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A Theorizing Evolution of Inter-organizational Information Systems on Long Timescales

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Keywords: Inter-organizational Information Systems (IOIS), evolution

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THEORIZING EVOLUTION OF INTER-ORGANIZATIONAL INFORMATION SYSTEMS ON LONG TIMESCALES

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Abstract
Inter-organizational Information Systems (IOIS) are computer-based systems shared by, or connecting, several organizations. The on-going use and evolution on long timescales of these large scale socio-technical systems so far cannot be satisfactorily explained on the basis of existing theories of IS adoption, implementation and use. In this paper, we present a theory of IOIS in which the on-going use and evolution of these large-scale systems is treated as a practical and socio-material accomplishment of communities through boundary practices and structures. We draw on the structure/action reproduction paradigm of Structuration Theory to account for the persistence of these systems and thus explain their structure, while using the embodiment of action from Practice Theory to treat the material nature of these systems. We distinguish three dimensions of structure -- material, normative and ideational -- and we also distinguish patterns of actions (along these three dimensions) from constraining and enabling structures. However, we attempt to treat these three structural dimensions and their reproduction processes symmetrically throughout. This symmetrical treatment leads us to propose that these action/structure dimensions are not reproduced in isolation but rather undergo an intimate mixing, or mangling, in the process, which in turn suggests a new kind of two-way causal accommodation between the various aspects of structure that we term “resonance”.

Introduction

Many countries engage in building ICT infrastructures in areas as diverse as customs clearance, electronic patient records or collection of road tolls. These infrastructures are by design multi-stakeholder enterprises, and many of them are crossing the boundaries between private and public sector. These infrastructures are broad in scale and scope; they affect the life of individuals, are likely to change the landscape of industries and claimed to have transformative power. They are also instances of Inter-organizational Information Systems (IOIS). As IOIS are evolving to become infrastructures for industries or even across industries, they need to be studied at that level.

In this paper, we argue that while the extant literature has largely succeeded in explaining success and failure of IOIS initiatives on the time scale of particular projects and at levels of analysis of single organizations, dyads and a little higher, it does not provide a

theoretical framework for addressing the evolution of IOIS over long timescales and at the scale of industries within nations, an issue which has been identified as a significant gap in the literature. Specifically, in a review of research on Electronic Data Interchange (EDI, a key IOIS technology), Elgarah et al. (2005) find that "most studies reviewed in this research … employed the technological imperative to understand the short-term benefits and shortcomings of data exchange" (p. 19). In addition the time frame of the majority of studies was categorized as "cross sectional single snapshot" (p. 16).

By contrast, when we take a view of IOIS on longer timescales than these, and at units of analysis larger than organizations or dyads, different phenomena become visible which are both challenging and important. Many significant IOIS, such as computerized airline reservation systems (Copeland and McKenny, 1988) and electronic ordering systems in pharmaceutical distribution (Short and Venkatraman, 1992; Klein et al., 2008), have persisted for several decades with a recognizably persistent identity despite changing material form and institutional embedding. The traditional theoretical themes of IOIS research which, according to a recent survey by Robey et al. (2008), are adoption, governance and organizational consequences, do not capture the nature of this phenomenon. Beyond adoption we need to be able to explain post adoption phenomena such as routinization, drift, adaptation to changing circumstances, in short, the evolution of IOIS. Beyond the usual conceptualization of governance in terms of hierarchies and markets (Robey et. al. 2008) the role and governance of IOIS as shared, and possibly contested, infrastructure comes into view. Beyond organizational consequences the issue of how to conceptualise the role of Information and Communication Technologies (ICT) in the transformation of whole supply chains, industries and institutions needs to be dealt with. In addition to managers as addressees of recommendations derived from theoretical models, policy makers in governmental organizations, trade associations and the like become an important target for practical insights of the IS discipline.

Explaining and modelling these phenomena requires theoretical tools which are different from those employed by IOIS research at the firm or network level of analysis

dominant in the literature. In this paper we put forward a new theory of IOIS consisting of a set of concepts and relations between concepts which, as we will argue in detail, are both required by the nature of this phenomenon and form a coherent framework for theorising IOIS in a way appropriate to this new timeframe and scale.

Development of a theory which operates on this level of analysis poses a significant challenge as any such theory has to resolve an issue which still puzzles many researchers, namely the way that technology, as a material structure, interacts with organizational and institutional forces (Orlikowski and Scott, 2008). Specifically, focusing on IOIS evolution on long timescales implies that we treat technology, as materiality, symmetrically with regard to other social forces such as norms and ideas since, over long periods of time, these forces mutually influence one another and none can be considered to be a purely passive element nor an external determining force that is beyond the reach of possible feed-back loops. Symmetrical treatment of material and other social influences also requires that we come to grips with the complex two-way causality implied by such a symmetrical treatment which we have done by developing a new concept referred to as resonance and dissonance. To make contact with the materiality of IOIS as technologies we have elaborated Structuration Theory (Giddens, 1984) with ideas drawn from Practice Theory (Wenger, 2002; Reckwitz, 2002) to include a material dimension along with normative and ideational dimensions to the structure-action-duality.

The theory we present here is the outcome of an extended comparative study of evolution of IOIS in the pharmaceutical wholesale supply chains of four countries which iterated between theory development and empirical work that extended over five years and is still ongoing (Reimers and Li, 2008; Klein et al., 2008; Reimers et al., 2008). Rather than developing a theoretical model that, supposedly, applies to all types of information and communication technology, we choose a specific technology as our theoretical focus, Inter-organizational Information Systems (IOIS) which can be defined as information systems shared by several organizations or connected across organizations. While we do not want to argue that it is in principle impossible to develop a comprehensive theoretical concept of

technology as an integral part of social theory, we submit that often disagreement on the proper role of technology in social science can be traced to incompatible concepts of technology that refer to different levels of analysis (e.g. infrastructure vs. specific applications), allow for different degrees of physical manifestation (machines vs. technological knowledge), or imply different degrees of 'systemness' (program code vs. information systems), to name just a few dimensions along which -- often implicit -- definitions of technology can vary in fundamental ways (Leonardi and Barley, 2008). Conversely, we decided not to further restrict the scope of our study object -- e.g. by focusing on IOIS supporting only certain functions -- because one of the phenomena we observe at the evolutionary timescale is change in the very function and scope of IOIS (see, for example, the evolution of an IOIS described in Reimers et al., 2008).

We set out by developing our theoretical model in a step by step fashion. Subsequently, we will discuss our theory in view of previous calls for creating better and more explicit theoretical bases for IS research and outline ways how our theory can be used to generate new and promising questions for IS research. The conclusions summarize the main ideas and contributions of the paper.

A Practice Theory of IOIS

Technology is a material structure which, in social systems, is intertwined with other dimensions of structure that jointly enable and constrain action (Orlikowski, 2000). In order to understand the role technology plays in shaping social systems it is necessary to understand the nature of this association between technology and other dimensions of structure. At the same time, structure (including technology) does not exist independent of action in social systems (Giddens, 1984). Therefore, understanding the evolution of social systems (and the role played by technology in that evolutionary process) also requires an understanding of the relationship between structure (including technology) and action.

While there have been multiple approaches towards theorizing the relationship between technology and other dimensions of structure on the one hand and between

structure and action on the other hand, only relatively recently have scholars attempted to consider these constructs in a symmetrical way (Orlikowski, 1992 and 2000). To our knowledge, however, there are no models which achieve symmetrical treatment of both the relationship between structure and action as well as that between technology and other dimensions of structure. By invoking the term "symmetry**"** we refer to a theoretical treatment which does not, per se, privilege one theoretical entity over another in a relationship. In this paper, we introduce a theory-based model that aims at such a symmetrical treatment.

We draw on several theoretical concepts developed in different but related literatures in order to assemble the elements from which we build a new model of inter-organizational information systems that allows us to describe IOIS in a standardized way and to explain persistence, resilience and evolution of IOIS. In the following, we present our model in a step-by-step fashion, beginning with a definition of social practices which is then extended to how social practices are learned in so-called Communities of Practice that we also view as the mechanism of structural reproduction. We continue by demonstrating a novel way of how materiality can be incorporated into a practice-based model of information system and conclude by synthetizing the several concepts into our IOIS model and by showing how this model can be used to understand evolution of IOIS. At each point we indicate why the theoretical elements are required by the phenomenon (evolution of IOIS) modelled.

Social practices

Reckwitz (2002) characterizes a practice as "routinized bodily activities" (p. 251). Bodily activity here is intended to encompass mental and emotional activities, use of things, and talking, reading and writing (discourse), in addition to other (routinized) movements of the body. However, mental and emotional activities are bodily activities only on a "certain level" (p. 251) and go beyond bodily activities in that they are routinized ways of understanding (knowledge) and desiring (motivation). Structure manifests itself in and through routine patterns of body movements and routinized ways of understanding, desiring, talking etc.[i] This notion of practice thus contains elements which can be used for empirically identifying a

practice, namely the repeated (routine) performance of a specific body movement, routine patterns of discourse and use of things. One cannot capture actions of a non-routine kind by this method, of course, which are enabled and constrained by structure just as well. This disadvantage, however, seems to be minor in the context of the study of IOIS since the operational aspect of IOIS implies a focus on routine action. Meanwhile, the huge advantage of basing a theory of IOIS evolution on the concept of practice is that practices are, by their very definition, ongoing phenomena which do not necessarily rely on conscious decision making for their explanation. For IOIS research on adoption of technology for specific instrumental purposes a focus on strategic decision-oriented modes of action is often appropriate. However, when discussing the persistence, evolution and resilience of socio-technical practices on timescales greater than single projects, a good account of the dynamics of routinized modes of action is essential.

Communities of Practice and structural reproduction

While Reckwitz thus provides a useful description of social practices as "the product of training the body in a certain way" (p. 251), it remains open how this learning process comes about. In addition, to understand IOIS evolution we need a formulation of social practices which allows us to describe practices as part of organizational (and cross-organizational) phenomena. We draw on Lave and Wenger (1991) and Wenger (2002) to obtain a description of this learning process and, at the same time, of practices as organizational phenomena. According to Lave and Wenger, learning always occurs in communities which they call Communities of Practice (CoP). As we describe the process of becoming competent in a practice we are also describing the process by which participation in the practice creates the conditions for is reproduction, and thus its durability. We will refer to the durable elements of the practice as its structure and distinguish several dimensions of this structure. The essential elements of our account of structure and structural reproduction derive from Structuration Theory (Giddens, 1984).

New members to a CoP become attuned to a practice through apprenticeship, i.e. by observing the behaviour of experienced members and their responses to own engagement in action. New members try to identify patterns of behaviour, attempt to make sense of these observed patterns, i.e. sense possible structures which could have enabled/constrained the actions resulting in the observed patterns and then tentatively engage in their own actions, thus continuously validating (or invalidating) their sense-making regarding rules and affordances. As such behaviour is repeated, parts of it become routine and automatic, i.e. some parts of behaviour are relegated to "body memory" (a "trained body" according to Reckwitz) which makes use of the affordances of the physical environment, including technology. Actors also develop a "moral sense" which helps them to distinguish right from wrong actions without the need for cognitive processing of information. Finally, actors learn how to rationalize their actions in view of ideas that are reproduced in that CoP. Figure 1 summarizes the ideas presented thus far.

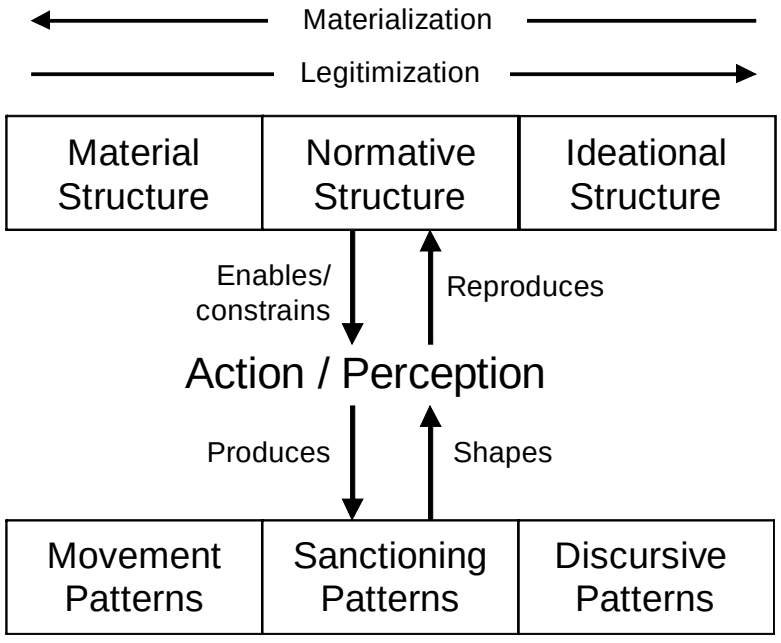

Figure 1: A proposed model of practice

The three dimensions of the structure of practices which emerge through these distinctions (material, normative, ideational structure) have a counterpart in corresponding patterns,

namely patterns of flows of physical things (including movements of the human body), sanctioning patterns and discursive patterns. Actors may accidentally, consciously or strategically change these patterns which may affect the reproduction of structures; in addition, actors may change their perceptions of patterns which could also affect the reproduction of structures (Giddens, 1984). Thus, the process of structural reproduction allows for changes while structures cannot be changed arbitrarily. We further propose that, within a Community of Practice, the three dimensions of structure tend to be mangled together in the reproduction process, i.e. material structure is not reproduced in isolation through movement patterns and so forth. Rather, actions and perceptions always involve bodily movements, sanctioning patterns and, generally, the exchange of arguments through discourses. This mangling together stabilizes the reproduction process through processes of materialization and legitimization.[ii] We will expand on this idea below.

This formulation of the reproduction process, based on the CoP concept, is useful to us as it provides a way to empirically identify practices, namely by making sense of observed patterns just as new members to a CoP would. However, we recognize that our formulation is also an extension of Structuration Theory, albeit theoretically compatible with it. According to Giddens, structural change occurs through "reflexive monitoring of action" (1984, p. 191). In so far as one monitors the actions of others, reflexive monitoring of action becomes a social process. Through perception of patterns of behaviours actors can sense the structural properties which have -- supposedly -- guided the actions of others. This 'reconstruction' (the reproduction of structure) thus takes place in and through the process of perception by observers who then use these structures to guide their own actions (which will be observed by others and so on). The theory of social practices, as formulated by Lave and Wenger (1991), views the reproduction of structure as a process of participation in which actors perceive and imitate each other because they are mutually engaged in a common endeavour; this process (social learning) is viewed as "a source of social structure" (Wenger, 2002, p. 96). Note that the concept of 'perception' does not necessarily or even generally imply a process of intentional thought activity; rather, the process of perception can be sub-

conscious in the sense that certain observed events 'automatically' -- i.e. through a learnt reaction template ("routinized ways of understanding, desiring etc." in terms of Reckwitz' concept) -- result in certain actions (cf. Michaels and Carello, 1981). This is a big advantage over rational theories of action often employed in research on adoption of particular IOIS projects which implicitly assume that relevant action (strategic decision) is reasoned, but which cannot capture important aspects of routinization of system use in post adoption phases and over longer timescales (see Smith et al., 2007); this is especially true in the context of operational information systems which are characterized by dominance of routine actions.

The two-way causal relationship between structure and patterns of action depicted in Figure 1 is an essential ingredient of our theory of IOIS evolution. When studying IOIS phenomena at smaller units of analysis such as adoption of specific IOIS technologies in organizations or dyads, it is reasonable to view cause and effect in a linear mode, for instance, as certain factors determining project outcomes. It is also reasonable to view action against a substantially fixed context external to the focal organizational actor. However, when modelling evolution of IOIS practices in larger units (supply chains and national industries) we must acknowledge that the contexts in which actions take place are substantially created and reproduced by those action themselves (Johnston and Gregor, 2000; Kurnia and Johnston, 2000). Consequently, the arc of causation linking structure and action is necessarily two-way while the constructs of structure and action are not independent but mutually constitutive. This is what is depicted by the vertical elements of Figure 1.

Material aspects

It has been noted that often IS studies fail to specify the role or the place of information technology as a material artefact in their conceptual frameworks (Orlikowski and Iacono, 2001). This is also true for earlier attempts at applying Structuration Theory to the study of information systems (Orlikowski, 2000). Integrating the materiality of information technology into the conceptual apparatus of IS studies is important for our purpose as we need to treat

information technology on par with organizational and other social forces in order to be able to address IOIS evolution. IOIS consist of material as well as organizational and other social elements that jointly affect each other and in this mutual interaction bring about continuous change. In order to overcome this weakness of Structuration Theory when applying it to our framework we draw on a proposal by Child (2000) who developed a framework for studying organizations across national cultures. Child, in turn, based his framework on a distinction between material and ideational forces introduced by Max Weber and suggests that these two forces influence institutions which then constrain and enable social action. The main idea of this framework is that cultural factors affect institutions through ideational forces while material forces represent some economic and thus universalistic constraints.

Child suggests that both ideational and material forces have an indirect and a direct effect on action; indirectly, they affect action through shaping institutions while also directly affecting action through task contingencies -- in the case of material forces -- and value preferences -- in the case of ideational forces. Earlier attempts to apply Structuration Theory have struggled with the idea of rules become 'inscribed' in technologies (Orlikowski, 2000). Application of the Child-framework allows for viewing rules as a separate category of structure which is not 'hard-wired' in technology while still being able to conceptualize material structure as constraining and enabling action. This can be illustrated by integrating Child's ideas into the model of practices developed above.

We are concerned here with the direct effects referred to by Child (while much of the literature that discusses technology from a structuration perspective is concerned with what Child would term indirect effects such as "embodiment" or "inscription" of social rules in technology). These direct effects could be understood, in the context of Reckwitz' practice concept, as "... stable relation between agents (body/minds) and things within certain practices …" (2002, p. 253) that are reproduced in practices. Reckwitz claims that these relations are social structures in exactly the same way as other social structures such as norms that involve relations between agents (ibid).

In the context of our extended practice model described above, analysis of reproduction of material structure in the same way as social structure can be illustrated as follows. Observation of moving bodies and things not only makes material structures visible but also informs about their affordances such as when a driver observes other cars racing by on a winter day. From this, he/she might (possibly wrongly) conclude that the street is not slippery. Another example is people moving along a hardly visible path indicating where exactly the path runs. Thus, observation of moving things indicates existence and material properties of material structures which then enable/constrain action, i.e. reproduction of material structure does not refer to their maintenance from a planner's or operator's point of view but to the perception of the material properties of an actor's environment which guides that actor's behaviour. This is strictly similar to how normative and ideational structure is reproduced. For example, observation of discursive patterns reveals to the knowledgeable actor (socially) valid cause-effect or means-ends relationships which then guide his or her actions. Again, reproduction here refers to the perception of ideational structures rather than to some form of objective, externally existing law (law of nature), i.e. to the socially mediated ideational structure which is reproduced through -- possibly reflective -- monitoring of discursive patterns (whether or not such external and objective laws of nature exist).

We explicitly refer to material properties, as opposed to physical properties, because the term emphasizes the world as it is encountered by the body, rather than the physicality of the world which is viewed by scientist (things, properties, atoms, etc).

Inter-organizational Information Systems

So far we have just considered reproduction of a practice within a single community. To make the connection to IOIS we must now consider how multiple distinct practices can become and remain aligned. In addition, to come to grips with persistent alignment of IOIS on long timescales over which even the material form of the systems may change, we tackle this problem in a way quite distinct from the standard IOIS literature, using practice theory notions. Different kinds of practices are distinguished by the differing enterprises in which the

members of the communities engage and around which they form their identities. Examples from our empirical context are the product ordering (procuring) practice and product provision (supply) practice. These are distinct Communities of Practices with separate procedures, objectives, legal restraints, languages, stories, norms, operating methods, etc.; in addition, these Communities of Practice are often -- but not necessarily -- located in separate commercial organizations, as is the case for a supply chain. However, the differing enterprises of these communities are necessarily connected through the "product" which must be passed from one to the other effectively if they are to fulfil their respective enterprises. Consequently, the connected communities must achieve some alignment of their practices which must be maintained over time along with the separate reproduction of these practices in each community. When these practices are located in different organizations, maintaining this alignment is problematic because the individual practices will tend to drift to accommodate changing circumstances in the particular organizations (Ciborra, 2000). Some possibilities for maintenance of such an alignment are discussed by Wenger (2002), and range from the brokering actions of individuals to full-blown separate practices whose enterprise is such an alignment.

According to the three dimensions of structure described above, several communities of practice can be connected through patterns of sanctioning behaviour and discursive patterns in addition to patterned movements of things (such as products). As things, sanctions and arguments cross from one CoP into another, they contribute to the reproduction of structure in both communities. For our study of IOIS, the case of practices that are connected through flows of things is the most relevant one. These things are primarily goods, money and data. We call flows of things across practices a transaction.

The material structures reproduced through transactions can be viewed as one type of boundary object (Wenger, 2002; Star and Griesemer, 1989). Bowker and Star (2000) describe a boundary object as an interface between different communities of practice; more specifically, they describe it as an entity which is shared by different communities of practice but viewed or used differently in each of them; this property, we argue, enables connections

between the several practices through transactions. A product file assigning standardised product codes to product descriptions can be such a boundary object: for the buyers the standardised product file facilitates splitting of orders across a number of suppliers while it enables suppliers to reach a large constituency of buyers who are adhering to the standard. According to Star and Griesemer (1989), boundary objects should posses a high degree of interpretive flexibility, i.e. they may be interpreted differently and thus lessen the degree of requisite alignment between practices in cases of transactions. However, in the context of information systems, boundary objects tend to lack interpretive flexibility when automated data processing is involved. While boundary objects can be material, normative, and ideational structures (Wenger, 2002), we focus on material boundary objects as for the specific case of IOIS we are interested in understanding how communities of practice are connected through data flows. Also, we prefer to substitute the term “boundary object” with the term “boundary structure” for the general case and reserve the term “boundary object” for a specific perspective on boundary structures, as explained below.

Patterned flows of things within a practice are, according to our theory, mangled together with the reproduction of norms and ideas. In contrast, if two practices are connected only by material flows, these horizontal stabilization processes of materialization and legitimization will be lacking. One could also say they are overly rigid or “brittle” as they concern only the material dimension. This brittle nature of material connections between practices -- if not compensated -- would lead one to predict that any resulting alignment will not be stable as they may become inconsistent with structures reproduced in the separate practices and, with no accompanying flows of discursive and sanctioning patterns that would make these material flows more plastic, they will not adjust to these changed structures. Consequently, in order to explain persistence and evolution of alignment in IOIS on long timescales we must consider how this brittleness is overcome as an on-going practical achievement rather than a rigid technical link.

Since purely material boundary structures are brittle, maintaining connections through transactions frequently requires additional effort which helps to make sense of transactions

or otherwise meaningfully relate to transactions. Such effort could consist of translation, coordination, or alignment actions (Wenger, 2002). Wenger describes such activities as brokering and encounters. Brokering is a unilateral activity, involving a member of one practice participating in the reproduction process of another practice through negotiation, translation, and coordination activities while encounters refer to a bilateral action in which "delegates" of two practices meet. We prefer to subsume both concepts under the more established notion of boundary spanning (Thompson, 1967). Boundary spanning can evolve into a separate practice (Levina and Vaast, 2005) which would be called a boundary practice (Wenger, 2002). The enterprise of a boundary practice is the alignment between the connected practices. The boundary structure is not a structure which is reproduced in the boundary practice; rather, the boundary structure becomes the object of actions enabled and constrained by other structures reproduced in the boundary practice, for example a versioning system that helps to keep track of different versions of an interface specification. That is, a boundary structure becomes a boundary *object* only from the perspective of a boundary practice. The reason for this terminological distinction is that actions performed as part of a boundary practice cannot directly affect the reproduction process of the boundary object (as structure) as it is manifested in the connected practices; however, they can modify the boundary object (as an artefact) in view of the knowledge of these reproduction processes. Such actions include facilitation of negotiations and translations.[iii]

We define an inter-organizational information system as a set of CoPs located in separate organizations which are connected through specific technological (i.e. material) boundary structures so as to facilitate transactions between these CoPs. IOIS boundary structures can be either shared definitions of data to be exchanged between data processing applications or shared databases, which connect data processing applications maintained in separate practices. This rather unusual definition of, and perspective on, IOIS has been necessitated by the phenomenon we wish to model. A particular IOIS can then be characterized by the identity and constellation of practices (including boundary practices) which are aligned with each other as well as by the structural properties of each involved

practice. Evolution of an IOIS can be described as changes in the structural properties of involved practices and as changes of the identity and constellation of practices forming the IOIS. Figure 2 illustrates our definition of an IOIS.

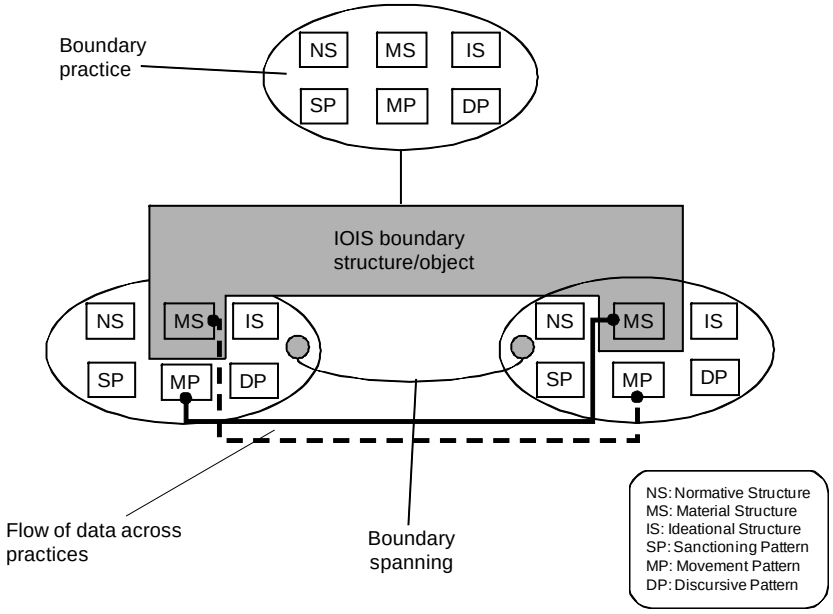

Figure 2: Conception of an IOIS in our practice theory model. Practices share an IOIS boundary structure. Alignment of the practices through the boundary structure requires either ad-hoc boundary spanning activity or a full-blown boundary practice (which views the boundary structure as a boundary object)

Evolution of IOIS

In order to understand the way the structural constitution of practices change, the horizontal relationships among structural dimensions need to be analyzed more explicitly. As proposed above, structural dimensions are not reproduced in isolation; rather, the reproduction process mangles together the several dimensions, thus creating a mechanism through which structural dimensions interact with one another. For example, as one uses an ATM for withdrawing cash, one may be reminded of the efficiency and convenience with which transactions in small-scale shopping are possible using cash payments; thus, the idea that using cash for shopping is (still) efficient "resonates" with the experience of (successfully and quickly) obtaining cash from ATMs. In terms of our practice model, (successfully) using an ATM not only reproduces the material structure that we call an ATM but also contributes to the reproduction of the idea that cash-based payments for small-scale shopping are (still)

efficient. We call such mutual confirmation or reinforcement of structures “resonance”. It occurs because structures, under the right circumstance, can be co-reproduced. Co-reproduction is possible, in turn, because the structural dimensions are mangled together in their reproduction, i.e. they are not necessarily individually reproduced in isolation. In sum, mangling is the process that, under the right circumstance, leads to co-reproduction which we call resonance. Conversely, the mangling can also lead to dissonance if reproduction of structure in one dimension denies reproduction of structure in another dimension.

The development (“implementation”) of an IOIS can then be re-conceptualized at our level of analysis as a process of embedding IOIS boundary objects in existing practices (thus extending the boundary objects into boundary structures). “Embedding” means that boundary objects are modified so as to resonate with existing structures in the several practices. Dedicated boundary practices may evolve that are concerned with maintaining and adjusting the boundary structure implying that the boundary structure becomes the object of their enterprise. An example would be the boundary practice of a retailer association to maintain product codes, which are used in the ordering and delivery practices of retailers and wholesalers respectively. Alternatively, boundary spanning activities must occur which affect the reproduction of the boundary structure as it manifests itself in the several connected practices. Over the lifetime of an IOIS, individual instances of (material, normative, ideational) structure may be replaced, added, or removed from the practices that -- together -- constitute the IOIS.

This conceptualization of technological change contrasts with standard alternatives such as technological determinism (e.g. Chandler 1980) and social shaping (e.g. Williams and Edge, 1996). From a technology determinist perspective, material structure would be considered to be privileged in explaining the development of an IOIS; for example, the initial technical characteristics of the IOIS might be considered to have a determining influence on its further evolution. A social shaping perspective would privilege some other structural aspects (such as power structures) in explaining the development of an IOIS (we recognize, though, that social shaping theorists generally avoid any reference to the notion of structure

in their explanations). From a rational perspective (such as economics) explanation of IOIS evolution would rely on the influence of some ideas, especially of improved efficiency through standardisation. None of these privileged determinisms is viable in explaining the phenomenon of evolution of socio-technical systems at long timescales. In contrast, based on our model we explain the evolution of an IOIS as processes of adding, removing and replacing instances of structure through reproduction processes in individual practices connected by boundary structures and/or in boundary practices that may have evolved. Agents are constantly trying to appropriate and manipulate structures to extend their influence while at the same time relying on the stability of structure to be able to act at all (for instance to keep transactions happening).

Discussion

In an influential paper, Markus and Robey (1988) distinguish three dimensions of causal structure in organizational theory, namely causal agency, logical structure, and levels of analysis, and suggest that "[b]y carefully considering each of the[se] dimensions of causal structure …, researchers should be able to construct sounder theories to guide more fruitful research." (p. 596). We have adapted and extended their theoretical meta-categories to contrast our approach with the conventional approach found in much of the current IOIS literature (Robey et al., 2008) as depicted in Figure 3.

Research Entity	Stylized IOIS theory	Our IOIS theory
Level of analysis*	Organisations or dyads Single layer	Supply chains, industries within nations Multilayer
Causal agency* (Mode of explanation)	Input/output Factors/conditions => outcomes	Two-way causality Emergence
Logical structure* (Theoretical paradigm)	Preceding event causes or conditions subsequent event	Duality of structure and action (simultaneous mutual conditioning)
Theory type**	Predictive, normative, descriptive	Explanatory
Unit of analysis	Episodes of organisational use of technical system	Time extended trajectory of sociotechnical practice
Phenomenon to be explained	Success/failure Use/non-use	Persistence Plasticity/resilience
Empirical data	Org. cases at present time	Historical cases
Relation of people to technology	People use technology Technology is tool	People and technology make constituting practices

* Category defined by Markus and Robey (1988)
** Category defined by Gregor (2006)

Figure 3: Characteristics of our theoretical approach relative to the majority of the current IOIS literature

Rather than attempting to accurately synthesize the existing IOIS literature into a single characterization -- an effort which would seem futile given the breadth and depth of the IOIS literature -- we have created a stylized characterization that we believe captures the majority of the literature without claiming to be comprehensive for the purpose of juxtaposing our approach and thus highlighting its novelty and possible contribution. The first three dimensions of this characterization are taken from Markus and Robey (1988) while the fourth draws on Gregor (2006). We have added another four dimensions which we believe bring out the novelty of our approach.

The IOIS literature predominantly studies single organizations adopting some type of technology used for building inter-organizational information systems or dyads of such organizations. Only relatively recently have researchers moved to higher levels of analysis such as a whole industry (Steinfield et al., 2005; Reimers et al., 2004; Damsgaard and Lyytinen, 2001; Johnston and Gregor, 2000). Our model extends across the organizational

and the network level, specifically through the concept of boundary practices along with 'constituent' practices which are linked by IOIS boundary structures.

While the IOIS literature predominantly relies on case research methodology and thus does not fall into the category of 'variance theories' (which require statistical sampling), the causal structure employed in explanations is nevertheless unidirectional, whether the causal agent is modelled as a factor or, more cautiously, as a condition or pre-condition. In contrast, our model of causality -- resonance -- is two-way, implying that events are not caused but emergent.

The dimension of logical structure is tightly related to that of causal agency; in our view, the main difference is that the former refers to a higher level of theorizing. The dominant view in the IOIS literature views events as unfolding sequentially in time; this, in our opinion, is also the reason why recent attempts to apply Structuration Theory in the IS field (Leonardi and Barley, 2008; de Vaujany, 2008; Volkoff et al., 2007; Dobson, 2001) rely on an episodic approach such that time is divided into periods in which unidirectional causality can be assumed. In contrast, our model attempts to achieve a treatment of theoretical entities such that simultaneous mutual conditioning can be captured.

In terms of Gregor's (2006) categories most models in the IOIS literature can be described as predictive, normative or descriptive in the sense that these theories do not describe an abstract mechanism which would explain observed events and outcomes. In contrast, the concepts of legitimization, materialization, and reproduction that figure prominently in our model can be viewed as abstract, "generative mechanisms" (Mingers, 2004) that explain observed events and outcomes while we also acknowledge that, given the inherent openness of agency, precise prediction is untenable.

Clearly, the distinctions made thus far transcend the often made distinction between variance and process theories. In fact, we would view both, variance and process theories as mostly converging on the left-hand side of our stylized spectrum of theories. This point is underscored by the main motive driving both many variance as well as process theory-type studies, namely an interest in explaining success and failure or use and non-use of IOIS at

the system project level. In contrast, our main interest turned towards explaining the phenomenon of persistence and resilience of IOIS which appeared on our radar once we started to look at IOIS over extended periods of time, not just single episodes of system adoption, implementation or use (implying the use of historical (case) studies). That different unit of analysis (extended trajectories of socio-technical practice) itself came into focus as a result of our different conceptualization of causal agency. Thus, along with our model emerged a new way of looking at the phenomenon which we propose will stimulate new, interesting and relevant research questions. For example, the literature on system failure or non-use often views such phenomena as resistance to change and increasingly relies on political causal agents for explanation. While researchers are often sympathetic with users who resist using new technology, they still view this as a problematic outcome that needs to be amended, albeit by methods more sensitive to the interests of users. In contrast, we would view such outcomes as resilience of existing, socio-technical practices, i.e. something which may also be seen as positive. Attention then converges on the issue of how amenable to change practices are and questions may be asked as how to lever existing degrees of plasticity or resilience for organizational purposes. Another significant difference in terms of the research questions emanating from our model is that the issue of adoption and implementation would fade into the background on these timescales. Rather, evolution of existing practices, including technologies which are always a constituting element of practice, would come to the fore. Thus, rather than asking whether users/organization will adopt certain new technologies or whether certain new systems will be implemented successfully, the very distinction between existing and new technology would seem to be problematic and researchers would rather focus on understanding how technology, as material structure, is evolving and changing along with the other dimensions of structure. The concepts of plasticity and resilience may then be extended and built upon in order to address questions of immediate organizational relevance, such as how an organization can build new capabilities or adapt to changing environments.

Finally, technology is viewed differently. It is less a tool that can be used for certain -- individual or organizational -- purposes. It is rather seen as a specific type of structure that becomes an integral aspect of the very phenomenon of human organization. Organizational theory is, as has been pointed out several times in the literature (Orlikowski and Barley, 2001) largely void of technology as if humans could build an organization entirely without technology and then, selectively and for specific purposes, amend organizational capabilities by adopting certain technologies. In contrast, our model suggests that the phenomenon of human organization is fundamentally intertwined with the development and use of technology and therefore becomes a constituting element of organization theory. Thus, our model suggests that the study of organizations necessarily has to include technology as a constituent of organizational phenomena. We anticipate that such an approach would reinvigorate both the organizational as well as the information systems literature which, so far, have largely maintained separate scholarly identities.

Conclusion

We have presented a new practice theoretical perspective for the purpose of explaining evolution of IOIS. We have argued that, as IOIS are evolving into the information infrastructure of whole industries, this change of perspective becomes necessary from both an academic and a practitioner's point of view. Our theoretical model allows us to identify and describe IOIS in a standardized way; as our model is theory based, it also allows us to describe possible influences on the evolution of IOIS as these factors are implicated in the processes that explain the very existence of IOIS, namely structural reproduction and materialization and legitimization.

The paper contributes to theory in the information systems discipline by presenting a theory of IOIS in which the on-going persistence and change of these large-scale systems is treated as a practical and socio-material accomplishment of communities of practice. The information technology and system component is modelled in terms of boundary practices and structures. The approach is novel and contrasts with existing rational theories of

"adoption" as a decision and technological determinist theories emphasising the technological manifestation of these systems at the expense of human interpretation and appropriation.

We have also made contributions to the social theory approach to information technology adoption and use. We draw on structuration-style reproduction and embodiment of practices to propose a symmetrical treatment of three dimensions of structure -- material, normative and ideational -- and associated patterns of actions. Recognition that material structures (as opposed to physical entities) are the experienced durable complement of bodily actions is an important and novel step which allows a material/bodily-action duality to be treated on a par with social and ideational structure/action dualities. This symmetrical treatment of structure/action reproduction leads us to propose that these action/structure dimensions are not reproduced in isolation but rather undergo an intimate mixing, or mangling, in the process, which in turn suggests a new kind of two-way causal accommodation between the various aspects of structure which we term "resonance". We believe they have wider applicability in the study of the use and evolution of use of technologies in general.

In the course of our theory development we have introduced extensions to Practice Theory -- as elaborated by Structuration Theory -- to show how meso-level social systems can be modelled from this orientation, using Inter-organizational Information Systems as a specific case. We propose that this approach could be fruitfully extended to develop a fresh theoretical perspective on meso-level organizational phenomena such as supply networks or large, divisionalized and multi-site firms. Practice Theory provides us with conceptual tools to specifically address inter-organizational issues and elaborate different ways how Communities of Practice can be linked to each other.

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Endnotes

[i] While Reckwitz draws, among others, on Giddens and Bourdieu, he claims that structure is not confined either to the minds of actors nor to the patterns created by their behaviour which may be interpreted to constitute a deviation from Giddens; Wenger (2002), in his exposition of the concept of *communities of practice*, emphasizes the emergent nature of structures and positions his concept relatively closer to Giddens' than to Bourdieau's notion of structure (p. 96). Below, we will make a proposal how to reconcile the slightly inconsistent notions of structure in practice theory and in Structuration Theory.

[ii] In a similar way Sewell (2005, p. 136) conceives the character of structure as "composed simultaneously of schemas, which are virtual, and or resources, which are actual. … if resources are instantiations or embodiments of schemas, they therefore inculcate or justify the schemas as well."; note, however, that we would not conceptualize material structure as "embodiment" of ideational structure while we also register concerns regarding the distinction between virtual and actual structure.

[iii] Our distinction between boundary object and boundary structure corresponds to that by Orlikowski (2000) between technology-in-practice and technology-as-artifact.

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