Organization Structure Description for the Needs of Semantic Business Process Management

Witold Abramowicz[1], Agata Filipowska[1] Monika Kaczmarek[1], Carlos
Pedrinaci[2], Monika Starzecka[1], and Adam Walczak[1]

[1] Poznań University of Economics, Department of Information Systems,
60-967 Poznań, Poland,
{W.Abramowicz, A.Filipowska, M.Kaczmarek, M.Starzecka,
A.Walczak}@kie.ae.poznan.pl
WWW home page: http://kie.ae.poznan.pl
[2] Knowledge Media Institute, The Open University, Milton Keynes, UK,
C.Pedrinaci@open.ac.uk
WWW home page: http://kmi.open.ac.uk

Abstract. Various attempts have been undertaken to further automate
the BPM lifecycle. One of the recent initiatives in this area is the Se-
mantic Business Process Management approach as pursued within the
SUPER project. It aims at bridging the gap between business and IT
worlds by increasing the degree of automation within the BPM lifecycle
using Semantic Web and Semantic Web services technologies. In order
to fulfil the SBPM vision, enterprises as well as their environment need
to be properly described. The main contribution of this paper is a set of
ontologies for describing organizational structures and examples showing
how they may be combined with further organizational information, e.g.,
business functions and business roles, to support the automatic analysis
of business processes.

1 Introduction

A business process may be defined as a set of related, ordered activities that
contribute to the production of good(s) or the delivery of some service. It em-
phasises how the work is done within an organization and by its organization
members. Therefore, organizations have their own context for any running busi-
ness process even if they operate in the same domain. This context embraces
information like used resources, strategies, enterprise structure as well as roles
and functions. However, when modelling business processes using current stan-
dardized notations (e.g. BPMN) a lot of information, especially on organizational
aspects, cannot be represented.

Various attempts were undertaken to achieve automation of the BPM lifecy-
cle. One of the most advanced initiatives in this area is the concept of Semantic
Business Process Management developed within the SUPER project (Seman-
tic Utilised for Process Management with and between Enterprises). It aims at

bridging the gap between business and IT worlds by increasing the degree of automation within the BPM lifecycle using Semantic Web and Semantic Web services technologies.

In order to fulfil the SBPM vision, apart from the semantic description of the process flow (control structure), the process content description is also required. The process content relates to the enterprise and its environment and therefore, must rely on a proper organization description. Furthermore, for these aspects to take part in any automated processing they need to be expressed in a formal and machine readable form. The goal of this paper is to present a set of ontologies that support capturing organisational information as required for realizing the Semantic Business Process Management vision. We present four ontologies supporting the semantic representation of a process content and position them within the entire organizational framework developed within the SUPER project. The overall approach we propose in based on the use of ontological descriptions of process flow enriched with additional descriptions of the related resources, the organisational entities involved, the roles required, etc as proposed earlier in [1].

The remainder of the paper is organized as follows: first, we discuss the scope for the semantic description of an organization. Then, four ontologies, namely Organizational Structure Ontology, Organisational Units Ontology, Business Functions Ontology and Business Roles Ontology are shortly described followed by an example of process description with the use of developed ontologies. Finally, we position our work within the state of the art in the area of semantic representation of an enterprise. Finally we present some conclusion and introduce lines for future research.

2 Semantic Representation of Organization

In order to describe an organization for the needs of the Semantic Business Process Management, an appropriate vocabulary needs to be provided. It should allow for the description of both processes and process artefacts (process content). As mentioned, the volume of knowledge needed to adequately describe all organizational details relevant to any given element of a business process is immense. In order to represent this knowledge, relevant contextual information need to be extracted as well as important elements and aspects need to be identified.

The main aspects that need to be captured are the process structure and enterprise domain specific terms (see Figure 2). The process related vocabulary is important to ensure a proper and unambiguous representation of control flow of processes within and between enterprises, while the latter part of stack is to provide a specific representation of a domain of given organization. Therefore, the process-related information (i.e. process ontologies) describes the structure of a process (i.e. tasks, control structures, links etc.), whereas organisation related ontologies provide a description of enterprise artefacts (i.e. actors, functions etc.) that are utilised or involved in the process realization. The domain ontologies provide the additional information specific to an organization from a given do-

main. As already stated in the introduction, the focus of this paper is on the organizational ontologies that provide a high-level view on the organization and process-related space. Therefore, it is to provide vocabulary and constraints for describing the environment in which processes are carried out from the organization's perspective i.e. to allow describing actors, roles and other resources that may be referred to in the process definitions [1].
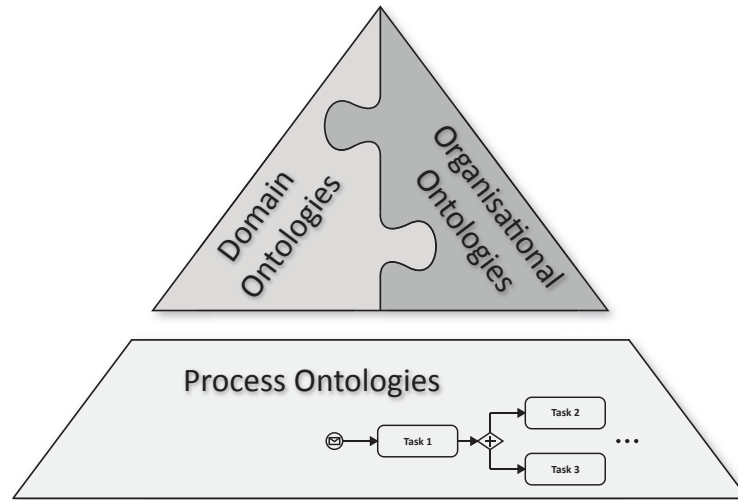

Fig. 1. SBPM Ontology Stack

Within the SUPER project we identified the following areas of the organisation description: business functions, business roles, organisational units, organisational structure, process resources, enterprise strategy and modelling guidelines. Each area is addressed by the respective ontology. All ontologies form an ontology stack for the needs of organizational aspects representation and usage within the business process modelling phase. The approach applied in SUPER was built based on previous achievements in the field of organisation modelling and was shaped by an extensive BPM practice while the preceding approaches involved mainly traditional managerial concepts. Hence, the SUPER view is more compact (e.g. it decomposes the institutional internal structure into functions and roles) whereas it also seems to be less human-centred (comparing e.g. skills and staff elements to resources of a process). The important similarities embrace the more general view on the organization; highlighting the elements that influence the institutional environment (i.e. strategy and modelling guidelines) in a comprehensive manner.

Defining a fully comprehensive model of an enterprise, is a particularly challenging and demanding task which would require an extremely extensive and complex conceptualisation which it would be difficult to manage, adapt, and

extend. Therefore, we propose instead a modular ontology stack that provides basic notions, systematizes them and thus provide the foundation for further development able to address the needs of a particular enterprise.

Below a short description of ontologies constituting the SUPER organisational ontologies stack follows:

– Business Functions - providing vocabulary to describe the hierarchy of different functions that may be carried out within a company (e.g. marketing, finance, HR) in order to enable vendor and domain independent classification of company processes and process fragments providing abstraction over single tasks constituting processes.
– Business Roles - representing roles in the organisation e.g. Designer, Process Modeller, IT Expert, CEO.
– Organizational Structure and Organisational Units Ontologies presenting detailed view on the organisational structure of an entity being described.
– Process Resources - describing applications and resources that should be spent when carrying out processes (e.g. documents, IT systems, or any other resources needed to accomplish a task) or that may be a result of a certain task in a process.
– Enterprise Strategy - in order to model information related to an enterprise strategy, targeted markets, beneficiaries of the company and some surroundings that influence the processes carried out in a company.
– Modelling Guidelines - used to describe policies and rules that should be taken into account during processes modelling.

In the following sections, the Business Organizational Structure Ontologies as well as the Functions and Business Roles Ontologies constituting a part of the ontologies stack are presented. The final shape (concepts and relations) of ontologies is a result of thorough analysis of the most representative ERP systems together with the critical approach towards the related work described in section 7. The expert knowledge was also an important source of inspiration. All mentioned ontologies were modelled using the WSML formalism.

3 Organization structure ontology

The Organizational Structure Ontology (OSO) focuses on supporting the definition of organisational structures. Following literature from this domain, the organisational structure may be defined as a structure and/or hierarchy of an organization and how its constituents work together to achieve common goals. Therefore, an organizational structure encompasses: departments, employees, their responsibilities, resources etc. as well as relations among them. The Organizational Structure Ontology is designed as an upper level ontology and therefore provides a main structure and relations aiming at achieving the domain independency. OSO structure is a result of analysis and mixture of a few described in a literature organisational structure models. The developed structure was based and/or inspired by [2–7].

Figure 3 depicts the proposed structure of OSO. For readability purposes, all designed relations, not just subsumption ones, are included in the figure.
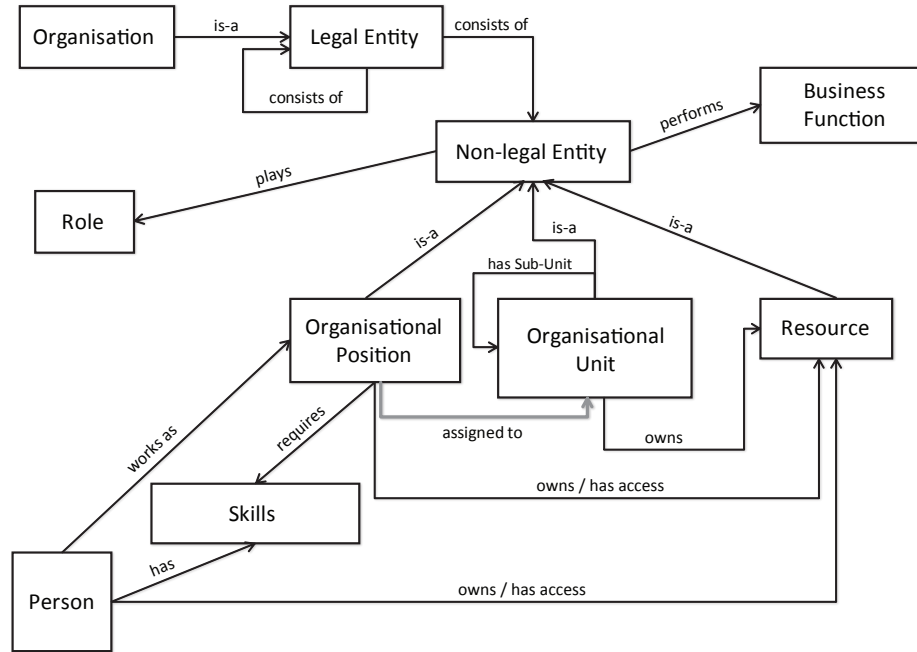

Fig. 2. Organizational Structure Ontology

The structure of the developed ontology makes it easy for other ontologies created within SUPER to import OSO concepts and use them as super concepts (e.g. Business Roles Ontology, Business Functions Ontology, Resource Ontology, and finally Organizational Unit Ontology may import OSO). OSO links all organizational ontologies developed so far in the SUPER project and enables description of organizational structure.

The following concepts are included in the OSO ontology:

– Organization - a social arrangement which pursues collective goals, which controls its own performance, and which has a boundary separating it from its environment Legal Entity - an entity that can enter into a legal contract [2].
– Non-legal Entity - an entity within a company with a role and business function assigned. It is a coherent formation in a company structure, but has no entitlement to act as an autonomous participant of economical processes [2].
– Organizational Unit - "any recognized association of people in the context of an enterprise. In a hierarchical structure, it may be a corporation, a division,

a department, a group or a team. In addition, it may be a committee, a task force, a project management organization, a class (for education) and so on" [4].

– Business Function - functional area of an enterprise such as Human Resources, Sales Management, etc.
– Role - a common super type for elements that define roles. It provides a common root for roles in organizations as well as roles in processes. A role defines a set of expected behaviours, prerogatives and obligations featured by an actor [4].
– Person - a human being regarded as an individual; an employee.
– Skills - a capability having two following features: it refers to a potential actor that is a person; the ability must be practiced or demonstrated to some measurable degree (eg. driving license, fluent German command, etc.)[2]
– Organisational position - defines the role of one or more people in an organization unit (eg. sales assistant, secretary) [4].
– Resource - an entity that can be used or consumed while carrying out some activity or business process [2].

4   Organization units ontology

This ontology is designed to provide a common vocabulary for description of "any recognized association of people in the context of the enterprise. In a hierarchical structure, it may be the corporation, a division, a department, a group or a team. In addition, it may be a committee, a task force, a project management organization, a class (for education) and so on"[4].

However, a variety of existing departments as well as naming standards, forced us to make some simplification. The developed ontology includes only the most common organizational departments. We assumed that we are modelling Organizational Units Ontology for a production enterprise (therefore, in order to describe some highly specific organizational units of e.g. publishing house or security company, appropriate concepts should be defined). The Figure 4 depicts the idea of OUO, whereby the arrows in the figure represent the is-a relation. As we decided to use Organizational Unit definition proposed by OMG in [4], we divided all units into temporary and permanent ones. Temporary units are entities, that are created in order to carry out a task, project etc. They exist in an organizational structure as long as the task or project is carried out, and disappear upon its completion. Permanent Units depicted in the figure above, were chosen as a result of analysis of different organizational structures of existing companies and organizations available in the Internet and SAP Solution Maps. Chosen units form a group that is common for many organizations being also domain-independent.

5   Business Functions and Business Roles Ontology

Within this section we give a short overview of Business Functions and Business Roles Ontology.
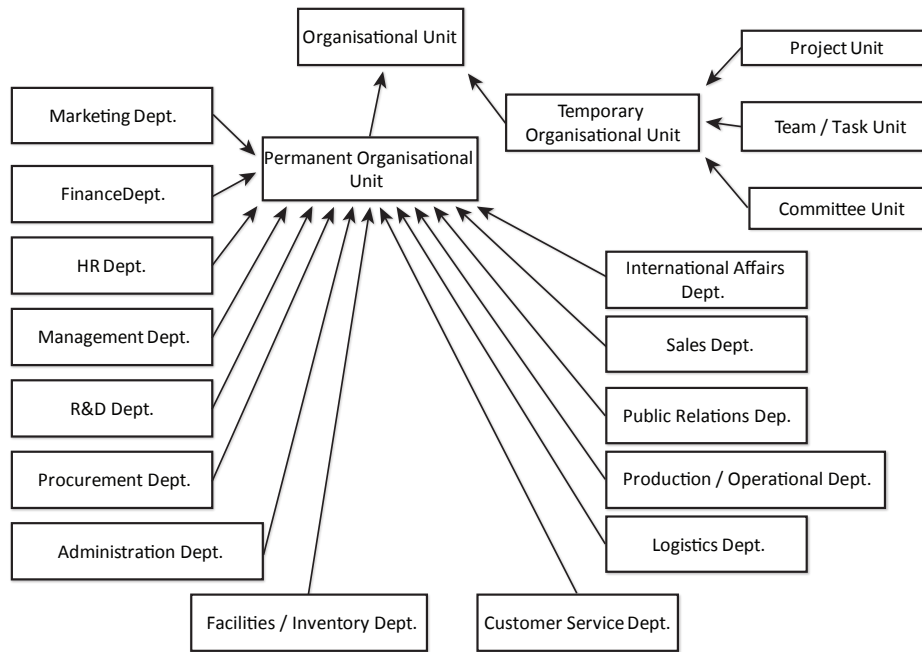
Fig. 3. Organizational Units Ontology

For a more comprehensive description please refer to [8]. The purpose of the Business Functions Ontology (BFO) is to provide foundation for structuring and defining business functions. As a business function, we understand the functional area of an enterprise such as Human Resources Management, Sales Management, etc. [8]. The BFO concept hierarchy consists of two parallel structures: one for function structure description and the other to group concepts representing activities connected or being part of a given functional area. The function sub-tree reflects main functional areas of the company e.g. Sales and Management. The ontology allows organizing knowledge on functions performed in the enterprise and explains what type of tasks are parts of those functions. BFO allows also decomposing business functions into smaller units (sub-functions).

In the functional approach, the structure of the business organization is being (partially) expressed with the functions carried out by an abstract entity (a group, an agent or a department). BFO has been created in order to provide a skeleton of business functions that would be common for every enterprise, regardless of the domain the enterprise operates in. The BFO ontology is a complete construction, nonetheless it is supposed to be a comprehensive - yet generic - starting point for further development. Therefore, BFO includes only the high level view on the functional side of an enterprise that should be extended by domain-specific ontologies.

In turn, the BRO ontology introduces the vocabulary needed to describe roles of both internal and external actors as performers of process' tasks. Therefore, the purpose of the Business Roles Ontology (BRO) is to specify the common meaning of concepts related to roles acquired and played by actors within the organizational microenvironment. We define a BusinessRole as a set of expected behaviours, prerogatives and obligations featured by an actor. Any actor may play more than one role and these roles may change depending on the situation (context). Three main elements of the BRO knowledge model encompass: InternalRole, ExternalRole and InternalRoleType concepts. Although BRO is a generic, top-level ontology, it aims at the fulfilment of the mentioned constraints and provides a minimal, yet comprehensive, set of concepts. By a microenvironment we mean both the inside structure of an organization or an enterprise and its close surroundings. The ontology is designed in a way that supports its further development and extensions.

6 Example

This section presents a simple business process described using organizational ontologies. We decided to keep the example very simple to assure clarity intelligibility of presented idea.

The process was modelled using Business Process Modelling Notation (BPMN) serialised to sBPMN (ontological version of the BPMN specification developed within the SUPER project [9].

The example presents an internal process of ordering printing paper in the Human Resources Department. It includes the following steps:

1. An employee goes to an office assistant and informs her about the shortage of printing paper.
2. The office assistant contacts a warehouse manager and places the appropriate order.
3. The warehouse manager makes the reservation for the paper in the system.
4. The delivery man delivers the paper to the office.

To describe the process, respective elements of the company must be described. This includes the description of the actors involved (i.e. office assistant, warehouse manager and delivery man), the functions performed by them as well as organisational units implicated. Let's name the office assistant MrsA. She works on position of an office manager. As an office manager, her roles in the company are: managing human resources and managing office. The following listing presents definition of appropriate instances of ontology concepts in WSML.

```
instance ManagingOfficeRole memberOf bro#OrganizationalAndAdministeringRole
instance HumanResourcesManagingRole memberOf bro#HRMRole
instance OfficeManager memberOf oso#OrganizotionalPosition
  playsRole hasValue {HumanResourcesManagingRole, ManagingOfficeRole}
  assignedTo hasValue {ouo#HRDepartment}
instance MrsA memberOf oso#Person
  worksAs hasValue {OfficeManager}
```

MrB works as a warehouse manager in the Inventory Department, thus his only role in the company is managing the warehouse.

```
instance ManagingWarehouseRole memberOf bro#ResourceAdministeringRole
instance WarehouseManager memberOf oso#OrganizationalPosition
  playsRole hasValue {ManagingWarehouseRole}
  assignedTo hasValue {ouo#InventoryDepartment}
instance MrB memberOf oso#Person
  worksAs hasValue {WarehauseManager}
```

MrC works as a delivery man in the Logistics Department, his role is distributing supplies.

```
instance SupplyDistributingRole memberOf bro#SupplementalRole
instance DeliveryMan memberOf oso#OrganizationalPosition
  playsRole hasValue {SupplyDistributingRole}
  assignedTo hasValue {ouo#LogisticsDepartment}
instance MrC memberOf oso#Person
  worksAs hasValue {DeliveryMan}
```

Finally, the process of processing the order for supporting commodity needs to be created.

```
instance SupportingCommoditySupplyOrderProcesing memberOf sbpmn#Process
isEnclosedInBusinessFunction hasValue bfo#SupplyOrderProcessing
```

In Figure 6 our exemplary process is presented. As comments, fragments of WSML code showing the use of OSO, OUO, BRO and BFO ontologies are included. Such a semantic annotation of the presented process allows for categorization of the process model (and its fragments) as well as a clear and informed assignment of roles/tasks/responsibilities. Moreover, as the entire process content is described in the machine accessible manner, the automatic processing and reasoning is possible. Therefore, employing appropriate algorithms developed within the SUPER project e.g. translation from the BPMN to BPEL process representation is possible. Moreover, business analysts are provided with new facilities for querying the process space may this be pre or post-execution. It is also possible to reason on who is responsible for what, who is doing what, what are the roles/functions associated with specific tasks. In addition, it is possible to answer questions such as i) which organizational units are responsible for carrying out given functions; ii) which organizational units are participating in a given process; and iii) which processes will be affected by changes in business process given (and how these changes will influence people, resources, etc.)?

Answers to such exemplary questions may be of great importance in various situations. Such information is needed whenever the organizational structure of an enterprise is being managed and amended e.g., when the top management re-
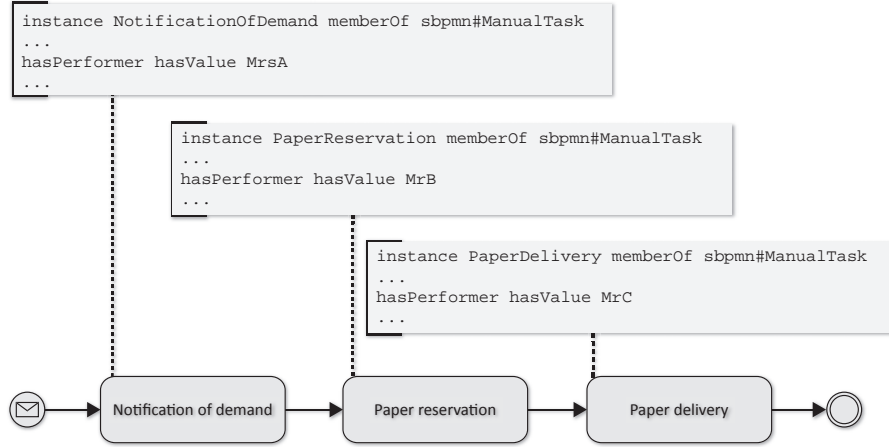
```
instance NotificationOfDemand memberOf sbpmn#ManualTask
...
hasPerformer hasValue MrsA
...
```

```
instance PaperReservation memberOf sbpmn#ManualTask
...
hasPerformer hasValue MrB
...
```

```
instance PaperDelivery memberOf sbpmn#ManualTask
...
hasPerformer hasValue MrC
...
```

Notification of demand → Paper reservation → Paper delivery

Fig. 4. Exemplary business process

structures the functional areas of the enterprise by outsourcing certain functions. Enhancing business process models with semantic descriptions enables reasoning on the process execution results, the main functionalities offered, process categorization, organizational units committed etc. Furthermore, a clear representation of the departments and/or employees interactions and their commitment in enacted processes allows for constant monitoring of their workload. Such an approach can noticeably improve the quality of business process management in the company. In case of BRO the sociological side of business organization is the clue to understand the potential use of this model. Normally, the sociological knowledge (meaning the behaviour, expectations, obligations, common interests, agent grouping configurations) is an ordinary and widespread knowledge when it comes to human beings. Yet, because of lack of experience and very impaired possibilities of real-life interactions, in case of automated information processing and machine reasoning there is a strong need of modelling such knowledge explicitly. Without it, no mechanism should be expected to know what is a customer, how a supervisor differs from any other employee or what does a stakeholder concept stand for in the context of a given organization.

7 Related Work

Within this section a short overview of the related work is provided. A detailed survey of research done in the field of formal enterprise and organization description may be found in[8].

In 1982 William E. McCarthy modelled the REA (Resource-Event-Actor) ontology [10, 11] containing only the concepts of resources, events and agents. The REA enterprise ontology is based on elements of the early REA model. Consequently theoretical background of REA comes from the field of microeco-

nomics. All REA concepts and definitions are applied to the collaborative space between enterprises where market exchange occurs among two or more trading partners [12]. It is considered one of the most promising business domain ontologies, but lack of formal representation makes it useless for practice. Additionally, it is criticized for inconsistent and confusing terminology for constructs [13], and lack of clarity [14].

As a result of works conducted in the TOVE project [15] set of integrated ontologies for modelling enterprises was developed. The goal was to create shared representation of an enterprise, definition of the semantics and symbols which depict defined concepts. Four Business Ontologies (Organization, Product and Requirements, ISO9000 Quality, Activity-based Costing) and two Foundational Ontologies (Activity, Resource) were developed. Although the proposed solution is one of the most interesting and advanced in the area, the scope covered by the ontologies and their granularity is still insufficient for the needs of business process description.

The e3-value ontology provides modelling constructs for representing and analyzing a network of enterprises exchanging items of economic value with each other [16]. The e3-value ontology was introduced as a tool to help explaining the concepts used to represent e-commerce ideas. For some more advanced aspects of organizations, such as strategic motivation that stem from environmental forces or factors in the environment that influence the constellation other extensions like e3forces, e3competences were developed. For the needs of business process description the level of detail proposed in e3-value ontologies is to general. It focuses on network of enterprises while our analysis is on the level of departments, roles, and business functions.

Business Process Management Ontology, described in [17], allows a business analyst to define private business processes, public business processes (a.k.a. business collaborations), business entities, business objects, services that implement process activities and follow the UN/CEFACT Modelling Methodology (UMM) for business process and information modelling. For the need of business process descriptions the authors use the following constructs: business entity, task and implementation. Organization structure aspect was neglected. Although the authors emphasize that for practical usage proper instances of the constructs must be created, we find the ontology is too coarse-grained to be suitable for our purposes.

A novel approach is presented in [18]. To provide further flexibility within the enterprise ontology the author suggests a contextual approach to ontology development. A context involves seven domains: purpose, actor, action, object, facility, location, and time. Created context-based enterprise ontology provides a unified view of an enterprise as an aggregation of contexts. This ontology can be specialized into task ontologies or domain ontologies to meet particular needs of enterprises, and still maintain connections of the specialized things to their contexts. From the methodological point of view this approach is the closest to our vision, and was an inspiration while designing the ontology stack for semantic description of business processes.

As far as the organizational structure is concerned interesting models were described in [2–4]. Each of them represents more or less the same level of detail, the main difference being the described relations and the scope of the models. The resulting structure of OSO ontology presented in this paper is a based on the analysis and combination of solutions taken from each of them.

The abovementioned initiatives provided an inspiration and foundation for developing the organizational ontologies. The structure of REA and Context-Based Enterprise Ontology are probably closest to our vision, yet they do not separate vocabulary from business process structure, which has been one of our main goals.

8 Conclusion

This paper deals with the semantic annotation of business processes in the context of the so-called Semantic Business Process Management approach. In particular, it focuses on the Organizational Structure Ontology divided into upper level organizational structure ontology and organizational units ontology. Additionally, two other ontologies, Business Functions Ontology and Business Roles Ontology are shortly discussed in order to show how the organizational structure ontology fits into the stack of organizational ontologies. The structure of the ontologies is inspired by the earlier work in the field, and extended in order to support the level of automation pursued. The solution proposed in this article is more comprehensive, provides extended flexibility when describing processes as well as adjusting the ontologies to the needs of the specific enterprise. Moreover, it is compatible with the recent emerging standards of the Semantic Web.

We do not foresee any major constraints in the use of the presented models. The separation of concepts used for more advanced description of organization into subontologies is a proper solution for achieving the desired power of expressiveness. Nonetheless, the proposed ontologies should be further validated and possibly extended in order to meet the real-life challenges including more detailed levels of information . In this respect, future work will be devoted to the extension of the ontologies and their integration with other models focussed on supporting Business Process Analysis [19].

References

1. Hepp, M., Roman, D.: An ontology framework for semantic business process management. In: proceedings of the 8th international conference Wirtschaftsinformatik 2007, Universitaetsverlag Karlsruhe (2 2007)
2. Uschold, M., King, M., Moralee, S., Zorgios, Y.: The enterprise ontology. Knowl. Eng. Rev. **13**(1) (1998) 31–89
3. zur Mühlen, M.: Evaluation of workflow management systems using meta models. In: HICSS '99: Proceedings of the Thirty-second Annual Hawaii International Conference on System Sciences-Volume 5, Washington, DC, USA, IEEE Computer Society (1999) 5060

4. OMG: Document bmi/2006-11-02; organization structure metamodel (osm); 2nd initial submission; in response to: Organization structure mtamodel rfp (omg document bei/2004-06-05); version 0.5 november 9. Technical report (2006)

5. Malone, T.W.: A formal model of organizational structure and its use in predicting effects of information technology. Working papers 1849-86., Massachusetts Institute of Technology (MIT), Sloan School of Management (1986)

6. Fox, M., Barbuceanu, M., Gruninger, M., Lin, J.: An organization ontology for enterprise modelling (1997)

7. Boella, G., van der Torre, L.W.N.: A foundational ontology of organizations and roles. In Baldoni, M., Endriss, U., eds.: DALT. Volume 4327 of Lecture Notes in Computer Science., Springer (2006) 78–88

8. Abramowicz, W., Agata, F., Kaczmarek, M., Starzecka, M., Stolarski, P., Walczak, A.: Semantic enterprise description for the needs of business process automation. In: SemBPM2008, Finland (to be published). (2008)

9. Abramowicz, W., Filipowska, A., Kaczmarek, M., Kaczmarek, T.: Semantically enhanced Business Process Modelling Notation. In: Proceedings of the Workshop on Semantic Business Process and Product Lifecycle Management (SBPM 2007) in conjunction with the 3rd European Semantic Web Conference (ESWC 2007) Innsbruck, Austria. (2007)

10. McCarthy, W.E.: The rea accounting model: A generalized framework for accounting systems in a shared data environment. The Accounting Review **Vol. 57**(No. 3) (July 1982) 554–578

11. Geerts, G.L., McCarthy, W.E.: An accounting object infrastructure for knowledge-based enterprise models. IEEE Intelligent Systems **14**(4) (1999) 89–94

12. Geerts, G.L., McCarthy, W.: The ontological foundation of rea enterprise information systems. working paper (August 2000) Michigan State University.

13. Lampe, J.C.: Discussion of an ontological analysis of the economic primitives of the extended-rea enterprise information architecture. International Journal of Accounting Information Systems **3**(1) (2002) 17–34

14. Guizzardi, G., Wagner, G.: A unified foundational ontology and some applications of it in business modeling. In: CAiSE Workshops (3). (2004) 129–143

15. Fox, M.S.: The tove project towards a common-sense model of the enterprise. In: IEA/AIE '92: Proceedings of the 5th international conference on Industrial and engineering applications of artificial intelligence and expert systems, London, UK, Springer-Verlag (1992) 25–34

16. Gordijn, J., Akkermans, H.: Value based requirements engineering: Exploring innovative e-commerce idea. Requirements Engineering Journal **8**(2) (2003) 114–134

17. Jenz, D.E.: Strategic white paper. ontology-based business process management. the vision statement; first edition november 2003 (2003)

18. Leppnen, M.: A context-based enterprise ontology. In Abramowicz, W., ed.: BIS. Volume 4439 of Lecture Notes in Computer Science., Springer (2007) 273–286

19. Pedrinaci, C., Domingue, J., Alves de Medeiros, A.K.: A Core Ontology for Business Process Analysis. In: 5th European Semantic Web Conference. (2008)