Towards a Collaborative Process Platform

Publishing Processes according to the Linked Data Principles

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ABSTRACT

Research in the area of process modeling and analysis has a long-established tradition. Process modeling is among others used in the medical domain to define an ideal workflow in order to ensure an efficient treatment of patients. These processes are often defined and maintained by multiple persons. Furthermore, multiple persons are interested in these defined processes to compare them with own defined processes for improvements purposes. Current solutions provide tools to model processes locally and export them in standard formats in order to exchange them. Besides, there are some collaboration tools available to model processes collaboratively and see changes dynamically. However, these solutions do not publish the data according to the Linked Data principles. Enriching processes with semantic information is useful in order to perform enhanced analysis. However, different users can only provide particular meta-information on same process steps. To address these problems we 1) developed an intuitive, open-source extension for Semantic MediaWiki that supports the graphical modeling of processes and stores the information in a structured way; 2) enable to enrich the processes with semantics from ontologies and knowledge graphs with references to external data sources 3) provide adapted views on meta-information in order to not overwhelm users with unnecessary information.

CCS Concepts

•**Information systems** → *Wikis; Process control systems;*
•**Applied computing** → *Health care information systems;*

Keywords

Business Process Model and Notation, Semantic MediaWiki, Linked Data principles, Collaborative Platform, User Roles

1. INTRODUCTION

According to the process definition from ISO 9000:2015 [1] are processes defined as a set of interrelated activities that transform inputs into an intended output. Modeling processes is done in multiple domains in order to define an ideal workflow, hence a framework is given for executing the process. Among others is process modeling used in the clinical environment to define clinical guidelines in order to ensure an efficient treatment of patients.

These clinical guidelines support physicians by recommending the sequence and timing of actions that is necessary to achieve an efficient treatment of patients [14, 9]. These guidelines are also called clinical pathways and are based on evidence from insights of former treatments of patients.

Each clinic has their own pathways based on their evidences and experiences. Therefore, there are multiple pathways available that target different problems and care needs [22, 12, 7]. These clinical pathways become more complex due to the increasing volumes of data and developments in the medical domain. At the same time, clinics are interested in clinical pathways of other clinics in order to improve their own pathways and adapt them to latest trends and insights.

Besides the structure of processes, there are also many semantic information about processes available. There are many ontologies and semantic information in different data sources like e.g. DBpedia[1] available that can be used for analyzing purposes. In addition, there are further semantic information about processes available that cannot be captured with current standard formats for storing process models.

Another important aspect that occurs nowadays is that processes become more complex and that they are usually maintained by multiple persons. These persons do not necessarily share the same location but are located in different countries. This is often the case in international projects. Therefore, a collaborative tool that allows to capture, annotate and share information about processes collaboratively is preferable in order to allow a simplified acquisition and exchange of processes and respective meta-information.

Linked Data is a method to publish data in a structured way[2]. Publishing data according to these principles facilitates the exploration and interlinks between different documents. Thus information can be looked up by a HTTP URI and are provided in a structured way. Additional links to other URIs offer the possibility to explore even more information and enrich further knowledge.

Applying the Linked Data principles on processes would allow to 1) model processes and its set of activities with unique HTTP URIs; 2) provide useful information about

[1]http://wiki.dbpedia.org, visited 24 January 2016
[2]http://www.w3.org/DesignIssues/LinkedData.html, visited 24 January 2016

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processes in a standard format like the Resource Description Framework[3] (RDF); and 3) interlink processes with information from other data sources.

During the acquisition of semantic information from users, one has to consider different views on processes and its elements. Thereby, different users can provide and are interested in different meta-information for same process elements. Considering this aspect, in order to not overwhelm users with meta-information that is not relevant for him, is an important aspect while acquiring corresponding meta-information about processes.

In order to address these problems, we present a collaborative platform that allows to acquire processes, applying the Linked Data principles on them, capture meta-information and enable different views on these meta-information.

We demonstrate the applicability of our solution by modeling a concrete perioperative process and enable users with different roles to see different views on provided forms, which they can use to annotate the elements. The used methods and an overview of the system are described in section 2. Overall, we address the following research questions:

1. How can we model processes and publish them according to the Linked Data principles?

2. How can we implement the infrastructure necessary for storing, accessing, and processing processes and the corresponding meta-information?

3. How can we introduce different views for entering meta-information?

We show that our approach is easy to use and extensible to capture multiple processes and semantic information, as well as applicable to other domains (Section 2). The used materials and methods are shown in section 3. The concrete implementation of our approach is shown in section 4. Furthermore, we show that our approach is sufficient to capture processes and meta-information, and allow different views on the entered information. For this purpose we will model a perioperative process and enrich it with meta-information from users that use different views (section 5). The evaluation of the system includes showing the application of the Linked Data principles on the modeled processes, demonstrating the functionality of the system and enable different views on the meta-information. A short discussion and lessons learned is given in section 7.

2. MOTIVATION

A major shortcoming of current process modeling languages is that they cannot capture semantic information. They concentrate on representing the structure of processes but do not include specification of a formal semantic. This is e.g. the case for the Business Process Model and Notation (BPMN) [19].

Capturing processes and semantics is nowadays usually done by multiple persons. Projects and workflows are currently by no means proceeded in one place and by one person. The workflows of processes are usually defined collaboratively, as well as the analysis of processes. Moreover, not only analysts are interested in process models but also people who actually performing the processes as well as people who are not performing the processes but working in the same domain. Hence, clinics are for example interested in clinical pathways from other clinics to get insights from their processes and treatments of patients. This exchange of information allows to improve own processes by the insights of other clinics.

However, processes do not store semantic information. Current formats like e.g. BPMN 2.0 XML[4], proposed by the OMG as standard format for storing Business Process Model and Notation (BPMN) diagrams, do not allow to capture semantic information like e.g. references to medical guidelines, responsible persons and conditions. Therefore, useful meta-information that can be used for analyzing processes gets lost. However, these information can be used to improve healthcare services in planning resources and improving the outcome of clinical pathways.

Therefore, we would like to provide a possibility to capture processes, semantics in processes and the accruing meta-information in a collaborative platform. Thus, multiple person can access the platform, add, edit and view processes, semantics in processes and meta-information collaboratively. This collaborative manner supports among others also the exchange of processes. Thus people from the same domain has access to these information at any time. Following this, the entered information are available for querying and performing process analysis. The vision of the collaborative platform is given in figure 1.

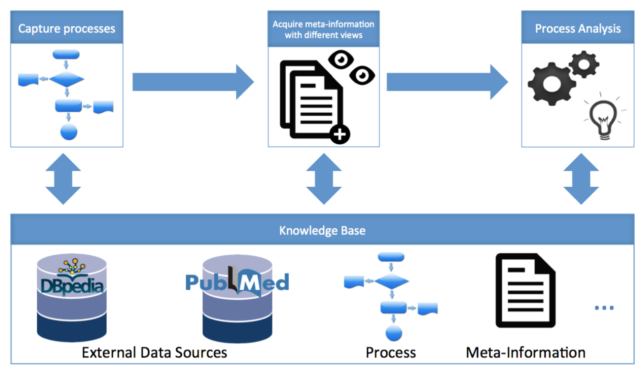

Figure 1: Vision of the collaborative platform. The collaborative platform consists of multiple stages, which are interlinked by the knowledge base that contains all available information. 1) Capture processes: Processes are captured by using a process modeling tool, converted into a machine-readable format and stored in the knowledge base. 2) Acquire meta-information with different views: Provide possibility to enter meta-information about processes and its elements. Different views are provided to users, which are adapted to their specific fields of expertise. 3) Process Analysis: The entered processes and meta-information are available according to the Linked Data principles. These information can be used in order to perform analysis like e.g similarity between processes.

We especially want to use the Linked Data principles[5] to

[3]https://www.w3.org/RDF/, visited 24 January 2016

[4]http://www.omg.org/spec/BPMN/2.0/, visited 24 January 2016

[5]http://www.w3.org/DesignIssues/LinkedData.html, vis-

publish process data. These principles are particular useful for linking, exchanging and exploring information .

Thereby, the platform will publish the entered information according to the Linked Data principles. Thus, unique HTTP URIs will represent process elements. In addition, the information provided by the platform will be available in a standard, machine-readable format. This allows to query the entered information for analyzing purposes. Entered information includes meta-information as well as useful references to external data sources like e.g. DBpedia[6], PubMed[7] or Medscape[8]. This allows to lookup further facts and information about entities and concepts, discover more things and connect the data from the collaborative platform with other data to avoid of having an unbounded web.

Information about the hierarchy of flow objects and connecting objects can be modeled with the collaborative platform. Meta-information like a responsible person for a specific task in a process, runtime, descriptions or references to external data sources, can be added to an element. These additional information, published according to the Linked Data principles, can be queried and used for enhanced analysis and can i.e. allow improved comparisons between processes [4].

The semantic information can be used to enhance analysis and providing additional information to users. However, an extensive provision of attributes that are shown to the users may overrun them and is therefore not feasible, because it prevents users more from entering meta-information instead of supporting them. In addition, not every user can provide all meta-information or rather is interested in them. Hence, we would like to introduce views on process meta-information that is relevant and useful for the user. Thus, the platform provides those meta-information to the user that is relevant to him without overwhelming him.

The information, provided by the platform, as well as the information from the referenced external data sources, allows performing analysis such as runtime analysis and similarity analysis of processes. By the variety of semantics and meta-information, provided by the platform and referenced from external data sources, are enhanced process analysis feasible that were not possible before.

3. MATERIAL AND METHODS

Our approach is based on several components that are part of a common collaborative platform that stores the data in a knowledge base. Section 3.1 describes the idea of the collaborative platform that publishes information using the Linked Data principles in more detail.

The collaborative platform should provide a possibility to model processes and reuse existing standards (section 3.2). Thereby, we have to consider that modeling processes should be as simple as possible due to the fact that domain experts will use the system and they may have no experience in using modeling tools.

Besides modeling processes, we are interested in capturing meta-information. Therefore, we need an approach to capture these information from the domain experts. In addition, we want to provide different views on same elements so users are not overwhelmed with unnecessary information (section 3.3).

3.1 Infrastructure

The infrastructure to model and annotate processes, providing different views on entering data and publishing the entered data according to the Linked Data principles, consists of multiple components. Figure 2 shows a high level overview of the planned infrastructure.

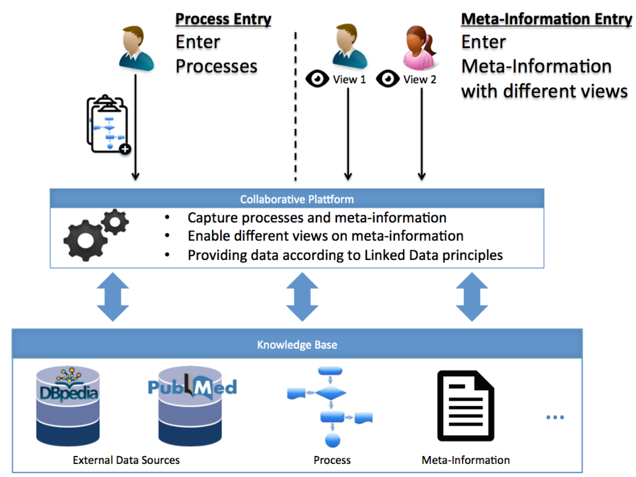

Figure 2: High level architecture of the system. It consists of three layers. Entry Layer: Users can enter processes, as well as meta-information. Different views for users with specific field of expertise are provided in order to not overwhelming them with unnecessary information. In addition, users can query the available information. Business layer: The platform takes care of entering processes and meta-information, providing useful views to users, query the data and publish them according to the Linked Data principles. Data layer: The knowledge base consists out of all available information like e.g. references to external data sources, as well as the entered processes and meta-information.

The needed infrastructure has to ensure an efficient data input and exchange that follows the Linked Data principles. However, the data entry has to abstract from the provision of standard formats like RDF. We have to consider already available standard formats for process models like e.g. BPMN 2.0 XML. Therefore, we need an infrastructure that allows to model and enter data in different ways and formats and provide the entered information automatically in a standard format like e.g. RDF.

Users can enter processes and meta-information into the collaborative platform. For entering meta-information, the system provides different views according to roles that are assigned to the user (see section 3.3). The entered data should be available according to the Linked Data principles so accessing the unique identifiers returns information in a standard format and it is possible to query the data.

ited 24 January 2016
[6]http://wiki.dbpedia.org, visited 24 January 2016
[7]http://www.ncbi.nlm.nih.gov/pubmed/, visited 24 January 2016
[8]http://www.medscape.com, visited 24 January 2016

The entered data will be stored in a knowledge base. The knowledge base consists of entered data, as well as linked data from external sources. Thus the knowledge stores modeled processes, meta-information about the modeled processes and information from other data sources like e.g. DBpedia[9] and PubMed[10] that is referenced.

3.2 Modeling Processes

There are multiple modeling languages available in order to model processes. We would like to provide the possibility in our platform to capture processes in multiple modeling languages. Modeling languages are visual representations of workflows and architectures. They define a structure how different elements are linked. However, they do not store semantic information.

Usually, domain experts are not familiar with semantic technologies and with modeling processes. Therefore, we have to provide a tool that allows domain expert to enter processes in a very simple way. Most of the modeling languages are a graphical representation, therefore a graphical user interface that allows to enter processes in a very simple way is preferable.

There are already formats available in order to store processes like e.g. BPMN 2.0 XML[11] proposed by OMG[12] as standard format for BPMN or EPML that defines a XML schema to store event-driven process chains [13]. The process modeler should reuse such standards.

Reusing standards allows to import and export processes so that these processes do not have to be modeled from scratch. Therefore, the reuse of standards allows the flexible exchange of modeled processes. Besides the import and export functionality of processes, the modeler should also allow to add new processes into the platform and edit existing processes.

Processes can be described by using different process modeling languages. Currently there are among others Business Process Model and Notation (BPMN), Petri Nets and Event-driven process chain available to model processes. Each process modeling language tackles a specific depiction of a process. This circumstance of describing one workflow by using multiple process modeling languages should be supported by the collaborative platform. Hence, users can enter processes using different modeling languages.

3.3 Annotating Processes with different Views

Annotating processes with semantic information allows to use these information among others for analyzing purposes. This can improve e.g. the comparison between processes and allows to find biomarkers in processes that have not been known before. Biomarkers in processes are indicators that have significant influence on the output of a clinical pathways.

However, different users have different perspectives on same tasks. Therefore, they can only provide particular information and will probably only use specific information. Forms allow a structured and easy input of semantic information for users. Providing one giant form, in which users can enter all information they have and view all available information in the system, may deter them in using the system. Different views on the task for entering semantic information allows to not overwhelm users with information which they cannot know and do not need. Figure 3 illustrates the idea of providing different views.

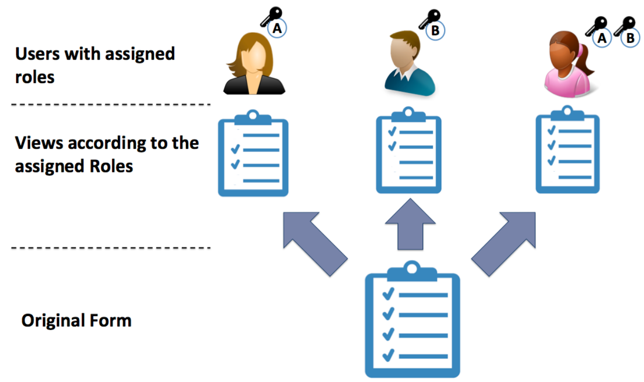

Figure 3: The system checks the assigned roles and displays only those information which are allowed by the role. Only the attributes with a tick are shown to the user.

We would like to introduce roles into the system and assign them to users. Each role contains information which attributes are interested by the user group and should be displayed to the them. Hence, the system checks which roles are assigned to the user and shows only these attributes to him.

The relationship between users and roles follow a $m : n$ relationship. So multiple roles can be assigned to one user and different users may have same roles. According to the assigned roles, the user will only see specific information.

The different views can be used to offer the possibility to secure information from unauthorized access. However, we will not focus on the security aspect but more on providing useful views for users.

4. IMPLEMENTATION

We implemented our approach by using a use-case scenario from the medical domain. The medical domain is very suitable for our approach, because in this domain are many experts that can provide different information about same clinical pathways. Furthermore, clinics are interested in clinical pathways from other clinics in order to improve their own clinical processes. Providing processes and meta-information as Linked Data allows to exchange clinical pathways across clinics and link them to already existing information to discover more things. The implementation of the infrastructure for the collaborative platform is described in section 4.1.

The realization of how processes are modeled in the collaborative platform is shown in section 4.2. We focused on BPMN as modeling language, however the approach can be adapted in order to capture processes in other modeling languages like e.g. Event-driven process chain and Petri net.

We also allow to capture meta-information about the process elements by providing forms. Users with different assigned roles get different views on same forms, so they are

[9] http://wiki.dbpedia.org, visited 24 January 2016
[10] http://www.ncbi.nlm.nih.gov/pubmed/, visited 24 January 2016
[11] http://www.omg.org/spec/BPMN/2.0/, visited 24 January 2016
[12] http://www.omg.org, visited 24 January 2016

not overwhelm with redundant information (section 4.3).

4.1 Infrastructure

In order to allow users to create, edit and view processes and process meta-information according to the Linked Data principles collaboratively, we need a collaborative platform that supports this feature. For this purpose we use Semantic MediaWiki[13] (SMW) as platform for modeling processes, capturing meta-information and publishing these information according to the Linked Data principles.

Semantic MediaWiki is a powerful collaborative knowledge management system to store and query data. Data resources, concepts and properties can be annotated internally, as well as linked to external data sources like e.g. DBpedia[14]). The possibility of linking concepts and properties enables the integration of well-known ontologies such as Dublin Core[15] and SNOMED[16]. Each wiki page has its own HTTP URI, provides its data in RDF and, if entered, provides useful links to other data sources.

Hence, the information, stored in SMW, is available as Linked Data on the web. We used existing tools and extended them in order to capture processes within SMW (section 4.2) and capture meta-information by providing different views (section 4.3).

Figure 4 illustrates the infrastructure for capturing processes, annotating them by users that use different views on same processes and query all available information in SMW by using the RDF export functionality of SMW.

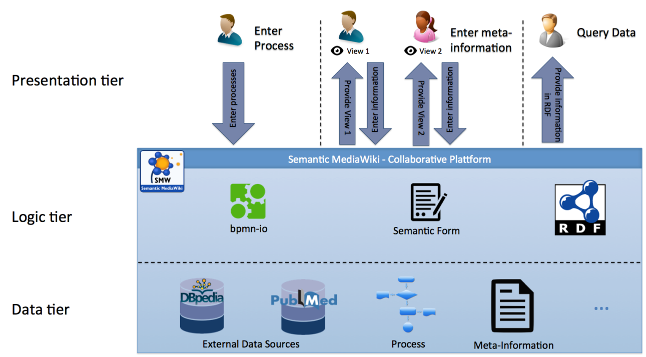

Figure 4: The infrastructure is a classical three tier architecture. Presentation tier: User can enter and view processes and meta-information with respect to their assigned roles. In addition, an export functionality is given by Semantic MediaWiki that allows to export the information in RDF. Logic tier: The process modeler allows to capture BPMN processes. Each BPMN element is represented by a wiki page. Semantic Forms allows to enter meta-information using forms. Assigned roles to users allow to display different views on same forms. The SMW export functionality publishes the data according to the Linked Data principles. Data tier: Stores all entered information. In addition, references to external data sources allows to include additional information and ontologies.

[13] https://www.semantic-mediawiki.org/wiki/Semantic_MediaWiki, visited 24 January 2016

[14] http://wiki.dbpedia.org, visited 24 January 2016

[15] http://dublincore.org, visited 24 January 2016

[16] http://www.ihtsdo.org/snomed-ct, visited 24 January 2016

The Semantic MediaWiki offers an infrastructure that allows to capture information and link it to other data sources in a very easy way. Flexible inputs and modifications of the entered data is possible. Furthermore, SMW takes care of publishing the data in RDF and according to the Linked Data principles. Thus the entered processes and meta-information is available in a structured way that can be used for analyzing purposes.

4.2 Process Modeler

Currently SMW does not support graphical inputs of process modeling languages. However, due to the fact that domain experts will enter process models, we want to facilitate the input as much as possible by providing a graphical user interface for modeling processes. As modeling language we chose BPMN 2.0.

For modeling BPMN diagrams, we used bpmn-io[17] as graphical user interface. bpmn-io is a graphical web modeler, based on JavaScript that allows to view, create and edit BPMN 2.0 diagrams. It is part of the business process management platform Camunda[18].

We extended bpmn-io with further functionality in order to embed it as process modeler in SMW. Each BPMN element (nodes and edges) is represented by an own wiki page. The wiki page contains all information about the BPMN element like e.g. the type of the element, labels, comments and entered semantic information by the user (see section 4.3).

bpmn-io allows to import processes in the standard format BPMN 2.0 XML[19] proposed by OMG[20]. Thus existing processes that are available in BPMN 2.0 XML can directly be imported via drag&drop into SMW using the process modeler. In addition, bpmn-io allows to export modeled processes in BPMN 2.0 XML and as an image in Scalable Vector Graphics (SVG) format. Thereby, we support standards and allow to reuse modeled processes.

Besides the provided functionality from bpmn-io, we allow to reload already depicted BPMN diagrams from SMW and allow to modify them. The following list describes the mapping between the process modeler and SMW.

- **Create BPMN element:** Creates a new wiki pages that represents the BPMN element and allows to store corresponding information of the element on this wiki page.

- **Edit BPMN element:** The modification of a BPMN element leads to modifications of information on the wiki page. Modification comprises among others shifting the position of an element, reconnecting flow elements and defining labels and comments for a BPMN element.

- **Delete BPMN element:** The deletion of a BPMN element leads to a deletion of the corresponding wiki page.

[17]http://bpmn.io, visited 24 January 2016
[18]https://camunda.org, visited 24 January 2016
[19]http://www.omg.org/spec/BPMN/2.0/, visited 24 January 2016
[20]http://www.omg.org, visited 24 January 2016

4.3 Process Annotation

Once processes are captured, we would like to enrich them with meta-information. For this purpose, we use Semantic Forms[21], which is an extension to SMW that provides forms for adding and editing data.

We use Semantic Forms to provide useful forms that help users to annotate process elements. Multiple forms can be created and used to annotate BPMN elements. The forms can include information like *Responsible Person*, *Goal*, *Condition* and links to *Guidelines*. These meta-information can be used to analyze processes and its elements. In addition users can use these information to get a closer look on the process and its tasks.

We imported the FOAF Ontology[22] and Dublin Core Schema[23] to model and describe the used properties. These properties are used in the forms to annotate the processes.

Forms can be arranged in a hierarchical model. So a form can inherit attributes from a superclass. However, the relationship between the superclass and its subclasses is $1 : n$. Hence, a subclass does not inherit from multiple superclasses, but a superclass can be used as a generalization for multiple subclasses [18].

We extended the functionality of Semantic Forms in order to provide different views on same forms. Therefore, admins can assign attributes to roles in the local settings file of Semantic MediaWiki. Each role stores attributes that are allowed to be viewed by the user that has the assigned role. Besides defining the roles, are the roles assigned to users. As the default setting, each attribute in a created form is allowed to be viewed for every user, independent from assigned roles. However, if adding the attribute *role* with the value *true* into the *div* element of the form, are the assigned roles for the user checked.

This check is done by a JavaScript file. Users are only allowed to view attributes that are defined in the assigned roles. Other attributes in the form are hidden. For this purpose we use the hide functionality from jQuery[24]. The corresponding HTML form is then presented to the user with hidden elements that he is not allowed to see.

The user uses these forms to enter additional information about the process element into the Semantic MediaWiki. The entered information are stored on the corresponding wiki page that represents the BPMN 2.0 element and is available according to the Linked Data principles.

5. EVALUATION

We evaluated the system according to its functionality and show the proof of concept. Therefore, we used an existing process in the medical domain. We imported an existing perioperative process that was modeled in BPMN 2.0 and enriched it with meta-information. The meta-information are entered by two users that use the same form, however with different views due to different assigned roles.

We successfully imported the perioperative process into the Semantic MediaWiki. Figure 5 shows the graphical representation of the process in the web modeler. Each element in the BPMN 2.0 process is represented by a wiki page that

[21]https://www.mediawiki.org/wiki/Extension:Semantic_Forms
[22]http://www.foaf-project.org, visited 24 January 2016
[23]http://dublincore.org, visited 24 January 2016
[24]https://jquery.com, visited 24 January 2016

stores the information about this element.

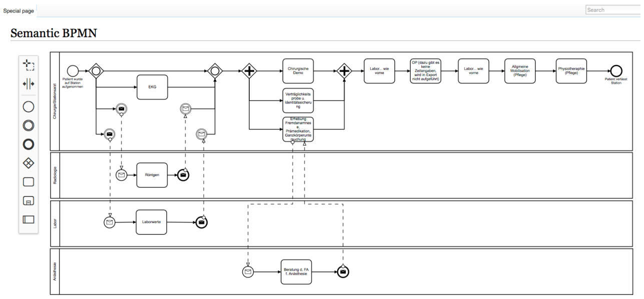

Figure 5: Imported perioperative process. Each element is represented by a wiki page that stores the corresponding information.

We use Semantic Forms to annotate the BPMN 2.0 elements and allow users to enrich them with meta-information. A role system allows to hide information from users that is not relevant for them. To demonstrate the functionality, we assigned two different roles to two different users and called up the form to annotate the task for radiography in the perioperative process. We called the roles *physician* and *radiologist*. Figure 6 shows the different views for the same form.

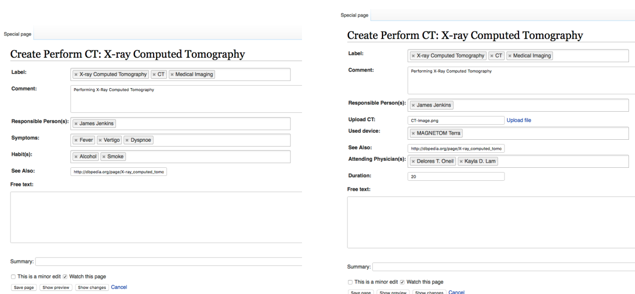

Figure 6: Different views on data with the same form. On the left is a view for a user that has the role *physician* assigned. He will e.g. not see with which device the CT were captured, because he may not be interested in it and he also may not know. On the right is the same form shown for a user with the role *radiologist* assigned. He can upload the CT image, sees the attended physicians and used device for capturing the CT image. However, he does not see the habits of the patient.

Although, users have different views on form, it is the same form. In some parts they can view the same information like label and comment, but some attributes can only be viewed by the radiologist like e.g. the used device to capture the X-ray image, which the doctor in charge might not know and is also not relevant for him.

However, the attributes are only hidden in the form. The information is still in the HTML code available but not presented to the user. Our approach hides the attributes on the client side and is therefore not suitable to prevent users from unauthorized access. For this case, a server side processing of the information is more suitable. However, we focused more on providing aligned forms for users without creating for each user group a particular form but assigning roles to them that hides specific parts of the forms.

With this approach we can create one giant form, instead of multiple forms that may only differ slightly. However, by using the roles, each user has a different view and perceive the same forms in a different way.

All the entered information into the SMW, which includes the perioperative process and the entered meta-information is available in RDF. The information can be accessed and queried by using the RDF export from SMW and is available according to the Linked Data principles.

6. RELATED WORK

Process modeling tools like Visio[25] allow to model processes on a local machine. However,a collaborative creation and maintenance of processes is not possible.

Collaborative modeling tools like Blueworks Live[26], BPMN Modeler[27], jBPM[28] and gluu[29] provide a web-based solution in order to allow modeling processes collaboratively. In addition these tools allow to import and export diagrams in various formats. Although these tools support a collaborative modeling of tools, the captured information are not published according to the Linked Data principles.

Flowchart[30] is an extension for SMW that allows to model diagrams by using flowchart elements. Each flowchart element is represented by a wiki page. Flowchart allows to model e.g. event-driven process chains. However, a graph can be displayed that shows the interlinks, it does not provide an interactive modeler. Modifications in the process must be done directly on the wiki pages, using the wiki syntax.

The modeling and capturing of information in a formal representationm using a Semantic MediaWiki, were done before in other projects [6]. Thereby, Data Science data are captured and provided in a structured way in order to use them collaboratively. Complex projects in the architecture often require a collaborative creation and exchange of building data. Therefore, theoretical framework exists to support multi-disciplinary scenarios [15].

SPUD is an environment to catalog, explore and process urban information based on semantic technologies and publish the data according to the Linked Data principles [11]. It uses existing vocabularies for modeling the data. Static, as well as stream data is used to perform traffic diagnosis.

Roles to restrict users from accessing specific data had been developed long time ago [2, 16, 8]. And since they are used in various systems to provide specific views on data, as well as restrict users from unauthorized access.

Annotations are used in different scenarios like e.g. annotating television and radio news with semantic information [3]. The annotations are used to produce a higher quality of descriptions of the news. The semantic information is used to improve conceptual search and browsing. Besides annotating television and radio news, there is also a semantic approach to annotate raw mobility data with semantic

[25]http://visio.microsoft.com, visited 24 January 2016
[26]https://www.blueworkslive.com, visited 24 January 2016
[27]http://www.trisotech.com/bpmn-modeler, visited 24 January 2016
[28]http://www.jbpm.org, visited 24 January 2016
[29]http://www.gluu.biz, visited 24 January 2016
[30]http://www.flowchartwiki.org, visited 24 January 2016

information [21]. Therefore, an annotation platform was created that supports the enrichment of the raw mobility data with meta-information.

Besides annotating data, there are also approaches available to annotate web services [10, 20]. SAWSDL[31] is a W3C recommendation to define how semantic annotations are added to WSDL documents. Annotating web services adds machine-readable descriptions on web services and thus allow a machine-to-machine interaction. Besides SAWSDL there is also OWL-S available [5] to add semantic annotations to web services. Ontologies were published to support the standardization of web service descriptions [17].

7. CONCLUSIONS

We showed an approach to capture processes and annotate them with meta-information by using a collaborative platform and providing different views for entering meta-information in order to not overwhelm users. The published information follows the Linked Data principles.

SMW provides the basis for storing the data and publishing them according to the Linked Data principles. Therefore, the captured and annotated processes are available in a machine-readable format that can be queried for analyzing purposes.

We used an existing modeler to model BPMN 2.0 diagrams, extended it with further functionality and embedded it in SMW. Each element in the BPMN 2.0 diagrams is represented by an own wiki page that stores the corresponding information. A modeler for modeling other diagrams like e.g. event-driven process chain can be implemented with the same approach as presented.

Role based forms support the annotation of BPMN elements so that redundant information is not shown to users that are not assigned to specific roles. The assigned roles focus on not overwhelming users with unnecessary information rather than on security purposes.

We evaluated the system according to its working functionality. We could import existing BPMN 2.0 XML diagrams, edit BPMN diagrams and enrich them with meta-information. The entered information is available in RDF and follows the Linked Data principles. Different views on forms allow specific entry of data by users.

Future work comprises among others the input of multiple processes and corresponding meta-information in order to use these data for performing process similarity and analysis. The entered meta-information helps especially in using them for comparing the processes on a semantic level. The consequent benefits helps to get new insights into processes like e.g. clinical pathways in order to improve them.

In conclusion, we have taken a first step towards capturing, annotating and processing processes according to the Linked Data principles that can be shared and used in order to analyze and refine processes collaboratively. Role based forms allows specific views on the data that are particularly interesting for users with the assigned roles.

[31]http://www.w3.org/TR/sawsdl, visited 24 January 2016

8. REFERENCES

[1] Quality management systems - fundamentals and vocabulary (iso 9000:2015). European Committee for Standardization, September 2015.

[2] C. W. Bachman and M. Daya. The role concept in data models. In *Proceedings of the Third International Conference on Very Large Data Bases - Volume 3*, VLDB '77, pages 464–476. VLDB Endowment, 1977.

[3] M. Dowman, V. Tablan, H. Cunningham, and B. Popov. Web-assisted annotation, semantic indexing and search of television and radio news. In *Proceedings of the 14th International Conference on World Wide Web*, WWW '05, pages 225–234, New York, NY, USA, 2005. ACM.

[4] M. Ehrig, A. Koschmider, and A. Oberweis. Measuring similarity between semantic business process models. In *Proceedings of the Fourth Asia-Pacific Conference on Comceptual Modelling - Volume 67*, APCCM '07, pages 71–80, Darlinghurst, Australia, Australia, 2007. Australian Computer Society, Inc.

[5] T. A. Farrag, A. I. Saleh, and H. A. Ali. Toward swss discovery: Mapping from wsdl to owl-s based on ontology search and standardization engine. *IEEE Trans. on Knowl. and Data Eng.*, 25(5):1135–1147, May 2013.

[6] Y. Gil, F. Michel, V. Ratnakar, J. Read, M. Hauder, C. Duffy, P. Hanson, and H. Dugan. Supporting open collaboration in science through explicit and linked semantic description of processes. In F. Gandon, M. Sabou, H. Sack, C. d'Amato, P. Cudré-Mauroux, and A. Zimmermann, editors, *The Semantic Web. Latest Advances and New Domains*, volume 9088 of *Lecture Notes in Computer Science*, pages 591–605. Springer International Publishing, 2015.

[7] D. Hindle and A. Yazbeck. Clinical pathways in 17 european union countries: a purposive survey. *Australian Health Review*, 29(1):94–104, 2005.

[8] G. Kappel, P. Lang, S. Rausch-schott, and W. Retschitzegger. Workflow management based on objects, rules, and roles. *IEEE Bulletin of the Technical Committee on Data Engineering*, 18:11–18, 1995.

[9] L. Kinsman, T. Rotter, E. James, P. Snow, and J. Willis. What is a clinical pathway? development of a definition to inform the debate. *BMC Medicine*, 8(31), 2010.

[10] J. Kopecký, T. Vitvar, C. Bournez, and J. Farrell. Sawsdl: Semantic annotations for wsdl and xml schema. *IEEE Internet Computing*, 11(6):60–67, Nov. 2007.

[11] S. Kotoulas, V. Lopez, R. Lloyd, M. L. Sbodio, F. Lecue, M. Stephenson, E. Daly, V. Bicer, A. Gkoulalas-Divanis, G. D. Lorenzo, A. Schumann, and P. M. Aonghusa. Spud – semantic processing of urban data. *Web Semantics: Science, Services and Agents on the World Wide Web*, 24:11 – 17, 2014. The Semantic Web Challenge 2012.

[12] K. Kris Vanhaecht, M. Bollmann, K. Bower, C. Gallagher, A. Gardini, J. Guezo, U. Jansen, R. Massoud, K. Moody, W. Sermeus, R. Zelm, C. Whittle, A. M. Yazbeck, K. Zander, and M. Panella. Prevalence and use of clinical pathways in

23 countries – an international survey by the european pathway association. *International Journal of Care Coordination*, 10(1):28–34, 2006.

[13] J. Mendling and M. Nüttgens. Epc markup language (epml): An xml-based interchange format for event-driven process chains (epc). *Information Systems and e-Business Management*, 4(3):245–263, 2005.

[14] M. Panella, S. Marchisio, and F. Di Stanislao. Reducing clinical variations with clinical pathways: do pathways work? *International Journal for Quality in Health Care*, 15(6):509–521, 2003.

[15] V. Singh, N. Gu, and X. Wang. A theoretical framework of a bim-based multi-disciplinary collaboration platform. *Automation in Construction*, 20(2):134 – 144, 2011. Building Information Modeling and Changing Construction Practices.

[16] F. Steimann. The role data model revisited. *Appl. Ontol.*, 2(2):89–103, Apr. 2007.

[17] H. H. Wang, N. Gibbins, T. R. Payne, and D. Redavid. A formal model of the semantic web service ontology (wsmo). *Information Systems*, 37(1):33 – 60, 2012.

[18] T. Weller and M. Maleshkova. Towards a process meta-model. In *Proceedings of the second Karlsruhe Service Summit Workshop - Advances in Service Research*, Karlsruhe, Germany, 2016. KIT Scientific Publishing.

[19] P. Wong and J. Gibbons. A process semantics for bpmn. In S. Liu, T. Maibaum, and K. Araki, editors, *Formal Methods and Software Engineering*, volume 5256 of *Lecture Notes in Computer Science*, pages 355–374. Springer Berlin Heidelberg, 2008.

[20] H. N. Yadav and R. V. Patel. Dbpedia based sawsdl for semantic web services. In *Computing for Sustainable Global Development (INDIACom)*, pages 35–39. IEEE, 2015.

[21] Z. Yan, D. Chakraborty, C. Parent, S. Spaccapietra, and K. Aberer. Semantic trajectories: Mobility data computation and annotation. *ACM Trans. Intell. Syst. Technol.*, 4(3):49:1–49:38, July 2013.

[22] K. Zander. Integrated care pathways: eleven international trends. *International Journal of Care Coordination*, 6(3):101–107, 2002.