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Designing the digital organization

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Abstract

Increasingly, organizations are assessing their opportunities, developing and delivering products and services, and interacting with customers and other stakeholders digitally. Mobile computing, social media, and big data are the drivers of the future workplace, and these and other digitally based technologies are having large economic and social impacts, including increased competition and collaboration, the disruption of many industries, and pressure being put on organizations to develop new capabilities and transform their cultures. In this article, we provide a conceptual framework for the design of effective digital organizations. Our framework is predicated on the current state of digitization across diverse sectors of the global economy. In the digital world, all activities and transactions leave digital marks, and all actors, things, and places can be reached and affected digitally. As a result, we can design for self-organization rather than using hierarchical mechanisms for control and coordination. Such designs require the strategic and cultural alignment of digital technologies within the organization and externally with stakeholders. We propose that "actor-oriented" principles are at the heart of designing digital organizations and that, if properly applied, can result in a workplace where organization members are highly engaged and productive.

Keywords: Digital technology, Digital organization, Digital disruption, New organizational forms, Organizational architecture, Workplace of the future, Collaboration tools

Digital technologies are transforming the global economy. In his pioneering book *Being Digital* (1995), technology futurist Nicholas Negroponte (1995), described how the old industrial economy would be eaten away by a new digital economy. Moreover, digital technology makes it possible for members of an organization to self-organize and thereby avoid the delays, distortions, and other damaging effects of hierarchically organized systems (Benkler, 2002). Established companies recognize that digital technologies can help them operate their businesses with greater speed and lower costs and, in many cases, offer their customers opportunities to co-design and co-produce products and services (Sambamurthy et al. 2003). Many start-up companies use digital technologies to develop new products and business models that disrupt the present way of doing business and take customers away from firms that cannot change and adapt.

Software tools and applications, robots, and a host of other digital technologies "… are doing for mental power – the ability to use our brains to understand and shape our environments – what the steam engine and its descendants did for muscle power" (Brynjolfsson & McAfee, 2014: 7–8). Properly harnessed, digital technology can enable individuals, firms, cities, and governments to become smarter – to expand their

capabilities and to adapt to new and changing conditions. As an agile organizational form (Alberts, 2007), the digital organization will be populated with individuals and teams who are facile with technology and who can collaborate both inside and outside the organization to make process improvements and develop new solutions.

In our article, we offer organizational designers, change agents, and managers a conceptual framework for the design of a digital organization – identifying its major components and showing how they should be put together. A fully digital enterprise is a powerful combination of people, technology, and organizing ability that is well suited to today's economic and social environment. In the first section, we discuss how digital technologies are used by organizations to increase their efficiency and effectiveness. Digital technologies augment and support work activities and decision-making, connect members of the organization, and aid in managing relationships with customers, suppliers, and other stakeholders. In the second section, we describe the organizational architecture that is appropriate for a knowledge-intensive, highly collaborative digital organization. This architecture is "actor" oriented – that is, it places a premium on the ability of organization members to self-organize while performing their work tasks. Actor-oriented organizations mostly rely on protocols, commons, and infrastructures to maintain control and coordination instead of hierarchical mechanisms. In the final section, we discuss how to apply the actor-oriented architecture for those organizations wanting to develop their digitally based capabilities. Here we address the skills and motivation of actors, the creation of commons that support their work activities, and the protocols and infrastructures that connect actors and facilitate their interactions.

Digital technology

Technology is a way of getting work done (Perrow, 1967). New technologies are seldom "invented" but rather are developed by combining technologies that already exist. Unlike older technologies, which mostly produce fixed physical outputs, digital technologies are generative (Zittrain, 2006) – they can be combined and recombined endlessly for fresh purposes (Arthur, 2009). In many cases, digital technologies also can enable replication and distribution of products and services at close to zero marginal cost (Shapiro and Varian, 1999; Varian, 2000). The domain of digital technology includes computer hardware, software, transmission networks, protocols, programming languages, very large-scale integrated circuits, algorithms, and all the components and practices that belong to these various technologies. Digital technology enables immense amounts of information to be easily compressed, preserved, and transmitted. In recent years, digital technology has disrupted one industry after another (Christensen, 1997), and it is rapidly transforming how people communicate, learn, and work. Many products and services are fully or partially digital, such as news and entertainment, and increasingly work is being done digitally.

The essence of the digital revolution has been concisely described by Brynjolfsson and McAfee (2014). They explain that technological progress in the digital era is due to three characteristics of technology: it is *exponential, digital,* and *combinatorial* (p. 37). The exponential aspect of technology means that its power and usefulness are getting better and better all the time and that "… what's come before is no longer a particularly reliable guide to what will happen next" (p. 55). Digitization turns various kinds of data and information into bits – the ones and zeroes that are the language of computers.

Advances in digitization have resulted in "… new ways of acquiring knowledge…and higher rates of innovation" (p. 62). Lastly, digital innovation is combinatorial: "Each development becomes a building block for future innovations" (p. 81). Coupled with human ingenuity, these three characteristics allow digital technologies to be developed and applied at a rapid rate.

Adaptation and disruption

Organizations adapt to the needs of the market; to the technologies available for the design, production, and delivery of products and services; and in their means of organizing (Miles and Snow, 1978). The digitization of society is affecting customer needs, product and service properties and delivery mechanisms, and organization design (Langer, 2017). Changes across these areas are coalescing. For example, music has changed from a product to a service industry wherein consumer demand has evolved from purchasing packaged CDs to accessing customized, streamed playlists which are organized by aggregators such as iTunes, Tidal, Spotify, and Pandora, with distribution driven by artists instead of studios. "Products as services" is a business model that is growing in many arenas (Porter and Hempelmann, 2014).

Technological innovations can be incremental or disruptive. Incremental innovations are characterized by small improvements to existing products, services, and processes. Disruptive innovations, on the other hand, may create new markets and business models, and often may displace market leaders (Christensen, 1997; Christensen and Bower, 1996). In past decades, organizational responses to technological changes were mostly incremental and, in part, enabled by IT improvements that allowed greater scope and dimensionality of organizational control and coordination. Most of those adaptive responses were made within existing hierarchical forms of organizing (Altman et al. 2015). Digital technologies, however, often disrupt established ways of organizing and require adaptation through collaboration as well as self-organization around situation awareness (Endsley, 2000) and knowledge commons (Hess and Ostrom, 2006; Ostrom, 1990, 2010). Self-organization and collaboration, as an adaptive response, is faster and more effective than a hierarchical response.

The technological manifestations of disruption in organization design are clearly visible, as are workplace changes and changes in inter-organizational relationships. What is less visible are changes in the associated design paradigm, which enable organizations to obtain efficiency and effectiveness improvements by investing in digital technology. The new organization design principles are similar to those used in designing digital technologies themselves. Their roots are found in object-oriented systems design (Dahl and Nygaard, 1966) and in the architecture of the Internet (Krol, 1993). In organizational terms, these principles are embodied in actor-oriented architectures (Fjeldstad et al. 2012).

Working and organizing digitally

Digital technologies play a role in all aspects of operating, controlling, and coordinating the activities of organizations (Setia et al. 2013). Broadly speaking, they are used for automating and augmenting tasks, communicating internally among organization members and externally with customers and partners, and in collaborative decision-

making among digital and human agents (Davenport and Kirby, 2015; Engelbart 1962; Huber, 1990; Licklider, 1960; Simon, 1973). At Tesla's manufacturing facility in Fremont, California, technicians work alongside 185 robots made by the German firm Kuka Robotics to assemble the electric cars. By using artificial intelligence "reinforcement learning algorithms," the robots are able to switch tools and perform certain tasks far better and faster than their human co-workers (Gershgorn, 2016). Surgeons at the Mayo Clinic use robots to augment a variety of surgical procedures in heart, head, and neck operations. The surgeons perform those operations by controlling surgical micro-instruments attached to robotic arms (Mayo Clinic, 2016).

Both intra- and inter-organizational transactions and communications have been performed digitally for a long time (Fedorowicz and Konsynski, 1992). Walmart exemplifies a highly digitized supply chain connecting its stores, distribution centers, and suppliers (Mata et al. 1995). Currently, social media such as Facebook and Twitter are used by companies to communicate with their customers and other stakeholders, and digital platforms such as Facebook at Work and Microsoft's SharePoint allow for internal communication and for collaboration with partners.

Digital technologies are also used for learning, decision-making, and design. E-commerce companies such as Amazon, Google, Airbnb, and Uber study the data trails of consumer behavior to design markets for greater efficiency and build new markets (Lohr, 2016). Intelligent digital design tools are used in engineering and creative industries. Those tools typically offer 3D representation of the objects under design, and they allow designers to simulate the operations and performance of alternative design choices (Fujitsu, 2016). In semiconductor manufacturing, the designs are digitally transmitted to equipment that manufactures the product. With continuing development and wider adoption of 3D printing technologies, the design-to-manufacturing process will become fully digital across many more industries (Sasson and Johnson, 2016). MTR Corporation, which owns and operates the Hong Kong subway system, uses artificial intelligence to schedule maintenance tasks. In a typical week, more than 10,000 people carry out 2,600 work orders. The system was "trained" by using expertise extracted from human experts and then transformed into work rules. The main difference between normal software and MTR's artificial intelligence is that it contains human knowledge that takes years to acquire through experience (Hodson, 2014). Some companies employ digital design tools in collaborating with their customers and partners. Lego provides toolkits on its website that enable entrepreneurs and customers to submit product ideas and start new Lego brick-based businesses (Heinerth et al. 2014). (See Table 1 for a summary of digital applications and leading digital firms and organizations.)

An organization is a goal-directed, boundary-maintaining activity system (Aldrich and Ruef, 2006). In traditional organizations, technological artifacts such as manufacturing equipment and computers are controlled by human operators. With the declining costs of global communication and information processing, hierarchy is being replaced by radically different ways of organizing (Fjeldstad et al., 2012), the digital elements of which include cloud computing, big data analytics, cognitive computing, and collaboration platforms. Artificial intelligence embedded in machinery and tools, as exemplified above, plays an ever-larger role in emerging digital organizations (for a survey see Kolbjørnsrud et al. 2016). As a result, employees collaborate with, rather than merely control, the technology in use, and organizational designs have to encompass both human and digital

Table 1 Digital applications used in leading digital firms

Target area	Goal	Leading digital firms and their industries
Customer experiences	Customer co-creation of products and services Customer engagement and loyalty Customized offerings	Burberry (clothing) Starbucks (specialty retailing) Caesars (gambling and entertainment)
Internal operations	Increased efficiency Lower costs Greater speed Higher quality	Asian Paints (paint and adhesives) Codelco (mining)
Business models	Reinventing industries Substituting products or services Creating new digital businesses Reconfiguring value delivery models Rethinking value propositions Market design	Airbnb (private lodging) Uber (taxi services) Amazon (online retailing) UPS (logistics services)
Product design and development	Intelligent product design User-driven innovation	Fujitsu (electronics) Nike (athletic shoes and apparel) Lego (toys)
Organizing	Agile organizations Collaborative processes Non-hierarchical means of control and coordination	IBM (technology and consulting) Accenture (professional services) NATO military forces (national defense)

Source: Adapted from Westerman et al. (2014)

agents. Organizing digitally means collaboration with more entities and less reliance on hierarchy for control and coordination. It also entails empowering employees, partners, and customers who use digital tools for the co-creation and co-production of products and services as well as providing digital platforms for self-organized collaboration (Boudreau et al. 2011).

Actor-oriented organizational architecture[1]

Digital technology is not only changing how organizations operate but also the way we think about organizing. Organizations increasingly include digital and human agents who share means of communication, control, and coordination. A traditional organization is arranged hierarchically – that is, control and coordination are achieved through an authority (reporting) structure in which superiors plan and coordinate the activities of subordinates, allocate resources, and resolve problems and conflicts (Simon, 1962). A hierarchical organization can be effective in stable and predictable environments because the organization does not have to regularly innovate or adapt to change. Many of today's environments, however, are not stable and predictable; they are volatile, uncertain, complex, and even ambiguous (Johansen, 2007; Suhayl & Joshi, 2015). Such environments are characteristic of knowledge-intensive industries like biotechnology, computers, healthcare, professional services, and national defense. Organizations operating in these types of environments rely heavily on the agency of their members. A hierarchical organization inevitably instills a hierarchical mindset among its members. Members understand that they are being paid to do a particular job, and they look to their managers to set goals, develop plans, and approve the quality of their work. As a result, organization members become psychologically as well as economically dependent on the hierarchy. In addition to the friction created by "relay managers" (Drucker, 1988) who merely pass along information,

hierarchical management styles tend to reduce intrinsic employee motivation to take initiative.

Prior research has proposed an actor-oriented organizational architecture that is appropriate for knowledge-intensive sectors where organizations must continuously learn and adapt (Fjeldstad et al. 2012). Actor-oriented organizations rely on self-organizing, with only minimal use of hierarchical mechanisms to achieve control and coordination. Such organizations are particularly useful for large-scale, multi-party collaboration – a required capability in knowledge-intensive industries (Benkler, 2002; Powell et al. 1996). Collaboration has been shown to reduce risk, speed products to market, decrease the costs of solution development and process improvement, and enable access to new knowledge, technologies, and markets (Eisenhardt and Schoonhoven, 1996; Hagedorn, 1993; Kogut, 1988; Wheelwright and Clark, 1992).

The actor-oriented architecture is composed of three elements: (1) *actors* who have the capabilities and values to self-organize; (2) *commons* where the actors accumulate and share resources; and (3) *protocols*, *processes*, and *infrastructures* that enable multi-actor collaboration (see Table 2). In actor-oriented organizations, control and coordination are based on direct exchanges among the actors themselves rather than on hierarchical planning, delegation, and integration. Although hierarchy is present in actor-oriented organizations, these designs mainly rely on lateral, reciprocal relationships among actors for control and coordination. As an illustration of how an actor-oriented organization works in an easy-to-grasp context, see Table 3, which describes the organization of ants foraging for food.

Actors

Actors – whether they are individuals, teams, or firms – must possess the capabilities and values to self-organize. They engage in self-management rather than wait to respond to directions received from the hierarchy. They also act with integrity, developing a reputation for consistent, competent behavior – social capital that can be used at other times and in other arenas to develop new relationships and business opportunities. The trust that is built up between actors saves the costs of designing and using elaborate control mechanisms that monitor and ensure proper actor behavior. In an actor-oriented organization, actors understand the overall structure and processes of the organization, and their decisions and actions are taken in pursuit of the organization's common good.

Table 2 Elements of an actor-oriented organization

Element	Function	Examples
Actors	Perform work activities by self-organizing and collaborating	Individuals or teams in an organization Firms in a collaborative community Citizens, firms, and municipal agencies in a smart city
Commons	Shared resources made available to actors to support their work	Shared knowledge Shared databases Shared situation awareness
Protocols, processes, and infrastructures	Infrastructures connect actors with one another Protocols guide actor behavior Processes that combine to create an agile organization	Software apps that announce projects as well as the availability and expertise of actors Shared norms and values concerning how actors should behave Intra- and inter-organizational collaboration

Table 3 Ants foraging for food

A queen ant lays the eggs that establishes the colony. She gives the ants their innate characteristics but does not directly control and coordinate what they do. Worker ants operate according to a set of processes and communication protocols that enable them to self-organize their work. For instance, when an ant finds food, it releases pheromones on the way back to the nest. The scent is a signal that mobilizes other worker ants to follow the chemical traces to the food source. They then collect and transport food in efficient columns back to the nest until the food source is empty. When there is no more food to collect, the ants stop releasing pheromones as they return to the nest. The scent weakens, and the ants start exploring new terrain to find more food.
This example includes the core elements of the actor-oriented architecture. The *actors* in the ant organization are the queen, workers, drones, and soldiers (Buckingham, 1911; Gordon, 2014), all of whom have different *capabilities*. The queen is the one who starts the colony and lays all the eggs. Drones are male ants who do not perform any work in the colony; their sole function is to fertilize a new queen. Soldier ants defend the nest. Worker ants perform a variety of tasks including nest building and maintenance as well as food foraging, and they coordinate by using pheromones as communication *protocols*. In food foraging, the worker ants search randomly for food in the absence of a nearby pheromone trail, drop pheromones on the way back to the nest while carrying food, and follow a pheromone trail to a food source. Thus, pheromone trails provide the ants with a *shared situation awareness* of food sources. The worker ants each contribute to updating the situation awareness, and they all use this *commons* to determine their own behavior. Updating and using the pheromone trail for navigation is part of the ants' collaborative capabilities.

By focusing on the common good, actors can take advantage of shared values, norms of reciprocity, and trust in the self-governance process (Hess and Ostrom, 2006; Ostrom, 1990, 2010).

Commons

Commons refers to resources that are collectively owned and available to actors (members of the organization). One type of commons is a knowledge commons, a repository of knowledge that organization members can both contribute to and use. For example, Blade.org, a collaborative community of more than 70 firms in the computer server industry, posted all of the solutions developed by member firms on the organization's website. Any Blade.org member firm could access the website and examine the solutions for ideas that might apply to its particular market or customer base (Snow et al. 2011). Smart Aarhus, the smart-city initiative of Aarhus, Denmark, has a database called Open Data Aarhus whose purpose is to make relevant data and information accessible to Aarhus citizens and organizations. These datasets can be used to develop new products, services, and digital applications. Any firm or individual citizen can access the more than 75 datasets in Open Data Aarhus and use the data for collective purposes (Snow et al. 2016).

Shared situation awareness is a commons that facilitates self-organization. Situation awareness refers to knowing what is going on in the organization (Endsley, 2000). Digitally shared situation awareness provides an up-to-date portrait of problems and opportunities in the organization's environment as well as the current availability of resources to address those problems and opportunities. Through digitally shared situation awareness, valuable information is widely available to organization members in their decision-making. Originally developed as an operational tool for fighter pilots in World War I, situation awareness is used today in air traffic control, power plants, and advanced manufacturing systems (Endsley, 2000), and its use is growing in healthcare and other sectors. When actors share an up-to-date awareness of the organization's situation, everybody in the organization can make the right decision or take the correct action without seeking direction or authorization from the hierarchy.

Infrastructures, processes, and protocols

Infrastructures connect actors and allow access to the same information, knowledge, and other resources. Actors who have the knowledge, information, tools, and values needed to set goals, and who can assess the consequences of potential actions for the achievement of those goals, can self-organize. Self-organizing actors use protocols to guide their collaborative interactions. Protocols are "codes of conduct" used by organizational actors in their exchanges and collaboration activities. An important category of protocols deals with the division of labor, the mobilization and linking of actors for a particular project or task. Examples are protocols by which actors advertise problems or opportunities as well as their own capabilities and availability, and protocols by which actors search for potential collaborators.

In summary, actor-oriented organizational architecture is focused on the organization's actors: the work that they do, and the principles and processes by which they relate to one another. Competent actors working for the common good of the organization can self-organize and self-manage with only minimal need for hierarchical control and coordination. Commons, infrastructures, and protocols are used to guide and support actor behavior, connecting organization members with one another and facilitating their work activities.

Applying the actor-oriented scheme to the design of the digital organization

Traditional organization design is centered on structural relationships – the boxes on the organization chart and the reporting lines that connect them. Actor-oriented design, by contrast, is centered on shared access to information and other resources as well as the protocols and infrastructures by which actors connect and collaborate. Born-digital companies can apply an actor-oriented design at their inception. Established firms, however, typically must be *re*designed. Redesign involves changing a predominantly hierarchical system supported by legacy technologies to an actor-oriented system (Langer, 2017). Having targeted a particular area for redesign, designers and decision-makers need to address each of the components of the actor-oriented scheme.

Collaborating, self-organizing actors

A competent actor is one who possesses the knowledge, skills, and values suited to an actor-oriented system. In building a digital organization, the effective composition and mobilization of a set of competent actors may require a combination of selection, training, mentoring, and replacement of personnel. An actor-oriented digital organization is especially conducive to use by millennials (people born after 1980) who have acquired knowledge and expertise from their Internet activities (Langer, 2017: Ch. 10), and it may be difficult to use by employees who lack social media skills and who have been ingrained with hierarchical approaches to organizing and managing (Espinoza and Ukleja, 2016; Saxena and Jain, 2012).

In 2015, millenials became the largest generation in the U.S. workforce, and by 2025 they will constitute 75% of that workforce (Meister and Willyerd, 2010). A forecasted skill set for the digital-age workforce is shown in Table 4. As shown, the digital organization will require its members to have a demanding set of both hard and soft skills. Hard skills include computational thinking and trans-disciplinarity. Soft skills

Table 4 Work skills required by an actor-oriented digital organization

Sense-making
Ability to determine the deeper meaning or significance of what is being expressed
Social Intelligence
Ability to connect to others in a deep and direct way, to sense and stimulate reactions and desired interactions
Cross-cultural Competency
Ability to operate in different cultural settings
Computational Thinking
Ability to translate large amounts of data into abstract concepts and to understand data-based reasoning
Media Literacy
Ability to critically assess and develop content that uses new media forms and to leverage these media for persuasive communication
Trans-disciplinarity
Literacy in and ability to understand concepts across multiple disciplines
Design Mindset
Ability to represent and develop tasks and work processes for desired outcomes
Cognitive Load Management
Ability to discriminate and filter information for importance, and to understand how to maximize cognitive functioning using a variety of tools and techniques
Virtual Collaboration
Ability to work productively, drive engagement, and contribute as a member of a virtual team
Source: https://www.sfu.ca/career/WCID/iftf_futureworkskills.html

include social intelligence, cross-cultural competency, and the ability to collaborate. To capitalize on these skills, the digital organization must provide flexible workspaces and policies that motivate millennials and enable them to be productive. Such workspaces will include appropriate collaboration tools and be designed according to sound psychological theories and principles. It is well established that people are extrinsically motivated by reward systems, evaluations, and the opinions others have of them (Herzberg, 1966). Self-determination theory (Ryan and Deci, 2017) holds that just as frequently people are motivated from within – by their interests, curiosity, concern for others, and abiding values. Following self-determination theory, jobs must be designed so that they meet the core psychological needs of *competence, relatedness,* and *autonomy.* Such designs foster the most volitional and high-quality forms of motivation and positive work outcomes, including enhanced performance, persistence, and creativity. Conversely, the degree to which any of these basic psychological needs is unsupported or thwarted in an organizational context will have a detrimental impact on people's well-being and performance in that setting.

The individual capabilities of actors must be turned into collective capabilities in order for the organization to operate at its desired scale and speed. The development of organizational capabilities occurs through a managed learning process in which individuals, technology, and organizational culture evolve together (Langer, 2017). At Valve Corporation, a digital distribution platform that operates with few hierarchical mechanisms, organizational capabilities are developed along actor-oriented lines (Felin and Powell, 2016). First, Valve recruits individuals who, in their estimation, have the capacity to create value in a marketplace of ideas. Second, those actors are allowed to

self-select the projects on which they want to work. Third, a new project can be started if at least three peers agree that it is worthwhile (the "rule of three"). Fourth, project teams are empowered to sense, shape, and seize their own market opportunities. It is expected that teams will engage with external stakeholders via open innovation methods such as crowdsourcing, user communities, innovation contests, and so on.

Historically, organizations have been populated by humans using tools and equipment to accomplish their tasks. Increasingly, human actors work collaboratively with digital agents such as robots, adding a digital actor to the organization. Newer robots with abilities in social interaction are able to learn from their human counterparts through cooperation and tutelage (Green et al. 2008). Effective collaboration requires human and digital agents to share goals and situation awareness as well as the capability to communicate directly with one another.

Commons that support collaboration

Designing commons for a digital organization will be specific to each organization and its needs, but two commons in particular deserve attention: situation awareness and knowledge. To be effective, actors need a shared awareness of the resources and activities in their environment. For example, in the self-dialysis clinic at the Ryhov Hospital in Sweden, all dialysis patients share a common electronic calendar that allows them to schedule their own treatment sessions. In addition, the equipment of the center is designed in a way that allows patients to perform their own treatment. The roles of the actors in this example are different from those of a hierarchically organized treatment center. Here patients self-organize their treatment while doctors and nurses use shared information about the patient's condition to intervene only if necessary (IHI Annual Report, 2012). Functionality that supports shared situation awareness is emerging across a wide variety of software platforms. Such platforms are extensively used by military organizations and advanced technology firms for collaborative problem solving and decision-making (Kolfschoten and Briggs, 2015; Nunamaker et al. 2009). Several recent software platforms support project management, and office productivity tools increasingly support real-time collaboration around documents and spreadsheets. Galbraith (2010) provides an account of how Procter & Gamble uses a collaborative spreadsheet program to speed up the reconciliation of corporate plans and budgets.

A knowledge commons is information and data that is shared by the actors who make up the organization. It is typical to distinguish between declarative and procedural knowledge (Kogut and Zander, 1992). Declarative knowledge is factual whereas procedural knowledge is know-how. For example, the Open Source Drug Discovery community maintains declarative knowledge in a repository of all scientific discoveries made by its members (Kolbjørnsrud, 2017). This allows all contributors to have a real-time awareness of the problem state (Newell and Simon, 1972) – how far the members of the community have come toward a solution and the knowledge gaps that still need to be closed. Many consulting firms, such as Accenture, maintain procedural knowledge of the best practices used by their consultant teams (Langer and Yorks, 2013). The overall purpose of a procedural commons is to provide a set of shared resources that helps an organization learn and adapt.

In a given digital organization, all actors may not use the entire commons. Some software platforms allow the commons to be subdivided such that actors can collaborate around selected subsets. Subdivision of the commons permits actors to use only those resources relevant to their task and situation.

Protocols, processes, and infrastructures that connect and guide actors

Guiding interactions among actors and accessing commons require protocols that reduce ambiguity and increase the effectiveness and efficiency of interaction. There are self-organizing processes associated with each protocol that actors follow in order to achieve control and coordination. In a digital organization, actors use their collaborative tools to signal both the tasks to be done and the availability of resources to perform them. Although protocols are specific to the type of collaboration, there are commonalities. Military and emergency response platforms, for example, have protocols and processes for publishing updates to the situation awareness database and subscribing to particular types of information, such as new events occurring in a geographic area (DeMarco, 2016; Liang and Gao, 2010). Similarly, platforms for collaborative project management (Chen et al. 2003) have protocols for inviting collaborators, sharing information about the whole project or particular tasks, and alerting collaborators to changes affecting their portion of the project (c.f. www.smartsheet.com). The infrastructure that allows the actors to connect with one another consists of communication networks and computer servers.

Conclusion

Digital organizations are increasing in both numbers and sophistication. We have described how digital technologies can be integrated into organizations and have shown how actor-oriented principles and designs can be used to organize and perform activities. Actor-oriented digital organizations are collaborative, agile, and minimally hierarchical. In many industries, they are populated by human and digital agents who work together collaboratively. Digital organizations need technologically aware and adept leaders who can set the digital agenda and create the context for the digitization of every relevant aspect of their organizations. Digitization is occurring at an accelerating pace; successful leaders need to synchronize their organizations to digital clock speed.

Endnote

[1]This section draws extensively on an article that introduced the actor-oriented framework (Fjeldstad et al. 2012).

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Authors' contributions

ODD and CCS developed the actor-oriented framework discussed in the article. AML has written books and articles on digital technologies and how to incorporate them into companies and other types of organizations. All three authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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