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SIX SIGMA-BASED KNOWLEDGE MANAGEMENT AND ITS APPLICATION IN IT. SYSTEMS MANAGEMENT

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ABSTRACT

Nowadays, information has involved in all activities and fields. Several organizations have been constructing information technology systems to collect, organize, store, and communicate information in order to strengthen the competitiveness, improve the quality of products and services, and aim at a sustainable development. An IT system includes several computers, servers, and other hardware (network devices, printers, projectors…) that are connected together. Hence, it is imperative to keep your enterprise's server system up and running, and solutions for eliminating errors from IT systems are necessary.

Six Sigma is one of effective methodologies that can support to such solutions. DMAIC and FMEA are the problem-solving tools in Six Sigma system. Effectiveness of DMAIC and FMEA depend up solutions, innovations, or plans proposed by experts or members in a Six Sigma project. However, knowledge created by Six Sigma tools is difficult to access or reuse..

This research aims at building a new model to manage knowledge created by Six Sigma tools and to investigate applicability of the model in management of IT. Systems. We are going to propose an integrated model of Six Sigma DMAIC and Knowledge management to resolve the research problem. The proposed tools related to the model are going to be experimented and evaluated carefully, scientifically and throughout. The results of this research is going to reveal the costs and time effectiveness and applicability of the proposed solution. Evaluation is going to be conducted completely based on literature, comparable analysis, experiments, and experts' opinion. Finally, the conclusion of the thesis is going to reveal scientific contributions and innovation of this research to the field of Quality Improvement and Information Technology.

Chapter 1. INTRODUCTION

1.1 The Problem Statement

Many solutions of integrating knowledge management and Six Sigma have been applying into many fields such as healthcare, automative, industry, textile… However, such solution to apply to IT systems management is not still found in literature or developed yet. Hence, a solution of Six Sigma-based knowledge management and its supporting tools that can apply into IT systems management are also a research problem of concern.

1.2 Research Objectives

This research includes several objectives that aim at proposing a solution of Six Sigma-based knowledge management and applying the model into IT systems management. The main objectives of this research include (1) designing a proposed model of knowledge management for Six Sigma DMAIC processes, (2) building a Knowledge Portal, (3) building a knowledge base of server breakdown/failure, (4) developing tools that support to the knowledge base.

1.3 Research Methodology

Qualitative and Quantitative methodology are important and common techniques applied in this research. Both of them use the large amount of the empirical data collected from research activities to compare features of the evidence they have gathered internally or with related evidence. Non-experimental and experimental research are also two main methods in research activities. Basing on the experimental research method, the researcher proposed an experimental design for collecting data to test the hypotheses.

1.4 Limitations of research

This research does not cover all of related models. The proposed tools are developed for a particular process only. Ontologies and tools are developed based on some available and free tools and languages. The reality impact of the proposed model for Six Sigma projects is limited, is should be validated in reality

1.5 The Thesis's Structure

Chapter 1: Introduction, Chapter 2: Related Works, Chapter 3: Six Sigma-based Knowledge Management, Chapter 4: KPD – A Six Sigma Knowledge Portal, Chapter 5: Six Sigma-based Server Failure Management, Chapter 6: Experiments Results and Evaluation, and Chapter 7: Conclusion, Contribution, and Figure Works.

Chapter 2. RELATED WORKS

2.1 Six Sigma, DMAIC, and FMEA

Six Sigma is a quality improvement methodology developed by Motorola in 1980s. Six Sigma uses a five-step breakthrough strategy proposed by (Sung H. Park, 2003) to define, measure, analyze, improve and control (DMAIC) defects of existing products, processes, or services which are defined as anything that causes dissatisfaction of customer (Revere & Black, 2003). It also ultilizes Failure Mode and Effects Analysis method to evaluate possible errors of processes or products and their effects and determine recommended actions that reduce the possible errors.

2.2 Knowledge Management and Ontology

Oxford Dictionaries defines knowledge as “facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject” or “awareness or familiarity gained by experience of a fact or situation”.

Knowledge can be represented by one of the popular approaces in which *Ontology-based approach* allow representing both tacit and explicit knowledge in hierarchical structure.

Ontology represent knowledge based on concepts, relationships of the concepts, properties, rules, restricts, and constraints.Knowledge can be transferred, stored, and retrieved via a Knowledge Portal.

Knowledge Portal also supports a process of knowledge management which is "the process of applying a systematic approach to the capture, structure, management, and dissemination of knowledge through an organization in order to work faster, reuse best practices, and reduce costly rework from project to project" (Dalkir, 2005), (Nonaka & Takeuchi, 1995).

2.3 Integrating Knowledge Management With Six Sigma

Several integrated models of KM and Six Sigma have been proposed such as a process model of knowledge creation opportunities, IKR model, DMAIC-KM model, and SECI/SIPOC Continuous Loop model. One trait that is common both KM and Six Sigma is to create valuable knowledge in the process of management. Recently, using Ontology to manage knowledge created by problem solving tools of Six Sigma is considered as an emerging approach.

2.4 IT. Systems management and Server Failure

In organizations, IT systems are known as computer systems constructed to organize, store, and provide information and information service to organizational activities such as Email system, Web system, Application system, Database system or Data Center… IT systems management is "*the activity of identifying and integrating various products and processes in order to provide a stable and responsive IT environment*" (Schiesser, 2010). The main objective of IT systems management is to bring stability and responsiveness to IT systems in 24 hours per day, 7 days per week. IT systems management aims at enhancing availability of whole system and ensures that IT systems are always ready to overcome a big amount of challenges and problems coming from several components of the systems.

Server failure impacts negatively on server availability and therefore results in outage or breakdown of server applications and services, degrading user experience and eventually causing lost revenue for businesses (Manish, Mishra, & Fetzer, 2008).

Chapter 3. SIX SIGAM-BASED KNOWLEDGE MANAGEMENT

3.1 Proposed model architecture

The proposed model (Ontology-based Knowledge Management process for DMAIC - OKMD) (Figure 3-1) is an integrated conceptual model that combines activities of DMAIC process, knowledge management and ontology engineering. The ultimate goal of OKMD model is to facilitate the knowledge management process for DMAIC deployment. Knowledge created during DMAIC execution is accumulated into a knowledge base by

Ontology techniques, and then is distributed to knowledge workers through a Knowledge Portal. Thereby, available knowledge resource from DMAIC improvement process will be preserved and reused sustainably. The activities of a knowledge management procedure (Figure 3-2) comprising Knowledge Creation/Acquisition, Knowledge Structure & Storage, Knowledge Protection, and Knowledge Application (Gold, Albert, & Arvind, 2001) are executed continuously within each of five DMAIC steps consisting of Define, Measure, Analysis, Improve, and Control.

3.2 Activities of OKMD model

3.2.1 K-Creation/Acquisition

The activities of K-Creation/Acquisition stage (arrow path 1 in Figure 3-3) is to obtain new knowledge (Gold, Albert, & Arvind, 2001). The stage should be started at the Gate review section of every DMAIC step where members of project team such as Black Belt, Green Belt, domain experts discuss and review problem-solving solutions or improvement plans basing on reports and documents created. The support of Knowledge Portal allows them to submit or upload their reports, documents, writings, and relevant files to Knowledge Portal.

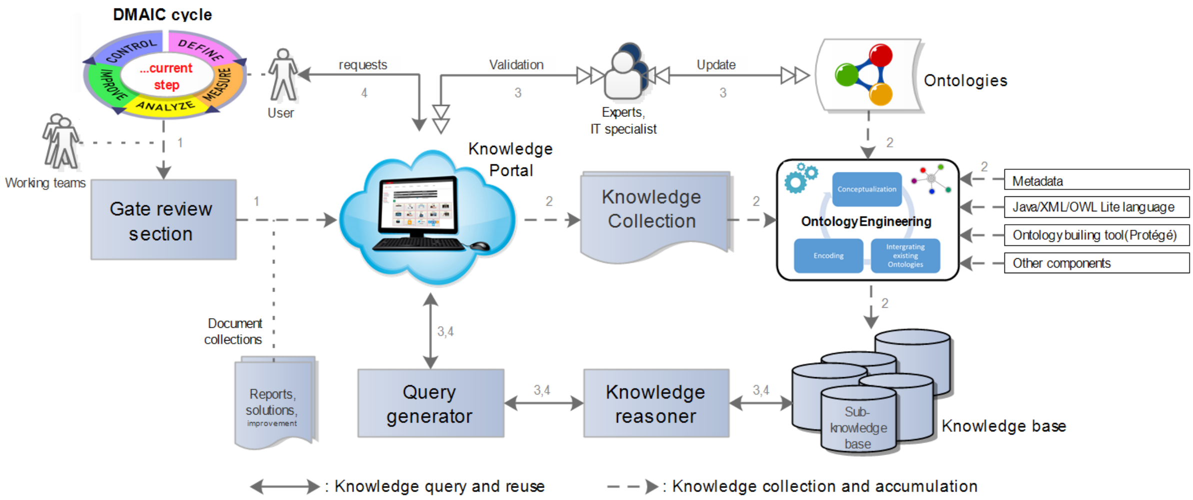


Figure 3-3. KM activities in OKMD model

3.2.2 K-Structure & Storage

K-Structure & Storage (arrow path 2) aims at cumulating new knowledge into sub-knowledge bases based on Ontology Engineering.

3.2.3 K-Protection

K-Protection (arrow path 3) is to prevent illegal or inappropriate behaviors of web users who are querying knowledge available on Knowledge Portal.

3.2.4 K-Application

K-Application (arrow path 4) is necessary to share and reuse created knowledge.

3.3 The proposed tools to support activities of knowledge management

In order for OKMD model to be implemeted and applicable effectively, many tools that support to its activities are proposed that presented in Table 3-1. Generally, the support tools are adapted from Six Sigma guideline, (ISO13053-1, 2011), interview, word processing softwares, Ontology building tools, programing languagues, and functionalities of Knowledge Portal comprising forums, chat rooms, modules for uploading and downloading files, search engine, email, user account, database, and inference/reason engine.

Chapter 4. KPD – A SIX SIGMA KNOWLEDGE PORTAL

4.1 A Proposed Knowledge Portal for DMAIC processes

4.1.1 The knowledge portal architecture

Interface layer that provides web-based interfaces to its users, presents content of KPD, and supports user login/authorization.

Service layer that provides essential functionalities for content and knowledge management described in Figure 4-2. Basing literature review, functionalities of KPD are grouped into five groups:

Content Management: A group of functionalities for managing and broadcasting organizational information, resources, and links to its customers and employees.

Knowledge Exchange: Functionalities for activities of knowledge exchange involving communication and learning, i.e. chat or discussion, organizing online courses and presentation. It also is a place for collecting reports created by Six Sigma tools.

Knowledge Dissemination. A group of functionalities that enables to share and retrieve DMAIC knowledge available and DMAIC reports for the reuse or evaluation purposes.

Supporting Document: Functionalities to search guidance, documents, and materials of IT.

Administration. The functionalities for administrators and IT specialists. They are divided into three sub-groups: User, System, and Configuration Management to create and control the security policies of various types of user, to support activities of system management for servers, databases, and SPARQL endpoint, and to create as well as customize flexibly modules and interface of Web sites by itself.

Data layer is built as a database in order to store organizational knowledge. In this layer all documents, multimedia files, data of courses, and reports are stored. It is also connected to knowledge bases in which knowledge is created from DMAIC reports and represented by Ontologies and provides query services based on MySQL and SPARQL.

4.1.2 Ontology-based knowledge representation

Simply, a DMAIC report is structured into columns, rows, and values of a table. The table is then translated into a sub-network or a branch of Ontology graph. Each row name of the table is translated into an instance name. Each column name can be translated into either a class name or a name of Data-type property. A value (a cell in the table) is mapped to a value of a Data-type property. Each property describes a relation from a class to a class or from a class to a value.

4.1.3 Knowledge Reasoner module

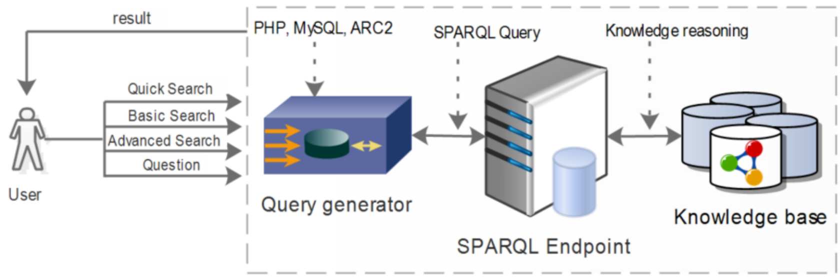


Figure 4-5. (a) Architecture of K-Reasoner module.

In order to search and infer DMAIC knowledge, a Knowledge Reasoner (K-Reasoner) module is developed. It enables to get and analyze query requirements, to connect to Ontologies through SPARQL endpoint, to generate and perform SPARQL queries, and to present query results found based various types of search such as Quick Search, Basic Search, Advanced Search, and Question-based Search (Figure 4-5.a).

Chapter 5. SIX SIGMA-BASED IT SYSTEMS MANAGEMENT

5.1 A Proposed System Model

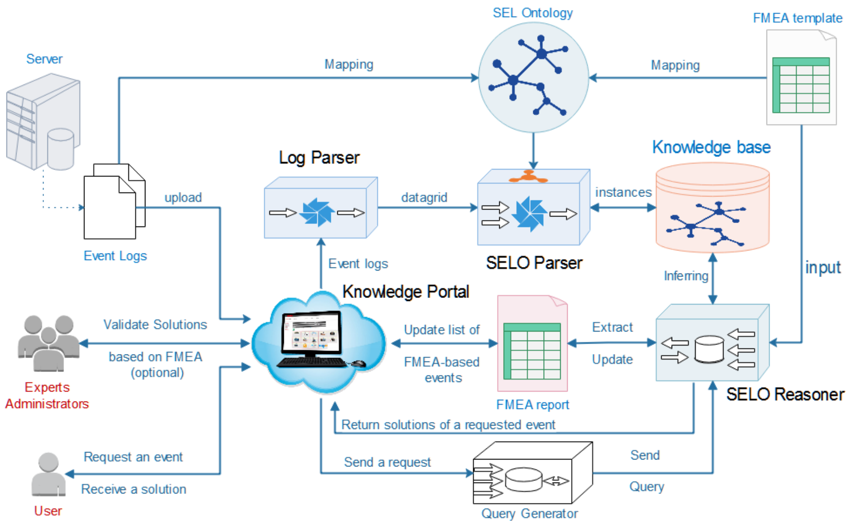


Figure 5-1. SELO Model

The proposed solution (i.e. SELO) is a combination of FMEA methodology, techniques of log mining and Ontology building. It may be illustrated based on a system model like Figure 5-1, and designed to enrich a knowledge base in which knowledge of server events and their solutions is acquired. SELO model introduces a process to transfers knowledge from event logs to a knowledge base. Specially, event logs collected from a server are first decoded to convert to the text-based format a data table by a *Log Parser*. Output data collected from the Log Parser is then used to populate instances of SEL ontology using *SELO Parser*. SEL ontology and its instances form a knowledge base that enables to share and reuse among individuals and computers. *SELO Reasoner* should be used to extract the knowledge from the knowledge base to FMEA reports and to support experts as well as administrators to insert or update the solutions of the failure events. The solutions can be either identified based on deploying FMEA methodology or the available solutions that have overcome the failure events. Furthermore, SELO Reasoner is responsible for updating the knowledge base with taken solutions or actions. Finally, a user who accesses the knowledge base can send requests to SELO Reasoner to look for solutions for some event. In this case, SELO Reasoner should return a FMEA-based report that includes information of relevant events and solutions, and the schema of SEL ontology that facilitates learning of SELO knowledge. Besides, it also allows a user to create and send SPARQL queries, and to display reports formatted based on structure of other DMAIC tools such as FMEA or Pareto chart.

5.2 SELO – FMEA-based Ontology for SEL

5.2.1 SELO Development Procedure

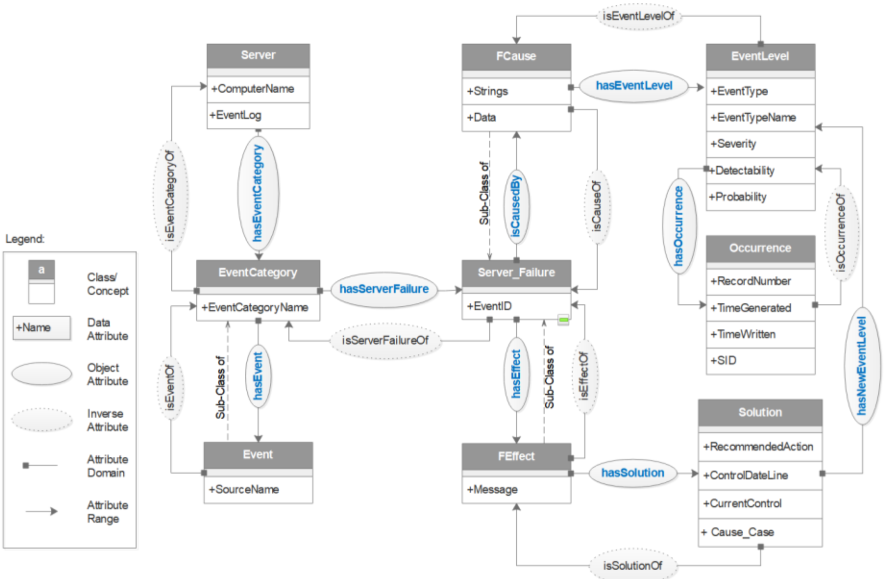


Figure 5-19. UML-based schema for SELO representation

Sever Event Log Ontology (SELO) is a schema to represent semantically and systematically concepts and relationships of the concepts involved in server events and solutions for the server events. It is designed based on the structure of event logs (EVT format) and FEMA report. The fields of the event log and the header of FMEA report are mapped to the main components of SELO consisting of classes and properties. The relationships between the EVT fields as well as between main components of MFEA are used to define the relationships and restrictions of SELO's classes and properties (Figure 5-18, Figure 5-19).

5.3 SELO Parser - Automatic Ontology Population from an Event Log

General Algorithm: Populating all instances from an EVT Log

$\boldsymbol{foreach}\ event\ e_i \in event \log L\ do$

$\quad \boldsymbol{foreach}\ column\ c_j \in event\ e_i$ do

$\quad\quad \boldsymbol{if}\ \exists c_j\ coresponding\ to\ C_k \in class\_list\ C\ \boldsymbol{then}$

$\quad\quad\quad \boldsymbol{if}\ number\_member\_of(C_k) = 0\ \boldsymbol{then}$

$\quad\quad\quad\quad create\ a\ new\ instance\ i_k\ of\ class\ C_k\ and\ update\ its\ attributes;$

$\quad\quad\quad\quad C_k.new_{instance} = true;$

$\quad\quad\quad \boldsymbol{else\ if}\ \left(e_i[c_j] \neq e_{(i-1)}[c_j]\right)\ or\ (attribute\_domain(C_k).new_{instance} = true)\ \boldsymbol{then}$

$\quad\quad\quad\quad save\ the\ current\ instance\ of\ class\ C_k;$

$\quad\quad\quad\quad create\ a\ new\ instance\ i_k\ \ of\ class\ C_k\ and\ update\ its\ attributes;$

$\quad\quad\quad C_k.new_{instance} = true;$

$\quad\quad \boldsymbol{else}\ C_k.new_{instance} = false;$

$\quad\quad\quad \boldsymbol{endif}$

$\quad\quad \boldsymbol{endif}$

On the basis of the proposed requirements, SELO Parser is developed to generate automatically instances of SELO from a server event log. We propose an algorithm for the Parser. In the proposed algorithm, it assumes that SELO includes a list of class names C_k, an event log comprises a list of event e_i, and a list of fields with the column/field names c_j. Since C_k is the name of a k^{th} class, and $c_k.new_{instance}$ is used when a new instance is created for the class c_k. The algorithm is described as the above

5.4 SELO Reasoner – Knowledge Inference and Reports Generation

In order to query and infer SELO knowledge, we proposed an inference engine called SELO Reasoner whose architecture is similar to our previous work for KPD. It is written in PHP language and SPARQL. Its algorithm consists of functions that enable to get and analyse query requirements, to connect to Ontologies through SPARQL endpoint, to generate and perform SPARQL queries, and to present query results found (Figure 5-21).

Chapter 6. EXPERIMENTS, RESULTS AND EVALUATION

6.1 Sustainability of OKMD model

Sustainable aspects of DMAIC process in OKMD model are discussed through criteria presented by (Harris, 2000), (Brundtland, 1987) and seven sustainable measures presented by the authors in (Mahesh, Henrietta, Laszlo, & Jozsef, 2008) (Ansari, Holland, & Fathi, 2010). The essential goals of sustainability are economic growth, environmental conservation, and social equity (Aparna & Keren, 2007). Moreover, sustainability of Six Sigma DMAIC process can be improved based on the KM process in OKMD model and seven sustainable measures (Nguyen & Kifor, 2015).

6.2 Knowledge Portal for DMAIC

Figure 6-2. Homepage of KPD

In order to validate the proposed model, a KPD has built based on the proposed steps of implementation (Figure 6-2). It provides funtions to collect data and knowledge from Six Sigma tools, and to retrieve knowledge from a knowledge base based on K-Reasoner tool (Figure 6-3).

6.3 Performance and Accuracy of SELO Tools

6.3.1 Experimental Parameters

To illustrate the proposed solution, we have built the all proposed components/modules of SELO model including SEL Ontology, SELO Parser, and SELO Reasoner based on the description presented in Chapter 3 of this thesis.

Table 6-1. The collected server event logs

No.	EVT log	EVT's Size	No. of Events (log messages)	Severities	Types of Event
1	Application.evtx	20.55 MB	6,627	3	7

2	Security.evtx	9.284 MB	13,097	2	17
3	System.evtx	20.55 MB	42,961	3	52
4	Web Server.evtx	1.092 MB	376	2	4

In our experiments, data is collected from a Web server that was running Windows Server 2008 at a university. Data includes various types of event log comprising Web Server.evtx, Security.evtx, Application.evtx, and System.evtx (Table 6-1). Each contains a number of log messages (or logged events), and is used to generate instances of SELO. In the event logs, the numbers of log messages, severity levels, and types of event are different. They are used to experiment performance and accuracy of SELO components.

The experiments are fulfilled on a machine with 2.8-GHz Intel Core i7-4558U CPU, 8GB RAM Memory, SSD Dual 2x128GB HDD, and Microsoft Windows 10 Professional OS 64bit. All parameters are averaged after five times of experimental run. We also have constructed SPARQL endpoints based on PHP, MySQL, and ARC2 package as well as Jena Fuseki to evaluate performance of the designed components.

6.3.2 Results and Evaluation

a. Performance

Table 6-3. SELO's sizes and the parsing execution time

No.	EVT log	EVT's Size	No. of Events	SELO's size	No. of generated instances	The average time of parsing	
						Log Parser 2.2	SELO Parser
1	Application	20.55 MB	6,627	8.390 MB	23,470	<<1	**0.44**
2	Security	9.284 MB	13,097	8.994 MB	26,227	<<1	**0.48**
3	System	20.55 MB	42,961	34.14 MB	97,836	<<1	**1.78**
4	Web Server	1.092 MB	376	383 KB	1,059	<<1	**0.04**

Figure 6-26. The parsing execution time of each event log

The Table 6-3 show the parsing execution time of every event log and the size of every SELO generated by SELO Parser. The average time of running parser varies from a low of 0.04 seconds for Web Server log to a high of 1.78 seconds for System log. SELO Parser can parse over 97,800 log messages within 1.78 seconds. The log files with the bigger number of log messages of event tend to be parsed for longer than the log files with the smaller number of log messages of event.

The experiments are conducted on both SPARQL endpoints, MySQL+ACR2 and Jena Fuseki. The experimental results are described as Figure 6-28. The bar chart illustrates the average time of query execution on six groups of events namely, all events, information event, warning event, error event, success audit event, and failure audit event in four event logs. Overall, the query execution time consumed by Jena Fuseki exceed upwards the time consumed by MySQL+ARC2 on all event logs excepted to Web Server log.

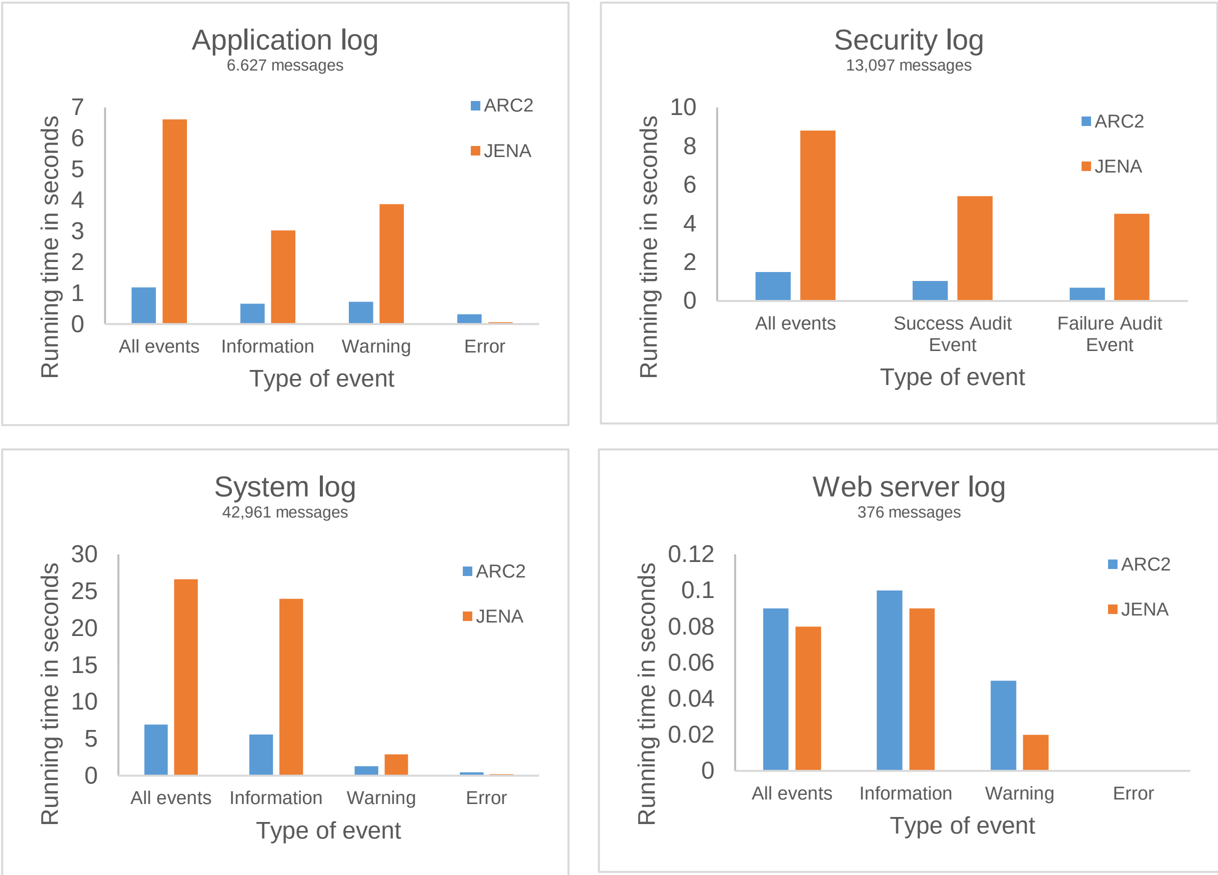
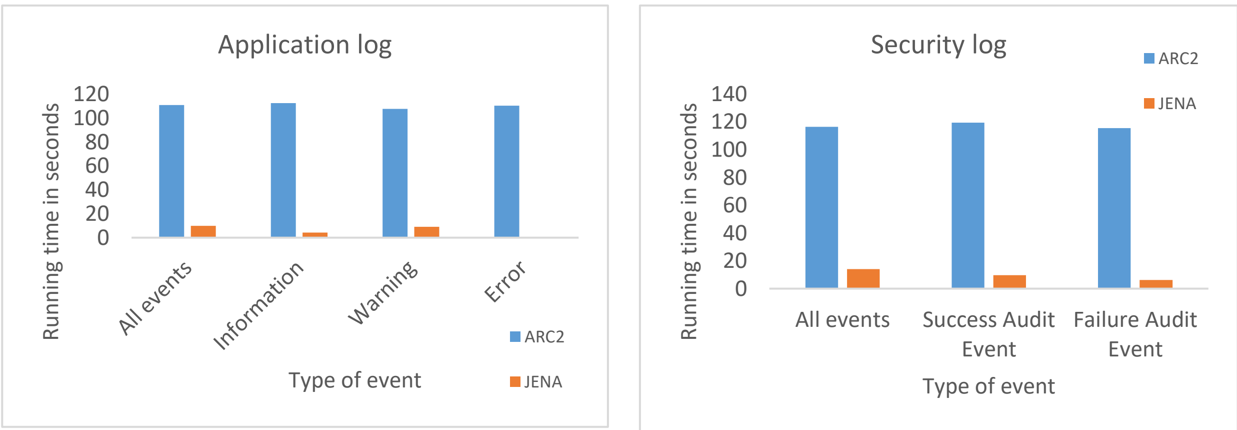


Figure 6-28. The query execution time run on ARC2 and Jena Fuseki by types of event

However, a contrary figure is found when we measure the FMEA report creation time on both the SPARQL endpoints (Figure 6-29). In general, the time to create a FMEA report on Jena is several times faster than the time on MySQL+ARC2.



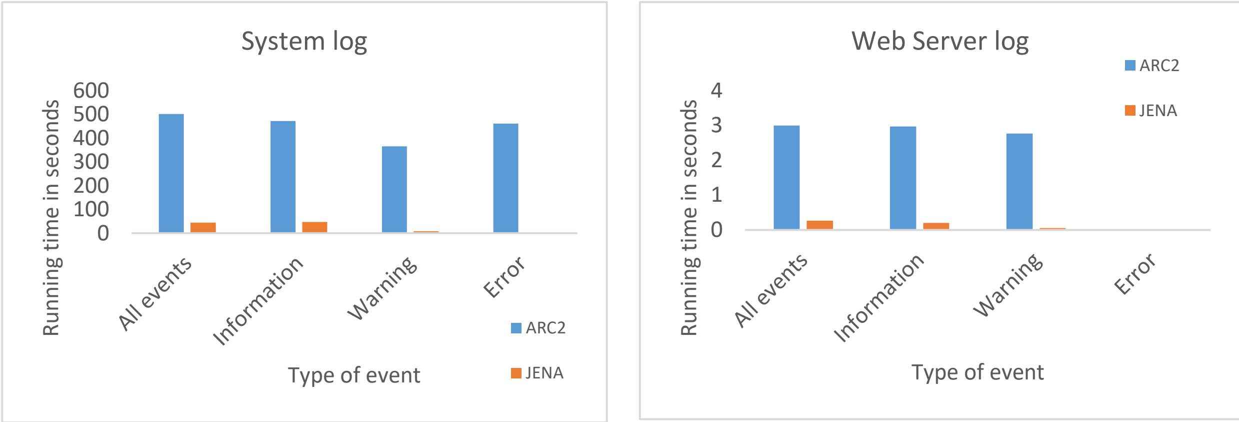


Figure 6-29. The FMEA creation time run on ARC2 and Jena Fuseki

In the next situation, we compare the running time to infer knowledge of SELO to the running time to infer knowledge of a FMEA-based ontology (FO) proposed by the authors in (Rehman & Claudiu, 2016) in order to evaluate the performance of our solution against their solution.

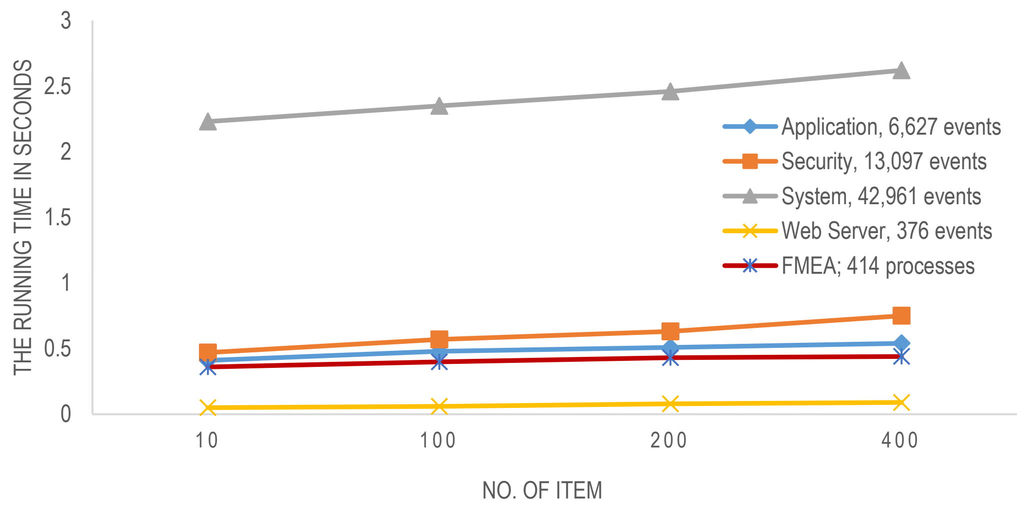


Figure 6-30. The query running time on the number of different events

In general, SELO needs more time to query than FO in most of event logs excepted to Web Server log. However, the numbers of items (events) in our data sets are much bigger than that (processes) in FO's data set. Hence, the average time to retrieve items for our solution much better than FO approach (Figure 6-30).

In the last situation, we evaluate the parsing execution time of SELO Reasoner on all event logs by varying the number of log messages, and compare the experimental results to other similar Parsers. In (Pinjia, Jieming, Shilin, Jian, & Michael, 2016). We choosed 2 of 4 log parsing methods (LogSig and SLCT) and 3 of 5 event datasets (BGL, Zookeeper, and Proxifier) to compare to our solution. Figure 6-32 shows the average parsing execution time of LogSig, SLCT, and SELO on the different numbers of log messages, from the different numbers of log messages.

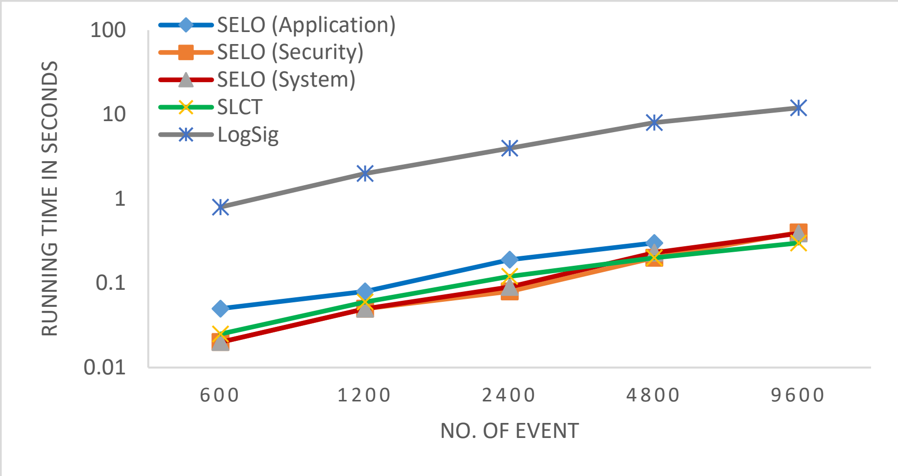


Figure 6-32. The parsing execution time of SELO, SLCT, and LogSig

The charts show an impressive performance of SLCT method in parsing event logs. It consumes a very short interval of time to parse 40,000 log messages in three log sets. Compared to SLCT, SELO Parser reveals a similar performance since our proposed Parser consumes 2 seconds in maximum to parse 40,000 log messages in three event logs. The parsing execution speed of SELO Parser may be a bit slower than SLCT method, but much faster than LogSig method. Moreover, in a range of 600 to 4,800 log messages, SELO Parser reveals a better performance than SLCT (Figure 6-32).

b. Accuracy

Accuracy is evaluated based on a comparison between the number of events found in experimental results and the number of events counted in Event Viewer. The experimental results represent an absolute accuracy (100%) of SELO model in parsing and querying log messages to / from knowledge base of SELO. The experiemt results also show that the proposed Parser archive a high accuracy compared to the similar approaches.

6.4 SELO Knowledge Base

6.4.1 Validate SELO based OntoQA technique

In order evaluate and validate an ontology, we used OntoQA technique proposed by the authors in (Tartir, Arpinar, & Sheth, 2010). The techniqua used a set of characteristics measuring different aspects of an ontology and the knowledge base built by the ontology.

- ***Evaluation of SELO schema***

SELO schema is evaluated based on its the richness, width, depth, and inheritance.

- Relationship Richness

$$RR_{SELO} = \frac{|P|}{|H| + |P|} = \frac{|6|}{|3| + |6|} = 0.67$$

- Attribute Richness

$$AR_{SELO} = \frac{|att|}{|C|} = \frac{36}{9} = 4$$

- ***Evaluation of SELO knowledge involved.***
  - Class Richness

$$CR_{SELO} = \frac{|C'|}{|C|} = \frac{|8|}{|9|} = 0.89$$

  - Class Connectivity

$$CCon_{SELO}(C_i) = |NIREL(C_i)|$$

  - Class Importance

$$CI_{SELO} = \frac{|Inst(C_i)|}{KB(CI)|}$$

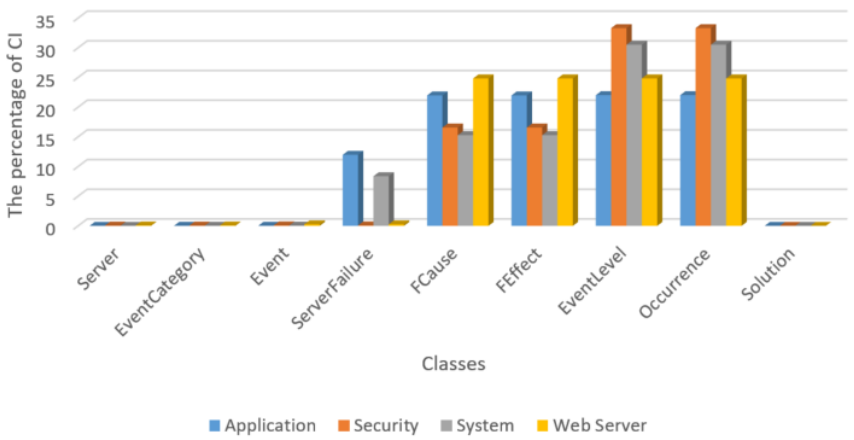


Figure 6-35. The importance of classes in SELO

- Relationship Richness

For SELO, this measure is **8 / 9 * 100% = 89%.**

6.4.2 Based on the Similar Approaches

SELO reveals some outstanding aspects that are not found in other approaches. First, SELO supports knowledge management of server events. Its approach is to rely on FMEA methodology that allows creating FMEA reports to support to the system administrators in determining feasible solutions for error events. Based on Ontology, SELO illustrates excellently knowledge of server events for computer users. This may help them to not only learn quickly the knowledge of event logs but also construct their own knowledge bases for the purpose of share and reuse. Second, SELO provides several tools supporting Ontology development and knowledge inference. Third, an approach to populate automatically instances of SELO without human intervention is proposed. Although a similar approaches is found in (Rehman & Claudiu, 2016), their approach aims at only preserving knowledge created during FMEA deployment. SELO facilitates operations to its users and provides a procedure of ontology development based on the popular methods of ontology development such as METHODOLOGY and 101 method.

6.5 An Evaluation of OKMD model Based on Experts' Opinion

6.5.1 The Survey's Parameters

The survey questionnaire is sent to 49 participants who have knowledge in the fields of Six Sigma, quality improvement or engineering, and IT in 5 weeks. The age of participants is between 24 years of age and 47 years of age. They are the experts (49% of respondents), professors (12%), Ph.Ds. (18%), and Ph.D. candidates and students (20%). 63% of respondents belongs to the ones who are working in the fields of Six Sigma or engineering (quality improvement) while the rests work in the IT. In Romania, 37 respondents are collected from 24 experts, 04 professors, 01 Ph.D., and 08 Ph.D. candidates and student. In Vietnam, 12 respondents come from 02 professor, 03 doctors, and 07 Ph.D. candidates.

6.5.2 The Results and Discussion

a. Evaluation based on sustainable criteria of KM, quality attributes and successful aspects of Six Sigma projects

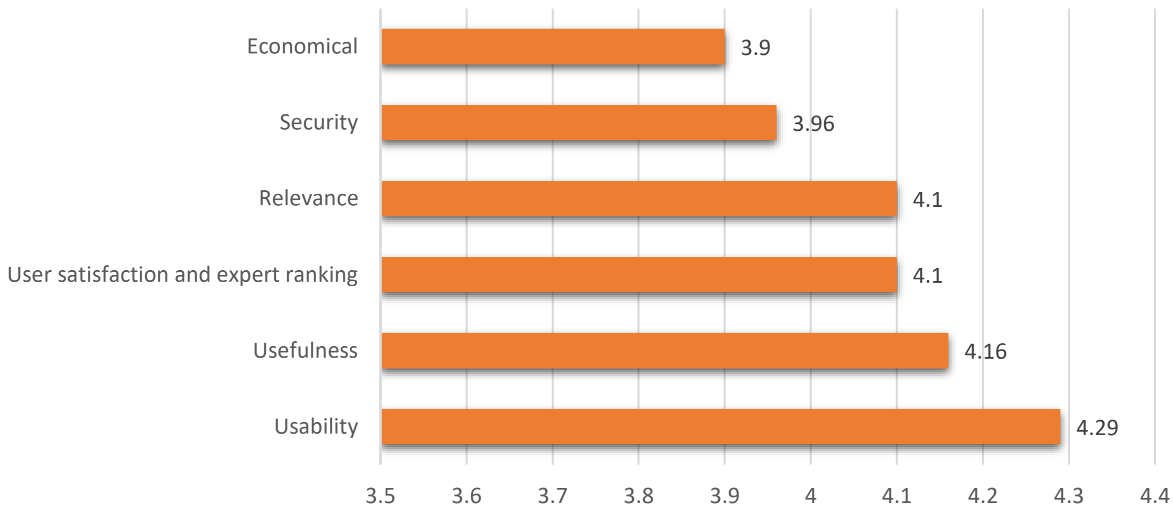


Figure 6-36. Evaluation of the quality attributes for KPD and OKMD

In order to rate the quality parameters of KPD, a table of ranking and rating (Subramanian & Geetha, 2012) is applied (Table 6-17). Based on the table, the higher the total score of KPD quality parameters, the better the usability of KPD. The Figure 6-36 represents the overall summary weightage for the quality attributes/parameters. On the basis of the ranking and rating table (Table 6-17) and the parameters, it is clear that KPD is an extremely usable model that can be applied effectively in DMAIC deployment, with the overall evaluation score of 4.2 (Table 6-16) though the aspects of economy and Security should be improved from the lowest scores (3.9 and 3.96 respectively).

b. Evaluation based on expert's opinion

On the basis of survey results, expert's opinion is analysed to validate the proposed model on the basis of sucessful aspects of Six Sigma, sustainable criterial of knowledge management, and usefulness of the proposed knowledge portal.

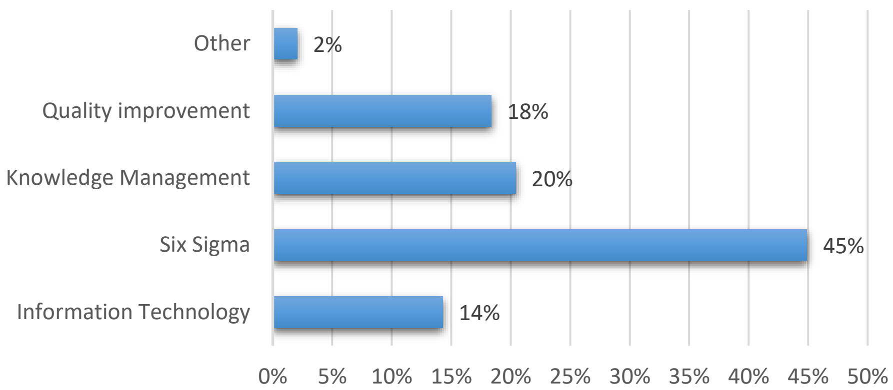


Figure 6-37 Areas and experience of survey participants.

On the bases of the working or researching fields and the number of experience year, we asked the respondents' opinion on effectiveness of the KPD model, which is a concretization of OKMD model, in different aspects.

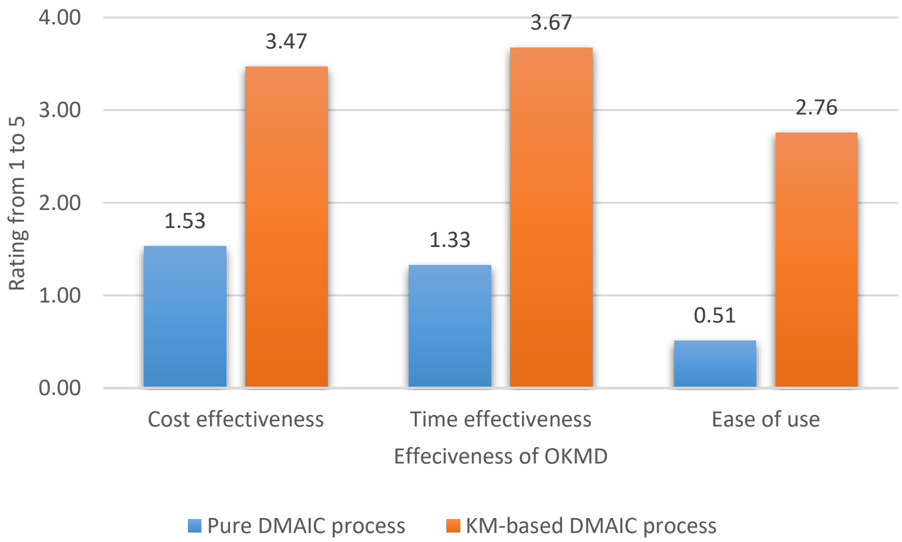


Figure 6-39. Cost, Time, and Use Ease Effectiveness based on survey results

The survey result is revealed in Figure 6-39. The first outstanding feature found easily is that the proposed model will enhace the use, time and costs effectiveness of DMAIC processes. Most of respondents agree that the model can mitigate the deployment costs and time of DMAIC processes, and it is easy to apply into Six Sigma projects, with the ratings 3.47, 3.67, and 2.76 respectively.

The approbation of the participants are also illustrated in the different aspects in the survey. Over 86% of respondents seconded that Six Sigma-based knowledge management will support employees and experts in quickly accessing the available knowledge resource. Althogh the rest of respondents were not sure if the model can support that or not (under 14%), they did not refuse it (Figure 6-40). Therefore, over 84% of respondents found agreed that the improvement skill of new employees will be enhanced relying on knowledge created by the past DMAIC processes (Figure 6-41). Also, lots of participants wapproved that SSKM will improve quality of Six Sigma project on the basis of available knowledge (Figure 6-43) and contribute knowledge to innovation and solutions of improvement Figure 6-44with just over 80% and 88% respectively though onlye 4% of respondents completely disagree this point of view.

Finally, an evaluation on the level of understanding the proposed model was conducted. Those who gained a good understand of KPD taken account the highest percentage of respondents (37%). With a very good understanding of KPD, 10% of resondents was found in the survey results. The rest of responses are divided into the remaining groups of respondents with 31% (Basic understanding) and 22% (Average understanding) respectively.

Chapter 7. CONCLUSION, CONTRUBITION, AND FUTURE WORKS

7.1 Research findings

This research uncover several findings related to the proposed model and tools including Six Sigma theory, Six Sigma tools, Six Sigma-based reports, processes of knowledge management, and integrated models of Six Sigma’s tools and knowledge management proposed in recent years. Another finding to note is that tools such Parser and Reasoner are indispensable ones to support knowledge management in order to construct a knowledge base as well as retrieve knowledge from the knowledge base.

Ontology-based knowledge representation is an effective method to apply into Six Sigma-based knowledge management.

IT system is considered as a heart of organizational activities. The breakdowns or outages of the system result in loss of repaired costs and efforts, and great damage in an organization. In order to enhance availability of an IT system, the important components of the system including servers should be always stable and ready to respond all requests from

IT system. A knowledge base of server failures provides them with valuable knowledge, access and sharing, and help them to improve their capacity of preventing, detecting, resolving, and eliminating server problems on IT systems.

7.2 Research Contributions

This research is conducted at “Lucian Blaga” university of Sibiu, Sibiu, some companies in Sibiu, Romania, and Quy Nhon university, Viet Nam. The theoritical research was conducted in “Lucian Blaga” university of Sibiu while data collection was fulfilled at Quy Nhon university in Viet Nam. The results presented in this thesis are the outcome of the three years of research and include contributions on theory, practice, and science.

7.2.1 Theoretical Contribution

- The procedures of KM and their activities have been investigated in order to determine suitable elements for applying into the field of Six Sigma and IT sector.
- A model of Six Sigma-based knowledge management has been proposed to accumulate and share knowledge created by DMAIC processes.
- A model of Six Sigma-based server knowledge management has been proposed to enhance IT systems management.
- An analysis of Parsers and Reasoners has been conducted, and therefore support to developing knowledge bases from server event logs.
- The algorithms for a Parser used to automatically generate instances of an ontology from an event log of Windows server.

7.2.2 Practical Contributions

- A Knowledge Portal (i.e. KPD) to support models of Six Sigma-based knowledge management.
- An ontology of server events built in Protégé with classes, properties and constraints of properties in order to achieve a consistency of knowledge.
- A Log Parser (i.e. SELO Parser) written by PHP language and integrated with KPD to support to automatically convert all Windows OS-installed server event logs (EVT or EVTX formats) to the knowledge base SELO.
- A inference module (i.e SELO Reasoner) written in PHP language and used to retrieve knowledge from the knowledge base SELO.
- A questionnaire-based survey has been conducted. Therby, they survey help the participants to improve their knowledge of a model of Six Sigma-based knowledge management and tools that can be applied into Six Sigma projects.

7.2.3 Scientific Contributions

From the research results of this thesis, we have contributed some international publications including 3 (three) international journal articles (one published, two under review) and 6 (five) international conference papers (one under review). The contents of most of papers and journal articles are included in this thesis.

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