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Abstract
This paper presents a metamodel designed to help in understanding, analyzing, and designing sociotechnical systems. The metamodel extends and clarifies the work system framework and related concepts at the core of work system approach for understanding IT-reliant work systems in organizations [Alter, 2003, 2006a, 2008a]. Development of the metamodel supports a larger goal of creating an enhanced work system approach that is understandable to business professionals but that is somewhat 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. The 32 elements in the metamodel include work system, the 9 elements of the work system framework (with information replaced by informational entity), and 22 other elements that clarify a number of questions and confusions observed in past applications of the work system approach. 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 can also be used to organize much of the know-how and many of the system-related research results in the IS field.

Keywords: Sociotechnical systems; systems design

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Metamodel for Understanding, Analyzing, and Designing Sociotechnical Systems

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Abstract

This paper presents a metamodel designed to help in understanding, analyzing, and designing sociotechnical systems. The metamodel extends and clarifies the work system framework and related concepts at the core of work system approach for understanding IT-reliant work systems in organizations [Alter, 2003, 2006a, 2008a]. Development of the metamodel supports a larger goal of creating an enhanced work system approach that is understandable to business professionals but that is somewhat 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. The 32 elements in the metamodel include work system, the 9 elements of the work system framework (with information replaced by informational entity), and 22 other elements that clarify a number of questions and confusions observed in past applications of the work system approach. 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 can also be used to organize much of the know-how and many of the system-related research results in the IS field.

This paper is organized as follows:

1. Background and goal
2. The work system framework and related research
3. Premises underlying the work system approach
4. Metamodel underlying the work system framework.

5. Discussion of items and groups of items in the metamodel
6. Extensions and future research

Background and Goal

The IS field is ambivalent about whether information systems are sociotechnical systems. On the one hand, sociotechnical concerns appear prominently in IS literature from authors strongly associated with sociotechnical issues (e.g, Cherns, Mumford, Trist, Pasmore, Avison, Fitzgerald, Majchrzak), system thinking (e.g., Ackoff, Ashby, Checkland, Churchman), social informatics (e.g., Kling) and implementation in organizations (e.g., Markus, Robey, Zmud). On the other hand, typical systems analysis and design textbooks basically treat "the system" as a technical object 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]. The widely cited IS Success Model proposed by DeLone and McLean [1992] views "the system" as a technical artifact that is used by users when it says that "system quality and information quality singularly and jointly affect use and user satisfaction." Likewise, the Aims and Objectives page of the web site for IFIP Technical Committee 13 on Human Computer Interaction adopts a similar view by referring to system usability, human-oriented computer systems, and "modeling the user as an aid to better system design." (see IFIP TC.13 [2009])

A recent *EJIS* article, "Defining Information Systems as Work Systems," [Alter, 2008a] explained how the IS field can have it either way. "A work system is a 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." Work systems change over time in a series of iterations. Increasingly, those iterations have led toward largely automated work systems in which people design, set up, and maintain the system, but do not participate directly in its intended operation [Davenport and Harris, 2005]. Examples include automated decision systems, automated manufacturing cells, autopilot systems, and coordinated control of traffic lights. Most of the basic concepts that apply to work systems in general also apply to these automated work systems.

In a long term project extending over more than a decade Alter [1995, 1999, 2003, 2008a, 2008b] 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 some of the tenets of design science research that were articulated in *MIS Quarterly* by Hevner et al [2004], such as relevance, basis in theory, testing, evaluation, 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 especially well-trained IT professionals, business professionals in most of their firms were not aware of well articulated analysis methods that they could use for thinking about systems and system improvement. 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."

A work system approach assumes that the topic of interest is a work system. Almost all current work 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 Georgia State University who analyzed work systems in their own organizations for class projects in spring 2009. The deliverable for their assignments was a management report (executive summary, background, etc.) written based on a work system analysis template. It included an appendix containing a required set of tables. That deliverable was similar in scope and intent to a midrange briefing that might be presented to a manager or a committee that would decide whether to put more effort into the analysis and how to allocate resources among various proposed projects. In other words, consistent with previous development of the work system method, 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" system.

Table 1. Examples of work systems analyzed by employed MBA students		
• Insurance policy renewals • Timekeeping for field technicians for a public utility • Receiving materials at a large warehouse • Controlling marketing expenses • Acknowledging gifts to a high profile charitable organization • Performing pre-employment background checks • Purchasing advertising services through an advertising agency	• Performing portfolio management in a wealth management organization • Planning and dispatching trucking services • Scheduling and tracking health service appointment • Determining salary increases • Operating an engineering call center • Administering budgets for grants • Collection and reporting of sales data for a wholesaler • Determining performance-based pay	• Finding and serving sales consulting clients • Determining government incentive for providing employee training • Invoicing for construction work • Performing financial planning for wealthy individuals • Planning for outages in key real time information systems • Approving real estate loan applications • Acquiring clients at a professional service firm

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. Information systems are a special case of work systems, all of whose 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 work systems such as entering orders and paying suppliers.

Work system modeling can be used to describe situations ranging from the work of filling out simple computerized forms through the work of producing airplanes. Its area of usefulness is between the two extremes. There is no reason to use a work system approach for understanding a simple procedure that always conforms 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 prompts the analysis effort. Since every work system can be viewed as a subsystem of a larger work system, the boundaries of a work system are treated as a carefully considered decision by the work system modeler. In general, the relevant work system for a particular analysis 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.

Goal of this research. Figure 1 uses a two dimensional framework (social vs. technical and big-picture understanding vs. precise, highly detailed documentation) to position the current the work system approach in relation to important groups of topics and concerns in the IS field. The current work system approach appears in the sociotechnical part of the horizontal axis (unit of analysis) because it tries to integrate the social and the technical. On the vertical axis it is closer to big picture issues, characteristics, and effects and further from precise, highly detailed documentation.

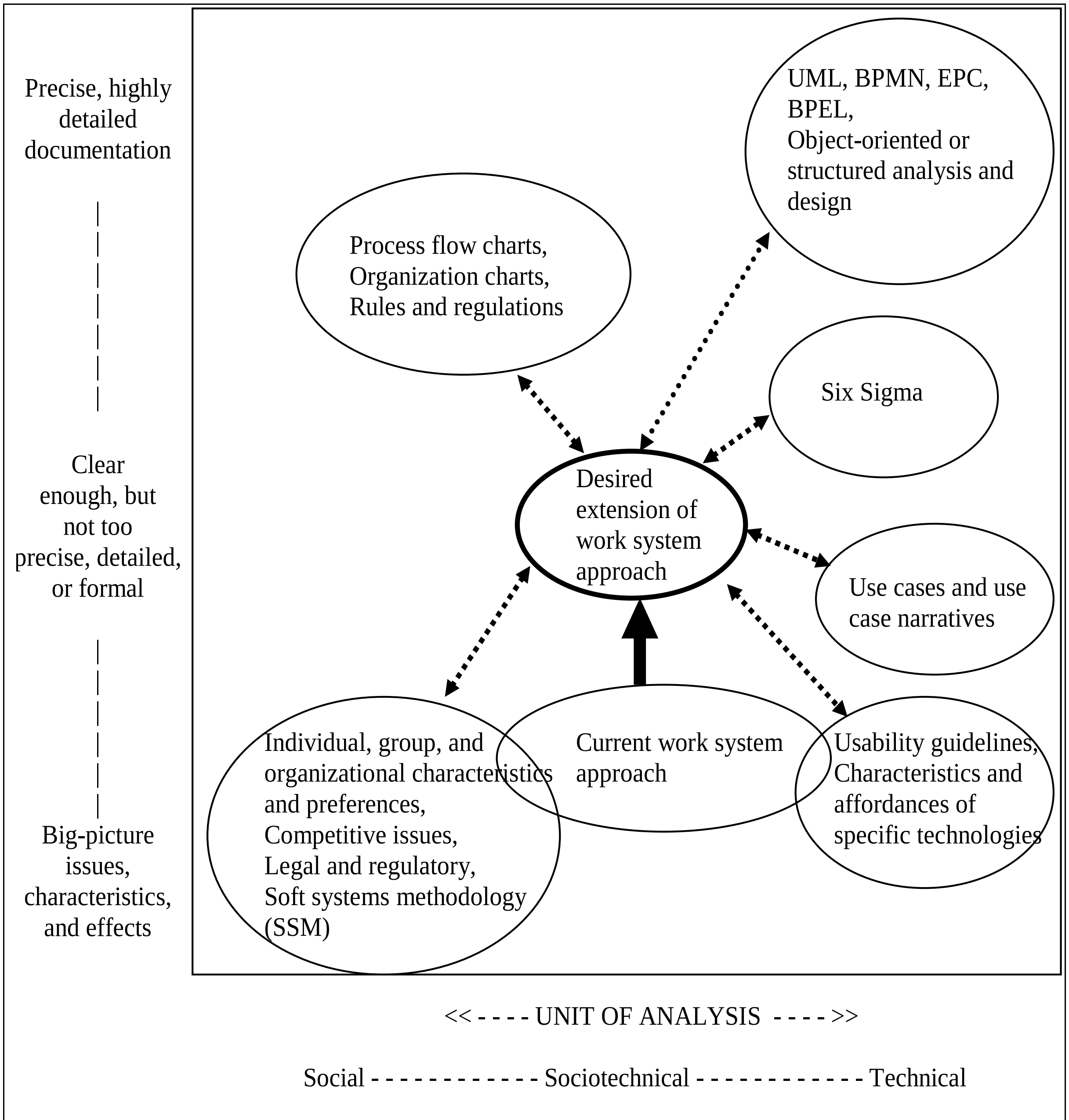


Figure 1. Direction for Extending the Work System Approach

A great deal of research has focused on developing ideas, tools, and methods associated with the top and bottom of Figure 1. In contrast, very little research has focused on developing tools and methods that try to be clear enough to help business professionals, but are not too precise, detailed, or formal. Ideally, such tools should integrate the social and technical, and therefore belong in the middle of the social vs. technical dimension, not at either end. A desired extension of the existing work system approach would make it more precise and detailed, but not "too precise," i.e., not so precise and notation-laden as to overwhelm business and IT professionals who are not accustomed to extremely detailed modeling.

The bolded arrow in Figure 1 highlights the goal of using the proposed metamodel to extend the work system approach in the direction of greater precision and detail, while leaving detailed flowcharts, UML specifications, and other precise documentation for a later stage. Since a work system approach focuses on creating basic understandings and better communication, it has no need for the level of rigor required for specifying reliable software. The dashed arrows in Figure 1 represent the potential for improved effectiveness of links between the work system approach and other approaches. One of the most interesting areas is potential links with precise, highly detailed technical methods and tools. Ideally, the clarity afforded by the new metamodel should make it easier for practitioners to trace progress from sociotechnical analysis in work system terms to rigorous specifications for technical systems. Other interesting possibilities include links to use case analysis and/or the ability to bypass use cases and move directly from a work system analysis to other UML diagrams. In an area often ignored by the IS field because it is associated with a different academic silo, another interesting possibility is greater integration between the work system approach and certain Six Sigma tools and methods.

Thus, the goal of the proposed metamodel is to help extend the work system approach from a somewhat under-researched area in the IS field (the sociotechnical area between the primarily organizational and the primarily technical) into the middle of Figure 1, an area where even less current research is occurring. That area integrates social and technical concerns and calls for a middle ground between precise, highly detailed documentation that is too overwhelming for most business professionals, and qualitative discussions of capabilities, characteristics, and tendencies that are too imprecise for building reliable software.

The next section summarizes the work system framework and related research. Subsequent sections identify the premises underlying the proposed metamodel and then look at the metamodel itself.

The Work System Framework and Related Research

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. The elements of the work system framework are defined briefly in Table 2. The other central framework in the work system approach is the work system life cycle model, which expresses a dynamic view of how work systems change over time. It is not discussed here.

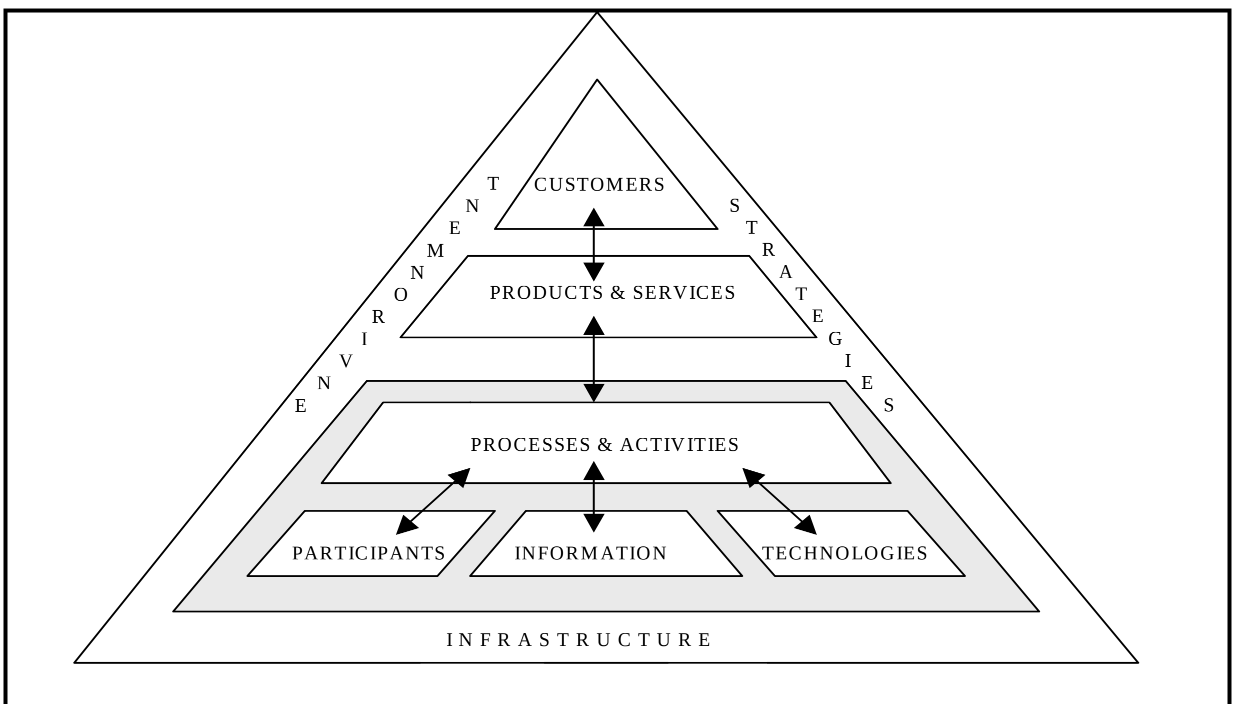


Figure 2. The Work System Framework. Alter [2006a], slightly updated

Table 2: Brief definitions of the elements of the work system framework
Customers are recipients of a work system's products and services for purposes other than performing work activities within the work system. For example, a doctor who receives a lab result while treating a patient might be viewed as a customer of the lab, but is not a customer of the work system of providing medical care. Internal customers are customers of a work system who happen to be employees or contractors of the firm within which the work system operates. External customers are not employees or contractors for that firm.
Products and services are the physical things, information, and actions that are received or used by the work system's customers and that provide direct benefit for its customers. Different groups of customers may benefit from different products and services produced by the work system.
Processes and activities are actions that occur within the work system to produce products and services for its customers. Processes and activities include much more than totally structured processes that appear in some IS definitions as "procedures." As happens in collaboration systems and many other situations, various processes and activities performed by participants may be structured, semi-structured, or unstructured.
Participants are people who do the work within the work system. They include both IT users and non-users. Thus, non-users of IT may still be important to include as participants in the work system. A work system's customers are also participants in many work systems that provide services. In self-service work systems, customers may be the only participants.
Information includes codified and non-codified information created and/or used by a work system.
Technologies include tools that are used by work system participants, plus other tools that perform totally automated activities. Technologies within a work system include IT and other, non-IT technologies that perform physical movements or transformations that are visible to users. Many technologies that perform physical activities (e.g., automobiles and microwave ovens) include embedded IT.
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.
Environment includes the relevant organizational, cultural, competitive, technical, and regulatory environment within which the work system operates. A work system's environment should be considered when analyzing a work system because its success depends partly on surrounding factors that are not part of the work system itself.
Strategies that are relevant to a work system include strategies of the work system, the organization, and the enterprise. Strategies may or may not be articulated. When articulated, strategies may help in understanding a work system and its environment.

A summary at the level of the work system framework is useful for thinking about how to improve business performance and for attaining mutual understanding about what system is being discussed by a group. In effect, the work system framework is a summary level metamodel that has been used by hundreds of MBA and Executive MBA students to analyze sociotechnical work systems in real world organizations. Table 3 is a "work system snapshot," a one page summary of a work system based on the six central elements of the work system framework. That work system snapshot is an excerpt from a large set of real-world work system analyses produced by advanced MBA students who used a work system analysis template (including a blank work system snapshot) to help them their analyses of work systems in their own firms. The author of the work system snapshot in Table 3 stated that the overall analysis of which it is a part turned out to have practical value for the organization he manages.

Table 3: Work system snapshot for a request fulfillment system in a testing laboratory

<table>
<tr><th colspan="3">Customers</th><th colspan="3">Products and Services</th></tr>
<tr><td colspan="3">Plant Managers
Quality Control Managers
Product Integration Managers
Package Designers
Sales Engineers
Package End Users</td><td colspan="3">Expert Opinions
Laboratory Reports
Laboratory Data</td></tr>
<tr><th colspan="6">Major Activities or Processes</th></tr>
<tr><td colspan="6">Laboratory service requests for plastic bottle testing are submitted by the requestor via our corporate intranet utilizing Sharepoint functionality.
Laboratory service requests are routed to the laboratory manager and initially scrutinized
A follow up is then initiated with the requestor if needed to ascertain a better understanding of the requestor’s objectives as they relate to the service request.
A laboratory technician is assigned to the request by the laboratory manager.
A test plan that meets the objectives of the request is then developed by the laboratory manager and the technician.
The technician executes the test plan on the bottles and collects the necessary data outlined in the test plan.
The technician completes the test plan by summarizing the data collected and submitting it to the laboratory manager for review.
The data is scrutinized by the laboratory manager in terms of meeting the objectives of the requestor and either orders follow-up testing by the technician or if the data is deemed sufficient a laboratory report is completed that explains how the data meets the requestor’s objectives.
The completed laboratory report is communicated electronically to the requestor and the laboratory manager follows up with the requestor to make sure the requestor’s objectives have been met satisfactorily.
The laboratory service request is then closed out.</td></tr>
<tr><th colspan="2">Participants</th><th colspan="2">Information</th><th colspan="2">Technologies</th></tr>
<tr><td colspan="2">Requestor
Laboratory Manager
Laboratory Technician
Materials Scientist
Internal Subject Matter Expert
External Subject Matter Expert</td><td colspan="2">Laboratory Service Request
Problem Description
Requestor Interview
Package Specifications
Industry Test Methods
Laboratory Test Data
Laboratory Reports</td><td colspan="2">Corporate Intranet
Sharepoint
Microsoft Excel Template
Microsoft Word Template
Laboratory Test Equipment
Telephone and E-Mail</td></tr>
</table>

The metamodel presented later in this paper is useful for drilling down to a deeper level of specificity without requiring the level of precision and type of notation that is required for software specifications. Development of a clearer and more extensive metamodel underlying the work system framework is a potentially important step toward developing new tools and developing traceable links between lightweight descriptions and analysis by business professionals and heavyweight analysis and documentation by IT specialists.

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 information systems, information system development, systems analysis and design, and project improvement. Specific usage contexts include:

- One or several lectures to provide context for courses including IS for generalists, systems in organizations (combining aspects of IS and operations management), IS development for specialists, systems analysis and design, and process improvement.
- Student exercises applying the work system framework to create "work system snapshots," which summarize a work system using the six central elements of Figure 2.
- Rationale and sanity checks for programming projects by computer science students, using either the work system framework, work system principles, or simple questions related to work system elements.
- Conceptual core of major projects in generalist undergraduate and MBA classes
- Conceptual core of projects in IS courses for IS majors

A number of researchers other than Alter have applied or cited the work system framework and other products of work system research in a broad range of contexts (e.g., Kosaka [2008, 2009], Lyytinen and Newman [2008], Petersson 2008; Petkov and Petkova [2007]; Carlsson [2006]; Cuellar et al. [2006]; Curtin et al. [2006]; Davamanirajan et al. [2006]; Gray [2006], Møller [2006], 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]; Ramiller [2002]; Borrell and Hedman [2001]. Other related research is in progress and has not yet been published.

Comparison with other frameworks. Table 4 provides brief summary comparisons of the work system framework with other somewhat related frameworks and approaches that have been used in teaching, research, or practice. After seeing this paper's discussion of the proposed metamodel, it would be interesting to imagine analogous metamodels for each of the other frameworks.

Table 4. Summary comparison of work system framework and other frameworks

Framework	***Characteristics or limitations in relation to the work system framework***
Work system framework	9 elements that are part of even a rudimentary understanding of an IT-reliant system in an organization. See Figure 2.

Business process	A business process is a set of steps with a beginning and an end, and a set of conditions that trigger each step. "Processes and activities" are one element of the work system framework, which identifies 8 other elements that are part of even a rudimentary understanding of the situation within which a business process occurs. Use of the term "processes and activities" recognizes that the activities performed in many work systems are not structured enough to qualify as business processes.
Input, processing, output	The mantra of input-processing-output emphasizes 3 elements. It is very useful for describing certain aspects of computer programs, 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 appears occasionally in text books and articles. It is useful for remembering that people, process, and technology are usually relevant, but usually is stated as three boxes that do not lead a deeper, more detailed analysis.
Leavitt framework	Leavitt's [1965] framework describes the dynamic equilibrium between 4 elements: task, structure, people, and technology. It emphasizes that changing any of its 4 elements often requires changes in the other elements. Comparison with the work system framework shows that it does not point to many other important topics for analyzing systems. For example, what about information, customers, products and services, environment, and infrastructure? Also, how is "task" related to "processes and activities"?
SIPOC: supplier, input, processing, output, customer	SIPOC is a 5-element framework that is used commonly in Six Sigma analysis of repetitive processes. SIPOC does not mention participants, technology, information, environment, infrastructure, and strategy. SIPOC is best suited to processes that have clearly defined inputs and outputs, and therefore does not fit many service processes whose suppliers, inputs, and outputs are not clearly specified.
Activity theory	Activity theory is "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] Engestom's model of activity theory "shows the relationship between the subject or individual, the object and the community, as well as how rules, tools, and the division of labor are used in the transformation of the object into the desired outcome." A graphical representation in Kuutti [1995] contains 7 elements: subject, object, community, tool, rules, division of labor, and outcome. [Waite, 2005]
GRITCKA ontology	This ontology for modeling multiagent-based business information systems contains 7 concepts: goal, role, information, task, capability, knowledge, and agent. It models agents instead of work systems, but its categories are relevant for further development of the metamodel presented in this paper. (See Zhang et al. [2003])
Zachman framework	The Zachman's 6X6 framework [Wikipedia, 2009] is an outline of an enterprise's architecture, and therefore is 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.
Generic Process Model framework	Based on Bunge's ontological model, the GPM framework defines a process as a sequence of unstable states leading to a stable state. Basic concepts in the framework include domain, sub-domain, state, event, interaction, stable state, unstable state, and stability condition. [Soffer and Wand, 2007]. This framework operates at a much more abstract level than the work system framework, which tries to describe reality in everyday business terms that can be applied readily by business professionals and IT specialists.
UML – use case diagrams, class diagrams, etc.	UML might be considered a framework because it provides a way to understand a situation. With the possible exception of use case diagrams, the diagrams in UML document the details of a technical system that operates according to well specified procedures and rules, and that uses precisely specified information. The idea of "use case" encourages focusing analysis and design on the use of technical artifacts rather than around improving business performance. UML is not well suited for documenting or analyzing the ways in which systems rely on human judgment and are affected by human variability.

Range of ongoing research. Research related to the work system approach is progressing along a number of tracks:

- **Demonstration of usefulness in teaching**. This research involves analysis of student work that uses work system ideas. Alter [2006b] and Petkov and Petkova [2007] illustrate steps along that path. Ongoing research focuses on student groups ranging from college freshmen to advanced MBA students.
- **Linkage to related fields**. Several recent papers [Alter, 2007, 2008b, 2008c, 2009a] demonstrate why the work system approach could provide fundamental ideas for the development of service science, which is being promoted by IBM and other technology and service firms [Spohrer et al. [2007]).
- **Development of tools**. Ideas and templates presented in Alter [2006a, 2007, 2008b], along with work system analysis templates used for teaching could lead to a set of tools that could support the analysis of sociotechnical systems and the linkage of that analysis to technical analysis of the type that uses UML.
- **Clarification of ideas underlying the work system framework**. The research presented in this paper is part of this track, which is motivated partially by questions from past users of work system ideas, and partially by the goal of developing traceable links between sociotechnical and technical analysis and description. Table 5 lists a number of questions and ambiguities that became apparent in previous applications of the work system framework. Any attempt to develop traceable links between sociotechnical and technical analysis would have to address those ambiguities (which are addressed by the metamodel presented here).

Table 5. Common questions and ambiguities found in applications of the work system framework

Question	***Resolution***
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 and supersystems of a work system?	Most work systems have subsystems and sub-subsystems that 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 further decomposition is not useful. In extreme cases, this is when the work system at the current level of decomposition contains only one meaningful activity. Every work system has supersystems whose operation and details do not have to be included in the analysis.
Is it possible for a customer to be a participant?	Yes, e.g., self-service work systems in which the customer performs self-service work and therefore is a participant.

Is it possible for a work system not to have a process?	Yes, if the work is better described as 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]).
Do all activities produce products/services?	Yes. Activities may produce internally directed products/services used by other activities within the work system, and/or customer products/services that provide benefits for customers.
Is it possible for a work system to be totally automated?	Yes, e.g., a totally automated manufacturing cell. In that case, 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 considered participants in separate work systems that perform those activities. Whether or not the activities of setting up and maintaining the machine cell should be included in the work system is choice of the analyst. They should not be included if the analysis focuses specifically on how the machine cell performs its automated operations.
How is it possible for a work system to have no participants if people necessarily 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 the work system of creating the automated system but are not participants in its automated operation.

Relation to conceptual modeling research. A complete discussion of conceptual modeling is beyond this paper's scope. Suffice it to say that conceptual modeling is an important stream of research related to systems analysis and design, IS development, and IS fundamentals. That research has progressed along at least five dimensions:

- Developing modeling grammars such as UML ,BPMN, EPC, and BPEL, and developing related methods and tools
- Exploring the completeness and expressiveness of modeling grammars. (e.g., Irwin and Turk [2005], Recker et al. [2005], Burton-Jones et al. [2009], Workflow Patterns Initiative [2009])
- Testing the usefulness and usability of conceptual modeling languages and tools (e.g., Dobing and Parsons [2006], zur Muehlen and Recker [2008], Recker et al. [2009],
- Identifying the range of situations that need to be modeled. (e.g., Workflow Patterns Initiatve [2009], Russell [2007])
- Conceptual modeling for business professionals and others who are not technical experts. (Alter [2005], Alter [2006b], Burton-Jones and Meso [2008])

This paper addresses issues related to conceptual modeling research, but does so at a level of abstraction that is quite different from conceptual modeling research that is concerned with the completeness and clarity of modeling grammars (Wand and Weber [2002]). The goal of work system modeling is to create basic understandings of business situations, and to identify areas that require deeper, more detailed analysis. Complete accuracy and precision is not particularly important for that type of modeling. Instead, the goal is to support effective communication and discussion that is often overlooked in the rush to produce precise specifications needed for programming.

Instead of trying to address the precision needs of programmers, the current research focuses more on attaining clarity in the use of everyday business concepts that typical business professionals can apply in relation to understanding systems in organizations. IT professionals need that same type of understanding in order to communicate and negotiate with business professionals. At some point the details need to be specified, but that point is not at the beginning of the analysis or at the point where business professionals are trying to understand the situation.

Premises underlying the work system approach

The metamodel presented here is based on the following premises, the last three of which extend the premises of the work system approach in general:

1. **Need to span two views of systems**. People in the IS field use the term system in two fundamentally different ways. In some cases, systems are viewed as sociotechnical systems in which people perform some or all of the important work. With this view, people are viewed primarily as system participants rather than primarily as users of technology. In other cases, systems are technical entities or tools consisting of hardware and software.[Alter, 2004] Sociotechnical systems are never totally deterministic because the skill, knowledge, judgment, incentives, and inherent variability of people have an important impact in their operation. In contrast, technical systems are designed to operate in a completely predictable manner based on how their technical components are specified, programmed, configured, and tested. Systems analysis and design should address both sociotechnical systems and technical systems. A metamodel that supports and encompasses the analysis of both sociotechnical systems and technical systems is a potentially important addition to systems analysis and design knowledge and methods.

2. **Goal of systems analysis and design**. The real goal of analysis and design is improving business performance. Businesses operate through work systems, most of which are sociotechnical. Analysis and design methods should pay attention to the performance of work systems and how that performance is related to business results. Those concerns involve much more than the detailed structured of data and software.

3. **Tools and methods for analysis and design by business professionals.** In general (but with many important exceptions), business professionals tend to focus more on sociotechnical systems, whereas IT professionals tend to focus more on technical systems. Ideally, business professionals and IT professionals should each have appropriate tools and methods that help them do their individual work and also help them communicate while collaborating in the analysis and design of sociotechnical systems. In particular, tools and methods for business professionals should help them think in an organized way about sociotechnical systems. Those tools and methods should help them communicate more effectively with IT professionals, whose tools and methods are far too precise and detail-oriented in relation to the analysis and design needs of business professionals.

4. **Uncertainty of a system's scope**. The system's scope often is not obvious at the beginning of the analysis of a sociotechnical system. Most systems, both sociotechnical systems and technical systems, can be viewed as components of other systems. The scope of the system that is to be analyzed depends on the purpose of the analysis. Different people with different purposes may define the relevant system differently. Even people with the same purposes may the relevant system differently based on differences of viewpoint, training, or opinion.

5. **Practicality**. Entire enterprises or organizations can be viewed as sociotechnical systems. However, in most systems analysis and design situations the relevant system is a portion of an organization or enterprise. Attempting to analyze or design an entire organization or enterprise at a detailed level is simply too overwhelming.

6. **Automated agents as work systems.** We define "automated agents" as work systems in which hardware software, and/or other machines perform all of the work. It should be possible to analyze and design automated agents using most of the same ideas that are used to analyze sociotechnical work systems. The main differences

are in two areas: First, the work system ideas related to the human aspects of participants will not be directly relevant to the automated agents. Second, the analysis of the automated agents will call for additional concepts that are primarily relevant to automated agents and are not applicable to work systems in general.

7. **Smooth, traceable transition between different views of technology in operation**. At different levels of analysis, technologies can be viewed as tools that are used by users or as automated agents that perform specific functions autonomously when triggered by user commands, external conditions, schedules, or other factors. For example, at a summary level, a doctor's stethoscope and a program that finds possible drug interactions could both be viewed as tools used in a sociotechnical system in which doctors assess patient problems and produce recommendations and drug prescriptions. At some point in the decomposition of that sociotechnical system into subsystems, the software that evaluates potential drug interactions might be viewed as an automated agent that uses automated means to respond to a command from a doctor. The analysis of the sociotechnical system should flow smoothly into the analysis of relevant technical systems of either type (tool or automated agent).

8. **Recursion**. Decomposition of a work system into smaller work systems uses the same concepts (customer, products and services, participants, etc.) for looking at subsystems and sub-subsystems. The use of the same terms at different levels in the recursion has the advantage of using the same business-oriented vocabulary instead of switching from one vocabulary to another.

The metamodel presented in the next section is designed for several purposes. It creates a bridge between a summary level description of a work system and the more detailed models as the work system is decomposed into subsystems and sub-subsystems during an analysis or design process. It clarifies the concepts at the summary level of the work system framework and guides their re-use during the decomposition of a work system into subsystems and sub-subsystems. Perhaps more important, it is a step toward establishing tighter links between sociotechnical analysis done by business professionals, consultants, and business systems analysis, and technical analysis and design work done by IT specialists in order to produce software. If developed fully and linked to straightforward translation tools, it might be the basis of traceability between sociotechnical requirements and technical details required for reliable, testable computer programs.

Metamodel Underlying the Work System Framework

Figure 3 is a metamodel underlying the work system framework. The work system framework contains 9 elements whereas the metamodel contains 32 concepts whose definitions and mutual relationships clarify a number of common confusions related to the work system framework and its possible application as the basis of tools and methods for systems analysis and design. Figure 3 uses shading to highlight the distinction between the elements in the work system framework and the concepts in the metamodel that are not in the work system framework. The terms in the metamodel are organized to emphasize the relationships between the various items. For the sake of visual simplicity, Figure 3 does not name relationships or multiplicities (e.g., 0 …*, 1…3) that clarify the relationships. Those factors are included later in more detailed looks at specific parts of the metamodel.

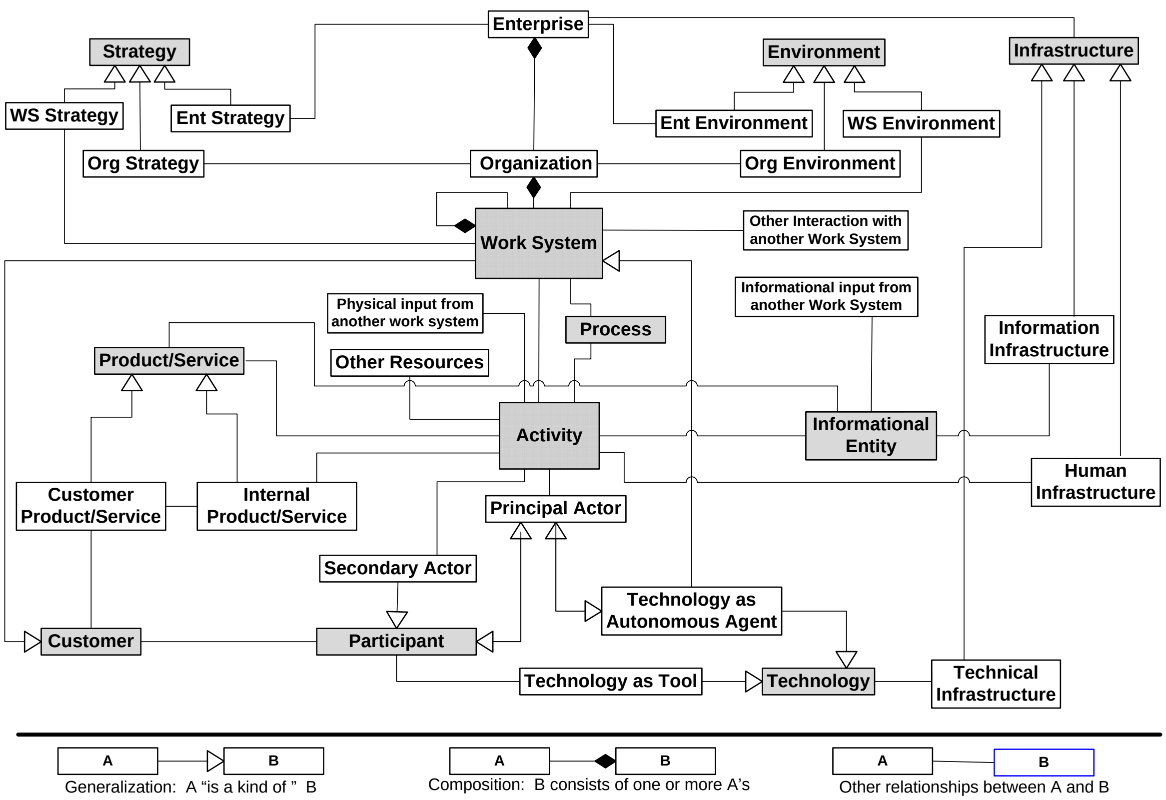


Figure 3: Metamodel underlying the work system framework

Many details in the metamodel could have been expressed in other ways. In general, representation decisions in the metamodel supported the goal of maximizing understandability and revealing potential omissions from an analysis or design process. For example, a construct called “principal actor” was introduced because an activity can be performed by a participant using technology or by a technology acting as an automated agent. Likewise, for the two constructs “technology as tool” and “technology as autonomous agent.” Also, for the sake of visual simplicity the representation of the metamodel in Figure 3 expresses a specific level of decomposition and contains only one reference to further decomposition of the work system or its elements. It says that a work system usually can be decomposed into smaller work systems, but does not say that technologies or informational entities often can be decomposed into smaller entities of those types. Decomposition for those entity types will appear later in focused summaries of specific parts of the metamodel.

Some of the definitions of terms in the more detailed level of the metamodel are inconsistent with the definitions of those terms as the summary level of the work system framework. For example, at the level of the work system framework “products/services” is whatever the processes and activities produce for a work system’s customers. At the more detailed level of the metamodel, a “product/service” is something that an activity produces; it may be a customer product/service and/or an internal product/service. That distinction is invisible at the level of the work system framework, but is important at a more detailed level because internal product/services are used by other activities within the work system, whereas customer product/services may or may not be used within the work system.

The next section of this paper subdivides the metamodel into a series of diagrams containing parts of the metamodel that should be explained together. Some of the diagrams focus on specific elements of the work system framework; others are organized around themes that involve a number of entities in the metamodel. Those diagrams use multiplicities in the following manner:

“ 1,… ” refers to one or more; “ * ” refers to 0 or more.

The direction of relations is indicated as follows by using > and <:

“entity A is related to entity B” is notated in diagrams as A is related to > B

“entity A is an instance of entity B” and B is an instance of A is notated as A <is a> B

In addition to filling in details that are not presented in Figure 3, the following discussion explains the need to reinterpret several elements of the framework, such as Product/Service or Processes & Activities, at this more detailed level of description.

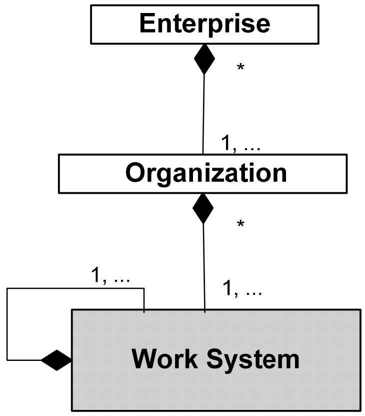
Discussion of Items and Groups of Items in the Metamodel

To explain the metamodel in a manner that is not overwhelming, we look at the following series of subdiagrams, each of which summarizes a coherent subset of the metamodel.

- Work system, organization, enterprise
- Work system, process, and activity
- Activity, product/service, and customer
- Customer and participant
- Information
- Technology
- Inputs and resources used by an activity
- Infrastructure
- Environment
- Strategies

Given the many relationships between different concepts in the metamodel, explanation through a set of subdiagrams should be easier to understand and should lead to quicker comprehension of the entire model than a sequential explanation of each term and all of its relationships.

Work System, Organization, Enterprise

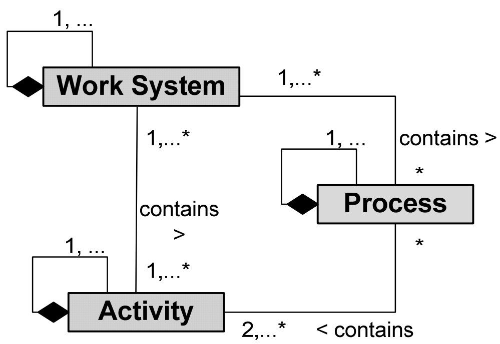


Entire enterprises and organizations can be viewed as work systems and can be subdivided into one or more work systems. Also, all but the smallest work systems can be subdivided into smaller work systems. Systems analysis related to the development and use of application software typically occurs in reference to one or several work systems because attempting to analyze an entire organization or enterprise as a system is usually overwhelming, with too many different roles performing too many different types of activities using too many different types of information.

Although enterprises contain organizations and organizations contain work systems, a given work system might not be part of a specific organization or enterprise. For example, the efforts of various types of virtual teams can be considered work systems (since they involve people performing work to produce something for customers) even for virtual teams that are not associated with a specific enterprise or organization.

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 work systems (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 factors. In comparison with truly sociotechnical systems, totally automated work systems are more amenable to analysis using typical systems analysis tools for IT professionals.

Work systems, Processes, and Activities



Work system vs. process. Everyday usage of the terms *work* and *process* often conflates a number of different ideas:

- Work: being physically present in a workplace
- Work: producing something useful related to goals of an organization
- Work: performing a process
- Process: doing something in an organized or semi-organized way, even if the activities are not structured or sequential.
- Process: a series of related, clearly specified steps with a beginning and end, and with specific conditions triggering each subsequent step

The work system framework assumes that work is the application of resources to produce something useful. Its use of the term "processes and activities" recognizes that the work being performed in a work system may not be a set of clearly specified steps whose beginning, sequential flow, and end are well-defined. (As described in both *Harvard Business Review* and *IBM Systems Journal* (Hall and Johnson [2009], Hill et al. [2006]), many important situations rely heavily on human judgment and improvisation and therefore are not totally structured.) The metamodel's inclusion of both "processes and activities" and "participants" recognizes that process specifications tell only part of the story because different people might perform the same idealized processes or activities differently and with different skill levels.

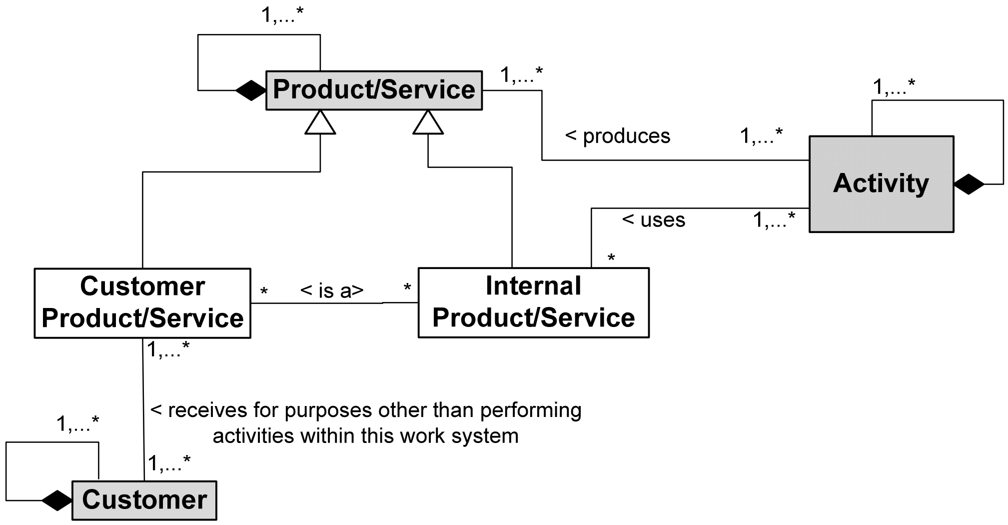
Processes and activities. In the metamodel a process is a set of two or more related activities that occur within the same work system and each of which is initiated by a known condition, such as the completion of a previous activity within the process. A given work system may contain multiple processes. 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 is not sufficient for performing that type of analysis.

Multiplicities.

- A work system always includes one or more activities. (Otherwise no work occurs.)
- A work system may contain zero or more processes because the work that is performed may not be structured or sequential enough to be called a process.
- A process includes two or more related activities. (There is no reason to call one activity a process.)
- Activities and processes that would be analyzed using work system concepts are always part of at least one work system.
- An activity may or may not be part of a process, especially if the work that is being done is not structured enough to call a process.

Decomposition. Something that is called an activity (or process) at one level of detail often can be subdivided into a set of activities or processes at a different level of detail. Although that point was not included in Figure 3 for visual simplicity, it is important in the transition from a top level work system snapshot (the six elements of Figure 1) to a description at the level of detail of specific computerized functions that occur within specific activities.

Activities, Products/Services, and Customers



The definition of work system says that a work system's purpose is to produce products and/or services for customers. As work systems are decomposed into subsystems, the implications of that definition need to be clarified.

The work system framework and the metamodel use the term product/service instead of more computer-oriented terms such as output because the term product/service is more effective when discussing sociotechnical systems, especially those that produce services for people rather than tangible goods. The metamodel does not distinguish between products and services because the long-standing debate about the difference between products and services is beyond the metamodel's scope. For aspects of that debate, see Vargo and Lusch [2004], Sampson and Froehle [2006], and Alter [2009]. For purposes of analyzing and designing work systems, the distinction between products and services is much less important than identifying and applying a set of continuous design dimensions such as tangible versus intangible, commodity versus customized, personal versus impersonal, etc., all of which are sometimes associated with product/service distinctions. (Another discussion that is beyond this paper's scope.)

"Products & services" is useful as a heading in the work system snapshot (a one page summary of a work system in terms of six central elements of the work system framework), but needs to be described in more depth in the metamodel.

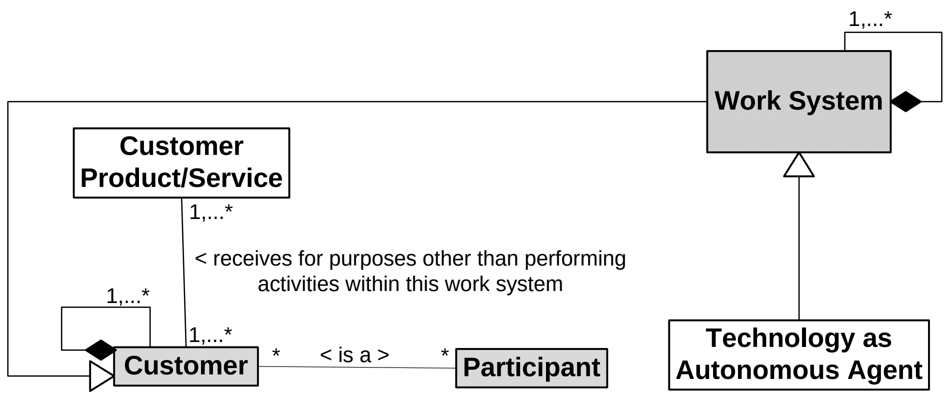
- Each activity within a work system produces something, i.e. some type of product or service. Otherwise, there would be no reason for that activity to occur.
- Products/services produced by a specific activity within a work system may include “internal products and services” that are used by other activities within the same work system, and “customer products and services” for the work system’s customers.
- “Customer products and services” are products and services that are received by this work system’s customers and used by them outside of this work system. (“This work system” refers to whatever work system is currently the focus, even if that work system is a subset of the work system that was the focus when the analysis began.)
- Something that is produced by an activity within a work system and is used by subsequent activities within a work system can also be a product/ service for the customer. In other words, “internal products and services” may also be “customer products and services” if the customer uses those products and services outside of the work system.

Multiplicities.

- An activity produces one or more products/ services. (If it doesn't produce anything, it is not included in the work system.)
- Every product/service produced by a work system is produced by one or more activities in the work system (allowing something to be produced several different ways).
- Any particular product/service is an “internal product/service” and/or a “customer product/service.”
- “Internal products/services” are used by at least one activity within the work system (by definition).
- A customer receives and uses one or more customer products/services for purposes other than performing activities within this work system. A person, role, or work system that receives no customer products/services is not a customer of this work system. (This distinction clarifies an ongoing confusion about whether stakeholders are customers. They are customers only if they receive something that the work system produces.)
- A “customer product/service” must be received and used by one or more customers (i.e., customer roles).

Decomposition. The previous diagram says that a product/service produced by an activity may be decomposed into smaller product/services. Something that is an internal product/service at one level of decomposition can contain both internal product/services and customer product/services at more detailed levels of decomposition. For example, assume that an activity in a much larger work system involves a human analyst performing a search for information. Decomposing that activity into smaller steps will result in some steps that are done by that human analyst and other steps that are performed by an automated agent. When the automated agent is viewed as a work system on its own right, it will produce customer products/services for the human analyst who is its customer.

Customers and Work Systems



Customers are the customers of a work system; they may or may not be customers of the organization or the enterprise. Participants are people (roles) who perform activities in a 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)

Customers of a totally automated work system may include other totally automated work systems. (See later discussion of technology.) This important special case is consistent with the definition of customer.

Multiplicities.

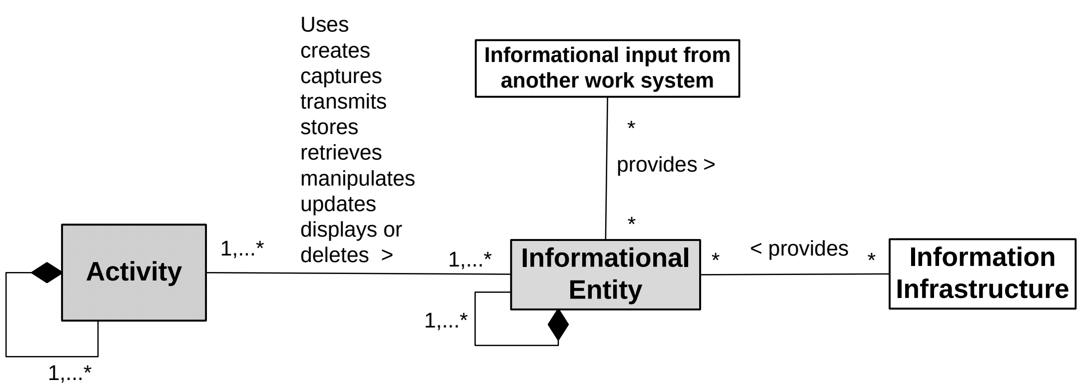
- A customer receives and uses at least one customer product/service.

- A customer receives and uses at least one customer product/service for purposes other than performing activities within this work system.
- Each customer product/service is received and used by at least one customer.
- A customer may or may not be a participant.
- A participant may or may not be a customer.

Decomposition.

- A customer that is an automated agent (i.e., a totally automated work system) may be decomposed into smaller work systems.
- A customer that is an organization may be decomposed into smaller groups.

Information



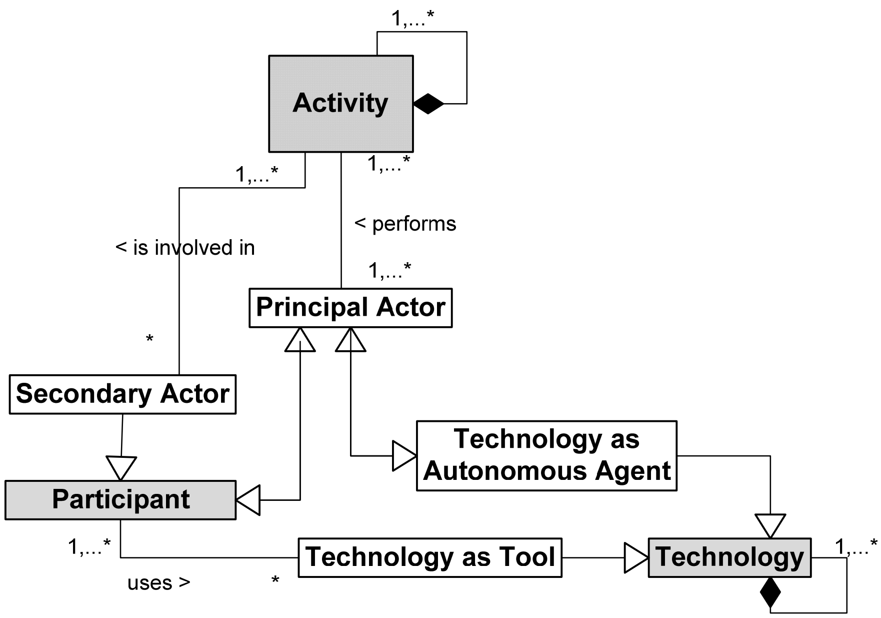
All work systems use information and depend on the quality of information they use. Therefore it is surprising that many common definitions of information system do not even contain the word information. [Alter, 2008b]. The complex relationship in the diagram (creates, captures, etc.) reflects the different things that activities can do in relation to information. As an analysis progresses, it is necessary to specify exactly what specific activities do in relation to specific informational entities. Informational entities may be generated by activities within the work system, may be informational inputs from other work systems, and may be provided by the information infrastructure of the enterprise.

Instead of the generic term information (which appears in the work system framework), the metamodel includes the term informational entity. Examples of informational entities include orders, invoices, warranties, schedules, income statements, P&L 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.) Informational entities can contain other informational entities. For example, an order can contain a line item, a document can contain a chapter, and a message can contain a heading. The term informational entity is used, rather than information, to encourage hierarchical descriptions of information instead of going immediately to the most basic units, such as data items in an order (e.g., name and address) or words in document.

Multiplicities.

- Each activity creates, captures, transmits, stores, retrieves, manipulates, updates, displays, and/or deletes at least one informational entity.
- Each informational entity is created, captured, transmitted, stored, retrieved, manipulated, updated, displayed and/or deleted by at least one activity. (Otherwise that informational entity would not be mentioned.)
- Informational entities contain one or more information entities, which may be data items, facts in a database, messages, and so on. All data items that are relevant to a work system are part of one informational entity.
- The information infrastructure of the enterprise may provide zero or more informational entities.
- Inputs from other work systems may provide zero or more informational entities.
- Informational entities may be provided by zero or more components of information infrastructure and by inputs from zero or more work systems other than the one being described.

Activity, Technology and Participants



Most, and perhaps all current work systems use identifiable technologies which may be applied within work systems in two different ways:

- **Technology as a tool used by a person**. The person performs and guides the work with the help of the tool. For example, a doctor using listening to a patient's heartbeat uses a stethoscope as a tool. The tool helps the doctor (through a user interface consisting of audible sounds delivered to earpieces), but the doctor is the principal actor.
- **Technology as an automated agent.** Technology acts as an automated agent when the core of the activity is performed automatically by a program or machine, which may request and use products/services produced by other automated agents in order to perform the activity. An example is a computer program that looks up all relevant drug interactions and returns a recommendation concerning whether the doctor's planned prescription might cause a problem for the patient.

The activities performed by technology as an automated agent are triggered by any combination of the following: people, programs, preconditions, schedules, or other actions of other entities. (This sounds like service-orientation). Thus, an automated agent is essentially an actor that performs an activity autonomously within the work system. For a sociotechnical work system, such an activity typically has visible consequences within the work system or for one or more customers. For a totally automated work system, the consequences may be visible physical actions or may be invisible actions of programs, such as computing a number or transferring a bit stream.

The distinction between the tool and automated agent cases is important as work systems are decomposed into successively smaller subsystems, some of which are totally automated. Even the decomposition of sociotechnical systems eventually gets to activities that are performed completely by automated agents. The distinction between tool usage and automated agents may be helpful in developing links between tools and methods for work system analysis and design by business professionals and technically oriented (i.e., automated agent-oriented) analysis and design approaches for IT professionals.

A work system participant may have either of two roles in non-automated activities: The participant may be the principal actor in the activity or may be another individual who is involved or is acted upon, but is not the principal actor. For example, in a non-automated medical diagnosis activity, the doctor is the principal actor and the patient is the secondary actor. Assistants or a member of the patient's family might be other secondary actors in that activity.

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 technical system that is "used" by "users." (The metamodel leads to systems analysis and design steps that do not start with "use cases" but could create use cases along the way if that would help in linking to existing UML tools.)

People create automated systems and maintain them, but do not participate in their operation and therefore are not participants in work systems that operate as automated agents. Instead, they are participants in other work systems that create, modify, set up, or maintain the automated work systems.

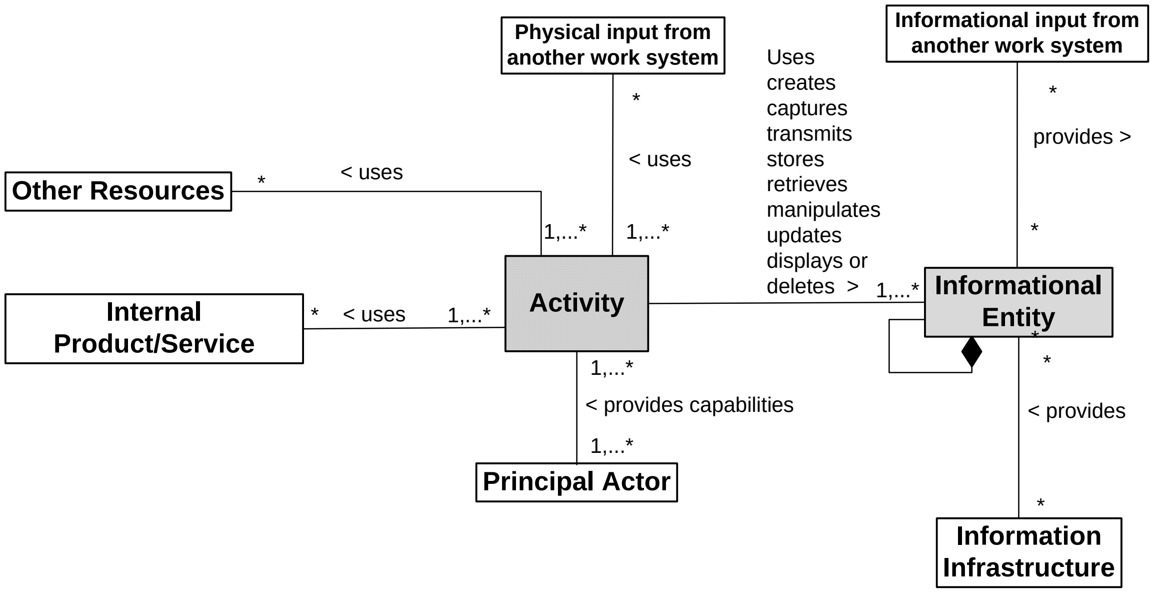
Multiplicities.

- Activities are performed by one or more principal actors, which may be human participants or automated agents. Most activities have just one principal actor, although some, such as negotiations, might be viewed as having several principal actors.
- The principal actor (whether a human participant or an automated agent) must perform at least one activity (to be deemed a principal actor).
- A secondary actor is involved in at least one activity.
- An activity may have zero or more secondary actors.
- The same participant may be a principal actor in some activities and a secondary actor in others.
- A participant may use zero or more technologies (as tools) when performing an activity.
- Technologies as tools must be used by one or more participant roles. (Technologies as tools that are not used by any participants are not part of the operation of a work system.)
- The above imply that a work system may have zero or more participants (thereby allowing totally automated work systems). A sociotechnical work system has at least one participant, whereas a completely automated work system has zero participants.

Decomposition.

- Most technologies can be decomposed into several constituent technologies.

Inputs and Resources Used by an Activity



Activities use inputs and resources including:

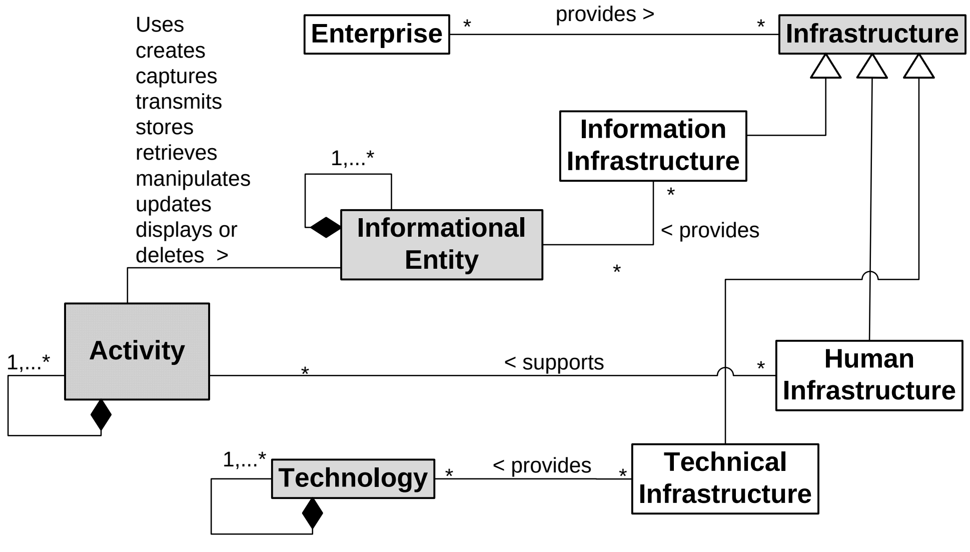
- Informational entities
- Internal products/services
- Information and/or physical inputs from other work systems. Examples of other inputs include inventories and electricity that are used in offices and in manufacturing.
- Other resources (physical things that are used but not consumed immediately). Examples include buildings, furniture, and transportation equipment.
- Capabilities of the principal actor. If the principal actor is human, those capabilities include skills, knowledge, and attention. If the principal actor is an automated agent, those capabilities involve programmed procedures and usually are related to information processing capabilities.

Multiplicities.

- An activity uses zero or more internal products/services.
- An internal product/service is used by one or more activity.
- An activity uses zero or more "other resource."
- An "other resource" is used by at least one activity. Otherwise it would not be relevant.
- An activity uses zero or more physical inputs from other work systems

- A physical input from other work systems is used by at least one activity. Otherwise it would not be relevant.
- An activity uses, creates, captures, transmits, stores, retrieves, manipulates, updates, displays, and/or deletes one or more informational entities. For example, almost most activities are triggered by information entities.
- An informational entity is used by at least one activity. Otherwise it would not be relevant.
- An informational entity may be an internal product/service. An internal product/service may be an informational entity.
- The principal actor for an activity provides capabilities to that activity.

Infrastructure



An enterprise's infrastructure includes resources that are shared among multiple work systems. Infrastructure can be subdivided into informational infrastructure, technical infrastructure, and human infrastructure. All three aspects of infrastructure can be essential to the operation of a work system. Nonetheless, infrastructure is generally considered to be outside of the work system because it is owned and controlled outside of the work system.

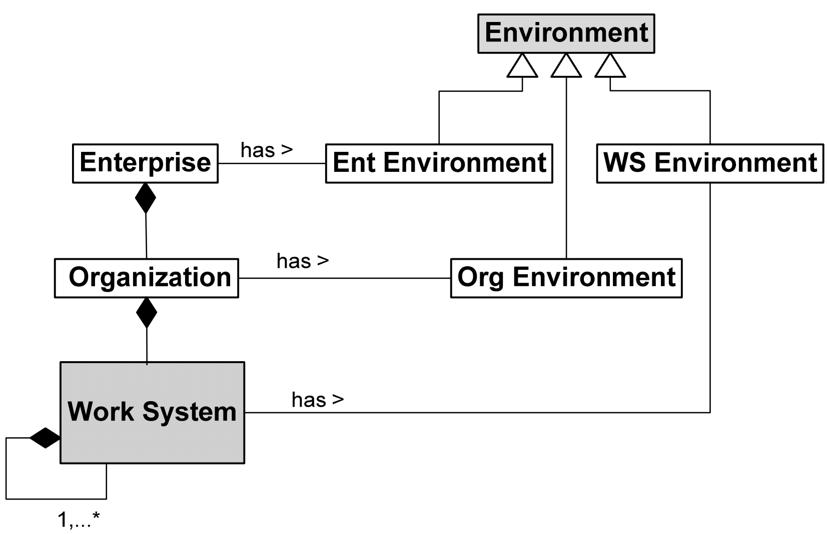
Technical infrastructure is technology that is shared among multiple work systems, is typically owned and controlled at the enterprise level, and is typically assumed to be an essential external capability when analyzing a work system. Examples include:

- Excel: The software is often part of infrastructure, while a specific spreadsheet is part of the technology within the work system.
- Internet: the Internet is part of infrastructure, while a specific ecommerce web site might be considered part of a work system in which a customer orders products or obtains information.
- ERP: The ERP suite is part of the organization or enterprise's technical infrastructure. Particular programs within the ERP suite (such as an order entry program configured for a particular work system) can be viewed as technology within the work system.

Human infrastructure is people who are attached to units that are viewed as human infrastructure but support activities within work systems.

Informational infrastructure consists of informational entities that are shared across an organization.

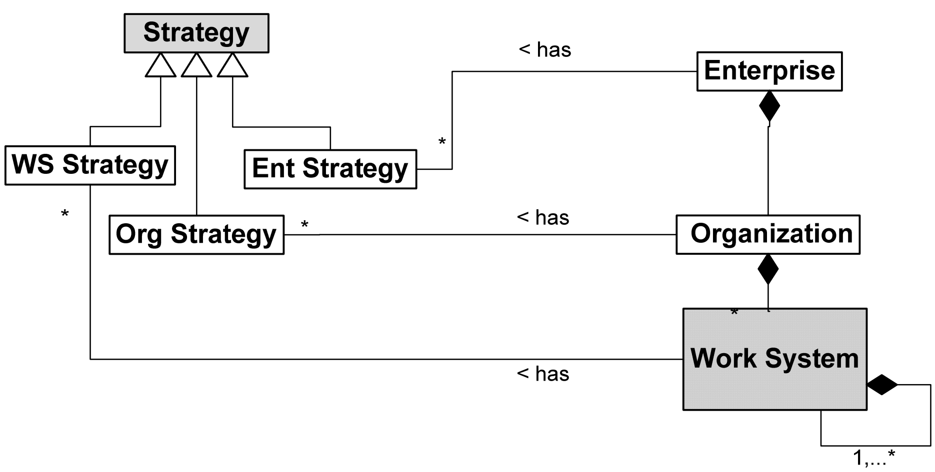
Environment



The environment of an enterprise, organization, and/or work system includes a series of factors including external stakeholders, culture, policies and procedures, history, internal politics, competition, standards, regulation, and demographics, and technology trends. All of those factors are relevant to the analysis and design of many work systems. In contrast to infrastructure, upon which the work system relies in order to operate (e.g., keeping the lights on, keeping the networks running, etc.), factors in the environment have a more indirect impact on factors such as performance results, aspiration levels, goals, requirements for change, and so on. Thus, analysis and design efforts that ignore important factors in the environment may overlook issues that may degrade work system performance or even cause work system failure.

In general, analysis of the environment should start at the enterprise or organizational level. Many specific issues that are important at that level may not be important at the level of work systems, especially for totally automated work systems that serve as automated agents and are largely or totally invisible to people in the organization. Thus, factors in the environment such as standards and technology trends may be relevant when analyzing or designing an automated agent, whereas organizational culture, history, and politics usually are not relevant (unless those factors are directly related to technology choices).

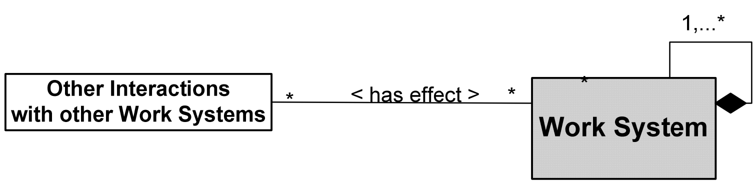
Strategies



The term strategies in the work system framework includes enterprise strategy, organization, strategy, and work system strategy. In general, strategies at the organization and work system levels should support the enterprise strategy. Similarly, strategy at the work system level should support the organization's strategy.

A general difficulty with discussing strategy in relation to work systems is that strategies any of the three levels may not be articulated or may be articulated in a way that does not reflect reality. Although it is generally preferable to analyze and design work systems in reference to a clear and realistic strategy, analysis and design in many situations must occur without a clear strategy, because no one has articulated such a strategy or because the strategies that have been articulated are internally inconsistent, unclear, or not shared or genuinely believed.

Interactions with other work systems



A work system can have many different types of interactions with other work systems. Two types of interactions with other work systems are included in the metamodel.

"Informational input from another work system" and "physical input from another work system" include inputs that are used by specific activities within the work system. The work system framework does not mention such inputs because it is assumed that they will be identified by examining processes and activities in more a more detailed way, such as by using the metamodel. In automated agents within totally automated work systems, those inputs may be messages that request action or provide information. Those are the types of inputs that would appear in a UML sequence diagram.

"Other interactions with other work systems" include many other types of interactions that affect specific work system elements or the work system as a whole. Those interactions include things such as sharing of human participants and other resources, various forms of interference that occur accidentally, and requirements that one work system imposes on another, either implicitly or explicitly. 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 network dependency diagrams (Tillquist et al. [2002]). A taxonomy encompassing planned and accidental interactions and explicit and implicit interactions exists in an unpublished working paper called "System Interaction Theory." (Alter [2009b])

Extensions and Future Research

This paper's purpose was to present a metamodel designed to help in understanding, analyzing, and designing sociotechnical systems. As described in the discussion surrounding Figure 1, the goal of the metamodel is to help extend the work system approach from a somewhat under-researched area in the IS field (the sociotechnical area between the primarily organizational and the primarily technical) into an area where very little current research is occurring. That area integrates social and technical concerns and calls for a middle ground between rigorous documentation this is too 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.

The 32 elements in the metamodel include work system, the 9 elements of the work system framework (with information replaced by informational entity), and 22 other elements that clarify a number of questions and confusions observed in past applications of the work system approach. The metamodel introduces and locates a number of ideas that were not present in previous descriptions of the work system approach, such as:

- technology as a tool vs. the technology as an autonomous agent
- customer product/service and internal product/service
- principal actor and secondary actor vs. (simply) participant
- technology as work system (when the technology is an autonomous agent)
- work system as customer (especially relevant in service oriented architectures)

The introduction of these ideas provides a clearer way to model sociotechnical systems and to see where control is transferred to automated components as sociotechnical systems are decomposed into subsystems.

A complete discussion of the implications and possible applications of the metamodel could take up an entire follow-on paper. Instead, we close by simply mentioning 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 clarifies topics within the work system method, and therefore at minimum is a step toward making that form of sociotechnical modeling more rigorous. It presents a challenge for other forms of sociotechnical modeling by identifying many concepts and relationships that are relevant in many situations and therefore should be included in some direct or implied manner in a complete sociotechnical modeling method. For example, if actor network theory or activity theory is applied to model a sociotechnical system, it is not clear how and where either theory would lead to the many topics in the metamodel. An entire follow-on paper might address this question for actor network theory, activity theory, and other approaches.

An especially important application area is establishing links between a sociotechnical view of systems and the concepts underlying the rapidly developing areas of BPM ("business process management") and SOA (service oriented architecture). In each area, a great deal of development has occurred at the concept, tool, and method level, and a great deal of hype has been presented at the sales and consulting level. The metamodel might support progress in clarifying the potential role of various versions of BPM and SOA in sociotechnical systems, and in linking sociotechnical analysis and design to BPM and SOA.

One of many interesting modeling issues concerns decomposition of sociotechnical systems into components, some of which are totally automated. 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 decomposing sociotechnical systems in the course of analyzing them. That research would start by compiling existing guidelines regarding 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.

Also, a more complete version 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.

Validating the metamodel. It is easy to achieve a base level of real world validation by identifying examples related to each element of the metamodel and to the relationships in the metamodel. The metamodel was developed based on subjective experience with 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 a shortcoming or ambiguity related to how well the work system framework could describe specific situations. Any effort at validation through examples should look for real world examples that don't fit.

Consistent with its purpose, the concepts in the metamodel were defined at the level of everyday business speech, and not in terms of a philosophically based ontology such as BWW. It might be possible to adapt the general thrust of Recker [2009] or Burton-Jones [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 imply a set of extremely simple tools in the form of tables that devote one column to a specific concept (e.g., activities, participants, or informational entities within the work system) and another column or columns related to specifics of the work system (e.g., participants in all activities at a particular level of decomposition, or informational entities used by each activity). It would be possible to develop tools that extend those tables across levels of decomposition. Attention to whether the principal actor in particular activities is a human participant or an automated agent could be useful in linking sociotechnical models to service oriented architectures.

Developing links between various methods for thinking about systems in organizations. A full validation of the metamodel would compare the metamodel with other possible metamodels based on the work system framework or based on other frameworks. Table 3 introduced that topic by listing a set of somewhat related frameworks. At minimum, it would be interesting to identify some of the ambiguities and limitations in each of the other frameworks, and to try to develop a more detailed metamodel that would clear up most the ambiguities and limitations in each case. It would be interesting to compare each of those metamodels with the metamodel proposed here. The explicit identification of concepts and relationships in the various metamodels could form the basis of comparisons between analysis methods based on different metamodels.

Developing links between "lightweight" systems analysis methods and tools for business professionals and 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. (1) It is possible to treat the activities listed in a work system snapshot as a set of use cases. [Tan et al., 2009] Each of those can be clarified through the relationships in the metamodel and through decomposition to subordinate levels. (2) Another approach bypasses the use cases altogether and simply analyzes the work system snapshot by using the metamodel in conjunction with appropriate decomposition. It is 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 the business result of better work system performance.

Including "non-functional" issues. The metamodel focuses on how a sociotechnical system functions. A separate set of issues that are sometimes described as "non-functional" include how well the sociotechnical system operates, what are its implications and impacts on participants and other stakeholders, and how amenable it is to reorganization, scaling up or down, and other forms of change. For example, the metamodel says nothing about the impact of activities on participants or the impact of technologies on their users. Follow-on research, somewhat in the spirit of the proposed ontology of IS in Alter [2005] could identify important properties of each element of the metamodel and of important non-functional relationships that are not explicit in the metamodel.

Developing a body of knowledge for the IS field. The topic of a body of knowledge for the IS field has been raised a number of times (e.g., Iivari et al [2004], Hassan and Mathiassen [2009]). Alter [2005, 2008a] proposed that a body of knowledge for the IS field might be organized around the work system framework because information systems and projects are special cases of work systems. The 32 elements of the metamodel and some of the relationships between its elements could be viewed as attachment points for organizing the part of the body of knowledge that is related to sociotechnical systems. The compilation method would involve looking at past IS research and deciding where its conclusions belong in the metamodel, i.e., where to attach each research conclusion. It is possible that some version of the central insight from Orlikowski and Iacono [2001] would apply, i.e., that a large percentage of the research is not directly related to specific parts of a metamodel that supports the description of real world sociotechnical systems. In a more positive sense, 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.

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