Information and Organization 24 (2014) 250–269

Contents lists available at ScienceDirect

Information and Organization

journal homepage: www.elsevier.com/locate/infoandorg

Beyond the organizational 'container': Conceptualizing 21st century sociotechnical work

Susan Winter [a,*], Nicholas Berente [b], James Howison [c], Brian Butler [a]

[a] College of Information Studies, University of Maryland, 4105 Hornbake Building, South Wing, College Park, MD 20742, United States
[b] Terry College of Business, University of Georgia, 303 Brooks Hall, Athens, GA 30602, United States
[c] School of Information, University of Texas at Austin, 5.404 UTA, Austin, TX, United States

ARTICLE INFO

Article history:
Received 26 March 2014
Received in revised form 9 October 2014
Accepted 10 October 2014
Available online xxxx

Keywords:
Work
Sociotechnical systems
Organizations
Infrastructure

ABSTRACT

The sociotechnical systems (STS) approach provides a framework that is well suited to grappling with many issues of work in organizations. By conceiving of work systems as mutually-shaping social and technological systems, the STS approach has provided decades of researchers and practitioners with robust analytical tools to consider both the social and the technical elements of organizational contexts. However, we identify two areas where the conceptualization of sociotechnical systems must be updated to reflect the role of information infrastructures as an enabler of trans-organizational work arrangements. First, with its view of nested systems, the STS approach *encapsulates* work and the infrastructure used to do it within organizations (either explicitly or implicitly) — often leading to a "container" view of organizations as the context of work and a venue for joint optimization of the social and the technical. Second, because work is generally treated as encapsulated within superordinate, nested systems, elements of that work are *inherited* from those superordinate systems. In this paper we characterize the limitations of industrial age assumptions of organizational encapsulation and inheritance that, rooted in the STS approach, underlie much of traditional information systems scholarship. We then theorize an updated sociotechnical framework (Neo-STS) and apply it to examples of contemporary work situations to highlight the importance and implications of trans-organizational information infrastructures and multidirectional inheritance.

* Corresponding author.
E-mail addresses: sjwinter@umd.edu (S. Winter), berente@uga.edu (N. Berente), jhowison@ischool.utexas.edu (J. Howison), bsbutler@umd.edu (B. Butler)

http://dx.doi.org/10.1016/j.infoandorg.2014.10.003
1471-7727/© 2014 Published by Elsevier Ltd.

> "The field of information systems … formed from the nexus of computer science, management and organization theory, operations research, and accounting … [None] of these areas or disciplines focused specifically on the application of computers in organizations. IS emerged as the field to do just that." (Hirschheim & Klein, 2012, pg. 193).

1. Introduction

Information systems (IS) research typically focuses on the application of computers in organizational contexts. This organization-centric view can be traced back to the field's birth, and in many ways marks its unique identity. Foundational work in the IS field argued for the value of IS to be assessed in terms of their use in and impact on organizations such as businesses (Davis, 1974; Keen, 1980; Leavitt & Whisler, 1958) and the emergence of IS groups in organizations has been identified as the beginning of the 1st Era of IS (Hirschheim & Klein, 2012).[1]

Early information technologies were expensive and were primarily adopted by large organizations such as corporations and the U.S. military. Thus a path-dependent tradition of what constitutes appropriate IS scholarship was set in motion. Implicit in this tradition are important assumptions drawn from earlier approaches and matured in the economic and sociotechnical systems (STS) approach (Trist, 1981) that influences much of the IS discipline.[2] A fundamental tenet of STS is that technologies themselves are not deterministic, but rather their impacts arise from complex interactions with industrial and organizational contexts. Many studies of IS build on this approach, either implicitly or explicitly, assuming that organizations act as "containers", encapsulating both the work that is done and the infrastructure used to do it rather than explicitly considering where and how information and work system boundaries could or should be drawn. Organizations are often assumed to provide overall goals, define work routines, and create technical systems to support those routines. Organizationally-created infrastructures are presumed to provide the context for work, constraining and enabling organizationally-designed work practices. Outcomes of IS implementations are considered in relation to organizational goals. These assumptions have informed interesting and useful STS research that has enabled IS scholarship and practice to thrive for decades (Hirschheim & Klein, 2012), but the organizational container perspective can also be problematic.[3]

There is an increasing awareness that many important work practices, routines, and digital artifacts occur outside of organizational containers; increasingly work is not cleanly encapsulated within a single organization's boundaries. For example:

- Generative platforms for innovation that are driven by, but not encapsulated within, an organization, such as Apple's iPod, iPad, iPhone, iTunes ecosystem of technical standards and developers in which governance of the ecology co-evolves and emerges with the technical platform (Tiwana, Konsynski, & Bush, 2010; Yoo, Henfridsson, & Lyytinen, 2010) spawning the Bring Your Own Device (BYOD) trend.
- Free and open source software (FLOSS) communities that coalesce around a technology and add elements of organization only as required to manage its development (e.g., Howison & Crowston, 2014; O'Mahony & Lakhani, 2011; Shah, 2006).
- International research cyberinfrastructures (CI) (e.g., software, hardware, standards) for access to distributed resources (e.g. the Large Hadron collider, supercomputers, telescopes) funded, managed, and shared by diverse science enterprises (Hey & Trefethen, 2005; Tuertscher, Garud, & Kumaraswamy, 2014).

In all of these cases, information systems play a central role, but related scholarship is seen as a weak fit with the IS field because the technologies and work systems are not contained within or linking across an organizational boundary. The technology reaches beyond traditional local sociotechnical ensembles, across large numbers of organizations, and shapes industries, institutions, and society. These are not organizational

[1] The advent of the PC and end user computing characterize the 2nd era; Departmental Computing and CIOs characterize the 3rd era; modification of corporate strategy for the Internet and outsourcing characterizes the 4th era.

[2] Some argue that the STS tradition is the root of the IS discipline (see Beath, Berente, Gallivan, & Lyytinen, 2013; Bostrom, Gupta, & Thomas, 2009). We do not make such a strong assertion, but it is clear that the STS tradition is an important thread running through the field with many IS researchers implicitly accepting its central assumptions.

[3] To highlight where STS could be updated, our depiction of STS and of related IS scholarship focuses on essential elements at the expense of some of the nuance and complexity.

infrastructures that embed managerial imperatives (Ciborra, 2000; Volkoff, Strong, & Elmes, 2007), but societal and field-level infrastructures that digitalize aspects of work and allow it to be performed outside organizational contexts (Tilson, Lyytinen, & Sørensen, 2010). While formal organizations and traditional work arrangements are not disappearing, discussions of work and technology that are implicitly or explicitly limited to activity and systems contained within or linking across traditional, formal organizations may yield incomplete understandings and misguided action.

IS scholarship that is rooted in the STS tradition will be limited in its ability to address the organization of work outside of traditional organizational containers. Organizations no longer create and control many of the IS their workers rely on. Infrastructures and systems exist outside of and independent of the organizations that use them. Cost barriers have been dramatically reduced allowing individuals to choose devices as consumer products and make use of data and information services in the cloud for work, learning, entertainment, and maintaining personal relationships. FLOSS development projects, maker communities, and citizen science all use extra-organizational infrastructures that facilitate work without any encapsulating organization, allowing new work arrangements with dynamic structures and goal multiplicity. So what is the relationship between organizations, information handling infrastructure, and work in this new world? How could the STS approach and related IS research be modified to allow researchers and practitioners to more effectively understand and leverage these new arrangements?

In this essay, we draw upon and extend the STS approach to account for cross-organizational infrastructures and extra-organizational work arrangements. In doing this we update an important conceptual foundation for the IS field, providing a basis for studying and organizing work and information technologies outside of organizational boundaries. In the following sections we discuss the established STS approach, how it informed an understanding of the relationship between organizations, information technology, and work. We also argue that much of the traditional research on information, information systems, and organizations shares, either implicitly or explicitly, both the critical assumptions and constraining limitations of the STS approach. Then we revisit the STS approach and revise it to deal with new technologies that alter the relationship between formal organization and work. We then show how the proposed Neo-STS approach provides a conceptual basis for IS scholars to engage and address emerging work trends and interesting technology-enabled phenomena and issues.

2. The STS approach and IS research

The STS approach has its roots in the post-World War II Tavistock industrial research in Great Britain (e.g., Emery & Trist, 1965; Trist & Bamforth, 1951). These early studies focused on work within organizations that had designed both the tasks to be performed and the infrastructure used to perform them: industrial coal mining carried out within coal mining companies. Two foundational elements of this tradition are: (1) a systems approach, and (2) an emphasis on the interplay between the social and the technological.

2.1. Systems approach

The STS movement was rooted in the "general systems" worldview which holds that a system is a collection of interrelated elements that work together in the service of the whole (Von Bertalanffy, 1950) and that any system is both part of a larger system and contains subsystems (Allen, O'Neill, & Hoekstra, 1984; Churchman, 1968). Analytically, it is useful to consider at least two levels of a system hierarchy — that of the system and of its parts (Allen et al., 1984; Hofkirchner & Schafranek, 2011). Bounding the "whole" system can be problematic, but once accomplished, the parts comprise and are contained within that system (Churchman, 1968).

The STS approach identified fundamental system characteristics, and extended these concepts into the organizational domain to theorize the nature of work and work systems. STS are systems — and are therefore nested and multilevel (Churchman, 1968) and the hierarchies are typically characterized in terms of system levels (e.g. organizational, departmental, work) within an organization (Trist, 1981). Adopting a systems approach, an organization can be considered a purposeful system, with work systems as parts supporting the organization's formal purpose (Beer, 1994). Although the components comprise the system, their value, purpose, and operational criteria are derived from the larger system (Beer, 1994). In this "downward causation" (Hofkirchner & Schafranek, 2011) the higher-level, emergent "whole" of the system shapes its component parts. Thus, (1) systems are nested, with a system *encapsulating* its subsystems; and (2) downward causation implies that parts inherit elements of their structure and purpose from the higher-level system. The STS approach extended the systems approach to characterize work and work systems in terms of a hierarchy of interrelated social and technical systems to be optimized.

2.2. Social and technical systems

A key insight of the STS approach involved treating organizational and human, or "social," elements together with the technical systems, because the two are "intertwined in a complex web of *mutual causality*" (Trist, 1981, p. 13). The social and technical elements of organizational systems co-produce one another — new technologies enable new possibilities for work, and new modes of work pave the way for technological change (Trist, 1981).

Though different theoretical positions have arisen regarding the mutual dependencies between the social and the technical (Leonardi, 2012, 2013), a central premise of the STS approach is that the dynamic and mutual interplay between people and technologies *jointly* generates outcomes. An important implication of mutual causality is that development of STS necessarily involves *joint optimization* of the social and the technical elements of work systems within some boundary. In many cases, the boundary relevant for joint optimization was posited to be an organizational or work system boundary. In his seminal work that laid the foundation for the IS field, Davis explicitly lays out this conceptualization:

> "*Recognizing that in terms of [performance] an organization is a sociotechnical system. As such, it is required to evaluate the impact of the technology design on the social system and of the requirements of the social system on the design and operation of the technical (work) system by jointly considering the best in either the technical or social system and its effect on having the best in the other.*" (Davis, 1977, p. 265)

For the better part of the 20th century, studies of the organization of work and work systems focused primarily on work that took place in the context of large, capital-intensive, industrial bureaucracies. Joint-optimization provided a conceptual foundation for highlighting the characteristics of the work related to the experience of the individuals performing it — a response to the instrumental view of organizations associated with scientific management. Thus the STS literature provided a conceptual basis for recognizing the importance of avoiding dehumanizing work and building work systems that aligned with individual and social factors. Yet it did so largely with the assumption that work and work systems necessarily existed within the boundaries of a larger organization.

Because of its focus on mutual causality and joint optimization, the STS approach came to be associated with the human relations school of management and its emphasis on jobs with autonomy, completeness, skill variety, individual and team learning, and quality of working life (Davis, 1977). While the STS approach has continued to evolve (Baxter & Sommerville, 2010), it has remained faithful to the core elements of systems theory: sociotechnical systems comprise the work systems that are *encapsulated* within or bridge across organizations, those work systems *inherit* their formal purpose, meaning, and relationship with other systems from the overall organization, and the social and technical elements should be jointly *optimized* in accordance with these organizational goals.

2.3. The STS approach and IS research

A significant portion of IS research is rooted in the STS approach and builds, either explicitly or implicitly, on its underlying assumptions (Hirschheim & Klein, 2012). Important foundational work in IS development and implementation explicitly adopted an STS approach (Bostrom & Heinen, 1977a, 1977b), taking a normative stance with the goals of simultaneously improving system development, humanistic, and organizational outcomes (Klein & Lyytinen, 1985; Mumford, 1983; Sandberg, 1985). Much of the work in participatory design and end user involvement is rooted in the STS tradition, "jointly optimizing" the technology and related work with attention to the overall user conditions within an organization (Floyd, Mehl, Reisin, Schmidt, & Wolf, 1989; Mumford, 2003). Reflecting its foundation in the STS approach, Bostrom and Heinen (Bostrom & Heinen, 1977b) proposed an analytical framework that includes four "interacting variable" classes: two in the social system (structure and people) and two in the technical system (technology and tasks) (Fig. 1).

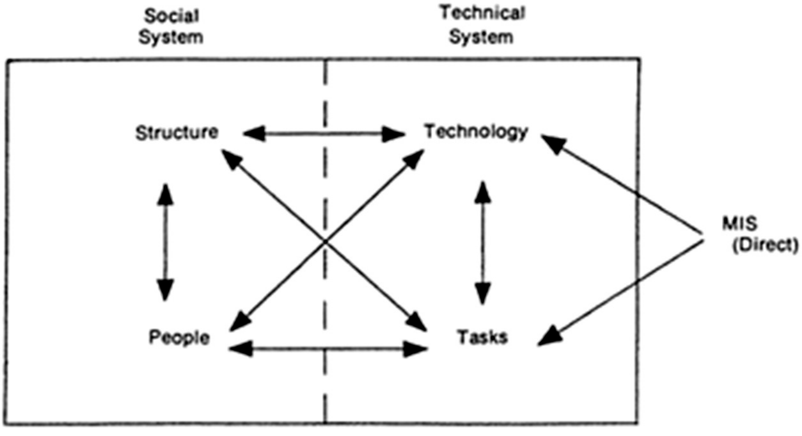

Fig. 1. Interacting variable classes within a sociotechnical work system (Bostrom & Heinen, 1977b).

Responding to early techno-centric, often deterministic views of the relationship between technology and organizations (Conway, 1968; Leavitt & Whisler, 1958; Mann & Williams, 1960; Zelkowitz, 1978), studies rooted in the STS approach argued that attending to all four elements of the work system resulted in the best outcomes from a managerial perspective. Later STS-informed organizational IS scholarship moved away from normative prescription toward explanations rooted in detailed description, mirroring movements in sociological and historical analyses of science and technology such as social construction of technology (SCOT) (Bijker, 1995), social shaping of technology (SST) (Williams & Edge, 1996), and actor-network theory (ANT) (Latour, 1987, 2005). These variants consider the mutual interplay between the material properties of technologies and social contexts albeit with distinct emphases on how the social and the technological relate to each other (Leonardi, 2012; Markus & Robey, 1988). Technologies and humans are viewed as forming mutually constitutive emergent "webs" of computing (Kling & Scacchi, 1983) with technologies newly introduced into organizations acting as "occasions" for social structuring (Barley, 1986). Organizational outcomes evolve through the mutual adaptation of organizational actions and technological modifications (Leonard-Barton, 1988a, 1988b) involving either gradual mutual interplay (Orlikowski, 1996) or punctuated change (Tyre & Orlikowski, 1994) in which the results of certain sociotechnical arrangements enable new sociotechnical arrangements (Boland, Lyytinen, & Yoo, 2007).

Common in these views is the premise that technologies become technologies only in so far as they are technologies-in-practice (Orlikowski, 2000) embedded in a social system (Orlikowski & Iacono, 2001). Though the interpretation and framing of how technologies-in-practice emerge, are composed, and evolve varies significantly,[4] much of the scholarship in IS emphasizing the social shaping of technology focuses on the "interpretive flexibility" of information technologies within an organizational context (e.g., Desanctis & Poole, 1994; Orlikowski, 1992). Though it is often useful to accept the organization as the container for both IS and work systems, the assumed importance of the encapsulating social/organization system is so great that some scholars have argued that studies of IS in organizations have failed to deeply engage the technological systems themselves (Orlikowski & Iacono, 2001).

Consistent with the mutual causality assumption of the STS approach (Leonardi, 2012, 2013), the more recent sociomaterial view in IS (Orlikowski, 2007; Orlikowski & Scott, 2008) brings the technological artifact into the foreground. In the sociomaterial view, the material and the human are not separable as antecedents or outcomes of organizational action (Orlikowski, 2007; Pickering, 1995) with both acting on and constituting

[4] In SCOT, for instance, social processes of meaning making form the primary source of generating and stabilizing technology, while SST argues that the social context, including the meanings, regulation and power, shapes the design, use and evolution of technologies. In ANT (Latour, 2005), to the contrary, both human and non-human agencies are explicitly assumed and are seen to jointly form sociotechnical ensembles continuously enabling and constraining the agency of the other. Together this process of assembling, or "translation", produces permanent actor-networks that shape the performative effects of technology.

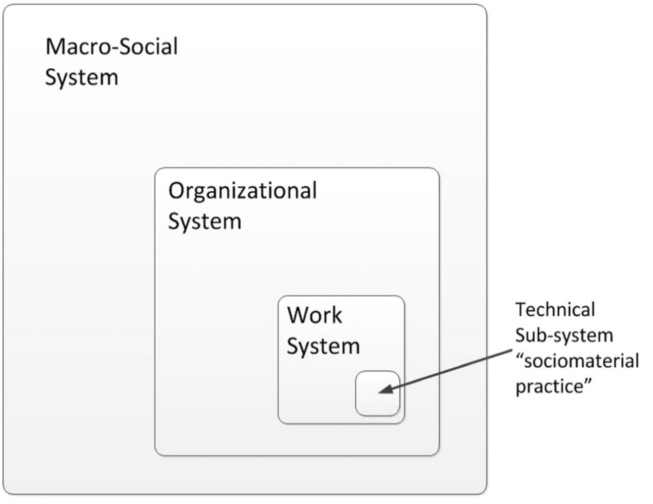

Fig. 2. Nested systems view of sociomaterial practice within a work system.

each other in what Pickering (1995) calls the “mangle” of practice. Humans and non-humans become ontologically inseparable in practice and emerge as relational categories that underlie any technology-in-practice (Orlikowski, 2010). Consequently, while the two can be analytically distinguished, the sociomaterial approach cautions that neither should be considered exogenous (Leonardi, 2010).

Over time, the prominence of different aspects of the STS approach in IS research has varied. While attention to mutual causality and joint optimization of the social and technical systems has waxed and waned, assumptions of encapsulation and inheritance have persisted. Leonardi (2012) considers sociomaterial practice to be equivalent to the technical subsystem of a sociotechnical work system (Fig. 2). Alternatively, a nested systems view considers sociomaterial practice to be a sociotechnical subsystem within a specific work system (though the focus on local work systems often ignores nesting and system level analyses). Yet, in either framing, work is assumed to take place within a “container” that defines the work and provides the necessary infrastructure (Alter, 2013). Though the STS approach may not always be explicitly referenced, STS notions of encapsulation, inheritance, and joint optimization underlie a significant branch of IS scholarship on work, information, and systems. Table 1 summarizes examples of STS-informed IS literature that illustrate the most central features of the STS approach.

While by no means an exhaustive review, these examples show how studies of IS and work have often used (or at least not rejected) the following assumptions of the STS approach:

(1) Work systems have social and technical elements (sociotechnical) that together form a coherent whole
(2) Work systems are nested within organizational containers (encapsulation)
(3) Work systems get their purpose, meaning, and structure from the organizational context (inheritance/downward causation)
(4) Improvement to work systems involves improvement with respect to the combined human and organizational goals (joint optimization).

Each of the examples in Table 1 arguably has its roots in the STS tradition.[5] Next we will briefly address how IS research often presumes an organizational container for work systems.

[5] Here it is important to emphasize that we are not claiming that *all* studies in each of these traditions necessarily fit the STS set of assumptions. The technology acceptance model, for example, has been used to study a variety of phenomena outside organizational boundaries, such as social media, and mobile computing. However, clearly, the seminal and prototypical TAM studies consider phenomena that are embedded within organizational contexts.

Table 1
Illustrative Instantiations of the STS approach in IS scholarship.

Systems approach	Sociotechnical systems approach	Examples in IS scholarship
1. Boundaries	1. Organizational encapsulation: Organization is the system boundary and element container (Encapsulation)	IS development Involvement of end users in development of organizational technological artifacts to impact employee use and benefit the organization
2. Inter-related elements Coherent & consistent: Working together In service of the whole	2. Joint optimization: Elements include: Technological artifacts, tasks, and workers Joint optimization of social and technical elements To benefit the organization	Mutual adaptation Context and technology evolve over time; departmental membership will structure group responses and shape local practice Task-technology fit
3. Nested systems Multiple levels Inheritance of structure and purpose	3. Downward inheritance: Organization is highest level Unidirectional (downward) Inheritance: Organization structures to lower level work systems Sociotechnical work: System is developed and implemented to reflect its container and inherits the goals of that container	Using the appropriate technology for a task will improve employee effectiveness; task and technology characteristics are predefined and “given” by the organization Technology Acceptance Model (TAM) Employees will use technologies provided by their employers that are useful in accomplishing their work tasks Strategic alignment Align IT organization with business and strategy for positive organizational outcomes

2.3.1. Organizational encapsulation: the “container” in IS research

Recognizing the metaphor of organizations as containers for work allows for problematization of how and where the boundaries of socio-technical systems can and should be drawn. The view of organizations as containers for work has dominated much of the IS discourse (Hirschheim & Klein, 2012) and is reflected in several early field-defining frameworks (e.g., Davis, 1974; Keen, 1980) identifying factors important in developing IS that would be used by members of the organization. Researchers focused on the question of why IS development projects failed to achieve the anticipated impacts highlighted the technical and non-technical factors that affect system acceptance, use, and performance (Benbasat & Barki, 2007). Some researchers operationalized and explicitly attended to the four dimensions of STS (Lyytinen & Newman, 2008). Others, invoked the STS approach as a term for any theoretical perspective that considers the social elements of a system (Luna-Reyes, Zhang, Ramón Gil-García, & Cresswell, 2005). Whether the STS approach is explicitly, implicitly, or nominally applied, the idea of organizations as containers for work is widely accepted in much of IS research (Bostrom et al., 2009; Straub, 2012).

Even in studies that focus on individuals, assumptions are often made about goals, values, and tasks that are consistent with the organization encapsulation of work. For example, the Technology Acceptance Model (TAM) literature (Davis, 1989; e.g., Venkatesh, Morris, Davis, & Davis, 2003) and task-technology fit studies examine the relationship between work and technology at the individual level (Goodhue & Thompson, 1995), but take for granted that the task is inherited from the organizational context. The “usefulness” construct in TAM implies that the system capabilities support exogenously determined goals; “task requirements” in task-technology fit models assume an existing task with externally defined expectations. While not always specified, these lines of work all posit the existence of defined goals, tasks, and values — an assumption that is reasonable given the underlying assumption that the work exists within an organizational container that, through inheritance, provides precisely these things.

From a more explicitly organizational perspective, IS research has identified the importance of mutual adaptation between a technology and its organizational context (Leonard-Barton, 1988a, 1988b), a process that can be punctuated, continuous, or nested and cascading (Majchrzak, Rice, Malhotra, King, & Ba, 2000; Orlikowski, 1996; Tyre & Orlikowski, 1994). Whether focused on departmental units, communities-of-practice, or coalitions of users, much of IS scholarship has assumed that the interplay between work and technology takes place within an organization (Lesser & Storck, 2001; Markus, 1983; Silva & Backhouse, 2003).

The assumption of local, sociotechnical arrangements nested within organizations can take a variety of forms in IS scholarship, some of which explicitly acknowledge the relationship of the work system to the organizational container. For example, the IS literature on business-IT alignment highlights the benefits incurred when sociotechnical work systems are aligned with their organizational contexts (Henderson & Venkatraman, 1993; Luftman & Kempaiah, 2007; McLean & Soden, 1977; Reich & Benbasat, 1996). This notion persists in IS research on the role of sociotechnical work systems in enabling organization-wide integration, agility, and reliability (Barki & Pinsonneault, 2005; Butler & Gray, 2006; Sambamurthy, Bharadwaj, & Grover, 2003) and on the fit between enterprise-wide systems and particular work systems (Davenport, 1998; Soh, 2003) which focuses on the local fit in the context of an organization-wide fit with systems. Although a portion of IS research has considered larger scale market, supply chain, profession, industry, or institutional factors (Berente & Yoo, 2012; Chiasson & Davidson, 2005; Kling & Iacono, 1989), the view of work systems as implicitly or explicitly encapsulated within organizations pervades much of IS scholarship.

Thus, while not all IS scholars reference STS, they often adopt assumptions consistent with the STS approach. This is understandable since both the STS approach and the IS field developed when information technology was prohibitively expensive. Only businesses and government organizations could afford the capital to acquire computers and the personnel for their maintenance and use, so thinking about computerization as an organizational phenomenon became a "default". Further, many IS scholars are housed in schools of business that emphasize the perspectives, interests, and needs of C-level business executives (such as CIOs) (Hirschheim & Klein, 2012). STS and IS research embraced a view that balanced agency and action (joint optimization) and inherent complexity (interrelated parts and emergent whole) with an implicit assumption of hierarchy and control that is consistent with a managerial mindset. Adopting the STS approach with the assumption of an organizational container was both phenomenologically defensible and practical.

However, in recent years, emerging phenomena have begun to challenge some of these shared precepts, giving rise to questions about the relationship between organizations, work, and information technology. Although viewing organizations as containers for work and IS is still appropriate in some cases, there are a growing number of instances where this assumption falls short, rendering STS-informed IS scholarship on the organization of work and work systems somewhat ill-equipped to engage these important domains.

2.3.2. Emerging infrastructures and the limits of the organizational container

The view of organizations as bounding and containing work systems has historically been useful, but scholars have recently chronicled a growing erosion and transcendence of traditional organizational bounds (O'Mahony & Lakhani, 2011). Though much work is still performed within an organization, increasingly, work can be coordinated through formal institutional arrangements (e.g. consortia, institutes, partnerships), through informal communities of practice or interest, and through multi-team systems that cross or even exist outside of the boundaries of a single organization.

The shift away from organizations as the primary container of the work system is enabled, at least in part, by changes in the nature of the technical and information infrastructures upon which work systems rely. Increasingly, work is no longer tied to systems built and managed by a single organization, but is rather enabled by broader infrastructures (Cummings, Finholt, Foster, Kesselman, & Lawrence, 2008). At the same time, infrastructure has itself become an object of research with recent work examining paths of development over time and "generative mechanisms" that drive its success (Henfridsson & Bygstad, 2013). Tilson et al. (2010) summarized the components[6] that have led to the increased capabilities of infrastructure, a process they call "digitalization". These capabilities combine with the increased sourcing of IT outside end-user organizations (e.g. cloud, service-oriented computing, and software as a service (SaaS)). Rather than being designed for a particular organizational purpose (with some improvisation), such infrastructures have "generative" potential and are "never fully complete … they have many uses yet to be conceived of" (Zittrain, 2008, p. 43).

These infrastructures offer commoditized flexible and affordable services with relatively few restrictions on their use. For many kinds of work, assembling a technical infrastructure of virtual machines and cloud services no longer requires daunting levels of capital. Free and Open Source Software (FLOSS) provides free, reusable, easily available software[7] and these infrastructure-based technologies are enduring even without an encapsulating organization to design and manage them. This combination of inexpensive, ubiquitous,

[6] These include "inherent flexibility of digitizing", ubiquitous networking (and the standards and standard-making involved) and increased capacity for "communicating, storing, and processing".

[7] The Open Source Institute only considers licenses to be open source licenses if they do not restrict "field of endeavor" or discrimination against any "persons or groups."

persistent and broadly available software, networking and servers can support work outside of a traditional organization, reducing the need for work systems to be encapsulated within an organization.

While the nature of work, work systems, and infrastructure has been changing and some IS scholars have considered the implications of such a shift, often IS research does more to highlight limitations and gaps in the literature than to answer fundamental underlying questions. For example, Bring Your Own Device (BYOD), FLOSS, and scientific big data cyberinfrastructure could be addressed as new forms of the old problem of organizational adoption (Chau & Tam, 1997; Thong, 1999). But much of the popular discourse associated with these innovations focuses on issues of policy and governance,[8] topics that are otherwise largely absent from the IS literature on the adoption of technology and the organization of work. Similarly these innovations could be addressed as just new forms of end-user computing (Cheney, Mann, & Amoroso, 1986; Rockart & Flannery, 1983), but the end-user computing discourse seldom takes into account systems that exist and operate outside of a single organization's influence. Spanning organizational boundaries, BYOD ecologies enable undetectable movement of sensitive data into the cloud and co-mingling of organizational and personal uses. Although BYOD could be conceptualized as a form of end-user computing, doing so does not acknowledge the ways it calls into question accepted notions of system architecture and organizational agency.

Both FLOSS and scientific cyberinfrastructure create novel relationships between infrastructure providers, software developers, intellectual property owners, users and funding streams. FLOSS systems might just be addressed as a form of outsourced software development, but FLOSS calls into question the centrality of individual organizations, the importance of organizationally specified software development practices, and the role of technology vendors in the larger institutional context of IS (Fitzgerald, 2006; Howison & Crowston, 2014). Scientific cyberinfrastructure may be just large-scale international, interorganizational IS, but its reliance upon complex partnerships among heterogeneous stakeholders including national funding agencies, universities, government labs, industry and organizations is largely unprecedented among interorganizational IS (Ahalt, Apon, & Neeman, 2010) and yet increasingly common.

3. A Neo-sociotechnical systems approach

While instances of work supported by technical systems originating outside particular organizations clearly have conceptual connections to topics considered in the IS literature, the characteristics of such systems are a weak fit with the IS theories and perspectives used to address the organization of work. This mismatch might be seen as an indication of a fraying disciplinary boundary or a declining emphasis on core concepts in the field — leading some to call for a refocusing on the “right” contexts, phenomena, or artifacts (Lyytinen & King, 2004). Alternatively, the mismatch between prior work and emerging issues can be seen as justification for radical conceptual revolution, abandoning old ways of thinking and moving in fundamentally new directions. However, a third approach based on critical reexamination of the conceptual foundations of prior work can build bridges between what is known and what is needed. The STS approach has important links with earlier generations of IS research focused on organizational systems and work practices. A reinvigorated neo-sociotechnical systems (Neo-STS) approach can be used in conjunction with prior IS work to provide a stronger foundation for a new generation of research addressing emerging 21st century phenomena related to work, work systems, and infrastructures that transcend organizational boundaries. To this end, we consider the foundational premises of the STS approach and propose alternatives that are consistent with both traditional studies of IS and work and emerging phenomena in this area.

3.1. Multi-encapsulation

As noted, increasingly work systems are not necessarily encapsulated within single organizations from which they can inherit their purpose, meaning, structure, and goals. However, in most cases, new infrastructure technologies reshape and restructure encapsulating boundaries without eliminating them. Previously the nature and implications of sociotechnical boundaries were often of only secondary concern. Even in cases where research went beyond the organizational container, such as studies of inter-organizational systems, organizational boundaries were essentially treated as given (e.g., Johnston & Vitale, 1988; Kumar & van

[8] Security concerns and development of specific organizational policies for BYOD (Miller, Voas, & Hurlburt, 2012; Thomson, 2012), intellectual property and project governance issues for FLOSS.

Dissel, 1996), and as a result they were not explicitly attended to or questioned. Without the presumption of organizational encapsulation, however, the creation, management, and implications of complex boundary systems become central to understanding the development, functioning, and outcomes of technology and work systems. Context collapse in social networking systems (Vitak, 2012) is not the elimination of boundaries so much as their reconfiguration. Studies of systems of online communities find significant boundaries associated with membership and content which are created and managed (Butler & Wang, 2012; Wang, Butler, & Ren, 2013). Similarly, FLOSS governance involves management of project boundaries and overlapping spheres of influence (e.g., O'Mahony & Bechky, 2008; O'Mahony & Ferraro, 2007; Shah, 2006). Dropping the organization-as-container assumption amplifies rather than eliminates the need to explicitly consider encapsulating boundaries. Thus the organizational encapsulation premise of STS approach can be restated as:

Neo-STS Premise 1: Work systems are necessarily encapsulated within one or more, potentially overlapping, sociotechnical systems.

Removal of the singular organizational container assumption does not imply that there is no container. Instead, this view points to the need to understand the different organizational contexts that complex sociotechnical phenomena may span. If the assumption of *singular* organizational encapsulation is removed, this does not mean that work continues without a container. FLOSS and cyberinfrastructure research show, for example, that if an organization does not exist, people will create it. Freelance and contract work and work systems do not take place in a vacuum, but rather at the intersection of at least two sociotechnical systems, a market and an organization. Stepping away from the presumption of a singular organizational container highlights ways in which elements can span multiple 'containers', drawing attention to the impact of pluralistic contexts on the nature of contemporary work, work systems, and the infrastructures that support them.

A multiple container view helps analysts consider the people, resources, activities, goals, information, and technical artifacts that comprise the work system, but simultaneously exist in different social systems, raising questions about how these work systems develop and function. While issues of boundaries have been present in prior IS research on the organization of work, including studies of outsourcing and project teams that cross organizational units (Majchrzak et al., 2000; Yoo, Boland, & Lyytinen, 2006), the Neo-STS approach warns against the fallacy of boundary elimination and calls for more careful attention to these questions by revealing the full range of potential relationships between work systems and boundaries that prior work often took for granted.

3.2. Complex interrelation of sociotechnical elements

A central insight of the traditional STS approach is that a work system is composed of interrelated social and technical elements that together form a coherent whole. This view encourages scholars and practitioners to prescribe rationality and coherence to the interrelation of system components. Strategy and systems should be aligned. Task and technology should fit. Yet studies of organizationally embedded work systems have recognized that being interrelated does not necessarily imply alignment and harmony. Research on the role of power and politics in IS highlights the presence of conflict, competition, and contradiction even in effective work systems (Jasperson et al., 2002). Theories of tensions and dialectics in information systems and organizations imply that positive outcomes are not necessarily dependent on consensus and unity (Robey & Boudreau, 1999). Institutional accounts of organizations highlight how pluralistic and potentially contradictory elements coexist in organizations (Berente & Yoo, 2012). Without a strong presumption of a single organizational container, the pretense of rational interrelation of elements can be difficult to maintain. Instead of viewing effective work systems as coherent wholes, the multi-encapsulation view allows for the pluralism evident in contemporary work that is enabled by loose coupling between elements (Berente & Yoo, 2012). Work systems are embedded in multiple containers – be they organizations, professional fields, or industries – and the norms, goals, and values of these multiple containers might be congruent, contradictory, or orthogonal (Winter & Berente, 2012). The assumption that social and technical elements necessarily need to be aligned or complementary for successful outcomes is likely to be misleading. Thus, this premise should be reframed as:

> *Neo-STS Premise 2: Work systems have interrelated, possibly complementary, redundant, competing, or conflicting, social and technical elements that may co-exist without ever being fully reconciled.*

This more complex view highlights the range of ways that the elements of work systems can be interrelated. Social and technical elements may co-exist and coevolve as dynamic mutually reinforcing complements or as redundant substitutes, with social and technical elements often providing alternative mechanisms for meeting a need. The elements of work systems can also constrain one another. While concepts of fit, alignment, and complementarity remain useful in some contexts, models of work systems must also account for the persistence of redundancy, competition, conflict, inter-locking constraint, and loose coupling in healthy, functional work arrangements.

3.3. Multi-directional inheritance

In conjunction with the organization as container assumption, the premise that work inherits its goals from its encapsulating organization supports a relatively clean model of organizational agency. In such a view, work systems inherit their purpose, meaning, and structure from the organization; work systems reflect the priorities and purposes of the organization that contain them. Underlying this premise are critical assumptions about sequencing, timescales, and precedence. Hierarchical nesting of work systems within organizations implies that organizations precede and exist independently of work systems allowing those systems to inherit purpose, meaning, and structure from the organization. Through the multi-container view, however, we leave behind the idea of organizations as the containers of work and work systems opening up the possibility of more complex inheritance structures. Thus this premise of the STS approach can be restated as:

> *Neo-STS Premise 3: Work systems can derive purpose, meaning, and structure from the multiple contexts in which elements are embedded and they may pass on purpose, meaning and structure to the sociotechnical systems that emerge around them.*

Multi-directional lateral inheritance implies that even when a single organization is no longer the container for work systems, nesting and inheritance of both structure and purpose remain central to their development and consequences. It also highlights that this inheritance is recursive. As multi-inheritance is enacted at the level of a work system, the resulting actions shape and influence the embedding contexts. Work systems that involve developers, infrastructure providers, content owners, organizational clients, and users will necessarily inherit purposes and meaning from multiple contexts, and will in-turn shape those contexts. This premise raises important questions of how multiple inheritance functions in work systems including whether, when, and how convergence of purpose and meaning occurs.

This recursive element of multi-inheritance highlights the possibility of *upward* causation — or the emergence of new forms that are greater than their components (Checkland, 1981). When technical infrastructures of work are independent of existing organizations, work systems can self-organize based on these infrastructures giving rise to new embedding organizations. While this does not mean that all work systems will exist completely outside bounded sociotechnical systems, it does recognize the possibility that formation of the technical and work systems may *precede* the emergence of their encapsulating organizations. Under these conditions, the larger sociotechnical system in which the work is embedded will inherit aspects of its purpose, structure, and meaning from the work and technical systems. The necessity of boundaries and the possibility of upward causation highlight the degree to which developers and participants in new work systems act as entrepreneurs and designers of organizations as they take steps to create viable sociotechnical work systems.

3.4. Continual negotiation

Several streams of IS research have wrestled with the implications of joint optimization (Baxter & Sommerville, 2010). Concern with user satisfaction (Gelderman, 1998), and user participation (Floyd et al., 1989) highlights the need to consider human goals and purposes when creating work systems. Attention to requirements elicitation (Hansen, Berente, & Lyytinen, 2009), project governance (Tiwana, 2009), and top management support (Thong, Yap, & Raman, 1996) reflect an awareness that fit with organizational goals emerges as effect systems develop. Although IS research has considered cases that involve multiple goals and stakeholders, those of the focal organization are often assumed to dominate. In this literature, information technologies provided by organizations *should* be accepted by individuals for success, and success factors are defined in terms of particular organizational objectives (Delone & McLean, 2003). As the source of critical resources, the owner of the artifacts, the site of the work, and the employer of the individuals, the organization has a defining role, while users are included as an important, but secondary matter. Yet, if the organization is no longer the sole container for the work or the system, and purpose, meaning, and structure are inherited from multiple sources, then previously assumed bases for the primacy of organizational goals become problematic. The resulting work systems are better described as a "negotiated order" among different organizations and individuals (Strauss, 1978). Thus this premise of the STS approach can be restated as:

> *Neo-STS Premise 4: Creation and continued existence of work systems involves simultaneous support for both performance of work and ongoing negotiation of goals, values, and meaning.*

Joint optimization of human and organizational goals presumes a basic level of agreement about the nature of the goals. The organization-as-container assumption is consistent with the unity of purpose and prioritization of objectives necessary for joint optimization to be a meaningful concept. In the absence of singular organizational encapsulation, joint optimization becomes problematic. Multi-inheritance raises questions about which goals, values, and standards are taken into account and introduces the possibility of systems changing the goals, purposes, or standards of the organization. Under these premises facilitating the creation and improvement of sociotechnical systems is not a matter of optimization and resolution, but of supporting the ongoing negotiation of goals and actions. Work systems that support both performance of tasks and the continual renegotiation of the structure and meaning of those tasks will be viable and effective.

As the nature of technology and work changes, phenomena have arisen that challenge the underlying premises of much of the existing research on information technologies and the organization of work. Engaging these challenges requires that scholars and practitioners critically reexamine long-held assumptions associated with the idea that organizations are the primary container for work.

4. Novel work arrangements and the Neo-STS approach

The proposed Neo-STS approach provides improved analytic leverage on questions and phenomena that have been challenging for much of the IS field. Next we show how they can be applied to yield valuable insights into three novel working arrangements: the enterprise ecology, free and open source software, and cyberinfrastructure-enabled science.

4.1. The enterprise ecology

At first, Enterprise Resource Planning (ERP) systems appear to be the quintessential organizationally-embedded work system. ERPs require significant capital investment, are implemented by organizations to serve organizational goals and support employees' work. Yet these complex software packages often structure adopting organizations around ERP vendors' understanding of "best practices" (Pollock & Williams, 2008). ERP-driven business process reengineering represents an important pivot from the classic STS approach as organizations change faster than the infrastructure and the work systems. The Neo-STS approach renders this clearly, shifting the focus from an organization implementing a system, to examining how standardized systems influence the goals, values, and practices of organizations and industries. It highlights the dynamics of ERP adoption or abandonment as these systems arise and are maintained as a negotiated order between vendor organizations and their numerous customers across industries and over time (Pollock & Williams, 2008). ERPs can be seen to structure organizations as much or more than any particular organization influences the structure of the ERP system.

Similarly, personal information technologies (e.g. mobile devices, social media platforms, and personal cloud computing services) designed for consumer use are being integrated into the workplace (sometimes referred to as "Bring Your Own Device" or BYOD). Interacting with existing routines, practices and culture, BYOD is generating new user expectations of technologies and work systems. Initial IS scholarship has engaged these issues from the perspective of IS departments facing employee demands to use personal devices and accounts for work. These technologies raise issues for corporate IS policy, from software licensing and audit implications to security concerns as organizations that have previously provided infrastructure now grapple with integrating existing technologies and user practices (Burt, 2011). Waiting until technologies cross the corporate boundary limits our understanding. The classic STS approach leads IS research to engage in somewhat torturous efforts to connect phenomena like mobile devices, Wikipedia, FLOSS and social media to corporate settings (e.g., Ransbotham & Kane, 2011; Stewart & Gosain, 2006).

In contrast, the Neo-STS approach encourages the study of work practices and infrastructures as they arise outside of organizations and raises the possibility of new boundaries arising within which processes of joint determination and optimization are occurring. From this perspective BYOD involves a dynamic, continuing negotiation between technologies, organizations and the lifeworld outside work — a much wider set of social units than STS and IS has typically considered. Yet, by engaging this larger intellectual project, studies of work, work systems, and technologies, IS research will be better positioned to address the needs of IS practitioners, whether or not they are organizationally-situated.

The production of information technologies is increasingly organized around platforms and the "app" ecologies they support. This is a far cry from the traditional organizationally-contained study of IS development. As Tiwana et al. (2010) put it, "the information technology (IT)-line function interface within the firm has historically been the locus of IS innovation in IS research." Instead IT production is increasingly based on platforms and inter-dependent components produced by sets of simultaneously cooperating and competing producers who may or may not be associated with an organization that is attempting to use the technology. The "generative" potential of platforms (Henfridsson & Bygstad, 2013, Tilson et al., 2010) means that "the conventional notion of firm boundaries is expanding to harness outside expertise and ingenuity on an unprecedented scale" (Tiwana et al., 2010). IS has begun to engage these phenomena, but the proposed Neo-STS approach provides additional analytic leverage: the platform ecology as a newly important system boundary within which processes of mutual determination between organization, work, information and technology play out. This calls attention to questions of how to organize for and around platforms, from the perspective of platform owners, producers and users; questions which are closely bound up in the architecture of the systems themselves (Baldwin & Clark, 2000; Boudreau, 2010; MacCormack, Rusnak, & Baldwin, 2006). A Neo-STS approach suggests that organizational structures around platforms may change more quickly than the platforms themselves, suggesting a need for renewed emphasis on both the organizational dynamics in non-firm organizations and of the implications for IS management in organizational settings (Ross, Weil, & Robertson, 2006).

4.2. Open source software

The Neo-STS approach is also applicable in understanding free and open source software (FLOSS) and its development. The infrastructures that support work on FLOSS (networks, licenses, tools and repository providers) are broadly and freely available. Ubiquitous Internet supports FLOSS distribution and provides the substrate for open source work systems. Open source licenses articulate foundational principles (Howison & Crowston, 2014) and the tools of open source collaboration are themselves mostly open source, including the source code revision control systems that enable the software to be built up over time (Howison & Crowston, 2014). Source code control provides a "shared field of work" (Schmidt & Simone, 1996) rendering the results of others' work visible and available. Finally, services are available at a minimal cost including hosted source code revision control, communication, and issue tracking tools.[9]

The power and availability of these infrastructures are sufficient for work to begin in the absence of a pre-existing encapsulating organization. In successful community-based FLOSS the start is typically a project founder providing a promising, but incomplete, technical artifact (Raymond, 1998; Senyard & Michlmayr, 2004) that attracts layers of improvement and incorporates user feedback. Work routines and norms emerge on the base of infrastructure-supported work and are shaped by the defaults and structures already present in the work product and infrastructures (Robbins, 2002). For example, Sourceforge includes a bug and feature tracker but each project can enact it differently through shared understandings, "How to report bugs"

[9] Providers include Sourceforge, the Free Software Foundation, the Apache Foundation and GitHub.

documents, roles (e.g. "Release manager", "Project leader", "Benevolent Dictator"), and decision-making procedures. Through these processes, successful FLOSS efforts build a sociotechnical system that includes the requisite work systems and infrastructures.

Many FLOSS efforts find that this level of organizational development is sufficient, but others create more complex organizational systems.[10] For example, the Apache Foundation has legal standing, a responsible board, and formalized decision making procedures. It provides hosting for project infrastructure and a set of standards (including how to describe a project and a template for project governance). Yet the Foundation is independent of associated projects and does not plan, staff, manage, or dictate their work. In this sense the organization is not a container for work: it is a support platform. As outlined by the Neo-STS approach, FLOSS development work, infrastructures, and formal organizations coexist, but in ways that are more complex than straightforward hierarchical embedding.

When and why projects seek increasing levels of organization and how their forms and organizing processes are influenced by infrastructure and work is a vibrant and important research question (e.g., O'Mahony & Lakhani, 2011). For example, formalization appears to be spurred by holding money or encountering a legal system because the legal system has a well-defined role for formal organization but not for collectives that merely work together. The question of when organization is necessary to surround work is one that our Neo-STS approach is well-suited for: organizing and organizations do not contain the work, but support it; mutual determination between infrastructure and work is expanded to consider how organizing and organizations are mutually determined by the work and infrastructure they support.

As with enterprise ecologies, even though much of the 'action' takes place outside of their organizational container, a more complete understanding of FLOSS work and work systems has implications for CIOs and IS managers beyond seeing FLOSS as "kinds of virtual teams … but with some unique aspects" (Stewart, Ammeter, & Maruping, 2006). Neo-STS may therefore help as firms seek to leverage FLOSS internally and to contribute to and participate in FLOSS projects (Fitzgerald, 2006; Germonprez & Warner, 2012). Whether the objective is to help FLOSS participants, FLOSS project leaders, or CIOs, the Neo-STS approach provides a nuanced characterization of work, work systems, infrastructure and organizations that can form a strong foundation for analysis, action, and decision making in this complex domain.

4.3. Cyberinfrastructure-enabled science

In contrast to the traditional assumption that the organization is the bounded container for work and technology, many scientists work at a university but identify professionally with their discipline — an invisible academic college of similar scholars. With the rise of large-scale team science (Fiore, 2008; Olson, Zimmerman, Bos, & Wulf, 2008; Wuchty, Jones, & Uzzi, 2007), research projects increasingly cross organizational boundaries involving scientists in different universities creating multi-team systems and sometimes spawning formal research partnerships, consortia or institutes (Kirsch & Slaughter, 2013). Universities hire scientists and provide some equipment, but responsibility for designing research work and garnering the resources required to perform that work often rests with the scientists themselves. Capital intensive technologies may be provided by the university, by a partnership among multiple universities, or by the government as part of a national facility (Ahalt et al., 2010). Access to shared technologies is often awarded on a competitive basis, violating the traditional STS assumption that these system elements are complementary, working together in service of a whole. With limited resources, scientists, colleges, departments, universities, centers, and facilities directly compete for funding, scarce personnel and journal space. The proposed Neo-STS approach provides analytical tools to better understand the effects of competition and scarcity and may suggest thresholds to guide resource allocation while accounting for goal multiplicity and ongoing negotiation of the performance and meaning of work.

Inheritance is also more complex in the scientific sociotechnical system with downward, upward and lateral inheritance in evidence. Elements such as academic departments may inherit their structure, meaning, and purpose from their encapsulating colleges, but faculty governance also enables upward inheritance, as scientists instantiate their values and favored routines in the structure, processes, and purpose of their departments, colleges, and universities. Lateral inheritance can be seen when these same values and routines are

[10] Typically an organization operating under the rules of the US tax code, section 501(c)(3). Well known examples include the Apache Foundation, the R Foundation (for the R statistics package) and the Wikimedia Foundation.

imported into interdisciplinary research teams and can result in significant tensions when team members bring together incompatible institutional logics (Winter & Berente, 2012). A Neo-STS approach allows the IS field to better theorize the implications of these multiple forms of inheritance as research work becomes increasingly interdisciplinary and collaborative.

Perhaps the most valuable contribution of the Neo-STS approach in understanding scientific work comes in recognizing the inverted temporal precedence among the inter-related elements. In science, the design of the work has largely driven the technical infrastructure with roles played by multiple organizations, some of which were created specifically to develop, manage and coordinate the technology, the work or both. For example, U.S. national defense priorities (King, 2010) and the needs of the scientific community (especially of high energy physicists) drove the creation of information technology during the Cold War (Aspray & Williams, 1994). Development of the scientific cyberinfrastructure transcended any single organization and crossed economic sectors due to the enormously expensive equipment, large numbers of expert personnel, and institutional support required (King, Grinter, & Pickering, 1997). ARPANet, NSFNet, (and its descendant, the Internet), the National Supercomputer Centers, and the initial "testbed" for the network emerged from partnerships between the Federal Government, academia, and private industry formed to create and manage the infrastructure to support scientific work across universities and labs (Winter, 2012). New organizations were created to coordinate these efforts (e.g., the NSF Directorate for Computer and Information Science and Engineering (CISE), supercomputer centers, ICANN, IELT). Due to the specialized needs of the scientific community, federal agencies continue to support advanced scientific cyberinfrastructure, funding new equipment, organizations required for its management, and research on cyber-enabled science.

The proposed Neo-STS approach provides analytical tools needed to better understand the complex relationships among the scientific work to be done and the technologies and organizations needed to do it by recognizing that increasingly causal agency may not align with managerial prerogative. Scientific infrastructure developers are necessarily organization builders, but little is currently known about the organizational forms a community engaged in scientific work will accept. Neo-STS provides analytical tools which can support development of a science of scientific enterprises that identifies the salient characteristics of organizational forms or policies and an understanding of scientist's perceptions of the organizational implications of IT infrastructures.

By highlighting the flexibility in temporal precedence between infrastructure, work, and organization we argue that the Enterprise Ecology, FLOSS, CI-enabled Science, and similar phenomena do not fall outside the purview of IS scholarship. Each of these has been difficult to fit within the classic STS approach because they are instantiations of more complex configurations of familiar and tractable STS concepts. The concepts of boundaries, inter-relating elements, and inheritance remain relevant, yet the system boundaries are different, the relationships between inter-relating elements more complex, and the patterns of inheritance altered, suggesting the importance of an entrepreneurial standpoint focusing on the elements of the sociotechnical system, their relative rates of change, points of leverage, and the creation of missing aspects. This means learning how to build systems necessarily involves knowing how to design and build organizations. The IS field can build a body of knowledge about the design and evolution of organizations intertwined with technology by investigating, for example, what it means to design a system that leads to a particular structure of decision rights, in regard to what will be built with the technologies (Tiwana et al., 2010) and what incentive systems can be established.

In Table 2 we reiterate the four principles of the Neo-STS approach and provide emerging directions for IS scholarship that each principle implies.

5. Conclusion

In the original sociotechnical studies, Trist and Bamforth ventured outside the mine and into the worker's village to understand why the reconfiguration of technologies in the mine had led to unexpectedly reduced production. Similarly, the field of information systems has the opportunity to take our theorizing outside of the organizational container and challenge our often implicit assumptions about how sociotechnical work relates to organizations. This is particularly important given the novel arrangements emerging in the digital age, including, but not limited to, enterprise ecologies, FLOSS efforts, and scientific computing infrastructures. The Neo-STS approach provides analytical leverage and a coherent framework for understanding how

Table 2
Premises and implications of a Neo-STS model of work and work systems.

Systems concept	Neo-sociotechnical systems premise	Emerging directions for IS scholarship
Organizational encapsulation	Multi-encapsulation: Work systems are necessarily encapsulated within one or more, potentially overlapping, sociotechnical systems (necessity of encapsulation & multi-encapsulation)	Identifying and theorizing complex forms of sociotechnical encapsulation, such as multiple institutional arrangements, overlapping boundary systems, platforms, infrastructures, work/life co-mingling.
Inter-related elements	Complex relations among elements: Work systems have interrelated, possibly complementary, redundant, competing, or conflicting, social and technical elements that may co-exist without being reconciled (complex interrelation of possibly non-coherent elements)	Reconceptualization of work system health and impact to include redundancy, competition, misfit, conflict, loose coupling, and destruction as aspects of functioning systems
Inheritance	Multi-inheritance: Work systems either derive purpose, meaning, and structure from the contexts in which elements are embedded (multiple inheritance) or they pass on purpose, meaning and structure to higher-level sociotechnical systems that emerge (upward causation).	What affects the emergence of sociotechnical systems from a work system? What are the distinguishing characteristics of work systems that facilitate self-organizing? Temporal relationship between sociotechnical systems and organizations? How ought we design organizations around work systems?
Joint optimization	Continual negotiation: Creation and improvement of work systems involves simultaneous support for performance of work and continual negotiation of goals, values, and meaning (negotiated viability).	What affects how (and when) work systems are able to support active renegotiation of objectives and priorities?

existing scholarship can connect with and inform the traditional and emerging organization of work, information, and technology.

The organizational container assumption is a comfortable one and relaxing it will not be painless. To do so, the IS field must grapple with questions of when and how to identify relevant boundaries for analysis of information systems and the organization of work. One problematic answer is that everything is emergent, everything is interrelated, and therefore “it is complex” and nothing can be understood, let alone done. But the Neo-STS approach rejects this, arguing that identifying boundaries of relevant encapsulating systems is crucial. In our examples we have highlighted important boundaries of systems already identified such as ecosystems, platforms, and communities of practice. Two general approaches in identifying others seem relevant. The first is to follow efforts to retrofit organizations to infrastructure-supported work, such as the founding and creation of foundations, or consortia. The second is to draw on work on defining boundaries from general systems theory, such as Ulrich's critical systems heuristics (Ulrich & Reynolds, 2010) and boundary critique (Midgley, Munlo, & Brown, 1998).

Regardless, useful boundaries are important and clearly sometimes an organization will be the appropriate boundary, but IS scholars focusing on IS and work should explicitly identify and justify the relevant system boundaries, rather than assuming organizational encapsulation. Similarly, the IS field should embrace an entrepreneurial standpoint: assessing a sociotechnical system, finding useful boundaries, and taking action to add any missing elements. Increasingly this is as likely to mean providing an organization around existing work infrastructure as it is to mean providing an information system within an organization. The proposed Neo-STS approach updates the central premises of the STS approach to provide a coherent foundational framework for studies of work and technology.

It's hard to tell when the world has changed — and when it just looks different. Overstating change leads to inefficiency and missed opportunities when existing knowledge is not applied and leveraged to the supposed new situation. On the other hand, failing to recognize fundamental change not only constrains effectiveness in the short term, it ultimately limits our ability to understand what we already know. Much of IS work in the past 30 years has been powerful because it helped distinguish between these two situations. The Neo-STS approach is a continuation of this tradition — building on what came before and pointing a way for scholars and professionals to productively engage, understand, and ultimately shape emerging 21st century forms of work, infrastructure, and organization.

References

Ahalt, S., Apon, A., & Neeman, H. (2010). Sustainable funding and business models for academic cyberinfrastructure facilities. *Technical report (Natl. Science Found. Workshop)*.

Allen, T.F., O'Neill, R.V., & Hoekstra, T.W. (1984). Interlevel relations in ecological research and management: some working principles from hierarchy theory. *General technical report RM-Rocky Mountain Forest and Range Experiment Station*.

Alter, S. (2013). Work systems theory: Overview of core concepts, extensions, and challenges for the future. *Journal of the Association for Information Systems*, *14*(2).

Aspray, W., & Williams, B.O. (1994). Arming American scientists: NSF and the provision of scientific computing facilities for universities, 1950–1973. *IEEE Annals of the History of Computing*, *16*(4), 60–74.

Baldwin, C.Y., & Clark, K.B. (2000). *Design rules: The power of modularity.* Cambridge, MA: Harvard Business School Press.

Barki, H., & Pinsonneault, A. (2005). A model of organizational integration, implementation effort, and performance. *Organization Science*, *16*(2), 165–179.

Barley, S.R. (1986). Technology as an occasion for structuring: observations on CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, *31*(1), 78–108.

Baxter, G., & Sommerville, I. (2010). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*. http://dx.doi.org/10.1016/j.intcom.2010.07.003.

Beath, C., Berente, N., Gallivan, M., & Lyytinen, K. (2013). Expanding the frontiers of information systems research: Introduction to the special issue. *Journal of the Association for Information Systems*, *14*(4/5), i–xvi.

Beer, S. (1994). How many grapes went into the wine: Stafford Beer on the art and science of holistic management. In R. Harnden, & A. Leonard (Eds.), Chichester; New York: Wiley.

Benbasat, I., & Barki, H. (2007). Quo vadis, TAM? *Journal of the Association for Information Systems*, *8*(4), 212–218.

Berente, N., & Yoo, Y. (2012). Institutional contradictions and loose coupling: Post-implementation of NASA's enterprise information system. *Information Systems Reearch*, *23*(2), 376–396.

Bijker, W.E. (1995). *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change.* Cambridge, Mass: MIT Press.

Boland, R.J., Lyytinen, K., & Yoo, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organization Science*, *18*(4), 631–647.

Bostrom, R., Gupta, S., & Thomas, D. (2009). A meta-theory for understanding information systems within sociotechnical systems. *Journal of Management Information Systems*, *26*(1), 17–47.

Bostrom, R.P., & Heinen, J.S. (1977a). MIS problems and failures: A socio-technical perspective, part II: The application of socio-technical theory. *MIS Quarterly*, *1*(4), 11.

Bostrom, R.P., & Heinen, J.S. (1977b). MIS problems and failures: A socio-technical perspective. Part I: The causes. *MIS Quarterly*, *1*(3), 17–32.

Boudreau, K. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, *56*(10), 1872.

Burt, J. (2011). BYOD trend pressures corporate networks. *Eweek*, *28*(14), 30–31.

Butler, B.S., & Gray, P.H. (2006). Reliability, mindfulness, and information systems. *MIS Quarterly*, *30*(2), 211–224.

Butler, B.S., & Wang, X. (2012). The cross-purposes of cross-posting: Boundary reshaping behavior in online discussion communities. *Information Systems Research*, *23*(3-Part-2), 993–1010.

Chau, P.Y.K., & Tam, K.Y. (1997). Factors affecting the adoption of open systems: An exploratory study. *MIS Quarterly*, *21*(1), 1.

Checkland, P. (1981). *Systems thinking, systems practice.*

Cheney, P. H., Mann, R. I., & Amoroso, D. L. (1986 Summer). Organizational factors affecting the success of end-user computing. *Journal of Management Information Systems*, *3*(1), 65–80.

Chiasson, M.W., & Davidson, E. (2005). Taking industry seriously in information sysems research. *MIS Quarterly*, *29*(4), 591–605.

Churchman, C. (1968). *The systems approach.* New York: Delta.

Ciborra, C. (2000). *From control to drift: The dynamics of corporate information infrastructures.* Oxford University Press.

Conway, M.E. (1968). How do committees invent? *Datamation*, *149*(4329), 31.

Cummings, J., Finholt, T.A., Foster, I., Kesselman, C., & Lawrence, K.A. (2008). *Beyond being there: A blueprint for advancing the design, development, and evaluation of virtual organizations.*

Davenport, T.H. (1998). Putting the enterprise into the enterprise system. *Harvard Business Review*, *76*(4).

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319–340.

Davis, G.B. (1974). *Management information systems: Conceptual foundations, structure, and development.* New York, NY: McGraw-Hill.

Davis, L.E. (1977). Evolving alternative organization designs: Their sociotechnical bases. *Human Relations*, *30*(3), 261–273.

Delone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9–30.

Desanctis, G., & Poole, M.S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science*, *5*(2), 121–147.

Emery, F.E., & Trist, E.L. (1965). The causal texture of organizational environments. *Human Relations*, *18*(1), 21–32.

Fiore, S.M. (2008). Interdisciplinarity as teamwork how the science of teams can inform team science. *Small Group Research*, *39*(3), 251–277.

Fitzgerald, B. (2006). The transformation of open source software. *MIS Quarterly*, *30*(3), 587–598.

Floyd, C., Mehl, W.M., Reisin, F.M., Schmidt, G., & Wolf, G. (1989). Out of Scandinavia: Alternative approaches to software design and system development. *Human-Computer Interaction*, *4*(4), 253–350.

Gelderman, M. (1998). The relation between user satisfaction, usage of information systems and performance. *Information & Management*, *34*(1), 11–18.

Germonprez, M., & Warner, B. (2012). Organizational participation in open innovation communities. In J.S.Z.E. Lundström, M. Wiberg, S. Hrastinski, M. Edenius, & P.J. Ågerfalk (Eds.), *Managing open innovation technologies* (2013th ed.).

Goodhue, D.L., & Thompson, R.L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, *19*(2), 213–236.

Hansen, S., Berente, N., & Lyytinen, K. (2009). Requirements in the 21st century: Current practice and emerging trends. *In design requirements engineering: A ten-year perspective* (pp. 44–87). Berlin Heidelberg: Springer.

Henderson, J.C., & Venkatraman, N. (1993). Strategic alignment: Leveraging information technology for transforming organizations. *IBM Systems Journal*, *32*(1), 4–16.
Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *MIS Quarterly*, *37*(3).
Hey, T., & Trefethen, A.E. (2005). Cyberinfrastructure for e-Science. *Science*, *308*(5723), 817–821.
Hirschheim, R., & Klein, H. (2012). A glorious and not-so-short history of the information systems field. *Journal of the Association for Information Systems*, *13*(4), 188–235.
Hofkirchner, W., & Schafranek, M. (2011). General system theory. *Philosophy of Complexity, Chaos, and Non-Linearity, Handbook of the Philosophy of Science*, *10*, 177–194.
Howison, J., & Crowston, K. (2014). Collaboration through open superposition: A theory of the open source way. *MIS Quarterly*, *38*(1), 29–50.
Jasperson, J., Carte, T.A., Saunders, C.S., Butler, B.S., Croes, H.J.P., & Zheng, W. (2002). Review: Power and information technology research: A metatriangulation review. *MIS Quarterly*, *26*(4), 397–459.
Johnston, H.R., & Vitale, M.R. (1988). Creating competitive advantage with interorganizational information systems. *MIS Quarterly*, *12*(2), 153–165.
Keen, P.G.W. (1980). MIS research: Reference disciplines and a cumulative tradition. *Proceedings of the First International Conference on, Information Systems* (pp. 18).
King, J.L. (2010). Project SAGE, a half-century on. *Interactions*, *17*(5), 53–55.
King, J.L., Grinter, R.E., & Pickering, J.M. (1997). The rise and fall of netville: Institution, infrastructure, and the saga of a cybserspace construction boomtown in the great divide. In S. Kiesler (Ed.), *Culture of the Internet* (pp. 3–34).
Kirsch, L.J., & Slaughter, S.A. (2013). Managing the unmanageable: How IS research can contribute to the scholarship of cyber projects. *Journal of the Association for Information Systems*, *14*(4), 198–214.
Klein, H.K., & Lyytinen, K. (1985). The poverty of scientism in information systems. *Research Methods in Information Systems*, 131–161.
Kling, R., & Iacono, S. (1989). The institutional character of computerized information systems. *Information Technology & People*, *5*(1), 7–28.
Kling, R., & Scacchi, W. (1983). In M.C. Yovits (Ed.), *The web of computing: computer technology as social organization. Advances in Computers*, *Vol. 21*. (pp. 1–90).
Kumar, K., & van Dissel, H.G. (1996). Sustainable collaboration: Managing conflict and cooperation in interorganizational systems. *MIS Quarterly*, *20*(3), 279–300.
Latour, B. (1987). *Science in action: How to follow scientists and engineers through society.* Harvard University Press.
Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory.* Oxford: Oxford University Press.
Leavitt, H.J., & Whisler, T.L. (1958). Management in the 1980s. *Harvard Business Review*, 36–48.
Leonard-Barton, D. (15(5), 1988a). Implementation characteristics of organizational innovations: Limits and opportunities for management strategies. *Communication Research*, *15*(5), 603–631.
Leonard-Barton, D. (1988b). Implementation as mutual adaptation of technology and organization. *Research Policy*, *17*(5), 251–267.
Leonardi, P. (2013). Theoretical foundations for the study of sociomateriality. *Information and Organization*, *23*, 59–76.
Leonardi, P. (2012). In P. Leonardi, B.A. Nardi, & J. Kallinkios (Eds.), *Materiality, sociomateriality, and socio-technical systems: What do these terms mean? How are they related? Do we need them? Materiality and organizing: Social interaction in a technological world* (pp. 25–48).
Leonardi, P.M. (2010). Digital materiality? How artifacts without matter, matter. *First Monday*, *15*(6–7).
Lesser, E.L., & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal*, *40*(4), 831–841.
Luftman, J., & Kempaiah, R. (2007). An update on business-it alignment: "A line" has been drawn. *MIS Quarterly Executive*, *6*(3), 165–177.
Luna-Reyes, L.F., Zhang, J., Ramón Gil-García, J., & Cresswell, A.M. (2005). Information systems development as emergent socio-technical change: A practice approach. *European Journal of Information Systems*, *14*(1), 93–105.
Lyytinen, K., & King, J.L. (2004). Nothing at the Center? Academic legitimacy in the information systems field. *Journal of the Association for Information Systems*, *5*(6), 220–246.
Lyytinen, K., & Newman, M. (2008). Explaining information systems change: A punctuated socio-technical change model. *European Journal of Information Systems*, *17*(6), 589–613.
MacCormack, A., Rusnak, J., & Baldwin, C.Y. (2006). Exploring the structure of complex software designs: An empirical study of open source and proprietary code. *Management Science*, *52*(7), 1015–1030.
Majchrzak, A., Rice, R.E., Malhotra, A., King, N., & Ba, S.L. (2000). Technology adaptation: The case of a computer-supported interorganizational virtual team. *MIS Quarterly*, *24*(4), 600.
Mann, F.C., & Williams, L.K. (1960). Observations on the dynamics of a change to electronic data-processing equipment. *Administrative Science Quarterly*, *5*(2), 217–256.
Markus, M.L. (1983). Power, politics, and MIS implementation. *Communications of the ACM*, *26*(6), 430–444.
Markus, M.L., & Robey, D. (1988). Information technology and organizational change: Causal structure in theory and research. *Management Science*, *34*(5).
McLean, E.R., & Soden, J.V. (1977). *Strategic planning for MIS.* John Wiley & Sons Inc.
Midgley, G., Munlo, I., & Brown, M. (1998). The theory and practice of boundary critique: Developing housing services for older people. *The Journal of the Operational Research Society*, *49*(5), 467.
Miller, K.W., Voas, J., & Hurlburt, G.F. (2012). BYOD: Security and privacy considerations. *IT Professional*, *14*(5), 53–55.
Mumford, E. (1983). *Designing human systems for new technology: The ETHICS method.* Manchester Business School Manchester.
Mumford, E. (2003). *Redesigning human systems.* Idea Group Inc (IGI).
O'Mahony, S., & Bechky, B.A. (2008). Boundary organizations: Enabling collaboration among unexpected allies. *Administrative Science Quarterly*, *53*(3), 459.
O'Mahony, S., & Ferraro, F. (2007). Governance in collective production communities. *Academy of Management Journal*, *50*(5), 1079–1106.
O'Mahony, S., & Lakhani, K. R. (2011). Organizations in the Shadow of Communities. In C. Marquis, M. Lounsbury, & R. Greenwood (Eds.), *Communities and Organizations. Research in the Sociology of Organizations. Emerald Group Publishing. vol*, *33*. (pp. 3–36).

Olson, G.M., Zimmerman, A., Bos, N., & Wulf, W. (2008). *Scientific collaboration on the Internet.*
Orlikowski, W.J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organizational Science*, *36*(3).
Orlikowski, W.J. (1996). Improvising organizational transformation over time: A situated change perspective. *Information Systems Research*, *7*(1), 92.
Orlikowski, W.J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organizational Science*, *11*(4), 428.
Orlikowski, W.J. (2007). Sociomaterial practices: Exploring technology at work. *Organization Studies*, *28*, 1448.
Orlikowski, W.J. (2010). The sociomateriality of organisational life: Considering technology in management research. *Cambridge Journal of Economics*, *34*(1), 125–141.
Orlikowski, W.J., & Iacono, C.S. (2001). Research commentary: Desperately seeking the 'IT' in IT research: A call to theorizing the IT artifact. *Information Systems Research*, *12*(2), 121–134.
Orlikowski, W., & Scott, S.V. (2008). Sociomateriality: Challenging the separation of technology, work and organization. *The Academy of Management Annals*, *2*(1), 433–474.
Pickering, A. (1995). *The mangle of practice: Time, agency, and science.* University of Chicago Press.
Pollock, N., & Williams, R. (2008). *Software and organisations: The biography of the enterprise-wide system or how SAP conquered the world.* US: Taylor & Francis.
Ransbotham, S., & Kane, G.C. (2011). Membership turnover and collaboration success in online communities: Explaining rises and falls from grace in Wikipedia. *MIS Quarterly*, *35*(3), 613.
Raymond, E.S. (1998). Homesteading the noosphere. *First Monday*, *3*(10).
Reich, B.H., & Benbasat, I. (1996). Measuring the linkage between business and information technology objectives. *MIS Quarterly*, *20*(1), 55–81.
Robbins, J.E. (2002). Adopting OSS methods by adopting OSS tools. *Proceedings of the ICSE 2nd Workshop on Open Source*.
Robey, D., & Boudreau, M. -C. (1999). Accounting for the contradictory organizational consequences of information technology: Theoretical directions and methodological implications. *Information Systems Research*, *10*(2), 167–185.
Rockart, J.F., & Flannery, L.S. (1983). The management of end user computing. *Communications of the ACM*, *26*(10), 776–784.
Ross, J.W., Weil, P., & Robertson, D. (2006). *Enterprise architecture as strategy: Creating a foundation for business execution.* Boston MA: Harvard Business School Press.
Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly*, *27*(2), 237–263.
Sandberg, A. (1985). *Socio-technical design, trade union strategies and action research.* North-Holland, Amsterdam: Research Methods in Information Systems, 79–92.
Schmidt, K., & Simone, C. (1996). Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. Computer supported cooperative work. *The Journal of Collaborative, Computing*, *5*(2–3), 200.
Senyard, A., & Michlmayr, M. (2004). How to have a successful free software project. *Proceedings of the 11th Asia-Pacific Software Engineering Conference* (pp. 91).
Shah, S.K. (2006). Motivation, governance, and the viability of hybrid forms in open source software development. *Management Science*, *52*(7), 1000–1014.
Silva, L., & Backhouse, J. (2003). The circuits-of-power framework for studying power in institutionalization of information systems. *Journal of the Association for Information Systems*, *4*(1).
Soh, C.S. (2003). Misalignments in ERP implementation: A dialectic perspective. *International Journal of Human-Computer Interaction*, *16*(1), 81–100.
Stewart, K.J., Ammeter, A.P., & Maruping, L.M. (2006). Impacts of license choice and organizational sponsorship on user interest and development activity in open source software projects. *Information Systems Research*, *17*(2), 144.
Stewart, K.J., & Gosain, S. (2006). The impact of ideology on effectiveness in open source software development teams. *MIS Quarterly*, *30*(2), 291–314.
Straub, D. (2012). June. Does MIS have native theories? *MIS Quarterly*, III–XII.
Strauss, A.L. (1978). *Negotiations: Varieties, contexts, processes, and social order.* San Francisco: Jossey-Bass.
Thomson, G. (2012). BYOD: Enabling the chaos. *Network Security*, *2012*(2), 5–8.
Thong, J.Y.L. (1999). An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems*, *15*(4), 187–214.
Thong, J.Y., Yap, C.S., & Raman, K.S. (1996). Top management support, external expertise and information systems implementation in small businesses. *Information Systems Research*, *7*(2), 248–267.
Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Research commentary—Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(4), 748–759.
Tiwana, A. (2009). Governance-knowledge fit in systems development projects. *Information Systems Research*, *20*(2), 180–197.
Tiwana, A., Konsynski, B., & Bush, A.A. (2010). Research commentary—Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, *21*(4), 675–687.
Trist, E. (1981). The evolution of socio-technical systems. *Occasional Paper*, *2*, 1981.
Trist, E.L., & Bamforth, K.W. (1951). Social and psychological consequences of the longwall method of coal-getting. *Human Relations*, *4*(1), 3–38.
Tuertscher, P., Garud, R., & Kumaraswamy, A. (2014). Justification and interlaced knowledge at ATLAS, CERN. *Organization Science*. http://dx.doi.org/10.1287/orsc.2013.0894.
Tyre, M.J., & Orlikowski, W.J. (1994). Windows of opportunity: Temporal patterns of technological adaptation in organizations. *Organization Science*, *5*(1), 98–118.
Ulrich, W., & Reynolds, M. (2010). Critical systems heuristics. In M. Reynolds, & S. Holwell (Eds.), *Systems approaches to managing change: A practical guide* (pp. 243–292).
Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425–478.
Vitak, J. (2012). The impact of context collapse and privacy on social network site disclosures. *Journal of Broadcasting & Electronic Media*, *56*(4), 451–470.

Volkoff, O., Strong, D.M., & Elmes, M.B. (2007). Technological embeddedness and organizational change. *Organization Science*, *18*(5), 832–848.
Von Bertalanffy, L. (1950). An outline of general system theory. *British Journal for the Philosophy of Science*, *1*, 134–165.
Wang, X., Butler, B.S., & Ren, Y. (2013). The impact of membership overlap on growth: An ecological competition view of online groups. *Organization Science*, *24*(2), 414–431.
Williams, R., & Edge, D. (1996). The social shaping of technology. *Research Policy*, *25*(6), 865–899.
Winter, S.J. (2012). The rise of cyberinfrastructure and grand challenges for eCommerce. *Information Systems and e-Business Management*, *10*(3), 279–293.
Winter, S.J., & Berente, N. (2012). A commentary on the pluralistic goals, logics of action, and institutional contexts of translational team science. *Translational Behavioral Medicine*, *2*(4), 441–445.
Wuchty, S., Jones, B.F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science*, *316*(5827), 1036–1039.
Yoo, Y., Boland, R.J., & Lyytinen, K. (2006). From organization design to organization designing. *Organization Science*, *17*(2), 215–229.
Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735.
Zelkowitz, M.V. (1978). Perspectives in software engineering. *ACM Computing Surveys (CSUR)*, *10*(2), 197–216.
Zittrain, J. (2008). *The future of the Internet—And how to stop it.* Yale University Press.