Business Process and Business Rule Modeling Languages for Compliance Management: A Representational Analysis

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Abstract

Organizations are under increasing scrutiny to document their compliance to regulatory requirements. To this end, they have to formally document their operating procedures to support their compliance management efforts. Both process modeling languages and rule modeling languages are candidates for the documentation of organizational policies and procedures. While both types of languages are currently used to document organizational practices, little work has been done to understand their synergies and overlap. Accordingly, in this paper we use the Bunge-Wand-Weber (BWW) representation theory as a basis for such an analysis. We perform a representational analysis of two popular rule modeling languages, *viz.,* SRML and SBVR. We compare their representation capabilities with those of four popular conceptual business process modeling languages, and focus on the aspects of maximum ontological completeness and minimum ontological overlap. The outcome of this study shows that a combination of two languages, *viz.* SRML and BPMN, is more suitable for documenting compliance than any single modeling language, and that the combination of process and rule modeling languages shows synergies.

1 Compliance Management

Organizations are under pressure to comply with an increasing number of external regulations, such as the Sarbanes-Oxley Act, HIPAA for healthcare entities, or FDA guidelines for pharmaceutical organizations. Traditionally, organizations assure compliance through regular audits and reviews. Due to the need to provide regular updates on compliant work practices, a more strategic approach to compliance management is desirable. Having compliance personnel spend brief periods of time to conduct high-level testing of individual processes does little to deliver the required enhanced assurance (Turner and Florio 2004). This situation implies a shift from regular reviews to continual assurance and introduces a need for advanced compliance management systems that support real time transparency (Baldwin, Beres *et al.* 2005). Organizations acknowledge this need to the extent that three in four U.S. multinational companies plan to perform significant technology changes to support their compliance management activities (Williams 2005).

Conceptual modeling languages are used both for documentation of user requirements and for the specification of design artifacts in information system design (Weber 1997). Compliance management introduces new aspects of the real world that need to be captured in conceptual models, such as the legal states of artifacts, or operations that are not permitted under certain circumstances. During the selection or development of a compliance management system, the choice of modeling language plays a significant role, since it provides the formalism to express current and future work practices and rules.

Compliance management systems must be able to represent all real-world concepts that are relevant to the compliance management domain. Specifically, conceptual modeling languages used for the design of compliance management systems must support all real-world concepts of behavior, work, people, organizations, rules, standards and regulatory requirements.

Traditionally, these concepts have been represented by two different classes of systems: Business Process Management Systems, which focus on people, work, and organizations, and Business Rule Management Systems, which focus on behavior, rules, standards and regulations. Hence, both process modeling languages and rule modeling languages offer constructs to represent work operations and constraints. While a significant amount of work has been done in terms of evaluating the representational capability of process modeling languages (Rosemann, Recker *et al.* 2006), the overlap between and complementarity of these languages and rule modeling languages remains unclear. Indeed, previous work by Recker *et al.* (Recker, Indulska *et al.* 2005) has identified a general lack of process modeling language capabilities to adequately model business rules. Green and Rosemann (Green and Rosemann 2000; Green and Rosemann 2002) also found limitations with respect to modeling business rules in their BWW-based investigation of all five views of Architecture of Integrated Information Systems (ARIS), a popular framework for integrated process modeling. Moreover, Herbst *et al.* (Herbst, Knolmayer *et al.* 1994) suggest that rule specification languages should be considered as a potential addition to graphical representation languages when modeling for Information Systems (IS).

It is an open question whether the two language types should be used in combination in order to increase the representation capability for the domain of compliance management. It is also unclear if these languages provide all constructs required for compliance management. Therefore, the main *goal* of the work reported in this paper is to investigate the representation capability of two popular rule modeling languages, *viz.,* The Simple Rule Markup Language (SRML) and Semantics of Business Vocabulary and Business Rules (SBVR), and place this evaluation in the context of previous representation capability evaluations of conceptual process modeling languages.

Accordingly, our *research questions* are as follows:

What is the representational capability, with respect to the BWW representation theory, of SRML and SBVR?

Are SRML and SBVR complementary or substitutive to process modeling languages in the compliance management domain?

The remainder of this paper is structured as follows. In the next section we present a brief review of business rules and business processes. Section 3 presents the justification for the use of the BWW representation theory as a suitable benchmark for the analysis of representation capabilities of process and rule modeling languages. The following section describes the research methodology used. In section 5, we present a summary of the results of the BWW-based representation analysis of SRML and SBVR in comparison to previous BWW-based representational analyses of process modeling languages. The interpretation of the analysis is also discussed in this section. We conclude the paper in section 6 with a discussion of limitations and future work directions in this area.

2 Background

2.1 Business Rules

A business rule is a statement that aims to influence or guide behavior and information in an organization (Steinke and Nikolette 2003). Business rules can be categorized in accordance to their source or structure:

- *Mandates;* published policies that must be followed, or consequences will ensue. Examples are the payment of taxes and adherence to the law.
- *Policies;* published policies that should be followed to adhere to company rules. Examples are budgets or mission statements.
- *Guidelines;* rules that may or may not apply, depending on circumstances. Examples are methodologies and management styles.

The different structural categories of business rules are (Wagner 2005):

- *Integrity* (or constraints); For example: each project must have one and only one project manager.
- *Derivation* (conditions resulting in conclusions); For example: platinum customers receive a 5% discount. John Doe is a platinum customer. As a conclusion, John Doe receives a 5% discount.
- *Reaction* (Event, Condition, Action, Alternative-action, Post-condition); For example: an invoice is received. The invoice amount is more than 1,000 US dollars. The invoice is forwarded to a supervisor.
- *Production* (condition, action); For example: there are no defects in the last batch of cars. The batch is approved.
- *Transformation* (change of state); For example, an employee's age can change from 30 to 31, but not from 31 to 30.

2.2 Business Processes

Business Processes are sets of activities that create value for a customer (Hammer and Champy 1993). While research in Business Process Management initially focused on the documentation and organizational governance of processes, organizations are increasingly automating processes using workflow systems, and are building elaborate management systems around their processes. Such management infrastructures integrate modeling, automation, and business intelligence applications. The inclusion of compliance management activities is a logical next step in governing the business process life cycle.

A variety of modeling languages exists for the specification of process models, and they can be classified according to their focal modeling construct (zur Muehlen 2004):

- *Activity-centered;* processes as a network of tasks or activities.
- *Process object centered*; processes as the legal sequence of state changes of the process object.
- *Resource centered*; process as a network of processing stations that interact with each other.

Process languages appear as Graph-based languages (e.g. BPMN, EPC), Net-based languages (e.g. Petri-nets, flow nets) and Workflow Programming Languages (e.g. BPEL).

3 Representation Theory

Ontology is the branch of philosophy that studies the most pervasive features of reality, such as real existence, change, time, causation, chance, life, mind, and society (Bunge 2003). An ontology, or representation theory, can be used as a benchmark to make predictions about the capabilities of a grammar to provide complete and clear representations of a real-world domain (Weber 1997). The application of an ontology for such a purpose is known as *representational analysis*.

Representational analysis is performed by comparing the constructs of the chosen representation theory with the constructs of the modeling grammar. Any deviation from a one-to-one mapping relationship between these constructs indicates potential representational deficiencies in the grammar. Two principal evaluation criteria are *ontological completeness*, i.e., the extent to which the modeling grammar has a deficit of constructs that map to the set of representation theory constructs, and *ontological clarity*, i.e., the extent to which the modeling grammar constructs are deemed overloaded, redundant, or excessive (Rosemann, Green *et al*. 2004). These criteria provide a theoretical basis on which conceptual modeling languages can be compared with regard to their completeness of representation and clarity.

In this study we use the Bunge-Wand-Weber (BWW) ontology (Weber 1997), specifically the representation model, since it is understood to contain all necessary constructs to describe things, and the interaction between things, in the real world. The representation model is Wand and Weber's adaptation of Bunge's rigorous ontology (Bunge 1977) and is based on a solid mathematical foundation and specifically adapted for the Information Systems domain. While other ontologies could be applied (for example Chisolm's ontology (Chisholm 1992) or the Enterprise Ontology (Uschold, King *et al*. 1997)), several studies have shown that BWW is a good basis to study the representational capabilities of conceptual modeling languages (Green and Rosemann 2002; Recker, Indulska *et al.* 2005; Recker, Indulska *et al*. 2006), which has been demonstrated in a large number of cases (Green and Rosemann 2000; Evermann and Wand 2001; Green and Rosemann 2002; Opdahl and Henderson-Sellers 2002; Loos 2003; Green, Rosemann *et al*. 2005; Recker, Indulska *et al*. 2005; Recker, Indulska *et al*. 2006; Rosemann, Recker *et al*. 2006; Green, Rosemann *et al*. forthcoming). A summary of BWW representation model studies involving process modeling languages is given in (Recker, Indulska *et al*. 2006). The Enterprise Ontology (Uschold, King *et al*. 1997) has potential application here, however we view this ontology as too broad for our purpose. Its main focal points are those of activity, organization, strategy, marketing, and time. While it appears comprehensive, very specialized constructs such as *for sale, potential sale, partnership, mission, brand*, etc, appear too specialized for the analysis of the overall representational capabilities of business rule modeling languages.

The BWW representation model, on the other hand, consists of some 40 higher level abstract constructs, which can be grouped into four categories: Things and their Properties, States of a Thing, Events and Transformations, and Systems and their Composition.

If a process or rule modeling language has a mapping to each BWW representation construct thought to be required for compliance management, then that language fulfills all the representation requirements criteria necessary for that domain and can be used in and of itself for that purpose, without limiting the user's representation capabilities. While this may be the case, the language may still suffer from lack of clarity (e.g. an overload of constructs), which impacts its usability. A language that is complete and has the lowest levels of construct overload, redundancy and excess should be chosen. When no one language provides the required representation capability, Green *et al.* [24] show that users will make use of combinations of languages that allow them to obtain maximum representation capability. Green *et al.* (Green, Rosemann *et al.* forthcoming) discuss two theories for selecting two or more grammars for Information Systems modeling. The first, Minimum Ontological Overlap (MOO), states that users will prefer languages with minimum overlap in ontological constructs, i.e., language combination where no more than one grammatical construct maps to one BWW construct. Higher levels of construct overlap will create confusion and conflict in the work of the users. The second, Maximum Ontological Completeness (MOC), states that users will select combinations of languages that, together, afford them the maximum possible representation power for their domain, i.e., if more constructs from an underlying ontology are incorporated in the chosen grammar, the expressive power of the resulting language combination will be higher. Together, the application of the MOO and MOC theories is known as *overlap analysis.*

3.1 BWW representation constructs relevant to Compliance Management

Recker *et al.* (Recker, Indulska *et al*. 2005) and Rosemann *et al.* (Rosemann, Recker *et al*. 2006) have used the BWW representation theory to analyze a large number of business process modeling languages. One of their findings was that constructs such as *lawful event space* and *conceivable state space* did not appear in more than 90% of the modeling languages analyzed. However, for the domain of compliance management we consider these two constructs to be very relevant. The *lawful event space* describes which events are permissible in a system, which could be interpreted as the whole collection of events that are legal in a compliant organization. The *conceivable state space* describes all states that a *thing* can assume. These aspects are very relevant to risk management, since they allow the detection of unexpected system contexts. Together with probability ratios, this would result in a strong analytic fundament for managing an organization's risk profile, which is one of the key elements of compliance management.

We expect to find constructs in business rule modeling languages that correspond to these BWW representation model constructs, as well as all other BWW constructs that contain the term *lawful*. In particular, we expect that the BWW construct *state law* is critical to the compliance management domain, since it allows the representation of the business rules. We therefore work under the assumption that any language, or combination of languages, used for the purpose of representation of this domain *must* include a representation for *state law.*

4 Methodology

4.1 Selection and Analysis of Rule Modeling Languages

Two languages were chosen for our initial study. The Simple Rule Markup Language (SRML) was selected as a representative example of a rule modeling language with a small vocabulary. A clear definition of its constructs is available and is not based on any other vocabulary (Coverpages.com 2001). The Semantics of Business Vocabulary and Business Rules (SBVR) was selected since it represents the latest attempt at the definition of a standardized rule modeling vocabulary (OMG 2006). SBVR is not an executable language; the vocabulary is intended to become a standard upon which many grammars can be based. For this reason its inclusion in the ontological analysis is useful.

In order to reduce subjectivity and increase internal validity of our research, we employed the extended representational analysis methodology as suggested by (Rosemann, Green *et al*. 2004). We followed the reference methodology as closely as possible:

To increase objective comparison, the ERD BWW meta-model was obtained from the authors of (Rosemann, Green *et al*. 2004) and an ERD meta-model of the SRML language was created to guide the mapping between SRML and the BWW constructs.[1] SBVR was not transformed into an ERD diagram because the SBVR specification contains many UML diagrams of the language constructs, which were sufficient for a thorough understanding of the language.

The recommended sequence of representation and interpretation mapping was followed.

Three researchers conducted the analysis independently, followed by coordination sessions, during which consensus was gained about the construct mappings.

The summary of the performed representational analysis of SRML and SBVR is shown in Table 1, where a tick indicates that the rule modeling language was found to have capability to represent the corresponding BWW representation model construct. The full details of the mapping reasoning are omitted due to paper length limitations.

4.2 Selection of process modeling languages and overlap analysis

The selection and analysis of conceptual process modeling languages was based on existing work. Many BWW-based representational analyses of process modeling languages have already been published, and some of them empirically tested (for an overview please refer to (Recker, Indulska *et al*. 2005)). We specifically focus on conceptual modeling languages rather than executable languages such as Business Process Execution Language (BPEL), since we concentrate on the documentation of policies and processes for compliance management rather than their execution. Accordingly, we chose Petri Nets, Event-driven Process Chains (EPC), Integrated DEFinition methodology – Process Description Capture Method ($IDEF_3$), and Business Process Modeling Notation (BPMN). We want to determine if business rule languages can indeed contribute to these graphical process modeling languages, as was speculated by Herbst *et al.* (Herbst, Knolmayer *et al*. 1994) for the IS domain.

The overlap analysis of the business rule and process modeling languages was performed based on the results shown in Table 1.

Language		**SRML**	**SBVR**	Petri-Net	EPC	$IDEF_3$	BPMN
Year / Version		**2001**	**2006**	1962	1992	1995	2004 v1.0
BWW Constructs							
Things	Thing	✓	✓	✓		✓	✓
	Property	✓	✓		✓	✓	✓
	Class		✓	✓			✓
	Kind						✓
States	State	✓		✓	✓	✓	
	Conceivable State Space	✓					
	State Law	✓	✓	✓	✓		
	Lawful State Space	✓		✓			
	Stable State				✓		
	Unstable State			✓			
	History						
Events	Event	✓		✓	✓	✓	✓
	Conceivable Event Space						
	Lawful Event Space						
	External Event				✓		✓
	Internal Event			✓	✓		✓
	Well-defined Event			✓	✓		✓
	Poorly-defined Event						✓
	Transformation	✓		✓	✓	✓	✓
	Lawful Transformation	✓		✓	✓		✓
	Coupling					✓	✓
	Acts on			✓			✓
Systems	System	✓	✓			✓	✓
	System Composition		✓			✓	✓
	System Environment						✓
	System Structure					✓	
	System Decomposition		✓			✓	✓
	Level Structure				✓	✓	✓
	Sub System						✓

Table 1. BWW Analysis results, including material from (Green, Rosemann *et al.* 2005) and (Recker, Indulska *et al.* 2005)

Each cell in the table is a quadrant indicating:

5 Discussion of Analysis Results

It is apparent that none of the languages analyzed provide complete coverage for all BWW constructs. In particular, representations for the BWW representation theory

[1] The SRML meta-model is available from the authors on request.

constructs of *history, conceivable event space,* and *lawful event space* are missing across all languages under consideration. This implies that even combinations of conceptual process modeling languages and business rule modeling languages are neither able to represent audit trails of activities nor all the possible or allowed events that can occur in a given situation. From the perspective of the compliance management domain, this is problematic.

While an overlap analysis shows synergies between rule modeling languages and process modeling languages, these do not appear to be as dramatic as we expected. It is clear that business process languages are fundamental to modeling for compliance management, and that BPMN is a construct-rich process modeling language that is enriched by the addition of SRML for this domain. Our initial results also support Recker *et al.*'s (Recker, Indulska *et al.* 2005) and Herbst *et al.*'s (Herbst, Knolmayer *et al.* 1994) early speculation that rule specification languages may help to alleviate some of the weaknesses of modeling business rules with graphical modeling languages.

A closer investigation of the overlap indicates that incorporating the use of SRML with any of the four popular conceptual process modeling languages allows users the ability to represent between fifteen and twenty-three representation theory constructs (i.e. MOC = 23). Minimal ontological overlap is equal to 6, implying that whichever combination of languages is chosen, a minimum of six constructs will be overlapping in the language pair. Considering both MOO and MOC, the analysis clearly shows that the combination of BPMN and SRML provides users with the highest representation power, while causing minimal ontological overlap. On the other hand, the analysis also shows that the combination of SRML and Petri Nets is not a good option, given the higher level of overlap and representation of only fifteen representation theory constructs, as compared to twenty-three from the BPMN/SRML combination.

6 Conclusions

This paper presents the first contribution towards the theory-backed analysis of representational capabilities of rule modeling languages. The consideration of our analyses, together with existing representational analyses of four popular conceptual process modeling languages, has allowed us to provide some initial direction, based on the BWW representation model, in terms of which combinations of languages provide users with the best representational capabilities for the compliance management domain. Our findings show that the combination of BPMN with SRML provides users with the highest representation power with an amount of construct overlap that is no higher than that of other language pairs. However, the analysis also shows that even this combination of languages is still deficient in some constructs considered to be important for this domain.

While our initial findings encourage further investigation of the linkage of process and rule modeling languages for compliance management, there are some known limitations to our current approach. First, the analysis of process modeling languages is based on the work of different authors, and their interpretation of the language constructs may differ from ours. Second, we currently use a binary model to rank the BWW representation model constructs in terms of their relevance to compliance management. In the future, we will conduct an expert study to investigate a more refined ranking of ontological constructs for this specific domain. Finally, the results of the mapping need to be tested against a real-world example. A related study of BPMN has been published by Recker *et al.* (Recker, Indulska *et al.* 2006), and we plan to follow their example in the rule modeling space.

A next step in this research is the inclusion of additional rule languages in the evaluation. It might be possible to derive more suitable combinations if more rule languages are included. Further work is also required to develop a cost/benefit calculation that would indicate whether the additional representational capability provided by, for example, SRML over and above BPMN, is worth the complexity of adding an additional language. Last, we see the need for research that focuses on how to achieve a meaningful and seamless integration of business process and business rule modeling languages.

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