The srBPA Ontology: Semantic Representation of the Riva Business Process Architecture

Rana Yousef [1] and Mohammed Odeh [2]

**[1] Department of Computer Information Systems, KASIT, The University of Jordan
Amman, Jordan**

**[2] Software Engineering Research Group, Faculty of Environment and Technology
The University of the West of England
Bristol, United Kingdom**

Abstract

This paper describes the development of the srBPA ontology, which is a formal ontology that conceptualizes the elements of the Riva-based business process architecture and the relationships between them. This ontology was instantiated using the UWE's CEMS faculty administration case study in an attempt to assess the correctness and the usefulness of the developed ontology. The assessment revealed that the srBPA ontology contributes remarkably as a source of business knowledge describing the process architecture of an organization to be semantically extracted and reused. Furthermore, in this paper we show how this ontology can be used to semantically identify services for an SOA-based system.

Keywords: *Ontology; Business Process Architecture; the Riva method; Service Oriented Architecture; Service Identification*.

1. Introduction

In software engineering, an ontology can be defined as "a specification of a conceptualization"[8]. A "Specification" means a formal and declarative representation, and "Conceptualization" means an abstract, simplified view of the world, based on the concepts, objects and other entities that are assumed to exist in an area of interest and the relations that exist among them [6].

The ontology use is becoming popular in the software engineering industry for two main reasons; ontologies facilitate interoperability and machine reasoning [3]. Ontologies offer the possibility for representing, organizing, and reasoning over complex sets of knowledge [3, 9].

In this paper, we describe the development and instantiation of the srBPA ontology, which conceptualizes the elements of the Riva-based Business Process Architecture (BPA) and the relationships between them. We also show the result of instantiating the developed ontology using the UWE's CEMS faculty administration case study [7] in an attempt to assess the correctness and the usefulness of the developed ontology.

The rest of this paper is organized as follows; Section 2 motivates the development of the srBPA ontology. Section 3 briefly explains the Riva method for realizing an organization's business process architecture. Section 4 explains the srBPA ontology development; Section5 uses the UWE's CEMS faculty administration case study to instantiate the srBPA ontology. Section 6 evaluates the srBPA Ontology as a result of the instantiation process. Finally, Section 7 concludes the paper.

2. Motivation

The literature provides a number of projects and frameworks that semantically manage business processes using ontologies. The SUPER project [17] is an EU-funded projects whose aim is to raise Business Process Management to the business level, from the IT level. For example, deliverable 3.3 [16] presents approaches to business process querying and process fragment identification. A method for choosing the formal foundations for the process querying framework is presented, followed by a formal definition of process fragments, the unit of reuse, etc. In addition, Deliverable 5.4 within the SUPER project [17] outlines mappings between two standards for representing business processes, EPCs and BPMN, to the Business Process Modeling Ontology (BPMO) the central ontology in SUPER. In this work and in an effort towards standardization, an ontologization of BPMN was developed within the SUPER project, namely the sBPMN ontology.

Other work in the same field was conducted by Zhao et. al. [20] who introduced an ontology based knowledge engineering for business modeling. They proposed the DOGMA framework of ontology representation and its derived AKEM methodology to knowledge engineering development. Also, Albani and Dietz [1] introduced a process for the identification of business components

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based on an enterprise ontology, being a business domain model satisfying well defined quality criteria.

Koschmider and Oberweis [12] proposed an algorithm for determining linguistic similarities between business process model variants in order to facilitate process redesign. Haller [10] presented a mapping architecture and implementation to populate a knowledge base with ontologically described process models and workflow longs.

None of the work available in the literature regarding ontology-based business process management explicitly distinguishes between business process architecture and business process models, i.e. none has developed a semantic representation of a BPA concepts and rules depending on an architectural methodology. Accordingly, it is desired to develop an ontology that formally represents the Riva-based BPA, so that a single source can be referred to extract or infer required business information. In [2] the authors have emphasized the need of having semantic comparison aspects, in addition to syntactic comparison aspects, in order to integrate models developed by different team members. Consequently, semantically representing a business process architecture will resolve the problems that could occur in the model integration step and particularly, in the comparison phase of the integration.

3. The Riva Method

Ould [14] proposed a methodological approach to derive process architectures from the essential entities of a business, which he later called the Riva method.

In order to identify an organization's process architecture in Riva, the following steps should be taken [14]:

1. *Agree the boundary of the organization*
2. *Brainstorm the organizations' subject matter to identify Essential Business Entities (EBEs)*
3. *Classify these EBEs that have a lifetime which is handled by, or are the responsibly of, members of the organization as Units of Work (UOWs)*
4. *Draw a UOW diagram that depicts the dynamic relationships between UOWs.*
5. *Assume that for each UOW, there is:*

a. *a case process (CP) that handles single instances of the UOW; and*

b. *a case management process (CMP) for dealing with the flow of instances.*

6. *Transform the UOW diagram into a first-cut process architecture; then, use the provided heuristics to generate a second-cut process architecture.*

The Riva method was shown to be simple and easy to understand and apply [7]. The Riva-based architecture is derived from an understanding of what business the organization is in, rather than its current structure or culture. So, once the architecture is understood, it becomes apparent what is required from the IT systems supporting these processes.

4. The Development Of The srBPA Ontology

The srBPA ontology conceptualizes the Riva-based Business Process Architecture. It consists of a hierarchy of concepts along with its attributes and a set of axioms that are used to generate the Riva process diagrams and allows to automatically checking if a given BPA diagram derived using Riva method is consistent.

2.1 The srBPA Ontology Language and Development Tool

srBPA Ontology is implemented in OWL-DL which is endorsed by the World Wide Web Consortium (W3C) group for web services [13]. Protégé 3.4.1 [15] is used as the ontology development tool to define classes and their properties as well as to edit and execute OWL axioms and SWRL rules [11] which are used to represent the Riva rules and the constraints that govern the relations between Riva concepts.

2.2 The srBPA Ontology Design Decisions

While developing the srBPA ontology, it was important to decide whether a specific Riva concept is to be considered as a subclass or an instance of specific concepts. A decision was to define each key concept existing in Riva method as class., e.g. EBE, UOW, CP, CMP, etc. Each class has the appropriate attributes according to Riva rules for deriving a BPA. Instantiating a BPA ontology for a certain enterprise means creating instances of its concepts, e.g. "Handle a module run" in the UWE CEMS Faculty BPA will be an instance of the CP class, not a subclass of it.

SWRL rules [11] had to be used to set constraints representing some Riva rules. SWRL is more expressive than OWL axioms and allows the use of variables which indicate instances of classes, and this is required as some Riva rules cannot be represented without the use of variable, e.g. the Riva rule to translate relationships between the UOW diagram and the 1st cut PA diagram.

2.3 The srBPA Ontology Classes and Properties

The srBPA Ontology classes represent the main elements of the Riva method, e.g. EBE, UOW, CP, CMP, etc. Figure 1 shows part of the srBPA ontology, where some classes and some relations between them are shown. Table 1 shows the main classes that correspond to the main Riva concepts along with a brief description of each and associated attributes.

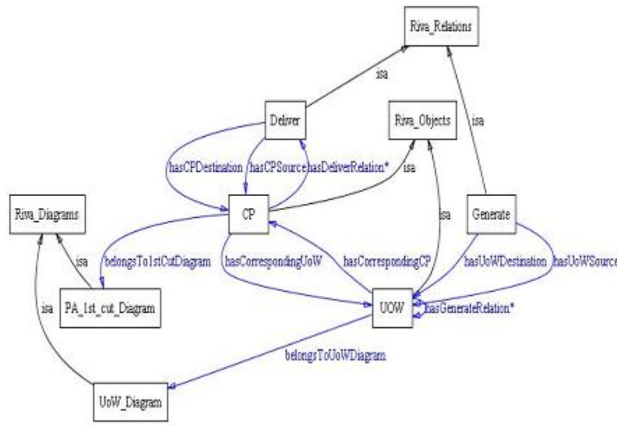

Fig. 1 Part of the srBPA Ontology

Table 1: srBPA Main Concepts and Attributes

Concept	**Description**	**Attributes**
EBE	The Essential Business Entities of an enterprise.	1) isConsideredUOW: Boolean.
UOW_Diagram	The units of work diagram according to the Riva method.	1) hasUOW of type UOW, and 2) hasOutsideWorld of type Outside_world.
PA_1st_Cut_Diagram	The 1[st] cut process architecture diagram according to the Riva method.	1) hasCP of type CP, 2) hasCMP of type CMP, and 3) hasOutsideWorld of type Outside_world.
PA_2nd_Cut_Diagram	The 2[nd] cut process architecture diagram according to the Riva method.	1) hasCP of type CP, 2) hasCMP of type CMP, and 3) hasOutsideWorld of type Outside_world.
UOW	The units of work in the UOW diagram, according to the Riva method.	1) BelongsToUOWDiagram of type UOW_Diagram, 2) hasCorrespondingCP of type CP, and 3) hasGenerateRelation of type Generate.
CP	The case processes in the 1st cut and 2nd cut PA diagrams, according to the Riva method.	1) BelongsTo1stCutDiagram of type PA_1st_Diagram, 2) BelongsTo2ndCutDiagram of type PA_2nd_Diagram, 3) hasCorrespondingUOW of type UOW, 4) hasRequestRelation of type Rrequest, 5) hasDeliverRelation of type Deliver, 6) hasStartRelation of type Start.

Table 1: srBPA Main Concepts and Attributes (cont'd)

CMP	The case management process in the 1st cut and 2nd cut PA diagrams, according to the Riva method.	1) BelongsTo1stCutDiagram of type PA_1st_Diagram, 2) BelongsTo2ndCutDiagram of type PA_2nd_Diagram, 3) hasManagingCP of type CP, 4) hasStartRelation of type Start, and 5) isActive of type Boolean.
Outside_World	The outside world in the UOW, 1st cut and 2nd cut PA diagrams, according to the Riva method.	1) hasOutsideWorldRelation of type Outside_relation, 2) BelongsToUOWDiagram of type UOW_Diagram, 3) BelongsTo1stCutDiagram of type PA_1st_Diagram, and 4) BelongsTo2ndCutDiagram of type PA_2nd_Diagram.
Generate	The generate relationship in the UOW diagram between UOW class members.	1) hasUOWSource of type UOW, 2) hasUOWDestinaiton of type UOW, and 3) belongsToUOWDiagram of type UOW_Diagram.
Request	The relationship in the PA diagram between members of the CP and the CMP classes.	1) hasCPSource of type CP, 2) hasCPDestination of type CP, 3) hasCMPDestinaiton of type CMP, 4) isActive of type Boolean, 5) belongsToPA1Diagram of type PA_1st_cut_diagram, and 6) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Deliver	The deliver relationship in the PA diagrams between the CP class members.	1) hasCPSource of type CP, 2) hasCPDestinaiton of type CP, 3) isActive of type Boolean, 4) belongsToPA1Diagram of type PA_1st_cut_diagram, and 5) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Start	The start relationship in the PA diagrams between members of the CP and the CMP classes.	1) hasCMPSource of type CMP, 2) hasCPSource of type CP, 3) hasCPDestinaiton of type CP, 4) isActive of type Boolean, 5) belongsToPA1Diagram of type PA_1st_cut_diagram, and 6) belongsToPA2Diagram of type PA_2nd_cut_diagram.
Outside_Relation	The relation from the outside world to a member of the UOW, CP or CMP classes.	1) hasOutsideWorldSource of type outside_world, 2) hasUOWDestination of type UOW, 3) hasCPDestination of type CP, 4) hasCMPDestination of type CMP, 5) isActive of type Boolean, 6) belongsToPA1Diagram of type PA_1st_cut_diagram, 7) belongsToPA2Diagram of type PA_2nd_cut_diagram, and 8) belongsToUOWDiagram of type UOW_Diagram.

The EBE class is defined to represent the essential business entities of an organization. The Boolean property isConsideredUOW is set to be true for all EBE that can be considered as UOWs.

Three classes were defined to represent the three diagrams that are generated during the Riva-based PA identification. These are: the UOW diagram which describes the dynamic relationships between units of work, the 1st cut PA diagram which can be automatically generated using the Riva rules and hypotheses, and the 2nd cut PA diagram which describes the final process architecture generated after applying some heuristics on the first cut BPA algorithm. The object properties: hasUOW, hasCP, hasCMP, and hasOutside_World are defined to relate each of the defined diagram classes to classes whose members constitute that diagram; these are the UOW, CP, and CMP.

The class UOW defines the units of work that should be present in the UOW diagram and which are actually the EBEs that can be considered as UOWs, i.e. members of the EBE class whose isConsideredUOW Boolean property is true. The CP and CMP classes define the case processes and the case management processes, respectively. These two classes are what constitute the 1st and 2nd process architecture diagrams. A set of object properties are defined to assert the diagram type (e.g. the UOW diagram, the 1st cut PA diagram, or the 2nd cut PA diagram) to which each of the EBE, CP and CMP classes belongs. Other object properties are also defined to help satisfying the Riva rules, for example hasCorrespondingCP is used to ensure that each UOW corresponds to a CP. Each CMP class has an object property, called hasManagingCP, to assert the CP corresponding to it.

The last four classes that were defined in the srBPA ontology are those that represent all relationships present in Riva diagrams, and these are: (1) Generate, which is used to indicate that a UOW generates another, (2) Request, which appears in the PA diagrams when one CP requests a CMP, (3) Start: which connects a CMP to a corresponding CP, and (4) Deliver: which can connect a CP to a CP or a CMP to a CP.

2.4 Ontologizing Riva Rules

OWL restrictions (OWL axioms) govern the relations between the defined classes, for example, using these axioms we can guarantee that each of the UOWs, CPs and CMPs belong to the correct diagram, so that if we want to inquire about some of those elements that satisfy certain condition we can specify the diagram in which they exist. Also, we relate each UOW to its corresponding CP and vice versa, and each CMP to its corresponding CP.

Other Riva rules were presented using SWRL rules, which are more expressive than OWL axioms. These rules guarantee that the proper diagrams were translated and/or generated. Table 2 separately explains these rules.

Table 2: SWRL Rules used in srBPA and their Explanations

SWRL Rule	**Description**
Rule_UOW_Instances: *EBE(?x) ^ isConsideredUOW(?x, true) → UOW(?x)*	Units of work are the essential business entities as can be decided to be considered UOW.
Rule_hasCorrespondingElement: *hasCorrespondingCP(?x,?y) → hasCorrespondingUOW(?y, ?x)*	This rule emphasizes that only elements corresponding to each other, do so in both directions. So, if a UOW corresponds to a CP, then this CP also corresponds to that UOW.
Rule_hasGenerateRelation.: *UOW (?u) ^ hasGenerateRelation (?u, ?g) →Generate(?g) ^ hasUOWSource (?g, ?u)*	All relations between UOWs are Generate relation. i.e. each UOW generates (or calls for or demands or activates or requires) another UOW. Although the concepts generate, calls for, demands, … each may include different functionalities or meanings but they can be treated the same in Riva. So we use the name Generate to refer to all these concepts and to mean in general that it will cause the generation of another UOW.

Table 2: SWRL Rules used in srBPA and their Explanations (cont'd)

Rule_1st_cut_translated_relations: *UOW(?a) ^ UOW(?b) ^ Generate(?g) ^ hasUOWSource(?g, ?a) ^ hasUOWDestination(?g, ?b) ^ hasCorrespondingCP(?a, ?acp) ^ hasCorrespondingCP(?b, ?bcp) ^ CP(?acp) ^ CP(?bacp) ^ hasManagingCP(?bcmp, ?bcp) ^ CMP(?bcmp) ^ hasRequestRelation(?acp, ?r) ^ hasStartRelation(?bcmp, ?s) ^ hasDeliverRelation(?bcp, ?d) ^ PA_1st_cut_Diagram(?d1)* → *Deliver(?d) ^ hasCPSource(?d, ?bcp) ^ hasCPDestination(?d, ?acp) ^ Request(?r) ^ hasCPSource(?r, ?acp) ^ hasCMPDestination(?r, ?bcmp) ^ Start(?s) ^ hasCMPSource(?s, ?bcmp) ^ hasCPDestination(?s, ?bcp) ^ belongsTo1stCutDiagram(?acp,?d1) ^ belongsTo1stCutDiagram(?bcp,?d1) ^ belongsTo1stCutDiagram(?bcmp,?d1)*	This long, yet simple, rule directly translates step 5 in the Riva method, where it states that the three relations in the 1st cut diagram, “Deliver”, “Request” and “Start” along with their proper sources and destinations are there because of a relation “Generate” between two UOWs. The sources and destinations of these two UOWs correspond to the CPs and CMPs in the 1st cut diagram.
Rule_inactive_CMP_relevant_Relations: *CMP(?bcmp) ^ isActive(?bcmp, False) ^ hasStartRelation(?bcmp, start) ^hasRequestRelation(?acp, ?request)^ hasCMPSource(?request, ?bcmp)* → *Request(?request) ^ isActive(?request, False) ^ Start(?start) ^ isActive(?start, False)*	This rule ensures that when we apply the heuristics to delete a CMP from the 2nd cut PA diagram, all relations related to it are deleted recursively.

5. Instantiation Of The srBPA Ontology

Instantiating the srBPA ontology for a particular organization is accomplished using SWRL rules and Jess rules after activating the SWRL and Jess tabs in Protégé. Classes of the srBPA ontology are mapped into the Jess expert system rule engine and then the required instances for the classes can be created as part of the srBPA ontology. The SWRL tab supports the editing and execution of SWRL rules.

Figure 2 shows a snapshot of the protégé editor for the instantiated srBPA ontology. Figure 3 shows the Riva-based BPA for the UWE’s CEMS faculty administration after deploying the steps of the Riva method. The rectangles in this figure represent the CPs (with captions starting with the word “Handle”) and CMPs (with captions starting with the words “Manage the flow of”). Relationships between CPs and CMPs are also represented in this figure.

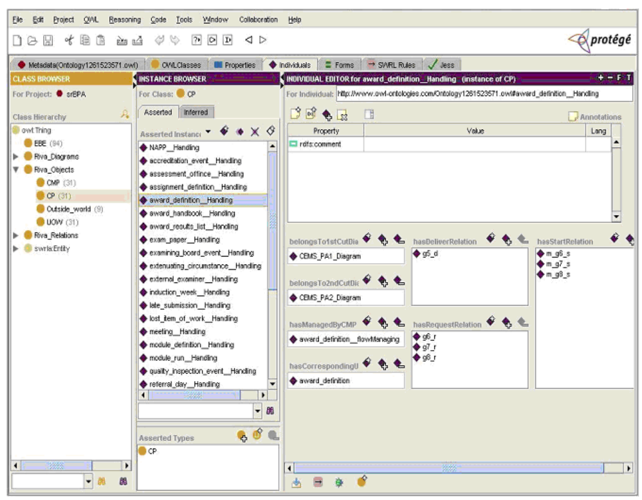

Fig. 2 A snapshot of the srBPA ontology

6. Evaluating the srBPA Ontology

Table 3 summarizes the techniques used to evaluate the srBPA Ontology where a static validation was used to evaluate the correctness of the srBPA ontology in terms of their satisfaction in representing the UWE’s CEMS Faculty administration Riva-based BPA.

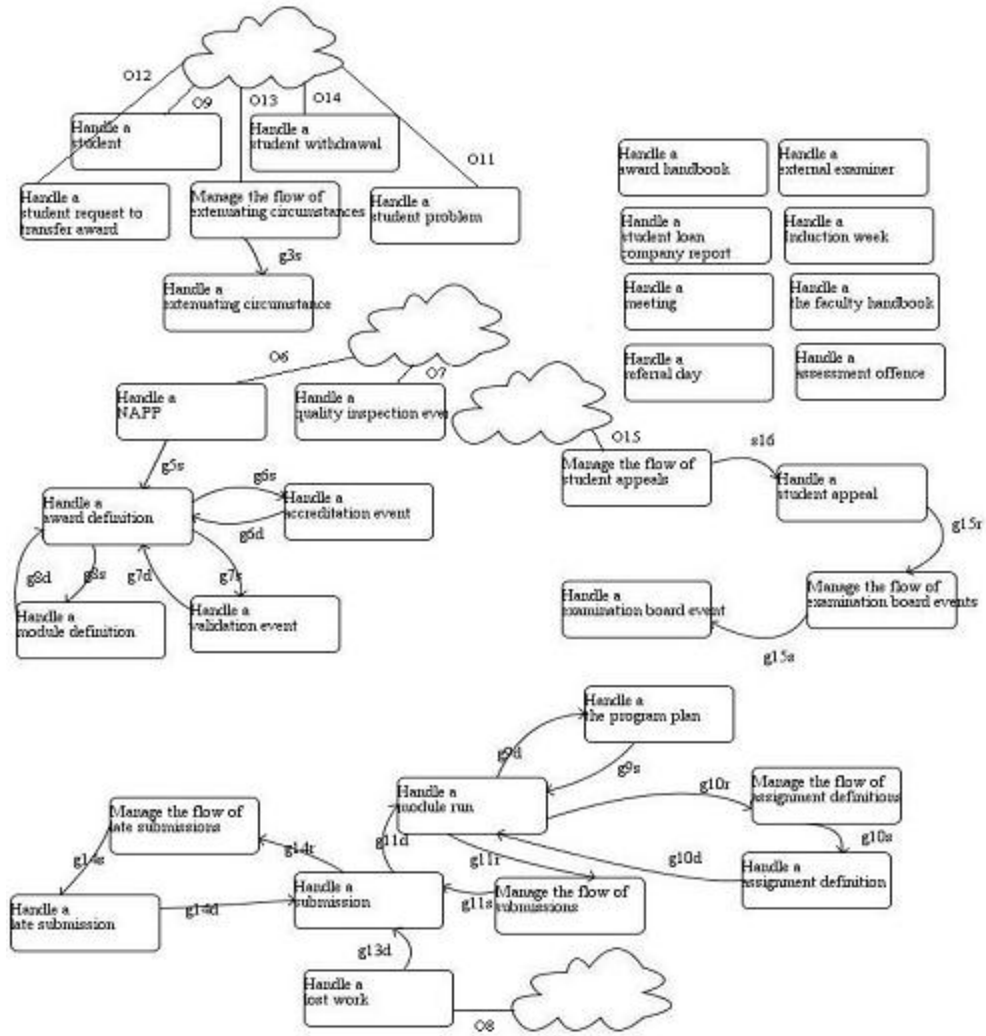

Fig. 3 The Riva-based 2nd cut BPA for the UWE's CEMS faculty administration

Table 3. Evaluation Techniques of the srBPA Ontology

What to Evaluate?	**How to Evaluate?**	
	Static Validation	Usefulness
The srBPA Ontology	Walkthrough (inspection) method to evaluate the correctness of the srBPA ontology in terms of their satisfaction in representing the UWE's CEMS Faculty administration Riva-based BPA.	Checking the Usefulness of the srBPA Ontology. Providing an application of the srBPA Ontology.

6.1 Static Validation

Having instantiated the srBPA ontology using the UWE's CEMS faculty administration case study, and after comparing the resulting ontology elements with the available Riva architecture, we were able to provide the following observations:

- The Riva elements were correctly captured, where the instantiation of the srBPA ontology using the UWE's CEMS faculty administration process resulted in the same number and semantics of elements in the 1st and 2nd cut BPA diagrams.
- The srBPA ontology representation is consistent as no errors were generated after performing consistency checking using the protégé development editor.

6.2 Usefulness

As was mentioned previously, the main motivation of developing the srBPA Ontology was to store all sources of business knowledge describing the process architecture of an organization in a single source to be extracted and reused. Instantiating the srBPA ontology using the UWE's CEMS faculty administration case study has emphasized the importance of developing this ontology, where it provides a formal description of the architectural concepts and relationships between them and to provide common semantics to communicate between stakeholders.
The srBPA ontology allows for the semantic processing of its architectural elements, where it facilitates building a tractability network so that elements of the business process architecture can be inferred according to the semantic relationships that were set between these elements. In addition, the srBPA ontology facilitates checking the semantic correctness of processes according to the rules that govern them as specified in this ontology.

7. CONCLUSION

In this paper we described the development of the srBPA ontology. The two main benefits of developing this ontology can be summarized as follows:

- The srBPA ontology allows for the semantic processing of its architectural elements.
- The design of the srBPA ontology emphasizes the principle of the separation of concerns where this ontology is only concerned with representing a BPA (identified using the Riva method).

The developed ontology have a significant role in the service orientation paradigm, which is to semantically perform the process of identifying services for a Service Oriented Architecture (SOA) system starting from its Riva BPA [18, 19]. This is because the BPAOnt ontology contains the necessary information required for identifying the set of services that conforms to the related SOA principles [4, 5]. Also, the srBPA ontology drives the automation of the SI process; as such semantic representation allows the use of SWRL rules to query the required information.
The semantic representation of the Riva BPA has been demonstrated using the UWE's CEMS faculty administration case study [7] to assess the correctness and the usefulness of the developed ontology.
In conclusion, the srBPA ontology contributes to formally describing business knowledge of an organization within a business process architecture context beyond only utilizing it for identifying services for SOA based systems, but also contributing towards automating the alignment between the business processes and associated BPA on the one hand and the supporting computer based systems on the other hand.

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