. "A couple of years ago, we transformed our ERP system into a global platform that consolidated core financials and supply chain. IT has built services that have become global standards, which have helped us scale for the future," he says. "As we have expanded into China and India, we have leveraged this platform not just for cost containment but to accelerate our time to market and to offer *business* services more effectively."[11]

MY TAKE

DAVID MCCURDY,
CHIEF TECHNOLOGY OFFICER
STATE OF COLORADO GOVERNOR'S OFFICE OF INFORMATION TECHNOLOGY

One thing I know about the citizens of our state: When engaging state agencies online to apply for benefits, renew licenses, or perform other official tasks, they don't like entering the same information over and over again. And a growing number—particularly Millennials—prefer self-service options. If they can't complete their business quickly using a mobile device, they don't want to do it at all. This realisation led to the creation of the position of digital transformation officer, along with an ambitious roadmap to modernise Colorado's technology landscape.

With citizen expectations of government interactions changing rapidly, we are rethinking how the state approaches service delivery. Over time, we've developed thousands of interfaces between our systems. While they each served a purpose, they've added up and make it difficult to share data and services across systems and departments.

"TECHNICAL DEBT CAN BE AN ASSET."

To begin the process of creating a horizontal everything-as-a-service model, we took a citizen-first approach: What products might citizens want that they don't have today? How can citizens interact with government with as few touchpoints as possible? How should agencies provide services based on modern digital ways of engaging instead of decades-old technologies or paper-based processes? We set ambitions, prioritised services, and made the case for change—a mix of soft benefits because of increased citizen experiences and potential savings. For example, the state was spending tens of millions of dollars in paper correspondence: fulfillment, processing, filing, archiving, and destruction of forms, files, and other assets.

Anchored around transforming the citizen experience, we set our sights on our core systems. Technical debt can be an asset; by uprooting the technology, you can embed new capabilities in an agency. A development team began converting a legacy mainframe system over to Java code. We then invested in a digital platform that makes it possible to develop applications that enable a new, organisation-wide service delivery model. This platform has been deployed with the future in mind. It simplifies the development process without creating a lot of technical debt. It also required deep remediation to deal with legacy data, process, and business rule issues—readying services for the brave new digital world. Others have tried a lighter approach of deploying mobile apps that can't do much or glossy websites that lack deep content. We're trying to transform.

Finally, our IT teams have taken a two-pronged approach to address the challenges of system integration. First, they deployed a cloud-based enterprise service bus to rework back-end systems and overhaul the way data flows—and, importantly, the way it can be shared—across departments. Step two is an ongoing transition to cloud- and hybrid-cloud-based services, a strategy that has been in place for several years. For both, the focus is on the outcome for the citizen, not the output of the system.

With enhanced capabilities in the areas of integration, development, and data sharing—leveraging both legacy assets and newly deployed systems—we have seen real results. Eligibility programs such as Medicaid and food assistance saw their enrollment processes move from multi-hour, sometimes multi-day, activities to an experience that now takes minutes—while still following the same steps and capturing the same information. And we're only getting started. We are assessing individual products and services to determine how we can approach service delivery more broadly and consistently to create a better user experience. Across the board we are finding so much upward possibility.

As companies begin evolving their traditional products, processes, and business capabilities into services that can be used both inside and outside organisational boundaries, it is important that the services they will be consuming or exposing have sufficient trust and security capabilities embedded, that application programming interfaces are secure, and that data verification and storage capabilities are trustworthy.

XaaS initiatives offer CIOs the opportunity to build new trust, risk management, and security capabilities into systems and processes during the earliest stages of development. But the XaaS model itself, in which discrete products and processes can be transformed into horizontal services that span the enterprise and beyond, may also offer an opportunity for CIOs to reimagine their basic approaches to risk and security. For example, would it be possible to approach risk as a collection of uniform services? Moreover, could some of these uniform services—for example, threat intelligence or identity management—be sourced externally?

Think about the potential efficiencies to be gained by deploying standardised "authentication-as-a-service" or "data validation-as-a-service" capabilities both internally and externally. Not only could this reduce redundant processes that have a long history of irritating users ("please enter your password again and again and again . . .")—it could create a single risk or security service that could simplify maintenance and speed development.

> "ARE THERE AREAS OF WEAKNESS WITH HIGH DEPENDENCIES THAT PUT EITHER YOUR ORGANISATION OR ITS PROJECTS AT RISK?"

In another example, are there areas of weakness with high dependencies that put either your organisation or its projects at risk? Perhaps a chronic shortage of skillsets in a specific area consistently slows down development initiatives or delivers subpar outcomes? Assessing this challenge through the XaaS lens, you may be able to identify nontraditional approaches to deploying talent resources—think engineering skillsets-as-a-service—that can simultaneously lower project and operational risk while utilising IT talent assets more efficiently.

Finally, in a loosely coupled environment that blends legacy systems and externally sourced capabilities, risk, trust, and security capabilities and processes will likely be more effective when they can be managed holistically. Particularly in the critical areas of data exchange and storage, the ability to take a unified, consistent approach to risk and security becomes critical to maintaining data integrity.

Where do you start?

The next step in reimagining core legacy systems involves reorienting from systems to services. No matter the size of your organisation, transitioning from end-to-end processes to a sequence of discrete services can be a complex undertaking. To get started—and to make the effort more manageable—consider the following approaches:

- **Reimagine current offerings as services:** Review your current systems and product offerings, and imagine how recreating them as services could expand or accelerate your business model. Opportunities may include carving out pricing, inventory, or logistics transactions that are deeply embedded in legacy systems and allowing other lines of business, digital experiences, or even external players to tap these core capabilities. Customer-related services that help users access account details, transaction history, and customer preferences also make promising candidates. Likewise, don't overlook internally focused services such as user authentication, access, and entitlement checking—all core functions that are too often replicated across systems and solutions. The most exciting opportunities might be services that could form the backbone of new products, services, or offerings. For example, exposing and potentially monetising IP such as data feeds, analytics models, or even business processes could have commercial value outside of your organisation's walls.

- **Start on the edges:** When moving to a services-based platform, start by taking small bites around the edges—an inventory tracking system or a customer help desk, for example—rather than tackling an ERP system right out of the gate. By transforming your front office or cash management system, you can methodically deploy each new service in a more manageable pilot program. From there, you can build upon each to link services throughout the enterprise and eventually offer them to the market. Remember this rule of thumb: Migrate first, then modernise. Starting with baseline services may provide the foundation you'll need to create more new services.

- **The five Rs:** The first step in reimagining core systems involves anchoring the technical journey in business imperatives. When thinking through the actual implementation path, there are several techniques that can help transform your legacy system, whether through an incremental upgrade or a radical modernisation:

  - **Replatform:** Enhance platforms through technical upgrades, software updates, or migration to modern operating environments.

  - **Revitalise:** Layer on new capabilities to enhance underlying core processes and data, focusing on improving usability for both customer and employee engagement.

  - **Remediate:** Address internal complexities of existing core implementation with "instance consolidation," master data reconciliation, integration, and/or rationalising custom extensions to packages to drive digital solutions.

  - **Replace:** Introduce new solutions for parts of the core, which may mean adopting new products from existing vendor partners or revisiting "build" versus "buy" decisions.

  - **Retrench:** Once you weigh the risks and understand the repercussions, doing nothing may be the strategic choice that allows you to focus on higher-impact priorities.

- **Acquire different skillsets:** IT will likely need new skillsets as it moves from traditional systems and processes to the new world of API management and cloud-based services. While you may be able to retrain some of your legacy talent, consider adding team members with a few battle scars from having worked in an XaaS environment. Everything-as-a-service actually represents a cultural and mind-set change more than a technical shift. Experienced engineers, designers, and other IT talent who have thrived in an XaaS culture can often serve as stem cells

for change in more traditional IT organisations. You can also maximise the effectiveness of new talent by deploying autonomic platforms[12] to speed development of new services and automate low-level tasks. This, in turn, can free your team to focus on higher-priority goals.

- **Shore up your foundation:** Once you've identified services to build and deploy, determine whether any are foundational systems you'll need to overhaul as part of the transition. A change to one element of an IT ecosystem can affect workflow, security, and integration across the enterprise, so it is critical to understand how a new service fits into the overall architecture.

Bottom line

Transforming existing business products, processes, and legacy systems into a collection of services that can be used both inside and outside the organisation can help streamline IT operations and, potentially, generate new revenue streams. Pursued incrementally, an everything-as-a-service strategy can also cast core modernisation in a new light: What was primarily a technical process of overhauling legacy systems becomes a broader operational and business effort to create greater efficiencies and to engage customers, employees, business partners—and maybe even your market—in new ways.

CONTACTS

MATT LACEY
Technology Strategy & Architecture leader
Deloitte MCS Limited
020 7007 8036
matthewlacey@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AARTI BALAKRISHNAN
Senior Manager, Technology Consulting
Deloitte MCS Limited
020 7303 7005
abalakrishnan@deloitte.co.uk

AUTHORS

GORDON ASPIN
Managing Director, Deloitte Consulting LLP

GEORGE COLLINS
Deloitte Digital chief technology officer, Deloitte Consulting LLP

PAVEL KRUMKACHEV
Principal, Deloitte Consulting LLP

MARLIN METZGER
Deloitte Application Modernisation practice leader, Deloitte Consulting LLP

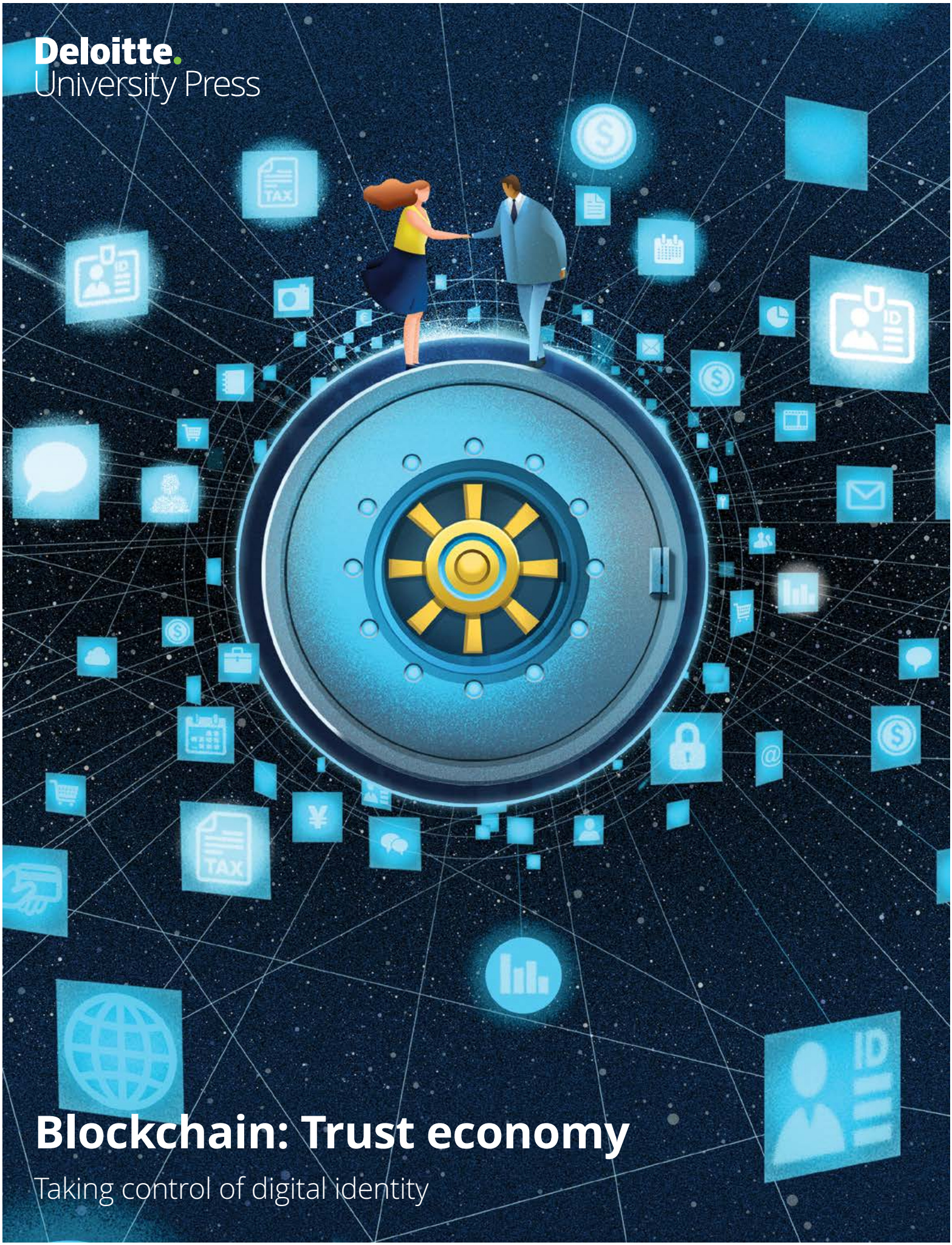
SCOTT RADEZTSKY
US deputy chief technology officer, Deloitte Consulting LLP

SRIVATS SRINIVASAN
SAP Practice Customer Sales and Operations Capability leader, Deloitte Consulting LLP

ENDNOTES

1. Scott Buchholz, Ben Jones, and Pavel Krumkachev, *Reimagining core systems: Modernising the heart of the business*, Deloitte University Press, February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/reimagining-core-systems-strategy.html.
2. Scott Corwin, Nick Jameson, Derek M. Pankratz, and Philipp Willigmann, *The future of mobility: What's next?*, Deloitte University Press, September 14, 2016, https://dupress.deloitte.com/dup-us-en/focus/future-of-mobility/roadmap-for-future-of-urban-mobility.html.
3. Amazon Services, https://services.amazon.com/, accessed October 24, 2016.
4. Greg Bensinger and Laura Stevens, "Amazon's newest ambition: Competing directly with UPS and Fedex," *Wall Street Journal*, September 27, 2016, www.wsj.com/articles/amazons-newest-ambitioncompeting-directly-with-ups-and-fedex 1474994758.
5. Derek du Preez, "GE staying Current by becoming an 'as-a-service' business," *Diginomica*, June 17, 2016, http://diginomica.com/2016/06/17/ge-staying-current-by-becoming-an-as-a-service-business/.
6. George Collins and David Sisk, *API economy: From systems to business services*, January 29, 2015, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2015/tech-trends-2015-what-is-api-economy.html.
7. Mulesoft, *Connectivity Benchmark Report 2016*, press release, May 3, 2016, www.mulesoft.com/press-center/digital-transformation-strategy-benchmark.
8. Collins and Sisk, *API economy*.
9. Interview with Andy Nallappan, vice president and chief information officer, Broadcom, October 20, 2016.
10. Interview with Irene Soter, manager, Internal Revenue Service, November 15, 2016.
11. Interview with Will Tan, senior director of operations at Cisco Systems, on January 9, 2017
12. Ranjit Bawa, Jacques de Villiers, and George Collins, *Autonomic platforms: Building blocks for labor-less IT,* February 24, 2016, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2016/bi-model-it-on-autonomic-platforms.html.

Deloitte.
University Press



Blockchain: Trust economy

Taking control of digital identity

BLOCKCHAIN IS OUTGROWING ITS ADOLESCENT CRYPTOCURRENCY IDENTITY, WITH distributed consensus ledgers becoming smart contracts facilitators. Beyond creating efficiencies by removing the legal and financial intermediary in a contractual agreement, blockchain is assuming the role of trusted gatekeeper and purveyor of transparency. In the emerging "trust economy" in which a company's assets or an individual's online identity and reputation are becoming both increasingly valuable and vulnerable, this latest use case may be blockchain's most potentially valuable to date.

BLOCKCHAIN, the shared-ledger technology that only a few years ago seemed indelibly linked in the public imagination to cryptocurrencies such as Bitcoin, is assuming a new role: gatekeeper in the emerging "trust economy."

First, a bit of background. Last year's *Tech Trends* report examined how maintaining the procedural, organisational, and technological infrastructure required to create institutionalised trust throughout an increasingly digitised global economy is becoming expensive, time-consuming, and in many cases inefficient.

Moreover, new gauges of trustworthiness are disrupting existing trust protocols such as banking systems, credit rating agencies, and legal instruments that make transactions between parties possible. Ride-sharing apps depend on customers publicly ranking drivers' performance; an individual opens her home to a paying lodger based on the recommendations of other homeowners who have already hosted this same lodger. These gauges represent the codification of reputation and trustworthiness. We are growing accustomed to the notion that positive comments appearing under an individual's name means we can trust that person.[1]

In a break from the past, the trust economy developing around person-to-person (P2P) transactions does not turn on credit ratings, guaranteed cashier's checks, or other traditional trust mechanisms. Rather, it relies on each transacting party's reputation and digital identity—the elements of which may soon be stored and managed in a blockchain. For individuals, these elements may include financial or professional histories, tax information, medical information, or consumer preferences, among many others. Likewise, companies could maintain reputational identities that establish their trustworthiness as a business partner or vendor. In the trust economy, an individual's or entity's "identity" confirms membership in a nation or community, ownership of assets, entitlement to benefits or services, and, more fundamentally, that the individual or entity actually exists.

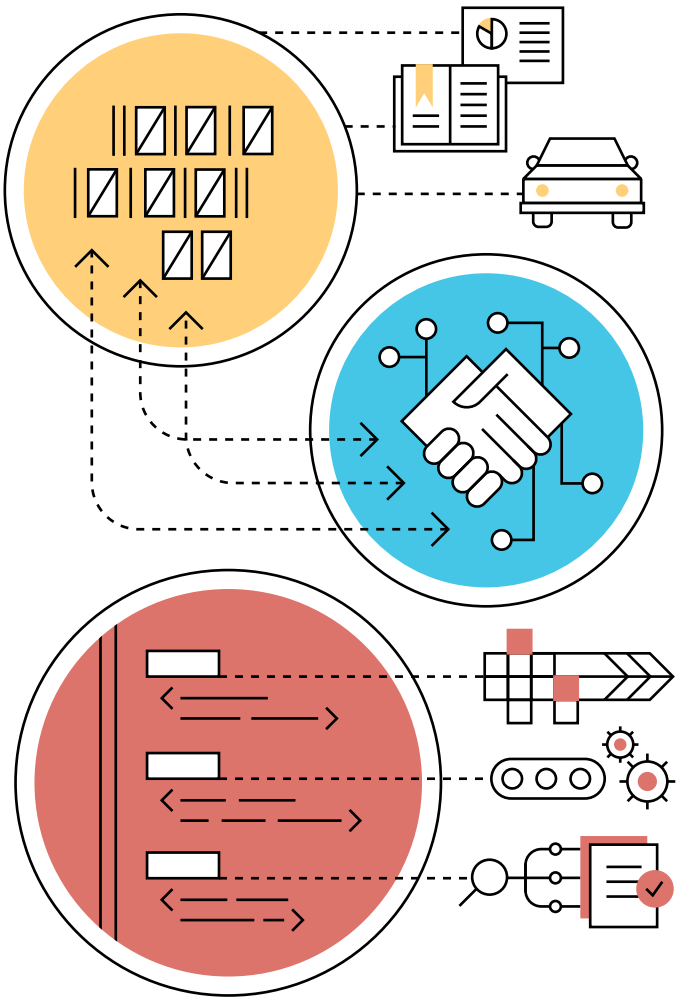
Beyond establishing trust, blockchain makes it possible to share information selectively with

others to exchange assets safely and efficiently and—perhaps most promisingly—to proffer digital contracts. This transforms reputation into a manageable attribute that can be baked into each individual's or organisation's interactions with others.

In the next 18 to 24 months, entities across the globe will likely begin exploring blockchain opportunities that involve some aspects of digital reputation. We're already seeing companies that operate at the vanguard of the trust economy acknowledge blockchain's potential. When asked during a recent interview about possible blockchain deployment by P2P lodging site Airbnb, company co-founder and CTO Nathan Blecharczyk replied, "I think that, within the context of Airbnb, your reputation is everything, and I can see it being even more so in the future, whereby you might need a certain reputation in order to have access to certain types of homes. But then the question is whether there's a way to export that and allow access elsewhere to help other sharing economy models really flourish. We're looking for all different kinds of signals to tell us whether someone is reputable, and I could certainly see some of these more novel types of signals being plugged into our engine."[2]

The blockchain/trust economy trend represents a remarkable power shift from large, centralised trust agents to the individual. And while its broader implications may not be fully understood for years

Figure 1. Three levels of blockchain



1 Storing digital records

Blockchain allows unprecedented control of information through secure, auditable, and immutable records of not only transactions but digital representations of physical assets.

2 Exchanging digital assets

Users can issue new assets and transfer ownership in real time without banks, stock exchanges, or payment processors.

3 Executing smart contracts

Self-governing contracts simplify and automate lengthy and inefficient business processes.

Ground rules Terms and conditions are recorded in the contract's code.

Implementation The shared network automatically executes the contract and monitors compliance.

Verification Outcomes are validated instantaneously without a third party.

Deloitte University Press | dupress.deloitte.com

to come, it is hardly a death knell for banks, credit agencies, and other transactional intermediaries. It may mean, however, that with blockchain as the gatekeeper of identity and trust, business and government will have to create new ways to engage the individual—and to add value and utility in the rapidly evolving trust economy.

In blockchain we trust

Given blockchain's starring role in the Bitcoin hype cycle, there may be some lingering confusion about what this technology is and the value it can potentially bring to business. Simply put, blockchain is a distributed ledger that provides a way for information to be recorded and shared by a community. In this community, each member maintains his own copy of the information, and all members must validate any updates collectively. The information could represent transactions, contracts, assets, identities, or practically anything else that can be described in digital form. Entries are permanent, transparent, and searchable, which makes it possible for community members to view transaction histories. Each update is a new "block" added to the end of the "chain." A protocol manages how new edits or entries are initiated, validated, recorded, and distributed. Crucially, privacy can also be selectively enforced, allowing varying degrees of anonymity or protection of sensitive information beyond those who have explicitly been given access. With blockchain, cryptology replaces third-party intermediaries as the keeper of trust, with all blockchain participants running complex algorithms to certify the integrity of the whole.

As the need for portable, manageable digital identities grows, individuals and organisations can use blockchain to:

Store digital records: To understand blockchain in the context of the trust economy, think of it as the tech-charged equivalent of the public ledgers that would be used in towns to record everything of importance: the buying and selling of goods; the transfer of property deeds; births, marriages, and deaths; loans; election results; legal rulings; and anything else of note. Instead of a bearded master wielding a long-stemmed stylus to record miniscule but legible entries in an oversised ledger, blockchain uses advanced cryptography and distributed programming to achieve similar results: a secure, transparent, immutable repository of truth—one designed to be highly resistant to outages, manipulation, and unnecessary complexity.

In the trust economy, the individual—not a third party—will determine what digital information is recorded in a blockchain, and how that information will be used. With an eye toward curating a single, versatile digital representation of themselves that can be managed and shared across organisational boundaries, users may record:

- Digitised renderings of traditional identity documents such as driver's licenses, passports, birth certificates, Social Security/Medicare cards, voter registration, and voting records
- Ownership documents and transactional records for property, vehicles, and other assets of any form
- Financial documents including investments, insurance policies, bank accounts, credit histories, tax filings, and income statements
- Access management codes that provide any identity-restricted location, from website single sign-on to physical buildings, smart vehicles, and ticketed locations such as event venues or airplanes
- A comprehensive view of medical history that includes medical and pharmaceutical records, physician notes, fitness regimens, and medical device usage data

As a repository of valuable data, blockchain can provide individual users with unprecedented control over their digital identities. It can potentially offer businesses an effective way to break down information silos and lower data management costs. For example, in a recent blog post, Bruce Broussard, president and CEO of health insurance provider Humana, shared his vision of a future in which hospitals, clinics, and insurance companies streamline administrative processes, increase security, and achieve significant cost savings by

storing and managing electronic health records on a blockchain.[3]

Exchange digital assets without friction: Using blockchain, parties can exchange ownership of digital assets in real time and, notably, without banks, stock exchanges, or payment processors—all applications requiring trusted digital reputations. Many of blockchain's earliest use cases for business involved facilitating cross-border payments and intracompany transfers. Applying that same basic transactional model to P2P transactions, blockchain could potentially become a vehicle for certifying and clearing asset exchanges almost instantaneously. What once took T + 3 days to clear now takes T + 3 milliseconds.

Though broad acceptance of P2P asset exchanges via blockchain may still be a few years away, the exploratory steps some companies are currently taking offer insight into where blockchain deployment may be headed. For example, Microsoft and Bank of America Merrill Lynch are jointly developing a cloud-based "blockchain-as-a-service" offering that will execute and streamline asset exchanges between companies and their customers.[4]

Execute smart contracts: Smart contracts represent a next step in the progression of blockchain from a financial transaction protocol to an all-purpose utility. They are not contracts in the legal sense, but modular, repeatable scripts that extend blockchains' utility from simply keeping a record of financial transaction entries to implementing the terms of multiparty agreements automatically. The fact that they are not legally binding makes trust even more important.

Here's how they work: Using consensus protocols, a computer network develops a sequence of actions from a smart contract's code. This sequence of actions is a method by which parties can agree upon contract terms that will be executed automatically, with reduced risk of error or manipulation. Before blockchain, this type of smart contract was impossible because parties to an agreement of this sort would maintain separate databases. With a shared database running a blockchain protocol, the smart contracts auto-execute, and all parties validate the outcome instantaneously—and without the involvement of a third-party intermediary.

Though smart contracts may not be appropriate for some legal agreements, they can be a worthwhile option in situations where networks of parties engage frequently, or in agreements where counterparties are performing manual or duplicative tasks for each transaction. For example, they could be deployed for the automated purchase or sale of financial instruments, parametric insurance contracts, and certain automatic market-making activities, as well as for digital payments and IOUs. In each case, the blockchain acts as a shared database to provide a secure, single source of truth, and smart contracts automate approvals, calculations, and other transacting activities that are prone to lag and error.[5]

Chain of tools

In the greater context of the trust economy, blockchain is not a cure-all for the challenges of establishing and maintaining trust. As a technology, it is still maturing; standards and best practices do not yet exist. The very features that protect blockchain against theft and fraud could also drive overhead if not correctly implemented—a potential obstacle on the path toward individual deployment of the technology. Finally, legal recognition of contracts and digitally transferred assets is currently limited. The good news is that organisations can take steps now to mitigate if not fully address these challenges.

Some pundits are likening the emergence of blockchain technology to the early days of the World Wide Web, and for good reason. In 1991, the foundations for distributed, open communication were being laid—network infrastructure, protocols, and a variety of enabling technologies from javascript to search engines to browsers. There were also new enterprise software suites that made it possible to take advantage of digital marketing, commerce, and linked supply networks, among countless other opportunities. Hyper-investment chased perceived opportunity, even as specific scenarios describing how the technology would change the world had not yet been defined.

Blockchain may lead to even greater disruption by becoming the new protocol for digital assets, exchanges, contracts, and, perhaps most importantly, identity and trust. With efforts to create a new stack for all facets of blockchain attracting investment, the time is now for enterprises to explore the underlying technology, and to envision how blockchain may be used for more than just the easy use cases of cost savings and efficiency within their own boundaries. Take a hard look at your core business, surrounding ecosystems, and even the long-established mechanics of the way your industry operates, and then direct your experimentation toward a truly innovative path.

Smart play with smart contracts

Delaware, home to more than 60 percent of *Fortune* 500 firms,[6] is teaming up with Symbiont, a distributed ledger and smart securities vendor, to launch a blockchain-based smart contracts system. Smart contracts are protocols that allow blockchain technology to record, manage, and update encrypted information in a distributed ledger automatically, without intermediaries.[7] The system will enable participants to digitise incorporation procedures such as registering companies, tracking shares, and handling shareholder communications. For companies incorporated in Delaware, this could make registration and follow-up steps in the process faster, less expensive, and more transparent.

At the heart of Symbiont's solution is an immutable, append-only database, which provides a single, global accounting ledger for system participants. Transaction history is appended and replicated across all network nodes, with access permissions restricted down to the specific organisation or even user level. Each company registering with the state of Delaware signs in with a private key that verifies its identity to other participants. Autonomous recordkeeping will trigger notifications when actions are required, such as new filing requirements when thresholds are met or when documents approach expiration.[8]

Project teams are taking a two-pronged approach to deployment. First, they will rebuild the public archives using a distributed ledger for storage and "smart records" to automate the control and encryption of public and private records. This critical step will make it possible for digital documents to be shared in multiple locations and, importantly, be recovered in the event of system failure.[9] Next, they will place incorporation and other legal documents on a smart contract-enabled blockchain and establish operational procedures for using and maintaining them.

This deployment is part of a larger effort called the Delaware Blockchain Initiative, which will lay the legal and technological groundwork needed to support blockchain-based systems going forward. The governor's office is currently collaborating with the legislature to build the legal framework required to support blockchain-based incorporation processes and digitally originated securities.[10] "We see companies allocate significant financial resources to correct and validate stock authorisation and issuance errors that could have been correctly and seamlessly handled from the outset," says Delaware Governor Jack Markell. "Distributed ledger [transactions] hold the promise of immediate clearance, immediate settlement, and bring with them dramatic increases in efficiency and speed in sophisticated commercial transactions."[11]

SWIFT: From middleman to enabler

Blockchain has the potential to rewire the financial industry and beyond, generating cost savings and new revenue opportunities. Payment rails have been the subject of various blockchain-driven initiatives. Payment transaction firm SWIFT has been testing use cases to demonstrate how its 11,000-plus member financial institutions can optimise the technology's transparency while maintaining the industry's privacy requirements in the emerging trust economy.

The organisation's new R&D arm, SWIFT Innovation Labs, was launched with an eye on eventually providing distributor ledger technology (DLT)-based services that leverage its standards expertise, strong governance, and security track record. DLT, it says, would provide trust in a disseminated system, efficiency in broadcasting information, complete traceability of transactions, simplified reconciliation, and high resiliency.[12]

SWIFT's team of 10 experts in standards, securities, architecture, and application development built a bond lifecycle application that tracks and manages bonds from issuance to coupon payments to maturity at an ecosystem level rather than by individual company. SWIFT applied its own ISO 20022 methodology to DLT to gauge interoperability with legacy systems in cases where all stakeholders were not on the distributed ledger.[13]

The bond life cycle proof-of-concept was built using an Eris/Tendermint consensus engine to enable smart contracts written in Solidity, a language for the Ethereum blockchain.[14] Monax's Eris platform was chosen because it is open-source; it enables a permissioned blockchain that can only be viewed and accessed by the parties involved in the transaction; it supports smart contracts; and its consensus algorithm has better performance than Bitcoin's blockchain.[15]

SWIFT's lab team set up five blockchain nodes (in its California office, at an account servicer in Virginia, and at investment banks in Brazil, Germany, and Australia)[16] on a simulated network that implemented the ISO 20022 standard, which covers transaction data for banks, securities depositories, and high-value payments. The standard's layered architecture consists of coded business concepts independent of any automation, which according to SWIFT "seems a good place to look for content that can be shared and re-used" via a distributed ledger.[17]

"SWIFT has been targeted in the press as a legacy incumbent that will be doomed by DLT," says Damien Vanderveken, head of R&D at SWIFT Innovation Labs. "But we believe SWIFT can leverage its unique set of capabilities to deliver a distinctive DLT platform offer for the [financial] community."[18] This could translate into cheaper, faster, and more accessible remittance and corporate disbursement services around the globe.

MY TAKE

JOI ITO, DIRECTOR
MIT MEDIA LAB

In my role with the MIT Media Lab, I spend my days exploring how radical new approaches to science and technology can transform society in substantial and positive ways. When I look at the current state of blockchain, I'm reminded of the early days of the Internet—filled with promises of disruption, a brand-new stack that needed to be built, unchecked investment, and more than a few crazy dreamers (I was, and remain, one of them). Much as naysayers initially did with the Internet, some consider blockchain, smart contracts, and cryptocurrencies to be fads, but in my opinion, they are not. The potential is real.

> "I'M REMINDED OF THE EARLY DAYS OF THE INTERNET—FILLED WITH PROMISES OF DISRUPTION, A BRAND-NEW STACK THAT NEEDED TO BE BUILT, UNCHECKED INVESTMENT, AND MORE THAN A FEW CRAZY DREAMERS."

In the early 1990s, we knew we were on the cusp of something big. But we were lacking the layers needed to take advantage of the promise: a universal networking protocol (TCP/IP), routers and switches for enterprises to establish and scale communications, a standard for client connectivity and information exchange (HTTP), and many others. The incumbents—cable companies and telcos—were building monolithic, closed systems in order to explore the new frontier. Largely informed by the reference point of their existing businesses, their approach led to set-top boxes, closed communities and online forums, and proprietary systems for search, messaging, and mail. But as we look back, most of the big winners of the era were the native Internet companies that provided each necessary layer that would eventually become the full stack we know today.

Blockchain is like that. There is a layer for transmitting bits and managing the shared ledger. There's a wallet for organising and conducting business with one's assets. There may be a bookkeeping layer for uniformly describing the content and context behind assets on the blockchain. There will be a smart contract layer, and others will likely emerge.

The currency piece of the blockchain is a lot like email was to the Internet. Email may be the most used function on the Internet, and it changed the way businesses work; it was a killer app that pushed the Internet to widespread deployment, after which came Google, Facebook, and Twitter. In the same way, many smart contract layers and other sophisticated use cases will be feasible once blockchain is deployed everywhere.

It remains to be seen whether American institutions will give blockchain the same kind of free rein the Internet enjoyed in its early days. Regardless, there is a need to redraw existing regulatory boundaries. If you diligently deploy a blockchain solution following the existing laws—especially those focused on money laundering—you could twist yourself into knots trying to design your business and products around old statutes. The interplay between technology and public policy played a central role in the Internet's adoption. Given that the stakes around blockchain are much higher and possibly even more transformative, anything we can do to amplify, accelerate, and advance our collective progress in a prudent but progressive way can transform the world around us to the benefit of society.

MY TAKE

MATTHEW ROSZAK,
CO-FOUNDER AND CHAIRMAN
BLOQ

I've been in the venture capital business for over 20 years, co-founding six enterprise software companies along the way. I began hearing about Bitcoin in 2011, while serving as chairman of one of the largest social gaming companies in Southeast Asia. In that business, cross-border payments and payment processing quickly becomes a core competency. As the buzz around Bitcoin grew, I initially discounted this technology as "silly Internet money," but by 2012, a number of people I trusted told me to take a harder look. So I did what I still tell people to do today: lock your door, turn off your phone, and study this new technology frontier for a day. I realised that this ecosystem will likely have incredibly profound effects on enterprise, government, and society—and is a generational opportunity for entrepreneurs and investors.

I began investing in a wide range of companies across the blockchain ecosystem, including digital wallets, payment processors, exchanges, and miners. This helped me develop a heat-map of the ecosystem, and more importantly, a network of technologists and entrepreneurs who were building the scaffolding for this new industry. It also led to my friendship, and later partnership with Jeff Garzik, with whom I co-founded Bloq.

Enterprise demand for blockchain is real, but there are many questions to be answered. What type of software infrastructure do you need? What can we learn from enterprise adoption patterns of other transformative technology?

To the first question, the emergence of an open source, enterprise-grade blockchain software suite is developing quickly, and we're investing an enormous amount of time and energy helping companies develop an infrastructure that, in many ways, defines the basic anatomy of a blockchain:

- **Blockchain** platform as the base communication and management layer of the network
- **Nodes** to connect to a blockchain network, which behave much like routers
- **Wallets** to securely manage and store digital assets
- **Smart contracts** to automate and streamline business processes
- **Analytics** to drive better decisions and detect network anomalies

The second question revolves around adoption curves. I see a story unfolding that is similar to those of the Internet and cloud computing. Right now, organisations are implementing blockchain technology internally to reduce costs by moving value and data in a more secure, more efficient manner. We are also beginning to see some activity in core operations and business processes that utilise blockchain's encrypted workflow features. These are important stepstones helping drive an architectural step change in blockchain adoption.

Next, companies deploying blockchain networks should consider extending those platforms to their customers, suppliers, and partners. This is where network effects should start to blossom, and will likely lay the foundation for pursuing new economic opportunities—measured in trillions of dollars—think central banks issuing digital currencies, land title registries, a secure digital identity, and more. Yet organisations don't strive just to be better—they want to operate at a different level. With blockchain, moving money should be as easy as email. In 10 years, banks may look more like Apple, Amazon, and Tencent, coupled with access to tons of products and services within those ecosystems. The discussion won't be about whether to use blockchain—it will be about the economics of the platform and how to develop strong network effects.

The blockchain genie is out of the bottle, although the adoption curve remains unclear—will it be three to seven years? A decade, or longer? These networks for money's new railroad will take time to adopt. In the late 1990s, CEOs wondered if they should risk their careers by investing in and innovating with the Internet; today CEOs are in the same boat evaluating blockchain. Like any great technology evolution, the blockchain transformation requires passion and investment, dynamics that drive innovation. Right now, neither appears to be in short supply.

Just as distributed architecture and open standards play spotlight roles in the inevitable architecture trend, they loom large in blockchain and the emerging trust economy. Blockchain is an open infrastructure technology that enables users operating outside of an organisational or network boundary to execute transactions directly with each other. Blockchain's fundamental value proposition is anchored in this universal availability.

It is also anchored in integrity. When someone adds a block, or executes a blockchain-based smart contract, those additions are immutable. The potential value of the numerous blockchain applications currently being explored—including regulatory compliance, identity management, governmentu nteractions with citizens, and medical records management—resides, to a large degree, in the security benefits each offers users. These benefits include, among others:

- The immutable, distributed ledger creates trust in bookkeeping maintained by computers. There is no need for intermediaries to confirm transactions.
- Transactions are recorded with the time, date, participant names, and other information. Each node in the network owns the same copy of the blockchain, thus enhancing security.
- Transactions are authenticated by a network of computer "miners" who complete complex mathematical problems. When miners arrive at the same solution, the transaction is confirmed and recorded on the "block."

> "THE DISTRIBUTION OF MINERS MEANS THAT THE SYSTEM CANNOT BE HACKED BY A SINGLE SOURCE."

The distribution of miners means that the system cannot be hacked by a single source. If anyone tries to tamper with one ledger, the nodes will disagree on the integrity of that ledger and will refuse to incorporate the transaction into the blockchain.

Though blockchain may feature certain security advantages over more traditional transactional systems that require intermediaries, potential risks and protocol weaknesses that could undermine the integrity of blockchain transactions do exist. For example, it has recently come to light that vulnerabilities may exist in the programming code that some financial services companies are using as they integrate distributed ledger technologies into their operations.[19]

Given that there is no standard in place for blockchain security, other potential cyber issues could emerge. For this reason, users currently rely—arguably too much—on crowdsourced policing. Blockchain is a relatively new technology, and therefore discussion of its potential weaknesses is somewhat academic. Somewhere down the road, an underlying vulnerability in blockchain may emerge—one that would put your systems and data at risk.

Though you should not let fear of scenarios like this prevent your company from exploring blockchain opportunities, as with other leading-edge technologies, it pays to educate yourself and, going forward, let standards of acceptable risk guide your decisions and investments.

Where do you start?

The hype surrounding blockchain is reaching a fever pitch. While this technology's long-term impact may indeed be formidable, its immediate adoption path will most likely be defined by focused experimentation and a collection of moderately interesting incremental advances. As with any transformative technology, expertise will have to be earned, experience will be invaluable, and the more ambitious deployment scenarios will likely emerge over time. The good news? It's still early in the game, and numerous opportunities await.

Here are some suggestions for getting started on your blockchain journey:

- **Come all ye faithful:** The financial services industry is currently at the vanguard of blockchain experimentation, and the eventual impact of its pioneering efforts will likely be far-reaching. Yet blockchain's disruptive potential extends far beyond financial services: Every sector in every geography should be developing a blockchain strategy, complete with immediate tactical opportunities for efficiency gains and cost savings within the organisation. Strategies should include more ambitious scenarios for pushing trust zones to customers, business partners, and other third parties. Finally, sectors should envision ways blockchain could eventually be deployed to challenge core business models and industry dynamics. While it often pays to think big, with blockchain you should probably start small given that the technology's maturity—like that of the regulations governing blockchain's use—is still relatively low.
- **Wayfinding:** Start-ups and established players are aggressively pushing product into every level of the blockchain stack. Part of your adoption journey should be understanding the fundamental mechanics of blockchain, what pieces are absolutely necessary for your initial exploration, and the maturity of the offerings needed for the specific scope being considered.
- **The nays have it:** Ask your blockchain gurus to define scenarios and applications that are *not* a good fit for blockchain. This is not reverse psychology: It's simply asking advocates to keep a balanced perspective, and thoughtfully casting a light on this emerging technology's current limitations and implications. Sure, expect challenges and prescribed roadblocks to yield to future advances in the field. But until then, challenge your most enthusiastic blockchain apostles to remain objective about the technology's potential upside and downside.
- **You gotta have friends:** Blockchain offers little value to individual users. To maximise its potential—particularly for applications and use cases involving digital identity—explore opportunities to develop a consortium or utility for blockchain use.
- **Stay on target:** Far-reaching potential can lead to distracting rhetoric and perpetual prognostication. As you explore blockchain, focus your brainstorming and your efforts on actionable, bounded scenarios with realistic scope that can lead to concrete results and—hopefully—better value. Wild-eyed aspirations are not necessarily bad. But they are best served by grounded progress that leads to hands-on proof and an earned understanding of what is needed to realise the stuff of dreams.

Bottom line

In a historic break from the past, the foundational concept of trust is being tailored to meet the demands of the digital age, with blockchain cast in the role of gatekeeper of reputation and identity. While the broader implications of this trend may not be fully understood for years to come, business and government are beginning to explore opportunities to selectively share composite digital identities with others not only to help establish trust but to exchange assets safely and efficiently, and—perhaps most promisingly—to proffer digital contracts.

CONTACTS

MIKE ROBINSON
Partner, Technology Consulting
Deloitte MCS Limited
0141 314 5804
microbinson@deloitte.co.uk

TYLER WELMANS
Senior Manager,
Technology Consulting
Deloitte MCS Limited
020 7303 5653
twelmans@deloitte.co.uk

ALEXANDER SHELKOVNIKOV
Senior Manager
Deloitte Ventures
Deloitte MCS Limited
020 7303 8895
alshelkovnikov@deloitte.co.uk

STEPHEN MERCER
Head of Technology
Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AUTHORS

ERIC PISCINI
Banking and Technology principal, Deloitte Consulting LLP

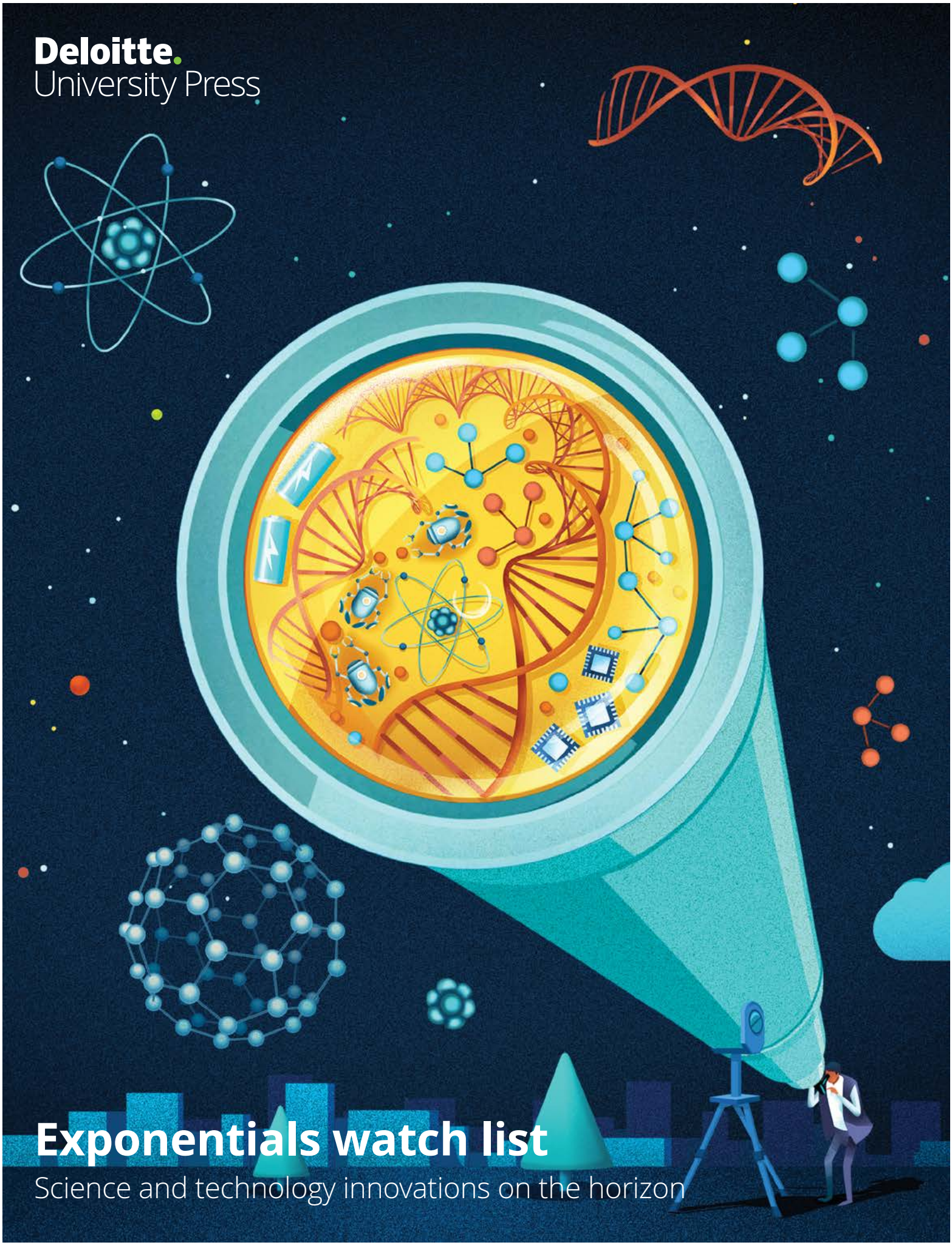
GYS HYMAN
Deloitte Digital principal, Deloitte Consulting LLP

WENDY HENRY
Federal Technology practice specialist leader, Deloitte Consulting LLP

ENDNOTES

1. Adriana Stan, "The future is the trust economy," *TechCrunch*, April 24, 2016, https://techcrunch.com/2016/04/24/the-future-is-the-trust-economy/.
2. Harriet Green, "Airbnb co-founder Nathan Blecharczyk talks Japan, business trips and blockchain," *City A.M.*, March 7, 2016, www.cityam.com/236040/airbnb-co-founder-nathan-blecharczyk-talks-japan-business-trips-and-blockchain-with-harriet-green.
3. Bruce Broussard, "Blockchain: Transformational technology for health care," LinkedIn blog post, August 8, 2016, www.linkedin.com/pulse/blockchain-transformational-technology-health-care-bruce-broussard?trk=vsrp_people_res_infl_post_title.
4. Microsoft, "Microsoft and Bank of America Merrill Lynch collaborate to transform trade finance transacting with Azure Blockchain-as-a-Service," September 27, 2016, https://news.microsoft.com/2016/09/27/microsoft-and-bank-of-america-merrill-lynch-collaborate-to-transform-trade-finance-transacting-with-azure-blockchain-as-a-service/.
5. John Ream, Yang Chu, and David Schatsky, *Upgrading blockchains*, Deloitte University Press, June 8, 2016, https://dupress.deloitte.com/dup-us-en/focus/signals-for-strategists/using-blockchain-for-smart-contracts.html.
6. State of Delaware, corporate law resources, http://corplaw.delaware.gov/eng/why_delaware.shtml, accessed December 1, 2016.
7. Ream, Chu, and Schatsky, *Upgrading blockchains*.
8. Deloitte Centre for Financial Services, www2.deloitte.com/us/en/pages/financial-services/topics/center-for-financial-services.html.
9. Karen Epper Hoffman, "Delaware's bet on blockchain," *GCN*, September 20, 2016, https://gcn.com/articles/2016/09/20/delaware-blockchain.aspx.
10. Deloitte Centre for Financial Services.
11. Giulio Prisco, "Delaware blockchain initiative to streamline record-keeping for private companies," *Bitcoin Magazine*, May 9, 2016, https://bitcoinmagazine.com/articles/delaware-blockchain-initiative-to-streamline-record-keeping-for-private-companies-1462812187.
12. SWIFT, "SWIFT on distributed ledger technologies," April 19, 2016, www.swift.com/insights/press-releases/swift-and-accenture-outline-path-to-distributed-ledger-technology-adoption-within-financial-services.
13. Ibid.
14. Michael del Castillo, "SWIFT's global head of banking argues blockchain isn't a disruption," December 14, 2016, www.coindesk.com/what-disruption-swift-welcomes-potential-of-blockchain-tech/.
15. Ibid.
16. Finextra, "SOFE Berlin: Swift unveils blockchain proof-of-concept," November 24, 2016, www.finextra.com/newsarticle/29813/sofe-berlin-swift-unveils-blockchain-proof-of-concept.
17. SWIFT, "Distributed ledgers, smart contracts, business standards, and ISO 20022," September 2016, www.swift.com/news-events/white-papers#topic-tabs-menu.
18. Finextra, "SOFE Berlin: Swift unveils blockchain proof-of-concept."
19. Hannah Kuchler, "Cyber attacks raise questions about blockchain security," *Financial Times*, September 11, 2016, www.ft.com/content/05b5efa4-7382-11e6-bf48-b372cdb1043a.

Deloitte.
University Press



Exponentials watch list

Science and technology innovations on the horizon

THOUGH BUSINESS APPLICATIONS FOR NANOTECHNOLOGIES, ENERGY SYSTEMS, biotechnology, and quantum technologies may seem light-years away, in reality they are approaching rapidly. In the next three to five years, expect to see business use cases emerge and pioneering deployments accelerate around these once-futuristic technologies. With this in mind, increasing numbers of CIOs, CTOs, and business strategists are already taking exploratory steps with these and other exponential technologies. They are sensing and scanning disruptive forces and putting in place deliberate, disciplined innovation responses. These leaders understand that waiting for exponentials to manifest as mature technology trends before taking action may be waiting too long.

UNLIKE other trends examined in this report that demonstrate clear business impact in the next 18 to 24 months, the exponentials we are discussing appear a bit smaller on the horizon. These are emerging technology forces that will likely manifest in a horizon 3 to 5 timeframe—between 24 and 60 months. But when they manifest, the speed with which they impact markets will likely grow exponentially.

For businesses, exponentials represent unprecedented opportunities as well as existential threats. As such, an analysis of exponential forces is a time-honored part of our annual discussion of emerging technologies. In our *Tech Trends 2014* report, for example, we collaborated with faculty at Singularity University, a leading research institution, to explore artificial intelligence, robotics, cybersecurity, and additive manufacturing. At that time, these emerging technologies were outpacing Moore's law—that is, their performance relative to cost (and size) was more than doubling every 12 to 18 months.[1] Just a few years later, we see these same technologies are disrupting industries, business models, and strategies.

In this year's report, we test specific aspects of four exponential forces that are being propelled by significant investment and research across the public and private sectors: nano-engineered materials, energy storage, synthetic biology, and quantum optimisation. For each, we provide a high-level introduction—a snapshot of what it is, where it comes from, and where it's going.

In each force, we seek to identify precursor uses or breadcrumbs of adoption for early application to business uses. Some if not all of these exponentials may disrupt industries in 24 months or more, but there can be competitive opportunities for early adoption. At a minimum, executives can begin contemplating how their organisations can embrace exponentials to drive innovation.

Don't let yourself be lulled into inaction. The time to prepare is now.

MY TAKE

ROB NAIL, CEO AND ASSOCIATE FOUNDER
SINGULARITY UNIVERSITY

We live in tumultuous times. As we have seen during the past year, political landscapes are shifting beneath our feet. News, signals, and random information come at us in torrents. At the same time, exponential technologies such as synthetic biology, advanced energy storage, nanotechnology, and quantum computing, among others, are poised to disrupt every part of our lives, every business model and market, every society. Eventually, they may even redefine what it means to be human.

> "EXPONENTIAL TECHNOLOGIES MAY EVEN REDEFINE WHAT IT MEANS TO BE HUMAN."

What are we to make of all this? Change is happening all around us at a pace that will only accelerate. Particularly in the realm of exponentials, when you see seemingly radical innovations emerging, we often experience it emotionally. We feel anxious about change. Our first reaction is often to cling to something that feels stable—the past.

At Singularity University, we are trying to understand where all this change is heading. Contrary to what some may see, we see a future that is hopeful and full of historic possibility. By leveraging exponentials, we could have a future in which cancer no longer afflicts our families. Everyone—even the most pessimistic—can agree that this is a desirable goal. This is the lens through which we should all view exponentials. By harnessing the power of quantum optimisation, nano-engineered materials, or synthetic biology to eliminate scarcity and uplift humans, we can tackle problems that have traditionally seemed so daunting that we've never imagined a world without them. Exponentials are an opportunity driver, not something to fear.

As use cases for exponentials emerge and technologies mature over the next three to five years, it will not be enough for the technology, science, academia, and business sectors to focus solely on their own goals. Collectively, we must also help build understanding throughout society of what these technologies are and where they can take us.

The future is already here. The world around is changing every day, and will continue to do so. Unless we equip ourselves with a new vision of the future and tools to navigate it, we will wake up every morning and be surprised. At Singularity University, we believe a better path is to come together to build an awareness of where we are going and, with some rigor, talk about how exponentials can help us all build a future of abundance.

Focus: Nano-engineered materials

The word nano is often used to describe something unusually small. For example, Tata Motors developed a compact automobile primarily for the Indian market it calls the Nano.[2] But beyond its diminutive descriptive usage in product marketing, nano has a much more precise definition. Using one meter as a measuring stick, a nanometer is defined as one billionth of a meter (that's 1/1,000,000,000). If this is hard to imagine, try using a single carbon atom as a measuring stick. A single nanometer is about the size of three carbon atoms placed side by side. In comparison, a single human hair is 80,000 to 100,000 nanometers wide.[3]

Nano-manufacturing—the process of making things at nano-scale—represents an important emerging capability. To create things smaller than 10 nanometers, we typically turn to advanced chemistry; to some degree, one can attribute the pharmaceutical industry's achievements to its ability to create precise molecules at these length scales. More traditional manufacturing technologies, such as machining, can get down to features that are close to the size of a human hair, but that leaves a thousand-fold gap in length scales from making molecules to machining. Nano-manufacturing is a set of technologies and techniques that enables making things at this range of size.[4]

The drive to develop nano-manufacturing capabilities comes from a variety of different challenges and opportunities that emerge at this scale. Perhaps the most visible driver has been the demand for cheaper and higher-performing computers. Moore's law, the periodic doubling of transistor density—the number of transistors that can fit on a chip—is a direct result of the development of machines that can create ever-finer patterns of semiconductors. In 2014, Intel shipped chips with 14-nanometer resolution. The smallest features on these chips were spanned by fewer than 50 silicon atoms.[5]

Medicine also drives demand for nano-manufacturing. Life emerges at nano-scale through a complex set of molecular "machines" that copy DNA and synthesise proteins; the molecules that carry out these processes are 10–100 nanometers in size. Nano-manufacturing could be used to make objects that either mimic this process—for example, to manufacture proteins that can then be used as drugs—or inhibit it directly to treat disease.[6]

A third area driving the development of nano-manufacturing is the role of nanostructures on surfaces, in the form of coatings, lubricants, and adhesives. Nanostructures can prevent water from wetting a surface, making water-resistant fabrics and mirrors and windows that don't fog. In a similar way, nanostructured surfaces can prevent the formation of ice—for example, on the wings of an airplane, making it much safer to fly and eliminating the need for the repeated application of liquid

de-icing agents.[7] An important business application today addresses wear and friction. These physical factors, as well as adhesion, are a product of the interaction between surfaces at the nano-scale.

Reality check

So what are some current examples of nano-engineered products that are likely to impact businesses today or in the near future?

In addition to integrated circuits, examples of products made through nano-manufacturing include nanoparticles of silver that kill bacteria and are integrated into clothing and medical devices to prevent infection; nanoparticles of titanium that block UV light and when integrated into a lotion or spray and applied to the skin prevent sunburn; and nanoparticles of pigment that make brighter paints and coatings that prevent corrosion.[8]

Manufacturing asperities—imperfections remaining on surfaces after modern milling and machining techniques—are commonly at micron scale, but lubricant molecules are still larger than that. By changing the surface features at nano-scale, or by introducing nanostructured materials between surfaces, friction can be reduced to provide super-lubrication or can be enhanced to provide super-adhesion.[9]

NanoMech makes a nanostructured lubricant designed to mitigate these effects for critical mechanical components such as gears, bearings, valves, and chassis points. It is designed to address issues like performance under extreme pressure, anti-wear, anti-friction, corrosion protection, and extreme temperature stability in order to enable extension of service life and reduce maintenance cost of mechanical systems. Beyond the fact that the lubricant or coating is engineered and manufactured for specific business use cases, rather than inventing wholly new ways to make nanostructured materials, the company uses off-the-shelf manufacturing technology and includes both top-down fabrication and bottom-up assembly in its process.

However science-fiction-like nanotechnology's capabilities might sound, applications are becoming evident today. For example, NanoMech's AtomOil and AtomLube are self-replenishing, which means as friction rubs the nano-manufactured lubricant molecules apart, additional molecules are drawn into the interface. Applications may include equipment for oil and gas production; engines and other machines used in the marine, agriculture, and mining sectors; and macro-manufacturing techniques, including die casting and machining.[10]

MY TAKE

JIM PHILLIPS, CHAIRMAN AND CEO
NANOMECH

At NanoMech, we consider ourselves pioneers in nano-mechanics. We design and engineer products at nano-scale while continuing to produce them at macro scale. Our company slogan is, "We make atoms work harder."

> "BY SOME ESTIMATES, EACH DAY EVERY HUMAN ON EARTH USES AN AVERAGE OF 10 MACHINES. AS THE POPULATION GROWS, SO WILL THE NUMBER OF MACHINES IN OPERATION."

In the world of industrial lubricants, there's an old saying: The best maintenance is low maintenance. Nano-engineered lubricants and coatings help our clients in the manufacturing, energy, automotive, and defense sectors increase mechanical performance, efficiency, and durability while reducing downtime. These designs also support sustainability: At nano-scale, we can eliminate materials traditionally used in lubricants such as chrome and petroleum products.

If all of the problems in mechanical systems and manufacturing are at nano-scale, then it follows that the solutions must be at nano-scale too. Our solutions are made possible by a powerful mechanical systems lens through which we view both present needs and future opportunities.

Consider the potential market for these products: By some estimates, each day every human on earth uses an average of 10 machines. As the population grows, so will the number of machines in operation, all requiring products like ours.

The ability to engineer at nano-scale is helping us meet this demand. Over the course of six years, NanoMech has grown from one product offering to 80. Moreover, we've been able to drive these levels of growth using off-the-shelf components. As a practice, we take machines designed and utilised for other purposes and adapt them for use in making nano-engineered and nano-manufactured products. We occasionally see companies approach nano-engineering by building the machines they need from the ground up. Working in nano-scale doesn't require that you reinvent the wheel; doing so is, in my opinion, a waste of time and money.

Expect to see nanotechnology take off in the next two to three years with the expansion of robotics, which represents an intersection of the mechanical and electronic worlds. Longer term, we will likely see a proliferation of nanotechnology solutions in niche markets. For example, the pharmaceutical industry is already engineering new molecules at nano-scale. And more will likely follow. As we journey into the future, materials science can be that catalyst for realising new possibilities.

Focus: Energy storage

As the world addresses its reliance on carbon-based energy, the sun is shining brightly and the wind is blowing at our backs. In 2014, wind and solar sources accounted for roughly 1 percent of energy consumed globally—only a tiny part of overall consumption but one that is growing rapidly.[11] Wind capacity has doubled every four years and solar every two for the past 15 years.[12] And with generation costs continuing to fall, this exponential trend is expected to continue, with these renewable sources projected to provide two-thirds of new generation capacity additions over the next 25 years.[13]

However, the achievements of renewable energy sources also herald a challenge that ultimately may limit their further adoption. Unlike many traditional modes of electricity generation, wind and solar are at the mercy of nature's vagaries—without wind or sunshine, no power is produced. There are ways to alleviate this challenge. For example, because wind production is typically greater at night than in the daylight hours,[14] there may be opportunities to deploy wind and solar capabilities synergistically.

Yet even if we embrace this approach, a fundamental challenge persists: aligning energy production with energy consumption. The challenge of storing energy on a massive scale until it is needed by consumers is hardly new. One solution, pumped hydroelectric storage, has applications dating back to the 19th century. In a pumped hydro storage facility, water is pumped uphill when electricity is abundant (and cheap) and then released to flow downhill to power generation turbines when electricity is scarce (and valuable). By some measures, the pumped hydro approach is wildly effective: This technology represents an estimated 99 percent of bulk energy storage capacity worldwide.[15]

But while pumped storage is a useful and relatively efficient storage mechanism, it is constrained by access to water and reservoirs as well as by topography. Therefore, the dominance of pumped hydro speaks less to its advantages than to the historic absence of credible alternatives targeted toward centralised large-scale storage on the electric grid. And this is a real problem: With the massive expansion of power sources such as wind and solar, and the increasing decentralisation of energy production, we will need more energy storage capacity overall as well as the ability to deploy it flexibly in different geographies, unit sizes, and industrial and consumer applications.

Reality check

The good news: The last decade has seen an explosion of new and improving storage technologies emerge, including more efficient batteries, compressed air, and molten salt. Utilities are deploying these approaches at or near sources of generation. The following examples highlight some notable developments:

- Favored with sunshine but facing high costs to import fuel, the Hawaiian island of Kauai is a leading consumer of renewable energy. On sunny days, solar contributes 70 percent of energy generation, which decreases with the arrival of cloud cover. What's more, peak energy demand is in the evening. To close the gap, the Kauai Island Utility Cooperative is working with power systems provider SolarCity to build a new solar farm and storage facility, with energy stored in lithium ion batteries supplied by automaker and energy storage company Tesla. The plant will generate capacity during the day, store the entire amount of energy generated, and then release it during the high-demand evening hours.[16]
- In Lake Ontario, Canadian start-up Hydrostor has launched a pilot program using compressed air. In this approach, air is compressed and pumped into a series of underwater balloons. When energy is required, the air is released, expanded, and used to create electricity.[17]
- In commercial operation since 2015, Solar-Reserve's 110 megawatt-hours Crescent Dunes Solar Energy Project in the Nevada desert has deployed a solar thermal system in which a large field of mirrors concentrates the sun's rays to heat molten salt. The hot salt is then stored at a temperature of over 1,000 degrees Fahrenheit in a 140-foot-diameter insulated storage tank until needed. At that point, the hot salt is used to create steam to power turbines, just like a

conventional fossil or nuclear plant. Using this method, each day the Crescent Dunes facility can store up to 1,100 MWh of energy generated by concentrating solar array within salt.[18]

Perhaps more significantly, energy storage technologies may soon offer more options for the end consumer, allowing consumers to store power at or near the point of consumption. The following examples highlight some notable developments:

- In Japan, the government has set a goal for all newly constructed public buildings to be able to generate all their energy needs by 2020, with the same zero-energy standard for private residences by 2030, providing a strong incentive for development of residential-scale storage.[19]
- In the United States, several utilities are offering energy storage products to customers, and with the growth in solar panel installations, energy storage innovators such as Tesla, Orison, and SimpliPhi Power are marketing their battery technologies directly to end consumers.

While the cornerstone of disruption may be exponential improvements in both energy generation and storage, the keystone may well be a coming business-model revolution, as new models supplement the traditional model of centralised power generation and one-way distribution to multiple distributed points of consumption. With such a broad and growing set of emerging energy storage technologies—each with different performance and economic characteristics—business and retail consumer adoption patterns will likely remain difficult to predict for the foreseeable future. But regardless of which technologies emerge as leaders, both consumers and producers of energy will be presented with more choice and more complexity, transforming the traditional supply, demand, and economic relationships between many parties.

If your business consumes large amounts of energy, what is your innovation response to this disruption force?

MY TAKE

TOMÁS DÍAZ DE LA RUBIA, PH.D.
CHIEF SCIENTIST AND EXECUTIVE DIRECTOR, DISCOVERY PARK
PURDUE UNIVERSITY

One of the key global megatrends that researchers study at Discovery Park is growing energy demand, which will increase by 40 to 60 percent by 2050, according to the World Energy Council. Transportation will likely account for a considerable part of that growing demand. My view has always been that we are nowhere near developing *optimal* energy storage technologies that can be used in cars, buses, trains, and other modes of transportation. Though we're seeing expanding use of lithium ion batteries today, there is only so much that can be done to improve battery performance and reduce costs through mass manufacturing. Moreover, there is too much innovation happening in this space to believe that lithium ion is going to be the only answer to our energy storage needs. Though development in this area is currently in the initial research stage, it is taking place globally.

I recently bought an electric car. This model is advertised as having a range of 85 miles, which is sufficient for driving around town. I've noticed, however, that if the temperature outside grows warmer or colder, this car can lose up to 30 percent of its range. This is the reality of lithium ion batteries in cars—the range they offer may be less than we expect.

But that is in the near term. There is an exponential trend in energy storage; there are technologies currently under development that will likely provide much higher energy density. Also, we may soon see different technologies emerge that can be used on the grid, rather than for transportation. The characteristics of volume and weight are not so important for the grid—and storage doesn't have to be a battery pack. Redox batteries, which are a combination flow battery and two-electrolyte system, are among the more promising technologies currently in play. As with many innovations, there can be materials challenges, but in principle redox batteries can be cheaper than lithium ion, which could make it better suited for use in the grid—either centralised or distributed around points of generation and consumption.

> "THOUGH WE'RE SEEING EXPANDING USE OF LITHIUM ION BATTERIES TODAY, THERE IS ONLY SO MUCH THAT CAN BE DONE."

While I do think advances in energy storage technologies may, in the coming years, deliver a breakthrough that makes $100 per kwH for grid storage possible, for the foreseeable future the transportation sector will likely drive innovation. There's more demand coming from transportation than from the grid, where renewable energy generation continues to grow. I also believe the public sector may have a critical role to play in this space, specifically in reducing some risks associated with research and development.

Focus: Synthetic biology

The Convention on Biological Diversity defines biotechnology broadly as any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use.[20] This definition makes clear that biotech's potential disruptive impact is not limited to big players in health care and agriculture. Indeed, as it ramps up in exponential impact, biotech has relevance for industrial products, energy and natural resources, high tech, and other industries.

This year we are focusing on one area of biotech—synthetic biology—and an imminent precursor technology for gene editing and repair. Asif Dhar, principal and chief medical informatics officer at Deloitte Consulting LLP, succinctly describes synthetic biology as "bio-engineering a thing that then creates a substance." An example might be engineering algae to produce alcohols for fuels, polymers, or building materials such as paints and coatings.[21] Much of the progress in synthetic biology is not about editing basic cell behavior but about adding code to the cell to make it respond differently to signals in a manner that cell will accept. This is a targeted redirection of a cell's intent, which requires a deep understanding of the specific cell to do with confidence.

The implications reach beyond the science and into business models across industries. Genetic diseases are relatively rare but usually severe—lifelong care or long-term therapeutics can be required. Chronic care today often seeks to push physiology back into place with ongoing pharmaceutical regimens. Synthetic biology could conceivably offer one-time therapy with no need to revisit treatment. In such a case, what is the best approach to payment and reimbursement when a lifetime of benefit comes from one treatment?

Understandably, there is controversy surrounding medical applications of biotechnology. Is environmental engineering possible? Will some part of society determine that germ-line or in utero engineering is acceptable? Will people start clamoring for other changes in their genome? Will ethics vary by country or culture? Those are big questions.

Regardless, the prospect of permanently correcting inherited genetic disorders such as cystic fibrosis, sickle cell anemia, and certain cancers can incite optimism for those suffering from the conditions and, potentially, fear for those imagining manipulation of the human genome in malicious ways. Regulatory and ethical debates have been just as vibrant as the scientific research, and these issues are far from settled. Nevertheless, understanding the medical, industrial, and synthetic biology applications of this disruption force is an important step toward sensing important business considerations that may shape our future.

Reality check

Currently, there is a flurry of synthetic biology inventions, patents, and IPOs, with one area in particular crackling with activity: gene editing with CRISPR.

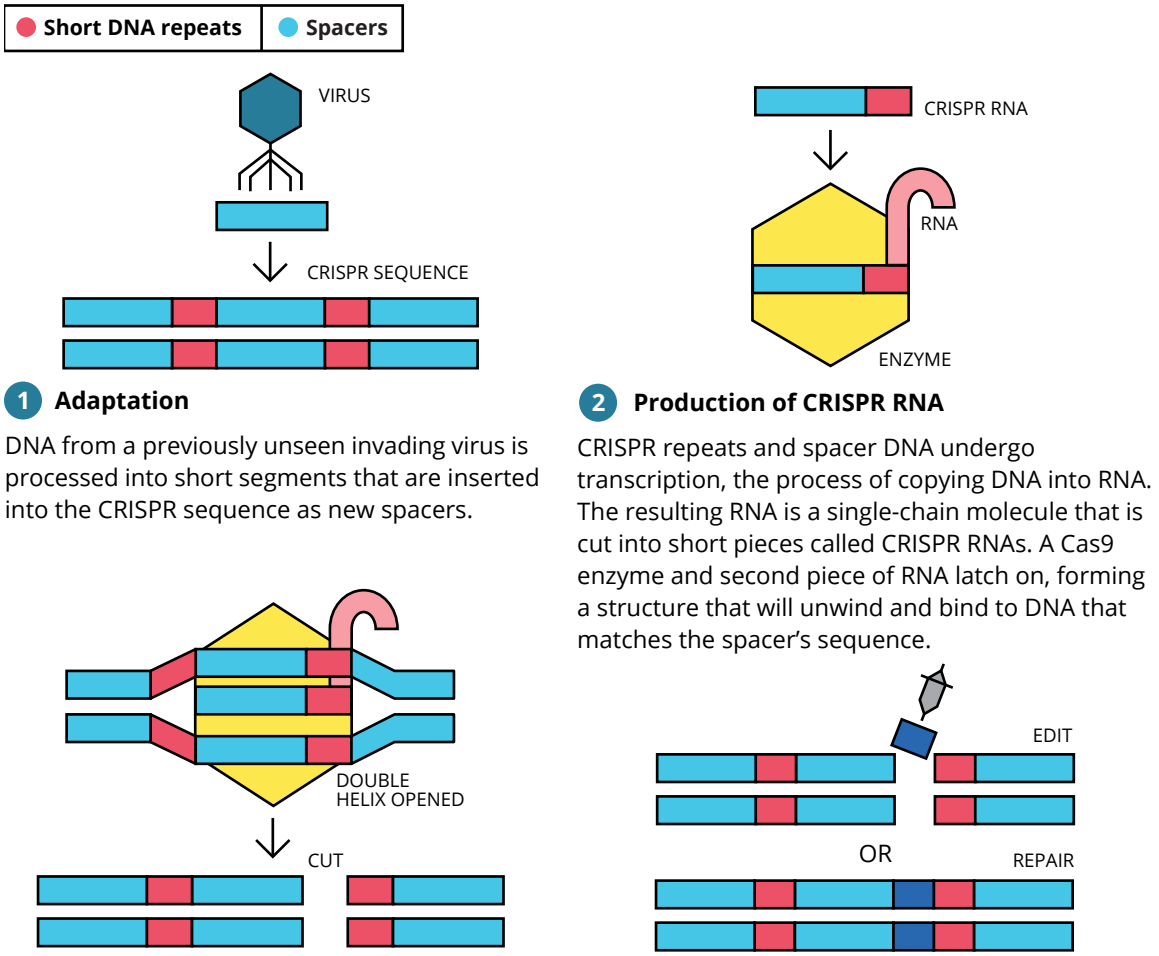
CRISPR—clustered regularly interspaced short palindromic repeats—is a genomic editing technology. Rather than focusing on creating new capabilities or behaviors, the CRISPR enzyme acts as molecular scissors, cutting the DNA at the specified point to allow editing and correction of genetic code to work as originally intended.[22] Tom Barnes, chief scientific officer of Intellia Therapeutics Inc., refers to the process of genome editing as "correcting typos in the Book of Life." Biologists have had the tools to edit the genome, but CRISPR represents a more efficient, accurate, and malleable technique than the other tools at their disposal.

To understand this process more clearly, imagine a factory that produces a single component for a large, complex machine. This component is but one of the machine's numerous parts, but it is critical nonetheless. Yet, due to a small error in the manufacturing software, this component tends to fail soon after the machine begins operation. Luckily, the company identifies the error and patches the software, and the component becomes a reliable part of the greater machine.

A human cell is like a tiny manufacturing facility, with DNA acting as software instructions for cellular function. The human cell possesses several checks and balances to ensure its genomic integrity, and while it is efficient in its task, errors do sometimes happen.[23] In some cases, environmental damage or genetic inheritance causes errors in these instructions. Before CRISPR, there was

Figure 1. How does CRISPR/Cas9 work?

The CRISPR/Cas9 system is derived from the bacterial immune system, a process used to defend against viruses. The CRISPR regions are composed of short DNA repeats and spacers, as well as upstream regions that encode for the machinery required to edit the genome (Cas proteins). The bacterial CRISPR immune system effectively edits the genome using the following basic steps:



1 Adaptation

DNA from a previously unseen invading virus is processed into short segments that are inserted into the CRISPR sequence as new spacers.

2 Production of CRISPR RNA

CRISPR repeats and spacer DNA undergo transcription, the process of copying DNA into RNA. The resulting RNA is a single-chain molecule that is cut into short pieces called CRISPR RNAs. A Cas9 enzyme and second piece of RNA latch on, forming a structure that will unwind and bind to DNA that matches the spacer's sequence.

3 Targeting

Because CRISPR RNA sequences are copied from the viral DNA, they are exact matches to the viral genome and thus serve as excellent guides. When a matching strand of DNA is found, the enzyme opens the double helix and cuts both sides, disabling the viral DNA.

4 Editing

Researchers are re-engineering the bacterial system to enable it to edit more than just viral DNA. They use the CRISPR/Cas9 tools to target regions of the genome, disable genes, or cut it and insert new DNA, effectively editing the DNA sequence.

Sources: Andrew Pollack, "A powerful new way to edit DNA," *New York Times*, March 3, 2014, https://nyti.ms/2k5xxdx; Ekaterina Pak, "CRISPR: A game-changing genetic engineering technique," Harvard University blog post, July 31, 2014, http://sitn.hms.harvard.edu/-flash/2014/crispr-a-game-changing-genetic-engineering-technique.

no inexpensive, efficient, and precise synthetic mechanism for identifying a target gene repair location and manipulating the code toward a positive therapeutic outcome—that is, no reliable synthetic method of "patching" errors in the human genome across the broad array of known genetic defects that result in disease or chronic conditions.[24]

While advances in synthetic biology may make it possible to turn any living system into one we can manipulate genetically, few systems are sufficiently well understood today to be amenable to that manipulation. The tools and tricks currently used to manipulate fruit flies, for example, were developed over the course of 100 years. There is currently little comparable knowledge or experience base that can be used to similarly manipulate other potentially valuable cell lines.

Current CRISPR use cases focus on repairing cells back to the intended function. That allows a less complex starting point and potentially a less controversial set of capabilities.

Similarly, the agriculture industry is using CRISPR techniques to move faster than selective breeding and hybridisation could in the past. For example, button mushrooms engineered with CRISPR do not go brown with handling and shipping.[25]

Today CRISPR is ready to advance from a bench tool into therapeutics. Academics are collaborating with business to address the regulation, scale, and rigors of development. Developments and applications of CRISPR technology will continue to be reported and debated as they advance, but it's not too soon for businesses to begin considering impacts.[26] With the National Institutes of Health projecting cancer costs to hit $158 billion by 2020,[27] CRISPR's potential as a treatment for cancer offers hope for health care consumers and providers buckling under the increased cost and complexity of new treatments. Pharmaceutical, oil and gas, and chemicals manufacturers are carefully following the potential of synthetic biology to engineer organisms to produce complex chemicals and other compounds.

MY TAKE

THOMAS BARNES, PH.D.,
CHIEF SCIENTIFIC OFFICER
INTELLIA THERAPEUTICS

Since the human genome was first mapped in 2000, scientists have identified the individual genes responsible for 4,300 genetic disorders, many of which can drastically negatively affect an individual's quality of life or reduce life expectancy.

> "MY COLLEAGUES AND I BELIEVE CRISPR HAS THE POTENTIAL TO TRANSFORM MEDICINE BY PERMANENTLY EDITING DISEASE-ASSOCIATED GENES IN THE HUMAN BODY WITH A SINGLE TREATMENT COURSE."

Imagine a future in which these genetic disorders—chronic conditions such as cystic fibrosis and hemophilia, which have afflicted humans since time immemorial—no longer burden us. At Intellia Therapeutics, we are developing therapies based on CRISPR technology that we believe will make this vision a reality.

At Intellia, my colleagues and I believe CRISPR has the potential to transform medicine by permanently editing disease-associated genes in the human body with a single treatment course.

CRISPR enables genome editing—the precise and targeted modification of the genetic material of cells. As an exponential technology, its disruptive potential is profound. In the pharmaceutical industry we have seen considerable work during the last 20 years to identify genes and gene variants that directly or indirectly drive disease. In agriculture, scientists are exploring opportunities to make crops more resistant to fungi and bacteria, and livestock more resistant to disease. And in industry and academia, scientists are gearing up to use CRISPR to edit cells in humans to fight a range of diseases.Like ripples spreading in a pond, CRISPR will likely disrupt the health care, pharmaceutical, agriculture, and other industries for many years. At the centre is the effect on those suffering from genetic disease. Yet, further out a number of ethical questions arise, for example, in editing the germline (sperm and egg DNA to permanently affect future generations), and editing and releasing organisms in the environment to shift ecological balances (gene drives). These questions need careful consideration by society at large, and warrant being addressed. At Intellia, we have chosen not to participate in germline editing and are focused on somatic cells, where we can directly target genetic diseases today.

Over the next five years, we will see different clinical efforts using genome editing technologies. We will also likely see CRISPR-driven advances in drug development, with useful therapies following shortly thereafter.

Beyond that, it is difficult to predict what the science of genome editing will look like in 2027 or beyond. Right now, we have the tool to go inside a cell and change its DNA. The challenge we encounter is getting inside the right cell. As we improve that process, we exponentially expand CRISPR's possibilities. And as we expand those possibilities, we will inevitably encounter ethical questions about how this technology can and should be deployed. At Intellia, we are focusing on all the good we can potentially do for people suffering from genetic diseases. Think about it: In the future, we may no longer have to take the cards we're dealt—we can swap some.

Focus: Quantum optimisation

Quantum technology can be defined broadly as engineering that exploits properties of quantum mechanics into practical applications in computing, sensors, cryptography, and simulation.[28]

Quantum mechanics, a branch of physics dealing with the nature of matter at an atomic or sub-atomic level—can be counterintuitive. Particles behave like waves, experience quantum uncertainty, and show the non-local entanglement phenomena that Einstein famously called "spooky action at a distance." Given that most quantum phenomena are confined to the scale of atoms and fundamental particles, nontraditional materials and methods are required to explore and exploit them.[29]

As a result, efforts to harness quantum technology for computing are hardware-driven, using exotic materials, and focused on the goal of achieving durable quantum states that are programmable—that is, pursuing a general-purpose quantum computer. Difficult engineering hurdles remain. Nonetheless, there is an active race under way to achieve a state of "quantum supremacy" in which a provable quantum computer surpasses the combined problem-solving capability of the world's current supercomputers—at least for a certain class of problem.

Currently, the Sunway TaihuLight supercomputer in Wuxi, China, can run 10.6 million cores comprising 40,960 nodes, and can perform 93 peta floating-point operations per second (FLOPS). That's roughly 10,000 times faster than a high-end GPU today. By contrast, a single quantum gate chip with around 60 quantum bits (qubits) would, theoretically, be more powerful than the TaihuLight computer.[30]

Any companies that win the race for "quantum supremacy" will harness some key quantum effects into their architectures, including superposition, tunneling, and entanglement.

Superposition allows a quantum bit to hold zero and one values *simultaneously*, and in quantum tunneling, particles behave like waves to cross certain energy states. These unintuitive facts allow quantum computers to solve complex discrete combinatorial problems that are intractable for classic computers in practical timeframes. For example, machine learning leverages pattern recognition—comparing many instances of large data sets to find the learning model that effectively describes that data. Applying superposition and tunneling allows handling many more patterns in many more permutations much more quickly than a classic computer. One key side effect is cracking current data encryption and protection schemes.[31]

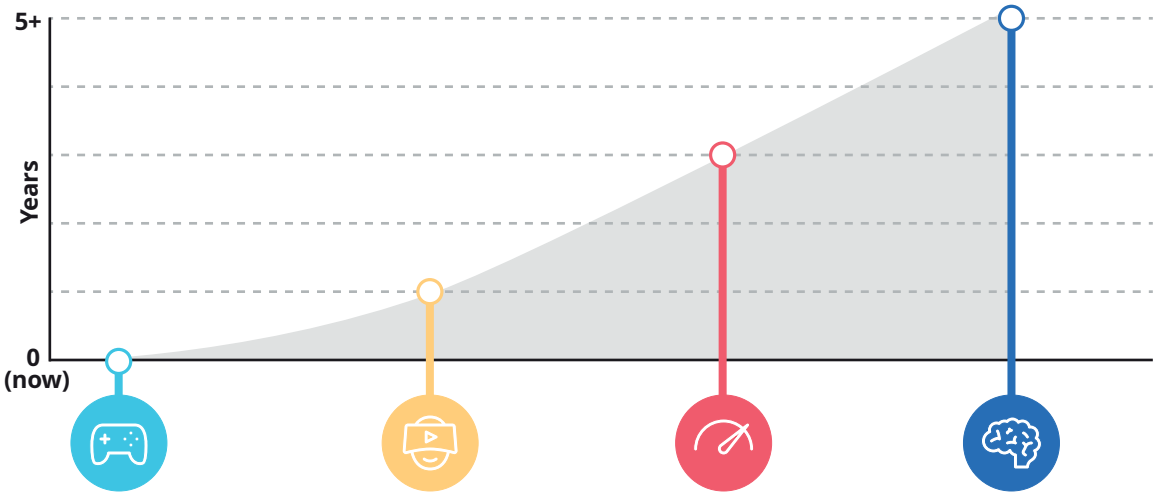
Fortunately, the entanglement effect supports quantum cryptography, using the "shared noise" of entanglement to empower a one-time pad. In quantum entanglement, physically distant qubits are related such that measurements of one can depend on the properties of the other. Measuring either member of an entangled pair destroys the shared entanglement. This creates a business use for senders or receivers to more easily detect "line tapping" in digital communications.[32]

Large-scale quantum computing, whenever it occurs, could help address real-world business and governmental challenges. Peter Diamandis offers examples from several disparate disciplines. Toward personalised medicine, quantum computers could model drug interactions for all 20,000-plus proteins encoded in the human genome. In climate science, quantum-enabled simulation might unlock new insights into human ecological impact. Finally, quantum simulations seem to better model many real-world systems such as photosynthesis. Addressing such processes with quantum computers may lead to biomimetic advances and discoveries across many industries and use cases.[33]

Reality check

As companies wait for a commercial gate model quantum machine with lots of qubits and high coherence—that is, a general-purpose quantum computer—they can experiment with certain applications using quantum simulation and quantum emulation. These approaches are in use today and can show both the path to and the potential of full quantum GPC (general purpose computing).

Figure 2. The future of quantum: Years to general business impact



Emulation

Quantum emulation solves specific problem types without using quantum-scale machines by leveraging math shortcuts that don't compromise the computational results from classic hardware.

Simulation

Quantum simulation implements the exact physics as accurately as possible using current hardware and tools to explore both real-world problems and quantum algorithm design.

Optimisation

Quantum optimisation takes advantage of quantum effects in special purpose architectures and machines to address hard discrete combinatorial optimisation problems, such as finding the most efficient way of doing a given task.

Quantum GPC

Embracing the full breadth of quantum physics effects, such as tunneling and entanglement, the race is on to build a general-purpose programmable commercial gate model quantum machine with lots of qubits and high coherence.

Deloitte University Press | dupress.deloitte.com

Quantum simulation implements the exact quantum physics (as we know it today) with the hardware and tools we have today. That is, quantum simulation directly mimics the operations that a quantum computer performs, using classic computing to understand the exact effects of every quantum gate in the simulated machine.

Quantum emulation targets quantum-advantaged processes without the exact physics, using mathematical shortcuts that don't compromise the results. That is, quantum emulation is only required to return the same *result* as a perfect quantum computation would. Instead of compiling an algorithm for specific quantum hardware, fast classical shortcuts may be executed by the emulator. Depending on the level of abstraction for the emulation, this may improve both speed and total number of operations.[34]

As an example, Kyndi leverages quantum emulation to handle the combinatorial complexity of inferencing complex data, putting the result to work as part of a broader machine-intelligence approach in places where the volume of data overwhelms human experts. The intent is not to replace the expert—rather, it is to automate the routine parts of large-scale analysis and free humans to focus on high value add. One Kyndi proof of concept delivered analysis in seven hours of processing that the client estimated would have taken a full year using human analysts alone.

Both quantum simulation and quantum emulation approaches are backed by formal proof theory—math results from theoretical computer scientists and physicists who have done the work to show what quantum computations can be done on classic computer architectures. Those theories, though, generally do not specify algorithm design or emulation abstraction.

In the slightly longer term, quantum optimisation solutions—such as the tunneling or annealing mentioned earlier—don't provide full general-purpose compute, but they do address hard discrete combinatorial optimisation problems, such as finding the shortest, fastest, cheapest, or most efficient way of doing a given task. Familiar examples include airline scheduling, Monte Carlo simulation, and web search.[35] More current uses include image recognition, machine learning and deep learning pattern-based processing, and intelligence systems algorithmic transparency (in which an algorithm can explain itself and how it came to its conclusions).

Quantum optimisation addresses limitations with both rules-based and traditional case-based reasoning in which multiple case examples are used to show levels of relationships through a commonality of characteristics. A practical problem for quantum optimisation would be not only recognising the objects in a photo but also making inferences based on those objects—for example, detecting a dog, a ball, and a person in a photo and then inferring that the group is going to play ball together. This type of "frame problem" is combinatorically large in classic rules engine approaches.

As for quantum optimisation's longer-term future, the ability to harness computing power at a scale that, until recently, seemed unimaginable has profound disruptive implications for both the private and public sectors, as well as for society as a whole. Today, we use statistical methods to mine patterns, insights, and correlations from big data. Yet for small data that flows in high-velocity streams with low repeat rates, these statistical methods don't apply; only the human brain can identify and analyse such weak signals and, more importantly, understand causation—the reason why. In the coming years, expect quantum computation to break the human monopoly in this area, and to become one of the most powerful models of probabilistic reasoning available.

MY TAKE

ARUN MAJUMDAR, FOUNDER AND CHIEF SCIENTIST
KYNDI

At Kyndi, we are working to change how society's hardest problems can be solved when human creativity and resourcefulness are complemented by smarter machines. Our technology draws from the quantum sciences to transform text in any language into a crystalline structure that provides answers to many questions.

Language is used in many different ways, and words can have multiple meanings. Normal computers struggle with reasoning in the face of such complexity. We solve this with a practical data representation inspired by methods of quantum computing. Our mapping technology automatically learns the makeup of any language and how it's used in a given field. We store those maps in crystalline structures as graphs showing how things are related to each other. We can efficiently store many maps with complex interrelationships and yet still recall them quickly using relatively little classic computing power. We then put those structures to work via machine learning.

> "HUMANS INTUIT AT HIGH SPEEDS; NORMAL COMPUTERS DO NOT."

In a world increasingly cluttered by big data, dark data, and cacophonies of signals and seemingly random information, the growing need for technology that can analyse and draw plausible, realistic, and timely inferences from complexity drives our efforts.

Humans intuit at high speeds; normal computers, on the other hand, do not. Quantum computation—and algorithms that emulate that computation—approach solving high-complexity learning and inference within the same time scales as traditional rules-based systems do on smaller problem sets. We have tackled this challenge using algorithms that emulate quantum computation. Emulation is not technically quantum computation, but it performs analogously with currently available computers.

This approach makes it possible to solve problems of super-exponential complexity that would stymie traditional rules-based computing systems. For example, a cancer patient works with his doctor to develop a treatment plan that may include chemotherapy, radiation, surgery, and dietary regimes. In this case, there are 24 possible combinations of the therapy statically planned at the start: One patient may start with diet, another surgery, etc. But if the treatment regimen allows for re-optimisation of the plan at every step, the number of possibilities jumps from 24 choices to 24 *factorial* choices. That's 6.2×10^{23} potential combinations!

Kyndi works on resolving other similarly challenging problems in global security today, such as competitive intelligence—scanning the horizon for surprises and understanding emerging science and technology patterns. The human brain can intuit around this kind of complexity; traditional computers cannot. Yet there are situations involving big data in which a chain of thinking quickly creates huge combinatory explosions that overwhelm even the most advanced thinkers.

In the future, quantum computing will likely far outperform humans in the arenas of probabilistic reasoning and inference. Until that day arrives, you don't have to be a quantum purist. Quantum simulation can help you understand the new concepts, and emulation can help you scale the quantum concepts to solve some important types of problems. For example, whereas it might take a human months to read and understand 500 articles on a given subject, Kyndi's quantum emulation systems can analyse those 500 articles in seconds and narrow the reading list down to six that explain the topic thoroughly. Quantum's day will come. Until then, think of simulation and emulation as two separate interim steps—learning and applying—as well worth exploring.

It may be several years before viable, mainstream business use cases for synthetic biology, advanced energy storage, quantum computing, and nanotechnology emerge. But even in these early days of innovation and exploration, certain risk and security considerations surrounding several of these exponential technologies are already coming into view.

For example:

Nanotechnology: The health care sector is developing many groundbreaking uses for nanotech devices, from microscopic tools that surgeons can use to repair damaged tissue, to synthetic molecular structures that form the basis for tissue regeneration.[37] Yet like medical devices, nanotech carries with it significant compliance risk. Moreover, the microscopic size of these innovations makes them nearly impossible to secure to the same degree one would other technologies. In some cases, nano-related risk will likely need to be managed at nano-scale.

> "EVEN IN THESE EARLY DAYS, CONSIDERATIONS SURROUNDING SEVERAL OF THESE EXPONENTIAL TECHNOLOGIES ARE ALREADY COMING INTO VIEW."

Energy storage: Batteries and grid-storage technologies do not, in and of themselves, carry significant levels of risk. However, the digital components used to control the flow of electricity, and the charge and discharge of batteries, do. As storage components become denser, more compact, and weigh less, new digital interfaces and energy management tools will emerge, thus requiring new approaches for securing them.

Synthetic biology: At the crossroads of biology and engineering, synthetic biology stands poised to disrupt agriculture, medicine, pharmaceuticals, and other industries that deal with natural biological systems. Yet its seemingly limitless potential will be bounded by formidable regulation that will, in turn, raise its compliance risk profile.

Quantum computing: With the kind of algorithms and data models that quantum computing can support, predictive risk modeling may become an even more valuable component of risk management. The difference between modeling with a few hundred data attributes, as one might today, and running the same models with 20,000 or more attributes represents a potentially game-changing leap in capacity, detail, and insight. Due to the growing complexity of managing cyber risk, platforms such as quantum will likely be essential cyber components in the future.

As we begin thinking about exponential technologies and their disruptive potential—however distant that may seem—it is important to consider not only how they might be harnessed for business purposes but also the potential risks and security considerations they could introduce upon deployment. Will they make your ecosystems more vulnerable? Will they expose your organisations to additional financial compliance or reputation risk? Or, as in the case of quantum computing, might they turbocharge your existing approaches to security by revolutionising encryption, predictive modeling, and data analysis?

Though we may not be able to answer these questions with certainty today, we do know that by adopting a "risk first" approach to design and development now, CIOs will be putting in place the foundational building blocks needed to explore and leverage exponential technologies to their fullest potential.

Where do you start?

While the full potential of the four exponentials examined in this report may be several years in the future, there are relevant capabilities and applications emerging now. If you wait three years before thinking seriously about them, your first non-accidental yield may likely be three to five years beyond that. Because these forces are developing at an atypical, nonlinear pace, the longer you wait to begin exploring them, the further your company may fall behind.

As you embark on your exponentials journey, consider a programmatic lifecycle approach involving the following steps:

- **Sensing and research:** To begin exploring exponential forces and their potential, consider, as a first step, building hypotheses based on sensing and research. Identify a force—nanotechnology, for example—and hypothesise its impact on your products, your production methods, and your competitive environment in early and mid-stage emergence. Then perform sufficient research around that hypothesis, using thresholds or trigger levels to increase or decrease the activity and investment over time. It is important to note that sensing and research are not R&D—they are preliminary steps in what will be a longer effort to determine an exponential force's potential for your business.
- **Exploration:** Through sensing and research, you have identified a few exponentials that look promising. At this point, you can begin exploring the "state of the possible" for each by looking at how others are approaching these forces, and determining if any of these approaches could apply broadly to your industry. Then convene around the "state of the practical:" Specifically, could these same approaches impact or benefit your business? If so, you can begin developing use cases for evaluating the "state of the valuable" in the experimentation phase.
- **Experimentation:** The move from exploration to experimentation involves prioritising business cases and building initial prototypes, doing in-the-workplace studies, and putting them into use. When the value proposition of the experiment meets the expectations set forth in your business case, then you can consider investing by moving into incubation. Be cautious, however, about moving too quickly from incubation to full production. Even with a solid business case and encouraging experiments with containable circumstances and uses, at this stage your product is not proven out at scale. You will likely need an incubator that has full scaling ability to carry out the level of enhancement, testing, and fixes needed before putting this product out into the world.
- **Be programmatic:** Taking any product—but particularly one grounded in exponential forces—from sensing to production is not a two-step process, nor is it an accidental process. Some think of innovation as nothing more than *eureka!* moments. While there is an element of that, innovation is more about programmatic disciplined effort, carried out over time, than it is about inspiration.

Finally, in your exponential journey you may encounter a common innovation challenge: The investment you will be making often yields less—at least initially—than the day-to-day approaches you have in place. This is part of the process. To keep things in perspective and to help everyone stay focused on end goals, you will likely need a methodical program that guides and accounts for the time and money you are spending. Without such a blueprint, innovation efforts often quickly become unsustainable.

Bottom line

Though the promise that nanotechnologies, energy systems, biotechnology, and quantum technologies hold for business is not yet fully defined, some if not all of these exponentials will likely create industry disruption in the next 24 to 60 months. As with other emerging technologies, there can be competitive opportunities for early adoption. CIOs, CTOs, and other executives can and should begin exploring exponentials' possibilities today.

CONTACTS

MARK LILLIE
Partner, CIO Programme lead
Deloitte MCS Limited
020 7007 2395
mlillie@deloitte.co.uk

STEPHEN MERCER
Head of Technology Consulting
Deloitte MCS Limited
0161 455 6836
stmercer@deloitte.co.uk

AUTHORS

MARK WHITE
US Innovation Office chief technologist, Deloitte Consulting LLP

TOM NASSIM
Deloitte Consulting Innovation senior manager, Deloitte Consulting LLP

JEFF CARBECK
Advanced Materials & Manufacturing practice specialist leader, Deloitte Consulting LLP

ASIF DHAR
Monitor Deloitte principal, Deloitte Consulting LLP

Biotechnology content developed in collaboration with **Jason Williamson**, executive director, XPRIZE. Williamson was previously a senior manager in Deloitte Consulting LLP's Innovation practice.

ENDNOTES

1. Bill Briggs, *Tech Trends 2014: Exponentials*, Deloitte University Press, February 20, 2014, https://dupress.deloitte.com/dup-us-en/focus/tech-trends/2014/2014-tech-trends-exponentials.html.
2. Tata Motors, http://nano.tatamotors.com/, accessed January 19, 2017.
3. The National Nanotechnology Initiative, www.nano.gov, accessed December 26, 2016.
4. Ibid.
5. Don Clark, "Intel details 14-nanometer chip aimed at tablets," *Wall Street Journal*, August 11, 2014, www.wsj.com/articles/intel-details-new-chip-aimed-at-tablets-1407775008.
6. Alliance for NanoHealth, www.nanohealthalliance.org, accessed December 26, 2016.
7. The National Nanotechnology Initiative.
8. NanoMech, www.nanomech.com, accessed December 26, 2016.
9. Ibid.
10. NanoMech, Products & services, www.nanomech.com/products-services/atomoil/, accessed December 26, 2016.
11. REN21 (Renewables Energy Policy Network for the 21st Century), *Renewables 2016: Global Status Report*, 2016, www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf, accessed December 26, 2016.
12. Tom Randall, "Wind and solar are crushing fossil fuels," *Bloomberg News*, April 6, 2016, www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels.
13. Bloomberg New Energy Finance, New Energy Outlook 2016, June 12, 2016, www.bloomberg.com/company/new-energy-outlook/.
14. Susan Kraemer, "Siemens figures out what to do with night wind," *CleanTechnica*, April 19, 2012, https://cleantechnica.com/2012/04/19/siemens-figures-out-what-to-do-with-night-wind/.
15. *Economist*, "Packing some power," March 3, 2012, www.economist.com/node/21548495.
16. Katie Fehrenbacher "An exclusive look at Tesla and Solar City's battery solar farm in paradise," *Fortune*, November 17, 2016, http://fortune.com/tesla-solarcity-battery-solar-farm/.
17. Katherine Tweed, "Toronto pilots world's first offshore compressed-air energy storage project," *Green Tech Media*, November 25, 2015, www.greentechmedia.com/articles/read/toronto-hydro-pilots-worlds-first-offshore-compressed-air-energy-storage.
18. Knvul Sheikh, "New concentrating tower is worth its salt with 24/7 power," *Scientific American*, July 14, 2016, www.scientificamerican.com/article/new-concentrating-solar-tower-is-worth-its-salt-with-24-7-power/.
19. Real Estate Japan K.K., "The present and future of net zero energy houses in Japan," August 6, 2015, http://resources.realestate.co.jp/buy/the-present-and-future-of-net-zero-energy-houses-in-japan/.
20. Convention on Biological Diversity, Text of the convention: Article 2, use of terms, www.cbd.int/convention/articles/default.shtml?a=cbd-02, accessed November 28, 2016.
21. Dani Bancroft, "Ultimate review: The unlimited biotech potential of algae," *GreenTech Reviews*, February 2, 2016, http://labiotech.eu/algae-review-industry-biotech-greentech-biofuels-nutrition-scrubbing/.
22. YourGenome, "What is CRISPR-Cas9?", www.yourgenome.org/facts/what-is-crispr-cas9, accessed December 26, 2016.

23. 1000 Genomes Project Consortium, "A map of human genome variation from population-scale sequencing," *Nature*, October 28, 2010, www.ncbi.nlm.nih.gov/pubmed/20981092?dopt=Abstract.

24. Heidi Ledford, "CRISPR: Gene editing is just the beginning," *Nature*, March 7, 2016, www.nature.com/news crispr-gene-editing-is-just-the-beginning-1.19510.

25. Emma Stoye, "CRISPR-edited mushroom dodges regulation," *Chemistry World*, April 26, 2016, www.chemistry-world.com/news/crispr-edited-mushroom-dodges-regulation/1010298.article.

26. Susan Noakes, "CRISPR gene editing heads to human trial as cancer treatment," CBC News, June 24, 2016, www.cbc.ca/news/health/human-trial-crispr-1.3651755.

27. National Institutes of Health, "Cancer costs projected to reach $128 billion in 2020," January 12, 2011, www.nih.gov/news-events/news-releases/cancer-costs-projected-reach-least-158-billion-2020.

28. Dylan Love, "From unbreakable codes to incredible computers, quantum technology is clearly the future," *Business Insider*, August 5, 2013, www.businessinsider.com/why-quantum-technology-matters-2013-7.

29. Chad Orzel, "Six things everyone should know about quantum physics," *Forbes*, July 8, 2015, www.forbes.com/sites/chadorzel/2015/07/08/six-things-everyone-should-know-about-quantum-physics/.

30. Nicole Hemsoth, "A look inside China's chart-topping new supercomputer," *Next Platform*, June 20, 2016, www.nextplatform.com/2016/06/20/look-inside-chinas-chart-topping-new-supercomputer/.

31. Jun-ichi Yoshikawa et al., "Generation of one-million-mode continuous-variable cluster state by unlimited time-domain multiplexing," APL Photonics, September 27, 2016, http://aip.scitation.org/doi/full/10.1063/1.4962732; Frank Wilczek, "Entanglement made simple," *Quanta Magazine*, April 28, 2016, www.quantamagazine.org/20160428-entanglement-made-simple/.

32. Peter Diamandis, "What are the implications of quantum computing?" *Tech Blog*, 2016, www.diamandis.com/blog/massive-disruption-quantum-computing, accessed December 31, 2016.

33. Thomas Haner, Damian S. Steiger, Mikhail Smelyanskiyy, and Matthias Troyer, *High performance emulation of quantum circuits*, April 2016, https://arxiv.org/pdf/1604.06460.pdf.

34. D-Wave Systems Inc., "Applications," www.dwavesys.com/quantum-computing/applications, accessed December 6, 2016.

35. Project on Emerging Nanotechnologies, www.nanotechproject.org/inventories/medicine/, accessed October 10, 2016.

AUTHORS

Executive editor

BILL BRIGGS
Global and US chief technology officer
Deloitte Consulting LLP
wbriggs@deloitte.com | Twitter: @wbdthree

Bill Briggs' 18+ years with Deloitte have been spent delivering complex transformation programs for clients in a variety of industries—including financial services, health care, consumer products, telecommunications, energy, and public sector. He is a strategist with deep implementation experience, helping clients anticipate the impact that new and emerging technologies may have on their business in the future—and getting there from the realities of today.

In his role as CTO, Briggs is responsible for research, eminence, and innovation—helping to define and execute the vision for Deloitte Consulting LLP's technology practice, identifying and communicating those technology trends affecting clients' businesses, and driving the strategy for Deloitte Consulting's evolving technology services and offerings.

As the founding global leader of Deloitte Digital, Briggs was responsible for the launch and growth of a new global practice redefining the vision of a digital consulting agency. Deloitte Digital offers a mix of creative, strategy, user experience, engineering talent, and technology services to help clients harness disruptive digital technologies to imagine, deliver, and run the future—to engage differently with customers, reshape how work gets done, and rethink the very core of their markets.

Briggs earned his undergraduate degree in Computer Engineering from the University of Notre Dame, and his MBA from the Kellogg School of Management at Northwestern University.

Cyber implications authors

ADNAN AMJAD

Cyber threat management leader
Deloitte & Touche LLP

Amjad serves as the cyber threat management leader for Deloitte & Touche LLP. This includes responsibility for cybersecurity strategy development, vulnerability management, security operations and critical infrastructure protection. Amjad's client base includes some of Deloitte's largest clients in the energy, financial services, and telecom sectors. In his role, Amjad interacts and liaises with academia, industry trade associations, media outlets, and global law enforcement agencies on issues related to cybersecurity.

ED POWERS

US national managing principal, Cyber Risk
Deloitte & Touche LLP

Powers is the national market offering leader for Deloitte's Cyber Risk Services practice, which helps complex organisations establish Secure.Vigilant.Resilient.™ programs to achieve strategic growth objectives in the face of increasingly sophisticated cyber threats. Under his leadership, the practice has been recognised by major analysts as the leader in cyber risk and security consulting.

IRFAN SAIF

US Advisory leader, Technology
Deloitte & Touche LLP

Saif is an advisory principal with Deloitte and Touche LLP. He has over 20 years of IT consulting experience and specialises in cyber security and risk management. Saif serves as the US Technology industry leader for Deloitte's Advisory business and is a member of Deloitte's CIO program and Cyber Risk practice leadership teams. He serves many of the firm's largest clients, helping them to be secure, vigilant, and resilient through the planning, design, and implementation of robust strategies, business processes, and technology solutions.

Chapter authors

IT UNBOUNDED

Tim Boehm
Application Management Services principal
Deloitte Consulting LLP
tboehm@deloitte.com

Martin Kamen
Human Capital IT Transformation leader
Deloitte Consulting LLP
mkamen@deloitte.com

Anthony Stephan
US Technology Strategy and Architecture leader
Deloitte Consulting LLP
astephan@deloitte.com

Atilla Terzioglu
Technology Strategy and Architecture principal
Deloitte Consulting LLP
aterzioglu@deloitte.com

DARK ANALYTICS

Tracie Kambies
US Retail Analytics & Information Management and IoT leader
Deloitte Consulting LLP
tkambies@deloitte.com

Nitin Mittal
US Analytics + Information Management leader
Deloitte Consulting LLP
nmittal@deloitte.com

Paul Roma
Deloitte Analytics leader
Deloitte Consulting LLP
proma@deloitte.com

Sandeep Kumar Sharma, Ph.D.
Deputy chief technology officer
Deloitte Consulting LLP
sandeepksharma@deloitte.com

INEVITABLE ARCHITECTURE

Ranjit Bawa
US Technology Cloud leader
Deloitte Consulting LLP
rbawa@deloitte.com

Scott Buchholz
Federal chief technology officer
Deloitte Consulting LLP
sbuchholz@deloitte.com

Ken Corless
Technology Strategy and Architecture principal
Deloitte Consulting LLP
kcorless@deloitte.com

Jacques de Villiers
Cloud Services director
Deloitte Consulting LLP
jadevilliers@deloitte.com

Evan Kaliner
Solutions Network practice leader
Deloitte Consulting LLP
ekaliner@deloitte.com

EVERYTHING-AS-A-SERVICE

George Collins
Deloitte Digital chief technology officer
Deloitte Consulting LLP
georgecollins@deloitte.com

Gordon Aspin
US Systems and Platform Integration leader
Deloitte Consulting LLP
gaspin@deloitte.com

Marlin Metzger
Application Modernisation practice leader
Deloitte Consulting LLP
mmetzger@deloitte.com

Pavel Krumkachev
Technology principal
Deloitte Consulting LLP
pkrumkachev@deloitte.com

Scott Radeztsky
US deputy chief technology officer
Deloitte Consulting LLP
sradeztsky@deloitte.com

Srivats Srinivasan
SAP principal
Deloitte Consulting LLP
srisrinivasan@deloitte.com

MACHINE INTELLIGENCE

Peter Lowes
Global Business Services principal
Deloitte Consulting LLP
plowes@deloitte.com

Nitin Mittal
US Analytics + Information Management leader
Deloitte Consulting LLP
nmittal@deloitte.com

Rajeev Ronanki
Cognitive computing and Health Care
Innovation practice leader
Deloitte Consulting LLP
rronanki@deloitte.com

Sandeep Kumar Sharma, Ph.D.
Deputy chief technology officer
Deloitte Consulting LLP
sandeepksharma@deloitte.com

Jerry Wen
Technology strategy and architecture
managing director
Deloitte Consulting LLP
jwen@deloitte.com

MIXED REALITY

Nelson Kunkel
Deloitte Digital national creative director
Deloitte Consulting LLP
nkunkel@deloitte.com

Steve Soechtig
Digital Experience practice leader
Deloitte Consulting LLP
ssoechtig@deloitte.com

BLOCKCHAIN: TRUST ECONOMY

Gys Hyman
Deloitte Digital principal
Deloitte Consulting LLP
gyshyman@deloitte.com

Eric Piscini
Banking and technology strategy
and architecture principal
Deloitte Consulting LLP
episcini@deloitte.com

Wendy Henry
Federal Systems Integration specialist leader
Deloitte Consulting LLP
wehenry@deloitte.com

EXPONENTIALS WATCH LIST

Jeff Carbeck
Advanced Materials and
Manufacturing specialist leader
Deloitte Consulting LLP
jcarbeck@deloitte.com

Asif Dhar
Chief health informatics officer
Deloitte Consulting LLP
adhar@deloitte.com

Tom Nassim
Ecosystems and Exponentials leader
Deloitte Consulting LLP
tnassim@deloitte.com

Mark White
Principal and US Innovation
Office chief technologist
Deloitte Consulting LLP
mawhite@deloitte.com

CONTRIBUTORS

Tony Andraos, Thomas Beck, Amy Bergstrom, Melissa Bingham, Jason Bowers, JT Brooks, Kevin Carter, Rajeswari Chandrasekaran, Amit Chaudhary, Kumar Chebrolu, Dominic Conde, Gillian Crossan, David Cruz, Doug Dannemiller, Matt David, Tony Demarinis, Mark Frank, Ryan Gervais, John Henry, Erica Holley, Lisa Iliff, Junko Kaji, Khalid Kark, Mark Kay, Ratul Kislaya, Ofek Lavian, Dawn Leach, Andrew Luedke, Dzmitry Maroz, Elina Melnikov, Nicholas Merizzi, Devon Mychal, Jayson Nath, Keara O'Brien, Doorlabh Panjwani, Ann Perrin, Florian Quarré, Turner Roach, Chris Rose, Andrew Ryscavage, Fatema Samiwala, Rachel Schwartz, Daniel Simmonds, Scott Sognefest, Richard Tisch, Kyle Viger, Jeff Walker, Savy Welch

RESEARCH TEAM

Leads: Rachel Bruns, Tom Carroll, Michael Davis, Al Dea, Inez Foong, Karthik Kumar, Alyssa Long, Jenny Zheng

Team members: Shelby Baker, Jasjit Bal, Jackie Barr, Daniel Beckerman, Gokul Bhaghavantha Rao, Annas Bin Adil, Arushi Bisen, Nick Boncich, Matt Butler, Alice Chien, Aaron Chu, Cassidy Clark, Sean Cremins, Deverau Denton, Roman Diaz, Binh Doan, Aminah Fawad, Alex Feiszli, Prakhar Goel, Sam Greenlief, Grace Ha, Rachel Halvordson, Lilian Hoang, Yili Jiang, Jasneet Kanwar, Solomon Kassa, Brooke Kennedy, Ava Kong, Varun Kumar, Anthony Lim, Luke Liu, Andrea Lora, Joe Manavalan, J.R. Mauricio, Talia O'Brien, Deepak Padmanabhan, Sarita Patankar, Ellie Peck, Akshai Prakash, Andrea Reiner, Katrina Rudisel, Brittney Shkil, Kyriakos Sotos, Cabell Spicer, Jenna Swinney, Ryan Sword, Nicholas Tawse, Mike Turco, Meera Valliath, Casey Volanth, Myette Ware, Jaclyn Williams, Christopher Yun

SPECIAL THANKS

Mariahna Moore for returning to your post leading our *Tech Trends* family. You somehow continue to do the impossible—raising an already unbelievably high bar. *Tech Trends* simply wouldn't happen without your leadership, drive, calm, patience, and perseverance.

Doug McWhirter for your tireless brilliance, turning research, interviews, and raw thinking into beautifully written and blindingly insightful prose. Your writing prowess is as appreciated as your editorial lens, forming *Tech Trends*' voice.

Dana Kublin for your singular brilliance, while piling on the indispensable hats as the OCTO creative director, design lead, infographics guru, agency liaison, and product owner. Your creative vision has become a signature part of *Tech Trends*.

Maria Gutierrez for continuing your rock-star ways, even while working on a much more amazing deliverable. You've become a consigliere for not just *Tech Trends* but our broader tech positioning—blazing new trails and pushing our definition of success.

Scott Radeztsky for joining the *Tech Trends* fray, helping shape our topics and perspectives, serving as a chapter SME in his inaugural year, and stepping up and stepping in wherever was needed to get us to the finish line. Looking forward to passing on the *Trends* baton in years to come.

Amy Booth for stepping in and more than filling big shoes, doing an excellent job driving our *Tech Trends* videos and helping evolve our broader marketing mission.

Ellen Kauffman for the second year wowing us all, making a huge impact on the OCTO and *Tech Trends*. You will be missed, but good luck on the adventures to come.

Sarah Frazee, **Stefanie Heng**, **Mary Hughes**, **Patricia Staino**, and **Melissa Doody** for the unbelievable impact made in your first year of Tech Trending—diving in to help wherever needed, and writing, designing, shaping, and improving our content. It is truly an honor to work with such an awesome, talented team.

Mitch Derman for your help with our wonderful "Five Minutes On" videos and internal communications.

Matthew Budman, **Troy Bishop, Emily Moreano**, and the tremendous Deloitte University Press team. Each year you manage to up your game, exceeding expectations even more. Thanks for your expertise and collaboration in pushing *Tech Trends* to even bolder heights.

 Follow @DeloitteOnTech

dupress.deloitte.com/tech-trends

Deloitte.
University Press

 Follow @DU_Press

Sign up for Deloitte University Press updates at www.dupress.deloitte.com.

About Deloitte University Press
Deloitte University Press publishes original articles, reports and periodicals that provide insights for businesses, the public sector and NGOs. Our goal is to draw upon research and experience from throughout our professional services organization, and that of coauthors in academia and business, to advance the conversation on a broad spectrum of topics of interest to executives and government leaders.

Deloitte University Press is an imprint of Deloitte Development LLC.