A Consumer Products Perspective

Tech Trends 2014

Inspiring Disruption

Deloitte University Press

Contents

Introduction

WELCOME to Deloitte's fifth annual *Technology Trends* report. Each year, we study the ever evolving technology landscape, focusing on disruptive trends that are transforming business, government, and society. Once again, we've selected 10 topics that have the opportunity to impact organizations across industries, geographies, and sizes over the next 18 to 24 months. The theme of this year's report is *Inspiring Disruption.*

In it, we discuss 10 trends that exemplify the unprecedented potential for emerging technologies to reshape how work gets done, how businesses grow, and how markets and industries evolve. These disruptive technologies challenge CIOs to anticipate their potential organizational impacts. And while today's demands are by no means trivial, the trends we describe offer CIOs the opportunity to shape tomorrow—to inspire others, to create value, and to transform "business as usual."

The list of trends is developed using an ongoing process of primary and secondary research that involves:

- Feedback from client executives on current and future priorities
- Perspectives from industry and academic luminaries
- Research by alliance partners, industry analysts, and competitor positioning
- Crowdsourced ideas and examples from our global network of practitioners

As in prior years, we've organized the trends into two categories. Disruptors are areas that can create sustainable positive disruption in IT capabilities, business operations, and sometimes even business models. Enablers are technologies in which many CIOs have already invested time and effort, but that warrant another look because of new developments, new capabilities, or new potential use cases. Each trend is presented with multiple examples of adoption to show the trend at work. This year, we've added a longer-form *Lesson from the front lines* to each chapter to offer a more detailed look at an early use case. Also, each chapter includes a personal point of view in the *My take* section.

Information technology continues to be dominated by five forces: analytics, mobile, social, cloud, and cyber. Their continuing impact is highlighted in chapters dedicated to wearables, cloud orchestration, social activation, and cognitive analytics. Cyber is a recurring thread throughout the report: more important than ever, but embedded into thinking about how to be secure, vigilant, and resilient in approaching disruptive technologies.

For the first time, we've added a section dedicated to exponential technologies, working with Singularity University to highlight five innovative technologies that may take longer than our standard 24-month time horizon for businesses to harness them—but whose eventual impact may be profound. Examples include artificial intelligence, robotics, and additive manufacturing (3-D printing). The research, experimentation, and invention behind these "exponentials" are the building blocks for many of our technology trends. Our goal is to provide a high-level introduction to each exponential—a snapshot of what it is, where it comes from, and where it's going.

From a Consumer Products lens, we provided industry sector specific perspective on majority of the topics including CIO as a venture capitalist (how to leverage brand categories perspective for portfolio planning), crowdsourcing (specific strategies including crowdfunding, flexible workforce and data analysis contests), wearables (discussing the Empowered Employee and the Persistently Connected Consumer) and digital engagement (Omnichannel Brand Engagement, Ubiquitous Sensors and other topics).

Each of the 2014 trends is relevant today. Each has significant momentum and potential to make a business impact. And each warrants timely consideration—even if the strategy is to wait and see. But whatever you do, don't be caught unaware—or unprepared. Use these forces to inspire, to transform. And to disrupt.

We welcome your comments, questions, and feedback. And a sincere "thank you" to the many executives and organizations that have helped provide input for Tech Trends 2014; your time and insights were invaluable. We look forward to your continued innovation, impact, and inspiration.

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Enablers

Cloud orchestration

From cloud to clouds (to core)

Cloud adoption across the enterprise is a growing reality, but much of the usage is in addition to on-premises systems—not in replacement. As cloud services continue to expand, companies are increasingly connecting cloud-to-cloud and cloud-to-core systems—in strings, clusters, storms, and more—cobbling together discrete services for an end-to-end business process. Tactical adoption of cloud is giving way to the need for a coordinated, orchestrated strategy—and for a new class of cloud offerings built around business outcomes.

CLOUD adoption across the enterprise is a growing reality. Forrester predicted that "by the end of 2013, enterprises will use an average of 9.6 software-as-a-service (SaaS) applications."[1] Yet much of the cloud usage is not in lieu of on-premises enterprise systems. Forrester also found that "only 18 percent of the enterprises that were first-wave adopters and less than 9 percent of the second-wave adopters have used SaaS as a full replacement."[2] As a result, these cloud services increasingly require integration back to core internal systems—linking edge offerings to legacy financials, order management, inventory, HR, manufacturing, and other enterprise systems. Companies are connecting clouds—in strings, clusters, storms, and more—and cobbling together discrete services to create end-to-end business processes. Tactical adoption of cloud is giving way to the need for a coordinated, orchestrated strategy.

As cloud services continue to expand in number and sophistication, gaps in managing cloud-to-cloud and cloud-to-core portfolios are beginning to appear, leading to new and smarter ways to operate in this hyper-hybrid[3] IT environment. It is also opening the door for a new category of offerings: pre-integrated and orchestrated cloud offerings delivering higher-order business outcomes-as-a-service.

All together now

Integration, data management, and enterprise architecture have long been aspirations for IT. With cloud, these practices have become more complex. And they've shifted from leading practices to critical core disciplines. Integration stability and reliability was the number two challenge in a recent survey on cloud adoption, trailing only security concerns.[4] Virtually every enterprise should be developing a strategy on how to integrate, aggregate, and orchestrate its collection of cloud and on-premises assets. Understanding the extensibility, portability, and reliability of a cloud service should begin at the sourcing stage.

- Extensibility refers to the ability to get information into and out of the service—the availability of data and transactions to be invoked by other parties and the ability to trigger external events from within the cloud service. Many cloud providers offer lightweight web services and RESTful[5] interfaces, but it's important to review the assets around APIs and data structures—documentation, toolkits, testing harnesses, backward compatibility, and deprecation policies.

- Portability represents the ease of migrating your business from the cloud service. Can data be exported? What about customized business logic? Are there contractual terms associated with intellectual property ownership?

- Reliability addresses performance of the service—not just the core cloud offering, but the surrounding stack. For an orchestrated process, the integration layer and dependencies on legacy systems should be able to scale dynamically to take advantage of the elasticity of cloud services. The end-to-end business process is only as strong as its weakest link.

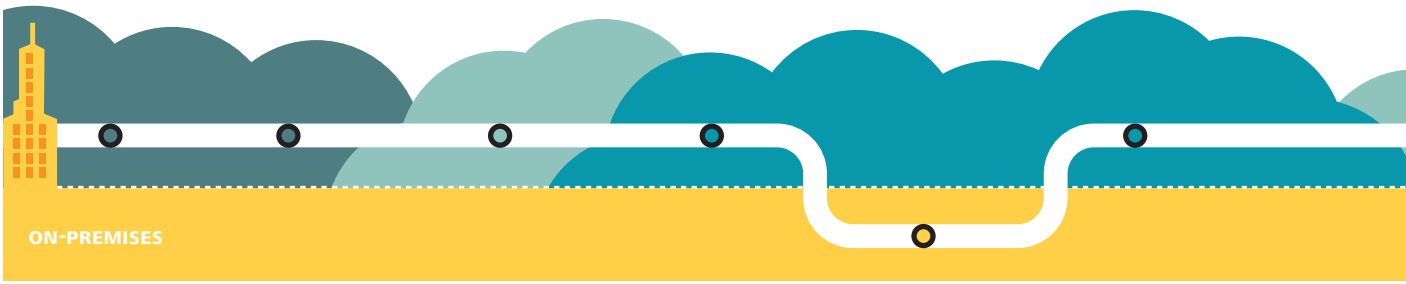
Cloud orchestration can build from a mature enterprise integration and architecture footprint. The underlying tenets are familiar: service orientation, data correlation, security services (especially authentication, entitlement management, and encryption), and a separation of business logic. Several integration platforms have emerged from the cloud, offering cloud-based deployment options as well as preconfigured connectors and integration patterns for popular cloud services. Providers include Boomi, CastIron, MuleSoft, and TIBCO's Cloud Bus.

New beginnings

The cloud provider market is starting to address the desire for higher-level, pre-integrated cloud orchestration services. For example, consider the example of a health plan's recruiting and HR service. Today, health plans contract with separate cloud providers for résumé sourcing, background checks, on-boarding, benefits, payroll, and performance management—which means they need to develop and maintain point-to-point interfaces between the various players to enable the full prospect-to-employee lifecycle. They are waiting for an end-to-end "hire to retire" service to emerge, which could provide contracting, configuration, and handoffs across various systems. The enterprise could subscribe to a single service, priced based on usage or, in an ideal world, on outcomes.

Traditional ERP players are acquiring and integrating cloud applications to supplement core offerings. Established cloud providers are

Tracking a business transaction in the cloud and core



INTEREST
A tweet in a new marketing campaign elicits a customer response.

LEAD
The customer requests a demo and receives an email from the company.

OPPORTUNITY
A marketing rep assigns the lead to a sales rep for review.

QUOTE
The sales rep creates a quote and converts the lead to a new account.

CREDIT
A collections agent performs a credit check and assigns a credit limit.

CONTRACT
With approval from the sales manager, the sales rep creates a contract.

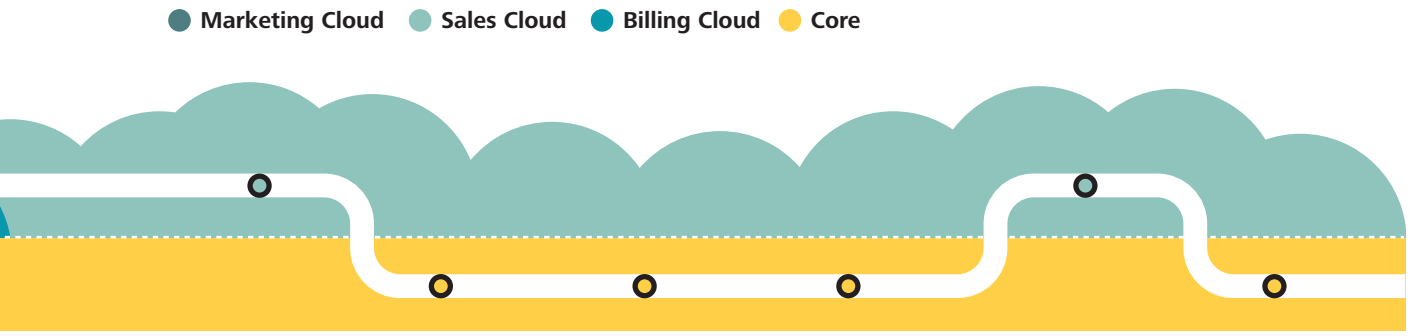
creating storefronts of complementary cloud solutions, which make choosing and buying an expanding inventory of services easier. But we are still in the early days of this expansion, and integration often remains the buyer's problem. Over time, technical compatibility within a vendor's stack should become less challenging. ERP and cloud providers are also planning improved interoperability between their products[6]—an encouraging development, to be sure, but of little help in the immediate term.

Others may yet enter the cloud orchestration market. Systems integrators and professional services firms that specialize in integrating diverse systems could expand and formalize their roles by pre-integrating the components of an end-to-end bundle. For such organizations, this may offer a way to monetize intellectual property around industry and process experience while diversifying from consulting to a product revenue stream. Several high-tech players looking to expand their offerings could emerge, such as Amazon, Google, HP, and Microsoft.

A brave new world

The initial market for effective cloud orchestration is likely to be startups and small- to medium-sized businesses. They could receive the benefits of one-stop access without the hassle of navigating vendor contracts, integrating systems, and managing data. Larger businesses in emerging markets are also natural targets. Like startups, their circumstances may not justify a full enterprise solution. Finally, serial acquirers could gain agility and advantage from being able to integrate diverse platforms more efficiently. In each case, IT's mission should be to create integration, data management, and security services to guide cloud adoption.

But the majority of the Fortune 1000 will be living with the reality of a mix of cloud and core offerings, even as sophisticated cloud orchestration emerges. IT's charter to own cloud integration, data, and security is even more important in this case—especially as businesses are increasingly dependent on hybrid operating environments. Build the components to orchestrate the cloud today, and you'll be ready to adopt more compelling services as the market develops.



ORDER
The sales rep closes the opportunity and initiates order fulfillment.

PROVISIONS
The provision manager creates license keys for the customer.

BILLING
The customer receives an invoice and serial keys from the collections agent.

PAYMENT
The collections agent follows up with the customer about payment.

REQUEST
The customer has a customer service request.

SERVICE
A service rep responds to the request and then resolves the case.

Lessons from the front lines

Linking the network[7]

LinkedIn, a social networking website, has three main enterprise lines of business: talent solutions, marketing solutions, and sales solutions. As Andres Bang, LinkedIn's head of global sales and operations systems, described recently: The company adopted cloud services to support sales and CRM functions, but found that its business was outgrowing standard out-of-the-box capabilities and that its processes increasingly required integration to ERP and proprietary systems for generating sales leads.

To address its immediate lead-to-cash process requirements, and to build a scalable solution for future orchestration, LinkedIn adopted a cloud-based integration platform. Bang explains that by using the integration platform, LinkedIn was able to connect multiple systems, including its lead generation tool, CRM system, financial system, data warehouse, and proprietary applications. Integrating both its cloud-based and on-premises systems created a "single pane of glass" for the company's salespeople to access the information they need to perform their jobs.

Orchestrated banking[8]

SunTrust Banks, a leading US financial services holding company, found that its relationship managers were encountering issues with accessing customer information in a timely manner, threatening their ability to provide quality customer service. The root of the issue was the company's reliance on an assortment of back-end systems for loan origination, underwriting, servicing, and CRM. SunTrust's architecture was a mix of cloud services, on-premises packaged software, and on-premises custom solutions. The company sought an integrated, scalable solution to expedite the delivery of services to customers—and pave the way for future cloud adoption.

The bank decided to adopt a cloud-based integration platform to address these challenges. By connecting SunTrust's back-end enterprise application and shared services to the cloud, SunTrust was able to eliminate its complex back-end business processes. Furthermore, the cloud enabled seamless integration with the bank's enterprise service bus and provided preconfigured connectors to cloud services.

Today, SunTrust maintains a scalable solution supporting its broader business process transformation. Furthermore, relationship managers are empowered with the tools and resources to access important customer information in a timely manner, reducing the time it takes to provide service to customers.

Hybrid high tech

A global hardware and software company was undergoing rapid change stemming from acquisitions, organic growth, and divestitures. The company's goal? To maintain its core hardware and product businesses while expanding its software and services offerings. The company's expansion introduced complexity in many areas, such as marketing, sales and incentive management, product configuration, pricing, and project and workflow management. Speed to market was a driving force, since the organization wanted to engage with customers from dozens of countries in a consistent and coordinated manner. The company also recognized that its strategy was built around continual transformation of its offerings—and that required flexibility and agility in the enabling systems.

The organization was vexed by decades of what it called "lumpy" expenditures—costly IT infrastructure refresh cycles, with a history of overspending for capacity because of unpredictable demand. But the concern was about more than cost and scale. The company also sought shorter time to market and the ability to more efficiently assimilate new ventures. This was important, given its recent wave of acquisitions.

The company's vision is to move to a 100 percent cloud-based infrastructure for the enterprise. As a first step in fulfilling this vision, and to continue to provide seamless, end-to-end business processes, the organization orchestrated a complex integration between multiple cloud services and its on-premises systems. A new sale requires smooth interaction between separate cloud systems for many processes: calendaring and messaging; materials development; lead and campaign management; opportunity, sales, and support management; configuration, pricing, and quoting services; sales and support management; and compensation and incentives. The integration enabled these systems to communicate with each other, and it also included hooks into on-premises systems for human resources and order and billing management. Recognizing that the glue to bring together the various services was as important as the individual functionality being delivered, the company created disciplines around cloud-to-cloud and cloud-to-core integration: tools, architectural standards, and a dedicated team to drive growth and adoption.

Through the company's efforts, maintenance costs have gone down: Instead of heavily funding incremental software improvements, the company is taking advantage of enhancements being rolled out by the cloud services. System performance has improved; outages have become shorter and less frequent. The company's global teams have enjoyed greater browser and device compatibility, as the cloud offerings have a wider footprint than was historically allowed. And the business feels better served by IT: IT's responsiveness has improved, as has the business's understanding of associated costs. Finally, the company has started to take the next step toward the overall vision by shifting to cloud hosting of traditional ERP to "rightsize" the underlying infrastructure—a solution that can scale up (or down) based on the company's circumstances.

Espresso with a shot of cloud[9]

Online distribution channels have transformed Nestlé Nespresso S. A. from a traditional, coffee-shop-and-boutique-store business model to a household brand in the single-serving coffee machine category. But in order to meet growing global customer demand, Nespresso needed to replace its home-grown, complex ERP system with a more scalable architecture and integrated cloud solution.

The business began enhancing its enterprise architecture by launching the Nespresso Open Architecture (NesOA) platform, a tool designed from service-oriented architecture (SOA) principles. With NesOA, Nespresso's IT department could support new distribution channels, manage increased consumer traffic, and introduce new applications and services to the business. Furthermore, by using a cloud-based integration platform, Nespresso could easily integrate a variety of systems, including the Nessoft ERP system, an interactive voice response system, an automated warehouse management system, and an emergency ordering tool.

As a result, Nespresso's NesOA transformed its home-grown enterprise into a scalable, automated, and more efficient solution to meet business needs. Furthermore, it mitigated the risk of disruption from a single point of failure with a solution based on clustering and redundancies. Nespresso is now poised to leverage cloud and traditional solution offerings to support future growth of its IT system landscape.

My take

Dounia Lievan, former banking executive
Director, Deloitte Consulting LLP

I formerly worked for a regional bank that generated the majority of its revenue from mortgage banking. The bank looked to diversify by focusing on both the retail and commercial banking lines of business. We recognized that we could drive immediate revenue in retail by elevating the customer experience at the point of sale. The longer-term goal was an integrated omnichannel experience driven by online and mobile capabilities, but initially the case for change was to better serve our customers in the branch—knowing that the technology we implemented could provide a solid foundation for our "connected customer" vision.

Previously, the process for opening an account with related services was lengthy and inefficient. Employees accessed multiple systems and entered duplicative data. In addition, we didn't provide bankers with tools or insight to identify customer needs, and we lacked an automated way to manage the ongoing customer relationship. To improve the experience for both the customer and banker, and with an eye toward the broader vision, we invested in a customizable cloud solution with native customer relationship management (CRM) capabilities. It provided one delivery system for branch bankers with increased flexibility, support for process improvement, and the option for future expansion across channels.

We chose to go to the cloud for several reasons: to generate revenue, to increase efficiency, to be agile enough to respond to changes in the marketplace, and to differentiate ourselves from our competitors—while reducing the burden on the IT organization. Cost factored into, but didn't dominate, the investment decision.

Our legacy systems didn't provide the functionality needed to solve the business problem, so we used the cloud and SaaS to connect multiple core and ancillary systems. Integration isn't a new concept, but with the cloud, a balance has to be struck between traditional methodologies and the flexibility that the cloud can introduce. Looking back, there are a few things we might have done differently, such as creating more real-time APIs versus batched transfers. But, overall, the project laid the groundwork for the longer journey.

During the course of the project, and especially after go live, the cloud changed how IT and the business work together. It drove collaboration and created a new team with an enhanced skill set and a different mindset. They're no longer completing a stand-alone project and moving on, but dedicated to driving continuous improvement and evolving the platform to deliver business results.

As you take the cloud integration journey, executive sponsorship and building enterprise support are key success factors. Create a strategic roadmap, and articulate your plans two to three years out. Upon completing the first phase, showcase the solution and use the roadmap to sell the vision to the C-Suite and across business lines. Provide regular updates on adoption metrics, user feedback, progress toward change, and—more importantly—return on investment. This keeps the platform top of mind and makes it easier to gain support to grow the platform and enhance its value.

As business leaders, we look for ways to drive revenue and efficiency, continuously creating value. At the heart of the banking business is the relationship we have with our customers, and building trust is the foundation of that relationship. What I love about this technology is that we used it to remove compliance and operational obstacles and gave bankers the tools they need to be effective and efficient. We used technology to enable bankers to be present, listen, ask questions, and help people—to make a stronger human connection.

Where do you start?

EVEN with the more sophisticated cloud offerings that span end-to-end processes, the challenge of integrating cloud-to-core remains. How does the CIO manage the definition of standards for cloud adoption? Establish architecture to support integration? Handle data correlation, retention, and migration? These are important questions to answer now—and they'll be even more important as cloud services spread across the enterprise. CIOs should be making deliberate investments in developing advanced integration and data management capabilities to support a cloud-to-cloud-to-core model.

- **Petition for a new cloud business model.** Many companies could save money if cloud pricing was based on usage and outcomes rather than licensing fees. If this is true for your organization, let the cloud providers know. And if your company is ready for an orchestrated cloud option now, connect with others who share your need. Let your voices be heard by the software vendor community.

- **Build an integration foundation.** Even if your organization doesn't operate in a cloud-to-core environment, it's likely you eventually will. Laying the groundwork now will make integration easier later. If you've already invested in middleware to link legacy systems, build from there. However, you may find that a cloud-based model requires new approaches.

- **Connect the dots.** Definitions of customer, product, employee, and other data elements vary from one cloud solution to another—and need to be mapped to your business's semantics and taxonomy. Understand how each application defines its dataset, and develop a strategy for funneling data from various cloud systems to support your organization's reporting and analytic objectives.

- **Read the fine print.** Develop a healthy skepticism of cloud provider contracts. Understand your rights to data ownership, portability, and migration. If you change providers, can you be confident that your data is protected? Negotiate terms where possible to maintain your flexibility.

- **Build a strong chain.** Overall business performance is limited by the weakest cloud solution in the process chain. Understand the performance variability your business will tolerate, and weigh whether each individual cloud service can meet those demands. And remember: The scalability and performance of the interconnected whole is only as strong as its weakest link. Cloud's elasticity could stress (and break) legacy solutions built around more modest, predictable requirements. Cloud-based integration platforms ramp up (or down) to meet your needs—similar to the cloud offerings you are looking to orchestrate.

- **Explore edge architecture.** Borrowing from the days of SOA, consider describing business capabilities and processes as services. The goal is to connect enterprise core, private, and public cloud offerings—which can be broken into a common set of services used to deliver on business needs. This will lead to deliberate identification and management of business rules, APIs, identities and personas, entitlements, workflow items, and interfaces. The goal is to promote reuse, standards adoption, and architectural integrity—from a business-driven mindset. A revamped IT delivery model will likely be needed, as will support from both IT and business executives for a new governance mindset.

Bottom line

As enterprises use disparate cloud offerings to handle critical business processes, the desire to link these offerings to core legacy systems and data grows. IT organizations will be asked to provide that orchestration. A recent Gartner survey shows that "over 70 percent of organizations that are using or planning to use cloud services expect internal IT organizations to assume the role of cloud services broker."[10] That need has generated challenges that extend beyond integration to include security, data integrity and reliability, and business rules for managing a hybrid state. It is also creating demand for cloud orchestration to link multiple cloud services to each other—and to the core. CIOs who have the disciplines of data management and integration architecture in place will be positioned to create harmony out of the existing landscape and to leverage orchestration services when they arrive.

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Endnotes

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Exponentials

One more thing . . .

EACH year, this report analyzes trends in technology put to business use. To be included, a topic should clearly demonstrate its potential to impact businesses in the next 18 to 24 months. We also require a handful of concrete examples that demonstrate how organizations have put the trend to work—either as early adoption of the concept or "bread crumbs" that point toward the fully realized opportunity. Our criteria for choosing trends keeps us on the practical side of provocative, as each trend is relevant today and exhibits clear, growing momentum. We encourage executives to explore these concepts and feed them into this year's planning cycle. Not every topic warrants immediate investment. However, enough have demonstrated potential impact to justify a deeper look.

Because we focus on the nearer-term horizon, our *Technology Trends* report typically only hints at broader disruptive technology forces. This year, in collaboration with leading researchers at Singularity University, we have added this section on "exponential" technologies, the core area of research and focus at Singularity University. The fields we chose to cover have far-reaching, transformative impact and represent the elemental advances that have formed technology trends both this year and in the past. In this section, we explore five exponentials with wide-ranging impact across geographies and industries: artificial intelligence, robotics, cyber security, additive manufacturing, and advanced computing.

In these pages we provide a high-level introduction to each exponential—a snapshot of what it is, where it comes from, and where it's going. Each exponential stems from many fields of study and torrents of research. Our goal is to drive awareness and inspire our readers to learn more. Many of these exponentials will likely create industry disruption in 24 months or more, but there can be competitive opportunities for early adoption. At a minimum, we feel executives can begin contemplating how their organizations can embrace exponentials to drive innovation. Exponentials represent unprecedented opportunities as well as existential threats. Don't get caught unaware—or unprepared.

My take

Peter H. Diamandis, MD
Co-founder and executive chairman, Singularity University
Chairman & CEO, XPRIZE Foundation
Author, *Abundance: The future is better than you think*

In 2012 the world experienced what I call "the new Kodak moment." A moment in time when an exponential technology put a linear thinking company out of business. Kodak, the company that invented the digital camera in 1976, and had grown to a 145,000-person,[1] 28-billion-dollar global company at its peak, ultimately filed for bankruptcy in 2012 as it was put out of business by the exponential technology of digital imagery. In stark contrast, another company—also in the digital imagery business—called Instagram, was acquired in that same year by Facebook for $1 billion. Instagram's headcount: 13 employees.

These moments are going to be the norm as exponentially thinking startups replace linear businesses with unprecedented products and services. Although a daunting challenge, exponential technologies offer extraordinary opportunities to the businesses that can keep pace with them.

The lessons learned from Kodak are the consequences of failing to keep up with what I call the "six Ds." The first D is digitization. Technology that becomes digitized hops on Moore's Law and begins its march up the exponential growth curve. Like many companies, Kodak was blindsided by the next D—deceptive growth. When a product, such as imagery, becomes digitized, it jumps from a linear path to an exponential trajectory. The challenge is that early exponential doublings are deceptive. The first Kodak digital camera was only 0.01 megapixels. Even though it was doubling every year, when you double 0.01, to 0.02, 0.04, 0.08, 0.16, this doubling of small numbers near zero looks to the mind like linear growth, and is dismissed. It's only when you continue forward past what is called the "knee of the curve" that it begins to change. Double seven times from "1" and you get to 128. Twenty-three more doublings (a total of 30) gets you to 1 billion. Business leaders often perceive the early stages as slow, linear progress. Until, of course, the trend hits the third D—disruption.

By the time a company's product or service is disrupted, it is difficult to catch up. Disruptive growth ultimately leads to the last three Ds—dematerialization, demonetization, and democratization, which can fundamentally change the market. The smartphone in your pocket has *dematerialized* many physical products by providing their virtual equivalents—a GPS receiver in your car, books, music, and even flashlights. Once these equivalents gain market traction, the established product's commercial value can plummet. It becomes *demonetized*. iTunes®,[2] for example, is impacting the value of record stores. eBay is doing the same to specialty retailers. Craigslist has stripped newspapers of classified advertising revenue. Once products become dematerialized and demonetized, they become *democratized*—spreading around the world through the billions of connected devices we carry around.

Many business leaders confront exponentials with a stress mindset. They realize that the odds of survival aren't great. Babson College noted that 40 percent of the Fortune 500 companies in 2000 didn't exist 10 years later.[3] However, the other side of the coin is an abundance mindset—awareness of the limitless opportunity. Between now and 2020, the world's population of digitally connected people will jump from two to five billion.[4] That growth will also add tens of trillions of dollars in economic value.

To land on the opportunity side of the coin and avoid shocks down the road, companies can take two immediate steps:

- **Conduct an impact assessment:** Identify the top five strengths that differentiate your company. Then look at which exponentials could potentially erode those strengths. Also look at the flip side. What are the top five pain points that exponentials could eliminate? How?
- **Evaluate the threat:** Determine how your company's products or services could be dematerialized or demonetized. Exploiting market adjacencies is a key part of the equation. Google, for example, is focusing on autonomous cars and Microsoft continues to make forays into gaming. The goal is to not only figure out who might disrupt your business's pond but whose pond your company can disrupt.

Your competition is no longer multinational powerhouses in China or India. Your competition now is the hyper-connected startup anywhere in the world that is using exponential technologies to dematerialize and demonetize your products and services. Someone in New York can upload a new idea into the cloud, where a kid in Mumbai builds on it and hands it off to a Bangladeshi company to handle production and marketing. Companies need to make sure their plans are in sync with this world and its dynamics.

Lastly, companies should consider their strategy in the context of leveraging two types of exponentials: First, pure exponential technologies such as artificial intelligence, synthetic biology, robotics, and 3D printing; and second, what I call "exponential crowd tools": crowdsourcing, crowdfunding, and prized-based competition incentive models. If companies then marry this portfolio of exponential assets with the understanding that today's grandest societal and planet challenges are also today's most promising commercial market opportunities, it can truly be a formula for abundance.

Exponential snapshots

Artificial intelligence

Computer science researchers have been studying Artificial Intelligence (AI) since John McCarthy introduced the term in 1955.[5] Defined loosely as the science of making intelligent machines, AI can cover a wide range of techniques, including machine learning, deep learning, probabilistic inference, neural network simulation, pattern analysis, decision trees and random forests, and others. For our purposes, we focus on how AI can simulate reasoning, develop knowledge, and allow computers to set and achieve goals.

The ubiquity and low-cost access to distributed and cloud computing have fueled the maturity of AI techniques. AI tools are becoming more powerful and simpler to use. This maturity is the first part of the story: how AI is becoming democratized and can be applied across industries, not just in areas such as credit card processing and trading desks, where AI has been gainfully employed for 45 years. The next part of the story focuses on our desire to augment and enhance human intelligence.

We are increasingly overwhelmed by the flood of data in our lives—1.8 zettabytes of information are being created annually.[6] But we are saddled with an ancient computing architecture that hasn't seen a major upgrade in more than 50,000 years: the brain. We suffer from cognitive biases and limitations that restrict the amount of information we can process and the complexity of calculations we can entertain. People are also susceptible to affectations and social perceptions that can muddy logic—anchoring on first impressions to confirm suspicions instead of testing divergent thinking.

AI can help solve specific challenges such as improving the accuracy of predictions, accelerating problem solving, and automating administrative tasks. The reality is that with the right techniques and training, many jobs can be automated. That automation is underway through many applications in several fields, including advanced manufacturing, self-driving vehicles, and self-regulating machines. In addition, the legal profession is availing itself of AI in everything from discovery to litigation support. DARPA is turning to AI to improve military air traffic control as automated, self-piloted aircraft threaten to overrun air-spaces. In health care, AI is being used in both triage and administrative policies. The world's first synthetic bacterium was created using AI techniques with sequencing.[7] Energy firms are using AI for micro-fossil exploration in deep oil preserves at the bottom of the ocean. AI can also be leveraged for situational assistance and logistics planning for military campaigns or mass relief programs. In sum, AI represents a shift, a move from computers as tools for executing tasks to a team member that helps guide thinking and can do work.

Despite these successes, many of today's efforts focus on specific, niche tasks where machine learning is combined with task and domain knowledge. When we add biologically inspired computing architectures, the ability to reason, infer, understand context, develop evolving conceptual models of cognitive systems, and perform many different flavors of tasks becomes attainable.

In the meantime, AI faces barriers to its widespread adoption. Recognize that in developed nations, its use may encounter obstacles, especially as labor organizations

fight its increased use and its potential to decrease employment. The ethics of AI are also rightly a focus of attention, including the need for safeguards, transparency, liability determination, and other guidelines and mechanisms that steer toward responsible adoption of AI. But these realities should not curb the willingness to explore. Companies should experiment and challenge assumptions by seeking out areas where seemingly unachievable productivity could positively disrupt their businesses.

Inspired by lectures given by **Neil Jacobstein**, *artificial intelligence and robotics co-chair, Singularity University*

Neil Jacobstein co-chairs the artificial intelligence and robotics track at Singularity University. He served as president of Singularity University from October 2010 to October 2011 and worked as a technical consultant on AI research for a variety of businesses and government agencies.

Robotics

Mechanical devices that can perform both simple and complex tasks have been a pursuit of mankind for thousands of years. Artificial intelligence and exponential improvements in technology have fueled advances in modern robotics through tremendous power, a shrinking footprint, and plummeting costs. Sensors are a prime example. Those that guided the space shuttle in the 1970s were the size of foot lockers and cost approximately $200,000. Today, they are the size of a fingernail, cost about 10 cents, and are far more reliable.

Robotics is fundamentally changing the nature of work. Every job could potentially be affected—it's only a matter of when. Menial tasks were the early frontiers. Assembly lines, warehouses, and cargo bays have been enterprise beachheads of robotics. But that was only the beginning. Autonomous drones have become standard currency in militaries, first for surveillance and now with weapon payloads. Amazon fulfillment centers are largely automated, with robots picking, packing, and shipping in more than 18 million square feet of warehouses.[8] The next frontier is tasks that involve gathering and interpreting data in real time. Eventually these tasks can be replaced by a machine, threatening entire job categories with obsolescence. Oxford Martin research predicts that 45 percent of US jobs will be automated in the next 20 years.[9]

On the not-so-distant horizon, for example, gastroenterologists won't need to perform colonoscopies. Patients will be able to ingest a pill-sized device with a camera that knows what to look for, photograph and, potentially, attack diseases or inject new DNA. Boston Dynamics is rolling out Big Dog, Bigger Dog, and Cheetah—robots that can carry cargo over uneven terrain in dangerous surroundings. Exoskeletons can create superhuman strength or restore motor functions in the disabled. Remote health care is coming. It will likely arrive first with robotics-assisted virtual consultation, followed by surgical robots that can interpret and translate a surgeon's hand movements into precise robotic movements thousands of miles away. Companies are also pursuing autonomous cars. Personal drone-based deliveries could disrupt retail. The limits are our imaginations—but not for long.

Robotics should be on many companies' radars, but businesses should expect workplace tension. To ease concerns, companies should target initial forays into repetitive, unpleasant work. Too often robotics is focused on tasks that people enjoy. Equally important, companies should prepare for the inevitable job losses. Enterprises should identify positions that aren't likely to exist in 10 years, and leverage attrition and training to prepare employees for new roles. The challenge for business—and society as a whole—is to drive job creation at the same time that technology is making many jobs redundant. Ideally, displaced resources can be deployed in roles requiring creativity and human interaction—a dimension technology can't replicate. Think of pharmacists. After as much as eight years of education, they spend the majority of their

time putting pills into bottles and manually assessing complex drug interactions. When those functions are performed by robots, pharmacists can become more powerful partners to physicians by understanding a patient's individual situation and modifying drug regimens accordingly.

At the end of the day, there are two things robots can't help us with. The first is preservation of the human species, a concern more civic and philosophical than organizational. But the second is more practical—indefinable problems. For example, robots can't find life on Mars because we don't know what it might look like. Everything else is fair game. Be ready to open the pod bay doors of opportunity—before your competition does.

Inspired by lectures given by **Dan Barry**, *artificial intelligence and robotics co-chair, Singularity University*

Dan Barry is a former NASA astronaut and a veteran of three space flights, four spacewalks, and two trips to the International Space Station. He is a licensed physician and his research interests include robotics, signal processing with an emphasis on joint time-frequency methods, and human adaptation to extreme environments.

Cyber security

A few hundred years ago, a robbery consisted primarily of a criminal and an individual victim—a highly personal endeavor with limited options for growth. The advent of railroads and banks provided opportunities to scale, allowing marauders to rob several hundred people in a single heist. Today, cyber criminals have achieved astonishing scale. They can attack millions of individuals at one time with limited risk and exposure.

The same technological advances and entrepreneurial acumen that are creating opportunities for business are also arming the world's criminals. Criminal organizations are employing an increasing number of highly educated hackers who find motivation in the challenges of cracking sophisticated cyber security systems.[10] These entrepreneurial outlaws are a new crime paradigm that is reaching frightening levels of scale and efficiency.

A few examples illustrate the daunting landscape: Hackers are available for hire online and also sell software capable of committing their crimes. A few years ago, for example, INTERPOL caught a Brazilian crime syndicate selling DVD software that could steal customer identities and banking information. The purveyors guaranteed that 80 percent of the credit card numbers pilfered through the software would be valid. Its customers could also contact a call center for support.

Cyber criminals are also leveraging the crowd. Flash Robs, for example, are becoming a new craze where social media is used to bring individuals to a specific store to steal goods before police can arrive. Another crowdsourced crime looted $45 million from a pre-paid debit card network. Hackers removed the card limits. Thieves then bought debit cards for $10 and withdrew what they wanted. In just 10 hours, the crowd made more than 36,000 withdrawals in 27 countries.

What looms on the horizon is even more daunting. With the Internet of Things, every car, consumer appliance, and piece of office equipment could be linked and ready for hacking. As fingerprints become the standard means of authentication, biometrics will become a powerful source of ingenious theft.

The experience of the US Chamber of Commerce portends the future. The organization's photocopiers, like many, are equipped with hard drives that store printed documents. In the past, industrial criminals disguised as repairmen removed the devices. However, when the chamber installed thermostats connected to the Internet, hackers could breach the copiers. Officials only discovered the attack through a defect that inadvertently sent the hackers' documents to the copiers.

There are steps that companies can take to combat cybercrime. The first is to establish risk-prioritized controls that protect against

known and emerging threats while complying with standards and regulations. Companies should also identify which of their assets would likely attract criminals and assess the impact of a theft or breach. Organizations should then become vigilant and establish situation risk and threat awareness programs across the environment. Security and information event management capabilities can be enhanced and new functionality can be mined from tools including endpoint protection, vulnerability assessment/patch management, content monitoring, data loss prevention, intrusion prevention, and core network services. The final step is building resilience: the ability to handle critical incidents, quickly return to normal operations, and repair damage done to the business.

Companies can also turn to the crowd. Security professionals have knowledge that can help investigations and warn of potential threats. The legal environment is also important. Business leaders should advocate for laws and policies that seek to contain cybercrime and also avail themselves of resources provided by federal agencies.

Cybercrime is accelerating at an exponential pace. In the not-so-distant future, everything from our watches to the EKG monitors in hospitals will be connected to the Internet and ready to be hacked. Companies should be prepared to survive in an environment where these threats are commonplace.

Inspired by lectures given by **Marc Goodman**, *chair for policy, law, and ethics and global security advisor, Singularity University*

Marc Goodman is a global strategist, author, and consultant focused on the disruptive impact of advancing technologies on security, business, and international affairs. At Singularity University, he serves as the faculty chair for policy, law, and ethics and the global security advisor, examining the use of advanced science and technology to address humanity's grand challenges.

Additive manufacturing

The technology that supports additive manufacturing, or 3D printing, is more than 30 years old. Its recent popularity has been fueled in part by patent expirations which are driving a wave of consumer-oriented printers. Prices have fallen, putting the technology within the reach of early adopters. 3D printing is democratizing the manufacturing process and bringing about a fundamental change in what we can design and what we can create.

But the story goes much deeper than hobbyists and desktop models. The cost of a 3D printer ranges from a few hundred to a few million dollars. The machines can print with hundreds of materials, including nylons, plastics, composites, fully dense metals, rubber-like materials, circuit boards, and even genetic tissue. Breakthroughs in speed, resolution, and reliability demonstrate potential not only for scale but also for unlocking new possibilities.

The real exponential impact, however, is in the simplicity of the supporting tools. They provide a means to digitize existing objects, customize and tweak open source designs, or create brand new designs based on structural and industrial engineering know-how. Intuitive, easy-to-use tools allow "things" to be created, manipulated, and shared.

In essence, 3D printing makes manufacturing complexity free of charge, allowing otherwise impossible designs to be realized. Objects are built one layer at a time, depositing material as small as 100 nanometers exactly where and when needed. Mechanical items with moving parts can be printed in one step—no assembly required. Interlocking structures mimicking nature's design laws are possible with nearly unlimited geometrical freedom—no tooling, set-ups, or change-overs. Moreover, objects can be built just in time when and where they are needed. The capability unlocks business performance in a highly sustainable manner by reducing inventory, freight, and waste. 3D printing's value is not limited to complex objects.

On-site creation of investment castings or construction molds can supplement traditional manufacturing techniques.

3D printing is not just for prototypes and mock-ups. Many sectors already use the technology for finished parts and products. The aerospace industry, for example, has led the charge on additive manufacturing. Jet engine parts such as manifolds require more than 20 pieces that are individually manufactured, installed, welded, grinded, and tested into a finished product. The 3D printed alternative is easier to build and service and also reduces overall system weight. Medical devices use 3D printing to customize and personalize everything from dental crowns to hearing aids to prosthetics.

The potential doesn't end there. More fantastical use cases are starting to become a reality, such as mass customization of consumer goods, including personalized products ranging from commodities to toys to fashion, with "print at home" purchase options. Even food printers are entering the market, starting with chocolates and other sugar and starch staples, but moving toward meats and other proteins. Organs, nerves, and bones could be fully printed from human tissue, transforming health care from clinical practice to part replacement—and even life extension. Leading thinkers are exploring self-organizing matter and materials with seemingly magical properties. One example is already here: a plane built of composites with the ability to morph and change shape, ending the need for traditional flaps and their associated hydraulic systems and controls.

The enterprise implications are many—and potentially profound. First, organizations should take an honest look at their supply chain and market offerings—and identify where the technology could enhance or replace these offerings. As we discussed in the *Digital engagement* chapter, intellectual property and rights issues will emerge, along with new paths to monetize and disrupt. Finally, business leaders should embrace the democratized creativity the technology is unleashing. Companies can use 3D printing to drive faster product innovation cycles, especially where it can push the boundaries of possibilities based on materials science and manufacturing techniques.

Inspired by lectures given by **Avi Reichental**, *co-chair for nanotechnology and digital fabrication, Singularity University*

Avi Reichental currently serves as faculty co-chair of the additive manufacturing program at Singularity University. He has been the president and chief executive officer of 3D Systems since September 2003.

Advanced computing

Advances in raw computing power and connectivity are frequently the building blocks of our annual tech trends report. Core lessons that have guided us through the Internet revolution remain true today, and are steering us toward exponential advances in the future of computing.

The first lesson is the importance of early adopters and how they personally and commercially kick-start industries and adoption. Early adopters have an insatiable demand for improvement and for the doubling of performance. Moore's Law forecasts how many transistors per dollar could be put onto a chip wafer. Engineering curiosity and scientific prowess have fueled many advances in the field. Nonetheless, to build growth and feed customer demand, companies continue to invest in seismic performance improvements because they know there is a demand for products that are twice as good.

The second lesson is an open, hackable ecosystem with a cost contract that encourages experimentation through its lack of incremental accounting for network usage. From the system kits of the PC revolution to the open source movement to today's Arduino and Raspberry Pi hobbyists, a culture of innovation and personal discovery is driving

advances in open groups instead of proprietary labs. Lessons and learnings are being shared that accelerate new discoveries.

The third lesson is that the magical ingredient of the Internet is not the technology of packet switching or transport protocols. The magic is that the network is necessarily "stupid," allowing for experimentation and new ideas to be explored on the edges without justifying financial viability on day one.

On the computing side, we are at a fascinating point in history. Rumblings about the end of Moore's Law are arguing the wrong point. True, chip manufacturers are reaching the theoretical limits of materials science and the laws of physics that allow an indefinite doubling of performance based on traditional architectures and manufacturing techniques. Even if we could pack in the transistors, the power requirements and heat profile pose unrealistic requirements. However, we have already seen a shift from measuring the performance of a single computer to multiple cores/processors on a single chip. We still see performance doubling at a given price point—not because the processor is twice as powerful, but because twice the number of processors are on a chip for the same price. We're now seeing advances in multidimensional chip architecture where three-dimensional designs are taking this trend to new extremes. Shifts to bio and quantum computing raise the stakes even further through the potential for exponential expansion of what is computationally possible. Research in the adjacent field of microelectromechnical systems (MEMS) and nanotech is redefining "hardware" in ways that can transform our world. However, like our modest forays into multi-core traditional architectures, operating systems and software need to be rewritten to take advantage of advances in infrastructure. We're in the early days of this renaissance.

The network side is experiencing similar exponential advances. Technologies are being developed that offer potentially limitless bandwidth at nearly ubiquitous reach. Scientific and engineering breakthroughs include ultra-capacity fiber capable of more than 1 petabit per second[11] to heterogeneous networks of small cells (micro-, pico-, and femtocells[12]) to terahertz radiation[13] to balloon-powered broadband in rural and remote areas.[14]

Civic implications are profound, including the ability to provide education, employment, and life-changing utilities to the nearly five billion people without Internet access today. Commercially, the combination of computing and network advances enable investments in the Internet of Things and synthetic biology, fields that also have the ability to transform our world. Organizations should stay aware of these rapidly changing worlds and find ways to participate, harness, and advance early adoption and innovation at the edge. These lessons will likely hold true through this exponential revolution—and beyond.

Inspired by lectures given by **Brad Templeton**, *networks and computing chair, Singularity University*

Brad Templeton is a developer of and commentator on self-driving cars, software architect, board member of the Electronic Frontier Foundation, Internet entrepreneur, futurist lecturer, and writer and observer of cyberspace issues. He is noted as a speaker and writer covering copyright law, political and social issues related to computing and networks, and the emerging technology of automated transportation.

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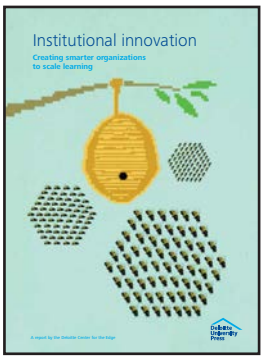

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