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THE ARCHITECTURE OF COLLABORATION

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Firms increasingly face competitive pressures related to rapid and continuous adaptation to a complex, dynamic, and highly interconnected global environment. Pressing challenges include keeping pace with shorter product life cycles, incorporating multiple technologies into the design of new products, cocreating products and services with customers and partners, and leveraging the growth of scientific and technical knowledge in many sectors. In response, we observe experimentation with new organization designs that are fundamentally different from existing forms of organizing. We propose that these new designs are based on an actor-oriented architectural scheme composed of three main 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. We demonstrate the usefulness of the actor-oriented scheme by applying it to organizations drawn from four different sectors: global professional services, open source software development, computer equipment, and national defense. We discuss the implications of the actor-oriented architectural scheme for future research on organizational forms as well as for managers who are involved in designing organizations. Copyright © 2012 John Wiley & Sons, Ltd.

INTRODUCTION

Knowledge-intensive industries such as computers, biotechnology, and microelectronics have been the spawning ground for the innovative organization designs that are evolving today. In industries where knowledge is complex, growing, and widely diffused, the locus of innovation extends beyond the individual firm (Powell, Koput, and Smith-Doerr, 1996). To leverage such knowledge, many firms have opened up their value creation processes through use of various types of multiparty collaboration (Baldwin and von Hippel, 2011; Chesbrough, 2003; Gray, 2000; von Hippel, 2005). Collaboration can increase value creation by expanding the availability and use of relevant knowledge and other resources.

Collaboration has been shown to reduce risk, speed products to market, decrease the cost of product development and process improvement,

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and provide access to new markets and technologies (Eisenhardt and Schoonhoven, 1996; Hagedoorn, 1993; Kogut, 1988; Wheelright and Clark, 1992). Traditional organizational forms employ hierarchical mechanisms as the primary means of control and coordination (March and Simon, 1958; Perrow, 1967; Thompson, 1967; Williamson, 1975), and those mechanisms can constrain broad collaboration both within and across firms. In contrast, alternative ways of organizing that are much less reliant on hierarchy are being explored in complex, dynamic environments (Majchrzak, Jarvenpaa, and Hollingshead, 2007). These newer organizational approaches represent clear departures from traditional models in areas such as incentives (Lerner and Tirole, 2005), governance (O'Mahony and Ferraro, 2007), coordination (von Hippel and von Krogh, 2003), and leadership (Manz, 1986; Stewart, Courtright, and Manz, 2011). In this article, we develop the actor-oriented architectural scheme and argue that it better explains how newer organizational forms are controlled and coordinated. In actor-oriented organizations, efficiency and effectiveness in the interaction among actors increase by way of actor capabilities and values, commons, protocols, processes, and infrastructures.

In the first section of our article, we discuss the concept of architecture and show how organization science has adopted the architecture notion in its discussion of organization design. In the second section, we discuss hierarchy as the architectural scheme underlying traditional forms of organizing and describe its use in control and coordination. In section three, we develop the actor-oriented architectural scheme and show how it helps explain a variety of recent organization designs that are being used in complex and dynamic environments. We apply this scheme to four organizations drawn from widely different sectors: Accenture (global professional services), Linux (open source software development), Blade.org (computer equipment), and Network Centric Operations (the organization of military forces). The fourth section compares the four cases according to the elements of the actor-oriented architectural scheme, thereby demonstrating its usefulness. In the fifth section, we discuss the implications of our theoretical framework for research and practice, and in the final section we present our conclusions.

Our article makes two contributions to the literature on strategic management and organization design. First, we introduce the concept of the *actor-oriented* architectural scheme and show how it can be used to describe and explain recent and emerging organization designs. We believe that future theorizing about organizational forms and how they relate to organizational purpose and strategy would benefit from including the actor-oriented concept. Second, we contribute to the understanding of the process of *large-scale, multiparty collaboration*. The newest organization designs enable such collaboration, and the field of organization science needs a deeper understanding of the dynamics of the collaborative process.

ARCHITECTURE: FORM, FUNCTION, AND FIT

The term 'architecture' is frequently used in the characterization of structures, such as buildings or cities, but increasingly the concept of architecture is being applied to other domains, including products (Sanchez and Mahoney, 2003), industries (Jacobides, 2005), and organizations (Ethiraj and Levinthal, 2004; Gulati and Singh, 1998; Lepak and Snell, 1999; Miller, 1993; Nadler and Tushman, 1998; Worren, Moore, and Cardona, 2002). Architecture is the synthesis of form in response to function (Alexander, 1964; Sullivan, 1896). Extended to complex systems and organizations, architecture can be defined as the

> 'fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution' (Maier, Emery, and Hilliard, 2001: 108).

Contained in this definition is the layman's understanding that structure should be consistent with purpose ('form must follow function'). Over time, the concept of architecture across a variety of domains has shifted from a focus on the design of specific structures to a focus on *principles* that foster coherence, growth, and change (Avermaete, 2005).

An organization is a goal-directed activity system (Aldrich and Ruef, 2006). As discussed by Barnard (1938), an effective organization is one that has been designed in a coherent manner.

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Chandler (1962) showed that if a firm changes its growth strategy, it must change its structure accordingly in order to pursue the new strategy. Miles and Snow (1978, 1984) added a dynamic dimension by describing how firms move through an adaptive cycle, continually facing and solving entrepreneurial, engineering, and administrative problems. During the adaptive process, effective firms maintain internal fit (alignment of strategy and structure), external fit (alignment of strategy and environment), and dynamic fit (maintenance and improvement of internal and external fit over time).

Organizing involves dividing and integrating resources in structures and processes that allow the control and coordination of activities (Lawrence and Lorsch, 1967; Mintzberg, 1983; Perrow, 1967). Organizations create and combine units and processes to address new opportunities and pressures, and they alter their orientations to the environment as the environment changes. Integration, on the other hand, is the quality of the state of collaboration that exists among organizational units that are required to achieve coordinated effort (Lawrence and Lorsch, 1967). To achieve integration, organizations employ a variety of mechanisms, including planning, supervision, standardization of processes and skills, and devices for mutual adjustment such as liaison personnel and cross-functional teams (Mintzberg, 1983; Thompson, 1967). In addition to the formal organization, the informal organization is a supplementary mechanism that helps get tasks performed properly (Roy, 1960). Informal social networks have been shown to be valuable in the innovation process (Allen and Cohen, 1969; Kleinbaum and Tushman, 2007; Tushman and Scanlan, 1981).

The complexity and dynamism of both the internal and external environments are major factors to which an organization design must fit (Burns and Stalker, 1961; Chandler, 1962; Galbraith, 1973). In reference to complex organizations, such as large firms and networks of firms, the law of requisite variety (Ashby, 1956) states that the variety of the internal environment must match the variety of the external environment. Further, an organization's ability to adapt requires a design that allows it to keep pace with changes in the environment. It follows that the more dynamic the environment, the more frequently the reconfiguration of internal and external relationships should occur. High dynamism coupled with high complexity challenges traditional organization designs. In response, leading firms in complex, dynamic environments are experimenting with reconfigurable organization structures (Galbraith, 2010).

THE HIERARCHICAL SCHEME

An architectural scheme is the manner in which a system is arranged. The dominant scheme used to describe and explain traditional organization designs is hierarchy. Simon (1962: 468), whose theoretical work incorporates economics, administrative theory, psychology, and computer science, provides two related definitions of hierarchy:

> (1) 'a system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem' and (2) 'a complex system in which each of the subsystems is subordinated by an authority relation to the system it belongs to.'

With respect to the latter definition, hierarchy is used for both control and coordination—setting goals and monitoring goal fulfillment, allocating resources, and managing interdependencies (Massie, 1965; Perrow, 1967; Williamson, 1975, 1999). Consistent with Simon's (1962) notion of nearly decomposable systems, Thompson (1967) provides a rich set of organization design principles for hierarchical organizations.

In an organization using hierarchy for control and coordination, higher-level members have the authority to resolve conflicts at lower levels in part because they have a broader view of the organization and its environment (March and Simon, 1958). Further, higher-level members typically have capabilities related to control and coordination which supersede those of lower-level members. Hierarchy allows higher-level units to control the goals and/or actions of subordinate units in cascading principal-agent relationships (Aoki and Jackson, 2008; Simon, 1962). Hierarchical coordination permits lower-level unit interdependencies to be resolved at higher hierarchical levels, either directly or indirectly, by way of planning and standardization (March and Simon, 1958; Mintzberg, 1983; Morgan, 1987). However, while hierarchy is

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Table 1. Hierarchical forms of organizing

Organizational form	Purpose	Control and coordination mechanisms
Simple hierarchy Simple structure Machine bureaucracy Professional bureaucracy	Achieve economies of scale through specialization of functions and expertise	Higher-level units control and coordinate lower-level units Planning Standardization of skills and values
Divisional	Respond to differentiated customer demand and achieve economies of scope	Division level controls and coordinates functional units Corporate level controls and coordinates cross-divisional activities and resources
Matrix	Combine responsiveness to differentiated customer demand with varied technological expertise	Multiple superiors (e.g., functional, product group, and regional/country) Cross-functional teams
Multi-firm network	Use flexible assembly of firms with specialized capabilities to achieve economies of scale and experience	Hierarchical control and coordination by the lead firm over the total network Hierarchical control and coordination within network member firms

the main architectural scheme, units of an organization at the same hierarchical level may also interact in nonhierarchical ways through formal and informal lateral relations such as cross-functional teams, liaison personnel and units, knowledge-sharing networks, and communities of practice (Galbraith, 1973; Hansen, 1999, 2002; Tsai and Ghoshal, 1998; Wenger, 2007). Research on the concept of 'small worlds' shows the importance of nonhierarchical relationships in complex organizations, particularly those where adaptation to changing environments is critical to effectiveness (Uzzi and Spiro, 2005; Watts, 1999).

Hierarchically organized firms have made myriad accomplishments over the years, including the building of early industrial empires in transportation, steel, and automobiles (Chandler, 1977) and presently in the management of huge global supply chains (Fung, Fung, and Wind, 2008). There are many manifestations of hierarchical designs, including the simple hierarchy, divisional, matrix, and multi-firm network forms (Chandler, 1962; Davis and Lawrence, 1977; Galbraith, 1973; Mintzberg, 1983; Miles and Snow, 1986, 1994). Each of these forms represents an organizational response to the opportunities and challenges facing firms at the time of their appearance. New organizational forms build on predecessor forms by relieving existing constraints on efficiency and effectiveness, and they tend to preserve the main capabilities of previous forms while adding new capabilities. See Table 1 for the main features of hierarchical forms of organizing.

Simple hierarchy and divisional forms

The functional form, originally developed in the railroad and steel industries in the late 1800s (Lawrence and Dyer, 1983), provides a design for the efficient differentiation and integration of sequentially linked activities which yields economies of scale in functions such as manufacturing, engineering, and marketing. Firms that adopt a functional design are able to generate sales volumes and cost savings that allow them to reap economic rewards by penetrating deeply into their markets. Activities are hierarchically controlled, and sequential interdependencies are managed by forecasting and planning at higher levels of the hierarchy. The strengths of the functional form—specialization and economies of scale—are offset by limitations in the ability to accommodate diversity and variability in the organization's environment. Another simple hierarchical form, the professional bureaucracy, is found in organizations operating in complex, stable environments. It is characterized by a simple hierarchical structure within which professional values and standards provide control and coordination (Mintzberg, 1983).

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General Motors introduced divisions as an added layer in the hierarchy that allows for effective adaptation to differentiated market demand (Chandler, 1962; Sloan, 1964). The benefits of divisional organization lie in the ability to collect and process information about various customer preferences and requirements and to meet those demands efficiently, primarily through the delegation of operating authority to the divisions accompanied by the centralization of R&D and finance. Thus, the divisional form enables the exploitation of economies of scope in the service of differentiated customer demand (Teece, 1980). Its main limitation is constrained resource sharing across divisional lines.

Matrix forms

In the matrix form, market-facing units draw on a variety of upstream capabilities both in the operation of existing businesses and in developing and delivering new products and services for new customers. The matrix is a hybrid structure with two or more distinct hierarchies (Davis and Lawrence, 1977; Mee, 1964). Typically, customer-facing units have budgets which they use to obtain resources from the functional dimension of the matrix. Mintzberg (1983) differentiates between matrixes with relatively stable interdependencies and an 'adhocracy' in which units, people, and their interdependencies vary temporarily. In global firms, a regional and/or country dimension often is added to a matrix design (Bartlett and Ghoshal, 1993; Chakravarthy and Lorange, 1991). Overall, the matrix form seeks to capture both the efficiency and specialization of the functional form and the customer focus and flexibility of the divisional form. The cost of simultaneous efficiency and flexibility is high internal complexity. The matrix is a multi-superior hierarchy (simultaneous functional, product group, and regional/country hierarchies) used to control and coordinate activities in a multidimensional external environment. Frequently, the matrix is supplemented with various lateral processes of control and coordination (Galbraith, 1973).

Multi-firm network forms

Firms in a variety of industries have chosen to focus on their core activities and to outsource noncore activities to external providers. As a result, vertically integrated activities are performed by multi-firm networks (Miles and Snow, 1986; Porter, 1985; Thorelli, 1986). The main benefits of such designs are flexibility, the variety of capabilities that can be assembled, and the economies of scale and experience that can be leveraged in each activity. The typical multi-firm network organization is also hierarchical (Zenger and Hesterly, 1997), organized around a lead firm that works more or less dynamically with network partners to produce and deliver its products or services (Dyer, 1996; Dyer and Nobeoka, 2000; Miles and Snow, 1994). Both the matrix and multi-firm network forms are directed at increasing the ability to create and combine capabilities from different sources (Gulati, 2007; Hedlund, 1994).

In summary, traditional organizational forms vary according to three main factors related to hierarchy: division of labor (number of different organizational units), number of levels, and number of superiors. The division of labor is determined by the types of functions needed to conduct activities, the number of hierarchical levels is determined by the span of control, and the number of superiors reflects variety across functions, product groups, and regions/countries. The multi-firm network form has less hierarchy than other traditional forms but does not eliminate it entirely.

THE ACTOR-ORIENTED SCHEME

The twenty-first century is marked by the global proliferation of communication, financial, and logistics services that create value by linking actors who are or wish to be interdependent (Castells, 1996; Stabell and Fjeldstad, 1998; Thompson, 1967). These societal infrastructure services reduce the cost of interaction and enable new ways of organizing exchange and innovation (Rochet and Tirole, 2003). The resulting complexity of global business and the need for rapid, effective responses to opportunities and challenges have put pressure on hierarchical organizational forms. Attempting to redesign organizations to cope with such pressure challenges the usefulness of hierarchy as the primary mechanism of control and coordination, prompting calls for collaborative organization designs (Adler, 2001).

Following the logic of requisite variety (Ashby, 1956), hierarchies themselves could be made more complex to match the complexity of the environment, but there are control and coordination costs

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associated with increased hierarchical complexity (Jensen and Meckling, 1976; Williamson, 1975). The limitation of hierarchy as a control and coordination mechanism lies in the filtering and delay it imposes on the interactions among organizational units and/or external partners who are or want to be connected. In large organizations, it is difficult for upper-level managers in a hierarchy to fully understand how resources contained both inside and outside the firm should be organized to take advantage of opportunities and overcome challenges. Further, when uncertainty increases because of introducing new products, entering new markets, or employing new technologies, the result is more exceptions, more information processing, and an overloaded hierarchy (Galbraith, 1974).

From hierarchy to actor oriented

New organization designs are emerging in which rich sets of resources are made available to large sets of actors who self-organize on unlimited sets of projects (Benkler, 2002). Common to these designs is the ability of organizational actors to dynamically form collaborative relationships. Reliance on self-organization and local decision making in the development and delivery of complex products and services requires mechanisms that allow actors to become aware of problems and opportunities and identify and form relationships with suitable collaborators. Collectively, the collaborating parties must be able to manage their common resources and goals (Ostrom, 1990) and overcome the agency problem of free riding (Alchian and Demsetz, 1972; Olson, 1965). The lateral nature of decisions about which projects to pursue, which resources to share, and how returns will be divided is a major difference between the architecture of these emerging organization designs and previous organizational forms.

The actor-oriented scheme draws on well-established architectural principles expressed in object-oriented computer systems (Dahl and Nygaard, 1966), agent-based and blackboard-based artificial intelligence systems (Davis and Smith, 1983; Hayes-Roth, 1985), and the architecture of the Internet (Krol, 1993; Licklider, 1960). The architecture of the Internet allows it to be self-organizing—that is, each node decides the best routing for its own traffic by assessing adjacent nodes. In emerging organization designs, control and coordination are based on direct exchanges among the actors themselves rather than by hierarchical planning, delegation, and integration. Although hierarchy, in the sense of near decomposability (Simon, 1962), is present in newer organization designs, these designs rely mainly on lateral, reciprocal relationships among actors for control and coordination. Where the hierarchical scheme establishes specific superior-subordinate relationships, the actor-oriented scheme contains mechanisms by which dynamic networks of relationships can be established, maintained, and dissolved.

Elements of the scheme

Our proposed actor-oriented scheme has 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. Taken together, these elements both create and function within organizational contexts consisting of various combinations of transparency, shared values, norms of reciprocity, trust, and altruism (Barney and Hansen, 1994; Eccles and Crane, 1988; Ostrom, 1990). Control and coordination are accomplished primarily via direct interaction among the actors themselves rather than by hierarchical subordination. *Infrastructures*—systems that connect actors—allow actors to connect with one another as well as access the same information, knowledge, and other resources. Competent actors who have the knowledge, information, tools, and values needed to set goals, and assess the consequences of potential actions for the achievement of those goals, can self-organize. Self-organizing actors use protocols to guide their collaboration. *Protocols* are codes of conduct used by organizational actors in their exchange 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. Other protocol categories deal with inter-actor coordination within the resulting network. *Commons* refers to resources that are collectively owned and available to the actors. One example of a commons is shared situational

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awareness—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. Another example is shared knowledge whereby relevant knowledge is collaboratively assembled and used (Hess and Ostrom, 2006). Collectively, the elements of the actor-oriented scheme enable large groups of collaborating actors to self-organize with minimal use of hierarchical mechanisms. Hierarchical structures can be generated and used within actor-oriented organizations, but such structures are complementary and may be transient.

CASES FROM DIFFERENT SECTORS

Four cases drawn from distinctly different sectors illustrate the elements of the actor-oriented scheme and demonstrate its value in explaining variation in recent and emerging organization designs contingent on their organizational purpose. The examples also demonstrate the scalability and generalizability of the actor-oriented concept. The case of Accenture illustrates how thousands of teams in a large global firm can be mobilized to work on client projects in the professional services sector as well as collaborate in the development of future organizational capabilities. The Linux case demonstrates how open source collaboration among thousands of voluntary developers can create sophisticated, high-quality computer software. Blade.org, a collaborative community of more than 250 firms in the computer server industry, illustrates the process of multi-firm product development and commercialization through the use of temporary collaborative networks. Network Centric Operations is a military organization design concept, developed by the United States and its NATO partners, that enables collaborative command and self-synchronizing of widely dispersed military forces held by multiple government agencies.

Accenture: collaboration across boundaries within a global firm

Accenture is a global management consulting and technology services firm with approximately 204,000 employees serving clients in more than 120 countries (www.accenture.com). There are substantial scale and scope benefits to be gained from being able to draw from a diverse and competent global workforce in the acquisition, development, and execution of client projects. Collaborations range in scope from brief exchanges of knowledge about how a particular problem can be solved to the global assembly of colocated or virtual teams, along with their associated resources.

Certain design elements enable extensive collaboration and self-organization at Accenture. First, in order to ensure the availability of competent consultants (actors) who can be mobilized for projects anywhere in the world, the firm invests significantly in the long-term development of its consultants, including training and the conveyance of core values guiding behavior and decision making with respect to both clients and colleagues. In addition to functional and industry-related skills, there is extensive career-long development of administrative skills adapted to company processes, methods, and tools. Among the core values that foster collaboration are 'one global network' and 'respect for the individual.' Conveyance of these and other values is an important part of both dedicated and on-the-job training. Two particular knowledge domains are targeted for capability development. The first focuses on industries, the second on professional practices such as management consulting, technology, and business process outsourcing. Further, special career counselors assist personnel at all levels in their career development.

Second, there are protocols and infrastructures for effectively and efficiently connecting potential collaborators within the organization. The protocols are embedded in software applications and in the communication systems that connect organization members, and they complement both formal and informal relationships among them. For example, one system is used to post projects that potential participants can join. An internal collaborative networking site containing information about employee knowledge and skill sets is used to identify people with relevant capabilities for a particular task or project. Since 'people profitability' is critical to the overall profitability of the firm, the global accounting system tracks revenues and costs at the level of individuals and their organizational units. In addition, there are mechanisms for tracking indirect contributions from organization members who help or support colleagues throughout the global network. Such tracked contributions affect individual career development. There is broad sharing of customer prospects

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and resource availability and there is considerable local discretion related to projects sought and how to staff them from the global organization. The detailed accounting for, and broad sharing of, information about resource availability and profitability, coupled with local decision-making autonomy, empower individual employees and local units to make decisions in support of global firm goals. In summary, there are explicit protocols for how resources are to be mobilized on a global basis and for how costs are allocated and revenues shared.

Third, all members of the organization collaboratively contribute to and share knowledge commons. Some commons are shared by all, whereas others are shared only by particular groups. There are protocols and processes for contributing to and using the commons. Also, protocols, processes, and infrastructures are used both in organizing specific client engagements as well as in organizing the internal development of solutions.

Accenture's knowledge management and people mobilization systems illustrate the essential elements of the actor-oriented architectural scheme. They are used in organizing projects for clients as well as in the ongoing development of the firm's capabilities. At the center is the recruitment and development of competent people (actors) who have the knowledge and values required to initiate projects and globally mobilize team members. Personnel can assess their own availability, and they have a high degree of autonomy with respect to how they commit and use their time. There is, to be sure, a professional hierarchy based on merit. The career of a typical employee is marked by advancement from junior consultant to director, and advancement is associated with the amount of resources that can be committed and to the sharing of profits. There are matrix dimensions related to setting goals and developing capabilities in particular industries or practice domains. Hierarchy, however, is not the main mechanism used for the performance of activities. Knowledge sharing and solution development are organized by a rich set of protocols, processes, infrastructures, and commons by which the members of the organization self-organize around the creation of value for their clients as well as develop the firm's own goals and capabilities. Thus, most of Accenture's activity system is organized in an actor-oriented manner complemented by hierarchical elements.

Linux: an open source software community

The case of the Linux community is well documented in the literature (Kogut and Metiu, 2001; Lee and Cole, 2003; O'Mahony and Ferraro, 2007; West, 2003), so we focus our discussion on its actor-oriented properties. Linux is a global open source software community dedicated to the development of a Unix-type operating system (www.linux.org). The Linux kernel, which is the core of a Linux system, is developed and released under the GNU General Public License, and its source code is freely available to everyone (the community shares the source code of the software that its members have collectively developed with anyone who wishes to download it from the Internet free of charge). The vast majority of Linux community members are individuals. Members voluntarily contribute to the provision of a public good, namely freely shared source code, and in doing so they gain private returns in the form of intrinsic rewards such as the enjoyment of the intellectual challenge and/or nonmonetary extrinsic rewards such as peer recognition, sense of belonging, learning from feedback, and the signaling of technical excellence to peers and software firms (von Hippel and von Krogh, 2003).

To enable its large-scale online collaboration effort, the Linux community uses the platform of kernel.org as its infrastructure for pooled collaboration. Kernel.org provides free services and Web-based tools that help Linux community members find software, develop new solutions, request assistance, and share their solutions with the global community. Such tools include blogs, e-mail archives, and e-mail lists that serve as a discussion forum for Linux developers as well as various text files (e.g., a credit text file that lists the names of recognized developers and a description of their contributions). Protocols and processes for access, use, submission, and commitment of code, as well as strong norms of good community citizenship, enable the orderly development of the code (O'Mahony and Ferraro, 2007). The behavior of community members is transparent in terms of their contributions to code development and compliance with community norms. In the aggregate, these mechanisms facilitate an evolutionary process of learning driven by criticism and error correction (Lee and Cole, 2003).

The open, shared source code constitutes the Linux commons. The global Linux community is

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in part made up of Linux User Groups (LUGs). These user groups create and distribute Linux improvements, adaptations, and additional software. Anyone is free to modify the code provided they comply with the Linux license requirements. Hence, there are multiple versions of Linux available, but the code in all of those versions is a commons available for all to use.

Blade.org: a collaborative community of firms

Established in 2006 by IBM and seven other founding firms, Blade.org (www.blade.org) is a collaborative community of more than 200 firms dedicated to the development, manufacture, marketing, and distribution of solutions (products) based on the blade server technology invented by IBM (Snow *et al*., 2011). The community consists of approximately 70 'complementor' firms (Brandenburger and Nalebuff, 1997) that collectively represent the different capabilities required to develop solutions for the blade server market as well as about 180 firms that are their customers. Blade.org is mostly self-governing with a principal office that provides infrastructures, administrative services, and strategic initiatives to operate and expand the community. In its first two years, the Blade.org community of firms developed more than 60 solutions, an indication of the overall effectiveness of this organization design in creating and commercializing product and market innovations.

Blade.org has nine technical committees staffed by volunteers from the member firms. These committees are organized by function and include committees on technology, solutions architecture, hosted client work group, power and cooling, compliance and interoperability, marketing, small and medium businesses, membership benefits, and bylaws and membership. The core rights that accrue from membership in Blade.org include opportunities to collaborate with other member firms and eligibility for participation in the work of the committees and subcommittees. Collectively, these rights allow technology developers, vendor firms, and customers to influence the direction and development of the blade server market.

The key to understanding Blade.org's organization design is to focus on the strategic role it is playing. IBM is the inventor of the blade technology, and it holds a number of patents related to that technology. Given IBM's size and capabilities, creating one or more dedicated blade business units that, in turn, would partner with select suppliers and lead users would be the taken-for-granted organizational approach to developing commercial applications for the blade technology. However, rather than attempting to exploit the blade IP through its own business units or through specific technology alliances with other firms, IBM, along with its fellow founding firms, chose to form a collaborative community of firms focused on accelerating the development and adoption of blade server solutions. Thus, the founding firms created an organization design that enabled relevant actors (firms) to develop their own solutions.

Solutions are developed through interfirm collaborations that can take one of four main forms: (1) customer collaboration (a Blade.org member firm collaborates with a customer on a new solution, perhaps using consulting advice from IBM as the inventor of the blade technology); (2) direct internal collaboration (a small temporary network of member firms work together on the development of a new solution); (3) pooled internal collaboration (Blade.org member firms supply ideas, information, and experiences to a central database called Bladeuser.org that is accessible by member firms wanting to pursue innovation projects); and (4) external direct collaboration (a Blade.org member firm works with a non-Blade.org firm on a one-off blade-based innovation project).

The actor-oriented architectural scheme can be used to analyze the design of Blade.org in the same manner as it was used to analyze Accenture, but in this case it is applied across firms as opposed to being applied across individuals and project teams inside a firm. In Blade.org, there are designed processes for the recruitment and selection of complementary firms (Stieglitz and Heine, 2007), and there are norms and values that are conveyed to those firms. Norms and values are aimed at enabling voluntary, direct, and open collaboration within the community. In addition, there is a principal office and infrastructures that (1) help member firms identify potential collaborators (the Web site, Webinars, technology symposia, all-member meetings, etc.) and (2) help the community grow and improve (the principal office's strategic initiatives which are derived from member firms' inputs). Lastly, the standards developed and maintained by the technical committees are a knowledge commons to be shared by community members, and there is a formal mechanism (solutions

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posted on the Web site) for tracking member contributions to solution development and ensuring their rights to potential future revenue streams.

Network Centric Operations: shared situational awareness and collaborative command and control among multinational, multi-branch military forces

Network Centric Operations is currently being developed and implemented by the United States and its NATO partners (Alberts *et al*., 2001; Alberts, Garstka, and Stein, 1999). It is based on collaborative principles and processes, and its purpose is to achieve increased survivability and lethality of military forces as well as to reduce the time required for mission accomplishment. Network Centric Operations requires building the capabilities to combat new kinds of threats (e.g., terrorism, weapons of mass destruction, attacks on vital infrastructure) and mobilize multiple types of actors (e.g., allies, NGOs, civilian specialists). Increasingly, military action is being taken in environments characterized by growing complexity of systems, increased heterogeneity of allies and opponents, and faster pace of strategizing and operations.

Network Centric Operations entails resource sharing and collaboration as the way to cope with complexity, uncertainty, and speed. One important area of collaboration is the creation of 'shared situational awareness.' Accurate information about and understanding of the situation, as well as effective and efficient command and control, are major challenges associated with military operations (von Clausewitz, 1873). There are two keys to shared situational awareness. The first is the ability to collect information from a wide variety of sources—on the ground, in the air, and from other sources—and to use this information to create a shared and current description of the situation. The second is the ability to use knowledge from a wide range of expert sources in order to interpret the common information. This often requires the temporary mobilization of a variety of actors who possess relevant knowledge and expertise, and who collectively contribute to and draw from the situational awareness commons. Also, a shared information infrastructure connects the relevant actors to the commons, and there are protocols for contributing to and using the commons.

Command and control entails the tight sequencing of short-term and long-term goals and the coordination of the activities required to meet those goals. Shared situational awareness, combined with information infrastructure and protocols, enable commanders to collaborate in goal setting. Similarly, infrastructures and protocols enable self-coordination of the assembled actors to meet their goals. Shared situational awareness allows military forces to adjust their actions both to changes in the local and broader environment they are operating in without detailed instructions from higher hierarchical levels. Network Centric Operations is a large and ambitious collaborative effort. Military personnel at all levels must have collaborative capabilities and values; signal and weapons systems must be interoperable across branches and nations; personnel and systems must be networked to allow shared access to the situational awareness commons; and personnel must be able to form and work in *ad hoc* temporary teams. Therefore, significant investments are made in the training of personnel, information infrastructures that support the required range and reach of exchange, and in interoperable network-enabled sensors and weapons.

Network Centric Operations includes actor-oriented design elements from all three of the previous organization design examples. Shared situational awareness is a commons, as is Linux's source code and Accenture's knowledge commons, but there are additional requirements related to real-time security and reliability. As in the Accenture and Blade.org designs, the Network Centric Operations design also includes temporary mobilization of actors drawn from a variety of actors in different locations and infrastructures and protocols enabling collaboration among those actors in the accomplishment of their goals. Lastly, the Network Centric Operations design, similar to that of Blade.org, includes the development of shared standards that enable interoperability of equipment and personnel across countries and military branches.

MULTIPARTY COLLABORATION ACROSS THE FOUR CASES

Although each of the organizations we have discussed has the overall purpose of enabling large-scale, multiparty collaboration, they differ

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somewhat in purpose and design. See Table 2 for a summary of purposes and control and coordination mechanisms.

The purpose of Accenture is to provide customized service solutions to international client firms by drawing on a global talent pool. The major challenges associated with the development and use of knowledge within a large firm are tapping into the tacit knowledge of individual employees and sharing knowledge across the firm as a whole. Accenture illustrates how the challenges of large-scale intrafirm collaboration can be overcome. First, a particular project potentially can draw on the entire pool of the company's resources. Infrastructures and protocols support the identification of project contributors and processes for the selection of project participants. Second, new knowledge gained from projects is codified and shared through a knowledge commons so that it can be made available to all consultants for future projects. A flexible, dynamic matrix structure complements the actor-oriented operating mechanisms.

The purpose of the Linux open source software community is to develop a free computer operating system by leveraging the capabilities of anyone who wants to contribute. Contributors create software versions adapted to particular needs, but all such adaptations are available to the entire community, and there are processes for integrating the source code from those separate versions into the common operating system. Collaboration is enabled by the kernel.org infrastructure. The protocols governing contributions to and use of the source code are predominantly provided by the Open Source Initiative (OSI) and supplemented by Linux-specific adaptations and additions. There are no mechanisms for value appropriation by the community *per se*, but there are collective benefits, in terms of free use of resources and sharing the costs of modifications, as well as private benefits (von Hippel and von Krogh, 2003). Correspondingly, investments in development capabilities are made privately by individual community members.

The purpose of Blade.org is to accelerate the development and adoption of blade server solutions by providing an organizational platform member firms can use to pursue product and market opportunities. As a collaborative community of firms, Blade.org enables interfirm networking—that is, it facilitates member firms' coordinated development and commercialization of complex solutions to which collaborating members contribute a complementary piece. Major challenges involved in the development of such organizations are to ensure commitment by all involved parties, facilitate self-control and self-coordination, and achieve compatibility among system components (Katz and Shapiro, 1994). Member firms own their respective solutions and extract private benefits from them, but the value of each solution depends on the quality of the total system. Solution posting on the community's Web site makes members aware of new developments and records solution rights. Blade.org *per se* does not appropriate value; member firms privately appropriate value and invest in their own capability development.

Network Centric Operations is a military organization design concept for controlling and coordinating geographically dispersed military forces from multiple countries and military branches. It includes the development of broad capabilities, management of shared situational awareness, and collaborative command and control. The various military forces are connected by a shared information infrastructure. Extensive protocols guide contributions to and use of the situational awareness commons, and they enable collaborative command as well as self-synchronizing of military forces.

In summary, an organization's form must fit its function, and in order to maintain fit over time, the architecture of an organization must be able to support change and growth. Under the actor-oriented scheme, actor capabilities and values, commons, and the protocols, processes, and infrastructures that enable collaboration among actors all must fit the purpose of the organization. The four cases illustrate variation in purpose, control, and coordination analogous to how hierarchical organizational forms vary the number of organizational units, hierarchical levels, and superiors according to a particular organization's purpose.

DISCUSSION AND IMPLICATIONS

We are currently witnessing the diffusion of various new organization designs, emerging primarily in complex, dynamic sectors of the global economy. Common to all of the new designs is that the locus of control and coordination mechanisms is the organizational actor. Such organization designs can be understood by applying the

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Table 2. Features of the actor-oriented scheme in the four cases

Case	Organizational purpose	Control and coordination mechanisms
Accenture	Provide customized service solutions to international client firms by drawing on a global talent pool	Actors Recruitment of high-potential human resources Large investments in human resource development Commons Shared knowledge bases Protocols, processes, and infrastructures Protocols for people mobilization on projects Collaboration tools
Linux	Develop a free and open computer operating system by leveraging the collective capabilities of anyone who wants to contribute	Actors Open membership in the community for individuals and firms Self-selected participation Commons Source code Protocols, processes, and infrastructures Protocols for accessing, contributing to, and committing source code Services and tools on kernel.org
Blade.org	Accelerate the development and adoption of blade-based computer server solutions by providing leadership to the blade community	Actors Invited membership of complementary and vertically related firms Member firm investments in their own capability development Commons Standards Solutions posted on Blade.org Web site (shared situational awareness and tracking of property rights) Protocols, processes, and infrastructures Protocols for member networking Member accessible Web site
Network Centric Operations	Achieve military effectiveness and efficiency by controlling and coordinating geographically dispersed military forces from multiple branches and countries	Actors An alliance of countries Recruited, selected, and trained personnel from multiple military branches Each country and branch invests in the development of its own capabilities and resources Commons Shared situational awareness Standards Protocols, processes, and infrastructures Collaborative command Selective resource mobilization Self-synchronization of forces

actor-oriented architectural scheme. This scheme represents a change from expressing organizational architecture as specific organization structures to expressing it as *principles* by which actors engage in organizational *relationships*. Such a change provides a truly dynamic perspective of organizational adaptation to continuously changing environments.

Any new theoretical construct begs the question of its boundary conditions—that is, under what conditions does the actor-oriented scheme apply? We believe this scheme is universally applicable. As exemplified by the cases, actor-oriented designs currently are being used to organize operational, administrative, and strategic activities within a variety of organizations. Moreover, such designs

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are found across different sectors of society, though the early adopters are found in complex, dynamic sectors where the costs of hierarchy—inflexibility, filtering, and delay—are high. The actor-oriented scheme is particularly well suited to the design of organizations tackling ill-structured or unstructured problems characterized by uncertainty about both ends and means such that a high degree of mutual adjustment among changing sets of actors is needed in order to (1) anticipate the shape of an unknown future, (2) generate alternatives for operating effectively in dynamic and uncertain environments, and (3) implement chosen strategies rapidly and efficiently (Simon, 1973, 1993). As the costs of global communication and information processing continue to decline, hierarchy will become a relatively more expensive way of organizing. Using the language of Thompson (1967), the actor-oriented scheme is an administrative technology. If this new technology follows the course of a disruptive innovation (Christensen, 1997; Christensen and Bower, 1996), it may become the dominant form of organizing. This does not imply the end of hierarchy. Providing actors with the necessary authority to allocate and use resources may require contractually based hierarchical relationships. When hierarchy is present, therefore, we expect that it will be used primarily for control rather than coordination.

The actor-oriented architectural scheme is consistent with core properties of organization theory. North (1990) shows how political and economic institutions, along with infrastructures for exchange, enable sustained macro-level value creation and growth. The four cases we have discussed may be seen as having internal institutional mechanisms analogous to the macro-level institutions and services described by North. Williamson (1975, 1985) shows how institutions affect the organization of inter-actor relationships. Consistent with Dyer and Singh (1998), the actor-oriented scheme provides mechanisms for knowledge sharing and the identification of complementary resources and collaborators. Access to resources, in turn, is affected by norms, trust, and the ties available to individual actors (Granovetter, 1973, 1985). Mechanisms that constrain actor opportunism and excessive value appropriation, such as transparency, shared values, norms of reciprocity, and altruism (Milgrom, North, and Weingast, 1990; Ostrom, 1990), enable actors to overcome the tragedy of the commons (Hardin, 1968) and thereby enjoy the benefits of joint value creation.

Implications for research

The emergence of organization designs that employ actor-oriented control and coordination mechanisms provides rich opportunities for research. In particular, we suggest four theoretical issues to investigate. First is the role of incentives and values in large-scale, multiparty collaboration. Actors need to hold collaborative values that include a concern for the welfare of collaborating partners and the equitable distribution of rewards (Appley and Winder, 1977). This results in the open and voluntary sharing of resources as well as helping others achieve their goals. Incentives need to be designed such that they reward people and firms for collaborating and, therefore, research is needed on how actor-oriented mechanisms can enable peer recognition, problem identification, and other means of stimulating multiparty collaboration on a large scale.

Second is the nature of control in actor-oriented organization designs. Control is the determination of goals, the allocation of resources to pursue them, and the monitoring of goal fulfillment and resource use. Shared situational awareness can play a role in self-monitoring of resource use and availability as well as goal fulfillment. Furthermore, actors can self-mobilize around problems and opportunities and, thus, determine goals and how resources are allocated to their pursuit. Research should investigate the limits of actor-oriented control mechanisms as well as their interplay with hierarchical control mechanisms.

Third are the processes of transformation from hierarchical to actor-oriented organization designs. Some organizations such as Linux arise spontaneously while others such as Blade.org are purposefully designed. Currently, many large firms are flattening their hierarchies and, thus, lowering the locus of interdependencies. We suspect that such flattening implies the use of actor-oriented mechanisms. There is a need for research on the particular characteristics, challenges, and enablers of various transformation processes.

Fourth is the issue of value creation and value appropriation in actor-oriented designs. In general, we expect total value creation to be greater and faster in organizations that create value collaboratively, both within and across firms. The cases

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we have discussed exemplify added value creation from the sharing of resources and the collective pursuit of goals. Extant organization theory predicts that actors appropriate value by spanning structural holes (Burt, 1992). In contrast, the elements of actor-oriented designs allow actors to close structural holes. Moderation in the appropriation of value may be a necessary condition for enjoyment of the increased opportunities for value creation made possible by collaboration. Further research is needed on how value can and should be appropriated in actor-oriented organization designs.

Implications for managers

If the actor-oriented scheme is valid, managers need to understand how it works and where it applies. In this regard, two practical implications are especially important. First, Utterback (1994) observed that a new technology often is used merely to augment existing ways of doing things. Examples are the transistor being used to improve the performance of radio tubes and electricity being used to improve gas lighting. Managers must realize that the most powerful applications of actor-oriented organization designs do not involve the augmentation of hierarchical organizational forms. Instead, they should use the actor-oriented scheme to redesign their organizations to enhance the ability to collaborate internally and externally. Second, managers must be aware that the successful use of a new organization design requires the development of the organizational capabilities and management philosophies required to operate that design (Miles *et al*., 2009). Unless a critical mass of collaborative capabilities and values is present in a particular sector, considerable joint investments and training will be needed to build organizations suitable for large-scale, multiparty collaboration (Miles, Miles, and Snow, 2005).

CONCLUSIONS

Recently developed organizational strategies, structures, and processes, such as those of Accenture, Linux, Blade.org, and the Network Centric Operations design, reflect a focus on large-scale collaborative behavior across sets of actors who follow protocols for sharing resources and rewards both within and across organizations. Multiparty collaboration is critical to the effective solution of complex problems and continuous adaptation to changing environments. Further, new organization designs demand changes in managerial attitudes and abilities that historically have taken decades to gain widespread acceptance and implementation. We hope researchers increasingly will focus their attention on the structures and processes of large-scale, multiparty collaboration because collaborative values and capabilities clearly have the ability to improve both resource utilization and returns to the benefit of the economy and society as a whole.

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