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From Looking Digital to Being Digital: The Impact of Technology on the Future of Work

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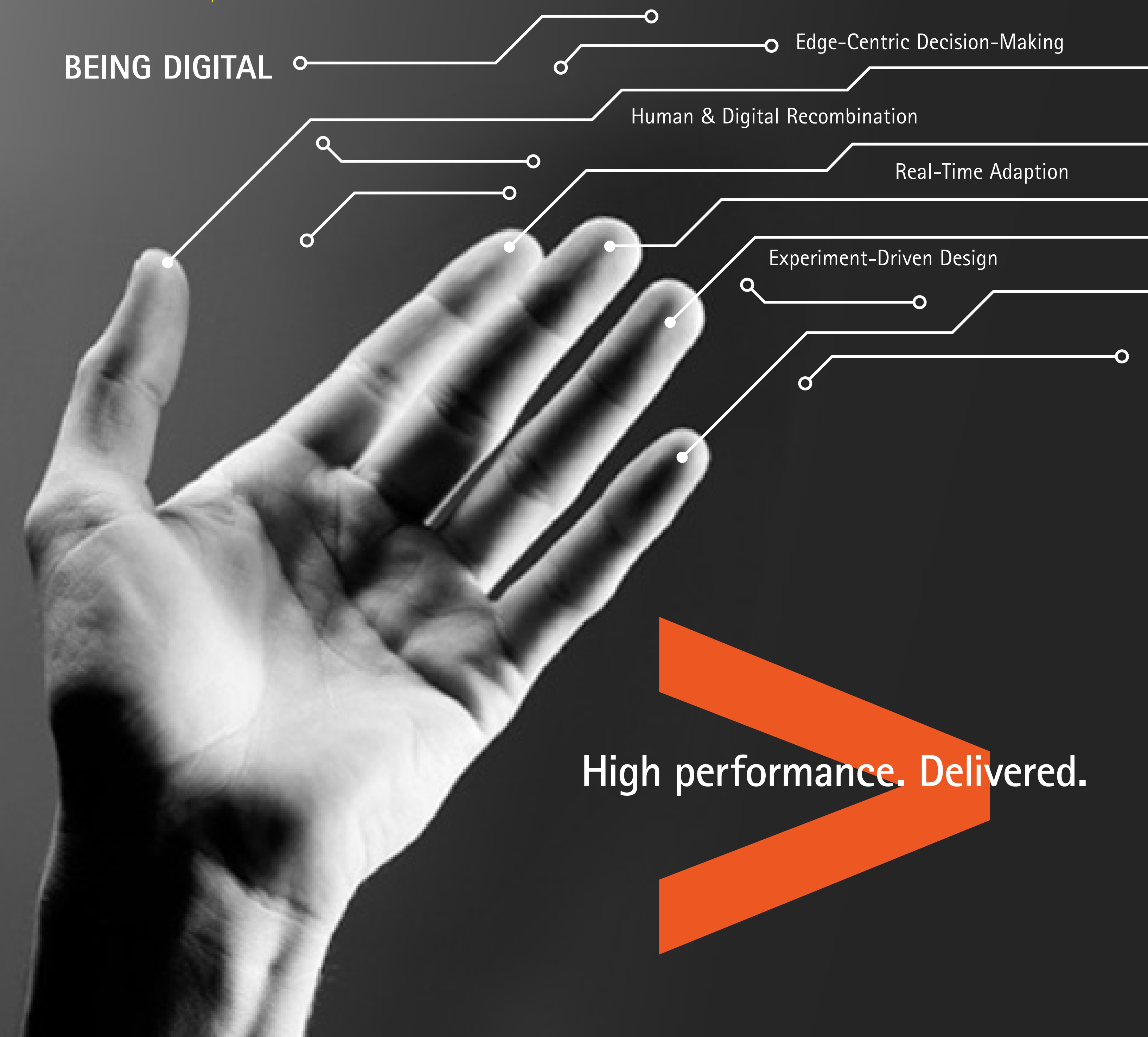

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Being Digital: Foreword

Companies are finding it challenging to capture the full value of revolutionary breakthroughs in digital technology. Many have used digital technology to drive down costs and get more efficient, which is akin to "looking digital," an important but surface-level change. Some, however, are taking things further and transforming data into new revenue and new sources of value. This more pervasive change is what we mean by "being digital."

To move from looking digital to being digital, companies must engage in a deep shift in the way they do business. For business leaders, that shift requires as much attention to culture and organization as it does to the technology itself.

Companies that want to lead in the digital era—no matter what their industry or their location—must rethink the way they get work done. Just as buying a rowing machine won't make you fit, simply installing digital technology will not change the way your company works.

For senior executives, this presents several critical challenges. Data will have to be available to many more people, not only within the organization but also with ecosystem partners. In seeking out talent, leaders will need to focus on four areas that don't often show up in resumes or performance evaluations: the ability to experiment, to learn, to exercise judgment, and to collaborate. Perhaps most importantly, they will have to place even more trust in first- and second-level management.

This report, the result of a significant collaborative effort between Accenture's Institute for High Performance and Technology Labs, will help executives understand the key issues and get started on the deep shift of digital transformation.

Shawn Collinson
Chief Strategy Officer

Executive Summary

Over the next five years, new digital technologies promise to dramatically change work outcomes and work experiences for employees of all sorts—manual workers, knowledge workers and managers alike—across a wide array of industries. The digital difference—or what we refer to as the difference between "looking digital and being digital"—derives from the ability of a new generation of technologies to augment, rather than to replace, the cognitive, collaborative and the physical capabilities of human beings. However, research undertaken jointly by the Accenture Institute for High Performance and the Accenture Technology Labs suggests that to reap the benefits of digital technologies managers must be prepared to undertake shifts—deep shifts—that are as much cultural as they are technical in nature.

Digital is transforming the future of work

Digital refers to an ensemble of new technologies that enhance the collection and analysis of information in ways that dramatically augment the capacity of human beings. Six underlying components of digital will have the greatest impact on the design of work:

- Ubiquitous data streams: Physical and virtual sensors combined with high capacity networks that make it possible to process and store many large streams of data.
- Advanced analytics and modeling: Tools that transform information into scalable process improvements.
- Rich digital representations: Software that translates physical objects into data files that can drive programmable tools, robots and 3D printers.
- Cognitive augmentation: Technologies that learn by observation and offload routine knowledge work to automated assistants.
- Physical augmentation: Advanced robotic devices that sense and adapt to their environment and that are small, safe, and flexible enough to be inserted into human workflows.
- Collaborative augmentation: Software that directly improves the ways employees coordinate work and co-create new products.

These technologies are coalescing into "intelligent digital processes" that change the key aspects of work design, including the who, when, where, and what of how work gets done (see Figure 1).

Emerging work practices

With the diffusion of intelligent digital processes, four new work practices will become much more prevalent in the next five years.

Edge-centric decision-making
Information and decision-making authority formerly the exclusive domain of a centralized authority will increasingly be pushed out toward the boundaries of the firm where intimate knowledge of context resides. Empowered by intelligent tools, employees will combine rich data streams with their contextual knowledge to make significant decisions—about inventory, pricing, and even product design—at a local level. Decentralized decision-making will increase employee autonomy and engagement and allow companies to more precisely respond to changing market conditions, thus resulting in higher customer satisfaction and sales.

Real-time adaptation
Digital technologies will help companies respond to changing business conditions in real time. Pervasive digital connections between systems, people, places and things—sometimes referred to as the "internet of everything"—will produce a dynamic flow of digital information about where machines and people are, what they are doing, and how they are doing. Intelligent assistants will use this information to help employees make smart decisions even when they cannot calculate the implications of all that data themselves. The potential for dynamic and speedier decision-making will bring greater levels of operational flexibility and productivity to industries.

Human and digital recombination
Advances in digital technology—including robotics, software and machine learning, sensors and analytical tools—will lead to newer and more creative ways for humans to work in concert with intelligent machines. Humans will be able to "project" themselves into a wide variety of situations through remotely-controlled avatars and vehicles. Moreover, flexible robots will participate directly in human work processes by sensing and adapting to their shared environment.

Experiment-driven design
As digital modeling and simulation make design iteration less expensive, work

processes will increasingly be structured around a series of "design-build-test" cycles that generate early feedback to uncover risks quicker and better align to user preferences and needs than traditional design approaches. As a result, work will become more fluid, with higher levels of improvisation and experimentation.

Becoming a digital enterprise requires deep shifts

Research on early adopters strongly suggests that becoming a digital enterprise requires deep shifts—changes that crosscut skills, roles and even culture. Three dimensions are key to the move from looking digital to being digital: employing the right tools in the right way; developing and deploying the right talent; and evolving the right management mind-set.

Employing the right tools in the right way
Enterprises need to empower workers at all levels by providing them with the data and the tools with which to make sound business decisions. Moreover, organizations need to get more comfortable with decisions being made in real time, in a distributed way, with emphasis on consistent and informed decision making rather than centralized planning and control. The net effect of these shifts will be to replace dominant paradigms that emphasize up-front planning and then sticking to the plan with the ability to re-plan frequently in response to new data and changing conditions. Making this change means having a much higher level of comfort with ambiguity and uncertainty and a willingness to move in the absence of complete agreement.

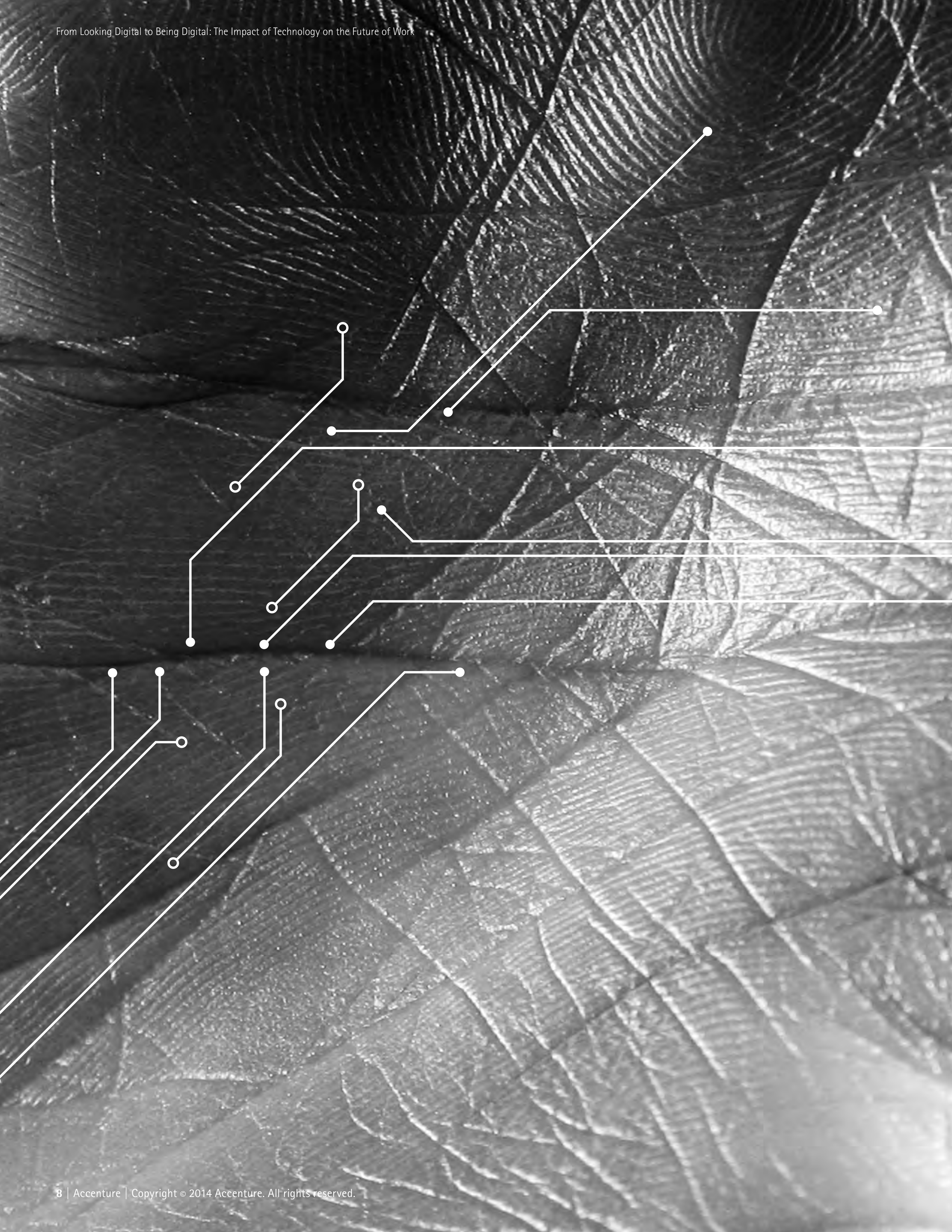
Developing and deploying the right talent
Four core talents will prove vital to being digital: the ability to experiment, the ability to learn and adapt, the skill to exercise judgment and the power to collaborate. Being digital presumes that employees are able to absorb new knowledge and data, adapt as needed, experiment and learn. Intelligent digital processes will have the greatest impact when employees are motivated to use data to improve products and practices rather than merely to execute rules and procedures handed down from above.

Evolving the right management mindset
The biggest shifts may be the ones required of management. Managers will need to be both literate and numerate if they are going to support employees in making the most of available data. They are going to be called upon to exercise judgment in reconciling what the intelligent tools recommend and what history, culture and customers demand. They will need to encourage responsible experimentation, deal with inevitable failures or breakdowns that experimentation produces, and translate strategic direction into operational action. Indeed, the transition of management to "being digital" means giving up tight controls, granting a measure of autonomy to operators and designers, shifting the focus from one of rule-following to value-finding, and getting comfortable with experimentalism (the foundation of a data-driven culture).

The benefits of being digital are clear. However, the deep shift from looking digital to being digital is predicated on intentional efforts to employ the new digital tools in new ways, to develop and deploy the right talents, and to drive new management mindsets. Therein lies the challenge for leaders: to recognize that a deep shift is necessary and to start building the foundation for it right away. Such organizations will become truly digital faster and more effectively.

Figure 1: Work design under a regime of intelligent digital processes

	Intelligent digital
1. Who makes decisions about the organization of work processes?	Managers and employees closer to the work, with information and analyses that are broadly shared
2. When are decisions made?	Closer to real-time in order to adapt to changing conditions
3. How is work structured?	Through a continuous process of experimentation and adjustment
4. Where is work located?	Remote work (via robots or remotely controlled drones) and work that is distributed across geographies becomes much more common
5. What skills are required (including management skills)?	Collaboration, experimentation, testing, data interpretation, judgment and value-creation



Chapter 1: The Deep Shift

Many companies today "look" digital. Few actually are. Sure, they've learned to convert paper into electron streams. They make available, and even use, video chat, social media, and a host of online tools via an internal portal. But "being digital" requires much more.

Reducing paper flows—that's a useful but ultimately superficial change. Companies must dig well below the surface. Those that truly want to be digital need to engage in a deep shift in the way they do business, in which the primary goal is to transform data into new revenue and new sources of value.[1] And that transformation is as much about culture and organization as it is about the wonders of technology.

Consider what this means for the future of work, and for work processes. To transform processes, organizations will have to combine three things: rivers of data about transactions, searches, physical movements, price changes and a host of other activities; intelligent tools like simulations, models and advisory applications; and local knowledge in the form of experience, judgment and intuition. Expressed in a sentence, maybe that doesn't sound too difficult. It is, and it will be.

Further, organizations will have to accelerate the empowerment of employees—front-line staff, managers and executives alike—by augmenting their abilities, with the help of technology, so that people can do work that is both creative and flexible. Again, translating that into practice won't be easy.

And yet, while this deep shift in the way people work may not be obvious to the untrained eye, it's already going on in some companies. Take, for instance the changes that have happened in recent years in two very different industries: retailing and iron ore mining. Convenience stores like 7-Eleven and mining companies like Rio Tinto share little in common when it comes to the things they sell. But a look behind the scenes reveals surprising similarities.

Both scan huge databases with sophisticated algorithms in search of clues to hidden treasure: underlying customer preferences for 7-Eleven and veins of iron ore for Rio Tinto. Both equip frontline employees with intelligent tools that allow them to make decisions that improve performance based on contextual knowledge. In the case of the retailer, employees select inventory best suited to local conditions; in the case of the miner, they adjust mining technique based on seismic data, satellite images and on-the-ground operator experience. Finally, both organizations rely on people and computers working together—one augmenting the other—rather than viewing human and machine as mutually exclusive sources of knowledge. That's why, in both instances, veteran employees with working knowledge—know-how—find digital technology a source of stimulation, not insecurity.

Unless you work for Rio Tinto or 7-Eleven, you're probably not aware of these changes. You can easily see the impact of digital technology on consumer products like cars. Slip into the driver's seat and you're quickly familiar with things like dashboard data centers, iPod hookups and electronic stability control. Less visible are the huge behind-the-scenes changes that are revolutionizing automotive design and manufacturing.

These include digital tools that compress the time it takes to create and test product designs; that both enable and demand intimate collaboration between marketing, engineering and manufacturing groups rather than "over the wall" exchanges; that link robots and humans in flexible production teams; and that employ analytics to give managers the ability to experiment in real time with more effective ways of working without disrupting the flow of production.[2]

Based on research we've conducted over the past year, one conclusion is clear: being digital changes work in fundamental ways. Companies that want to lead in the digital era—no matter what their industry or their location—must rethink the way they get work done. Buying and installing digital technology will not accomplish the task any more than buying exercise equipment will make you healthy. Technology by itself won't enable a company to keep pace with rapid change in product markets. But technology is making possible a radical leap in the way work gets done in organizations. We call the enablers of this change "intelligent digital processes."

The emergence of intelligent digital processes

The chief way that companies "look digital" without "being digital" is through the process of digital substitution: gradually replacing physical processes with equivalent digital ones.[3] Make no mistake, this change does bring about improvements in speed and cost without the need to dramatically re-architect the workplace or the workforce.

Digital documents replace the paper variety, making it easy to share and modify them. People can access all kinds of digital artifacts—not just documents but photos, music, videos, spreadsheets and more—from multiple places at once, making it possible for teams of far-flung members to collaborate with speed and efficiency.

Technology is making possible a radical leap in the way work gets done in organizations.

But companies that limit themselves to this sort of digital mimicry are only scratching the surface. They're not just limiting their potential to find new revenue-generating opportunities; they're also hurting their ability to anticipate upcoming industry disruptions.[4] Music companies that were intently focused on the transfer of digital information to CDs, for example, missed the fact that CDs would someday be usurped by digital information that could be streamed to tiny mobile devices.

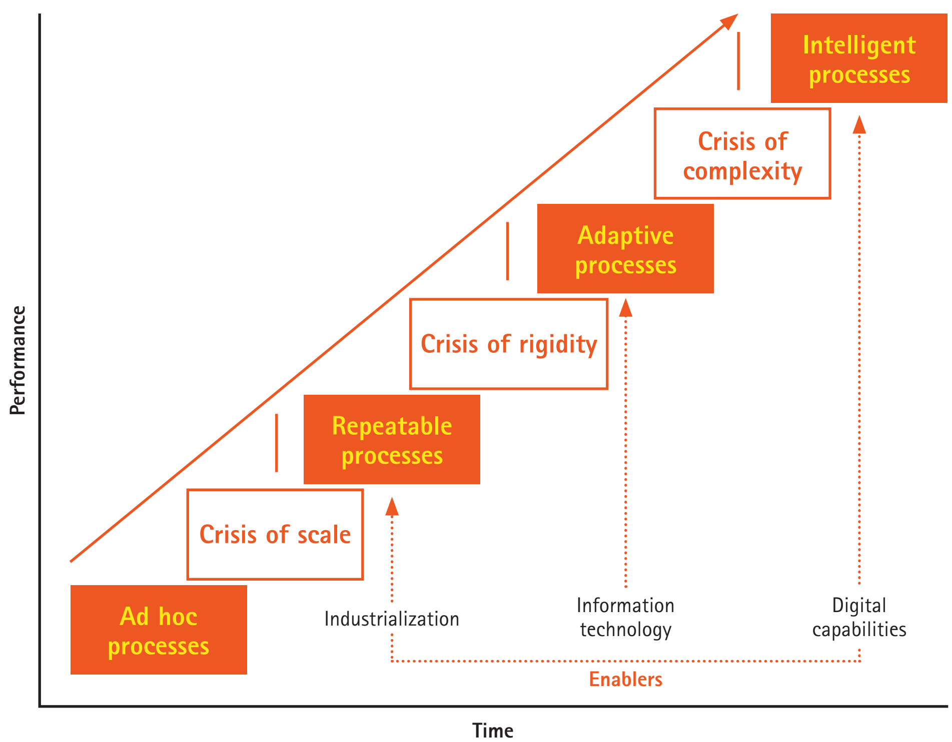
The bigger breakthroughs are coming from efforts that go beyond mimicry and isolated optimization to intelligent digital processes. These processes represent the next stage in the evolution of work.

One way to understand intelligent digital processes is to trace the evolution of work. (See Figure 2.) First came the craftsman who labored over a pair of shoes in an ad hoc or artisanal process; by its very nature the artisanal mode was difficult to scale. Next came the Industrial Revolution with standardized parts and repeatable processes, vastly improving productivity but at the expense of variety and flexibility. More recently, the norm has been adaptable processes, in which the same people and equipment can be adapted to provide more variety. Enabled by IT systems that more effectively linked supply and demand and coordinated "islands of automation," adaptable processes nonetheless became fraught with complexity—often a product of the fact that much more information is generated than can be comprehended and usefully deployed. Each stage in the evolution of work processes has reached a crisis that was resolved through the discovery and implementation of a new technology.

Intelligent digital processes resolve the crisis of complexity by accomplishing two things simultaneously: generating and analyzing masses of information and augmenting human capabilities. (See "Key components of intelligent digital processes"). On the surface, that may not sound particularly revolutionary, but on closer examination it turns out to be a game-changing development.

Figure 2: The path to intelligent digital processes

The evolution from ad hoc to intelligent processes is not unlike the way experts in everything from chess to basketball develop mastery: from a hit-or-miss beginning, to the repetition of basic moves that lead to a greater sense of mastery, to the variations based on having absorbed the basic moves, to developing the ability to improvise and actively experiment—and, finally, to creating breakthrough innovation.



Key components of intelligent digital processes

An ensemble of new technologies makes possible intelligent digital processes. Together, they collect and analyze information and augment the capacity of human workers to make rapid adjustments and exploit opportunities. There are six key component technologies:

Ubiquitous data streams: New physical and virtual sensors combined with high capacity networks make it possible to process and store many large streams of data. These tools systematically sense (and remember) both internal (workstream) and external (ecosystem) events at enormous scale.

Advanced analytics and modeling: Big-data analytics provide new ways to transform data into insight. These analytics can also be used to automatically discover which process variations have resulted in higher performance so that companies can replicate those practices elsewhere.

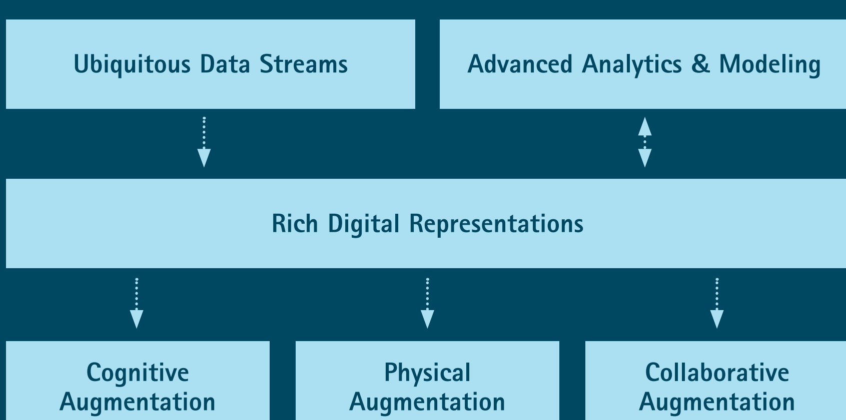
Rich digital representations: Increasingly, physical objects that are intermediate or final work products are also being replaced by digital representations; these are translated into physical form as late in the process as possible by programmable robots and 3D printers.

Cognitive augmentation: Technologies can augment thinking by offloading routine knowledge work to automated assistants. These tools will only become increasingly sophisticated thanks to voice recognition, natural language processing, and other technological advances, and the line that separates a tool from an assistant—or even a teammate—will start to blur.

Physical augmentation: This comes about thanks to advanced robot technologies that are small, safe, and flexible enough to be inserted into human workflows. These new robots can sense and adapt to their environment, enabling them to interact directly with people to create a hybrid human-robot workflow.

Collaborative augmentation: Technologies can improve the ways in which employees coordinate work and co-create new products. Among these technologies are systems that enable social networking, discussion forums, online file sharing, real-time videoconferencing, and virtual task and project management.

Intelligent Digital Processes



Start with information. Intelligent digital processes are embedded with sensors that monitor every action—from a wheel spinning in a pump to a clerk scanning a box—and feed those observations into sophisticated models that allow people and software to make real-time adjustments and decisions. They exploit the connected nature of devices—both within and between organizations—to establish a data web that is both active and interactive.

Add in analytics. Powerful modeling techniques search for patterns in the data—some based on hypotheses, others dredged out of the data itself—that bring a level of self-awareness to seemingly isolated activities. Models make it possible to establish a virtuous cycle of constant improvement, fed by continuous feedback. But, even more important, they can identify opportunities for adaptation (for example, a revenue opportunity such as a niche in the market or a reconfiguration of the value chain), analyze tradeoffs and clarify decision alternatives, and then adapt faster and more efficiently. Reports that used to describe "what happened" last quarter or yesterday are now active conversations between machines as they react to isolated events as well as to trends.

Next, enrich with visualization tools. Advances in the visual display of information—fueled in part by parallel developments in electronic gaming and aviation—make it possible for operators and managers to literally see systems rather than tables in a report. The same tools that now enliven social networking sites are migrating to the factory floor and to office environments—not just to enable communication but to support real-time work flow adjustment, as well.

Finally, move to augmentation. Intelligent digital processes augment human capabilities on three levels. With cognitive augmentation, they enhance the alertness of human beings to new developments, tee up alternative courses of action and make it possible to test alternatives or even to experiment via simulation. Intelligent digital processes also employ new generations of communication and workflow tools to connect people across time and space—that's collaborative augmentation. And, finally, through physical augmentation, they extend human capabilities and perspectives by means of next-generation robotics.

Intelligent digital processes at work

Consider the operation of a contemporary power plant. Before the advent of intelligent digital processes, power plant operators focused almost exclusively on operational efficiency rather than, say, exploiting market opportunities. Service contracts for key equipment like turbines specified operating parameters; power company decisions about what kind of turbine to purchase set real constraints on plant managers and crews. From a cost and liability perspective, operating conditions were either inside or outside the specified parameters; there wasn't a lot of gray area.

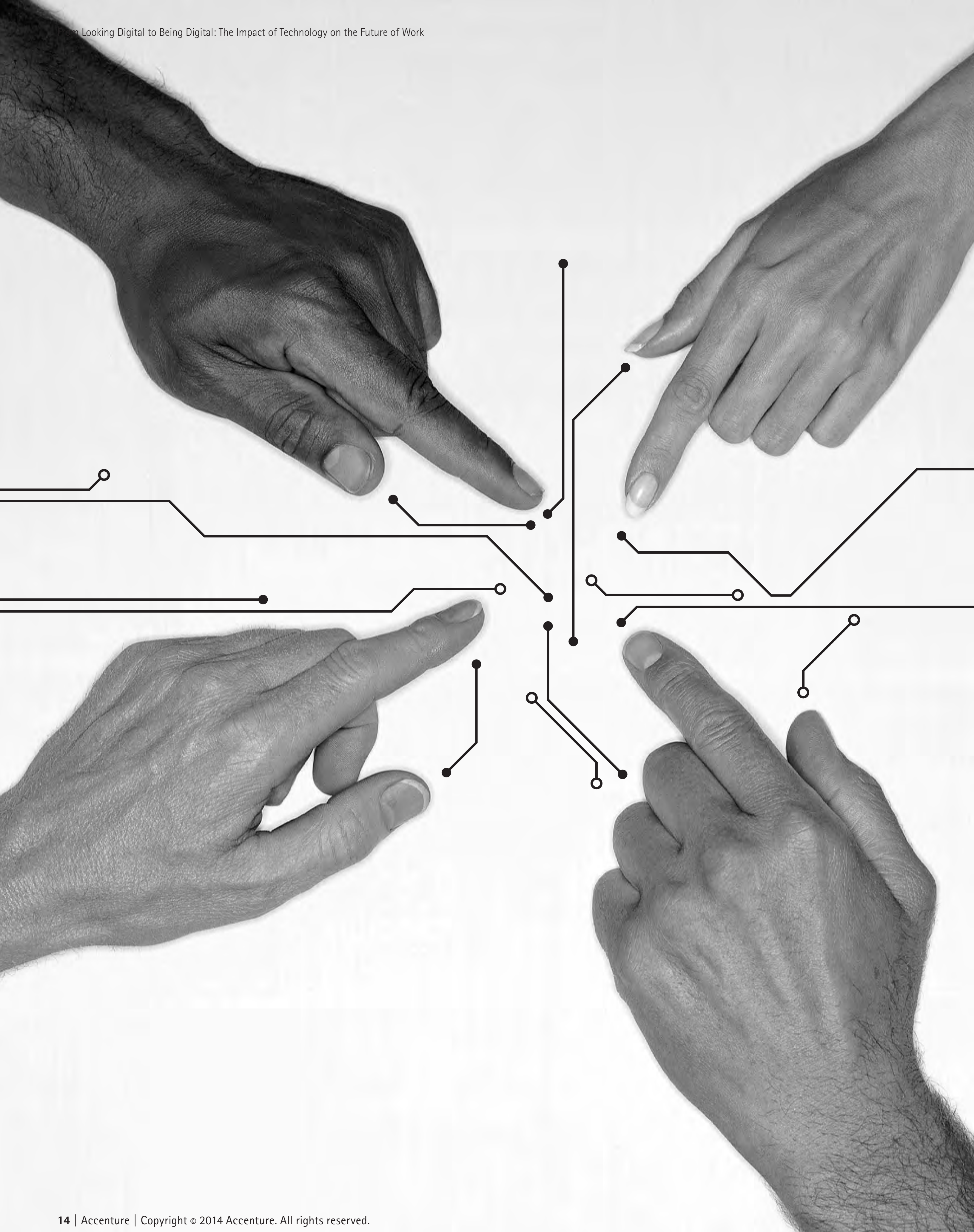
In the era of intelligent digital processes, other options are available to plant operators. Equipment manufacturers like GE now routinely put sensors all over the turbines they sell (and usually all over the power plant, in pumps, relays, cooling equipment and condensers). As a result, they are now constantly collecting data about all the components and how they operate under all manner of conditions. With advanced analytics they are able to develop sophisticated algorithms and models to optimize assets and operations. Standard operating parameters are now just a starting point.

From the company's perspective, intelligent digital processes have made the system more agile. The speed of decision-making can improve by an order of magnitude. Because intelligent digital processes are driven by data derived from both upstream and downstream sources, they make it possible to optimize an entire system rather than just a series of work islands.

The benefits to be derived from intelligent digital processes are certainly attractive. Companies should beware, however, that the technologies themselves are merely the tip of the iceberg. Beneath the surface are huge changes in the ways that work is organized and managed—changes that require a dramatic modification in mindset. The employees and managers of 7-Eleven and Rio Tinto, for example, work very differently now. Their jobs and roles have fundamentally changed. Being digital is a transformation, not an installation.

To better appreciate the nature of the deep shift, we need to look more closely at how work practices are changing in the era of intelligent digital processes. In Chapter 2, we highlight four emergent work practices.

Intelligent digital processes optimize an entire system rather than just a series of work islands.



Chapter 2: Emerging Work Practices in the Digital Enterprise

Intelligent digital processes open up new options in work organization. Some of these options were not practical a few years ago. Some were inconceivable. All of them, however, challenge traditional management mindsets.

In the course of our research, we've seen four emerging work practices that radically break with conventional approaches. Individually and in combination, these practices stand to become the hallmarks of a new era of work organization.

Take the work of product engineering in the automobile industry. As recently as five years ago, engineers toiled away in a maze of subcomponent design groups. These teams relied on complex committees and management layers to translate the voice of the customer into design parameters and then to integrate the disparate parts designs into a vehicle.

The most sophisticated companies used digital design software and online collaboration tools so that engineers could work together on virtual teams spanning time zones. But the work of design remained fundamentally an assembly line, much as it had been for the past 50 years. With the advent of intelligent digital processes, however, the work of product engineering is undergoing a revolution.

At Audi, for example, design engineers engage in web-based, real-time exchanges with customers as they experiment with new infotainment system options.[6] What might in the past have appeared to be a bureaucratic shuffle of blueprints between different functions and departments now more closely resembles a spirited conversation between communities of experts.[7] Teams of software, instrument and mechanical engineers and marketing professionals rapidly iterate through new approaches, assimilate customer feedback and preferences, and submit new options in a matter of days, rather than months. Digital files containing their designs are distributed at light speed to other groups, including test engineers, who assess their implications for cost, weight, durability, and integration with other control systems.

Speed is not the only thing that's changed. In the realm of design, companies now rely on engineers to master the intelligent tools, and on algorithms to interpret massive volumes of data and to evaluate the manufacturing implications of a design change. In some instances an "app" is considered a team member.

The difference between traditional and contemporary approaches to product engineering—between adaptable processes and intelligent digital processes—ought not be reduced to a distinction between "low tech" and "high tech." The automobile industry has been a high-tech industry for many years. Companies like Ford and General Motors were among the pioneers in math-based design. But being high-tech and being digital are not the same. To get the benefit of intelligent digital processes, you need to think differently about the organization of work.

New thinking and old in work design

Companies may no longer have a formal work-design department, but executives, managers, and engineers are constantly making choices among the different ways to translate business objectives and market conditions into processes, tasks and jobs. Their choices are influenced by both business and technological factors, but cumulatively those choices have a powerful influence on the performance of people and processes. Think of it like the design of a racing yacht: the designer may not sail the boat, but his or her choices about things like the size and shape of the keel, the hull and the sails have a huge influence on what the yacht is capable of doing. Carrying the analogy a step further, the "work" of sailing a racing yacht has changed a great deal as a result: contemporary America's Cup boats use sensors to monitor the wind and adjust the carbon fiber wing that's replaced the fabric sail; crew members scan LED screens as much as they do the physical horizon; and data captured during a race is reviewed repeatedly in preparation for the next heat.

For decades, work organization was guided by the legacy of scientific management—so-called Taylorism. Industrial engineers, for example, focused on standardization, repeatability and process control. This led companies to search for the "one best way" to organize work. A legacy of scientific management, that goal remained the central pursuit in many industries well into the 1980s.[8]

Toward the end of the twentieth century, companies began to seek more flexible approaches to work organization, such as lean manufacturing and socio-technical design. Both lean and socio-technical approaches start from the assumption that successful implementation of a new technology requires a mutual adaptation of technology and people. The same basic technology, for example, can be implemented in very different ways—with very different work-design outcomes. Consequently, instead of seeking "one best way," companies began to organize their work processes by considering the broader context of business and organizational culture alongside task and technology. Proponents of these approaches call for "smarter systems" that combine the right technical solutions with the most effective and engaging methods of organizing human skills and judgment.[9] Avant-garde thinking has incorporated the "entanglement perspective," which views human beings and technologies as inseparable: each has the capacity to augment and extend the other.[10]

Work in a new light

Workplace architecture has changed a great deal in the past century—witness Google headquarters, Bloomberg's fishbowl offices and the explosion of home workstations—but a surprisingly large fraction of our thinking about work organization hasn't changed much in the past century. (See "New thinking and old in work design.") Division of labor, chain of command, span of control, serial workflows and the relentless pursuit of efficiency are perennial concerns that drive "work design"—a somewhat intuitive but specialized term that, at a simple level, refers to efforts to improve employees' experience of work (including ergonomics) while at the same time boosting productivity. Time and motion studies are no longer overt, but work monitoring and measurement is as popular as it's ever been.

However, there is growing evidence that digital technology is changing the nature of work design. It helps to start with the five central questions of work design: who, when, how, where and what. (See Figure 3.)

Who makes decisions?

The dominant practice under a regime of adaptable processes tends to be top-down, driven by managers and technical experts from R&D, process engineering, vendors, or consultants. Implicit knowledge (know-how) carried in the heads of people who actually do the work tends to be discounted when it comes to work design. It's rare for collaboration among co-workers to be seen as anything more than accommodation to formal process definitions—or worse, as a kind of rate-setting that limits improvement opportunities. Information about the performance of a given work process tends to be circulated only to those with a need to know.

In contrast, emerging practice under a regime of intelligent digital processes tends to involve employees in a much more direct way, in large measure because digital technology makes it much easier to push relevant information to a broader spectrum of people. People use intelligent tools

Figure 3: Work designs under the adaptable and intelligent digital regimes

	Adaptable	Intelligent digital
1. Who makes decisions about the organization of work processes?	Managers and experts at the corporate center, based on information and analyses that are closely controlled	Managers and employees closer to the work, with information and analyses that are broadly shared
2. When are decisions made?	Long-lead evolution—after extensive planning and analysis, in line with annual budgeting and capital allocation processes	Closer to real-time in order to adapt to changing conditions
3. How is work structured?	Through a plan-driven approach	Through a continuous process of experimentation and adjustment
4. Where is work located?	Concentrated in work centers (factory complexes, major offices and campuses, laboratories) with satellites; distributed virtual teams that have a single hub	Remote work (via robots or remotely controlled drones) and work that is distributed across geographies becomes much more common
5. What skills are required (including management skills)?	Rule-creation and rule-following; incremental improvement; capital substitution to maximize cost savings	Collaboration, experimentation, testing, data interpretation, judgment and value-creation

that augment analysis or collaboration to make decisions about how best to address customer needs and desires—in many cases, much closer to the customer or much more immediately between the customer and the producers. Collaboration and implicit knowledge are increasingly recognized as vital elements of work design—not aberrations—because they add flexibility and make it possible for complex systems to recover more quickly from disturbances.[11]

For example, employees in the far-flung stores of a retail company now have the ability to utilize analyses of sales data to customize the mix of products on their shelves in response to local consumption patterns or weather conditions. And they can do so without sacrificing the economies of scale in purchasing and distribution that led to the chain-store concept to begin with.

When are decisions made?

Work processes must adapt and change over time. Under the adaptable process regime, the dominant practice for altering a work process tends to require time-consuming analyses, considerable upfront planning, and long lead-times. This is partly due to the technologies themselves, which evolved slowly in the past or were proprietary with limited functionality that was difficult to change. Another factor was the relatively long payback periods for technological investments. As a result, companies resisted large-scale changes without a major triggering event, such as a dramatic shift in product technology or customer demand.

In contrast, under the intelligent digital regime, adaptation can occur in real-time as a process is being executed. With sensors monitoring the performance of machines and people, managers can identify opportunities to rapidly alter or reconfigure a work process to respond to various contingencies such as supplier prices, spikes in customer demand, and fluctuations in the weather. Recall the power plant example, where operators can alter the work process to take advantage of market opportunities without having to invoke higher levels in the chain of command.

Work evolves through a continuous, iterative process of experimentation and adjustment.

How is work structured?

Adaptable and intelligent digital processes take starkly different approaches to the structuring of work. Under the adaptable process regime, work structuring tends to be linear and top-down, going from high-level designs to more detailed models. Revising work processes can be prohibitively expensive especially after prototypes have been built.

In contrast, in the intelligent digital regime, work evolves through a continuous, iterative process of experimentation and adjustment. This approach is made possible by easy access to relatively inexpensive digital models and workflow templates. In the healthcare industry, for example, new work processes for the management of patients' electronic records can be simulated on a computer, deployed, and updated on a continuous basis rather than launched once and revised only after long implementation cycles. Moreover, companies can now undertake experiments in real-time. In the past, companies would have had to conduct experiments off-line or in a simulated environment (in a pilot facility appended to an R&D organization, for example) and then scale up before implementing changes in the core of their operations.

Where is work located?

One major assumption behind adaptable processes is that work and workers should be located in the same place. While virtual teams have become increasingly commonplace over the past decade, organizations continue to think about supervision and control in traditional ways—for instance, one person or group "owns" the data, is responsible for a process or, more commonly, the outcome of a process, and teams (and tasks) tend to be arranged hierarchically.

Under a regime of intelligent digital processes, companies no longer need to co-locate work and workers. As in the mining industry, entire complexes of machinery and equipment can be operated from distances of hundreds of kilometers. Real-time transmission of data and virtually instantaneous response times make this possible.

What skills are required?

The relationship between humans and technology is being transformed in the era of intelligent digital processes. Adaptable processes drive toward automation: simple replacement of human inputs by mechanical devices, robots and software that have limited functionality. This reflects the economic logic of using dedicated capital assets to improve productivity. It also reflects the historical legacy of scientific management and its emphasis on simplification and enhanced control.

Increasingly, however, digital technology—and robotics in particular—are being used in much more creative ways. Rather than focusing solely on the replication of human motion, digital technology offers flexible tools that can be reconfigured for multiple purposes—not just physical but also cognitive and collaborative augmentation—while still generating an attractive return on investment. Moreover, thanks to advances—in sensors, software and machine learning, robotics, and analytical tools like advisory systems—humans and machines can now interact in much more productive ways. Robotic technology is increasingly able to learn from and augment human beings.

Different answers to traditional questions... and answers to questions we never thought to ask. Digital technology has huge implications for the kinds of skills needed under an intelligent digital regime. For example, field-service technicians once needed to commit a lot of knowledge to memory; people needed to know a lot. Now, with digital technology making information (and even remote collaboration) available as needed, it is more critical for the technician to be able to absorb new knowledge quickly, to form sound judgment and solve novel problems. Rote knowledge is less critical. Likewise, managers of intelligent digital processes need to be far more comfortable asking questions of the models they have at hand, designing experiments and interpreting the data they get back, and making judgments based on a combination of data, direct observation and experience.

Emerging work practices

In terms of work practice, the "who, when, how, where and what" receive different answers if one is talking about intelligent digital processes rather than adaptable ones. That's why a new set of work practices have emerged recently to take advantage of new possibilities.

Edge-centric decision-making

Centralized corporate managers now command terabytes of data. So, as masters of the data, they should control decision making when it comes to work organization, right? Well, yes, up to a point. But technology that gathers localized data can empower local decision making, or what we refer to as edge-centricity.

With edge-centricity, information and decision-making authority are pushed out to the most customer-facing points in the organization where intimate knowledge of context resides. It means, for example, that employees are armed with intelligent tools that make it possible to combine rich data streams with contextual knowledge—of specific countries, cities or even neighborhoods. They can thus make decisions about how to best serve customers, whether they are retail consumers or businesses and governments. And, rather than pandemonium ensuing, the rest of the organization will see and understand the improvisation happening at the edge and, where necessary, replicate it or accommodate it.

Real-time adaptation

The evolution of sensor technology has brought with it the opportunity to exploit the pervasive digital connections between systems, people, places and things—sometimes referred to as the "internet of everything." The promise resides in rapid awareness of change based on a dynamic flow of digital information about where machines and people are, what they are doing, and how they are doing. An oil pipeline leak can be detected immediately and repaired. Fluctuations in the performance of a jet engine can be monitored and failure can be prevented long before it might occur. A cruise line can use real-time weather and navigation data to adjust ship-board entertainment, meal preparation and staffing.[12] With intelligent digital processes, people and organizations can now do much more than react to change: they can anticipate it, even exploit it to achieve unprecedented results while minimizing risk.

Human and digital recombination

Advances in machine vision and software controls for robots are behind new approaches to work design that are growing in popularity and impact. The first is relatively familiar: Humans "project" themselves into situations that are hostile or toxic through remote control robots—bomb disposal, for example. Increasingly, another sort of remotely guided vehicle is showing up in medical and even educational applications. Telerobotics enable doctors to "visit" patients by maneuvering a robot equipped with a camera and video screen through hospital corridors. Children sick at home can still participate in classrooms through similar devices.

The rest of the organization will see and understand the improvisation happening at the edge.

The second approach is more novel. Small, flexible robots interact with human workers by sensing and adapting to their shared environment in real time. The two can learn from each other and together create a division of labor that captures the cognitive power and creativity of human beings and the physical dexterity and endurance of machines.[13]

Experiment-driven design

Using digital technology to dramatically increase the speed and flexibility of design processes (while at the same timing reducing design risk) represents more than just the pursuit of digital efficiencies. It also reimagines the design process as a way to surface design options and risks earlier than traditional processes do. We use the term "experiment-driven design" to describe a family of approaches that includes iterative design, iterative development, rapid prototyping, or rapid iteration.

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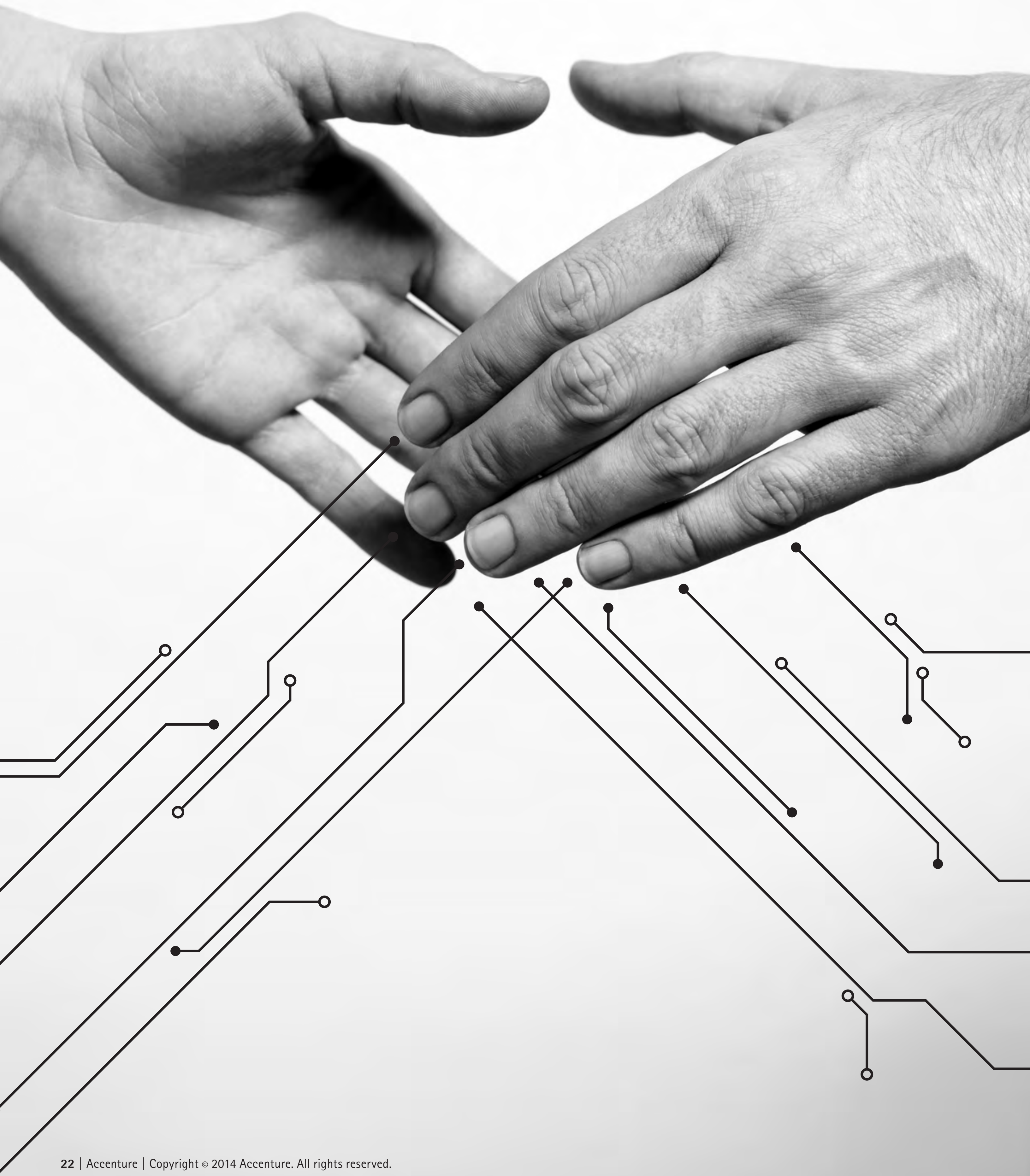
Two impacts of experiment-driven design are paramount. First, the work of design can be much more fluid, iterative and discovery-oriented (leading to a much more intensive use of data generated by increasingly sophisticated experiments). And, second, the design of work can be changed immediately and dramatically. With flexible tools and software, it is possible to imagine greater improvisation occurring in even the most capital intensive and regimented work settings.



Chapter 3: Choice Points on the Road to Being Digital

We offer detailed examples of the choices faced by a cross-section of companies as they seek to leverage the digital technology and the new work practices we just described.

Companies can push decision-making to the front lines (edge-centric decision-making); they can make those decisions in real time (real-time adaptation); they can recombine human labor with advanced robotics in novel ways (human and digital recombination); and they can deploy a continuous, iterative process of experimentation and adjustment (experiment-driven design). Pursuing any or all of those practices is a matter of choice that deserves careful consideration.

Edge-centric decision-making

Ten years ago, analysts challenged the US Department of Defense to distribute "power to the edge," that is, to empower "individuals at the edge of an organization to provide access to available information and expertise and to eliminate procedural constraints."[14] Since then, technology has evolved to such an extent that power—or at least information—has indeed moved to the edge in many organizations. Not only that but the authority to make decisions is moving to the edges along with that information. And, in a growing number of companies, valuable insights are traveling from the edges to the core and from edge to edge. For example, a decade ago leading-edge practices focused on providing customer service representatives with greater information about clients so that they could be more responsive to their needs. Today, a newer and more radical form of decentralization is taking place, giving individuals who might be far removed from the corporate center a level of "situational awareness" that was previously restricted to managers further up the chain of command.[15]

Such edge-centric decision-making means that employees who are at the frontlines of the organization can have the information, the tools, and the authority with which to make decisions and, in some cases, to formulate strategy. And, rather than chaos ensuing, the rest of the organization will accommodate and learn from this improvisation, even replicating certain practices elsewhere.

Consider 7-Eleven, Inc. the international chain of convenience stores. Nearly a decade ago, the company implemented a global IT system to centralize inventory information and to consolidate its supplier base. In today's terms, it was hardly a revolutionary effort. But what distinguished 7-Eleven even then was its goal of optimizing its supply chain while allowing store managers and employees to capitalize on their knowledge of local markets in order to generate additional revenue.

Specifically, transactional data transmitted from point-of-sale terminals to a central data repository gave 7-Eleven the ability to identify purchase and restocking patterns—information that was key for company buyers to gain bargaining leverage with suppliers. At the same time, the system allowed store managers to customize their orders to account for local conditions.

More recently, each store has been given access to a Mobile Operation Terminal, commonly referred to as a MOT.[16] A MOT is a wireless specialized table that gives each sales associate data about sales trends and inventory levels of each SKU at their store, as well as other relevant data such as impending threats to the supply of given products. MOT uses visualization techniques to show highly granular data that can be used to forecast sales for the next ordering period. The effort to balance central and local paid off for 7-Eleven, making it one of the most successful convenience store chains in the world.

In an effort to accelerate the development of innovative, customer-focused products and merchandising, the company has begun sharing shopping cart-level data with an expanded network that includes corporate procurement staff, suppliers, store operators and their employees. The common database—described as "one version of the truth"—provides unprecedented visibility into what items should be stocked and supplied to local stores.[17] Such moves are a signal that 7-Eleven and companies like it are becoming increasingly digital by moving information, decision-making responsibility, and innovation to the edge.

Sales associates are now trained to place "sales forecasts" as opposed to "sales orders."

A distinguishing feature of 7-Eleven's edge-centricity is the fact that humans remain very much "in the loop." Availability of this much data at the hands of sales associates doesn't necessarily guarantee better results on its own. So 7-Eleven has taken further steps to improve odds of success. The first step is a cultural change. Sales associates are now trained to place "sales forecasts" as opposed to "sales orders." The former emphasizes the need to evaluate data and make a conscious and better-informed forecast (judgment) while the latter refers to the traditional practice of repeating last week's order.

In addition, to foster responsibility and ownership, 7-Eleven has moved to "Certified Order Writers," that is, store sales personnel who are trained to write orders and can advance to run part of the store. These individuals are assigned specific categories of each store. As a result, they can gain deeper expertise in the line-up of the products offered in that category. The sales associates can better understand local-market demands for products in their categories, form hypotheses about it (for example, "I think there may be demand for larger packaging of barbecue flavored chips"), and then validate it using data tools at their disposal ("how has this item fared in other stores?"), so they can make a decision as to whether the demand is worth the shelf-space. Sales associates feel a sense of ownership about their categories and their performance. To further strengthen this, MOT shows sales associates their own store's profit goals as well as gross profit achieved when they are placing forecasts, so not only are they cognizant of the importance of their forecasts, but they also feel a sense of completion about achieving their goals.

The implications for work design are significant. The story of digital technology at 7-Eleven is about technology empowering workers rather than displacing them; it is also about "up-skilling" rather than "de-skilling". In fact as new versions of the inventory system come online, sales associates will have access to far more data than ever before. For example, with "Perpetual Inventory" technology currently being tested, employees can see at any given minute of the day what levels of each SKU were on hand during the last week. This data allows sales associates to know that they ran out of chocolate donuts at 12:22 PM last Sunday—currently, they would only know that they ran out sometime in the afternoon). As a result of these changes 7-Eleven expects that its most successful sales associates will be increasing analytical and data-savvy.

Real-time adaptation

This work practice has the potential to bring speedier decision-making and greater operational flexibility to industries where a fraction of a percent improvement in productivity can add greatly to the bottom line. For example, according to a General Electric study, rail operations costs could be reduced between 1 percent and 2.5 percent with the use of real-time system controls—netting between $27 billion and $67 billion in savings to rail operators over five years.[18]

The evolution of sensor technology has brought with it the promise of networked machines, data and people—what GE has labeled the "industrial internet."[19] The promise resides in rapid awareness of change thanks to a continuous flow of digital information between machines and people. General Electric, among the world's leaders in locomotive technology, has targeted rail transport as an industry open to the benefits of real-time adaptation.

The core of real-time adaptation is the ability to collect, analyze and model data about the performance of machines—things like motors, switches, pumps and wheels—and then to integrate that with knowledge of context to make and enact decisions that can lead to previously unimaginable revenue opportunities. Complex systems suddenly become manageable. Local knowledge which previously stayed local can now be accessed globally. Parts of a system that were previously optimized to the (unintended) detriment of the whole can now be managed as a system.

> Real-time adaptation can dramatically reduce (or even eliminate) the time lag between modeling a complex system and changing it.

Real time-adaption can dramatically reduce (or even eliminate) the time lag between modeling a complex system and changing it. New forms of machine learning, automation and augmentation—cognitive (in the form of powerful algorithms that extract answers to immediate questions) and collaborative (in the form of intuitive tools for information sharing)—now enable locomotive engineers, network operators and transport analysts to eliminate waste; schedule train movement to optimize track usage; regulate speed, acceleration and braking of train engines; and make strategic tradeoffs—between speed and fuel consumption, for example.

According to a GE study, instrumented trains and tracks make it possible to closely monitor over 250 operating parameters.[20] In addition to allowing the rail yard operators to optimize schedules, data collected from these sensors is also used to augment the operator's ability to make real-time adaptations to the network.

Robots learning from humans and humans interacting seamlessly with computers are hallmarks of intelligent digital processes.

For example, suppose a train's engine sensor detects overheating. In the pre-digital world, the train operator would slow the train down to mitigate the overheating problem, which would cause, mostly unpredictable levels of disruption to cascade throughout the network. Network operators would be more or less in reactive mode. Now, by combining data about the operating conditions of all the trains, along with other relevant data, such as the nature of the each train's cargo and cost of delays, the network operation center is able to play an advisory role. This system helps the network operators make real-time adaptations to the network, which may mean taking some lower-priority trains off the system, re-routing others, and speeding some trains up while slowing others down, in order to maximize the overall profitability of the network.

As in the case of edge-centric decision-making, real-time adaptation challenges key assumptions in work design. Most important among them is the growing need for "transdisciplinary" skills—that is, an understanding of the behavior of complex systems that makes it possible for a train operator and a network operator to share both understanding and control of a sophisticated web of people and machines.[21] Rather than insist on rigid lines of demarcation between jobs or professions, real-time adaptation encourages a blurring of knowledge domains and a greater emphasis on systemic knowledge and systemic roles.

Human and digital recombination

In conventional automation, the objective is to become cheaper and faster by replicating human work that is repeatable and programmable. In an era of intelligent digital processes, the relationship between machines and humans is more complementary, with the two often being recombined in novel ways.

The objective of human-digital recombination is to enhance productivity by multiplying the effects of human physical and cognitive capabilities, enabling managers and employees to make better judgments. This recombination—with robots learning from humans and humans interacting seamlessly with computers—is one of the hallmarks of intelligent digital processes, and the need for such flexibility is great in industries as different as mining and online retailing.

One of the most interesting examples of human-digital recombination can be found in mining, an industry that predates the dawn of the computer age. Today in companies like global mining giant Rio Tinto, skilled operators, data analysts and engineers guide the intricate interplay of gigantic drills and excavators, gargantuan earth movers and dump trucks, and trains pulling hundreds of cars headed to ports and refineries around the globe. But, by contrast to traditional automation—where the objective is to replace direct labor with more consistent, accurate and repeatable mechanical processes—Rio Tinto's engineers and managers have adopted a systemic view: where the objective to achieve a quantum leap in performance comes about by more effectively combining human and machine intelligence.

Rio Tinto introduced its Operations Centre in 2010 as part of its Mine of the Future™ programme to service its iron ore business in Western Australia. The Operations Centre in Perth is "Mission Control" for Rio Tinto's entire Pilbara network that consists of 15 mines, up to 1,500km of rail, and 3 port terminals as well as power and other infrastructure.

The Operations Centre is exactly what it sounds like: a facility where equipment operators sit in a command centre hundreds of miles away from the mine.

Built originally to provide a more attractive work environment for always-scarce skilled workers, the Operations Centre has brought operators face-to-face to share common screen views of the mine and its environs, and to orchestrate their work in response to changing conditions like weather, truck breakdowns or major equipment moves. Physical proximity encouraged operators to collaborate and mutually adjust. As one senior executive put it, "they could finally look each other in the eye and know that the other person is going to make good on a commitment."

More importantly, the Operations Centre has turned out to be an essential ingredient in the transformation of mining operations. It serves as an operational hub and as a rich repository of mining, transport and supply chain experience. In many respects it represents the optimal combination of high-tech work environment and traditional mining know-how. And, it provides a hugely important link between the company's growing staff of quantitative analysts and the mines themselves.

The Operations Centre has already demonstrated clear and impressive results: increased efficiency, improved reliability, decreased variability and better identification of performance issues.

Analysts, many of whom are scientists and mathematicians with only a passing knowledge of mining, grind through massive databases generated hourly by sensing equipment in mines throughout the world and make recommendations to operators in the Operations Centre about new approaches to their jobs. Common dedication to improving system yield—whether in the mines themselves or through timely maintenance of equipment or the avoidance of delays in the ports—complements common access to the operational data. The net effect is a remarkably productive combination of human and machine talents.

Recombination of human and machines is also integral to Amazon.com's ability to deliver an extraordinary variety of retail goods—including in some cases perishable groceries—on-time with accuracy and low-cost. As a result of its acquisition of Kiva Systems in 2012, Amazon now operates one of the world's largest fleets of industrial robots in its warehouses.

These devices, resembling turtles because of their low center of gravity and broad backs, are guided by computers to pick up pallets, deliver them to central stations where employees select items in line with a pick list, and return pallets to their previous location—saving miles of walking on the part of fulfillment center workers. As Amazon senior vice president Jeff Wilke explained, "Technology is unlocking human potential. Technology is allowing humans to spend less time doing non-valuable things like walking to spend more time on process improvement for customers and the company."[22]

Kiva warehouse robots combine machine intelligence and learning with a human capacity for spotting improvement opportunities. Like the delicate interplay between remotely operated mining equipment, warehouse robots can be choreographed to move in complex and shifting patterns based on fluctuations in market demand, improvement suggestions made by kaizen teams of warehouse employees or continuously updated supply chain data. For example, during the days leading up to Valentine's Day, racks with relevant items such as chocolates in heart-shaped boxes are automatically moved closer to packing stations.[23]

Human-digital recombination challenges a number of assumptions in work design. Prominent among those challenges is the rejection of an impenetrable divide between humans and machines. The challenge surfaces two ways. In the first instance, the practice of real-time adaptation assumes that humans and machines can learn from each other. For example, at Rio Tinto data analysts and machine operators have a new appreciation for the behavior of the machines with which they work. Data generated from dozens of mines and hundreds of pieces of equipment reveal vital clues as to how to mine more effectively. Observation of the behavior of robots and algorithms reveals equally powerful insights into how to organize warehouse inventory.

With regard to the idea of separate and distinct universes for people and machines, work designers are coming to learn a lesson that game designers learned years ago: that human beings increasingly experience the world through computers, not versus computers. This insight flows against the long-standing view (or caricature) of humans treating computers and robots as alien. Today, by contrast, everything from wearable computers (like Google Glass) to handheld accessories (like smartphones) and ubiquitous access to search assumes that humans and computers don't just coexist, they collaborate.

Experiment-driven design

Experiment-driven design is a work practice that generates feedback as early as possible, to uncover user (customer or worker) preferences, catch design flaws, and create a better end product than

Human beings increasingly experience the world through computers, not versus computers.

Experiment-driven design can eliminate the need for the most expensive kind of rework.

the original design vision would have produced. It represents a shift away from having a design fully fleshed out up front, before building commences, and toward an approach in which a series of rapid "design-build-test" cycles is used to evolve the design.

The potential of this emerging work practice is perhaps best captured in the words of Luana Iorio, who oversees General Electric's research on three-dimensional printing: "The feedback loop is so short now that in a couple of days you can have a concept, the design of the part, a test as to whether it's valid, and within a week you have it produced."[24] In other words, experiment-driven design is important for both the work of design and the design of work.

The work of design

In industries where the product itself is digital—like software or web-site design—we have witnessed a shift over the past decade from linear to non-linear, iterative design processes, with dramatic increases in the speed of product development and equally impressive reductions in design risk. Perhaps the most familiar evidence of this shift has been seen in companies like Google and Facebook, where engineers are encouraged to eschew lengthy waterfall approaches to design and iterate rapidly, get feedback and improve.[25]

Slogans like "fail fast" and "move fast and break things" might seem like endorsements of chaos and inefficiency, but in practice the opposite is true. Iterations are used effectively to acquire information about the suitability of the current version of the design. The objective of each iteration, especially early on, is less about nailing down the "right" design and more about exploring the design space, testing new ideas (usually by exposing customers to them), and systematically gathering data that will inform later iterations. As such, the most successful early design iterations are those that uncover the most useful information to inform the ultimate design. When implemented properly, experiment-driven design can eliminate the need for the most expensive kind of rework, namely the unplanned redesign that happens late in the overall process after major design flaws are uncovered.

Experiment-driven design is not relevant only in software. In fact, its influence in automobile design has also grown rapidly in recent years. A case in point: Audi's Virtual Lab and crowdsourcing initiatives are quickly changing the tempo and the flow of design engineers' work. Audi's

Virtual Lab, first used to co-create Audi's software-based infotainment system, is an online network that automatically evaluates R&D prototypes based on crowd-sourced responses from customers.[26]

The crowdsourcing component of Audi's online Virtual Labs system asks customers to design their ideal product based on the amount they are willing to spend, creating a simulated purchasing decision similar to what happens at a car dealership. The system uses rapid data analysis (machine learning) to continually refine the questions it asks customers based on existing virtual prototypes (developed by Audi's R&D team), customers' demographic profiles and their real-time responses.[27]

Audi engineers compare the results to the prototypes they have already developed.[28] This approach helps engineers identify and distinguish between "must-have" and "nice-to-have" features based on customer demand, which improves the next round of simulated prototyping.[29] Iterative engagement with customers has paid off: Audi recently won awards for its infotainment systems, including being named "connected car of the year," and for its R18 Ultra Chair.[30]

The design of work

The second aspect of experiment-driven design involves the design of work. Though embryonic, this could have a dramatic effect in the next five years.[31] It's not news to report that novel product designs frequently have downstream impacts on the organization of work; for example, the decision to replace rolled steel with plastic or carbon-fiber for the door panels of cars meant a great deal of change for how panels were fabricated and how doors were assembled.[32]

However, the shift to which we refer involves new ways of organizing work that are enabled by digital technologies. For example, team-based work is rapidly becoming second nature because the cost and complexity of collaboration is being reduced (or absorbed) by intelligent tools; so, we are seeing teams being deployed in work processes that previously would have been carried out by solo experts or by groups of people working in isolation from one another.

Pharmaceutical companies, for example, now use combinatorial chemistry, bioinformatics, and other technologies to generate and test potential new drugs in a fraction of the time of more traditional methods. In other words, not only has the product changed, but so too has the work. For example, scientists can now experiment with a more diverse array of compounds while reducing the complexity of individual tests. Without ever entering the laboratory, data analysts can now comb databases composed of the results of hundreds or even thousands of experiments and arrive at candidate drugs.

In the auto industry, manufacturers like Audi and BMW now routinely employ computer simulations of vehicle crashes in order to develop and test new designs before—and, in some instances, instead of—building expensive prototypes. They save millions of dollars each year by not building and then destroying cars and gain much-needed insight into the behavior of expensive materials and complex systems.[33] In the healthcare industry, new work processes for the management of patient electronic records can be simulated on a computer, deployed, and updated on a continuous basis rather than launched once and revised only after long implementation cycles.[34]

Combinations and implications

Thus far we have discussed the four different work practices individually, but we have found that companies will frequently deploy them in different combinations in order to tap into the full power of intelligent digital processes.

Take the example of 7-Eleven. The company has deployed edge-centric decision-making to empower store managers, franchisees and employees, and those frontline workers use their knowledge of the local market to make smarter decisions about which products to stock. That has enabled 7-Eleven to take advantage of another work-organization option: real-time adaptation. When a hurricane or other adverse weather event is imminent, for example, the 7-Eleven stores in the affected area can quickly increase their inventories of batteries, bottled water, and other essential supplies.

Whether a company pursues just one or multiple options for work organization, that choice will have major implications for the organization as a whole. Consider just the practice of experiment-driven design. Improvements in software development do not come just from speeding up traditional processes. Instead, the bigger wins come from restructuring a linear process into an iterative, experimental one.

But this necessitates key changes in employee skills and managerial approaches. For one thing, the looping, iterative nature of experiment-driven design requires new thinking about project planning and estimating. Moreover, employees must now adopt an experiment-driven mindset, which is not always easy for those who are accustomed to conventional approaches. Developers, for instance, must get accustomed to much faster design cycles, meaning that a design may still be "half baked" before being developed and tested. They must also understand how to design for experimentation during early iterations.

In the following chapter, we discuss those and other implications in greater detail. As we shall see, oftentimes the technological changes are not what companies struggle with most; it's the organizational, managerial, and employee changes that typically present the largest challenges. That's why we say that being digital demands a deep shift.

The bigger wins come from restructuring a linear process into an iterative, experimental one.

Chapter 4: The DNA of a Digital Enterprise

Becoming a digital enterprise requires deep shifts—changes that crosscut skills, roles and even culture. Based on our research, we contend that there are three key dimensions to the deep shift from looking digital to being digital: employing the right tools in the right way; developing and deploying the right talent; and evolving the right management mindset.

Employing the right tools in the right way

There's no question that companies can save money and increase efficiency by digitizing paper-intensive processes. But that's not the same as using technology to extract data that addresses a customer need (and thus adds value) or using it to infuse information into physical objects to make them smarter. And it's not the same as using data to dramatically improve the performance of a process. Intelligent digital processes deliver real benefit by eliminating redundancy, accelerating improvement and matching enterprise capabilities with customer needs.

Two of the most powerful—and challenging—features of an intelligent digital process are the ability to make data available to a broader spectrum of employees and to engage in experiments in the design of both products and processes. For example, retailer 7-Eleven handed over data and tools to store-level personnel so they could make choices about what to stock for what market niches and how long. At Audi it meant engaging a wider variety of professional communities, as well as customers, in an iterative design process. At Rio Tinto, it meant giving analysts a window through which to view real-time operations and model alternative solutions to perennial problems.

The power of data access comes from the opportunity it provides for people to make timely and more intelligent and impactful business decisions. The challenge, however, comes from making the inner workings of the enterprise more visible—to workers, managers and ecosystem partners—and therefore to enable more people to ask more questions about why things work the way they do and what might be accomplished by making a change.

In a growing number of software and services companies, access to digital assets—in those cases, access to code—is considered an absolute must in order to accomplish business objectives. Not so in many companies where access to data is still considered to be a source of privilege. The message is clear: if data is the raw asset, it must be available to those who can turn it into information, knowledge and value.

The power of experimentation is evident in the results that companies like Audi and GE have gotten from high-speed refinement and improvement of products and services. But the challenge comes in mustering the courage to wiggle free from a dominant paradigm of fixed and final designs as the only way to move from idea to outcome. That explains why companies in the automotive and pharmaceutical industries are starting to look more and more like their software industry counterparts as they try to identify and explore new products using models, simulations and digital exchanges with customers and suppliers before committing to build anything. And, once the decision to build is made, they are using advanced procedures (like limited releases and collaboration with advanced user communities) to pressure-test and refine those designs, to explore their implications for downstream processes like manufacturing and distribution, and to move much more quickly to market.

However, making these changes requires a more open approach to data distribution, a much higher level of comfort with ambiguity (such as a willingness to go with something that's 80 percent right or directionally correct versus 100 percent locked down) and a willingness to move in the absence of complete agreement.

Developing and deploying the right talent

Fredrick Taylor, progenitor of scientific management a century ago, famously remarked that all an employer really wants in a worker is a pair of hands and a strong back; unfortunately, he argued, the hands also came with a head. Thinking and interpreting human beings were anathema to scientific management. Today, managers in the digital enterprise need to recognize that the right heads are essential to being digital. Tools are not enough. With more and more of the work of data collection embedded in sensors and intelligent tools, the demand in the years ahead will be for employees who are capable of working with data and who are motivated to use data to improve products and practices. Based on observations drawn from a disparate set of cases, we believe that four core talents will prove critical:

First, the ability to experiment. This might seem obvious, but the virtual flood of data generated by digital tools can easily overwhelm any effort at experimentation. Think of what the first generations of enterprise resource systems did to decision-making. The dictum of "garbage in/garbage out" comes to mind. The ability to arrive at testable propositions is crucial even in an era of smart machines.

Whether those propositions are arrived at inductively (through careful observation of events and a search for patterns) or deductively (driven by hypotheses of cause and effect) matters less than the ability to ask questions of the data that lead to productive answers. This assumes a heightened level of numeracy on the part of front-line employees and managers. Case in point: store personnel at 7-Eleven engage in experiments on a virtually daily basis with their inventory choices. The availability of a massive data base, smart planning tools and internal business advisors enables them to test their ideas, see what works and communicate the results immediately.

The message is clear: if data is the raw asset, it must be available to those who can turn it into information, knowledge and value.

Second, the ability to learn. Experimentation is random motion if it's not fueled by curiosity and the ability to retain what's been discovered. Learning is compulsory in the digital enterprise because the pressure to improve performance—both of products and processes—is relentless and will only become more so.

Interestingly, openness to learning is something that has traditionally been regarded as an age-related phenomenon. That is, we tend to view young people as more open to learning—indeed, more eager to learn—than their senior counterparts. This view has been reinforced in recent years by the attention drawn to differences in learning environments and learning styles among young people, including the generation that's grown up with computers and smartphones.[35] Research that's been done on these so-called Millennials suggests that they expect the latest in digital technology at the workplace and are willing to use their own computers, tablets and phones in place of the "archaic" technology they are issued by their employers.[36] To the extent that companies seek to become digital, they will need to equip young people with the tools that they use to learn with.

It is essential to recognize that older, veteran employees often possess a level of curiosity and an openness to learn equal to their younger counterparts.[37] Not only do they relish the opportunity to do something different, they demonstrate a high level of ingenuity in solving problems. In other words, the ability to learn is not reserved to those who've grown up digital.

Judgment is often a more difficult feat than action because it demands a moment of reflection before hitting the go button.

The third required core talent: judgment. A first-line supervisor we interviewed made the point succinctly: "You have to have the right information and then you have to do the right thing… even if it doesn't agree with the information." Doing the right thing—whether the question is moral, ethical, operational or financial—requires the ability to balance evidence and potential consequences, along with a working knowledge of local values. Judgment should lead to action (even if the decision is to not act) and action is something we expect from employees (especially managers).

But judgment is often a more difficult feat than action because it demands a moment (or more) of reflection before hitting the go button. In an environment of rapid change and ambiguity brought on by the drive to explore more possibilities, judgment will be the talent that keeps the digital enterprise on course. Think of it like the brake that enables you to drive fast—and slow down when you're about to lose control.

Judgment is something that companies like Rio Tinto and GE are rediscovering even as they strive to bring digital technology to a wider expanse of industry. Rio Tinto managers discovered that bringing remote operators together gave an increased level of flexibility and agility to a highly interdependent set of operations. It also gave those operators a systemic view of "pit to port" that made it possible to combine computers and people with deep operational knowledge to make decisions and evolve operating principles that saved millions of dollars.

The final required core talent is collaboration. The dictionary defines collaboration as "working together." Strictly speaking, any work that relies on the cooperation of two or more people would qualify as collaboration. However, collaboration in the digital enterprise means something more profound because the opportunities that exist for creating new value through discovery and experimentation are so great. That's why we suggest that it is essential to highlight a truly distinctive feature of collaboration: the unstructured and voluntary component of working together.

Collaboration is vital to creativity and innovation but it cannot be taken for granted. Simply equipping people with the latest social media or collaboration software will not induce them to use it to generate new products or to find ways to delight customers. GE has recognized as much when it underscores the importance of cultivating "adventurous" employees who relish the opportunity to invent and experiment.[38] Likewise, 7-Eleven and Audi—operating in very different environments—both encourage their employees to engage in dialogue with customers. Rio Tinto needs data scientists and machine operators to collaborate in making sense of shared data, undertaking experimental adjustments in the use of extremely expensive capital equipment, and in evolving a systemic view of people and machines. Moreover, Rio Tinto (along with a rapidly expanding cadre of companies) recognizes the importance of developing and deploying competence in the use of social media and collaboration software in both its younger and its older employees.

The net effect on skills and competencies of being digital are summarized in Figure 4 below. This table captures changes in the nature of skills required and in the cadence and even the culture of the digital enterprise. Experimentation assumes that one can both follow and question rules using data and method. Working through computers means that the historic divide between workers and machines yields to collaboration with and through smart machines. The capacity to live with change is a shift occasioned both by the nature of the external environment and by the need to adapt and change at work to accommodate or even anticipate change. Finally, the role of search expands from one that is linear and solution-oriented to one that is lateral and opportunity-oriented.

Figure 4: What being digital means for skills and competencies

From	To
Follow rules	Experiment
Work with computers	Work through computers
Tolerate robots	Team with robots
Expect stability	Expect change
Search is a skill	Search is a way of life
Knowledge work	Judgment work

Evolving the right management mindset

In an article written nearly 40 years ago, management scholar Rosabeth Kanter offered a solution to what she foresaw as an impending "power failure in management circuits."[39] Her observation applies with even greater relevance today: in an era when companies need (and say they want) greater innovation and agility, managers need to be willing to relinquish control—or release their death grip—on work processes. Innovation demands breathing room—not an abandonment of rules, hierarchy or the responsibility that comes with representing the interests of owners and shareholders—but instead a doubling-down on tools, methods and management practices that give people the room to experiment and take calculated risks without fear of severe reprisal should they fail.

The case studies bring to light two important issues that arise with being digital. First, it is entirely possible to increase systemic control while loosening local control. This is the core message from our examples of edge-centricity. If by control we mean the ability to reliably and repeatedly accomplish desired outcomes, then managers who equip their teams with the tools and the training necessary to both do and innovate will extend system control—even if it means that managers whittle back their individual control.

At one level, there's nothing especially new in this insight. We've known for a long time that delegation is essential to managers' ability to oversee larger numbers of people and more complex processes. However, there's a dimension here that goes beyond simple delegation. That is, one of the lessons of the quality movement in the 1980s and 1990s was the importance of measuring and charting the behavior of complex, end-to-end processes in order to bring them "under control"—recall the practice of drawing control charts as part of statistical process control.

The computer power to do that automatically did not exist then but it does today, and the highly instrumented nature of many processes means that it is possible to "control chart," model and experiment with much larger segments of a system than ever before. In fact, the ability to model without intervening means we can experiment without shutting down; in some instances, it is possible to experiment even in the midst of routine operation without introducing undue risk.

By increasing system control, management is not rendered redundant; it's given a new mission: from a core objective of controlling processes to one of finding ways to unlock value in processes or to create new value by applying well-understood processes in new ways.

The second insight from the case studies is much more focused on the behavior of a stratum of management that only gets attention fitfully: first- and second-level management. These are the men and women responsible for being the universal gear that connects line employees and higher levels of management.

Why focus on first- and second-level management? Their jobs are likely to change the most in the transition to being digital. They will need to be both literate and numerate if they are going to support employees in making the most of available data. They are going to be called upon to exercise judgment in reconciling what the intelligent tools recommend and what history, culture and customers demand. They are going to play the essential role of encouraging responsible experimentation, dealing with inevitable failures or breakdowns that experimentation produces, and translating strategic direction into operational action.

Military organizations the world over have recognized the critical role of non-commissioned officers for centuries. But it was the emergence of guerilla tactics, asymmetrical warfare and terrorist attacks that forced the US military into driving "power to the edge." And, when they got there, they discovered even greater importance in the role of unit leaders. The military has moved from a centralized system of command and control to one in which strategic command set objectives and rules of engagement and leaves operational control to unit commanders. It has also reshaped the way companies like Rio Tinto look at command and control. Recall that the head of innovation and technology at Rio Tinto described the role of remote data centers as an advisory one for mining operations, not a command role.

We expect to see over the next five years a similar development in digital enterprises. But the most significant break with the past will be the exercise of restraint on the part of core management. That is, the ability to scoop up data from the edges will tempt managers in the core to second-guess decisions made at the edges and, worse, to usurp those decisions. So, just as the Pentagon has marveled at technology that allows the US President and the Joint Chiefs to see operations in real-time, it has also had to resist the impulse to make decisions at the edges. Figure 5 below details other changes we anticipate seeing in the role of management in the years ahead.

The point is, therefore, relatively simple: first- and second-level supervision in the digital enterprise will need to be carefully chosen, developed and rewarded. Otherwise, the promise of being digital is likely to wither on the vine.

Figure 5: What happens to management?

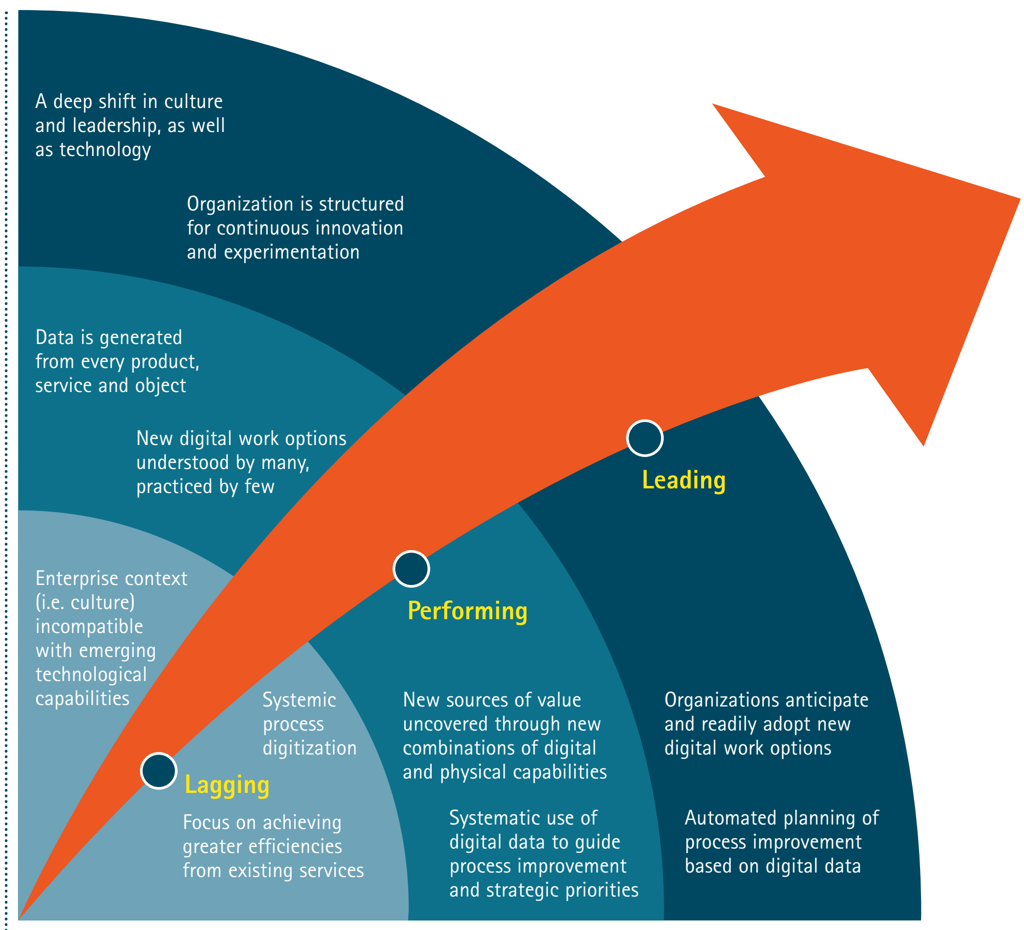
From	To
Control process	Unlock value
Process information	Make judgments
Plan-check-do	Experiment-then-scale
React	Initiate
Deploy apps	Listen to apps
Manage	Inspire

Self-diagnosis

We have tried to capture the subtle as well as the obvious elements that make up the deep shift to becoming a digital enterprise in Figure 6 below. By framing the challenge in both pictures and words, we also seek to highlight the interactions between strategy, structure, culture and technology. A careful self-assessment can uncover important topics to address in the short- and the long-term.

Figure 6: Digital enterprise maturity model

Business dimension:
- Strategic context
- Organization structure and work processes
- Culture and behavior



Technology dimension:
- Technical capabilities
- Data content

	Lagging	Performing	Leading
Strategic Context	• Technologies meet some, but not all, of the needs of strategic priorities • Incompatible goals/activities among key workforces reduce potential gains • Value is gained from efficiencies created through faster, cheaper ways of delivering existing services	• Technology meets most of the needs of strategic priorities • Key workforces have no conflicting objectives, but the objectives may be poorly defined • Value comes from new sources which do not resemble the organization's existing services, and can only be delivered through new combinations of digital and physical capabilities	• Technology not only meets all of the needs of strategic priorities, but helps redefine them • Key workforces have well-fitting objectives and activities • Value not only comes from new sources, but is optimized along the entire chain
Technical Capabilities	• Digital technology replaces, almost one for one, analog technology or human labor (e.g. online catalog instead of printed catalog) • The ability to introduce a new digital service is a function of technology lifecycle investment • Digital services are offered in isolated hard-to-connect silos	• Digital services are used as building blocks which can be rapidly recombined and connected through APIs to offer new services • Technology life-cycle is a function of service delivery needs	• Digital services, as well as physical products and analog are frequently modified to improve the quality of relevant data
Data Content	• Data is generated by a byproduct of traditional processes	• Data is generated from every product, service and object	• The organization has a new core competency: Vertical-specific data. The organization captures every level of data along the entire value chain (i.e. how its products are acquired, produced, delivered, consumed, repaired and recycled)
Organization Structure and Work Processes	• Organization structure and processes, and work design options, are optimized for efficient error-free production • Work is performed by hyper-specialized groups of workers in traditional organizational layers and divisions • Decision-making is still top-down	• Organization structure and processes, and work design options, encourage experimentation with the goal of uncovering and delivering new sources of value • Work is performed by workers in and outside the organization, but in traditional organizational layers and divisions • Decision-making is not always top-down; decisions may be made on the edge, in the middle, or at the center, as appropriate for the given workflow	• Organization structure and processes, and work design options, are focused on continuous innovation and experimentation. • Work is performed by allowing teams of experts to form around new ideas and experiments in non-rigid organizational layers • Decision-making processes are optimized at each stage of the workflow
Culture and Behavior	• Some change management in place for introducing new technologies • Industrial age management beliefs still dominate the organization	• Workers at all levels of the organization are supported to manage and personalize new technologies in everyday work processes • Traditional management roles evolve as a result of deploying new technologies	• The organization establishes a new digital culture—undertaking a deep shift in culture and leadership, as well as technology • New management principles introduced for leadership in the digital enterprise

Conclusion

In 1996, Nicholas Negroponte, then director of MIT's Media Lab, wrote that being digital was almost genetic... and that each generation would become more digital than the one that preceded it.[40] Observing developments in a growing number of companies, it is hard not to see the prophetic nature of that remark. There is also something very contingent about it. That is, being digital is a profound shift that an organization is not likely to stumble into or blindly evolve toward.

The benefits of being digital may be substantial—as indicated by the case examples laid out in this report. However, the deep shift from looking digital to being digital is predicated on intentional efforts to employ these tools in new ways, to develop and deploy the right talents, and to drive new management mindsets. Therein lies the challenge for leaders: to recognize that a deep shift is necessary and to start building the foundation for it right away.

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Acknowledgments

Sponsors
Shawn Collinson
Paul Daugherty
Matthew Reilly
Yaarit Silverstone

Supporting authors
A special thanks to Masoud Loghmani
Charlene Tsang
Richard Amico
Ryan Coffey
Siddhanth Munukutla

Reviewers
Jeanne Harris
David Light

The authors would like to thank the following people for their insights and assistance:
John McGagh; Preston Chiaro; Mary "Missy" Cummings; Wanda Orlikowski; Mark Little; Bill Ruh; Arvind Agnihotri; Erick Glazer; Evren Eryurek; Israel Alguindigue; Brandon Harvey; Bob Suh; Bruno Gouraud; Steve Holland; Joe Howard; David Schwartz; Ari Gesher; Andrew Stevens; Peter Cheese; Ana Dutra; April LaCroix; Kelly Dempski; Mark McDonald; Sanjay Dawar; Robin Murdoch; John Lichtenstein; Rachel Bartels; Khayyam Jahangir; Deepak Phatak; Ankit Mehta, Florin Rotar; Meena Vembusubramanian; Myriam Curet; John DelSanto; John Hindle; Tom Heatherington; Jeff Elton; Andreas Baier; Jim Golden; Susan Mann; Bruno Berthon; Raghunath Krishnagiri; Michael Ebels; Jordi Roca; Philippe Guittat

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