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Editorial

Business process modeling: An accounting information systems perspective

Countless definitions of the term business process can be found in the literature (Lindsay et al., 2003), with the following being one of the most cited: "A business process is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Hammer and Champy, 1993). Their definition emphasizes the transformation and value-added nature of business processes. For this special issue, and thus this editorial, we adhere to the broadest possible interpretation of the term business process.

A model is a simplified representation or abstraction of a part of the world, and a business process model is therefore a simplified representation of a business process. Again, for simplicity purposes, we adhere to the broadest possible interpretation of the term business process model. For example, and we fully understand that this is an over-simplification (Henderson-Sellers, 2011), we consider an instantiation of an enterprise ontology as a special type of business process model.

The business process modeling (BPM) research landscape is vast and complex, and this is primarily due to the wide variety of uses of such models and the different angles from which the research is conducted. Consider just the following: representation of as-is models, validation of as-is models, grounding of BPM grammars in terms of upper-level ontologies, representations of business processes that enable assessment (such as calculating time and cost), representation of to-be business processes for analysis and simulation purposes, translation between business process model notations for different uses, and specifications for the development and implementation of IT systems. These are all topics that are part of the BPM research landscape, and an in-depth analysis and structuring of such a vast area is beyond the scope of this editorial. However, Fig. 1 sketches a framework that allows us to (1) identify some of the research streams in this area, and (2) position the four papers that are part of this special issue. The remainder of this editorial is organized as follows. Next, we briefly discuss the three main components of Fig. 1: (1) definition of business process models at different levels of abstraction, (2) intra-layer research, and (3) inter-layer research. We then discuss the BPM research landscape from an accounting information systems (AIS) perspective. Finally, we briefly discuss the four papers that are part of this special issue and their contribution to the AIS literature.

1. Definition of business process models at different levels of abstraction

Above, we defined a model as an abstraction of a part of the world, but there are different levels of abstraction at which models can be defined. The center in Fig. 1 shows the four levels of abstraction, known as layers, which are part of the Object Management Group's (OMG's) Modeling Infrastructure—M3, M2, M1, M0—in decreasing order of abstraction from left to right. The OMG's infrastructure was proposed

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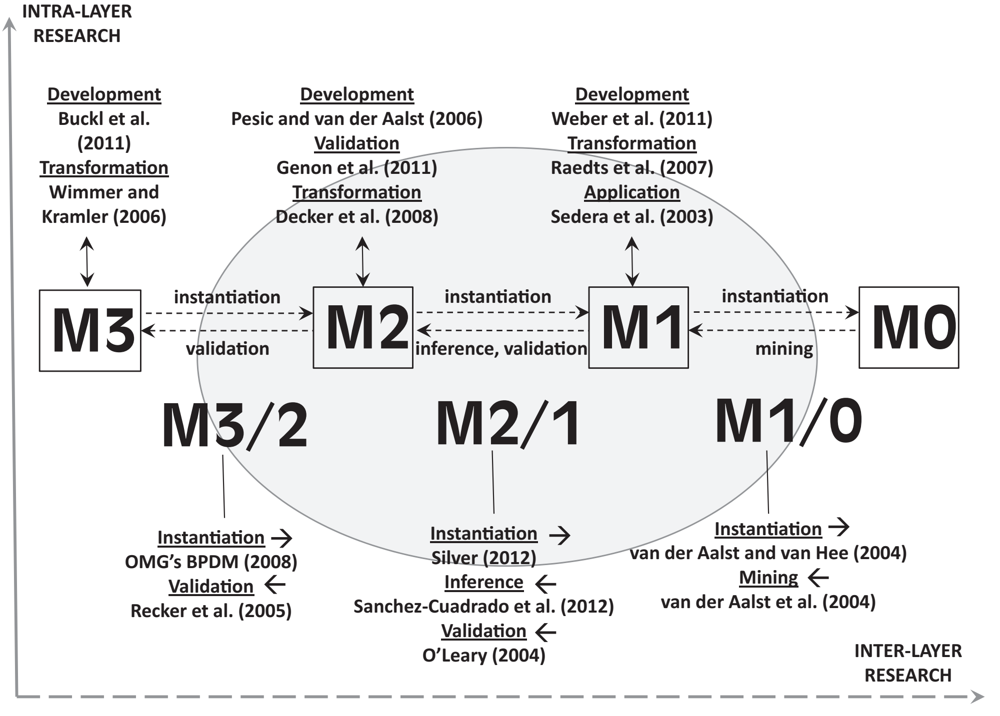

Fig. 1. A framework for analyzing the nature of business process modeling research.

with software development in mind, but its categorization is also useful for our purposes. Below, we briefly discuss the importance of each layer for BPM.

- M3 A domain-independent grammar that can be used for the definition of BPM languages. Examples of such grammars are the OMG's Meta Object Facility (MOF) (OMG, 2014) and the Extended Backus–Naur Form (EBNF) (ISO, 1996).
- M2 A BPM grammar that can be used for the definition of actual business process models. Examples of BPM grammars include the Business Process Model and Notation (BPMN) (OMG, 2006) and the Resource–Event–Agent (REA) model (McCarthy, 1982).
- M1 Business process model definition, i.e., a model that describes how an organization creates value. See Silver (2012) for an order-to-cash BPMN model.
- M0 Business process instantiation, i.e., the actual data instantiation—e.g., run-time objects—of a business process model. See van der Aalst and van Hee (2004) for an overview of how workflow management systems can be used to instantiate business process models.[1]

2. Intra-layer research

There are two main research streams that apply to the M3, M2, and M1 layers: development and transformation. Development refers to the definition, restructuring, and re-engineering of models; definition creates a model, restructuring reorganizes a model definition without changing its content, and re-engineering changes a model's content. Transformation refers to the mapping between representations, e.g., from one notation to another or from a detailed to a coarse-grained representation. For

[1] Given that M0 specifications really represent data, we will ignore them in the remainder of this editorial but we will consider the interactions between M1 and M0 in our discussion.

intra-layer research, restructuring, re-engineering and transformation occur at the same level of abstraction. In Fig. 1, the vertical axis is used to represent intra-layer research, and at least one paper is included for both development and transformation research at the M3, M2, and M1 levels for illustration purposes. For example, in the north-west corner in Fig. 1, we list Buckl et al. (2011) as an example of development research and Wimmer and Kramler (2006) as an example of transformation research at the M3 level. Next, we discuss intra-layer research efforts specific to the M3, M2, and M1 levels.

2.1. M3 layer (meta–metamodels)

M3 models are domain-independent and therefore not directly related to BPM. The M3 grammar that is used most for specifying BPM grammars is OMG's MOF, which has been relatively stable. Examples of M3 development research include Gitzel et al. (2007) and Buckl et al. (2011), both presenting MOF extensions (re-engineering). On the other hand, Wimmer and Kramler (2006) provide an example of transformation research by discussing the mapping between two M3 models, MOF and EBNF.

2.2. M2 layer (metamodels)

Throughout the years numerous business process modeling languages (BPMLs) have been proposed (development) that focus on different aspects of a business process (Mili et al., 2010). Most of them concentrate on representing the control flow between activities, and examples of such languages include Petri nets, activity diagrams, event-driven process chains, and BPMN. However, languages with a different focus exist as well. For example, declarative process modeling languages concentrate on the constraints that processes need to take into account (Goedertier et al., 2013) instead of on the order between activities. An example of a declarative BPML is ConDec (Pesic and van der Aalst, 2006). There is also a group of BPMLs that focus more on representing how value is created, including the REA model (McCarthy, 1982) and the E^3-value modeling language (Gordijn and Akkermans, 2001).

Many of these BPMLs have been the subject of an in-depth analysis that has resulted in modifications that often take the form of extensions. The following are three examples of such re-engineering efforts. First, based on an analysis of the practical complexity of BPMN, zur Muehlen and Recker (2008) have indirectly contributed to some modifications to its specification. Second, ConDec has been extended to ConDec++ by Montali (2010) in order to support more complex constraints. Third, the REA model has been the subject of numerous re-engineering efforts, including the integrated specification of location (Hollander et al., 1996) and the integrated specification of commitments (Geerts and McCarthy, 2000b).

Another research stream strongly intertwined with grammar development is intra-layer validation. An example of such research is Genon et al. (2011) who evaluate BPMN through the lens of the Physics of Notations (Moody, 2009).

Specific uses of business process models often require specific representations, and this results in a need for transformation. A good example of transformation research related to BPMLs is that of Decker et al. (2008) who argue that while “BPMN is the de facto standard for modeling business processes, YAWL [Yet Another Workflow Language] allows the specification of executable workflow models.”

2.3. M1 layer (models)

An important concern of model development is quality assurance beyond grammar compliance. BPM guidelines are discussed in Becker et al. (2000) and Mendling et al. (2010). Much attention is also given to model refactoring, i.e., restructuring of a model with the intent of improving understandability and maintainability. Weber et al. (2011) provide an in-depth discussion of the application of refactoring to BPM.

The transformation of business process models comes in different shapes and forms, as is illustrated by the following two examples. First, different uses of a business model often require it to be represented with different notations. For example, Raedts et al. (2007) discuss the mapping from BPMN to Petri net notation to facilitate verification and validation. Second, an emerging research stream is business process model abstraction; this explores the transformation of detailed business process descriptions into coarse-grained business models that are easier to understand (Polyvyanyy et al., 2010; Smirnov et al., 2011). Other types of model transformations are discussed in Di Ruscio et al. (2012).

An additional research stream at the M1 level explores the use of business process models for specific applications. Sedera et al. (2003) provide an extensive literature review of business process model uses.

3. Inter-layer research

The four layers discussed above obviously do not exist in a vacuum, and the broken lines in Fig. 1 show three different areas of interaction: $M_{3/2,}$ $M_{2/1,}$ and $M_{1/0.}$ A number of research efforts associated with each of these three areas are discussed below. Note that all three associations are bi-directional and that we use arrows to indicate the direction for a specific type of research. In Fig. 1, the horizontal axis is used to represent inter-layer research, and we list at least one paper per research area for each of the three associations.

Two prominent research areas in the $M_{3/2}$ space are instantiation (→) and validation (←). Research regarding instantiation of meta–meta models (M3) is often related to metalanguage (M2) design. For example, the MOF (M3) is used for the definition of OMG's Business Process Definition Metamodel (BPDM) (OMG, 2008), a general metamodel for BPMLs (M2). Validation, on the other hand, is typically part of re-engineering efforts where BPMLs are validated against upper-level ontologies. For instance, Recker et al. (2005) validate the ontological completeness and clarity of BPMN in terms of the Bunge–Wand–Weber (BWW) upper ontology.

Three distinguishable research areas in the $M_{2/1}$ space are instantiation (→), inference (←), and validation (←). First, instantiation in the $M_{2/1}$ space is similar in nature to instantiation in the $M_{3/2}$ space. Among others, methods are being developed that describe how to apply specific grammars for the creation of business process models. An example of such a method for BPMN is discussed in Silver (2012). Second, metamodels (M2) can be inferred starting from actual models (M1). An example of such a bottom-up metamodeling approach is discussed in Sánchez-Cuadrado et al. (2012). They interactively create a metamodel (M2) starting from some model fragments (M1). Third, validation is often a worthwhile exercise when independently created grammars and business models exist. A good example of such research is O'Leary (2004) who validates the REA-ness (M2) of SAP business processes (M1). Note that in this case, it is the grammar that is being validated.

Two prominent research areas in the $M_{1/0}$ space are instantiation (→) and mining (←). Here, instantiation refers to the process of creating occurrences (M0) for a model (M1). For example, van der Aalst and van Hee (2004) explain how workflow management systems can be used to instantiate process models that are represented as Petri nets. There is also an extensive body of research that mines actual data for discovery of as-is business processes. For example, numerous papers, including Datta (1998), Agrawal et al. (1998), and van der Aalst et al. (2004), discuss how business processes can be discovered from event logs. The use of process mining techniques in the context of auditing is discussed in Jans et al. (forthcoming).

4. The business process modeling research landscape from an accounting information systems perspective

The discussion above sketches the BPM research landscape as being vast, diversified, and complex. However, BPM research in the AIS literature [2]is sparse at best. We searched the AIS literature for the following terms: business process model, enterprise ontology, refactoring, transformation, and (data) mining. Our search resulted in 17 papers [3]listed in column four of Table 1, and we further grouped these into three broad BPM–AIS research streams (column 1): (1) BPML (grammar) development and use, (2) BPM applications, and (3) business process mining. Column 2 in Table 1 defines the main research question or questions being addressed in each of these streams. [4]Column 3 indicates the types of research

[2] Here defined as publications in any of the issues of the three leading AIS journals*: International Journal of Accounting Information Systems* (IJAIS), *Journal of Emerging Technologies in Accounting* (JETA), and *Journal of Information Systems* (JIS).

[3] This excludes the four papers that are published in this special issue and that are listed in italics in Table 1. We will discuss them in the next section.

[4] Again, the entry in italics (#1.4) will be discussed later.

Table 1
The BPM–AIS research landscape.

BPM–AIS research stream	Research questions	Research types	Publications	ID
BPML (grammar) development and use	Repurposing: How do BPMLs need to be modified to support specific accounting applications?	M2	Denna et al. (1994), Church and Smith (2007), White (2008), Weigand and Elsas (2012), Sedbrook (2012), Gailly and Geerts (2013)	#1.1
	Validation: How good is the grammar?	$M_{3/2}$, M2, $M_{2/1}$	Geerts and McCarthy (2002), O'Leary (2004), Carnaghan (2006), Tegarden et al. (2013)	#1.2
	Reasoning: How to use grammars as part of accounting applications?	M2, $M_{2/1}$	Geerts and McCarthy (2000a), Geerts (2004), Geerts and Wang (2007), Gailly et al. (2008), Sedbrook and Newmark (2008)	#1.3
	Definition: What concepts are needed to describe a specific accounting application?	*M2*	*Heise et al. (2013-in this issue), vom Brocke et al. (2013-in this issue), Heravi et al. (2014-in this issue)*	*#1.4*
BPM applications	For what purposes can business process models be used in an accounting environment?	M1	Borthick (2012), *Heidari and Loucopoulos (2013-in this issue)*	#2
Business process mining	What do data tell about actual business processes?	$M_{1/0}$	Jans et al. (2013)	#3

being conducted related to each question. The fifth column is used to identify each entry (#), which makes our discussion below easier.

The dominant BPM–AIS research stream is the development and use of BPMLs (grammars) (#1), which focuses almost exclusively on the REA model. An exception is Carnaghan (2006) who validates a number of BPMLs, including system flowcharts, Unified Modeling Language diagrams and BPMN. As shown in column two of Table 1, this research stream addresses research questions regarding repurposing, validation, and reasoning.

Repurposing (#1.1) has exclusively focused on the REA grammar (M2) and addresses the following research question: what modifications—in particular extensions—does the REA model need to support specific accounting applications? For example, Weigand and Elsas (2012) extend REA so it can support owner-ordered auditing. Other repurposing efforts include Denna et al. (1994), Church and Smith (2007), White (2008), Sedbrook (2012), and Gailly and Geerts (2013).

Validation (#1.2) of BPMLs in an accounting context has taken the following three forms. First, validation of a grammar in terms of an upper-level ontology ($M_{3/2}$). Geerts and McCarthy (2002) validate the REA model against Sowa's upper-level ontology, while Tegarden et al. (2013) validate the REA model against the BWW upper-level ontology. Second, validation of a grammar against a set of criteria. Carnaghan (2006) evaluates the completeness of a series of BPMLs (M2) for audit risk assessment starting from a set of constructs and concepts that she extracted from existing standards, audit textbooks, and related material on audit approaches. Third, validation of a grammar starting from some actual business process models ($M_{2/1}$). O'Leary (2004) validates SAP business processes against the REA model.

Reasoning (#1.3) refers to the knowledge-intensive use of a BPM grammar (M2) as part of accounting applications ($M_{2/1}$). A requirement for reasoning is the transformation of the grammar into a machine-readable representation as is discussed in Geerts and McCarthy (2000a), Geerts (2004), Geerts and Wang (2007), Gailly et al. (2008), and Sedbrook and Newmark (2008).

The second research stream (#2) explores how business process models (M1) can be used in an accounting environment. This is an underdeveloped area, and the only study that has been published in the AIS literature thus far is Borthick (2012) who illustrates the use of business process models to identify internal controls.

The third, emerging, research stream (#3) employs data to help understand business processes ($M_{1/0}$). The first study in the AIS literature to explore this area is Jans et al. (2013). They use data mining for process discovery in an auditing context. It is worth noting that the same authors have a follow-up paper on the same topic that is forthcoming in *The Accounting Review* (Jans et al., forthcoming).

At least three conclusions can be drawn from the analysis above. First, BPMN–AIS research is sparse and heavily focused on the REA grammar. The strong focus on grammar is not surprising since it is similar to theory building (Geerts et al., 2013). Second, grammar-related research has multiple dimensions, including repurposing (M2), validation against a set of domain-specific criteria (M2), validation against upper-level ontologies ($M_{3/2}$), validation against business process implementations ($M_{2/1}$), and formalization for reasoning purposes (M2). Third, while research streams #2 and #3 need further development, other elements of the framework presented in Fig. 1 and discussed above are yet to be explored in the AIS literature. Examples include refactoring, abstraction, and inference.

5. Contributions to the special issue

In this section we summarize the four papers that are part of this special issue on BPM and we position each of them in terms of the framework presented in Fig. 1—type of research—and in terms of the research landscape presented in Table 1—research contribution.

Heidari and Loucopoulos (2013-in this issue) present a quality evaluation framework that enables assessing business process quality through their models. They present a structured approach of assessing the quality of business processes (M1) starting from a framework that consists of a quality metamodel (M2) and a method for applying it ($M_{2/1}$). In addition, they define an extensive set of applicable quality factors as well as corresponding quality metrics that can be applied to business process models defined in any notation ($M_{2/1}$). They further demonstrate the use of their framework by means of an example ($M_{1/0}$). Their paper is not about how to present business processes with a BPML but instead about the development of a grammar that enables quality analysis of business processes. In Table 1, we characterize their research contribution as a BPM application (#2): use of business process models as part of a structured approach to assess business process quality.

Heise et al. (2013-in this issue) argue that BPMLs have provided only limited support for assessing a firm's internal control system and propose a dedicated domain-specific modeling language (DSML) for internal control modeling. Their main contribution is the definition of a DSML (M2)—ControlML—for which they heavily rely on terminological analysis. The authors define it as an extension to the Multi-Perspective Enterprise Modeling method ($M_{3/2}$) and demonstrate its use by means of an example ($M_{2/1}$). In Table 1, we characterize their research contribution as grammar definition (#1.4), which refers to the creation of a new grammar for a specific business application as opposed to the repurposing of an existing grammar (#1.1). It is worth noting that McCarthy (1982)—definition of the REA model—is an example of grammar definition.

vom Brocke et al. (2013-in this issue) define an ontology—OLPIT: ontology for linking processes and IT infrastructure—that models the relationship between business processes and IT resources with the purpose of measuring the business value of IT. Applying OLPIT should help manage both the effect of IT on business and the effect of business on IT. Their main contribution is the definition of OLPIT (M2), which heavily relies on frameworks intensively used in practice (ITIL v3; COBiT v4.1) and competency questions. They ground OLPIT in terms of a foundational ontology ($M_{3/2}$)—the Unified Foundational Ontology—and demonstrate it by means of an example that addresses instantiation, inference, and validation ($M_{2/1;}$ $M_{1/0}$). In Table 1, we characterize their research contribution as grammar definition (#1.4).

Heravi et al. (2014-in this issue) use the Ontology-based Standards Development methodology (OntoStanD) for developing an ontology for the ebXML (Electronic Business using eXtensible Markup Language) Business Process Specification Schema: the ebBP ontology. It explicitly captures the semantics embedded in business-to-business processes, which can then be shared and reasoned with. Their main contribution is the definition of the ebBP ontology starting from textual specifications and an XML Schema and validating it for consistency and completeness (M2). The application of the ebBP ontology is demonstrated by means of an “ordering process” example ($M_{2/1;}$ $M_{1/0}$). In Table 1, we characterize their research contribution as grammar definition (#1.4).

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