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2010

BRIDGING THE CHASM BETWEEN SOCIOTECHNICAL AND TECHNICAL VIEWS OF SYSTEMS IN ORGANIZATIONS

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Completed Research Paper

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Abstract

This paper presents a metamodel that addresses the long standing gap between technical and sociotechnical views of IT-reliant systems in organizations. The metamodel provides an integrated set of concepts that extend and clarify the work system framework and related work system concepts, thereby helping in understanding, analyzing, and designing technical and sociotechnical systems. The metamodel is a step toward an enhanced work system approach that is understandable to business professionals, is more rigorous than most current applications of work system concepts, and can be linked more directly to precise, highly detailed analysis and design approaches for IT professionals. Specification of the metamodel clarifies ambiguities in the work system framework and forms a clearer conceptual basis for tools and methods that could improve communication and collaboration between business and IT professionals. It also might be used to organize a body of knowledge for the IS field.

Keywords: sociotechnical systems, metamodels, work systems, work system framework, body of knowledge for the IS field, lightweight systems analysis

A New Approach to a Fundamental Problem

The Track Description for the Systems Development and Alternative Methodologies track at ICIS 2010 notes, "despite 50 years of ISD experience, the perception of the so-called "software crisis" still persists. Unfinished and run-away projects, systems poorly aligned with businesses and user requirements and the pervasive problem of the costs required simply to play in the IS game even before realizing any tactical or strategic advantage all continue to top the list of executive concerns about the IS function." (Truex and Kautz, 2010) In other words, this problem has proved relatively intractable despite a broad range of innovations in practice and in research.

This paper addresses two aspects of the problem: 1) conceptual and methodological gaps between sociotechnical and technical approaches and 2) communication and knowledge gaps that block and degrade collaboration between business and IT professionals. Progress in these areas could yield significant benefits for the IS field.

This paper's breakthrough idea is a specific metamodel, an integrated set of concepts that bridge the chasm (Moore, 1999) between sociotechnical and technical views of systems in organizations and that can support many methods for describing, analyzing, and designing both sociotechnical systems and the hardware/software configurations they contain and use. (A metamodel is a summary of relationships between concepts for producing conceptual models of specific situations in a domain. For example, if the concepts "informational entity" and "user role" were part of this paper's metamodel, then the conceptual model of a specific system in an organization would identify informational entities and user roles for that specific system.)

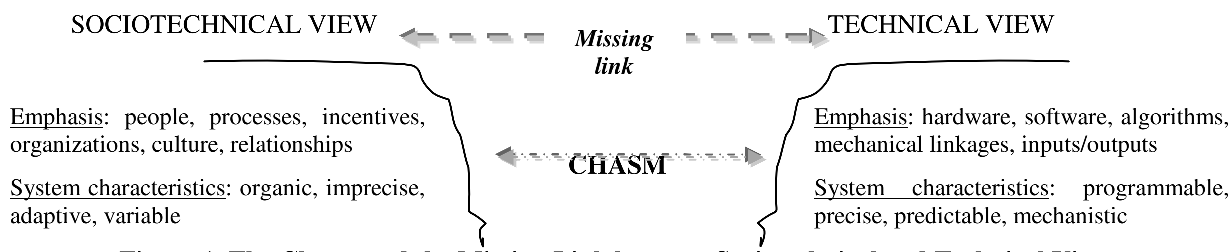


Figure 1. The Chasm and the Missing Link between Sociotechnical and Technical Views

The metamodel is a significant reformulation and extension of the work system framework, which was developed as a step toward bridging the chasm shown in Figure 1, but which has a number of limitations that the new metamodel addresses. As will be discussed, the work system framework and other aspects of the existing work system method have been used and discussed in a variety of ways. While the framework is effective for summarizing work systems and for organizing business-oriented analysis and design of IT-reliant work systems, the new metamodel explicitly represents topics and issues that are not represented by the work system framework and that are important when trying to understand specific work systems at a level deeper than an executive summary or an MBA term paper. In addition to forming the basis for extensions of the work system method, the proposed metamodel has potential applications in many important aspects of the IS field, including:

- evaluating and comparing various ISD methods (Which aspects of the metamodel does each method emphasize, downplay, or ignore? What are the implications concerning the limitations of those methods?)
- summarizing and evaluating communication between business and IT professionals (Which topics and issues in the metamodel are emphasized, downplayed, or ignored?)
- comparing and evaluating different IS theories (Where do they belong in the metamodel? What topics and issues do they address that do not appear in the metamodel?)
- codifying the body of knowledge for the IS field (What is known about each element and relationship in the metamodel? Which general topics and important types of examples have not been studied adequately?)

Criteria for an integrated metamodel. A genuinely useful, integrated metamodel that bridges the chasm between sociotechnical and technical views of systems in organizations should meet the following criteria:

1) To foster better communication between business and IT professionals, the metamodel should consist of terms that are understandable to typical business professionals. UML concepts such as object, class, abstraction, encapsulation, inheritance, and polymorphism would not fit in this type of metamodel.

2) The metamodel should guide the analysis of a system to include important topics and issues that might otherwise be overlooked. An overly simple metamodel containing just a few terms (e.g., "boundary, input, transformation, output" or "task, structure, people, and technology") would not provide enough guidance unless each of those terms was connected to a second or third layer of concepts that might not appear in a summary diagram.

3) The metamodel should assume that human participants are usually essential elements of the system, not just users of hardware and software. Its default assumption should be that the term "system" refers to a sociotechnical system rather than a computer system or hardware/software configuration.

4) The metamodel should cover all operational systems that perform work within or across organizations, rather than just manual systems, computerized tools that are used by users, totally automated systems, or entire enterprises.

5) The metamodel should include customers because sociotechnical systems exist in order to produce products and services for internal and/or external customers.

6) The metamodel should provide concepts that are useful in telling stories about a system, rather than just specifying its abstract structure. (See Ramiller and Pentland, 2009; Guber, 2007). It should recognize that stories that appear during analysis and design of sociotechnical systems often involve aspects of alignment between resources, structure, and intentions. Resources include technology, information, human participants, and any other resources that are relevant. Structure includes the structure of resources, activities, and actor roles. Concepts related to intentions include strategies, goals, metrics, and incentives, among others.

7) The metamodel should support the decomposition of sociotechnical systems into successively smaller subsystems. That process will reveal hardware/software configurations that should be analyzed and designed using technical methods that are designed for IT professionals but are usually ineffective for business professionals.

8) The metamodel should provide the means for tracing all aspects of a proposed system and its subsystems back to high level summary descriptions of resources, structure, and intentions.

Organization. First is a summary of some of the literature related to topics and issues that make the development of this type of metamodel desirable. Aspects of the work system approach and work system framework (Alter, 2003, 2006, 2008a, 2008b) are discussed since the metamodel itself is an extension of the work system framework and was developed partly in response to limitations of that framework as an analytical tool rather than as a tool for high level summarization. The metamodel is presented as a complex diagram containing 31 concepts and numerous links among pairs of concepts. The discussion of the metamodel covers its general form and explains how the nine elements of the work system framework are clarified in the metamodel. A final section on extensions and future research shows that the metamodel qualifies as a breakthrough idea because it points to new or improved paths for exploring ideas and issues that are significant in describing, analyzing, and designing systems in organizations.

Literature Survey

After decades of experience, the success rate on IS/IT projects remains unacceptably low. The many reasons that have been cited include, among many others, inadequate business/IT communication, inadequate user participation in projects, lack of support by business executives, difficulties with implementation in organizations, technical and conceptual complexity of IS/IT projects, inadequate resources for projects, unrealistic project schedules, and staff turnover. IS/IT research has addressed these issues from various viewpoints, such as studying:

- alternative information system development methods (Iivari et al. 2000-2001; Checkland, 1999; Mumford and Weir 1979; Truex et al. 2000; Beck et al., 2001, Browne and Ramesh, 2002)
- characteristics and extent of the system development challenge (e.g, Rubinstein 2009)
- system and project risks (e.g., Straub and Welke,1998; Wixom and Watson, 2001)
- business/IT communication and business/IT alignment (e.g., Beath and Orlikowski, 1994; Reich and Benbasat 2000; Luftman et al. 2006; Cramm, 2010).
- the usefulness and pitfalls of IS development tools for IT professionals (e.g., zur Muhlen and Recker, 2008; Dobing and Parsons, 2006; Siau et al, 2005; Topi and Ramesh, 2002; Purchase et al, 2001)
- concepts and models related to paths to success (e.g., critical success factor models (Rockart, 1979); the technology acceptance model, TAM (Davis, 1989); task-technology fit (e.g., Goodhue and Thompson, 1995), IS success model (DeLone and McLean, 1992), user participation models (e.g., Markus and Mao, 2004))

Many of the original problems remain despite the many hundreds of papers that have been published related to these and other topics. Non-trivial IS/IT projects are still comparatively risky, contentious, and difficult to execute.

Most directly pertinent literature. Certain parts of the literature are particularly relevant to the current research.

For decades, communication and knowledge issues have appeared in discussions of problems related to user participation (e.g., Markus and Mao, 2004). The literature on communication and knowledge gaps goes back to C.P. Snow's (1961) discussion of the sciences and the humanities as two separate cultures of modern society. Beath and Orlikowski (1994) describe common biases in system-related interactions between business and IT professionals. The issue of business/IT alignment elevates that issue to a broader organizational level. (See references above.)

The education of IT professionals contributes to the communication and knowledge gap. Typical systems analysis and design textbooks treat "the system" as a technical artifact that is "used" by users. For example, in a summary of the design phase of the SDLC, Hoffer et al (2008, p. 13) say "analysts must design all aspects of the system, from input and output screens to reports, databases, and computer processes." Similar statements appear in Kendall and Kendall (2008, p. 13), Dennis et al. (2002, p. 7), and Mathiassen et al. (2000, p. 7). If reducing communication and knowledge gaps were an important goal, the education of IT professionals might recognize more fully that most business professionals are more concerned with improving business performance rather than with specifying IT-based tools that they might use. Another aspect of the education of IT professionals is that widely used methods and tools such as UML are far from perfect even for their use. (See references above.)

To satisfy criteria mentioned earlier, the metamodel adopts a different stance through the default assumption that a system in an organization is typically a sociotechnical system (Cherns, 1976; Davis and Taylor, 1979; Trist, 1981; Pasmore, 1985; Majchrzak and Gasser, 2000; Majchrzak and Borys, 2001; Lamb and Kling, 2003). Two articles with sociotechnical themes (Bostrom and Heinen, 1979a, 1979b) appeared in the first volume of *MIS Quarterly*, but attempts to develop systems analysis and design methods with more of a sociotechnical focus have remained largely in the research domain. Examples include Mumford's ETHICS methodology (Mumford and Weir,1979; Hirschheim and Klein,1994), client-led design (Stowell and West, 1995), and Multiview (Avison and Wood-Harper, 1990). The work system approach underlying the metamodel tries to address some of the same concerns.

Finally, this paper's metamodel fits into basic research concerning IS concepts (Falkenberg et al, 1995), conceptual modeling (Wand and Weber, 2002), ontologies (IEEE P1600.1, 2003), and metamodels and enterprise architecture. (e.g., Glissman and Sanz, 2009; Kurpjuweit and Winter, 2007; Leung and Bockstedt, 2009; Mettler et al., 2008).

Background about the Work System Approach

This paper's integrated metamodel for describing, analyzing, and designing sociotechnical and technical systems is based on the work system framework. This section provides background about the work system approach in general and the work system framework in particular.

A long term project extending over more than 15 years (Alter 1995, 1999, 2003, 2008a, 2008b, 2010b; Truex et al. 2010) tried to develop a systems analysis method that can be used by business professionals for their own understanding and can support communication between business and IT professionals. That research anticipated many of the goals of design science research (Hevner et al., 2004), such as relevance, testing, and iterative improvement. For example, Alter believed that the problem was relevant based on his experience in a manufacturing software firm and based on reports by his Executive MBA students that, unlike well-trained IT professionals, most business professionals were not aware of well articulated analysis methods that would help them organize their thinking about systems and system improvement in their firms. The core of the resulting approach was a set of ideas of a type that Gregor (2006) described later in *MIS Quarterly* as a "theory for understanding." The new metamodel extends the previous research and fits with a largely European design science research tradition of creating constructs and models that are rigorous and that are relevant to many situations (Winter, 2008).

A work system approach assumes that the unit of analysis is a work system, a sociotechnical system in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products and/or services for specific internal or external customers. Almost all value chain and support systems are IT-reliant work systems that rely on IT but are not IT systems. Table 1 lists a subset of 75 such systems that were analyzed by advanced MBA students at a major East Coast university who looked at work systems in their own organizations for class projects in Spring 2009. The deliverable was a five part management report (executive summary, background, system and problem, analysis, recommendation and justification) written based on a work system analysis template that included tables for summarizing the "as is" work system, assessing how well it operated and where problems existed, summarizing a proposed "to be" work system, and clarifying why proposed changes would probably improve performance. That deliverable was similar in scope and intent to a midrange briefing for a manager or a committee that would decide whether to continue the analysis and how to allocate resources among proposed projects. Consistent with the general goals of the work system approach, this was a preliminary analysis for developing, understanding, and clarifying issues, rather than a precise, highly detailed specification of an "as is" or "to be" work system. (Truex et al., 2010)

Table 1. Examples of work systems analyzed by employed MBA students

Renewing insurance policies Timekeeping for field technicians for a public utility Receiving materials at a large warehouse Controlling marketing expenses Acknowledging gifts at a high profile charitable organization Performing pre-employment background checks Performing financial planning for wealthy individuals	Planning and dispatching trucking services Scheduling and tracking health service appointments Operating an engineering call center Administering grant budgets Collection and reporting of sales data for a wholesaler Invoicing for construction work Determining performance-based pay	Finding and serving clients of a marketing consulting firm Determining government incentives for providing employee training Planning for outages in key real time information systems Approving real estate loan applications Acquiring clients at a professional service firm Purchasing advertising services through an advertising agency

Work system modeling can be used to describe situations ranging from the work of filling out simple computerized forms through the work of assembling airplanes. Its area of usefulness is between the two extremes. There is no reason to use a work system approach for simple procedures that always conform to a simple flow chart. At the other extreme, large organizations are best understood through decomposition into multiple work systems that can be analyzed individually in relation to whatever problem, opportunity, or issue prompted the analysis. Since every work system can be viewed as a subsystem of a larger work system, work system boundaries are treated as a decision by the work system modeler. In general, the relevant work system is the smallest work system that exhibits or possesses the problems, issues, and/or opportunities that prompted the analysis. It is always possible to look at a larger work system, but work system expansion typically results in a more complicated and time consuming analysis process.

With a work system approach, work system requirements are assumed to evolve over time because a work system's goal is to provide value for its customers, not just to operate consistent with its own original specifications. Work systems change over time through iterations of planned change (projects) and through incremental adaptations and innovations that may be unplanned. In many situations, those iterations have led to largely automated work systems in which people design, set up, and maintain a work system, but do not participate directly in its intended operation (e.g., Davenport and Harris, 2005). Examples include automated decision systems, automated manufacturing cells, automated warning systems, and coordinated control of traffic lights. Most basic concepts that apply to work systems in general also apply to these automated work systems. Many discussions of the relationship between service-oriented architectures and enterprise architecture seem to imply goals related to this type of automation.

Information systems are a special case of work systems in which all processes and activities are devoted to processing information. Other special cases include supply chains, ecommerce systems, and projects. Commercial software suites such as ERP and CRM are not generally considered work systems; rather, they are technical infrastructure, specific parts of which are used in specific work systems such as entering orders and paying suppliers.

Work system framework. The work system approach contains two central frameworks. The work system framework (Figure 2) identifies nine elements that can be used to summarize how a work system operates at a particular time, including who the customers are, what products and services are produced, what are the major processes and activities, and so on. These elements were defined in Alter (2006, 2008a) and are explained further in the discussion of the metamodel. Figure 2 says that work systems exist to produce products and services for customers. The arrows say that the elements of a work system should be in alignment. The other central framework in the work system approach is the work system life cycle model (explained in Alter (2006, 2008a, 2008b, 2010b), but not discussed here) which expresses a dynamic view of how work systems change over time.

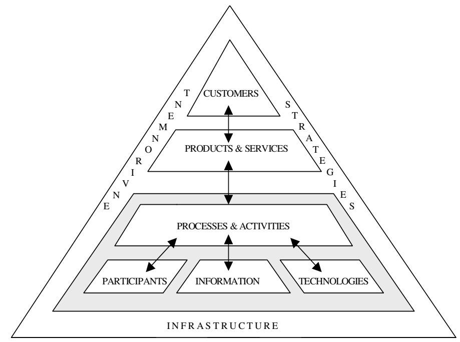


Figure 2. Work System Framework

Usage to date. The work system framework and other aspects of the work system approach for understanding systems have been used in North America, Europe, Asia, and Australia as a component of university courses for undergraduate business majors, undergraduate IS majors, generalist MBA students, and MBAs majoring in IS. The courses have included introduction to IS, systems analysis and design, business process improvement, IS development, and ERP systems. In some cases the usage involved one or several lectures to provide context for the course or for important topics. Some courses asked students to apply the work system framework to create "work system snapshots," which summarize a work system using the six central elements of Figure 2. The work system framework, work system principles, or sets of questions related to work system elements have been used to establish the rationale for programming projects by computer science students. The ideas have also served as the conceptual core of projects in generalist undergraduate and MBA classes (e.g., the projects mentioned in Table 1).

Beyond its use in teaching, a number of researchers other than Alter have applied or cited the work system framework and other aspects of the work system approach in a broad range of contexts (e.g., Luukkonen et al. (2010), Granlien (2010), BenMoussa (2010), Kampath and Röglinger (2010); Madsen and Vigden (2009); Gericke and Winter (2009); Ou and Banerjee (2009); Adams (2009); Lafaye (2009); Pinhanez (2009); Kosaka (2008, 2009), Lyytinen and Newman (2008), Mettler (2008); Singh and Woo (2008); Petersson (2008); Petkov and Petkova (2008); Kurpjuweit and Winter (2007); Sewchurran, and Petkov (2007); BenMoussa (2007); Goodhue (2007); Benbasat and Zmud (2006), Cuellar et al. (2006); Curtin et al. (2006); Davamanirajan et al. (2006); Gray (2006), Møller (2006), Lucas and Aggarwal (2005), Dumas et al. (2005), Irwin and Turk (2005); Casey and Brugha (2005), Fortune and Peters (2005); Munk-Madsen (2005); Patten et al. (2005); Petrie (2004); Rowe et al. (2004); Siau et al. (2004); Walls et al. (2004); Mora et al. (2003), Nurminem (2003); Mursu (2002); Ramiller (2002); Hedman and Kalling (2002), Borrell and Hedman (2001)). Other related research is in progress.

Possible alternative frameworks. The work system framework is certainly not the only possible framework that could be used in teaching and research situations related to systems in organizations. It was developed over time to guide its users to develop a basic understanding of an IT-reliant work system in an organization. It would be possible to write a paper comparing the work system framework to other concepts or frameworks that might be nominated as alternatives. Due to space length constraints, we can only list some of the candidates:

- **Business process**. Obviously an important lens, but consisting of only one element instead of the nine elements of the work system framework. The work system approach has been called a business process approach, but it involves much more than just the detailed logic of the business process.
- **Input-processing-output**. An important way of looking at computer programs and at large scale economic systems, but much less useful for describing the operation of IT-reliant work systems in organizations, especially service systems that rely on judgment and improvisation.
- **People, process, technology.** This 3-sided framework is a reminder that people, process, and technology are almost always relevant for thinking about systems in organizations. When presented as three boxes with no additional layers it does not lead a deeper, more detailed analysis.
- **Leavitt framework (1965)**. Describes dynamic equilibrium between 4 elements: task, structure, people, and technology. Comparison with the work system framework shows that it does not point to other important topics for analyzing systems, such as information, customers, products and services, environment, and infrastructure.

- **SIPOC**. A 5-element model used in Six Sigma analysis: supplier, input, processing, output, customer. SIPOC is best suited to processes that have clearly defined inputs, processing, and outputs, and therefore does not fit many service processes whose suppliers, inputs, and outputs are not clearly specified.
- **Activity theory**. "A set of basic principles which constitute a general conceptual system. … [These] include object-orientedness, the dual concepts of internalization/ externalization, tool mediation, hierarchical structure of activity, and continuous development." (Bannon, 1997) A graphical representation in Kuutti (1995) contains 7 elements: subject, object, community, tool, rules, division of labor, and outcome.
- **GRITIKA ontology**. An ontology containing 7 concepts: goal, role, interaction, task, information, knowledge, and agent. Suggested by Zhang et al. (2004) for modeling e-service applications.
- **Zachman (2008) framework**. A 6X6 framework outlining an enterprise's architecture, and therefore at a different level than a work system model. The 6 rows include scope, business model, system model, technology model, detailed representations, and functioning enterprise. The six columns include what, how, where, who, when, why.

Layers. Many additional concepts are required for meaningful analysis whenever the work system framework or any of the alternatives above are used. Alter (2005) proposed the architecture of an ontology called "Sysperanto" as a way to organize many of the concepts used in the IS field. The general approach was to identify nouns (components and phenomena), verbs (actions and functions), adjectives (characteristics), adverbs (performance indicators), and generalizations or principles related to the nine elements of the work system framework. Most of those concepts would be inherited by special cases of work systems, such as information systems and projects.

The new metamodel is based on a similar idea since each element and relationship may have many attributes that are not shown in the top level visual representation in Figure 3. For example, each element has many characteristics that can be treated as stable for purposes of the analysis (e.g., for participants, age, education, and incentives; for activities, complexity and degree of structure). Similarly, each element may have many relevant performance indicators (e.g., for participants, error rate and job satisfaction; for activities, cycle time and rework rate). Goals are treated as attributes of elements and relationships. It would be interesting to propose a similar second layer for each of the alternative frameworks, and then to examine the degree of overlap between the new metamodel and the expanded frameworks, including their top layer and the second layer of additional concepts.

Current status. The work system framework was developed to support the preliminary analysis and design of sociotechnical work systems in organizations. The amount of rigor in the work system framework is adequate for supporting that purpose, and for supporting communication between business and IT professionals. The framework provides useful guidance by identifying nine elements that are part of a rudimentary understanding of any work system. Business and IT professionals can discuss those elements without becoming overwhelmed by excessive detail and without requiring jargon that is impenetrable to most business professionals.

Results from the framework's use to date in teaching are encouraging. The framework and related ideas are teachable and have been applied by hundreds of MBA and Executive MBA students in preliminary analyses of IT-reliant work systems in real world organizations. Characteristics, metrics, and principles related to the elements of the work system framework were summarized in Alter (2006) and can be included in relatively simple tabular analysis templates such as those that have been used by MBA and Executive MBA students. One of the primary tools in this analysis is a "work system snapshot," a one page summary of a work system based on the six central elements of the work system framework. While the framework is not yet commonplace in research, it has influenced researchers who were pursuing a broad range of topics. In some cases it helped researchers recognize the limitations of research that focuses on only one or two work system elements.

Confusions in using the work system framework. Both classroom discussions and written assignments produced by MBA and Executive MBA students have revealed a number of areas in which confusions sometimes arise, and where greater clarity would be helpful. Some of the most common issues are in the following areas:

What determines a work system's scope? For purposes of any analysis or design effort, the work system should be defined as the smallest work system that exhibits the problems, issues, and opportunities that led to the analysis. Analysis of a smaller work system is likely to omit important issues. Analysis of a larger work system will absorb time and effort that might be expended for other purposes.

What about subsystems of a work system? Most work systems have subsystems and sub-subsystems that also can be described using the work system framework. The decomposition of work systems into subsystems helps the analysis unfold in an orderly and efficient manner. Useful decomposition ends when proceeding further provides no additional insights for analysis or design. In extreme cases, the end point occurs when the subsystem at the current level of decomposition contains only one meaningful activity.

Why aren't goals part of the work system framework? In many cases, several or many goals exist for multiple elements of a specific work system, such as the processes and activities, participants, information, technologies, and products/services. Although goals must be considered in any serious analysis, the work system framework would become crowded and confusing if the picture contained goals for each element.

Is it possible for a customer to be a participant? In self-service work systems such as using ecommerce web sites, the customer is a participant who performs self-service work. Parts of the service literature (e.g., Sampson and Froehle, 2006; Vargo and Lusch, 2004) say that the customer is always a co-producer of services.

Where are the inputs? The work system framework does not mention inputs because it assumes that they will be identified through more detailed examination of processes and activities.

Where does knowledge appear? Knowledge appears everywhere. It is not identified as a separate element because it resides in each of the nine elements. For example, knowledge is built into processes and activities, exists in the heads of work system participants, and can be provided through documents and knowledge bases.

Must a work system have a business process? Not necessarily. The work may involve a set of activities that are not structured or sequential enough to call a process. (e.g., Hall and Johnson (2009), Hill et al. (2006)).

Don't all activities produce products/services? Yes. Activities always produce something that is used by other activities in the work system and/or by the work system's customer. When speaking of a work system as a whole, products/services are the products/services that are received and used by the work system's customers. In contrast, the products/services produced by a specific activity within a work system might be directed at internal customers (e.g., the next person in an assembly line) or at external customers.

Where are the users of technology? Participants and customers may or may not be users of technology within the work system. The work system framework does not specify who uses specific information or technologies.

Is it possible for a work system to be totally automated? Yes. If the work system is a totally automated manufacturing cell, then all of the work within the work system is performed by machines, and the work system has no participants. People who create, set up, or maintain the machine cell are participants in separate work systems that perform those activities. The purpose of the analysis should determine whether or not the activities of setting up and maintaining the machine cell should be included in the work system that is being analyzed.

How is it possible for a work system to have no participants if people create and maintain the work system? The author of a book is not an active participant in learning from the book. Similarly, people who create an automated system are participants in a separate work system of creating the automated system. They may not be participants in its automated operation, and may have left the organization years ago.

Need for Metamodel that Goes Deeper than the Work System Framework

Although useful for the purposes mentioned earlier, the work system framework is less effective as a tool for deeper analysis of work systems. The difficulties mentioned above are examples of ways in which the work system framework may be unclear to some users for some purposes. Ideally, a framework for deeper analysis should provide greater clarity about concepts and more specific guidance about relationships that are often important. A more rigorous framework might support more rigorous analysis without requiring terminology (e.g., objects and classes) that is impenetrable to most business professionals.

The metamodel presented in the next section builds upon the work system framework by making its concepts clearer, more rigorous, and more amenable to use in work system documentation and software development.

It creates a bridge between a summary level description of a work system and more detailed models as the work system is decomposed into subsystems and sub-subsystems during an analysis or design process. It does that without requiring the precision, terminology, and notation that is required for software specifications.

It addresses the above-mentioned confusions that were observed in past applications of the work system framework. It does so by clarifying the concepts at the summary level of the work system framework and guiding their re-use during the decomposition of a work system into subsystems and sub-subsystems.

When articulated fully (including a second layer identifying common characteristics, metrics, and principles for specific elements), it might support traceability between sociotechnical requirements and technical details needed for reliable, testable software. New tools based on the metamodel might support traceable links between lightweight analysis by business professionals and heavyweight analysis and documentation by IT specialists.

Metamodel Bridging the Chasm between Sociotechnical and Technical Views of Systems in Organizations

Figure 3 is an integrated metamodel for the analysis and design of sociotechnical and technical systems. Earlier versions of this metamodel were presented at WITS 2009 and the 2009 JAIS Theory Development Workshop. It was also discussed separately with other knowledgeable experts in conceptual modeling. The metamodel contains 31 concepts whose definitions and mutual relationships clarify confusions that sometimes arise in using the work system framework. Figure 3 uses shading to highlight the distinction between elements in the work system framework and other concepts that are not in the work system framework. As explained below, some terms that appear in the work system framework are defined differently in the more detailed metamodel. In general, representation decisions in the metamodel attempt to maximize understandability while revealing potential omissions from an analysis or design process. The metamodel uses an icon for "composition" (see legend at the bottom of Figure 3) to identify elements that are likely to be decomposed into smaller elements in some analysis and design situations. It names relationships and uses the pointed end of "<" and ">" to indicate the direction in which relationships apply. It also identifies multiplicities (e.g., (0… *) means zero to many; (1…*) means at least one).

Within this paper's page limits it is impossible to explain all 31 elements, all of the relationships between elements, and the rationale for all of the representation choices. After an overview of the metamodel's organization, the revised representation of each of the original elements of the work system framework will be discussed briefly.

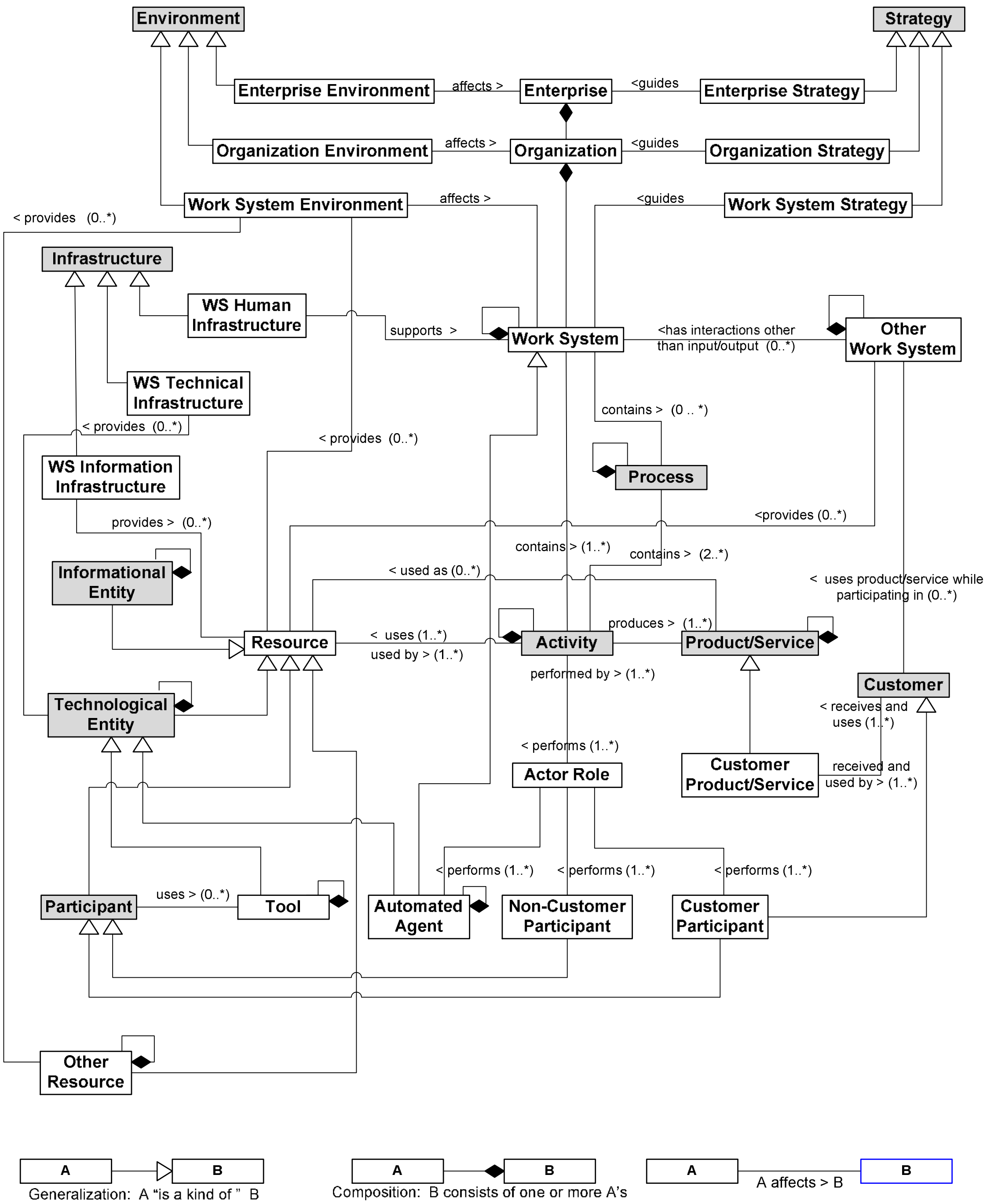
Organization of the Metamodel

Resources, structure, and intention. In contrast with the triangular representation of the work system framework (Figure 2), the metamodel is organized to emphasize the interplay of resources, structure, and intentions. Ideally a work system's resources and structure should be aligned with intentions of relevant stakeholders. The analysis of a work system usually occurs when an existing work system's performance outcomes do not satisfy stakeholder intentions and goals. In general, the metamodel is laid out with resources on the left side, structural and operational elements in the middle, and elements related to intention on the right. The central elements in the metamodel are the work system itself and activities that it performs.

Resources for a work system include participants, technological entities, informational entities, and other resources used by activities. Non-human resources might be produced by previous activities within the work system, or might come from other work systems, from the environment, or from the relevant infrastructure.

Structure starts with the enterprise and organization. Organizations consist of work systems that may or may not include a well-defined process but that must contain at least one activity. Each activity is performed by one or more actor roles including non-customer participant, customer participant, and automated agent. (explained below)

Concepts related to intentions that are visible in the metamodel include product/service, customer, and strategy. Strategies summarize intentions about how resources should be used to produce products and services. Product/service and customer appear on the side for intention because the purpose of a work system is to produce products and services for its customers. Other concepts related to intentions such as goals, metrics, characteristics, and incentives are relevant to all sociotechnical work systems but are not shown in Figure 3, but rather are treated as attributes of specific elements or relationships. Showing goals and metrics attached to many of the elements would turn Figure 3 into an incomprehensible jumble. (Compare Fig. 2 in Thomas et al.(2008), which includes beliefs, values, and goals under the heading of spirit/purpose.)



Note: Many elements in the conceptual model have goals, attributes, performance indicators, and related principles, patterns, and generalizations that do not fit into a one page representation, and that must be included in more detailed explanations.

Figure 3: Metamodel for integrated analysis and design of sociotechnical and technical systems (not showing multiple goals, attributes, principles, and other important concepts related to specific elements)

Decomposition of work systems into subsystems. Typical work systems can be decomposed into at least several layers of smaller work systems (subsystems). That type of decomposition can continue until the work system contains only one activity or until there is no benefit from further decomposition. As that decomposition proceeds, it typically reveals subsystems of the original work system that are automated agents, i.e., that perform work automatically and autonomously after being triggered by preconditions, commands from people, schedules, requests from machines, or other conditions. In comparison with loosely structured sociotechnical systems, totally automated work systems are more amenable to analysis using typical systems analysis tools for IT professionals.

Enterprise, organization, and work system. Entire enterprises and organizations can be viewed as work systems and can be subdivided into one or more work systems. Attempting to analyze an entire organization or enterprise as a single work system is usually overwhelming, however, with too many different roles performing too many different activities using too many different informational and technological entities. In practice, systems analysis proceeds by subdividing enterprises and organizations into a series of work systems, each of which can be subdivided further.

Inclusion of "other work system." The metamodel contains separate elements for the specific work system being analyzed and for other work systems that it interacts with. The metamodel is explicit about this distinction for two reasons: to support decomposition of work systems into separate subsystems and to make it easier to describe interactions between a work system and other work systems. First, when work system A is subdivided into subsystems B and C, usually B and C usually B interact with each other in some way that is relevant to subsequent analysis of each subsystem. Second, explicit inclusion of "other work systems" makes it possible to model supplier/customer relationships between work systems and to include other types of interactions. Aspects of those interactions have been addressed partially in research related to task interdependency (Thompson, 1967), coordination theory (Malone, et al., 1999, Crowston et al., 2006), and loose coupling theory (Orton and Weick, 1990). The most obvious interactions between work systems are related to inputs and outputs, i.e., receipt and consumption of resources provided by other work systems and the production of products/services for use by other customers associated with other work systems. Other types of interactions (labeled as "interactions other than input/output") are also important in analyzing many work systems. Those interactions include sharing of human participants and other resources, various forms of interference that occur accidentally, and requirements that one work system may impose on another, either implicitly or explicitly (Alter, 2010a).

The Metamodel's Representation of the Elements of the Work System Framework

Since the metamodel clarifies work system elements and their interrelationships, this section looks at each element of the work system framework in turn, providing a brief definition at the level of the work system framework and then explaining how that concept is defined in the metamodel and how it is linked to other metamodel elements. In general, the sequence of the discussion goes from top to bottom and left to right in Figure 3.

Environment includes the relevant organizational, cultural, competitive, technical, regulatory, and demographic environment within which the work system operates, and that affects the work system's effectiveness and efficiency. Organizational aspects of the environment include stakeholders, policies and procedures, and organizational history and politics, all of which are relevant to the analysis and design of many work systems. Factors in the environment may have direct or indirect impacts on performance results, aspiration levels, goals, and requirements for change. Analysis and design efforts that ignore important factors in the environment may overlook issues that degrade work system performance or even cause system failure.

Environment appears at three levels in the metamodel because the environment at the enterprise or organizational level may not be important at the work system level. For example, cultural and political issues that may be crucial for a corporate planning work system may be irrelevant to a work system that performs repetitive manufacturing. Such issues are also far afield when analyzing automated work systems or subsystems that are automated agents and are largely invisible to people in the organization.

Infrastructure includes relevant human, information, and technical resources that are used by the work system but are managed outside of it and are shared with other work systems. Infrastructure can be subdivided into informational infrastructure, technical infrastructure, and human infrastructure, all of which can be essential to a work system's operation. Human infrastructure includes departments and groups from the larger organization that provide support activities for the work system being analyzed and for other work systems. Informational infrastructure consists of informational entities such as databases that are shared across an organization. Technical infrastructure provides technology that is shared among multiple work systems and is typically viewed as an essential external capability when analyzing a work system. For example, Excel spreadsheet software is often part of infrastructure, while a specific spreadsheet model used in a specific activity is part of the technology within a specific work system. Likewise, the Internet is part of an organization's infrastructure, while a specific ecommerce web site is technology within a self-service work system in which a customer orders products or obtains information. An entire ERP suite is part of the enterprise's technical infrastructure, while an order entry program within the ERP suite might be viewed as technology within an order entry work system.

Strategies that are relevant to a work system include enterprise strategy, organization strategy, and work system strategy. In general, strategies at the three levels should be in alignment, and work system strategies should support organization and enterprise strategies. Unfortunately, strategies at any of the three levels may not be articulated or may be inconsistent with reality or with beliefs and understandings of important stakeholders. Although it is generally preferable to analyze and design work systems in reference to clear and realistic strategies, analysis and design often occurs in situations that lack a clear strategy because no one has articulated such a strategy or because the announced strategies are internally inconsistent, unclear, or unrealistic.

Processes and activities are defined somewhat differently in the work system framework and the metamodel. In the framework, processes and activities occur within the work system to produce products and services for its customers. Use of the term "processes and activities" recognizes that the work being performed may not be a set of clearly specified steps whose beginning, sequential flow, and end are well-defined. Many important work systems perform organized activities that rely heavily on human judgment and improvisation (e.g., Hall and Johnson, 2009; Hill et al., 2006) and therefore may not be structured enough to qualify as a process by some definitions.

The metamodel treats process and activity as separate elements. A work system must contain at least one activity. Otherwise it does not do anything. Activities are initiated by triggering conditions, such as completion of a previous activity. A work system may contain one or more processes, each of which is a process because it contains two or more well-defined activities that are linked sequentially or logically. Both processes and activities might be decomposed into smaller processes or activities during the analysis. The metamodel emphasizes activities rather than processes because any reasonably deep analysis of a work system needs to determine which activities are performed by which participants using what technologies and information, and which activities are totally automated. Saying that participants, information, and technologies are associated with a process (thinking at the level of the work system framework rather than the metamodel) is not sufficient for performing that type of analysis.

The metamodel recognizes that many, if not most, activities produce products and services that are used as resources by other activities within the same work system. As explained later, products and services that are received and used by the work system's customers are called "customer products/services." The metamodel represents resources that are used by activities as a combination of:

- Products/services produced by other activities within the work system
- Human participants who play actor roles (but are considered resources as well)
- Informational entities that may have been provided by other activities within the work system, by other work systems, by the relevant informational infrastructure, or by the relevant environment
- Technological entities that are used in performing the activity
- Other resources that are used and may or may not be consumed immediately, such as buildings, furniture, transportation equipment, and inventories not linked to other work systems for the purposes of the analysis.

Participants are people who perform work within the work system, including both users and non-users of IT. The work system framework is unclear about which participants perform which activities. The work system method resolves that ambiguity early in an analysis through use of a "work system snapshot," whose processes and activities section uses complete sentences to identify separate activities and related actor roles. (Alter, 2006)

The metamodel is more specific than the framework about the relationship between work systems, activities, actors, and participants. Activities that are performed by people are described in terms of actor roles that typically call for certain levels of capability, knowledge, personal characteristics, attention, and ambition. Other actor roles may be performed by automated agents. The metamodel's inclusion of activity, actor role, and participant recognizes that the formal specification of an activity or process tells only part of the story because different people might perform the same processes or activities differently and with different skill levels.

Work system participants may or may not be users of technology. In particular, there is no reason for starting the analysis or design of a sociotechnical system with an assumption that the system of interest is a hardware/software system that is "used" by "users." In the author's opinion, the IS field's long term overemphasis on users and user participation is seriously flawed if the real goal is to improve the performance of IT-reliant work systems (Alter, 2009) The metamodel could lead to a systems analysis and approach that does not start with "use cases" but could create use cases along the way if that would help in linking to existing UML tools.

A sociotechnical work system has at least one participant, whereas a completely automated work system has no human participants. People who create, modify, set up, or maintain automated work systems are participants in other work systems that create, modify, set up, or maintain the automated systems. In dealing with a highly automated system, the analyst must choose whether to treat it as a partly automated system that includes human participants or whether to focus only on totally automated subsystems. In either case, decomposition of such a work system eventually leads to one or more totally automated subsystems that contain no human participants.

In some situations, the analysis may identify a principal actor who is in charge of a specific activity. For example, in a non-automated medical procedure, the physician is the principal actor and the patient, medical assistants, and family members may be viewed as secondary actors. In situations such as online testing, an automated agent can be viewed as the principal actor for a specific activity that controls or provides instructions for human participants.

Information appears in the metamodel in the more specific term "informational entity" to be specific about exactly what information is used, created, captured, transmitted, stored, retrieved, manipulated, updated, displayed, and/or deleted by a specific activity. Informational entities include orders, invoices, warranties, schedules, income statements, reservations, medical histories, resumes, job descriptions, and job offers. (IBM researchers such as Wu et al. (2008) used the term "business entity" to refer to a similar idea.) Non-codified informational entities include verbal requests and commitments. Informational entities may be generated by activities within the work system, may be inputs from other work systems, and may be provided by information infrastructure. Informational entities may contain other informational entities. For example, an order may contain a line item, a document may contain a chapter, and a message may contain a heading. The advantages and disadvantages of paper and electronic versions of documents demonstrate that the physical form of informational entities is often quite important.

Technologies appear in the metamodel as technological entities to encourage specificity about which technology is used by a specific activity. It is clearer to identify a specific technological entity such as a specific Excel spreadsheet model rather than just a category of technology, such as "spreadsheet." Technological entities include both tools that are used by work system participants and automated agents that are hardware/software configurations that perform totally automated activities. That distinction is crucial as work systems are decomposed into successively smaller subsystems, some of which are totally automated. The distinction between tool usage and automated agents may prove helpful in developing links between lightweight analysis and design methods for business professionals and heavyweight analysis and design approaches for IT professionals. (Tan et al., 2008)

When a participant performing an actor role uses a tool, the participant performs and guides the work with the help of the tool. For example, when a doctor uses a stethoscope to listen to a patient's heartbeat, the tool helps the doctor through an interface that delivers audible sounds. In contrast, automated agents are actors that perform activities autonomously within a work system. Activities of automated agents may be triggered by previous activities, programs, preconditions, schedules, or other conditions. Those activities may have visible consequences for human participants and/or the work system's customers. In a totally automated work system, automated agents may produce physical machine actions or may produce invisible computed actions, such as calculating a sum or transferring a bit stream. An automated agent may request and use products/services produced by other automated agents in order to perform an activity, as when a computer program uses a database to find drug interactions and returns recommendations concerning possible side-effects of the doctor's planned prescription.

Customers are recipients of a work system's products and services for purposes other than performing work activities within the work system. Thus, an employee who receives an output from step #4 in order to perform step #5 in a 10-step process within a work system is a work system participant but not a work system customer. For purposes of work system analysis, customers are customers of a work system; they may or may not be customers of the organization or the enterprise. External customers are work system customers who are the firm's customers, whereas internal customers are work system customers who are employed by the firm, such as customers of the firm's payroll work system. Customers of a work system may also be participants in the work system (e.g., patients in a medical exam, students in an educational setting, and clients in a consulting engagement). The metamodel's distinction between non-customer participant and customer participant is important in such situations because expectations related to the treatment and responsibilities of customers are often different from expectations related to non-customer participants. Another type of customer becomes apparent as automated agents are isolated during the successive decomposition of sociotechnical systems into smaller subsystems, Human participants will be customers of some of those totally automated subsystems (e.g., automated agents that provide lists of drug interactions to doctors as a safeguard against inadvertent errors in prescriptions); in other cases, the customers of automated agents may include other totally automated work systems (e.g., when programs launch other programs).

Products and services consist of information, physical things, and/or actions produced by a work system. Neither the work system framework nor the metamodel distinguish between products and services because the long-standing debate about the difference between products and services is beyond their scope and has not been resolved fully (e.g., see Sampson and Froehle (2006);Vargo and Lusch (2004)). For purposes of analyzing and designing work systems, the distinction between products and services is much less important than consideration of a set of continuous design dimensions that are sometimes associated with product/service distinctions, such as tangible versus intangible, commodity versus customized, and personal versus impersonal (Alter, 2010b).

At the level of the work system framework, "products/services" include whatever the work system's processes and activities produce for the benefit of the work system's customers. At the more detailed level of the metamodel, a "product/service" is something that is produced by an activity and often is used as a resource by subsequent activities within the same work system. A "customer product/service" is a product/service that is received and used by one or more of the work system's customers for purposes other than just performing activities within the work system for the benefit of other customers. A customer product/service may be used by the customer within the work system or may be used outside of the work system, often in another work system in which the customer participates.

Summary, Extensions, and Future Research

The metamodel in Figure 3 addresses the longstanding gap between sociotechnical and technical views of systems (Figure 1) by providing an integrated basis for systems analysis and design that incorporates concepts from both views. Sociotechnical concepts include customer and non-customer participants, actor roles, activities, environment, and human infrastructure. Technical concepts include technical and informational entities and technical and informational infrastructure. Attributes of those concepts also represent both sociotechnical and technical concerns. For example, goals, incentives, and job satisfaction are attributes that would typically appear in analysis from a sociotechnical viewpoint.

The metamodel builds upon the work system framework (Figure 2), which has been used in teaching and research, and which was developed in a long term design science research project aimed at helping business professionals think about systems in organizations. The metamodel clarifies shortcomings of the framework that were observed by examining hundreds of reports by MBA and Executive MBA students who used various versions of work system analysis templates for analyzing IT-reliant work systems in their own organizations. The representation of the metamodel in Figure 3 combines resources, structure, and intentions. Goals, characteristics, metrics, and principles and other concepts that pertain to multiple elements and to the work system as a whole are attributes that are not shown. The use of the metamodel in analysis situations would apply those concepts as the analyst defines the problem or opportunity, evaluates the "as is" work system, and justifies proposed improvements that would appear in the "to be" work system. Many straightforward analysis tools can be constructed based on selected combinations of elements and relationships in the metamodel. An example is a three column table that summarizes aspects of a process by identifying responsibilities of non-customer and customer participants (columns 1 and 2) and includes in the third column the informational entities that are used or created at each step, or the business rules used at each step. Another example uses the same first and second columns and identifies problems or opportunities at each step in the third column Another identifies knowledge requirements in the third column.If the metamodel is really a breakthrough idea, it should point to new or improved paths for exploring important ideas and issues in the IS field. Implications and possible applications of the metamodel could take up an entire follow-on paper. Instead, we close by identifying some of the directions for follow-on research:

Developing a conceptually rigorous form of sociotechnical modeling that encompasses non-technical and technical issues. The metamodel provides an integrated view of social and technical aspects of systems in organizations. It inhabits a rarely visited middle ground between precise documentation that is too abstract and overwhelming for most business professionals and qualitative discussions of capabilities, characteristics, and tendencies that are at best indirectly helpful in analyzing or designing technical components of sociotechnical systems. In trying to inhabit that middle ground, the metamodel adopts the unusual stance of aspiring to enough clarity to foster genuine analysis and communication, but avoiding the level of precision and abstraction in documentation produced by IT professionals to specify testable software.

This paper's integrated metamodel was designed to help in understanding, analyzing, and designing sociotechnical and technical systems. The metamodel clarifies topics within the work system method by answering many common questions about work system modeling, such as whether customers can be participants and whether work systems can be completely automated. Therefore at minimum it is a step toward increasing the clarity and rigor of that form of sociotechnical modeling and analysis.

The metamodel's integration of sociotechnical and technical topics presents a challenge for other forms of sociotechnical modeling. By identifying and organizing many concepts and relationships that are essential for understanding IT-reliant work systems, it highlights concepts that should be included directly or indirectly in a practical sociotechnical modeling method for systems in organizations. The challenge for actor network theory, activity theory, or any other form of sociotechnical modeling is to provide straightforward ways to incorporate the equivalent of those concepts into the modeling process or to explain why equivalent concepts are not needed.

Validating the metamodel. A base level of real world validation of the metamodel has already been achieved by identifying examples related to each element of the metamodel and to the relationships in the metamodel. For example, every IT-reliant work system involves informational entities, technological entities, and actor roles. The metamodel was developed based on examination of many hundreds of work system examples from two types of sources: (1) papers by MBA and Executive MBA students about real world work systems in their organizations and (2) system-related stories in magazines, newspapers, and academic publications. In many instances, one or several cases motivated specific features of the metamodel by illuminating shortcomings or ambiguities that became apparent in trying to use the work system framework to describe specific situations. Additional efforts at validation through examples should look for real world examples that don't fit the metamodel.

Consistent with the metamodel's purpose, its concepts were defined at the level of everyday business speech, and not in terms of a philosophically based ontology such as the Bunge-Wand-Weber (BWW) ontology. It might be possible to adapt the general thrust of Recker et al. (2009) or Burton-Jones et al. (2009) to validate the metamodel's theoretical completeness or internal consistency.

Developing new tools for analyzing and designing sociotechnical systems. The relationships in the metamodel lead directly to a set of simple tools in the form of tables based on links in the metamodel. Such tables devote one column to a specific concept in the metamodel (e.g., activity, participant, or informational entity within the work system) and devote another column or several columns to directly related entities. Typical tables might include participants in all activities at a particular level of decomposition, informational entities used by each activity, or a set of characteristics or metrics related to activities, informational entities, or participants. (Alter, 2008b) It is possible to develop hierarchy-oriented tools that extend those tables across levels of decomposition. Attention to whether the principal actor roles in particular activities involve human participants or automated agents could be useful in linking sociotechnical models to service oriented architecture.

One of many interesting modeling issues concerns decomposition of sociotechnical systems into components, some of which are totally automated. The path of decomposition is not obvious in advance because it depends on the analyst's goals. For example, someone primarily interested in management control issues would decompose a work system around points of control, whereas someone primarily interested in developing software might decompose the same work system around opportunities to isolate software-based functions. The metamodel provides clarifications that should help in decomposition from one level to the next. Those clarifications are not guidelines, however. Additional research could develop guidelines for successive decomposition of sociotechnical systems. That research would start by compiling existing guidelines regarding system decomposition that appear in the computer science literature (for technical artifacts), in the organization literature (for departmentation and division of labor), and possibly in other literatures.

Developing links between various methods for thinking about IT-reliant systems in organizations. A full validation of the metamodel would compare the metamodel with other possible metamodels based on the work system framework or "alternative frameworks" such as those listed earlier. It would be interesting to identify ambiguities and limitations in each of the other frameworks, to develop a more detailed metamodel for each framework that would clarify most of its ambiguities and limitations, and then to compare the resulting metamodels with the metamodel proposed here. Explicit identification of concepts and relationships in the various metamodels could form the basis of comparisons between analysis methods based on different metamodels.

Exploring conceptual overlaps with current research areas. BPM ("business process management") and SOA (service oriented architecture) are important areas in software tools and architectures where a great deal of development has occurred at the concept, tool, and method level, and a great deal of hype has appeared at the sales and consulting level, with many claims about how BPM and SOA can improve business performance. Most of those claims imply that BPM and SOA will increase effectiveness and/or efficiency of work systems. The metamodel might clarify the potential role of various versions of BPM and SOA in specific sociotechnical systems, and might help in linking sociotechnical analysis and design to BPM and SOA. Another interesting area for possible linkage is service-dominant logic (Vargo and Lusch, 2004), which has been debated widely in marketing, has been proposed as a basic idea of "service science" (IfM and IBM, 2008; Spohrer et al., 2008), and could have implications for the IS field. The metamodel contains a number of features that are related to service-dominant logic, such as including the customer explicitly, recognizing that the customer may be a participant in a work system, and providing a means for adding service-orientation to process modeling by being clear about how activities, processes, and entire work systems are triggered.

Developing links between "lightweight" methods and tools for business professionals and "heavyweight" methods and tools for IT professionals, such as UML and BPMN. The metamodel can support two approaches for establishing links between lightweight and heavyweight analysis approaches. First, activities in a work system can be used as the starting point for identifying a set of use cases that can be documented using object-oriented tools. Each use case can be clarified through the relationships in the metamodel and through decomposition to subordinate levels. A second approach bypasses use cases altogether and simply analyzes the work system by using the metamodel in conjunction with appropriate decomposition. It might be possible to show that the first approach is redundant because summary versions of work system models can serve the same general purpose as use cases without overemphasizing the use of computer systems and with greater emphasis on better work system performance and better business outcomes rather than on the use of technology.

A more complete representation of the metamodel might take the form of a UML class diagram that would treat each element as a class and would include attributes and methods for each element. Developing that class diagram would require careful consideration of exactly which attributes and methods to include for each element. Justification of which attributes and methods to include and exclude would be challenging because so many attributes and methods are potentially relevant for different types of sociotechnical systems.

Developing links between sociotechnical modeling and various forms of business analysis, such as cost/benefit analysis, Six Sigma, and system simulation. Cost/benefit analysis related to IT innovations is often questionable because the benefits are difficult to articulate beyond the level of slogans (e.g., better information, better decisions, happier customers). The metamodel's level of specificity could lead to clearer descriptions and quantification of business performance benefits. Using the metamodel to express the justification at the work system level (i.e., moving from the "as is" work system to the "to be" work system, not just installing new software capabilities that seem potentially helpful) could provide a more realistic view of what would change and of the difficulties in accomplishing those changes. Similarly, the metamodel might guide the application of Six Sigma techniques if the required data is available or can be collected. In addition, the metamodel is a step toward supporting simulation of sociotechnical systems by providing a conceptual structure that is amenable to simulation. Specific elements could be characterized in terms of capabilities and other operationally relevant attributes. Activities could be initiated by a statistically generated flow of triggering events. The metamodel might even serve as the basis of an agent-based simulation for greater insight into variability caused by personal differences.

Overcoming limitations of the metamodel. As with any model, the new metamodel has a number of limitations. It would be very interesting to develop extensions that address limitations such as:

- **A somewhat mechanistic emphasis on structural aspects of work systems**. The metamodel assumes that a sociotechnical system can be described using its 31 elements. Some observers might find any metamodel of this type too mechanistic to represent the inherent variability, uncertainty, and path dependence in human activities and relationships. For example, one reviewer of this paper argued in general that the impoverished vocabulary provided by models and theories tends to limit and deform communication. While there is a valid question about the limitations of models and theories in many practical situations, the assumption underlying the metamodel is that its elements and relationships suggest the minimum scope of a reasonably through analysis of an IT-reliant work system. Such an analysis should certainly should incorporate other ideas as well.
- **Focus on the form of systems rather than the process of change in systems**. The metamodel can be used to represent organized projects as a type of work system whose goal is to produce something and then go out of

existence. The work system life cycle model (Alter, 2006, 2008a, 2008b, 2010b) represents an iterative process through which work systems evolve over time through a combination planned change (projects) and unplanned change including adaptations and improvisation. Neither the metamodel nor the work system life cycle model address emergent change, computing ecologies (e.g., Lyytinen (2010), or pervasive computing environments (e.g., El Sawy (2003)) in a deeper way. It would be interesting to see whether and how insights from activity theory, ecological approaches, and pervasive computing could enrich the metamodel.

- **Focus on pre-defined activities rather than gray spaces**. Researchers such as Suchman (1987), Schmidt and Bannon (1992), and Star and Strauss (1999) emphasize the importance of articulation work, coordination, and improvisation that is not expressed in typical process models, which focus mostly on work flows, triggering conditions, resource requirements, business rules, and post-conditions of specific activities. For example, Suchman (1987) notes that plans describe what should have happened by a particular time, not exactly how things are done.

This paper as a whole has the additional limitation of not providing an illustrative real world example. Unfortunately, a non-trivial example would increase its length far beyond the ICIS page limits. The nature of such an example is illustrated in Truex et al. (2010) in the form of three tables from one of 75 analyses of real world systems produced by currently employed MBA students averaging six years of business experience. That analysis was based on the work system framework and a related tool called a work system snapshot. The elements and relationships in the metamodel suggest many other similar tables that would not have been implied directly by the work system snapshot. Examples include:

- Table of resources created or used by each activity
- Table of interactions other than input/output interactions between the work system and other work systems
- Table identifying actor roles (non-customer participant, customer participant, or automated agent) in each activity.

Developing a body of knowledge for the IS field. The topic of developing a body of knowledge (BoK) for the IS field has been raised a number of times (e.g., Iivari et al., 2004; Hirschheim and Klein, 2006; Hassan and Mathiassen, 2009). Alter (2005, 2008a) proposed that such a BoK might be organized around the work system framework because information systems and projects are special cases of work systems. The 31 elements of the metamodel and some of the relationships between its elements could be viewed as attachment points for organizing the part of the BoK that is related to the operation of sociotechnical systems in organizations. (Other parts of the BoK are related to change and evolution of sociotechnical systems, especially those that rely most heavily on IT.) Use of the metamodel for this purpose, rather than the work system framework, would be beneficial because the links in the metamodel contain clearer locations for important theories and phenomena such as TAM (the technology acceptance model) and impacts of technologies on users. For example, findings concerning TAM would refer to the link between participant and tool in the lower left corner of the metamodel. Similarly, topics and generalizations related to eservices in which customers are participants to varying degrees would refer to actor role and customer participant. The BoK would be compiled by looking at past IS research and deciding where its conclusions belong in the metamodel, i.e., where to attach each research conclusion. A separate part of the BoK related to construction and implementation of sociotechnical systems could be organized using the same constructs because projects can be viewed as work systems. Mapping research results onto concepts and relationships in the metamodel could reveal areas where research is needed and other areas where further research is less important.

Acknowledgements

While any remaining errors and omissions are my responsibility, I would like to thank a number of individuals who provided a wide-ranging variety of suggestions about how to improve various versions of the metamodel: Narasimha Bolloju, Andrew Burton-Jones, Joerg Evermann, Matt Germonprez, Michael Goul, Dirk Hovorka, Liette LaPointe, Lars Mathiassen, Jeffrey Parsons, Jan Recker, and Douglas Vogel.

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