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How Should Business Informatics Integrate Service, Process, Work System, and Enterprise Orientations?

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***Abstract*— Current research related to the subject matter of business informatics reflects divergent orientations that are fundamentally about representing, analyzing, and designing services or processes or work systems or enterprises. After summarizing those four orientations and citing typical exemplars, this paper identifies a variety of paths toward greater integration between different orientations within business informatics. It identifies central topics for each orientation along with areas in which each orientation provides ideas that complement other orientations and reveal possible synergies. Both the approach for identifying potential synergies and the proposed synergies themselves could encourage greater integration within business informatics.**

Keywords— business informatics, process orientation, service orientation, work system orientation, enterprise orientation

I. TOWARD AN INTEGRATED ENGINEERING SCIENCE

The Call for Papers for the 2015 IEEE Conference on Business Informatics [1] describes an overarching goal of "aligning core concepts from management science, organisational science, economics information science, and informatics into an *integrated engineering science*." (italics added) The domains to be included in this *integrated* engineering science combine terms such as engineering, innovation, method, and modeling with areas of primary focus such as business processes, business systems, business models, services, and enterprise architecture. Contrary to this goal of integration, these areas of interest are often seen as quite separate both in research and practice communities. For example, research on business process management (BPM) often does not speak directly about business models, service innovation, or enterprise architecture. Corresponding comments apply to the other areas of primary focus as well.

Maintaining separation between those areas of primary focus conflicts directly with creating an integrated engineering science of business informatics. Continuing to operate with silo-like separation between the areas may develop the areas individually, but is not likely to encourage significant integration, either in research or in practice. Therefore it will not facilitate creation of an integrated engineering science, or at best will achieve that goal very slowly.

Goal and organization. This paper's goal is to contribute to discussions that could accelerate realization of some of the desired integration, either by identifying practical paths directly or by encouraging debates that might find different paths. This paper starts by summarizing the four different types of orientation and mentioning several selected examples of central ideas or approaches within each orientation. After establishing that basis, it summarizes ways in which each orientation might contribute to research and practice related to the other orientations (see Table 1).

In essence, this paper is an invitation for others to argue for alternative views in order to encourage faster progress toward an integrated engineering science. The underlying assumption is that no single orientation can possibly address most of the important topics and issues. Faster progress toward greater integration calls for direct discussion of blind spots and areas of synergy that in combination could reveal valuable research areas and directions for improvements in practice.

Caveat. A short paper covering many diverse topics is guaranteed to miss many important topics and issues. This paper expresses one person's current subjective view of what belongs under the four orientations and what are possible directions toward greater integration. Other authors who are much more expert in specific areas have proposed their own views of specific aspects of those topics and issues. Recognizing this caveat, readers should not be surprised if their particular areas of interest are not represented well. Ideally, those areas will be represented more fully in a future iteration.

II. SERVICE ORIENTATION

A difficulty in trying to summarize service orientation is that marketing, operations, and computer science construe service quite differently. Based on widely varying definitions of service discussed in [2] and elsewhere, definitions of service can be grouped under three general portrayals:

1. A service is an act performed to produce outcomes for the benefit of others.
2. A service is an outcome produced for the benefit of others.
3. A service is an encapsulated functionality that produces outcomes for the benefit of others after being triggered by a request or precondition.

The first definition of service is simplest and most natural in everyday business situations, such as providing food services, gardening services, or police services. The second

applies most directly to controlled, contract-driven situations, such as IT services performed under service level agreements. The third applies most directly to delegated production of precisely defined outcomes by human or automated agents that produce those outcomes independently, with no oversight or visibility for the requesting entity. It treats service as an encapsulated functionality that performs activities triggered by a request or precondition. Each portrayal of service will be mentioned briefly along some of their central topics.

Service as acts for others. Thinking about services as acts for others implies that services have customers, and therefore that understanding customers' needs, interests, and value creation processes is important for understanding whether a particular service is appropriate. Just that point is of some significance for business informatics which tends to focus on provider systems rather than value for customers. The portrayal of services as acts for others usually assumes that service systems are sociotechnical systems whose human participants may include customers. Interactions between service providers and service customers often affect overall customer experiences and customer perceptions of service quality.

The literature in marketing and service science contains debates about the nature of service, even within this portrayal. For example, many textbooks say that services are intangible, heterogeneous (customized), inseparable (consumed as produced) and perishable, summarized with the acronym IHIP. A serious shortcoming of IHIP-style definitions is that most people would view many non-IHIP activities as services. For example, many services are not intangible (e.g., fixing a client's roof), are not customized (e.g., public transportation), and so on. Far beyond IHIP, if services are acts performed to produce outcomes for the benefit of others, then almost any economic activity is a service. Some researchers use the term product/service to indicate that outputs of many systems and enterprises include some characteristics typically associated with products and others typically associated with services.

There are also debates about whether services are necessarily coproduced, and whether value from services is actually produced by customers rather than providers. The idea of co-production is stressed by researchers [3] who assert that customers must play a role in producing services, even if that role is no more than requesting the service. The idea of coproduction focuses on joint responsibilities of customers and providers in relation to attaining value from services. Some researchers say that customers create value for themselves through the use of services [4]. A contrasting view is that firms facilitate value creation by customers through provision of resources for customer use. Hence, value co-creation is optional since suppliers decide whether and how to engage directly with customers' value-generating processes. [5]

Service as outcomes for others. Thinking of services as acts for others is not helpful in some service contexts such as IT service management, where many corporate clients do not want to hear that IT services are just a set of actions and prefer to deal with services as outcomes that will be produced or possibly guaranteed by service level agreements. In that spirit, ITIL, a widely recognized set of IT service management practices, defines a service as "a means of delivering value to Customers by facilitating Outcomes Customers want to achieve without the ownership of specific Costs and Risks" [6, p. 66]. That perspective on service makes sense in an IT service management context but might seem ridiculous in hospitality or entertainment contexts.

Service as encapsulated functionalities. Developers of the Unified Service Definition Language, USDL, defined services as follows, "Services constitute encapsulated and exposed functionality drawing from core artifacts, e.g., those related to business processes, applications, objects, and resources ... Whereas business process activities are said to be orchestrated across collaborating resources, service capabilities are delivered to consumers by providers. ... They provide functionality aimed at delivering value to consumers in terms of expected outcomes, subject to delivery constraints, e.g., availability, pricing, copyright or disclaimers. In doing so, they alleviate consumers with ownership of resources, costs or risks" [7, p. 158]. A service can be manual, semi automated, fully automated, or abstract [p. 164]. The idea of encapsulated functionalities that are exposed, selected, and executed fits most naturally with totally automated services, but can apply to sociotechnical services such as process outsourcing if those services are genuinely encapsulated.

The three portrayals of service are quite different, but all of them emphasize providing or facilitating value for customers. All assume that services will be produced by some type of service system. They emphasize customers in different ways, however, either by focusing on customer activities and value for customers or by assuming that customers initiate service instances that produce value. The next three sections will show how the three other orientations place more emphasis on how work is performed or how enterprises operate.

III. PROCESS ORIENTATION

Process orientation has played an important role in management thinking for at least three decades. A highly influential book by Porter [8] discussed value chains as the primary groups of activities through which companies produce their products. Other influential books promoted process innovation [9] and business process reengineering [10]. While those books focused on changing business operations in fundamental ways, process thinking became the basis of workflow management (WFM) software, which later was generalized as business process management (BPM) software. Today, BPM and business process modeling notation (BPMN) constitute an important part of business informatics focusing on the description, documentation, analysis, design, and evaluation of processes and process models.

BPM. A commonly cited definition of BPM is, "operational processes involving humans, organizations, applications, documents and other sources of information." [11] Recently [12] identified six "core elements" of BPM as strategic alignment, governance, methods, information technology, people, and culture. The definition from [11] and the core elements from [12] make BPM sound like a study of work systems [13] or operations management or even a branch of general management. On the other hand, [14, pp. 27-28] demonstrated numerically that most BPM research papers at

academic conferences focus on abstractions, BPM languages, and computerized methods. It also identified 20 BPM research use cases divided into six categories that are mostly related to process models rather than the operation of processes.

- Use cases to obtain models
- Use cases involving configurable models
- Use cases related to process execution
- Use cases involving model-based analysis
- Use cases extracting diagnostics from event data
- Use cases producing new models based on diagnostics or event data.

Thus, in contrast with broad, management-oriented views of the scope of BPM, most of the topics in the recent review of BPM research barely touch typical management concerns related to the definitions and core elements, such as achieving productivity and quality, satisfying customers, and assuring conformance to process specifications. The integrated engineering science mentioned at the outset should cover those topics or should exclude them for clear reasons.

Types of processes. An important issue related to the scope of BPM is the nature of the processes that are included. Consider four common types of processes involving different degrees to which activity sequences and content are explicit, formalized, or prescribed:

- *largely unstructured creative processes* (such as many design and management processes) that might use tools but that have no pre-specified sequence and may involve extensive iteration guided by concerns, abilities, and intuition of people performing the work,
- *semi-structured knowledge processes* (such as medical diagnosis or legal analysis) that use tools and procedural knowledge but also have no pre-specified sequence and may involve extensive iteration,
- *workflow processes* (such as invoice verification or reimbursement) with a prescribed sequence but whose individual steps may be treated as black box subroutines whose details are unknown or are viewed as unproblematic,
- *highly structured processes* (such as pharmaceutical and semiconductor manufacturing) where both workflow sequence and details of each step must be specified and followed precisely.

The first two types are mostly beyond the scope of today's prevalent view of BPM as basically an extension of workflow management (WFM) – which applies to the third case above. The fourth case is more related to process aware information systems (PAISs), which "include traditional WFM systems and modern BPM systems, but also include systems that provide more flexibility or support for specific processes." [14, p.1]

BPMN. According to the standards organization OMG, "BPMN is a standard set of diagramming conventions for describing business processes. It is designed to visualize a rich set of process flow semantics within a process and the communication between independent processes." [15] "The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation. Another goal, but no less important, is to ensure that XML languages designed for the execution of business processes, such as WSBPEL (Web Services Business Process Execution Language), can be visualized with a business-oriented notation." [16, p. 1] The following elements of BPMN can be used in initial design efforts and also in specifying processes precisely enough to support automated execution:

- flow objects (events, activities, gateways)
- data (data objects, data inputs, data outputs, data stores)
- connecting objects (sequence flows, messages flows, associations, data associations)
- swimlanes (pools and lanes for grouping primary modeling elements
- artifacts (groups and text annotations)

Related to the distinction between four types of processes, BPMN 2.0 distinguishes between executable and non-executable processes. "An executable Process is a Process that has been modeled for the purpose of being executed according to [BPMN] semantics" … "Of course, during the development cycle of the Process, there will be stages where the Process does not have enough detail to be 'executable.' A non-executable Process is a private Process that has been modeled for the purpose of documenting Process behavior at a modeler-defined level of detail. Thus, information needed for execution, such as formal condition Expressions are typically not included in a non-executable Process." [16, p. 23]

The OMG website [15] devoted to BPMN also notes that "UML takes an object-oriented approach to the modeling of applications, while BPMN takes a process-oriented approach to modelling of systems. Where BPMN has a focus on business processes, the UML has a focus on software design and therefore the two are not competing notations but are different views on systems. The BPMN and the UML are compatible with each other. A business process model does not necessarily have to be implemented as an automated business process in a process execution language."

IV. WORK SYSTEM ORIENTATION

The sociotechnical movement that has existed for decades, focuses on the joint optimization of social and technical systems. [17] The term work system appears occasionally in the sociotechnical literature [17,18,19], but usually without careful definition. In this paper, work system orientation refers to focusing on sociotechnical and/or automated systems within organizations, in contrast with orientations focusing mainly on services or processes or enterprises. This paper's coverage of work system orientation is based on [13] because that set of concepts was designed to apply to sociotechnical and totally automated work systems.

Definition of work system. A work system is a system in which human participants and/or machines perform processes

and activities using information, technology, and other resources to produce product/services for internal or external customers. Enterprises that grow beyond a largely improvised start-up phase can be viewed as consisting of multiple work systems. Typical business enterprises contain work systems that procure materials from suppliers, produce products, deliver products, find customers, create financial reports, hire employees, coordinate work across departments, and perform many other functions. There are a number of important special cases of work systems. Information systems are work systems all of whose activities are devoted to processing information. Projects are work systems designed to produce specific product/ services and then go out of existence. Sociotechnical work systems have human participants, in contrast with totally automated work systems which operate autonomously and automatically after being launched.

Work system theory. As explained in depth in [13], work system theory (WST) is a perspective for thinking about systems in organizations in which the unit of analysis is the work system. The three pillars of WST are the definition of work system (above) and two central frameworks.

The work system framework provides a static view of a work system as it exists during a particular time interval when its identity and overall function are maintained even though it may be undergoing small incremental changes. It says that a basic understanding of a work system includes the following topics: the customers, product/services produced, processes and activities, participants, information, technologies, environment, infrastructure, and strategies. By including those nine topics as part of a basic understanding, WST incorporates aspects of business reality that are not included fully in the various service-oriented approaches (focusing on acts for others, outcomes for others, or encapsulated functionalities) or in process-oriented research and methods that focuses primarily on process models.

The work system lifecycle model outlines a dynamic view of how work systems evolve over time through a combination of planned and unplanned change. Planned change is represented as four phases: operation and maintenance, initiation (of projects), development (or acquisition) of resources, and implementation in the organization. Unplanned change is represented as the cumulative impact of workarounds and incremental adaptations that occur as part of both established work practices and projects.

Work system metamodel. An important part of the link to other orientations is a work system metamodel (for a recent version see [20]) that augments the work system framework. The work system framework helps in summarizing a work system and achieving mutual understanding of the scope and nature of a work system. It is less effective as a tool for detailed analysis. The more complete and rigorous metamodel is more precise about concepts required to support deeper analysis without requiring terminology that is impenetrable to most business professionals.

The metamodel makes concepts in the work system framework clearer, more rigorous, and more useful for work system documentation and software development. This creates a bridge between summary level descriptions and more detailed models during analysis and design. It does that without requiring the precision, terminology, and notation of BPMN or of rigorous software specifications. When used with a second layer that identifies common characteristics, metrics, and principles for specific elements, it can support traceability between a summary level analysis and more detailed analysis and documentation by IT specialists.

The metamodel is a more detailed re-interpretation of the elements of the work system framework. Information becomes informational entity, technology is divided into tools and automated agents, activities are performed by three types of actors, and so on. Representation decisions in the metamodel try to maximize understandability while revealing potential omissions from an analysis or design process.

V. ENTERPRISE ORIENTATION

Enterprise engineering, enterprise architecture, and enterprise transformation are at the core of another significant area of business informatics. As mentioned earlier in regard to BPM, despite the very general scope of many descriptions of this area (business engineering, organization change management, enterprise architecture, information system engineering, and so on), much of the recognized business informatics research in this area focuses on various types of enterprise modeling. Several approaches for enterprise modeling will be mentioned next, along with at least one specific example for each approach. The approaches include business typologies, business models, component business models, and integrated models of business and IT architecture,

A. Business typologies

Some research with an enterprise orientation focuses on differences between different types of enterprises. Two examples are research related to sectors of the economy and to different types of business logic.

Sectors of the economy. Much of the GDP of advanced economies comes from the service sector, i.e., the enterprises that are associated with services rather than manufacturing or agriculture. For example, statistics from the World Bank say that over 75% of the GDP of the United States and United Kingdom have come from the service sector since 1995. [21]. Perhaps surprisingly, attention to the service sector proved relevant to business informatics because service science [22] research energized attempts to link service concepts in marketing, operations management, and computer science.

Different types of business logic. Another approach to business typologies focuses on different types of business logic. The main point here is that broad generalizations such as the concept of value chain actually do not describe the operation of many companies that do not operate through value chain logic. An excellent example here is the distinction between value chains, value shops, and value nets [23]. A value chain is a set of steps that transform inputs into products for customers. In a value net, such as a bank or Internet service provider, the enterprise serves as an intermediary between a set of providers and a set of customers. A value shop such as a consulting firm deals with novel situations that call for both in-depth knowledge and flexibility from work system participants.

B. Business Models

Much research has studied concepts and formats for expressing business models. The business model canvas and DEMO are representative examples.

Business model canvas. This popular approach to summarizing business models uses a one-page document with nine categories including customer topics such as customer segments, customer relationships, channels, and value propositions; production topics such as key activities, key resources, and key partners; and financial topics such as cost structure and revenue streams. [24] It works well for small enterprises such as startups, but is not as effective for huge organizations that produce many different types of products for different types of customers.

DEMO. This acronym stands for Design & Engineering Methodology for Organizations. As described in [25], "the ontological model of an organization in DEMO-3 consists of the integrated whole of four submodels, each taking a specific view of the organization." The submodels include:

- The construction model is the ontological model of its construction including actor roles, kinds of transactions, and information links.
- The action model consists of action rules specifying the (production and/or coordination) acts that must be performed, as well as related facts.
- The process model is the ontological model of the state space and the transition space of its coordination world.
- The fact model is the ontological model of the state space and the transition space of its production world.

Even a brief comparison between the business model canvas and DEMO reveals major differences in formality and ambition. The business model canvas is meant to help in producing brief, informal summaries of business models. DEMO is meant to produce models that are formal, rigorous, carefully documented, and internally consistent.

C. Component Business Model

The idea of a component-based model (CBM) was "developed by IBM and is applied in consulting activities by IBM Global Services. … It is used for business transformation, by prioritizing strategic targets and their linkage to solutions through traditional package solutions for SOA solutions." [26, p. 12] The CBM approach is based on straightforward concepts (e.g., business competencies, components, and operation level) that are easily understood from several one-page examples in the form of tables whose columns represent important competencies, whose rows represent three operational levels (direct, control, and execute), and whose cells contain whatever important business components are related to both the competency and the operational level. In a typical example in [26], a component called credit check appears under a competency called customer service and sales; another component called business planning appears under a competency called business administration.

A component business model is a terse, loosely coupled model of an enterprise. Each component contributes to the enterprise in an important way, but the model itself does not represent links between the components. Those relationships would be established in subsequent analysis. The goal of CBM is to identify important components, to decide which are or are not problematic, and to use those insights decide how to proceed with improvement projects.

D. Integrated views of business and IT architecture.

The first three examples of enterprise orientation could be used in IT-related projects, but were not specifically about IT. Given the great importance of matching IT capabilities to organizational form and strategy, several enterprise-oriented models explicitly separate business activities and IT capabilities. A prominent example is Archimate, an enterprise architecture language that is a technical standard approved by the Open Group. The Archimate core can be viewed as a 3 x 3 matrix whose rows include a business layer, application layer, and technology layer, and whose columns include passive structure, behavior, and active structure. For example, behavior in the business layer includes business processes realized as business services, whereas the application layer includes application components triggered by an application interface.

Published in 2012, Archimate 2.0 adds extensions of several types. It adds a new layer for implementation and migration (including topics such as deliverables and work packages) and a new column for motivation (including topics such as stakeholder, driver, goal, principal, requirement, and constraint). [27] Overall, the basic goal is to try to rationalize an IT architecture in relation to how an enterprise operates.

VI. Steps toward Integration across the Four Orientations

Table 1 summarizes the core of all four orientations along with possibilities for synergy between the orientations, i.e., steps toward greater integration. Each cell on the diagonal (darkened slightly for emphasis) identifies the core of an orientation. The other cells show how one orientation might augment another. For example, the cell {row 1, column 3} says that service orientation might support a focus on work systems by elaborating customer focus in a variety ways and by taking care of black box steps in work system models. Likewise, the cell {row 1, column 4} says that service orientation could support enterprise orientation by contributing to the concept of service oriented enterprise or by using service-dominant logic [4] to explore issues related to service as economic exchange.

Using one orientation to illuminate another. The darkened areas in Table 1 represent areas where an orientation provides the most useful guidance and insight. For example, in comparison with the other orientations, service orientation related to acts for others or outcomes for others is more directly applicable to concerns of customers, just as a process orientation tends to be more useful in relation to the detailed modeling of processes (via BPMN) or the control of repetitive processes via BPM software. A work system orientation assumes that the unit of analysis is a work system whose operation and evolution are described by WST and its extensions. An enterprise orientation assumes that the unit of

analysis is an entire enterprise. Each orientation brings ideas that are especially relevant to its own primary focus.

In many instances, central topics for one orientation provide opportunities to augment research or practice that is generally associated with a different orientation. Those instances occur where the other orientation pays little attention to the first orientation's central topics and may even ignore them altogether. The remainder of this section looks at ways in which concepts within each orientation might augment research or practice based on the other orientations, thereby moving in the direction of the integrated engineering science promoted by the IEEE CBI 2015 website.

Using service orientation to augment other orientations. Across all three portrayals of service mentioned earlier, the main contribution of service orientation is the emphasis on value for the customer. In general, service orientation could augment process, work system, or enterprise orientation by encouraging greater concern about value for customers rather than modeling of internal processes, work systems, or enterprises as a whole. At the simplest level this would call for asking whether a process model, work system model, or enterprise model said enough about value to the customer and about what customers are willing and able to do to achieve that value. Since models, research, or practice based on each of those three orientations would not tend to emphasize customer issues highlighted by service orientation, it is quite possible that service orientation could augment them with useful ideas.

Treating services as acts for others or as outcomes for others (the first two of the three portrayals of service), places greater attention on customer responsibilities, coproduction of services, and possibilities for co-creation of value. Process orientation tends to say little about those topics. Work system orientation recognizes them to some extent because customers can be work system participants, but those topics might be explored more deeply through other ideas and methods from service orientation. Similarly, enterprise orientation approaches that emphasize internal business and IT architectures might become more valuable if they could establish better links with value for customers. At a theoretical level, service-dominant logic [4] and other abstract descriptions might lead to new types of rationales for enterprise architecture.

Focusing on services as encapsulated functionalities (the third portrayal of service) directly addresses boundaries of process, work system, and enterprise orientations. In all three cases, there are situations that call for totally automated functions or capabilities that produce results once launched by specific actions or conditions. In all three cases, the concept of encapsulated functionalities raises the question about whether that topic needs to be considered at all, and if so, which issues addressed by USDL would be most important, e.g., service level agreements, pricing, legal issues, and so on.

Finally, all three portrayals of service within service orientation are relevant when firms consider outsourcing related to important processes or work systems. At a general level, that outsourcing directly affects process or work system models. At a detailed level, some issues addressed by USDL might be quite relevant even though they might not approach the top of the stack for the other orientations in isolation.

Using process orientation to augment other orientations. Process orientation could augment service orientation in two general ways. In relation to services as acts or services as outcomes (the first two portrayals of service), it might reveal more of a process flow from a customer viewpoint by augmenting service blueprinting [28] in some way. Service blueprinting already represents a relatively simple process flow from a customer's viewpoint, but it might be possible to provide additional clarity by applying insights or methods from process orientation. In relation to services as encapsulated functionalities (the third portrayal), process orientation could provide BPMN or other graphical modeling tools to specify the process flow within a functionality or capability, thereby possibly serving as a stepping stone toward the type of object oriented specifications assumed by USDL.

Similarly, BPMN and/or other modeling tools could augment work system orientation by expanding on the relatively simple process views in the work system framework and work system metamodel. Of particular importance, some form of integration between BPMN and the work system metamodel could make that metamodel more valuable by facilitating the transition between three levels of specification: 1) simple summaries such as a one-page work system snapshot [13], 2) more complex summaries based on the metamodel [2], and 3) detailed process logic that might even be executable.

Ideas from process orientation might augment enterprise orientation by providing enriched process views, either of an entire value chain or of an enterprise as a set of processes with various types of dependencies.

Using work system orientation to augment other orientations. This could increase the coverage of many of the topics that are part of the content of business informatics. For example, WST and its extensions are directly applicable to "information processes and related phenomena in their socio-economical business context, including companies, organisations, administrations and society in general" [1] and also for "aligning core concepts from management science, organisational science, economics information science, and informatics" [1]. The nine elements of the work system framework are directly related to service, process, and enterprise orientations because a thorough understanding of a service, process, or enterprise calls for an understanding of customers, product/services, processes and activities, human participants, and so on. The work system lifecycle model is relevant because non-moribund enterprises change over time through a combination of planned and unplanned change. A broadly applicable aspect of WST is its recognition that work system operation may or may not conform to specifications. Business informatics should not ignore the often high likelihood of noncompliance with process specifications, not to speak of exceptions, unintentional interactions, accidents, uncertainties, and workarounds [29].

Work system orientation could augment other specific orientations in specific ways. Seeing service systems as work systems can provide a richer view of how sociotechnical services and processes are performed, including co-production and value co-creation. This is equally applicable for services and processes that are completely within one enterprise and

outsourced services and processes (e.g., process outsourcing) in which information and other resources pass between enterprises. Work system orientation could augment enterprise orientation by treating an enterprise as interrelated work systems. It also could help in visualizing trans-organizational enterprises such as supply chains and value constellations.

Using enterprise orientation to augment other orientations. Service, process, and work system orientations all focus on parts of an enterprise. Enterprise orientation can augment the others through enterprise-level topics such as culture, policies, strategy, demographics, and infrastructure. IT services and other types of services occur within enterprise contexts and sometimes need better alignment with the needs of the enterprise. Process orientation that often focuses on process models per se could incorporate enterprise-level process issues, such as the extent to which a process plays an important role in the enterprise and the extent to which it might be possible to outsource all or part of a process. Work system orientation that usually focuses on work systems within an enterprise could be challenged to say more about the enterprise as a whole, such as by developing methods for identifying and measuring mutual interference between work systems within an enterprise. That type of interference occurs when the same people participate in multiple work systems, sometimes calling for them to perform unrelated activities at the same time.

VII. CONCLUSION

This paper's goal was to contribute to an overarching ambition of transforming business informatics into an integrated engineering science. Its title asked how business informatics should integrate service, process, work system, and enterprise orientations. Accomplishing that goal seems far off when most business informatics research focuses within orientations that often seem like unrelated silos.

This paper's approach for answering the question in its title was to describe the four orientations and identify a number of ways in which each orientation could augment the others, thereby suggesting directions toward the goal of an integrated engineering science. A number of incremental synergies between service, process, work system, and enterprise orientations were summarized in Table 1 and discussed briefly in the previous section.

Looking at a particular set of links between the orientations illustrates how steps toward an integrated discipline might be pursued. Assume that the work system metamodel (which captures a business view of a work system) is augmented through links with BPMN (which documents process logic in a more detailed way). That would start to create a bridge from a less detailed business view to a more detailed technical view. Assume that areas of complementarity between BPMN and USDL were described. That would link detailed process logic with rigorously defined service capabilities or functionalities. Assume that enterprises were modeled as work systems using the work system metamodel. If articulated carefully, that sequence of complementarities across different orientations might provide a way to link enterprise–related descriptions at different levels of detail and abstraction. A form of linkage between the service, process, work system, and enterprise orientations would be achieved, increasing the extent to which business informatics could be viewed as an integrated engineering science.

On the other hand, this paper's attention to four different orientations is surely debatable. Some readers might prefer different ways to separate the current streams within business informatics. Others might argue that the whole idea of distinct orientations is flawed, citing the way IBM researchers did not use such a categorization scheme in their attempt to summarize different business architecture approaches. They used one level for topics that are (or would be) in separate orientations in this article, e.g., BPMN, event-driven process chains, CBM, Archimate and other approaches. That article [26] also found some degree of service focus in a number of the approaches.

As mentioned at the outset, a short paper like this cannot avoid omitting some important views of topics that are being researched actively and are debated widely. Its identification of the four orientations and some of their possible synergies was not meant as an endpoint. Rather, it was meant as a way to encourage discussion about what an *integrated* engineering science might look like. Instead of speaking generally about the nature of integration, it identified specific paths that might be followed at some point. Ideally, discussion and evaluation of those possibilities, both the good ideas and the ideas that are not so good, will lead to better conceptualizations of the kinds of steps that would generate the desired integration.

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TABLE I. CORE OF SERVICE, PROCESS, WORK SYSTEM, AND ENTERPRISE ORIENTATIONS AND HOW EACH ORIENTATION COULD AUGMENT THE OTHERS

	(To enact or augment) **Service orientation**	(To enact or augment) **Process orientation**	(To enact or augment) **Work systems orientation**	(To enact or augment) **Enterprise orientation**
(Use) **Service orientation**	• Different portrayals of service ✓ acts for others ✓ outcomes for others ✓ encapsulated functionalities • operations view: co-production • marketing view: value co-creation • client-server logic • service-oriented architecture • service computing, e.g., USDL	• Services (as encapsulated functionalities) take care of black box steps in process models • Extend process analysis by focusing on customers and possibilities for value co-creation	• Elaborate on customer focus for work system ✓ Customers as participants ✓ Customer responsibilities ✓ Value creation ✓ Value co-creation • Services (as encapsulated functionalities) take care of black box steps in work system models	• Service-oriented enterprise (even if the enterprise produces physical things) • Apply service-dominant logic to explore issues related to service as economic exchange
(Use) **Process orientation**	• Reveal more of a process flow from a customer's viewpoint by expanding on service blueprinting • Use BPMN or other graphical tools to specify the process flow within services that are otherwise treated as encapsulated functionalities	• BPMN • BPM • BPM use cases in research • value stream mapping • different types of processes • process mining	• Use BPMN or other graphical tools to expand the simplified process flow in the work system framework and work system metamodel • apply BPM research use cases to more work systems, not just systems governed by workflows	• Expand upon the traditional value chain notion by supporting a more developed process view • Provide better ways to treat an enterprise as a set of business processes with various types of dependencies.
(Use) **Work system orientation**	• Highlight all elements of work system framework in describing services • Include operational realities, e.g., exceptions, unintentional interactions, accidents, uncertainties, workarounds, noncompliance • Recognize co-production • Recognize use of resources • Recognize internal and external measures of performance	• Extend BPM by considering all 9 elements of the work system framework, not just the process • Include operational realities, e.g., exceptions, unintentional interactions, accidents, uncertainties, workarounds, noncompliance • Recognize co-production • Recognize use of resources • Recognize internal and external measures of performance	• Work system theory ✓ Work system framework ✓ Work system life cycle model • Work system metamodel • Work system method • Work system principles • Work system design spaces • Recognize common forms of noncompliance to process specifications	• See an enterprise as a group of related work systems • See parts of the enterprise as a component in a work system that crosses separate enterprises (e.g., supply chains, value constellations)
(Use) **Enterprise orientation**	• See services in the context of the enterprise as a whole • Recognize enterprise policies related to computerized services • ITIL service strategy	• See process in the context of the enterprise as a whole (contribution to the enterprise, interactions with other processes) • Recognize enterprise issues, e.g., enterprise culture, politics, competition, and demographics	• See work systems as components of an enterprise • Recognize deeper aspects of enterprise issues such as enterprise culture, politics, competition, and demographics	• Enterprise logic ✓ Value chain ✓ Value network ✓ Value shop • Business model canvas • Component business model • DEMO (Dietz) • Archimate