Semi-automatic Methodology for Compliance Checking on Business Processes

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Abstract. The paper aims to provide a semi-automatic methodology, which can be used to validate and improve business processes. The main goal is the process ontology matching, based on ontologies derived from business process models and regulations, rules and policies. The paper introduces a method using ontology building and matching for compliance checking on business processes partway automatically. The objective of this approach is to transform the business process into process ontology and to build reference process ontology from unstructured documents in order to apply ontology matching procedure to restructure, validate and improve the business process. Processes in public administration are also complex and changing fast according to the changes in regulatory environment. In the case study, we illustrate the methodology related to the process of "Assessment of the KICs past performance", to improve the process at the European Institute of Innovation and Technology (EIT).

Keywords: Process ontology · Ontology learning · Ontology matching · Compliance check

1 Introduction

Organizations create enterprise models to represent their structure and dynamics. These enterprise models are used to document the as-is reality of an organization as well as to plan the to-be scenarios. It is common for them to maintain repositories of business process models in order to document and to continuously improve their operations. Business process models play important role in the analysis and improvement of the performance of an organization. The quality of a business process model has a direct effect on the business performance.

In many application domains processes have to comply with regulations, rules and policies as well. Processes in public administration are also complex and changing fast according to the changes in regulatory environment. The rapid growth of the internet led to an enormous amount of machine readable documents online. This increasing text data come from different domains and has been growing exponentially for several centuries. A given organization is likely to be under jurisdiction of several regulations concurrently. These regulations are usually described in a natural language document which is unstructured form, and difficult to understand by non-experts of the field the

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regulation acts on. It is very difficult to extract rules from unstructured documents and therefore, such data cannot be used for any reasonable purpose.

Organizations have to invest a great amount to elaborate their business policies in order to comply with various regulatory requirements. Validating existing process models with business policies are critical issues for recent organizations. Processes have to comply with semantic constraints (e.g. business level rules and policies), however, the currently available tools and techniques for Business Process Management (BPM) lack of semantic description. Analyzing business policies and validating business process models is a critical task in organizations, which is currently done in an ad hoc way due to the lack of systematic methodologies [1].

Semantic technologies provide the foundation for formalizing the complex relationships of a business in a common model using ontology language. Ontologies enable holistic view to a BPM system.

In order to increase quality and reduce the cost in terms of human capacities and time of compliance checking, feasible to use semantic technologies. In our case, it is necessary to deal with semantically extended process models, and regulations have to be structured and expressed using formal means making their automatic processing possible.

The challenge of automated compliance checking can be seen as spreading the business processes model to include semantic aspects and enabling the required automation in checking the business processes model against the regulations. We provide mechanisms to structure and formalize regulations, then the semantics have to be framed into business processes [2, 4]. In the case of Semantic Business Process Management (SBPM), this means creating a reference process ontology to evaluate the compliance with the given process ontology.

In our approach, the reference process ontology directly created from regulations in semi-automated manner, and for the compliance checking we use heuristic ontology matching algorithms.

The paper aims to provide a semi-automatic methodology, which can be used to validate and improve business processes (c.f. Fig. 1). The main goal is the process ontology matching, based on ontologies derived from business process models and regulations, rules and policies. The paper, hence, introduces a method using ontology building and matching for compliance checking on business processes partway automatically. The objective of this approach is to transform the business process into process ontology and to build reference process ontology from unstructured documents in order to apply ontology matching procedure to restructure, validate and improve the business process. The presented methodology has been partly developed, applied and tested in the context of eBest project [3], PROKEX project [4] and on higher education processes.

In the case study, we illustrate the methodology related to the process of "Assessment of the KICs past performance", to improve the process at the European Institute of Innovation and Technology (EIT). The mission of the EIT is to grow and capitalize on the innovation capacity and capability of actors from higher education, research, business and entrepreneurship from the EU and beyond through the creation of highly integrated Knowledge and Innovation Communities (KICs) [5].

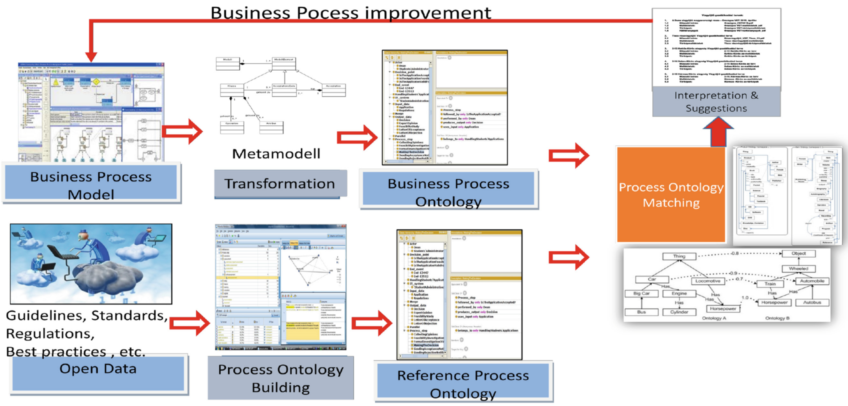

Fig. 1. Compliance checking methodology

2 Theoretical Background

2.1 Semantic Business Process Management

In the new networked economy organizations emphasize the importance of Business Process Management (BPM) and reorganize themselves around their business processes [6]. The Gartner Group predicted that by the year 2015 there will be an explosion of interest in business process management suites and their integration with underlying software infrastructure [7].

By managing processes with continuous improvements, the organization can reduce costs, increase efficiency, and strengthen the ability to respond to change. BPM Systems facilitate the management of business processes using graphical process models [8]. Many organizations already use efficiently BPM to increase their operating agility. Managing business processes means focusing on the important activities and resources of an organization. The aim is to design and control the organizational structures in a very flexible way so they can rapidly adapt to changing conditions.

It is not easy to analyze business processes, to define them and to install them, because a lot of business information, such as information about events, actors, conditions and artifacts, is needed to understand the process. If businesses and business strategies are changing, the underlying business processes also have to be changed and adopted. Once a model of a business process is available, various analytical methods need to be used to check if the process delivers the product or service in the most optimal and cost-effective way [6].

In spite of the great importance of BPM tools and techniques, they include fundamental problems such as:

- difficulty in querying and reusing business processes [9, 10]
- difficulty in integrating business processes across organizations [11]
- inability to transform automatically a business process model to an executable workflow model [12]

- lack of semantic description in business process execution language specifications for dynamic discovery and automatic composition of web services [13],

BPM has gained significant attention by both academy and industry, however the level of automation in BPM is very limited so far and does not provide a uniform representation of an organization's process space on a semantic sphere, which would be accessible to semantic functions, like intelligent queries [11].

Semantic web technologies provide suitable, standardized representation techniques to overcome this barrier. Fensel and his colleagues have proposed to combine semantic web technologies and BPM and provide one consolidated technology, which they call Semantic Business Process Management (SBPM). SBPM is a new approach of increasing the degree of automation of BPM by representing the various spheres of an enterprise using ontology languages and semantic web frameworks. Ontologies have key role in SBPM as well as semantic web [2]. Ontology is responsible for domain conceptualization, structuring knowledge embedded in business processes. It describes not only data, but also the regularity of connection among data. The most important description language of semantic web is the OWL (web ontology language) preferred by W3C [14, 15].

The goal is to be able to apply machine reasoning for the translation between the spheres for the discovery of processes, process fragments and for process composition [10]. The use of ontologies is a key concept that distinguishes SBPM from conventional BPM. Within SBPM two types of ontologies are utilized: domain ontologies and process ontologies. With the semantic description of the data, business process analysis can be semantically enhanced since the semantic meaning of the data is preserved during all phases of the process lifecycle [11].

Ontologies, as general but formalized representation can be used for describing the concepts of a business process. According to our research, process ontologies have no precise definition in the academic literature. Some refer to it simply as a conceptual description framework of processes [16]. In this interpretation process ontologies are abstract and general. Contrary, task ontologies determine a smaller subset of the process space, the sequence of activities in a given process [17].

In this paper the concept of process ontologies is used, where ontology holds the structural information of processes. The solution of establish the links between process model elements and ontology concepts has been prepared in the methodology. The attempt is to provide an extension for the standard ontology definition in the form of an annotation scheme to enable ontologies to cover all the major aspects of business process definition [18]. The approach is identified as a semi-automatic generation of BPM defined ontology.

2.2 Ontology Learning and Matching

The objective of ontology learning is "to generate domain ontologies from various kinds of resources by applying natural language processing and machine learning techniques" [19]. Statistical, rule-based or hybrid ontology learning technique can be distinguished. The goal of the process ontology building and matching tool is to identify process model objects based on their semantic and relations between them using semantic rules. With this object the system uses rule-based ontology learning technique.

Ontology matching procedure can be defined as follows: "given ontologies O1 and O2, each describing a collection of discrete entities such as classes, properties, individuals, etc., we want to identify semantic correspondences between the components of these entities." [20]

The goals of combining ontologies are to merge, transform, integrate, translate, align or map etc. them into a new or an existing ontology. The goal of this paper is to present a solution for executing a compliance check between an actual and an expected process, hence ontology mapping, matching or alignment seemed to be the best method regarding our solution.

The general ontology mapping tools use different kind of method to identify the semantic correspondences between two ontologies [21, 22]. Borbásné Szabó I. (2012) investigated these tools by their dynamism and reusability. [23] Built-in function in Protégé 4.X development environment was found the most appropriate tool to execute an ontology matching within a flexible business environment.

Process specific methods used logical assertions and similarity measures to facilitate the interoperability among processes [24]. Some other research used Petri nets to submit an operational semantics that facilitates composition, simulation, and validation of business processes [25].

3 Our Methodology

The focus in our methodology is given to the extension and mapping the conceptual models to ontology models by using meta-modeling approach and to build reference process ontology from unstructured documents in order to apply ontology matching procedure to restructure, validate and improve the business processes. The usage of semantic technologies does not affect the main phases of the BPM lifecycle, but increases the automation degree within the phases and enhances the BPM functionalities. Meta-models offer intuitive way of specifying modeling languages and are suitable for discussion with non-technical users. Meta-models are particularly convenient for the definition of conceptual models. In our approach the links between model elements and ontology concepts are established.

The main steps of our methodology are:

- Business process modeling
- Semantic annotation of business process models
- Mapping the conceptual models to ontology models
- Ontology building from unstructured documents
- Compliance check using Ontology matching

In the case study, we will illustrate the methodology related to the process of "Assessment of the KICs past performance", highlighting the context of SBPM. To produce an assessment of the KICs past performance the EIT Head Quarter analyze the outputs of the assessment of the reporting for the previous years and give an evaluation based on the rules defined in the previous phase. In the analysis of the past performance the EIT Head Quarter and in particular the KIC Project Officers and Continuous monitor Officer evaluate the KICs past performance by taking in account also the previous assessment on the reporting performed by experts in the previous years and the information collected during the management of the relationship with the KICs. EIT staff need to know if there are knowledge gaps that need to be filled.

3.1 Business Process Modeling

Business process modeling is the first phase of the BPM lifecycle. In the case study discussed in this paper the process models have been implemented using the BOC ADONIS modeling platform [26]. However, our approach is principally transferable to other semi-formal modeling languages [27].

ADONIS is a graph-structured BPM language. The integral model element is the activity. The ADONIS modeling platform is a business meta-modeling tool with components such as modeling, analysis, simulation, evaluation, process costing, documentation, staff management, and import-export. Its main feature is its method independence. Figure 2 presents the "Assessment of the KICs past performance" sample process model in ADONIS.

The next step after the modeling phase is the semantic annotation to explicitly specify the semantics of the tasks and decisions in the process flow. The semantic annotation can either be embedded in the process model itself or can exist as ontology outside the process model. Ontology-based process modeling has to reflect also the semantics of the processes.

3.2 Mapping the Conceptual Models to Ontology Models

For the mapping the conceptual models to ontology models by using meta-modeling approach the models are exported in the structure of ADONIS XML format. The "conceptual model - ontology model" converter maps the Adonis model elements to the appropriate ontology elements in meta-level.

The model transformation aims at preserving the semantics of the business model. To avoid loss of information during the transformation inserting information into annotation attributes of the target elements is needed. The model elements must be annotated to get properly processed by the transformation, model or code generator tools.

There are various languages for the explicit and formal representation of ontology. OWL will be used as the language for representing ontologies due to its increased acceptance. The Portégé-OWL application supports building ontologies.

The general rule used in our approach is to express each ADONIS model element as a class in the ontology and its corresponding attributes as attributes of the class. This transformation is done by means of XSL Extensible Style sheet Language (XSL) translation which performs the conversion.

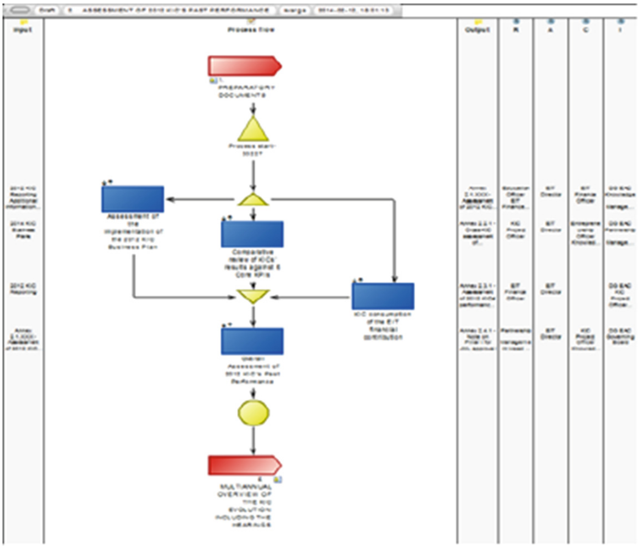

Fig. 2. The ADONIS model of the “Assessment of the KICs past performance” process.

To specify the semantics of ADONIS model elements through relations to ontology concepts, the ADONIS business model first must be represented within the ontology. In regard to the representation of the business model in the ontology, one can differentiate between a representation of ADONIS model language constructs and a representation of ADONIS model elements. ADONIS model language constructs such as “activity”, as well as the control flow are created in the ontology as classes and properties. Subsequently, the ADONIS model elements can be represented through the instantiation of these classes and properties in the ontology. The linkage of the ontology and the ADONIS model element instances is accomplished by the usage of properties. These properties specify the semantics of an ADONIS model element through a relation to an ontology instance with formal semantics defined by the ontology. A mapped ontology should define all the entities involved in the business process including how they relate to each other and what properties they have. The converted process is visualized in Fig. 3.

The meta-level mapper has been used to convert the ADONIS model elements to the appropriate ontology elements. The ontology contains all the entities involved in the process, including how they relate to each other and what properties they have.

4 Process Ontology Building

The next architecture presents a solution to build process ontologies from pure texts (best practices, regulations, guidelines etc.) and use them to investigate actual business processes to discover their similarities and discrepancies with business processes extracted from these documents.

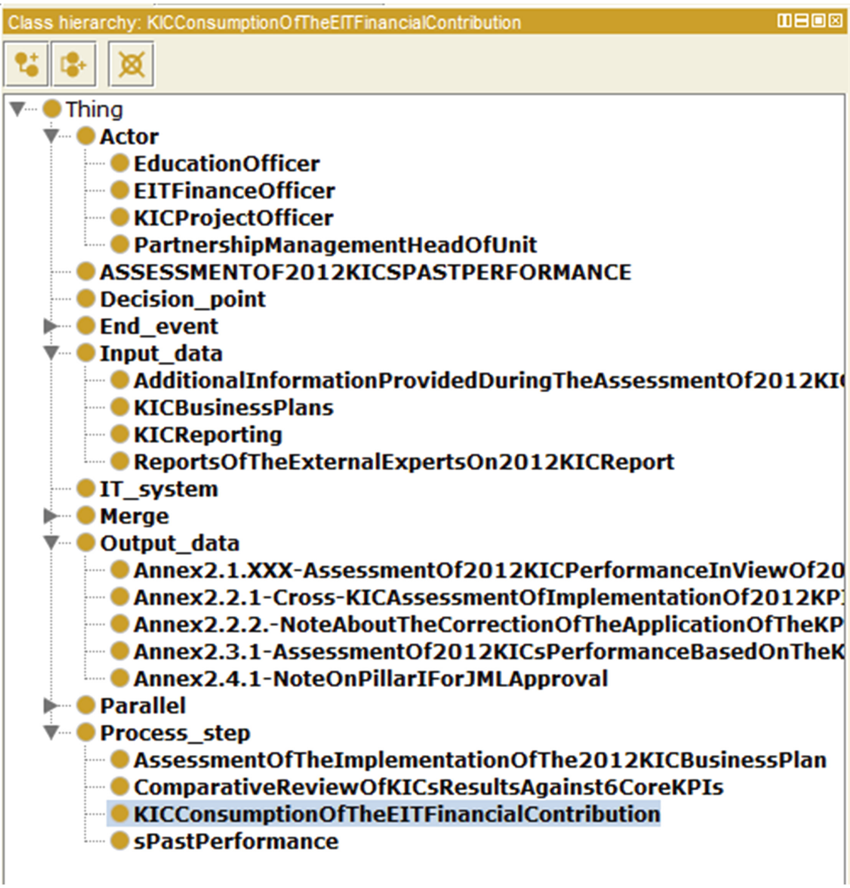

Fig. 3. The process ontology in Portégé

The architecture has two pillars: building process ontologies and matching them to create a report about similarities and discrepancies for process owners. The development of this system is ongoing but some parts are already implemented. XSLT mapper is ready to use. Matching procedure was elaborated and implemented in the SMART project [23, 29] and adapted for SBPM purposes [28, 30]. Hence this paper presents only the process ontology building part (Fig. 4).

4.1 Process Ontology Building

Two ways for process ontology building were taken into our consideration:

- general procedure without any information about the actual business process

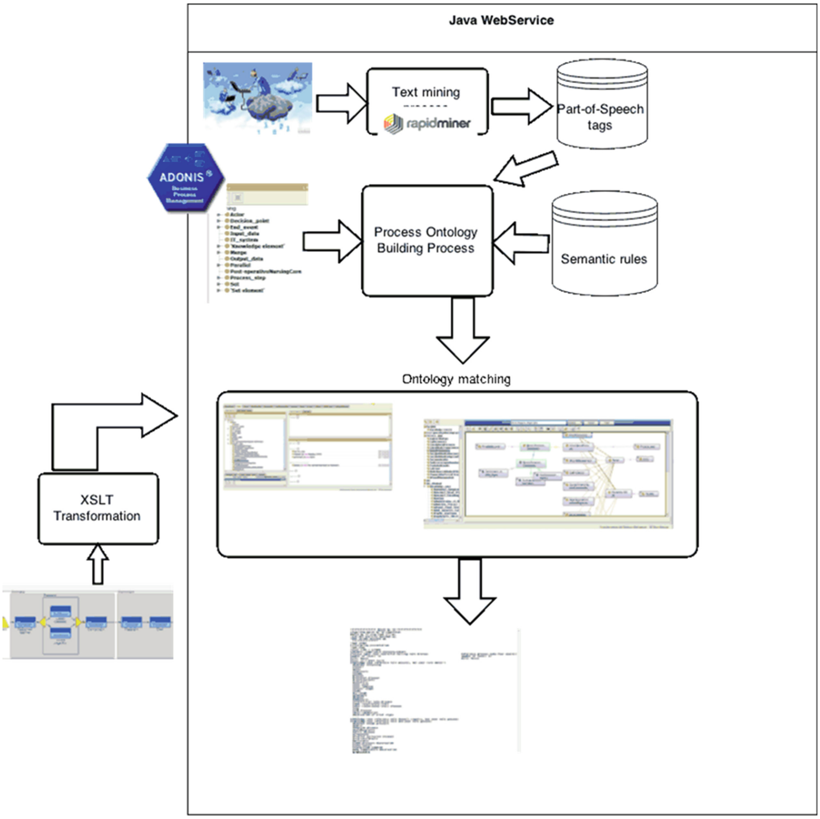

Fig. 4. Process ontology building and matching architecture

- heuristic procedure in that model elements from the actual business process are used to identify them within the unstructured documents and discovering the changes related to these element.

The first one is a very challenging field and the elaboration of accurate algorithm needs a long term period, hence we started to work the second procedure out.

4.1.1 Heuristic Procedure

The input sources of this system are unstructured documents like best practices, standards, protocols, regulations etc., and well-defined classes from the process ontologies transformed from Adonis process models (see Fig. 5).

The heuristic procedure uses the process ontology of the actual business process (actualPO) as basis to create the process ontology of the reference business process (referencePO).

The first step of this system is to identify the actual business process steps within the reference documents. It collects the subclasses of Process_step class one after the other and having split them into words. It finds the sentences containing all words or

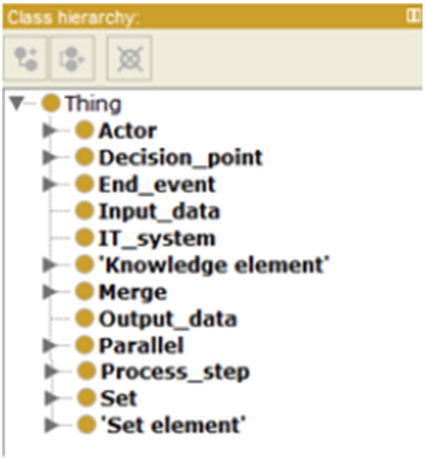

Fig. 5. Class hierarchy based on Adonis process models

some of them within these documents. Around the best fit, it identifies the related Actor using "by the" semantic rule.

In general, tasks are performed by actors. Based on this truth, we can formalize the next rule < task performed > by the < actor >. If we find a sentence whose structure follows this rule, we extract the actor from it. Having identified sentences containing "by the", the algorithm splits these sentences into two parts and the second parts will be the actors.

Having identified an actor, the algorithm create a new subclass of Process_step from the above-mentioned discovered sentence and a new sublcass of Actor and connect them with each other using "performed_by" relation. To elaborate other type of semantic rules is in progress.

These semantic rules can be complemented by grammatical rules that are constructed from part-of-speech tags. A RapidMiner process is responsible for identifying and collecting verbs and nouns from actual document into lists (see Fig. 6).

Process steps are discovered by using expressions represented by combination of verb and noun. Based on this grammatical rule, the identified process steps can be detailed by determine their activities or related other process steps. This algorithm has been implemented in Java. The next section will present the working of this program on the above-mentioned EIT process.

4.1.2 'Assessment of KICs Past Performance' Business Process

Having run the program, the next process ontology was created from the reference documents (Fig. 7).

Having created the reference process ontology by following this procedure, ontology matching procedure will be executed by using built-in ontology matching tool in Protégé 4.X ontology environment. However semantic corresponding checking between the actual and reference process ontology will be executed firstly, if it is needed.

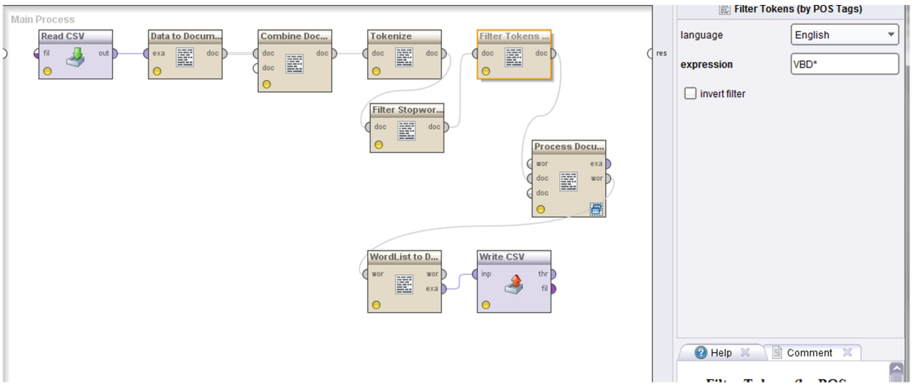

Fig. 6. RapidMiner process

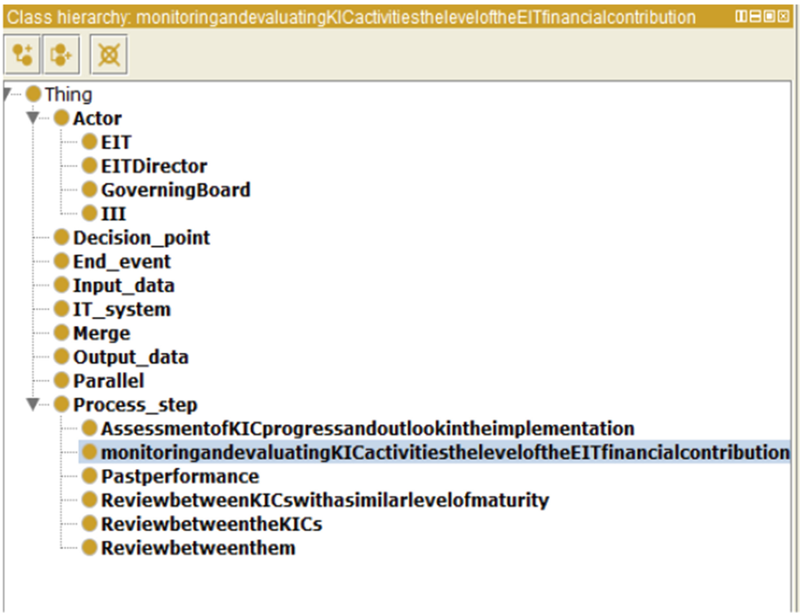

Fig. 7. The process ontology in Portégé

The matching report contains three blocks:

Created blocks show process model elements that are in the reference process, but not in the actual process.

Deleted blocks present process model elements that are in the actual process, but not in the reference process.

Renamed and modified blocks discover process model elements that are in the both processes.

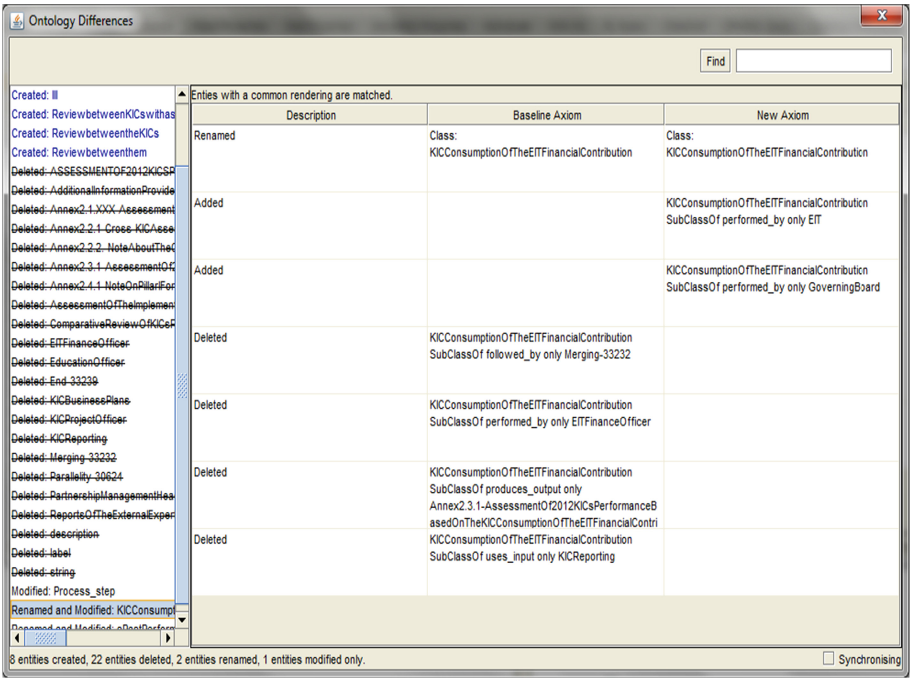

Fig. 8. The matching report

The picture presents an example about what type of information can be delivered for process owners by the report (Fig. 8).

This picture shows that ‘KIC Consumption of the EIT Financial Contribution’ process step are in the reference and actual business process as well. But the 2016 guideline requires to execute this task by EIT and Governing Board, not by EIT Finance Officer.

5 Conclusion

The paper aimed to provide and elaborate a semi-automatic methodology, which can be used to validate and improve business processes. The main goal is the process ontology matching, based on ontologies derived from business process models and regulations, rules and policies. The paper, hence, introduces a method using ontology building and matching for compliance checking on business processes. The objective of this approach is to transform business processes into process ontologies and to build reference process ontology from unstructured documents in order to apply ontology matching procedure to restructure, validate and improve the business processes.

We illustrated the methodology related to the process of “Assessment of the KICs past performance”. We have improved the process on the basis of the 2016 guideline at the European Institute of Innovation and Technology (EIT).

In the future, we plan to test the elaborated tool that creates process ontology from unstructured document with several complex processes in public administration in the dynamic regulatory environment.

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