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SOP NAVIGATOR: ONTOLOGY AND SEMANTIC-BASED KNOWLEDGE MANAGEMENT SYSTEM FOR STANDARD OPERATING PROCEDURES

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Abstract

Standard Operating Procedures (SOP) is a form of explicit knowledge at the technical level. SOP documents are very important because they are regulating the business process in an organization. SOP documents are something very necessary, but can not be used easily anytime and anywhere whenever needed. The knowledge contained in the SOP document is a precious asset for an organization, but it is not yet managed well. This research aimed to develop a knowledge management system based on ontology and semantic network that could display knowledge of SOP documents, navigate between knowledge visually, and manage SOP knowledge. This system was called SOP Navigator. Ontologies were used to capture the relationship between knowledge and a semantic network was used to display a representation of knowledge. SOP documents that used in this study is the SOP documents for technical field of information technology, the academic process of Graduate School, and personnel administration. The knowledge contained in the SOP document codified in the semantic network model in the form of nodes that related. Nodes and relationships could have different properties according to their knowledge. Modelling stored in a graph database that allows users to managed SOP data. SOP Navigator was implemented using the Ruby programming language, Sinatra web framework, and Neo4j graph database.

Keywords : ***graph database, knowledge management system, ontology, semantic network, standard operating procedures***

1. INTRODUCTION

Standard Operating Procedures (SOP) is a set of written instructions that document a routine or repetitive followed by an organization (US EPA 2007). SOP is a real form of explicit knowledge that exist within the organization (Chai et al 2003)). SOP documents is something very necessary, but can not be used easily. SOP is only stored in a thick book or a file on a computer that is rarely accessed by the employee further. Whereas the knowledge contained in the SOP documents is an asset that can increase the effectiveness of the organization if it managed optimally (Jibin and Geetha 2014). SOP is also a useful tool for dissemination of knowledge within the organization (Amare 2012). This is particularly beneficial in the case of the transfer of personnel within the organization. With the SOP, the transfer of knowledge from the old employees to new employees can be well facilitated (Amare 2012).

As an organization, Bogor Agricultural University (IPB) has implemented an SOP (Mustafa and Yulia 2007). SOP documents have been stored digitally on the computer, although some organizational unit stored them in printed form. The application of SOP is still fragmented at each organizational unit so that the knowledge contained on the SOP can not be shared with the other. To that is required an integrated SOP document management on each unit in IPB. Management of SOP documents is also not an easy thing to do. Structure and format

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of SOP documents are varied, so that makes it difficult to know the contents of the document to be updated. On the other hand, there are needs for management of SOP documents that is sensitive to changes in regulations. SOP is often considered obsolete because it does not comply with the regulations and the actual conditions. That makes users reluctant to use SOP documents as guidelines for work instructions. This has become one of the main reasons the importance of ontology-based SOP document management. By using semantic ontology properties, SOP can be mapped to the regulations that shelter it so the maintenance and revision of SOP documents if the rules have changed can be facilitated. Therefore, the SOP documents are always up-to-date and following the real conditions.

In 2010, IPB developed a knowledge management systems (KMS) called IPB Knowledge Management System (IPB-KMS). With this, the relevant knowledge can be accumulated and systemized so that knowledge can be used optimally (Seminar et al 2010). On IPB-KMS, a document is saved digitally in pdf and doc/docx format. With that format, users are difficult to search the appropriate document content that is needed. No mechanism that allows users to search the appropriate content partially or wholly. The users must first download the document then open and search to find the correct information. Until today, no research that focus on the knowledge contained in SOP documents. This research proposed a knowledge management system that will do an acquisition of knowledge contained in SOP documents, codification the knowledge into the ontology models and find relationships between the knowledge so that can shape semantic patterns. The obtained models are implemented into a KMS so the users can use and manage the knowledge.

2. RESEARCH METHOD

The phase of this research includes analysis, knowledge acquisition, KMS blueprint design, verification and validation of KMS. The analysis phase includes analysis and KMS development requirement gathering. The analysis conducted within the scope of the problem and development requirements. The analysis result modeled in software requirement specification that includes event tables, use case diagram, activity diagram, and sequence diagram.

Knowledge acquisition phase is done to obtain knowledge, tacit and explicit knowledge (Stollberg et al 2004). This research only does an acquisition of explicit knowledge because the SOP document is one form of explicit knowledge that can be the main reference for the acquisition of knowledge (Courtney 2001). SOP documents acquired in this study is the SOP documents for technical field of information technology, the academic process of Graduate School, and personnel administration. The information in the documents is identified to be formulated into a form of knowledge that can be incorporated into the KMS. Various patterns of information can be assembled into a useful knowledge. Some examples of information that can be assembled into knowledge are the purpose of document creation, to whom the document intended, when is the document was issued, and an explanation of the contents of the documents.

The knowledge that has been gathered in knowledge acquisition phase is modeled into the ontology model, and the result is incorporated into the KMS. In the process of knowledge creation formulated in four patterns of knowledge creation (Nonaka 1991), the process undertaken in this study is an explicit to explicit. In this phase, mapping knowledge to form the semantic information between objects begins. The semantic information stored in a database so that the information can be kept up to date.

KMS verification and validation phase include KMS implementation and KMS function testing. KMS implementation is a process to write the ontology model into the application code. KMS developed in web-based, so the users access it anytime and anywhere. KMS function testing is done by using black box testing methods. Black box testing methods are usually called functional testing (Nidhra and Dondeti 2012). In functional testing, the users do not have access to internal details of an application. Users provide an external input and observe result from the application. Inputs are selected based on requirement specification from the user who have previously defined in the analysis phase of software development (Naik and Tripathy 2008). From this stage can be concluded that if a developed KMS is ready to distribute to users.

3. RESULT AND ANALYSIS

3.1. Knowledge Acquisition and Codification

SOP documents obtained from the authorized organizational units. SOP documents that are entered and displayed in the KMS should be the final

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documents. SOP document that is under revision is not entered into the KMS. This is done to avoid differences in public perception. SOP document itself is a legal aspect that can be the basis of a law provision, so it must be a final one before it is being distributed to the public. Changes in the document that happened had to be a revision of the previous document, not a change of an existing document.

In this study, we used a couple of SOP for the implementation of SOP Navigator. The scope of this research is SOP documents relating to the technical field of information technology, the academic process of Graduate School, and the personnel administration. Table 1 shows the business process and the acquisition sources. SOP describes business process more detail so that it can be a reference to regulation of the organization.

Table 1 Business process and acquisition sources of SOP documents

Business Process	Description	Source	SOP Documents
Technical information technology	Technical process in information technology to develop software in IPB	Directorate of Data Integration and Information System	SOP of Project Management, SOP of Software Design, SOP of Software Documentation
Academic process of Graduate School	Administrative process that support student academic and activities	Graduate School	SOP of Student Selection, SOP of Advisory Committee Determination, SOP of Course Implementation
Personnel administration	Personnel administration process	Directorate of Human Resource	SOP of Lecturer Promotion Service, SOP of Promotion Service, SOP of Lecturer Scientific Work Assessment

The knowledge contained in these documents codified so it can be used and managed. For example is the search focused on the content of the document. Without knowledge codification, KMS cannot work (Al-Busaidi et al 2010). Existing knowledge in the SOP document consists of chapters and subchapters that make up the SOP document. Chapters and subchapters were made into a property of an SOP document. The biggest problem of this process is the format of SOP document that does not have a specific standard, so there is a difference between SOP documents. In addition to knowledge as a property attached to the SOP documents, there is another knowledge that can be extracted and made separate relevant knowledge. The knowledge can come from within or from outside of the document. That knowledge is very supporting and can form linkages with other SOP documents. The knowledge relation that can be extracted from an SOP document are:

1. Regulation is underlying the SOP. With this knowledge, the regulation that underlie an SOP can be prepared and learned more about the importance of these rules. So that the policies that will be taken can pay attention to the regulation.
2. The document's authors. With this knowledge, the person who creates, assess and legitimize the document can be identified and traced.
3. The creation dates of a document. With this knowledge, the creation date can be seen more clearly so it can later be known whether the document is still relevant or is outdated.
4. The needed requirements to run the SOP. With this knowledge, the requirements to run an SOP can be seen clearly and detail, making it easier for those who want to run the SOP.
5. The targeted object. With this knowledge, the intended object by this SOP document can be more precise so the implementation of the SOP can be more effective and efficient.
6. Revision of SOP. With this knowledge, the novelty of a document can be identified so the consistency can be maintained. Besides that, the SOP document can become more sensitive to changes.
7. The field of SOP. With this knowledge, the SOP can be developed to focus more on the field.

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The knowledge that has been acquired in the previous phase structured, encoded in the ontology model, and represented in a form of semantic network. A semantic network is a graph structure to represent knowledge into a pattern of links between nodes and arcs (Sowa 2006). Modeling Ontology of SOP documents shown in Figure 1. Codification process into the ontology model produces classes that relate to each other. The classes that can be formed from the codified knowledge of the SOP documents are:

1. SOP. This class stores information about SOP documents. This class is the core of the ontology built so that other classes will have a relation to this.
2. Field. This class stores information about the field of SOP documents. In this research, fields of the SOP is limited to three areas, that is academic, personnel administration, and technical fields of information technology.
3. Regulations. This class store the information from the underlying rules of the SOP document.
4. User. This class store the information to whom the SOP intended.
5. Requirements Document. This class stores information about the requirements documents to be able to run the SOP.
6. Position. This class stores information about the SOP authors.
7. Organizational unit. This class stores information about the organizational unit that issued the SOP.

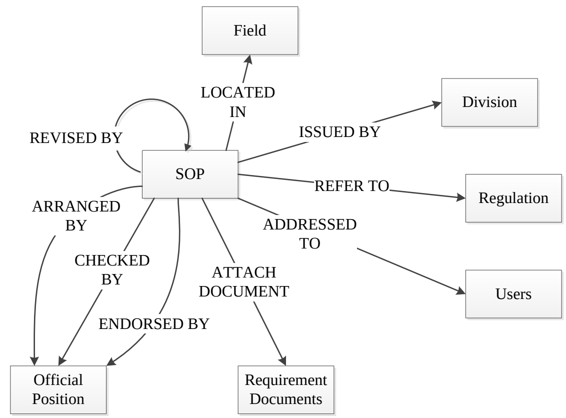

Figure 1. Modeling ontology of SOP

SOP document is a continuous growing document. Regulatory changes that may occur resulting in the SOP document should always be possible to be updated by the policies of the organization. It requires an appropriate database to store the semantic patterns of knowledge that exist in the SOP. SOP Navigator uses a graph database to store the semantic network of knowledge that is depicted in the form of nodes, relationships and properties (Batra and Tyagi 2012, Miller 2013). The database used by SOP Navigator is Neo4j. There is a slight adjustment to Neo4j against ontology representations that have been made. Neo4j have a Labels definition to incorporate nodes that have the same type of information. By doing so, Labels can be used to represent the Field Class in ontology. Representation of semantic network in Neo4j shown in Figure 2.

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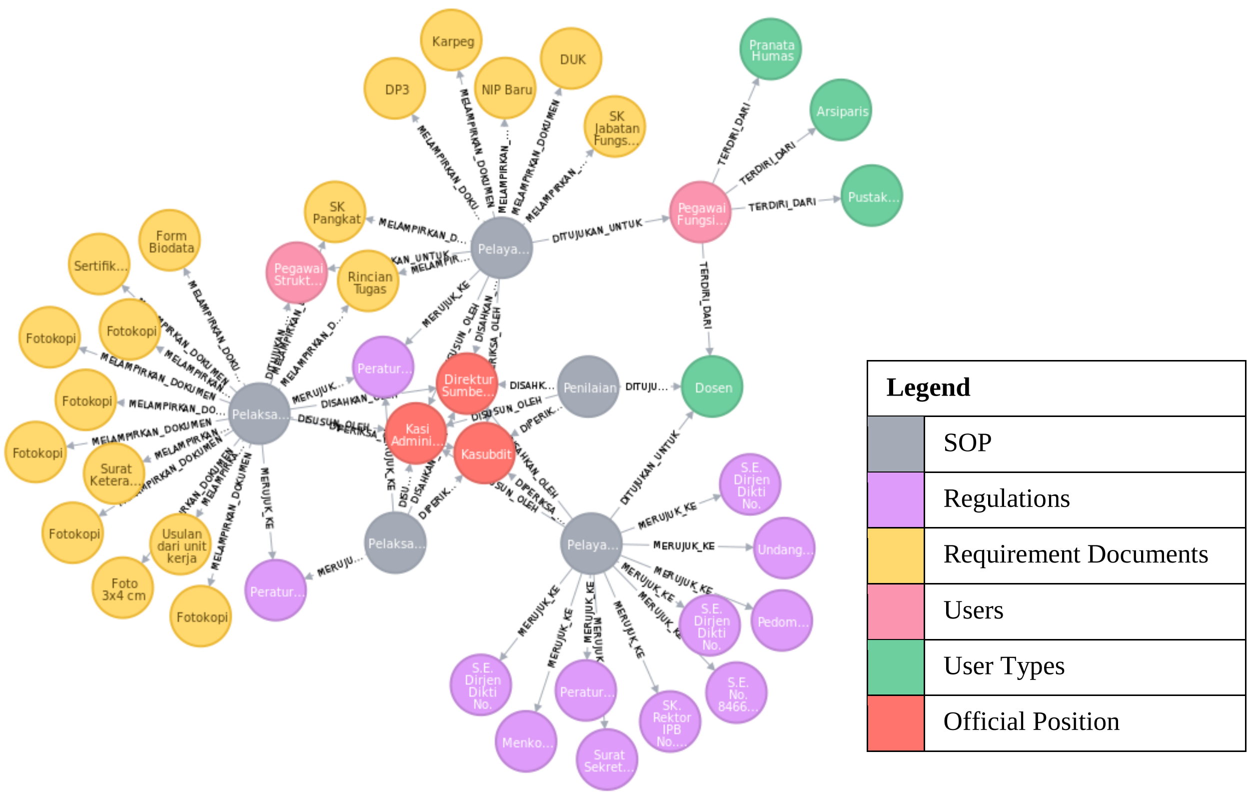

Figure 2. Semantic network representation in Neo4j

3.2. KMS Design and Implementation

The main function of developed KMS is to perform SOP data search, represent knowledge visually in the form of nodes and relationships, show other information relating to the SOP, navigate between knowledge, and manage SOP data. The KMS prototype called SOP Navigator. SOP Navigator developed in web-based to be accessible to the public. SOP Navigator developed from Neovigator applications made by Max De Marzi (Marzi 2012). SOP Navigator was developed using the Ruby programming language and Sinatra web framework. The database used is Neo4j graph database by using Web API Neography as a link between Ruby and Neo4j. Table 2 shows the system operational environment built and descriptions related to system architecture environment used.

Table 2. Operational Environment of SOP Navigator

No	Item	Sub-Item	Description
1	Hardware	Server	Server-based computer
		Client	PC IBM Compatible
2	Operating System	Server	Linux
		Client	Windows/Linux
3	Browser	Client	Mozilla Firefox, Google Chrome
4	Database	Server	Neo4j
5	Web Server	Server	Rack
6	Programming Language	Server	Ruby
7	Framework	Server	Sinatra, Bootstrap
8	Web API	Server	Neography
9	Visualization Language	Client	Processingjs

SOP Navigator users are public users and administrators. Public users can search and trace SOP

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data. Administrators can manage SOP data. Use case diagram is used to show the different types of users and the relation with the system (Satzinger 2010). Use case diagram is shown in Figure 3.

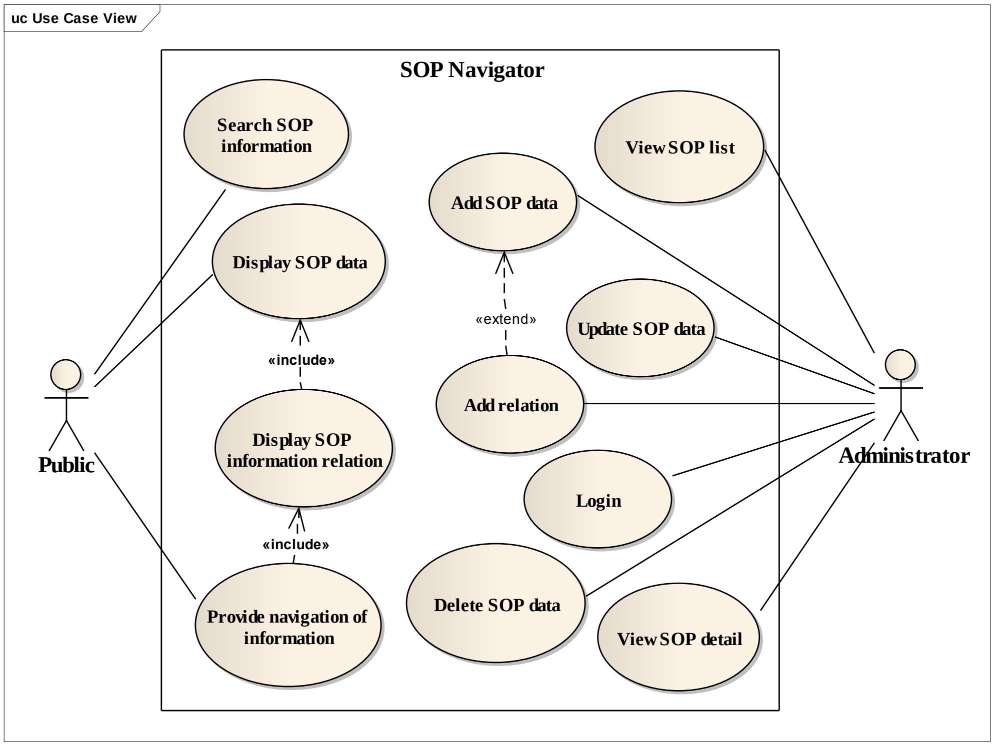

Figure 3. SOP Navigator use case diagram

The main page of the SOP Navigator prototypes shown in Figure 4. On this page, the user inputs a keyword to display SOP data. Figure 5 show the knowledge in the form of nodes and relationships. The content of the information can be seen on the right panel. Users can navigate through knowledge as shown in Figure 6. The user can display the information by clicking relations contained in the node. Data management illustrated in Figure 7 where the user can perform CRUD (Create, Read, Update, and Delete) SOP data. All of the SOP Navigator features on Figure 3 was tested using the Black Box methods.

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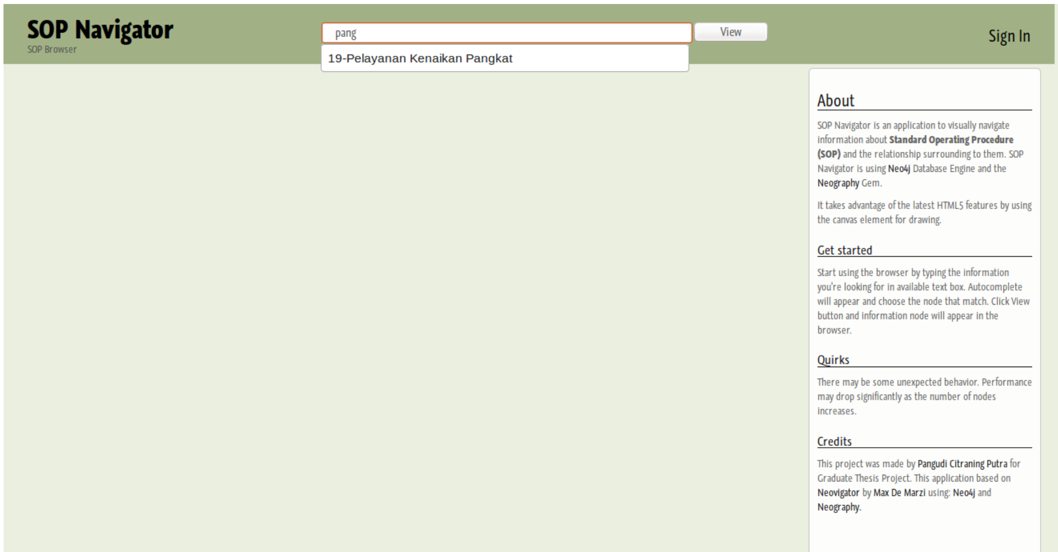

Figure 4. The main page of SOP Navigator

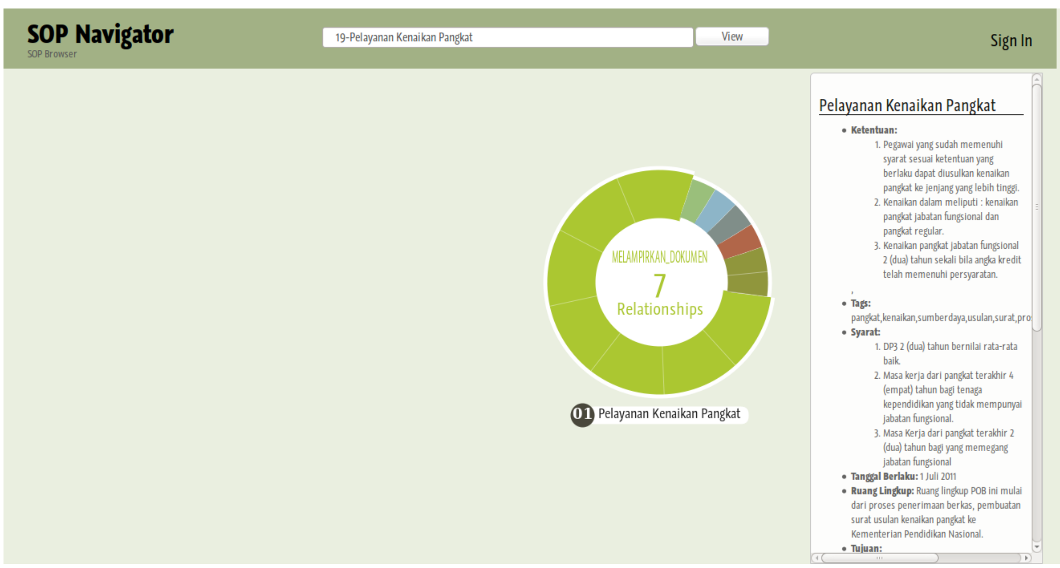

Figure 5. Displaying knowledge in the form of nodes and relation

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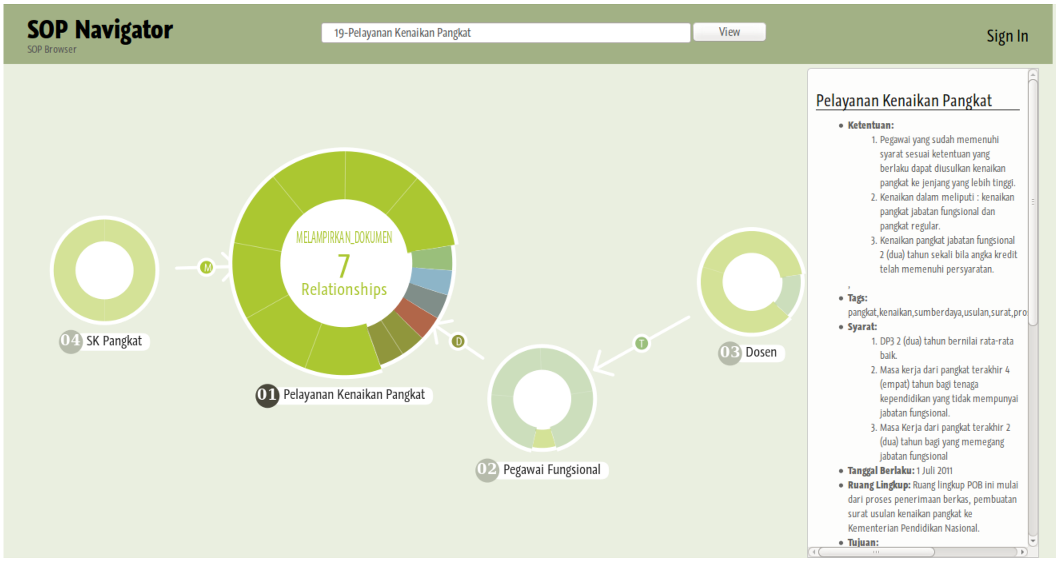

Figure 6. Knowledge navigation

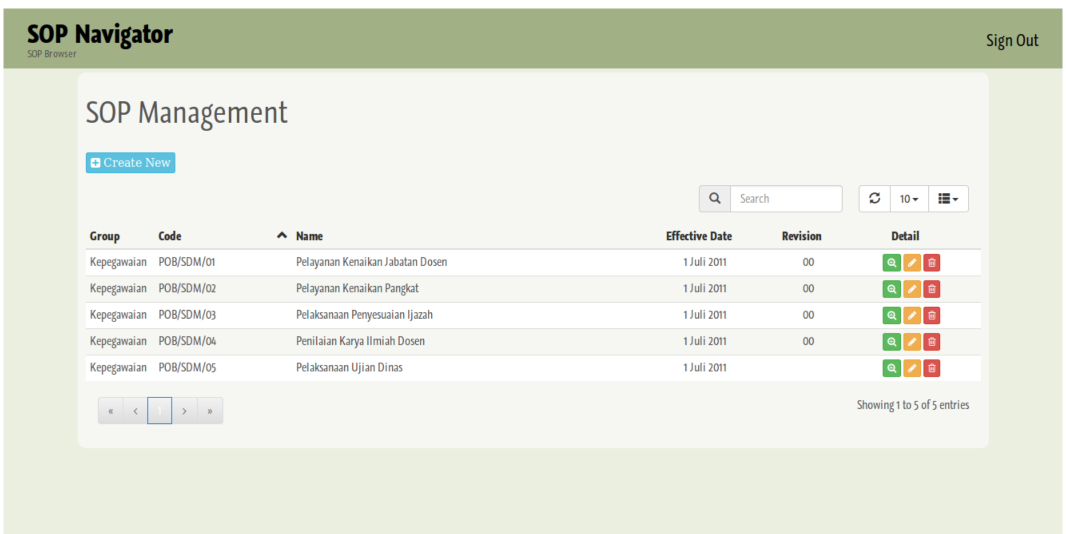

Figure 7. SOP data management

4. CONCLUSION

In this study, the relationship between knowledge is conceptualized using ontology. Semantic network is used to describe their association. Codification result performed on SOP documents produced seven classes, namely SOP, fields, regulation, user, required documents, official position, and division. The prototype of the knowledge management system developed using the Ruby programming language, Sinatra web framework, and Neo4j graph database. The prototype of this knowledge management system called SOP Navigator. SOP Navigator features the SOP data search, display knowledge visually in the form of nodes and relationships, navigate between knowledge, and manage SOP data. The testing of SOP Navigator features has been performed using black box method.

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