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The surface of emergence in systems development: agency, institutions, and large-scale information systems

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Abstract
There is a strong tendency in the systems development literature to focus primarily on the system under development and to underemphasize the role of pre-existing information systems. Pre-existing information systems are treated largely as black boxes that serve as resources or constraints on development. A case study of a large-scale information system within a major university system in the U.S. is used to explore the role of pre-existing information systems in the development and emergence of a new system. The case study develops the argument that pre-existing information systems are active forces in systems development. Their influence occurs both through the material constraints and directions inherent in existing systems and through the experiences and learning from previous systems, which shape developers' approaches to building the new system. The study also develops a theoretical framework that integrates elements of structuration theory and actor-network theory to provide a more fine-grained analysis of how information technologies and institutional features interact in the structuring of organizational information systems. This study offers several theoretical and practical implications for IS development.
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Introduction

Is it possible for a large-scale information system to be developed 'from scratch'? Accounts of system development and the systems development literature often focus primarily on the new system and tend to underemphasize the role of pre-existing systems. Among the numerous information systems (IS) development methods (Hirschheim *et al*., 1996; Iivari *et al*., 1998, 1999), few pay much attention to the role of pre-existing information systems in IS development. To the extent the new system must integrate with pre-existing systems or use existing hardware and software, these are viewed as placing some parameters on development, but they are treated as fixed parameters and the pre-existing systems themselves remain black boxes. Existing systems have also been regarded as problems or barriers to the development of new IS and as disablers of IS-based organizational innovation and change (e.g. Markus, 1983). This approach, too, tends to treat pre-existing systems as objects, black boxes.

Orlikowski & Iacono (2001) argue that most IS literature treats IS as separable from the social and organizational contexts in which they are

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instantiated, appropriated, and enacted. When IS are viewed as technical artifacts that are relatively stable, discrete, independent, and fixed, it is easy to view the introduction of a new IS into an organization as an independent event. This view encourages the belief that history (including pre-existing systems) has little to do with the development of new IS. IS development driven by business process re-engineering and other similar technocentric views of IS calls for discarding existing practices and reconstituting an organization on the basis of completely fresh ideas. This view omits the role of human agents and the existing organizational and social contexts in the introduction of new technology (Sarker & Lee, 2002), assuming that organizations can be fully redesigned through new technology. This model can also be found in influential work on IS-strategy and information infrastructure deployment and investment (Ives *et al.*, 1993; Broadbent & Weill, 1997).

The case study reported in this paper develops the argument that pre-existing IS are active forces in IS development. Their influence occurs both through the material constraints and directions inherent in existing systems and through the experiences and learning from previous systems that shape developers' approaches to building the new system. It builds on the empirical findings of many studies of IS development and implementation that new technology is always problematic in light of pre-existing systems comprised of existing practices, culture, technologies, and other socio-technical elements (cf. Gosain, 2004).

This study attempts to contribute to our understanding of IS development by exploring the role of pre-existing IS in the evolution of a large-scale system. We follow the ensemble view of IS (Walsham *et al.*, 1988; Lee, 1999; Orlikowski & Iacono, 2001) and in particular the institutional view of IS (Kling & Iacono, 1989; Avgerou, 2002). We view information systems as social institutions (North, 1990; Friedland & Alford, 1991; Sewell, 1992; Dryzek, 1996) that exert their own types of agency that interact with human agency in the systems development process (Pickering, 1995). The case analysis sheds light on the temporally emergent aspects of pre-existing IS and the interaction between different varieties of material, disciplinary, and human agency in IS development.

The next section presents the theoretical foundations of the case analysis. The need for these foundations emerged as we conducted a case study of large-scale information system development in a major U.S. university system. The influence of pre-existing IS and institutions on development was so profound that we required a theoretical framework that could enable us to trace and understand their activity. Pickering's (1995) mangle of practice offers a conception of interacting agencies that captures the multiple roles of material and human agents in the development process. It also enables us to link elements of structuration theory (Giddens, 1984) and actor-network theory in an analytical scheme that opens up the black box of pre-existing systems and shows how institutional features influenced system development. While these theoretical foundations are presented prior to the case in order to set up the subsequent analysis, it is important to acknowledge that the framework crystallized in the course of studying the case.

Perspectives on IS, agency, and pre-existing systems

A number of IS scholars have brought an institutional lens to bear on information systems (Kling & Scacchi, 1982; Laudon, 1985; Kling, 1987; Kling & Iacono, 1989; Kraemer *et al.*, 1992; King *et al.*, 1994). Much of this work focuses on how institutions such as governmental bodies, industries, and organizations shape and influence IS innovation, development, and implementation. This influence is brought to bear through social and political processes that act to preserve or reshape existing organizational and social structures. When it is considered in these analyses (e.g., Kling & Iacono, 1989), pre-existing IS are treated as either constraints on development and barriers to implementation of new IS or, alternatively, as enablers that supply infrastructure and have stimulated the organization build absorptive capacity. In either role, pre-existing IS function largely as 'furniture,' props around which the actors who are the main focus of analysis operate. While these studies have generated important insights about IS development and implementation, they have relegated pre-existing IS to 'black box' status. As a result, the dynamics by which IS might shape institutional processes have not been articulated as well as they might be in this research.

Social constructivist research traditions have devoted more attention to the issue of how information technologies enter into action. One of the most prominent lines of work is research on the structuration of IS (Poole & DeSanctis, 1990, 2004; Orlikowski, 1991, 1992; Orlikowski & Robey, 1991; Walsham, 1993; Jones, 1999). This perspective focuses on how organization and IS are mutually structured through the implementation and use of IS. The structuration of organization and IS occurs through the appropriation of the IS by actors and the production and reproduction of the organizational system so that IS and organization are mutually adjusted to each other. This structurational approach to IS has made important contributions to our understanding of how IS affect organizations and the types of unintended consequences that occur during implementation and use of IS.

Structurational approaches to IS have been criticized on the grounds that they treat IS generically and do not take the particulars of the technology into account. Monteiro & Hanseth (1995) comment that structurational approaches such as Orlikowskis' and Walsham's are 'not fine-grained enough with respect to technology to form an appropriate basis for understanding or to inform design' (p. 328). They observe that IS in these analyses is typically treated as something generic, such as a CASE

tool (Orlikowski, 1991) or at a fairly large level of granularity, such as IBM *vs* non-IBM technology or centralized *vs* decentralized system architectures (Walsham, 1993). This weakens the ability of the structurational perspective to illuminate how IS enter into action and are restructured as a result. Subsequent work in this line of research has focused on identifying generic processes of structuring, such as meta-structuring (Orlikowski *et al*., 1995) or applying the practice lens to structurational analysis (Orlikowski, 2000), and has not addressed this shortcoming adequately. There seems to be an assumption that structuring occurs in such a wide variety of forms that it can only be referred to generically.

Monteiro & Hanseth (1995) argue that actor-network theory addresses this problem directly through its differentiation of various components of an action network and specification of how they influence one another. The actor-network is a socio-technical web that links together humans and non-humans in a stable set of relations that align their interests. Material objects in the actor-network are treated as inscriptions of human interests that vary in terms of '(i) what is inscribed: which anticipations of use are envisioned, (ii) who inscribes them, (iii) how are they inscribed: what is the material for the inscriptions, and (iv) how powerful are the inscriptions: how much effort does it take to oppose an inscription' (Monteiro & Hanseth, 1995, p. 330). For an actor-network to stabilize, it is necessary for the actors to align their interests through translation of the interests of others in such a way that they are compatible in the network. Once a stable network forms, it often has a good deal of staying power because the interests of many actors (both actors actually in the network and those who are not in the network directly but have inscribed their interests into material objects in the network) are incorporated in it. Callon (1991) advances the concept of the irreversibility of an actor network as a function of whether it is possible to go back to a point where a translation is not regarded as 'true' or 'the way things are,' and the extent to which a particular translation is the foundation of subsequent translations that, in effect, hold it in place. Actor-network theory can thus incorporate particular aspects of IS into the analysis as inscriptions. However, actor-network theory has its own shortcomings as a framework for the analysis of IS. It does not differentiate the means by which actors and material objects function in the structuring of action as clearly as structuration theory, with its distinction of three modalities. Actor-network theory tends to collapse the three modalities into the power modality. Moreover, the interests inscribed into material objects are taken as fixed and 'always on' in the sense that these interests are presumed to affect action regardless of what actors do. Inscriptions vary only in terms of flexibility and power. This neglects the role that actors play in drawing out or enrolling some interests in an artifact and neutralizing or even ignoring others as they structure them into an actor-network and act within that network. Monteiro & Hanseth (1995) propose to counteract these problems by joining actor-network theory and structuration theory together, but it is not clear how one might do this.

Pickering (1995) lodges a more potent criticism when he argues that actor-network analysis essentially treats human and material parts of actor-networks the same. Because of this, the role of human agency in sustaining actor-networks (even very powerful and irreversible ones) is not given sufficient emphasis and the agency of material entities is ignored altogether. To achieve the type of finer-grained analysis that Monteiro and Hanseth call for requires us to distinguish different types of human and IS roles in actor networks.

Our attempt to understand the development of a large-scale IS in a major U.S. university system made us aware of the need for a theory and analytical framework that addressed the issues just discussed. This case confronted us with a complex process, multiple actors, and multiple influences, many of which related to pre-existing IS and cultural elements that had evolved over decades. Development of this large system implemented by a number of different units of the system could not be satisfactorily explained in terms of technological determinants because organizational units with similar characteristics adopted the IS in different ways. Moreover, several units actively pursued negotiations regarding the nature and configuration of the system, which highlighted the role of agency. The easiest explanation, that IS development and implementation were political processes, seemed uninformative and also insufficient, because it was clear that both institutional and technological factors set important parameters on the IS that were not obviously open to negotiation. We chose to articulate the political explanation in terms of an account of the structuring of the IS during development. As we attempted to develop an understanding of the structuration of the IS, the shortcomings of existing theories highlighted above became clear. This stimulated our effort to build a more expansive model of structuration that encompassed both institutions and technology in an integrative framework that was capable of illuminating their active role in the development of the IS.

Pickering's theory of the practice of science suggested key insights for an analysis of agency in IS development and implementation. Following the tradition of critical realism (Harre & Madden, 1975), Pickering argues that agency is, at base, the ability to do something or have effects. He distinguishes different types of agency: the *material agency* of natural world, which acts via natural laws; *human agency*, characterized by individual intent, reflexive monitoring of action, and meaningful construction of the social world; and *disciplinary agency*, in which the agency of a discipline – elementary algebra or a systems design methodology, – leads people through a series of actions and also naturalizes these actions for them. Pickering argues that these different types of agency, which will be discussed in more detail below, are linked in what he terms 'the mangle of practice.'

A mangle is an old-fashioned machine used to squeeze the water out of laundry. It presses previously tangled and expansive fabrics flat, reworking and remaking them. Pickering argues that much the same happens in scientific inquiry:

> *My basic image of science is a performative one, in which the performances – the doings – of human and material agency come to the fore. Scientists are human agents in a a field of material agency which they struggle to capture in machines. Further, human and material agency are reciprocally and emergently intertwined in this struggle. Their contours emerge in the temporality of practice and are definitional or and sustain one another. Existing culture constitutes the surface of emergence for the intentional structure of scientific practice, and such practice consists in the reciprocal tuning of human and material agency, tuning that can itself reconfigure human intentions. The upshot of this process is…the construction and interactive stabilization of new machines and the disciplined performances and relations that accompany them (*Pickering, 1995*, p. 21).*

This perspective on science emphasizes activity and process rather than static representation of the world. It views science as a process in which scientists are active beings who intentionally construct new machines and methods to capture insights into the physical world, such as cloud chambers, electron microscopes, and mathematical models. They then observe the performance of material agency in the machine and ask whether the machine worked as intended. Usually it does not, and then the scientist's human agency comes into play as the machine is tuned in another attempt to achieve the desired effects. The scientist then turns the field back to material agency, evaluating whether the machine works and properly captures material agency. Science proceeds through these cycles of human and material agency. These cycles takes the form of 'a dialectic of resistance and accommodation' (Pickering, 1995, p. 22; cf. Giddens' dialectic of resistance, 1979, p. 93 and Latour, 1992, pp. 141–145), in which material and human agency interact and gradually adjust to one another as the machine is perfected and becomes an accepted scientific instrument or model. In the course of these events, human intentions are reshaped; they do not simply drive the process, but emerge during the course of inquiry and co-relate with material agency. Social institutions such as the existing base of scientific knowledge and the community of scientists working in the area are drawn into the process via disciplinary agency that shapes the scientist's thinking and sense of the significance of the work and thus is incorporated into the mangle. Disciplinary agency, too, is reshaped through the interaction with material and human agency.

We concur with Jones (1998) that the mangle of practice offers a useful analytical scheme for IS. It offers a way to draw together insights from structurational and actor-network approaches. Its emphasis on action and performance can support a fine-grained view of the role of IS in social processes such as system development, while bringing specific institutional effects in.

A model of IS structuration that incorporates different types of agency will advance structurational research by providing a finer-grained analysis of the structuring process. It will advance the actor-network tradition in IS by differentiating the roles of various actors in the network and providing a scheme for understanding the dynamics by which they interrelate. And it will contribute to the useful integration of the two traditions that provides insights into the institutional analysis of IS, as called for by Monteiro & Hanseth (1995), and others.

In the remainder of this paper, we first set the stage by articulating different types of agency that might come into play in IS development, implementation, and use and how human agents appropriate other types of agency in the structuration process. We then illustrate these concepts in the case study from which they emerged through a study of the development of a large-scale IS in an academic organization. We believe that the utility of the framework and its contribution to the IS research traditions sketched above become evident through this analysis. Finally, we consider some implications of the study and framework.

The surface of emergence in IS development

Varieties of agency

The starting point of our discussion is a view of the development of IS as an interplay of various types of agency. Pickering (1995) distinguished three types of agency: human agency, material agency, and disciplinary agency. In the general sense, agency refers to a thing or person that acts to produce a particular result. In social scientific thinking, the term agency has generally been associated with *human agency*, which Emirbayer & Mische (1998) define as 'a temporally embedded process of social engagement, informed by the past (in its 'iterational' or habitual aspect), but also oriented toward the future (as a 'projective' capacity to imagine alternative possibilities) and toward the present (as a 'practical-evaluative' capacity to contextualize past habits and future projects within the contingencies of the moment)' (p. 962). Human agency involves self-reflexive monitoring and adjustment of action in order to achieve desired ends, 'Ends' sometimes take the form of explicit intentions and plans, but in other cases ends may be retrospectively formulated as actors look back over where their actions are leading.

Material agency refers to the things the physical and biological world does. Harre & Madden (1975) argued that material agency is in the actions of 'powerful particulars' (forces) that create their effects through generative mechanisms. These effects emerge in the course of practice. With regard to the distinction between human and material agencies, Pickering argues: 'Material agency is captured by machines as material objects, separate from us as creatures of flesh and blood. Machines display regular, predictable, and nonvolitional powers

that we can set in motion and direct, but that are not reducible to human powers' (p. 242).

Following Foucault, Pickering (1995, pp. 114–117) defines *disciplinary agency* as the shaping and channeling of human action by conceptual and cultural systems. Disciplines are bodies of knowledge that preserve concepts, practices, and values that can be employed in action. Mathematicians (Pickering, 1995, Chapter 4), physicians (Foucault, 1994), and systems developers work within disciplines that provide a scaffolding for their actions. As Orlikowski & Robey (1991, p. 159) put it:

> *System developers draw on the values and conventions of their organization, occupation, and training to build information systems … they are informed by systems development methodologies and knowledge about their organization to build information systems.*

Disciplines provide generalizable procedures applied in the production and reproduction of IT artifacts. They are represented in human agents' schema (Weick, 1979) or frames (Gioia, 1986), but they are largely based on social structures. For example, the Danish approach to CSCW incorporates participatory design as a basic part of the discipline of system design (Taylor *et al*., 2001). Disciplines range in degree of generality from fields such as algebra and medicine to more specialized bodies of practice such as information systems development to organizational cultures. While a discipline requires a large social structure to sustain it, such structures may vary in scope.

The disciplinary elements used in IS development are neither fixed nor predetermined, but always emerge in action. These virtual elements do not just impose constraints on innovation; they are also enabling to the extent that they provide a repertoire of already existing institutional principles (e.g., models, analogies, conventions, concepts) that human agents enroll in their activities. Disciplinary agency helps to explain why IS are designed differently in different contexts. From empirical studies we know that different IS planners and designers develop different IS using similar computer languages and machines. This is because the discipline of system development differs according to national and organizational culture, as shown in the studies of Taylor *et al*. (2001) and Barrett & Walsham (1995).

In attempting to decipher the role of agency in our case, we found that IS present a unique combination of human, material, and disciplinary agency. This is because an IS has a special status that is neither material nor disciplinary in nature. For instance, an intranet 'does things' that enable people to interact with one another. So in a sense it is an agent that human beings can enroll in a system of action. The characteristics of the intranet influence how people act and constrain their actions. The intranet enables one to communicate rapidly with colleagues via email. But it also shapes how this communication occurs. At the present time there is insufficient bandwidth to videoconference, so when we communicate with someone else via the intranet we use text and perhaps attach pictures and documents. This limits out choices, so in a real sense the network is an agent limiting our actions. But its influence is not limited to our actions, it also influences how we think about and understand our actions.

The intranet also makes us think of communication in different terms, reshaping our understanding of communication. Just as one human agent's words and deeds influence how another agent interprets the activity they are engaged in, the intranet influences our interpretation of what communication is and our plans for how we will communicate with others. As we use the intranet, it is actively shaping our actions, just as if it were a person whom we have to adjust our actions to in interaction. Hence, it has a similar effect to that of a material agent. However, we believe the agency of IS operates through different channels than material agency, which is grounded in natural laws.

An IS also cannot be reduced to disciplinary agency. Disciplinary agency is not grounded in an artifact, as is an IS. The development of the IS is guided by disciplinary agency, and disciplines give developers ideas about the intentions to embed in the IS. However, the IS itself is a separate amalgam that operates through components that act according to natural laws, is given form by the disciplinary agency of design (March & Smith, 1995), and embodies traces of human agency that resurface as it comes into action.

An IS is clearly not a human agent. It does not formulate intentions in immediate activity, so it does not exert the type of conscious agency that human beings do. Its influence is more passive. But it is organized around developers' intentions, plans and goals, so in a sense it has intentionality embodied in it, a type of 'frozen' agency. This is relevant, because as actors employ the intranet, they construct a notion of what the intranet can 'do' that is in part informed by their construction of the intentions of the designers of the intranet.

This embedding of agency in material artifacts makes an IS a unique combination of agencies. As the IS is utilized by human agents, its embedded human intentions are 'brought to life,' in a manner of speaking, and affect the course of action in an interplay with human, material, and disciplinary agency. While we were tempted to coin yet another type of agency for the IS, at present it seems more productive to think in terms of combinations or layerings of agency.

Constitution of the surface of emergence

The surface of emergence in IS development is a sociotechnical construction constituted by human agents who draw on previously existing machines and disciplines. By appropriating Foucault's phrase 'surface of emergence' (1972, p. 41), Pickering (1995) uses it to refer to temporally emergent quality of machines and disciplines instantiated in a particular historical context. Human agents act through appropriating structural features of

existing machines and disciplines, which in turn introduce material, disciplinary, and embedded human agency into the process. These other types of agency lend their own direction to the process, which may lead human agents to alter their courses of action and revise their intentions and engagement with the situation.

IS developers are never free of the agency of pre-existing IS. They start building with the materials they have at hand (Star & Ruhleder, 1996; Lanzara, 1999). In attempting to develop a new IS, they apply existing material and disciplinary elements such as programming languages, software modules, information infrastructure, and IS development methodologies and tools, and these bring with them the legacy of pre-existing systems. The surface of emergence primarily builds from the pre-existing organizational context, because this is what is most relevant to developers. However, elements may also be imported from outside the organization. For instance, when an ERP package is implemented, the design embodied in the ERP is imported as a material constraint for the organization. It is increasingly the case that organizations are advised to tailor their work processes around the ERP rather than trying to adapt the ERP to their circumstances (Markus *et al*., 2000).

In constituting the surface of emergence human agents appropriate machines and structures, mobilizing their agencies. The IS is constituted through the ensuing dialectic of resistance and accommodation. Appropriations put particular aspects of pre-existing IS, institutions, and other structural features (e.g., context-specific norms) into play, and it is through specification of these and their agency that the fine-grained analysis called for by Monteiro & Hanseth (1995).

Human agency affects the surface of emergence not only through the intentions and projects agents enact, but also in the ways in which they appropriate IS, institutions, and other structural features. As noted previously, the modalities of structuration give a specific force and character to the material, disciplinary, and embedded human agencies at play. Further, while organizational-level structuration theories treat IS and other structural features rather generally, adaptive structuration theory (Poole & DeSanctis, 1992; DeSanctis & Poole, 1994) describes the specific moves that human agents make in appropriating pre-existing IS, institutions, and other structural features.

Adaptive structuration theory (AST), sometimes misunderstood as a positivistic theory (e.g., Jones, 1999), provides a conceptual framework for studying how structures are incorporated into action that has been used in a number of case studies (Poole & DeSanctis, 1992; DeSanctis *et al*., 1993; Scott *et al*., 1998; Faber *et al*., 1999; Majchrzak *et al*., 2000; Maznevski & Chudoba, 2000). The core of this framework is the concept of appropriation moves that characterizes how a structural feature enters into structuration. In describing appropriation moves for group support systems (GSS), DeSanctis & Poole (1994) describe four different ways in which groups may appropriate GSS features: groups may choose to (a) directly use the structural feature, enabling it to channel their work and interaction, (b) combine or otherwise relate the structural feature to other structures drawn from the group context (e.g. decision making norms) as they use it, (c) talk about the structural feature or combination of features in order to constrain or interpret it (Orlikowski *et al*. (1995), term this meta-structuring), or (d) evaluate and either decide to continue or discontinue using the structural feature. They provide a scheme that differentiates 31 particular types of structuring moves for the use of GSSs and other standalone IT within these four general categories.

The categories described in DeSanctis & Poole (1994) are designed for analysis of the structuring process when a group uses a single IT, and so must be adapted for this study, in which the interplay of multiple structural features is the focus. We will briefly describe the five major types of appropriation moves we found at play in the case, which adapt the categories in DeSanctis & Poole (1994) to the analysis of large-scale systems development:

- *Direct appropriation* refers to cases when structural features (elements of pre-existing IS, institutions and other structures) directly influence and give form to the structuring process. For example, a set of accounting standards might be used a key design requirement for a financial system, directly channeling its design and use.
- *Partial appropriation* describes a use in which only part of a coherent structural feature is appropriated. For example, developers might use only a subset of the accounting standards in the financial system.
- *Substitution* occurs when a structural feature is replaced by a different structural feature that performs a similar role. For example, substitution would occur when one set of accounting standards that is acknowledged by developers as an important requirement of a financial system is replaced by a different set of rules that are actually built into the system. The new set of rules would perform a similar role in the structuring process to that of the old set of rules, but channel structuration of the financial system in a different direction.
- *Contrast* occurs when a structural feature is invoked to express what the IS should not be. For example, a set of accounting standards from Enron can be used as a contrast to guide the design of an ethical financial system.
- *Paradox* describes the situation when two different structural features that are inconsistent, mutually antagonistic, or even contradictory are imported into the structuring process. For example, accounting standards from Enron and a more conservative firm might be built into a financial system by developers who aspire to be responsible by conservative standards yet take advantage of some of the more progressive (so to speak) accounting practices employed by firms such as Enron (which are legal, but shade the line).

Paradoxical appropriations introduce potential conflicts into the development of the system, because developers and stakeholders in the development process must resolve potential inconsistencies in design philosophy and in the actual implementation of the design. How these conflicts are avoided or resolved determines the course of the structuring process in system development.

These five appropriation moves represent the different ways in which pre-existing IS and other institutions can enter into and channel the system development process. The structuring process through which the surface of emergence is constituted extends through time and space, and this offers opportunities for multiple (and sometimes conflicting) structural features to come into play and interact. This interaction is both a technical and political process. Analysis of the constitution of the surface of emergence as technical enactment shows the role of appropriations of pre-existing IS and other institutional features in forming the large-scale system. Analysis of this process as a contest of appropriations advocated by parties with different degrees of power illuminates the role of 'politics' in system development.

Our study of the development of a system-wide financial IS in a major university system led us to conclude that: (a) Pickering's concept of the mangle of practice provided a promising framework for analysis of IS development; and (b) that identification of the modalities and appropriation moves could provide a fine-grained analysis of the role of IS and institutions in the development process. The case study was initially guided by the question 'What is the role of pre-existing IS in a new IS development?', but as time wore on we realized that the larger institutional context had to be taken into account as well. We started with structuration theory and ANT as loose guiding frameworks, and as we progressed it became evident that the mangle of practice concept offered a way to integrate the two theoretical frames that neutralized some of their problems. Further analysis convinced us that a better developed conceptual system was needed to adequately describe the particular ways in which IS and institutions figured in the constitution of the surface of emergence, which led us back to the modalities and AST. Following is a description of our methods and the case study, which we hope will show the application of our framework and demonstrate its potential in the study of IS development of large scale systems.

Case study methodology

This study employs interpretive case study methods (Myers, 1997; Walsham, 1993, 1995) to explore the development of University Management Information System (USMIS), an internally developed enterprise system in a major U.S. university system, Land Grant University System (LGUS). Currently LGUS consists of nine universities, the central system administration office (HQ), eight State research and extension agencies in the areas of agriculture, engineering, veterinary science, and forest service, and the Health Science Center (see Table 1). Currently, LGUS serves over 100,000 students and employs more than 23,000 faculty and staff located throughout State. The annual budget of LGUS is over $2.0 billion US dollars.

Data collection focused on the development and implementation of USMIS by the project team and members of LGUS from the earliest inception of the system in the mid-1980s. Data included archival records, personal notes kept by participants, and interviews. Document collection was accomplished through follow-ups on interviews, reading private collections of documents by selected key individuals in the project, site-visits, library search, archival research at the USMIS Project Team site, and information provided by software vendors. In all, approximately 4000 pages of documents were reviewed.

A diverse group of people were interviewed. Those interviewed included the initial sponsors of the USMIS system, the former and current USMIS project management, CFOs of LGUS' units, members of IT steering committees at the system and unit level, unit-level and department-level users, directors of IT departments in a number of units, system analysts involved in implementing the USMIS system, and a university system-level IT auditor. A total of 25 interviews were conducted between October 2001 and October 2002. The average duration of the interviews was over 70 min. The format was semi-structured in that each participant was asked some general, open-ended questions, and then asked to expand on various issues that seemed important. The format

Table 1 The Land Grant University System

The universities	*The agencies*	*Health science center*
• Big Campus (the largest campus)	• Agricultural Research Station (ARS)	• College of Dentistry (CD)
• West Campus	• Agricultural Extension Service (AXS)	• College of Medicine
• Southeast Campus	• Veterinary Extension Service (VXS)	
• South Campus	• Engineering Research Station (ERS)	
• Northwest Campus	• Engineering Extension Service (EXS)	
• Four other campuses	• Forest Service (FS)	
	• Transportation Research Station (TS)	
	• Wildlife Management Service (WMS)	

combined elements of the interview guide approach, standardized open-ended interviews and dialogic interviews (Rossman & Rallis, 1998). Each interview was transcribed immediately after it was conducted.

To begin to draw out insights from the case, we wrote research memos detailing ideas and themes that stood out and questions that arose during the interviews and document reviews. The memos highlighted any cues that pointed to key events in the development (e.g., problems, tone, mood) before, during, and after the interview, the interpretations of events, and the linkage between the data and the research framework and the concepts presented earlier in this paper. Memos were also written while reading and interpreting archival records. Later, these memos were combined into interim case summaries that were then developed into several case studies, including a basic case that presented a narrative of the events and issues in the development of USMIS (Chae & Poole, 2005). During the data collection, we developed and shared a case report that included a case summary and preliminary elements of our analysis with three key individuals including the former and current project managers involved in USMIS development. They commented on this and gave us confirmation of many points and qualifications of others. Drawing on the basic case, the interview and archival data, and the research memos, we developed the present analytical case.

In the course of conducting the original research, it became evident that pre-existing IS and institutions both within and outside LGUS had played a critical role in its development, and the writing of the basic case strengthened this conviction. So we focused on identifying elements of institutions and pre-existing IS and how they shaped USMIS development. A set of constructs were drawn both from the case and from the IS institutional literature cited above to help identify key institutional features relevant to USMIS (e.g. government accounting standards, existing systems that USMIS might be modeled on, where budget was attached, etc.). Once a core set of institutions and IS had been identified, we arrayed them on a rough time line and also considered where in the LGUS system the main action of the institutional feature had occurred. We then turned to the theoretical literature on structuration and ANT, and particularly Pickering's (1995) analysis for concepts that could guide us in working out how the IS and institutional features had figured in the emergence of USMIS. We then went back to the original data, identified more key institutional and IS features and then used theory to work out their relationships, and so on through several more iterations.

Case study analysis

Overview

A decentralized organization with a need for integration LGUS was established about 50 years ago, although several of its units have been in existence for over 100 years. It has grown through annexing existing universities, and most of its units have been added in the past decade. Its member units vary greatly in mission and purpose, from major universities to teaching colleges to research institutes and extension services. The LGUS strategic plan recognizes that 'each member of the system has its own goals, traditions, and culture … The system values diversity and honors the principle 'one size doesn't fit all.'' Traditionally, there had been a decentralized culture within the system, and many of our interviewees expressed the opinion that the system was the most decentralized major university system in the U.S. Each unit regards itself as different from all the others and works to maintain its uniqueness and independence.

Somewhat counter to this principle, business and IS integration have been emphasized and sought at the system level. USMIS, an enterprise information system that incorporates financial regulations applicable to the units of LGUS, is one of the major initiatives taken to pursue this end. LGUS is an inter-organizational system that integrates 30 databases that function as a unit across five independent modules or subsystems: a financial accounting system, a purchasing system, a fixed assets management system, a system for sponsored research accounting, and annual financial reporting. It was first introduced in 1990 for Fiscal Year 1991. The USMIS Project Team has been responsible for the development and support of USMIS since the late 1980s. This team, part of the Department of Information Resources (DIR) within the LGUS Central System Administrative Unit (HQ), is in charge of the management and maintenance of USMIS. The team reports directly to the DIR within HQ. The head of the DIR reports to the Office of the Vice Chancellor for Business Services, which reports to the Chancellor, the chief executive officer of the LGUS.

'One system for everyone' Several internal and external factors and institutional arrangements contributed to the emergence of the USMIS system. Between 1977 and 1986 LGUS had experienced 22% growth in student enrollment, a 193% increase in research expenditures and a 115% increase in overall budget. More growth was expected, since there were plans to add more units. This growth led top administrators and the LGUS Board of Regents to recognize the need for comparable and consolidated information to properly manage the $800 million annual operation. The proper level of coordination among and control over units became an important concern for the top management in HQ. The existence of separate financial management systems supporting diverse accounting rules and practices throughout LGUS created a major barrier for enterprise-wide integration and control.

These internal factors were closely interwoven with LGUS's external environment and institutional arrangements. The most direct external pressure came from State auditors and the development of a State-Wide Management Information System (SWMIS). The use of automated

information systems was a major strategic thrust of the State. In 1987, legislation required the State Comptroller's Office institute uniform collection and reporting of statewide payroll and personnel data, which resulted in the creation of the SWMIS for the Comptroller's office. One of the original objectives of SWMIS was to meet state agencies' general accounting requirements and thus reduce the number of separate accounting systems in the State. In fact, the best scenario for the State would be to have 'one financial information system' that replaced all existing systems with SWMIS.

In response to this pressure, LGUS proposed to maintain its own information systems and interface them with SWMIS. The vehicle for accomplishing this, USMIS, was welcomed by the SWMIS Project Team, because it could provide the Comptroller's office with a single, standardized channel to communicate with all parts of LGUS.

The champions of USMIS planned to develop an enterprise information system to support not just financial management and interfacing with SWMIS, but also other administrative functionalities, including contracts and grants management, purchasing, office automation and communication, cashiering, travel advances, enterprise and departmental accounting, *ad hoc* reporting, and information management. They planned to create a centralized staff so each unit of LGUS would no longer need to dedicate computer/information systems personnel to support its financial information systems. A perceived advantage of centralization was that modifying the systems to respond to environmental changes such as new State laws and regulations would need to be done only once, saving the duplication of effort across units. In the words of the interviewees, the original goal of the USMIS project was to develop 'a fully integrated enterprise-wide IS,' 'one ERP-like system for everyone.'

The original plan was to develop 'a fully integrated IS by the summer of 1990 for fiscal year 1991 and to implement USMIS completely in all units within 4 years.' At the outset, use of USMIS was planned to be mandatory, 'everyone had to be on USMIS.' However, the development of USMIS took a lot longer than anyone anticipated.

Design and implementation process In 1989, a three-way agreement was signed between LGUS, Information Associates, and Software AG. It called for Information Associates' popular Financial Records System, originally programmed in COBOL, to be redesigned and re-engineered using NATURAL, Software AG's fourth-generation language and the ADABAS data management system.

On receipt of the modified software package in 1989, USMIS went live in September 1990 with the first two of five modules, the Financial Record Systems (FRS) and Financial Accounts Receivable (FAR), which were implemented in three units – Big Campus, HQ, and one research agency (VXS). Also in September 1990, the Sponsored Research (SPR) module went live with limited functionality. In June 1993, the Fixed Assets (FFX) subsystem went live for five universities and one agricultural research agency. In September 1993, the first phase of the purchasing system went live for Big Campus. In January 1994, the Budget module implementation began. In July 1998, the Annual Financial Report (AFR) module and in 1999, the Executive Information System (EIS) was developed and integrated with USMIS.

As this timeline indicates, the design process took much longer than originally planned. USMIS was developed locally within particular units of LGUS rather than globally, as the principle of 'one system for everyone' might imply.

Delays can be traced to a number of complex and interwoven elements. Several leadership changes occurred at the top of LGUS – five different chancellors served during the USMIS implementation period, and there was turnover in project leadership as well when the director of the USMIS Project resigned. Needs and preferences of users were more diverse than anticipated and there was a long list of user requests regarding system maintenance and enhancements. Some units resisted using USMIS, and this slowed implementation as well. The State mandated several policy changes during this period, which made the system something of a moving target. There were also difficulties in creating interconnection with other information systems, both locally and at the State level.

USMIS today is quite different from what was originally envisioned by the project sponsors and the USMIS Project Team in contrast to the initial grand plan to develop 'a fully integrated large-scale information system' that would serve as a standard solution for fiscal and administrative problems, the system developed in modules that were gradually rolled out and continuously modified over the decade of development and implementation. Moreover, USMIS has never realized its goal to be a fully integrated enterprise-wide fiscal and administrative system that meets the needs of all levels of users from system-level to departmental-level and all units in USMIS, from large universities and research agencies to small universities. Currently, Northwest Campus and two research agencies, ERS and EXS, have not committed to USMIS implementation.

The surface of emergence in USMIS development

Raw materials for the surface of emergence The initial goal of the USMIS project to develop a 'fully integrated fiscal and administrative information system' for all units in LGUS implied a major transformation of LGUS's information systems. In effect, the aspiration was for USMIS to be a wholly new system that brought a new level of integration to LGUS. However, development of USMIS occurred in the context of pre-existing ISs, and this tempered its capacity to deliver radical change.

Systems that influenced the development of USMIS included:

- The Budget/Payroll/Personnel (BPP) System and the Student Information Systems (SIS), which were developed for Big Campus. BPP was fully implemented at Big Campus in 1979 and SIS was put into operation in 1986.
- The SWMIS, which was developed in the late 1980s and began operation in 1993.
- Financial accounting management information systems developed and installed at other universities in State and at referent universities outside State.
- Standalone financial information systems running in several units of LGUS, some based on the BPP system and others developed by the units themselves. Most of the units in LGUS had their own unique chart of accounts and accounting practices throughout LGUS were very diverse.
- Computing infrastructure in LGUS, including hardware, software, and programming languages.
- A decentralized, consensus-based organizational structure and culture of emphasizing self-autonomy of units in LGUS.
- The project director's experiences and technological frames from previous system developments.
- The hierarchical, top-down organizational structure at the top level of LGUS.
- The existing human resources, system analysts and programmers, and their technical knowledge.

Hence, USMIS was not developed 'from scratch,' but in varying degrees challenged, borrowed from, built on, and displaced several pre-existing information systems.

Considerations of length prevent us from going into detail concerning all of these elements, so we will treat a few as 'figure' – specifically the computing infrastructure in LGUS, standalone IS running in units of LGUS, the SWMIS, and the organizational culture of LGUS – and treat the remainder as 'ground' in the analysis of surface of emergence of USMIS. Table 2 shows the roles the various pre-existing systems and institutions played in the process of structuring USMIS.

Pre-existing IS and the surface of emergence of USMIS The developers mobilized pre-existing resources during the development of the USMIS system. Over the course of development, several different systems were put into play in the surface of emergence.

A strong imprint was put on USMIS by existing computing infrastructure and information systems from Big Campus. The USMIS Project Team had to conform to technical commitments embodied in two major information system procurements from the 1980s: SIS and IBM 3090-200E mainframe computer system. The lack of resources to purchase new systems effectively locked the USMIS project into a particular trajectory of development. The SIS system was in line with the focus on long-range planning that was being redirected toward the financial information system and was partially appropriated in the design of USMIS. SIS used Software AG's ADABAS as the primary database system and COBOL and NATURAL as the main development languages. The SIS procurement cost over $1.6 million and it was evident from the outset that purchasing another database was not an option. The former director of the MIS Project commented that 'We had one important technical commitment which was 'ADABAS'. This was the database and could not be changed.'

The IBM 3090-200E system constituted another material element of the surface of emergence for USMIS. This $8.2 million mainframe computer was installed on Big Campus in 1987. The mainframe computer and SIS were the most expensive IT investments ever made by Big Campus, and they were taken for granted as important parameters in the development environment. The expertise in COBOL and NATURAL developed during the implementation of SIS was brought into the USMIS project as several of the members of the MIS Project Team had helped to maintain SIS for LGUS-C.

The activities of the USMIS Project Team were channeled by the material agency provided by the mainframe via the disciplinary agency of ADABAS, COBOL, and NATURAL. Direct appropriation of ADABAS resulted in a database design that was not truly relational, as a system based on ORACLE would have been. The interface was a 'green screen' because the IBM system and languages did not support GUIs. The disciplinary agency of the SIS system also exerted itself via the norms that shaped report formats and navigation via key. The team designing USMIS, somewhat paradoxically, emphasized the projective aspects of agency but were strongly informed by the past, by the channeling of material and disciplinary aspects of pre-existing systems. Several of the members had previously worked on SIS and mastered ADABAS and NATURAL, which disciplined their performances. They had to align the material and disciplinary agency of these systems with the projected view of USMIS as a single integrative system for all units. Since SIS had been an integrative agent for the complex subunits of Big Campus, it seemed to be a good model for USMIS and so was partially appropriated in the design of USMIS.

SWMIS also played an interesting role. The USMIS Project Team studied the system in depth as another alternative to purchasing and developing USMIS. The initial plan for SWMIS was to develop a powerful framework that could be used by all state agencies, but this goal later shifted so that SWMIS was mandatory only for smaller state agencies. For the larger agencies such as LGUS, it provided standards to use in designing their own systems to interface with or deliver data to SWMIS. In essence, USMIS substituted for SWMIS, and to do so the USMIS development team had to partially appropriate standards from SWMIS to incorporate into USMIS. This substitution articulated well with the culture of LGUS, which guarded local control of system information jealously, and pointed to the value of USMIS as a system

Table 2 Elements involved in structuring of surface of emergence for USMIS

Pre-existing element	*Type of agency exerted on IS development process*	*Strength of influence on IS development process*	*Modality of structuration*	*Appropriation type*
1. The Budget/Payroll/Personnel (BPP) System and the Student Information Systems (SIS)	Material, disciplinary	Strong	Norm; facility	Partial appropriation of BPP/SIS structures into USMIS
2. The State-wide Management Information System (SWMIS)	Material, disciplinary	Moderate	Norm; interpretive scheme	Substitution of USMIS for SWMIS; partial transfer of SWMIS standards into USMIS
3. Financial/accounting systems in other State universities (public and private)	Disciplinary	Weak	Interpretive scheme	Contrast; partial appropriation
4. Financial/accounting systems in other universities outside State	Disciplinary	Weak	Interpretive scheme	Contrast; partial appropriation
5. Standalone financial/accounting information systems running in units of LGUS	Disciplinary, embedded human	Moderate	Facility	In some cases, substitution of USMIS for standalone systems; in other cases, paradox in which standalone systems operated alongside USMIS with no official acknowledgement
6. Computing infrastructure in LGUS, including hardware, software, and programming languages.	Material, disciplinary	Strong	Norm; facility	Direct appropriation
7. Decentralized, consensus-based organizational structure and culture of emphasizing self-autonomy of units	Disciplinary	Strong	Norm; interpretive scheme	Direct appropriation of structure and culture; Paradox with #8
8. Hierarchical, top-down organizational structure at the system administration level of LGUS	Disciplinary, embedded human	Moderate	Norm; facility; interpretive scheme	Direct appropriation of structure and culture; Paradox with #7
9. Project director's technological frames and experience from previous system development	Disciplinary, human	Strong	Norm; Facility; Interpretive Scheme	Direct appropriation
10. Existing human resources: system analysts and programmers and their technical and organizational knowledge	Disciplinary, human	Moderate	Facility	Direct appropriation
11. The MIS project team's informal culture	Disciplinary	Moderate	Norm; interpretive scheme	Direct appropriation; paradox with #8

that would enable LGUS to sustain control of its own destiny. In one case, USMIS developers even developed standards for SWMIS, as developers generated an application to track deposits.

Spatially distant IS both within and outside State also entered into the process. One important charge for the USMIS Project Team was to discover a good model for this ambitious, large-scale, multi-site IT project. The team studied several information systems at universities within and outside State. Through this process they identified several alternative models for the USMIS project and combined them with the team's own visions for the new IS. In this case – as often occurs in large system development – this approach was the only viable source of new ideas. However, as Offe (1996) notes, approaches that model systems on other systems may create an appearance of clarity about a solution without really testing its applicability to the present context. External university systems were also presented as useful models, but inadequate to meet the needs of LGUS, appropriating them to contrast with the USMIS system. They suggested some desirable attributes, but also were not in themselves suitable for USMIS. So systems outside LGUS served two roles in the surface of emergence, as sources of ideas, and as antitheses that re-emphasized the unique needs of LGUS and the need to build USMIS internally.

The developments described to this point were primarily orchestrated by agents working from Universityburg, the city in which Big Campus and HQ were located. This enabled the primary advocates of USMIS to exert a good

deal of control over the features of pre-existing IS and institutions that were appropriated. A core network formed that included members of the USMIS Project Team, key managers from HQ, IT personnel from Big Campus, and machines and software sited in Universityburg. Members of the Board of Regents, which often met in Universityburg, had weak ties to this network as well. This network represented one site for potential stabilization of USMIS through aligning the agencies of the material and disciplinary elements in a configuration that could then be presented to other units as a stable system and implemented throughout LGUS. However, since development was far from complete, the network did not have time to fully stabilize before other actors made their bids to reshape USMIS.

Existing freestanding information systems in different units of LGUS provided opportunities for developing the actor network, as well as challenges to it. Several units of LGUS had sunk considerable resources into their own financial systems and were likely to resist USMIS because they believed their systems were better suited to their needs than USMIS. These freestanding systems, in effect, represented standards (disciplinary agency) for USMIS, because USMIS would have to replicate their functions (and, ideally, better them) to be acceptable. In some cases, these systems were appropriated directly into USMIS. For example, in its early days USMIS did not have a sponsored research module. In response to demands from research institutes that had an immediate need for subsystems to support their sponsored research activities, the MIS Project team and the initiators looked backward to explore the potential of redeveloping and extending a standalone system developed by ARS for system-level use. In 1993, the team completed the development of the Sponsored Research Module, which was modeled on ARS's system.

Freestanding IS also conflicted with USMIS in some cases. These systems introduced new elements into the network that had the potential to generate paradoxical structures. How these were dealt was strongly influenced by organizational structure and culture.

Spatial distanciation and agency in USMIS development The organizational culture of LGUS and the Big Campus IT group, as well as the experiences and frames of individuals in the USMIS Project Team, were important constituents of the surface of emergence. As noted previously, the former director of the USMIS Project Team was very influential in the design of USMIS, particularly during the period from 1988 to 1991. He had previously served as vice president of information systems with an airline company in private industry and as a senior financial manager with several universities. He had also received his undergraduate and graduate education at Big Campus, and therefore was quite familiar with Big Campus's organizational culture. After joining the university, he was quickly brought up to date on LGUS' administrative culture and politics by diverse individuals, particularly one of the 'founding fathers' of USMIS, who had known him well and hired him for the project.

The former director's approach was strongly shaped by his previous experiences and training. The technological frame he brought to the job is evident in the following comments.

> *Users had little tolerance for changing.*
> *Flexibility does not mean much to users … it is not something users want … they want what they are familiar with … try as few changes possible … so we [the project] team didn't want a lot of changes … tried to do as few changes as possible …*
> *Large-scale information systems don't go live on time. The development of large-scale information systems is difficult and seldom meets the original plan.*

The director's technological frame resulted in a relatively conservative approach to the USMIS project that rested on creating as few changes as possible in the pre-existing IS at Big Campus. This resulted in USMIS having a 'Big Campus' flavor that was antithetical to some other units of LGUS. An IT manager of a research agency commented that:

> *… the USMIS project team was in on the vendor selection … they were less interested in a brand new system but more in a system which is compatible with SIS … they were considering two vendors AMS and IA … Did anyone mention SCT in the interview? [The primary investigator indicated that no one had] … Actually SCT was under consideration … I supported that vendor and technology (SCT's Banner financial module) … to me, SCT was the best … it was based on advanced technologies not like 'Green Screen' [meaning non-GUI interface] … They were looking at 'Green screens' and 'ADABAS and Natural' … They argued that SCT was not a good choice because it was risky and that their approach was less risky …*

The decision on the new project was made at the top level of LGUS: the Board of Regents delivered the directive, and HQ had to execute the directive. In addition, adoption of USMIS was made mandatory for all units of LGUS. Thus the USMIS Project Team played a critical role as a proxy agent (Bandura, 2001) by saying to LGUS' units 'you got to be on USMIS. This is not an option. No alternative is allowed.' The value of 'one system for everyone' emerged as a key aspect of the surface of emergence and much discourse, in due course contested, focused around this symbol.

As noted, LGUS' culture emphasized decentralization and its organizational structure was decentralized. These institutional features were appropriated in attempts to counteract the emerging configuration of USMIS. The USMIS Project Team had to develop a centralized system while working in culture premised on decentralized decision making and action. As the project proceeded, the USMIS Project Team adopted a more 'customer or user-oriented' approach to USMIS design, something that departed from the discipline of IS development as it had evolved in Big Campus, which tended to be more technologically-centered. In a group interview one of

the USMIS's system analysts and the USMIS manager commented,

> *The system's motto is 'here to help'. Our team tried to accommodate individual members' needs into the USMIS design as much as possible.*

This is quite different from the initial approach in the emerging actor network in Universityburg, which followed the hierarchical organizational structure and attempted top-down change. This initial approach fostered strong resistance from LGUS' decentralized organizational culture, which emphasized the uniqueness of each member and strong local autonomy.

On the other hand, the more 'customer-oriented' approach had some unintended consequences. The USMIS Project Team was forced to use design an 'average' system that would work for everyone, no matter whether they were large or small universities or research agencies, not an integrated enterprise software for LGUS. The former director pointed out in fact 'one system for everyone' is 'nothing for nobody'.

This average system was then customized to the needs of powerful units in LGUS, which entailed a considerable number of workarounds. However, tailoring has not supported the stabilization of an actor network that includes all of the units in LGUS. Two of the research institutes and Northwest Campus still run their own freestanding financial systems that are interfaced with USMIS. The political process by which this evolved is described in Chae & Poole (2004). Several other units have developed their own shadow information systems that they use alongside USMIS to meet their local accounting needs and practices. At the time this study was completed, the actor network in which USMIS is stabilized does not include all of LGUS.

As currently stabilized within its surface of emergence, USMIS projected material and disciplinary agency in an attempt to unify LGUS. Human agency pushing for centralization and unification of LGUS is strongly embedded into USMIS as a result of 10 years of development. However, a countervailing disciplinary agency stems from the decentralized culture of LGUS, introducing a paradox into USMIS: The composite of human and disciplinary agencies built into LGUS embodies conflicting currents in that USMIS is meant to centralize but not undermine the decentralized culture of LGUS.

Distanciation played an important role in the structuring of this paradox into USMIS. Northwest Campus is hundreds of miles from Big Campus and so can maintain its independence more easily than it could were it fifty miles away. A relatively small university, Northwest Campus also had a 'trump card' because its president succeeded to the Chancellorship of LGUS and took a position that while USMIS was the LGUS major financial system, adoption of it by all units was not mandatory (see Chae & Poole, 2005). But the research agencies exhibited a different type of distanciation, one that might be called 'disciplinary distanciation.' They were both located in Universityburg, but had developed quite independent cultures and worked as more or less freestanding units that could make a case for freestanding IS. The two research institutes also brought in considerable resources to LGUS and so had a power base of their own. However, Northwest Campus and the research institutes had to engage in a lengthy process of resistance and negotiation to achieve their current status (Chae & Poole, 2005).

Nor can the actor network really be considered 'stabilized,' in any final sense. Maintaining the constellation of agency in USMIS is a continuing process. While USMIS has achieved considerable inertia and can be considered part of what Star & Ruhleder (1996) term the 'installed base,' our analysis suggests that it maintains its status through a continuous performance of structuring processes whereby USMIS continues to be adjusted in order to maintain the alignment of the human, material, and disciplinary agencies it embodies. If the USMIS Project Team, the major human agency in the current actor network, did not continue to 'tweak' and expand the system, it would be less useful for units currently enrolled in the network and there would be calls for its replacement with a new enterprise system.

Outcomes: stabilized structuration USMIS emerged on a surface comprised of several pre-existing IS, which were borrowed spatially and temporally. The surface of emergence of human, disciplinary, and material agencies were enmeshed in the IS development practice in the USMIS Project Team. Over the years, USMIS has *been designed* and *drifted* simultaneously. The emergence of the system was a very complex process that included an uncountable number of interactions among human and non-human elements – politics, leadership, culture, users, developers, administrators, accounting rules and regulations, local practices, technology and state audits, to name a few – within and outside the USMIS project.

The pre-existing ISs that formed part of the surface of emergence were themselves the complex product of previous alignments of cultural, material, and human agencies. In some aspects the disciplinary elements of USMIS shaped the material elements, just as the material elements reflected back to reinforce and reshape disciplinary elements (Sewell, 1992). For instance, the decentralized organizational structure and culture had influenced the development of material resources in USMIS, such as charts of account, income codes and accounting procedures. Each unit in LGUS had maintained its own vendor list, chart of accounts and accounting practices prior to USMIS and this had become part of the pre-existing IS. USMIS had to adapt to this diversity.

In USMIS development, material and human agency also interacted in a dualistic matter: material agency enabled and constrained human agency, and human agency resisted and accommodated material agency. Initially, pre-existing IS offered agents at the top of LGUS

with a motive to eliminate several standalone IS and to develop an enterprise IS. However, these motives collided and interacted with other human, material, and institutional agencies in such a way that they diluted the initial agency and prevented the development of a fully integrated, 'brand new' IS. However, the force of the initial agency was strong enough that it promoted the development of a system which offered the members of LGUS with the opportunity to meet such needs as State reporting, unit-level finance and accounting management, and purchasing, and thus advances the impulse for unification. Material agency did not fully and precisely determine the system. Rather, there has been the active role of human agency and its interests in strategic action under constraint (Ingram & Clay, 2000). Initially, the designers and initiators developed a grand vision for a fully integrated financial and administrative IS (Swanson & Ramiller, 1997). Within the surface of emergence, the original vision was modified to fit with pre-existing ISs, thus enrolling their agencies in the effort as much as was possible. Thus, to some extent human agents had to continuously look forward and backward in developing their vision for the project.

While USMIS is based on its numerous predecessors, it also incorporated novelty. Interviewees commented that USMIS led to increasing order and centering at the system level and has supported system-wide collaboration and control. USMIS has also offered a common communication channel between the state and member organizations of the system. It has also introduced economies of scale. Overall it has increased the system-wide technology and business integration, which supported an ever more complex organizational structure.

The development of USMIS has also led to unintended consequences. While there was an effort to foster system-level integration through USMIS, it also created disorder, decentralization, and less control in some respects. USMIS has fostered both centralization and decentralization, both system-level integration and disintegration, and both order and disorder (Baker, 1993). Perhaps most important, the process confirmed the power of certain units not to enter into the stabilizing actor network of an integrated IS. Having units within the boundaries of LGUS that are not enrolled in the actor network presents a constant threat to destabilize the network.

At present, LGUS is considering implementing a new enterprise system to succeed USMIS. The tailoring and resistance with the system is continually threatening to unravel the stabilized network. However, replacing LGUS requires structuring a new actor network to sustain development of the new system. This will be a formidable task in view of the decentralized culture of LGUS, so at present the USMIS Project Team proceeds apace with upgrades, adjustments, and improvements to LGUS, including a GUI supported by middleware.

Theoretical and practical implications

The case study illustrates the active role of pre-existing IS and social institutions in the development of USMIS and the utility of the concept of surface of emergence to illuminate an ensemble in which technical and social dimensions are inextricably interrelated. In this section we discuss implications for IS research and practice.

First, this case analysis underscores the importance of focusing on the dynamic and emergent nature of IS and IS development. As noted earlier in this paper, one common view holds that IS development is primarily a technological process. On this view, IS development is a systematic, stable, step-by-step process, and the environment surrounding development is viewed as controllable and to some degree capable of being insulated from the development process (Buscher *et al.*, 2001). However, buying software does not mean the purchaser now has an information system (Sawyer, 2000). Rather, IS, particularly large-scale IS such as ERP, can be better viewed as social institutions, and IS development as the process of institution building, which is multilayered, dynamic, and ongoing (Orlikowski & Hoffman, 1997). In this process, human, disciplinary, and material agency interact on the surface of emergence. This shift of understanding can lead to new insights in IS research and successful outcomes in practice.

This analysis has employed Pickering's (1995) concept of the mangle of practice to join the structurational and ANT perspectives. The resulting framework views the development of IS as an active performance in which various types of agencies are mobilized by human agency, resulting in an emergent IS that reconfigures the intentions of the human agents involved. It suggests a more active view of IS than is adopted by most previous research. On this view, IS mobilize material agency, the disciplines that underlie their design and construction and the prior human agency involved in producing them (reconstituted in current agents' ideas of what the system is intended to do). This implies that pre-existing IS may emerge as more active and influential in enterprise system development than in traditional, small-scale IS. During ERP implementation aiming at organizational redesign, for example, the surface of emergence is likely to be on a grand scale, since diverse material, disciplinary and human agencies will be interacting.

The context of large-scale IS development introduces additional considerations. In large-scale IS development, multiple human agents and organizations are involved and they are likely to have quite different interests and projects. Further, for large-scale systems, the problem with existing cultural infrastructure or the installed base is quite significant since not only are the resources committed extensive (Kling & Iacono, 1989; Hanseth & Monteiro, 1997), but also disciplinary structures such as organizations and IS development systems are complex, multiple, and anchored in with many other structures. While IT artifacts may be changed and replaced relatively

quickly, there is always a problem with cultural infrastructure, which often takes a longer time to develop and change in large systems. This confronts developers with a difficult problem in that large-scale projects like ERPs typically require a heterogeneous group of users with very different priorities and vocabularies to radically rethink the organization and its habitual practices, but work habits, values, and dilemmas faced by users working with legacy systems are likely to carry over and confront the new system (Alvarez & Urla, 2002). This potentially creates more serious problems than in traditional system projects.

The case shows that pre-existing structures play an active role in constraining and enabling human agency in the development of IS. Human action needs to marshal pre-existing IS structures, and initiators and designers must work diligently both to resist and to accommodate them. We suggest that IS professionals and organizations should take pre-existing IS very seriously and take advantage of their duality as enabler and constraint in IS development. The focus on the role of pre-existing IS in this study works along the same line as Schumpeter's (1934) idea of combination and Usher's (1954) view of innovation as a cumulative synthesis of evolutionary ideas.

To take advantage of pre-existing IS, organizations should take a learning perspective on IS development and IS-based organizational innovation. Management and IS professionals need the capacity to learn 'paradoxically' from both the past and the future, to both exploit and explore in the terms of the organizational learning literature. Exploitation engages in the use of things already known, and thus involves refinement of existing systems and practices and drawing on existing competencies in the development of new IS, while exploration engages in the pursuit of new things, and includes search, variation, risk taking, experimentation, discovery, and innovation (March, 1991). As both institutional theorists (Offe, 1996) and technological innovation researchers (Garud & Karnoe, 2002) have observed, IS project initiators and designers are likely to face dilemmas between exploitation and exploration. It should be noted that seeking one at the expense of the other is likely to result in self-destructive outcomes in IS development both in the short and long run. Some recent studies (Lyytinen *et al.*, 2002) illustrate that this kind of paradoxical learning is needed and successfully used in practice.

This study suggests that the outcome of IS development is inherently uncertain. The interaction between human, disciplinary, and material agencies on the surface of emergence makes outcomes unpredictable. Indeed, an irony was introduced by unintended consequences of USMIS development: in attempting to develop 'one system for everyone,' the effort eventuated in (for all practical purposes) multiple systems adapted to local contexts yet bearing a similar name. As March & Olsen (1989) note, 'change rarely satisfies the prior intentions of those who initiate. Change cannot be controlled precisely' (p. 65). Both human and material agencies are temporally emergent rather than pre-determined and fixed. Thus, the feasibility of the deterministic view of development that has been depicted as the 'IT Professional Approach' (Suchman, 1994), the 'breakthrough approach' (Garud & Karnoe, 2002), or the 'decision-making school' (DeSanctis & Poole, 1994) is called into question by the case. Thus, for enterprise systems development, the popular approach such as business process re-engineering or re-everything by organizations may be self-defeating in practice.

The theoretical framework used in the study promises to advance both structurational and ANT perspectives on IS research. By enabling a closer focus on the IT itself and how it figures in development, the analytical concepts support Monteiro & Hanseth's (1995) call to take technology seriously and to open the 'black-box,' as well as Ciborra & Lanzara's (1994) call to take 'formative contexts' seriously. In recent years, a number of suggestive critiques of both structurational approaches and ANT have been registered, and they suggest routes that could be followed to strengthen these approaches. Re-working adaptive structuration theory concepts to suit the large-scale system development context offers a scheme adapted to fine-grain analysis of structuration during system development.

Finally, Truex *et al.* (2000) discuss two opposing schools of thinking about IS development: methodical and amethodical systems development. Methodical IS building in which IS development is viewed as a rational, universal, determined and goal-driven process is privileged in IS practice as well as most of IS theory. On the other hand, amethodical IS building is post-modernistic in that IS development is viewed as random, completely unique and negotiated. Thus, the former emphasizes formal (deliberate) approaches and the latter informal (emergent and situated) approaches to IS development. Our study suggests that large-scale IS are designed and drifting simultaneously. Taking pre-existing IS seriously is to see the opportunities and challenges emerging out of them in IS development. Then, from both theoretical and practical standpoints, IS development needs to be both methodical (deliberate) and amethodical (emergent). While the two are in tension, both are necessary for successful IS development, and if the tension can be managed they can complement each other's limitations. Order emerges out of chaos and *vice versa*. The informal emerges out of the formal, just as the formal emerges out of the informal. What is needed in IS development is continuously moving backwards and forwards between methodical and amethodical, being simultaneously emergent and deliberate. In this regard, such approaches as improvisation (Orlikowski & Hoffman, 1997), techno-change prototyping (Markus, 2004), and bricolage (Lanzara, 1999) that are said to be both emergent and deliberate could be adopted in enterprise systems development cases and empirical findings from those cases will

be helpful for the advancement of enterprise system development theory and practice.

Conclusion

There is a strong tendency in the systems development literature to focus primarily on the system under development and to underemphasize the role of pre-existing information systems. Pre-existing information systems are treated largely as black boxes that serve as resources or constraints on development. To overcome these limitations, this study attempted to shed light on the temporally emergent aspects of pre-existing IS and the interaction between different varieties of material, disciplinary, and human agency in IS development. The case of USMIS is used to explore the role of pre-existing information systems in the development and emergence of a new system. The case study develops the argument that pre-existing information systems are active forces in systems development. Their influence occurs both through the material constraints and directions inherent in existing systems and through the experiences and learning from previous systems which shape developers' approaches to building the new system. The study also develops a theoretical framework that integrates elements of structuration theory and actor-network theory to provide a more fine-grained analysis of how information technologies and institutional features interact in the structuring of organizational information systems. This study offers several theoretical and practical implications for IS development. We believe that the proposed concepts and theoretical framework, case findings and analysis, and implications in this paper can offer researchers and practitioners with new opportunities to advance the theory and practice of IS development by taking the role of pre-existing IS very seriously.

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