TÉCNICO LISBOA

Mapping Enterprise Governance of IT Models using Text Analyses

Paloma Andrade Gonçalves

Thesis to obtain the Master of Science Degree in

Information Systems and Computer Engineering

Supervisor: Prof. Miguel Leitão Bignolas Mira da Silva

Examination Committee

Chairperson: Prof. Luís Manuel Antunes Veiga
Supervisor: Prof. Miguel Leitão Bignolas Mira da Silva
Member of the Committee: Prof. Rúben Filipe de Sousa Pereira

October 2019

Acknowledgments

Firstly, I want to thank to my family, friends, and partner for all the support, patience and advice. Thanks for being there in difficult times, but also in the most fun ones. I am lucky to only be surrounded by amazing people.

I would like to acknowledge my advisor, professor Miguel Mira da Silva, for all his help throughout this dissertation.

I would also like to express my deepest gratitude to Rafael Almeida for all the availability, valuable guidance, expertise, and support.

Abstract

Enterprises are drawing upon the practical relevance of generally accepted good-practice models to implement Enterprise Governance of IT (EGIT). Despite the number of options for models available nowadays, when these models are used independently, they are not sufficiently wide-ranging to meet all the needs of an organization. No single model is sufficient to implement EGIT completely and efficiently. Therefore, organizations are concurrently implementing multiple models since most of these models only cover a specific aspect of Information Technology (IT).

The ability to analyze large amounts of text reduces the need for skilled human resources. Therefore, a text analysis becomes a natural solution to compares core concepts of Process Assessment Models (PAM)s of EGIT models. The main goal of this thesis is to propose an artifact that enables the auditors and other stakeholders in an organization to perform quantitative and automatic pre-assessment about the conformance of an organization's processes compared to EGIT models with efficient human resource utilization. A Design Science Research Methodology was used to conduct this work. The research proposal was demonstrated and applied to COBIT 5 PAM and TIPA for ITIL PAM core concepts to highlight their similarities. To evaluate how this research helps reduce the complexity of simultaneous assessments, surveys and interviews with field experts were performed. We identified some relevant findings with positive results regarding the objective established.

Keywords

Enterprise Governance of Information Technology, COBIT, ITIL, Natural Language Processing, COBIT 5 PAM, TIPA for ITIL

Resumo

As empresas estão a recorrer a relevantes modelos de boas práticas geralmente aceites para implementar a Governação Organizacional das Tecnologias de Informação (EGIT). Apesar das opções de modelos disponíveis atualmente, quando usados independente, eles não são suficientemente abrangentes para cumprir a todas as necessidades de uma organização. Nenhum modelo é suficiente para implementar EGIT de forma completa e eficiente. Portanto, as organizações estão a implementar simultaneamente vários modelos, uma vez que a maioria dos modelos englobam apenas um aspeto específico da TI.

A capacidade de analisar grandes quantidades de texto reduz a necessidade de especialistas. Portanto, uma análise de textual torna-se uma solução natural para comparar os conceitos principais das PAMs dos modelos de EGIT. Esta tese tem como principal objetivo propor um artefacto que permite auditores e outras partes interessadas numa organização a realizar uma pré-avaliação quantitativa e automática acerca da conformidade dos processos de uma organização comparada com modelos de EGIT utilizando recursos humanos de forma eficiente. Metodologia de Pesquisa em Ciência do Design foi usada para realizar este trabalho. A proposta da pesquisa foi demonstrada e aplicada aos principais conceitos dos modelos COBIT 5 PAM e TIPA for ITIL PAM de forma a destacar as suas semelhanças. Para avaliar como esta pesquisa pode ajudar a reduzir a complexidade de avaliações simultâneas, questionários e entrevistas com especialistas da área foram realizadas. Identificamos algumas conclusões relevantes com resultados positivos relativamente ao objetivo estabelecido.

Palavras Chave

Governação Organizacional das Tecnologias de Informação, COBIT, ITIL, Processamento da Língua Natural, COBIT 5 PAM, TIPA for ITIL

Contents

List of Figures

List of Tables

Acronyms

EGIT	Enterprise Governance of IT
IDF	Inverse Document Frequency
ISACA	Information Systems Audit and Control Association
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITSM	IT Service Management
NLP	Natural Language Processing
OGC	Office of Government Commerce
PAM	Process Assessment Models
PRM	Process Reference Model
TIPA	Tudor's IT Process Assessment
TF	Term Frequency
VSM	Vector Space Model

1

Introduction

Contents

Information Technology (IT) has become a success factor in achieving competitive advantage. It plays a crucial role in the sustainability and growth of organizations [5] [6]. Therefore, IT has become more than a commodity. Nowadays, IT is recognized as a strategic partner. It improves business by helping deliver faster and better products [7]. Given the importance and the advantages that come with IT, Enterprise Governance of IT (EGIT) started to receive more attention in order to ensure efficiency, decrease costs and increase control of IT infrastructures [8] [9].

In support of this, enterprises are drawing upon the practical relevance of generally accepted good-practice models, frameworks, best practices, and ISO standards [10]. Throughout this research, to unify these different terms, we only use the term “model or models”.

The lack of top management support, communication, compatibility with existing models, formalization, centralization, complexity of understanding, and the use of these models are some of the factors that influence the adoption of EGIT models [11] [12].

Every organization tries to deliver value from IT while managing an increasingly complex range of IT-related risks. The effective use of EGIT models can help organizations avoid reinventing their policies and procedures, optimize the use of IT resources and reduce the occurrence of major IT risks [13].

As a result, several questions arise when organizations decide to implement EGIT models. The increasing demand of industries force organizations to adopt multiple EGIT models. Thus, practitioners not only need to choose the appropriate models for their environment but also need to determine how to integrate them simultaneously [13] [14]. Each EGIT model has its own scope, definitions, and terminologies. This complicates the understanding of the overlap between different models [15]. Therefore, organizations struggle to assess and implement multi-models, leading to the research problem: there is no comprehensive approach to understand and identify the similarities between core process concepts of similar models. The goal is to provide a comprehensive approach that can help to perform a simultaneous assessment of different Process Assessment Models (PAM)s of EGIT models by identifying the similarities between process core concepts.

To achieve the goal of this research, it is proposed an approach that through text analysis techniques compares the similarities between the core concepts of the PAMs of EGIT models. Most of the data used in EGIT models is textual data. The ability to analyze large amounts of text becomes crucial to the success of an organization. Therefore, a text analysis becomes a natural solution to reduce the need for skilled human resources. [16] [17]. To demonstrate the use of the proposal, the proposed artifact was applied to two of the most common EGIT models Process Assessment Models – the Control Objectives for Information and Related Technologies (COBIT) PAM and Tudor’s IT Process Assessment (TIPA) for Information Technology Infrastructure Library (ITIL) PAM core concepts to highlight their overlap. This proposal is more scalable, flexible, and dynamic than manual efforts in aligning EGIT models.

To evaluate how this research helps reduce the complexity of simultaneous assessments two evaluations were performed: one with comparison with a specialists' mapping as a baseline, and another through surveys and interviews with field experts. We identified some relevant findings with positive results regarding the objective established.

To communicate the results to the scientific community, the results of this thesis were submitted and accepted in an international journal.

1.1 Research Methodology

The methodology chosen in this research was the Design Science Research Methodology (DSRM). DSRM is a method used in Information Systems due to its ability to produce incremental solutions.

DSRM is an interactive methodology that aims at creating IT artifacts intended to solve an identified organizational problem [18]. The artifact developed should be based on existing theories with organizational acceptance. These artifacts can be constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems) [18].

Figure 1.1 describes each of the design science research methodology phases in the context of this research.

DSRM is composed of six defined activities: Problem identification and motivation, Define the objectives for a solution, Design and development, Demonstration, Evaluation, and Communication. Next, we will briefly define in what consists each activity:

1. **Problem identification and motivation:** describe a specific research problem and explain the importance of a solution.

2. **Define the objectives for a solution:** define the objectives of the solution. The objectives should be rationally inferred from the problem definition and the knowledge of what is possible and feasible.

3. **Design and development:** create the research artifact. In this phase, the desired functionality and its architecture should be determined.

4. **Demonstration:** shows that one or more instances of the problem can be solved with the use of the artifact.

5. **Evaluation:** observe and measure the artifact performance in the context of the problem. This evaluation involves the comparison of the objectives of the solution defined earlier were achieved with this artifact.

6. **Communication:** communicate the problem and the importance of the artifact, its utility, its novelty, and its effectiveness to researchers and other relevant audiences such as practicing professionals, when appropriate.

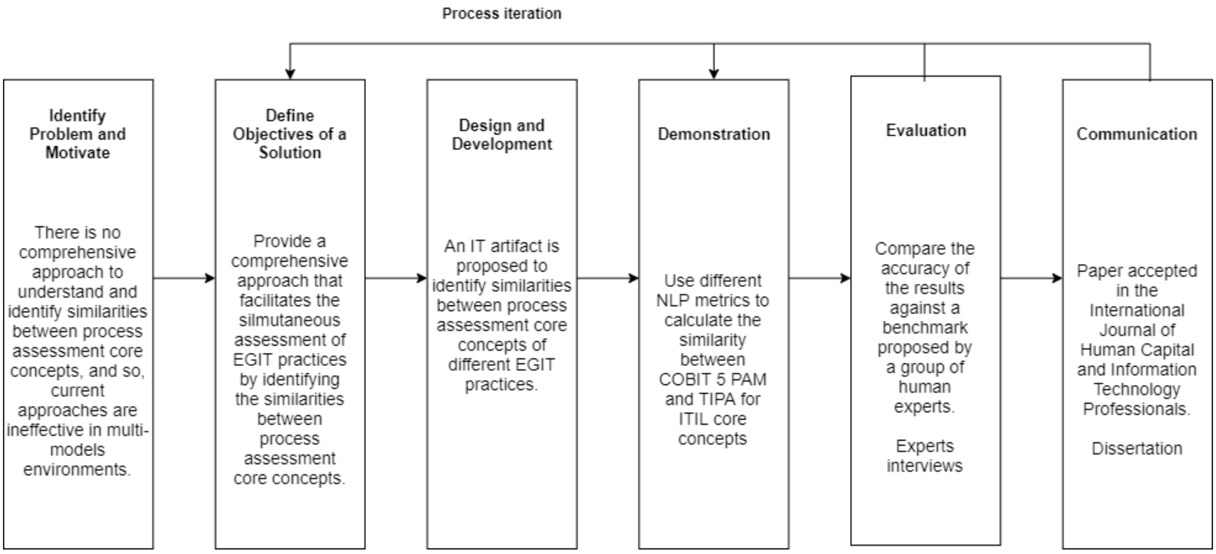


Figure 1.1: DSRM Process Model [1]

1.2 Outline

This thesis content agrees with the structure of DSRM. In Chapter 2 is presented the research problem. Chapter 3 presents some theoretical background like concepts and definitions needed to understand this research. In Chapter 4, there is an overview of the literature about the research area. The research proposal, as well as its objectives, are explained in Chapter 5. In Chapter 6 we present how the proposal was demonstrated and in Chapter 7 we explain how the proposed artifact was evaluated. Finally, Chapter 8 summarizes the main conclusions, limitations, and contributions of this research. It also points out some aspects that can be researched in future works.

2

Research Problem

This chapter defines the specific research problem and justification of the value of a solution, corresponding to the first step of DSRM: problem identification and motivation.

Enterprises are increasingly making tangible and intangible investments in their EGIT [10]. The number of EGIT models and their area of application have increased. Organizations can benefit from the various models since they can adopt models that best adapt to their needs [19] [20]. Many organizations value the implementation of EGIT models. Not only has the number of organizations that implement EGIT models grown, but also the number of organizations that are implementing several models simultaneously [21].

At least 315 EGIT models have been identified [22], and the number continues to increase. Most of these models only cover a specific aspect of IT, such as information security, service management, or project management. Organizations can benefit from this heterogeneity and variety of models [23] since it allows organizations to select which models better accommodate their needs [24]. Nevertheless, the independent adoption of these models may prevent organizations from fully asserting IT management and governance because each model has limitations in its application of a determined IT area [15]. This situation has led to certain problems in the use of EGIT models, e.g., ambiguity, instability, subjectivity, incompatibility, amongst others [25].

The implementation of any of these models requires specific experience, knowledge, and resources, along with a high degree of effort and investment [19], in order to be successful. This means that it is not an easy task, and there is a significant risk of failure [26]. Although compelling in theory, these models can be challenging to implement in practice. Not only because of an increase in the number of models, and a widening of the area of application [27], but also because each EGIT model defines its own characteristics: scope, structure of process entities, definitions, terminology quality systems and approach, among other things [28].

COBIT and ITIL are currently among the most valuable and popular EGIT models adopted and adapted by organizations [12] [29]. They intend to facilitate effective EGIT [11] by providing a set of best practices that are often implemented according to the organization's needs. COBIT seeks to provide a holistic approach to the alignment of IT with enterprise governance. It creates value and generates benefits with optimal risk and resources [3]. In turn, ITIL provides detailed guidance on the management of IT processes, functions, roles, and responsibilities related to IT Service Management (ITSM).

The choice of ITIL is justified by its supremacy over other IT service management models. This was the first model created for this purpose. Over the years, it consolidated as the de facto reference in this area. It covers the whole life cycle of IT services, namely: strategy, design, transition, operation, and continuous improvement.

As for COBIT, it has been, since the 1990s, the main reference in EGIT and management. This model is constantly evolving, always in tune with the most modern market and academic methodologies in this field. Its organization of domains, processes, and enablers allows a structured and systematic approach, which enhances EGIT and management in public and private sector organizations.

Practitioners view these models as complementary rather than competitive [30] hence organizations can evaluate and adopt a combination of models that is more relevant to their business [31]. COBIT can help define what should be done by the organization and ITIL can provide the how for service management aspects. Also, COBIT can be used at the highest level, providing an overall practice based on an IT process model that should generically suit every organization. Specific models such as ITIL cover discrete areas and can be mapped to the COBIT model, thus providing a hierarchy of guidance materials.

Organizations are forced to adopt multiple EGIT models due to the increasing demands of the different industries coupled with compliance requirements [13]. This situation has increased the complexity of implementing models. This is because organizations struggle to understand how to adopt several models simultaneously. They also struggle with how to integrate them since these EGIT models often overlap [15]. The complexity of an organization increases with the implementation of multiple models. Lack of guidelines governing processes and different terminologies across different models are some of the challenges in integrating them. Implementing multiple models is often associated with higher effort, time, and cost than a conventional single model approach [14] [13] [19].

Besides its complexity, many benefits that result from integrating multiple EGIT models. Integrating models enable features that would not be available through the use of individual models, leading to a more comprehensive and efficient approach [21] [15] [32].

One of the opportunities identified in integrating multiple models is to optimize costs in audits and assessments [33]. In a recent survey, it was found that 3 out of 4 organizations needing to comply with multiple regulations are struggling to meet audits each year with a large number of IT resources being spent specifically to demonstrate IT security compliance [34]. On average, more than one-third of IT resources are being spent on satisfying multiple regulatory compliance demands [34]. While organizations are compelled to work with multiple models to satisfy the different regulatory requirements, automating the compliance and governance process becomes a challenging semantic problem [34].

Interoperability between the models for heterogeneous compliance management is required [34]. It requires identifying similarities between process assessment's core concepts and then to manage how the implemented models are related to these core concepts. An ad-hoc approach is prone to inefficiencies that can jeopardize compliance objectives and cost-effective implementations of multiple models.

Natural Language Processing (NLP) allows the analysis of large amount of text very fast. This is crucial to perform a mapping between process core concepts of different PAMs. Therefore, NLP becomes a natural solution to reduce the cost and time, and to optimize the use of human resources.

Several studies addressed the mapping or integration between different models [35] [36] [37]. However, these studies usually involve specialists' interactions, so they are very time consuming and difficult to replicate.

Therefore, the research challenge addressed in this thesis is described as "there is no comprehensive approach to understand and identify the similarities between core process concepts of similar models, thus current approaches are ineffective and inefficient in multi-model environments".

This research has one primary objective: Provide a comprehensive approach that can help to perform a simultaneous assessment of different EGIT models by identifying the similarities between process core concepts.

3

Theoretical Background

Contents

In this chapter, we describe some theoretical background concepts about the relevant issues in the context of this thesis. We start by introducing fundamental concepts related to Enterprise Governance of IT, COBIT 5, ITIL, and Natural Language Processing.

3.1 Enterprise Governance of IT

The way IT is used in business has experienced some transformations in the past decades. For many years, business executives considered IT a support area of the main business, so IT was not considered essential to be addressed at the board of directors.

Nowadays, IT is recognized as a powerful resource to achieve the enterprise objectives, to support business growth and process control since it is pervasive bringing myriad benefits, such as lower costs, better performance, efficiency, risk control and effectiveness [8] [5] [38]. The use of IT has become a crucial part of the support, sustainability, and growth of an organization [39].

The investments made in IT are often very large. There is a need to ensure that these investments will generate business value, and will mitigate the risks related to IT. Hence, business requires better IT governance solutions, as technology and business become more inseparable [8] [39].

The concept of IT governance received a lot of attention when it emerged in the late 1990s. IT governance was expected to be on the business side, where a business should take the leading role. However, this was not the case. Many still believed that IT governance was mainly an issue within the IT field due to the focus on ”IT” [5].

As IT has become more crucial to business and in order to create value from the investments, it was necessary to manage IT as an asset instead of managing IT as a cost. This led to a shift in the definition of IT governance, focusing on the business involvements, toward ”Enterprise Governance of IT” [5].

EGIT can be defined as “an integral part of corporate governance and addresses the definition and implementation of processes, structures and relational mechanisms in the organization that enable both business and IT people to execute their responsibilities in support of business IT alignment and the creation of business value from IT-enabled business investments” [5]. Therefore, EGIT is the responsibility of the board and business executives.

According to the IT Governance Institute [27], EGIT aims to elevate the strategic importance of IT, enabling an enterprise to sustain its operations and extend activities into the future while mitigating associated risks.

3.1.1 Enterprise Governance of IT Mechanisms

To successfully deploy EGIT models, organizations should adopt a holistic approach by using a mixture of EGIT mechanisms, namely structures, processes and relational mechanisms [40] (Figure 3.1).

These mechanisms enable both business and IT people to execute their responsibilities in support of business/IT alignment and the creation of business value from IT-enabled business investments" [41].

- EGIT structures include "organizational units and roles responsible for making IT decisions and for enabling contacts between business and IT management (decision-making) functions (e.g., steering committees)" [5]

- EGIT processes refer to "formalization and institutionalization of strategic IT decision-making or IT monitoring procedures, to ensure that daily behaviors are consistent with policies and provide input back to decisions (e.g., portfolio management)" [5]

- The relational mechanisms are about the "active participation of, and collaborative relationship among, corporate executives, IT management and business management and include announcements, advocates, channels and education efforts" [5]

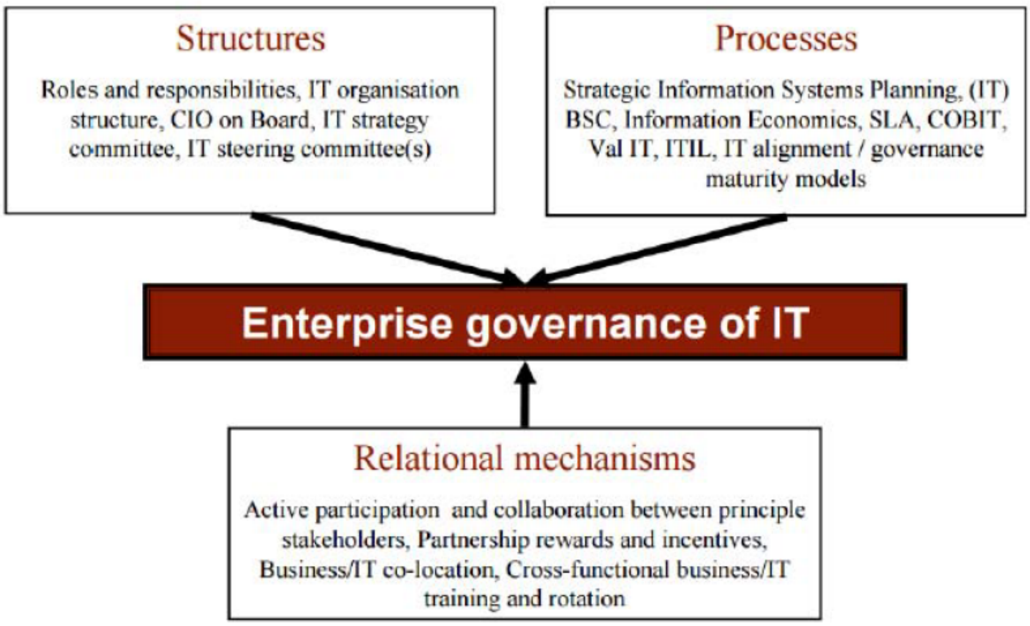


Figure 3.1: EGIT Mechanisms [2]

It is important to recognize that there are factors influencing the effectiveness of EGIT models. Each organization should understand which strategies and tactics work. The strategies and tactics are highly dependent on the context and surrounding environment. Therefore, determining the appropriate mechanisms to implement EGIT can be a rather complex task [42].

3.1.2 COBIT 5

COBIT is the acronym for Control Objectives for Information and Related Technologies. It was created by the Information Systems Audit and Control Association (ISACA) in 1996. Originally, COBIT was built as an IT audit guideline since it was composed by a comprehensive set of guidelines to improve audit and compliance and provided detailed guidance on governance practices. Nowadays, COBIT 5 is widely recognized as being one of the most used models for IT Governance [43] [13].

Currently, COBIT is in its fifth edition and was released in 2012 [3]. According to ISACA, COBIT 5 is ”a comprehensive framework that assists enterprises to achieve their objectives for the governance and management of enterprise IT. [...] COBIT 5 enables IT to be governed and managed in a holistic manner for the whole enterprise, taking in the full end-to-end business and IT functional areas of responsibility, considering the IT-related interests and external stakeholders” [3].

COBIT 5 is a good-practice framework that assists enterprises in achieving their objectives for EGIT and its management in terms of assurance communities, business, IT, risk, and security. Nowadays, COBIT 5 is one of the most used EGIT models.

The COBIT 5 Goals Cascade is the mechanism to translate stakeholder needs into specific, actionable and customized enterprise goals, IT-related goals and enabler goals [3]. COBIT 5 is built around five core principles (Figure 3.2) that are essential to the governance and management of IT within an organization [3, 5]:

- Meeting stakeholder needs;
- Covering the enterprise end-to-end;
- Applying a single, integrated framework;
- Enabling a holistic approach;
- Separating governance from management.

COBIT 5 Process Reference Model (PRM) describes in detail a set of governance and management processes that are commonly found in organizations. COBIT 5 PRM divides enterprise IT into two main process blocks of domain: Management and Governance. These blocks are subdivided into four domains, with a total of 37 processes (fig. 3.3).

- Governance processes- includes five processes within the domain of Evaluate, Direct, and Monitor (EDM).
- Management processes - includes thirteen processes within Align, Plan and Organise (APO) domain, ten within Build, Acquire and Implement (BAI) domain, six within Deliver, Service and Support (DSS) domain, and three within Monitor, Evaluate and Assess (MEA) domain.

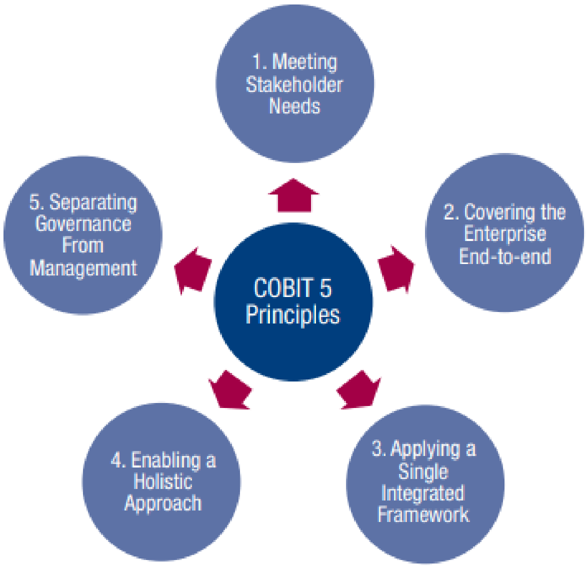


Figure 3.2: COBIT 5 principles [3]

In order to align the stakeholders' needs with the business' needs, these sets of processes should be implemented and managed.

3.1.2.A COBIT 5 PAM

COBIT 5 provides a process assessment model (PAM) for its 37 enabling processes that is based on ISO/IEC 15504.

The COBIT 5 PAM [44] is composed of a set of indicators of process performance and process capability. The indicators are used as a basis for collecting objective evidence that enables an assessor to assign ratings.

The assessment output consists of a set of process attribute ratings for each process assessed, termed the process profile, and may include the capability level achieved by that process. The range of the capability level goes from 0 (Incomplete) up to 5 (Optimizing). In order to achieve a given level, the previous level has to be completely achieved.

3.1.3 ITIL

ITIL is a set of detailed practices for management of IT services. It was introduced by the Office of Government Commerce (OGC) to promote efficient and cost-effective IT operations as a consequence of growing dependence on IT. ITIL is the most accepted and used models for ITSM [45].

ITIL v3 consists of a set of five publications: Service Strategy, Service Design, Service Transition, Service Operation, and Continual Improvement.

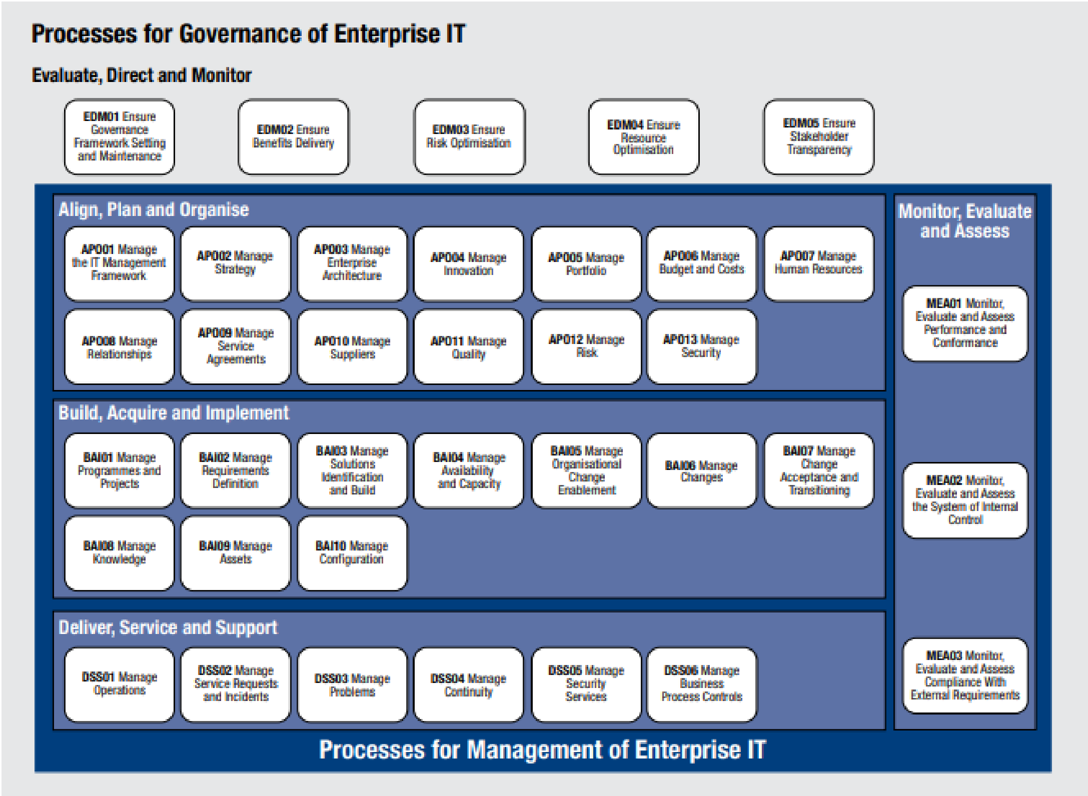


Figure 3.3: COBIT 5 Process Reference Model [3]

The ITIL benefits that are recurring addressed in the literature are: improvement of service quality, improvement of customer satisfaction, improvement of return on investment [46] [47]. However, ITIL presents some weaknesses such as the lack of holistic visibility and traceability from the theory (specifications, glossary, guidelines, manuals, amongst others) to its implementations and software applications; its focus on the logical level of processes, instructing what should be done but not how; and its poorly definition of the information models corresponding to process description [48].

3.1.3.A TIPA for ITIL

TIPA began in 2002. TIPA is a robust and internationally recognized model that results from the work of more than ten years of research, including experimentation on how to combine ITIL with the ISO/IEC 15504 [49]. TIPA uses the generic approach for process assessment published by the ISO in ISO/IEC 15504-2 – Process Assessment (now ISO/IEC 330xx Requirements for performing process assessment). TIPA is a standards-based approach to ITIL (v2, v3 and v3 2011) process assessment that can address challenges (posed by improving the quality of product manufacture or IT processes) in several important ways by providing a repeatable, consistent method for conducting process assessment [50].

The overall TIPA model is composed of a set of artifacts including process models, namely a PRM and a PAM, result of the transformation of the set of requirements and practices respectively included in the ISO/IEC 15504 standard and the ITIL de facto standard, into the TIPA for ITIL PAM.

3.2 Natural Language Processing

According to various authors, NLP can be defined as the area of research and application that explores how computers can process and analyze natural language. The main goal of the NLP field is to get computers to extract results from tasks involving human language, tasks like enabling human-machine communication, improving human-human communication, or merely doing useful processing of text or speech [51] [52].

NLP can be viewed as a pipeline of various stages used to extract knowledge from unstructured text. These steps are needed to transform the raw text into a machine readable format. Also, it is important to clean the data since usually it is inconsistent, or contains an error. Below, there is an explanation of three less intuitive pre-processing techniques performed:

- **Tokenization:** Given a character sequence, tokenization is the task of chopping the sequence into pieces (usually words), called tokens perhaps at the same time throwing away certain characters, such as punctuation. NLTK Library has word_tokenize and sent_tokenize to easily break a stream of text into a list of words or sentences, respectively.
- **Stop words:** These words add little meaning to a text but that are very frequently used (such as 'the', 'a', 'an', etc.). Usually, these words are removed.
- **Lemmatization:** Reduces the number of inflectional forms of each word into its root. Normally, it removes inflectional endings in order to transform into a dictionary form of a word, also known as lemma.

There are other pre-processing techniques such as removal of empty rows, change all text to lower case, remove punctuation, and remove non-alphabetic characters.

3.3 Text Representation for Computational Analysis

Extracting information and categorizing texts have become a crucial technique for dealing with text data. But before performing any algorithm to organize the textual information, first it is necessary to find the best representation for the textual data.

Traditionally, computers have been able to compare objects that can be represented either mathematically (e. g. vectors) or as strings of characters. However, formal representation enables computers to manipulate concepts that are difficult to represent mathematically.

Since computers can't understand text as humans, it is important to convert documents into a numerical representation. One of the most common ways to represent documents is Vector Space Model (VSM) [53] [54]. In this approach, documents are represented as vectors where each dimension corresponds to a separate term from the vocabulary. If a term occurs in the document, then the value is mapped to a numeric value different than zero [54]. There are many different weighting techniques to compute this value, which have the target to differentiate between the terms that are more important for a document [55].

A common weighting technique is the TF-IDF approach [56]. This measure calculates how important a word is in a document from a document collection [57]. This approach combines two methods: Term Frequency (TF) and Inverse Document Frequency (IDF). TF can be a simple count in which $tf_{i,j}$ is defined as the number of occurrences of a word t in a document d divided by the total number of words in the document. TF can be calculated as follows:

$$tf_{t,d} = 1 + \frac{n_{t,d}}{\sum_k = n_{t,d}} \tag{3.1}$$

IDF is used to attenuate the effect of words that occur too often, also known as stop words, like "the", "is", etc. Document frequency df_t is the number of documents that contain the term t. The IDF can be defined as follows:

$$idf(w) = \log(\frac{N}{df_t}) \tag{3.2}$$

The parameter N is the total number of documents divided by $\frac{N}{df_t}$, the number of documents that contain the word w.

Finally, the TF-IDF is simply the multiplication of TF by IDF:

$$idf(w) = tf_{t,d} \times \log(\frac{N}{df_t}) \tag{3.3}$$

Therefore, TF-IDF is a statistic that measures the relevance of a word in a particular document. The higher frequency terms are more important for representing the meaning than lower frequency terms.

The simple TF-IDF model works well and gives importance to the uncommon words rather than treating all the words as equal in the case of binary bag of words model. However, this approach fails to perform accurately when it encounters any sentence containing negations [58]. TF-IDF is an example of a traditional and very popular representation to compare texts [56] [59], and to classify text documents - both short and long [60] [61].

Other weighting methods can be used like Information Gain (IG), Chi-square, Mutual Information, etc. TF-IDF considers two documents as similar if they share rare, but informative, words [62].

3.4 Text Similarity Metrics

Similarity measures computes the distance or similarity between the description of two documents into a single numeric value. This value depends on two factors — the properties of the two documents and the measure itself. It is important to bear in mind that there is no universal measure best measure since their performance is depended on the data or the context of the problem.

3.4.1 Euclidean Distance

Euclidean Distance measures the distance between two points in the space. Euclidean distance is widely used in clustering problems, including clustering text. To measure the distance between two documents, represented by the vectors $\vec{t_a}$ and $\vec{t_b}$ respectively, the Euclidean distance can be defined as [63]:

$$D_E(\vec{t_a}, \vec{t_b}) = (\sum_{t=1}^{m} |w_{t,a} - w_{b,t}|^2)^{\frac{1}{2}} \tag{3.4}$$

Where the vocabulary is $T = \{t1, ..., tm\}$. TF-IDF can be used to compute the weights of the terms $w_{t,a}$.

3.4.2 Jaccard Coefficient

The Jaccard coefficient measures similarity as the intersection divided by the union. In the context of textual similarity, the coefficient divides the sum weight of common words in both documents with the sum weight of words that are present in either two documents. Jaccard Coefficient can be defined as follows:

$$SIM_J(\vec{t_a}\vec{t_b}) = (\frac{\vec{t_a} \cdot \vec{t_b}}{|\vec{t_a}|^2 + |\vec{t_b}|^2 - \vec{t_a} \cdot \vec{t_b}} \tag{3.5}$$

3.4.3 Cosine Similarity

Cosine similarity measures the similarity between two vectors. When documents are represented as vectors, the similarity between the documents is measured by the cosine of the angle between two vectors and. Cosine similarity is one of the most popular similarity measures applied to text documents, such as in in-formation retrieval applications and clustering [64].

Having cosine similarity as a measure, we have:

$$SIM_C(\vec{t_a}\vec{t_b}) = \frac{\vec{t_a} \cdot \vec{t_b}}{|\vec{t_a}| \times |\vec{t_b}|} \tag{3.6}$$

where $\vec{t_a}$ and $\vec{t_b}$ are dimensional vectors over the terms of the vocabulary $T = \{t1, ..., tm\}$. A cosine value of zero means that the two vectors are at 90 degrees to each other (orthogonal) therefore, there is no match between them. Contrariwise, a cosine value of one corresponds to the smaller angle thus a greater match between vectors [65].

Cosine similarity is a standard TF-IDF similarity and is a measure widely used in information retrieval [63]. It is also used to measure how similar documents are irrespective of their size.

Vector representation provides appropriate support for the automatic manipulation of information. In this context, document similarity is a technique that assigns a numeric value to a pair of concepts by comparing the deviation of angles between each concept vector.

4

Related Work

Contents

4.1 Enterprise Governance of IT Multiple Models Adoption

Authors such as [66] [67] [68], have noted that there is no single EGIT model that suits all organizations, and the available models serve as a starting point for organizations to create an EGIT model that will be compatible with their organizational structure, strategy, history, and culture [66]. Therefore, no single model covers all EGIT processes on its own and is sufficient to implement EGIT completely and efficiently [69], and so, organizations implement practices from more than one model to support their needs.

According to Wong et al. [34], an organization would like to be officially certified against a model, but due to incompleteness or abstraction of the model, the organization would like to consult additional details from other models that have an official certification process. Mappings between the models would then be necessary in order for the models to be interpreted complementary.

Also, an organization could want to consult COBIT as a high-level model (due to its abstractness), use ISO 27001 as complementary materials (for completeness), and employ ITIL to supplement knowledge on IT performance [34]. Semantic integration between the models bridging their differences is then required to provide an integrated view.

Therefore, integrating models provides a more comprehensive and efficient approach, enabling features that would be unavailable through individual models [15] [21] [32]. However, the proliferation of EGIT models is one reason why many organizations become overwhelmed and confused when deciding which model is the most pertinent to their needs [23].

4.2 Enterprise Governance of IT Models Mappings/Integration

Several studies addressed the mapping/integration between different models. But those mappings are either general focused or requirements focused [35]. Many research approaches have been used, such as manual mappings, ontology based, text analysis based solutions. However, manual mapping/integration performed by experts is the most typical type of comparison.

For example, ISACA has made a significant investment over the years in mapping COBIT to other models, with detailed mappings of COBIT 4.1 to ten other models including COSO (which was designed to help businesses establish, assess and enhance their internal control), ITIL, PMBOK (a set of standard terminology and guidelines for project management), and TOGAF (an enterprise architecture model that helps define business goals and align them with architecture objectives around enterprise software development) [70].

Sahibudin et al. [36] propose a comprehensive practice by integrating the ITIL, COBIT, and ISO/IEC 27002 into an EGIT model that they suggest could be used in every company. Another research was done by Karkoskova & Feuerlicht [37]. In their approach, the authors analyze three different models (ITIL, COBIT, and Management of Business Informatics - MBI, which is a consistent and flexible methodological model for IT management explicitly designed to suit small and medium-sized enterprises) to identify the relationships between these models.

Alignment between COBIT and ISO 27001 has been approached by several researchers [12] [71] [72] [73]. However, these researches either map models at a very abstract level, matching process similarity criteria or have mapped previous versions that have been superseded such as COBIT 4.1 and ISO 27001:2005.

Almeida et al. mapped, modeled and integrated COBIT 5 and COSO in ArchiMate [74]. Another research [75] proposed a model that uses TIPA for ITIL, COBIT PAM and ArchiMate to analyze the impact of ITIL implementation on COBIT 5 processes performance, and vice-versa.

4.2.1 Ontology

Ontologies are sets of concepts of a given domain [76]. Ontology can be defined [77] as a ”specification of a conceptualization”. A conceptualization is an abstract model of the objects, concepts, and entities that exist in an area of interest and the relationships that hold among them. There are matching algorithms that can be used to calculate the semantic similarity between ontologies.

In the work of Wong et al., an ontology based solution has been proposed [34]. Their approach relies on an ontology mapping algorithm that bridges the semantic differences between ontologies of different models. This type of approach has the potential to automate and reduce the process of mapping and matching multiple models. Their approach maximizes semantic expressiveness, facilitating machine-interpretation and intelligent reasoning. This allows a comparison between concepts with more complex semantics when compared to other techniques like graph and set based approach [34].

Percheiro developed ontologies for describing TIPA for ITIL and COBIT 5 PAM [78]. Through semantic ontology matching, they calculated the similarity between the processes core concepts (base practices, inputs/outputs, outcomes, and expected results). The author presented two alignments between the two PAMs: one using a combination of names and descriptions of the base practices, and the other using only the descriptions of the base practices.

4.2.2 Text Mining

Text analysis is the automated process that allows machines to extract and classify information from raw text. Combining text analyses with data mining and machine learning provides the possibility to eliminate or at least significantly reduce the need for expert human resources for manual analyses of textual information [79] [16].

Borges uses semantic similarity to understand the relatedness between models [80]. Taking advantage of the Spacy software, the similarities between the processes core concepts (base practices, inputs/outputs, outcomes, and expected results) were calculated. However, in the majority of the domains, this technique was not aligned with the manual mappings [80].

The publication by Zaraffy et al., presents an automatic and quantitative tool using text analysis, data mining and machine learning to identify similarities between models [81]. Their tool can be used to connect process elements of different models. It generates similarity maps between models with high accuracy when compared to the preexisting manual mappings [81].

Despite their valuable contribution to the field, these studies usually involve human interaction, and so they are very time consuming and difficult to replicate, and so, undoubtedly, these works do not scale. Moreover, the studies that use (semi) automatic approaches, do not focus on the assessment process.

The author of this thesis has been unable to identify any research quantifying the extent of multiple concurrent adoptions of EGIT models such as those discussed in this thesis.

5

Proposal

Contents

In this chapter, it will be explained in detail our proposal to solve the problem identified in chapter 1. It starts by presenting the objectives that we pretend to achieve with the use of this proposal, followed by the details of our solution.

5.1 Objectives

This subsection is related to the second activity of the DSRM – "Define the objectives for a solution". The main objective is to provide a comprehensive approach that can help to perform a simultaneous assessment of different PAMs by identifying the similarities between process core concepts.

5.2 Proposal

A joint approach of the PAMs of different EGIT models can contribute to a consistent focus on different but complementary domains, promote synergy and minimize duplication of the resources needed to perform process assessments.

The proposal is divided into four main activities, namely Data Collection, Pre-processing, Vectorizing, and Measure Similarity which are summarized in figure 5.1.

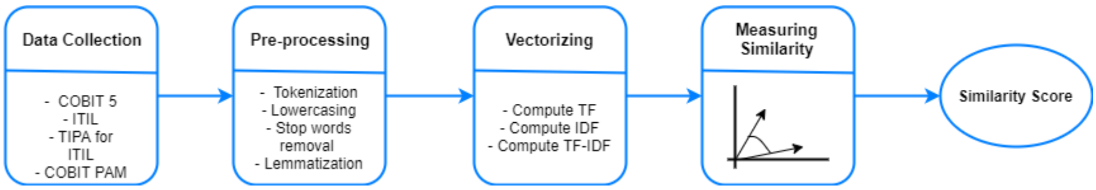


Figure 5.1: Main steps of the pipeline

5.2.1 Data Collection

The Data Collection step consists of collecting data from a specific domain. In our case, the domain is the EGIT field, mainly the EGIT models that have been proposed to improve EGIT in the organizations. From the raw data presented in the different publications that introduce and describe these EGIT models, we created a pipeline to extract the description from each process assessment core concepts (namely the Process Description of Outcomes (Os), Base Practices (BPs), and Work Products (WPs).

5.2.2 Pre-processing

Pre-processing is one of the most important steps when dealing with text. This step is used to clean and prepare the text for subsequent classification. Properly pre-processing text facilitates the extraction of the most important information presented in unstructured text and reduces the number of variant words in a sentence. By reducing the size of the dataset, there will be an increase in the effectiveness of the classification process.

The techniques used to pre-process the text can vary according to the problem statement. In our case, we applied a few simple pre-processing techniques such as Sentence Splitting and Tokenization, Removal of Stop words, Lemmatization, and Lowercased tokens. These techniques were applied in order to reduce the sparsity and vocabulary size of the data previously collected.

We started the pre-processing by breaking the generic dataset into words (tokens), a process also known as tokenization. Then, each token was converted to lowercase. All the punctuation from our dataset was then removed since they are just symbols that usually do not add any useful information. Then we removed several stop words, which are words that often appear in a text but do not contribute any additional value to the context as they are used to join words together in a description. There is not a unique list of stop words, and so, in this research, a list of 179 stop words (like “the”, “is”, etc.) was used.

Finally, the lemmatization technique was applied to the dataset. Lemmatization is the process of removing inflectional endings from words in order to find the dictionary form of a word, also known as the lemma of the word. This situation allowed us to analyze words with different inflections as the same token, reducing the number of different tokens.

5.2.3 Vectorizing

In order to assess the similarity between process descriptions, we first need to convert the pre-processed text into a format that computers can recognize. Vector Space Models (VSM) is a way to convert text into numeric vectors. In our research, we chose the Term Frequency-Inverse Document Frequency (TF-IDF) approach since it is a very popular representation to compare text representations with each other [56]. Term frequency is the proportion occurrences of a word in a document to the total number of words in that document. Inverse document frequency is used to attenuate the effect of words that occur too often, also known as stop words. TF-IDF considers two documents as similar if they share rare, but informative, words [62].

We derive a vector using TF-IDF scores to represent each process description. After pre-processing the raw text, we compute the TF scores. TF measures the number of times a word occurs in a description. Next, we compute the IDF scores to compute the total number of descriptions and the number of descriptions that contain the word.

As mentioned earlier, this step weighs down words that occur too frequently. Then, we compute the TF-IDF that returns a vector per word per process based on the frequency of that word in that process and the collection of all processes. The vector will be a list of frequencies for each unique word in the dataset - the TF-IDF value if the word is in the process, or 0 otherwise. After modeling the descriptions as vectors, we can calculate the similarity between two vectors. To do so, the cosine of the angle between the two vectors is computed. The values range between -1 and 1, where 1 is perfectly similar.

5.2.4 Score calculation

Taking into account two documents, an effective similarity measure should be able to determine if the documents have an identical meaning. Considering the variability of natural language, two documents are similar if they represent the same idea. There are several similarity measures, such as Jaccard Similarity, Dice Coefficient, Euclidean Distance, and Cosine Similarity.

To understand the matches between two processes, we made a pairwise comparison between all the concepts (we just compared similar concepts: Outcomes with Outcomes, Base Practices with Base Practices; and Work Products with Work Products). An example of a pairwise comparison is presented in figure 5.2. Two processes are more similar if they have a common set of Base Practices, Outcomes, and Work Products.

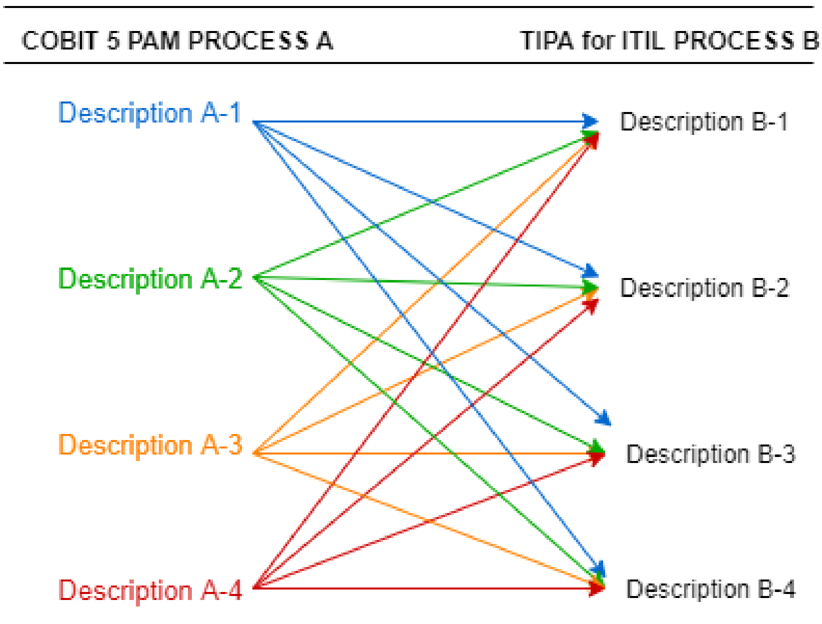


Figure 5.2: Pairwise comparison

Each core concept score is calculated by the average of each core concept description of one process with all the core concept description of the other process. Then, the highest average value is chosen to be the similarity core concept score between two processes.

The overall similarity score of two processes is obtained by the average similarity score of the three concepts:

$$PS = \frac{BPS + OS + WPS}{3} \tag{5.1}$$

The main goal of this step is to represent every set of descriptions from each concept as a vector whose length is equal to the vocabulary size of the dataset.

6

Demonstration

This chapter demonstrates the capacity of the proposed artifact. This demonstration can be made with experimentation, simulation, case study, proof or other appropriate activity solve one or more instances of the problem. This corresponds to the fourth step of DSRM: demonstration.

Without loss of generality, we demonstrate our proposal using COBIT 5 and ITIL, which are among the most adopted, popular, and valuable models. Since we just focused on the process assessment core concepts, we took advantage of two PAMs developed specifically to address COBIT 5 and ITIL, namely the COBIT 5 PAM and the TIPA for ITIL PAM.

However, it is important to point out that the proposal is generic and can be applied to all the EGIT models that have a similar process structure. Although the generalization to other models and domains should be made with caution.

In these EGIT models, the individual processes are described in terms of process name, purpose, and Outcomes. Also, the process dimension of the process assessment model provides information in the form of Base Practice, Outcomes and Work products. In this research, we considered that every process is decomposed into BPs, Os, and WPs. For example, the COBIT 5 EDM01 Ensure Governance Framework Setting and Maintenance process is composed of three Os, three BPs, and 22 WPs.

We start by cleaning the data by pre-processing it. Every process description was tokenized. Then, we calculate the TF-IDF score for each word in the description to accentuate the words that are relevant to the specific description. This process is exemplified in figure 6.1.

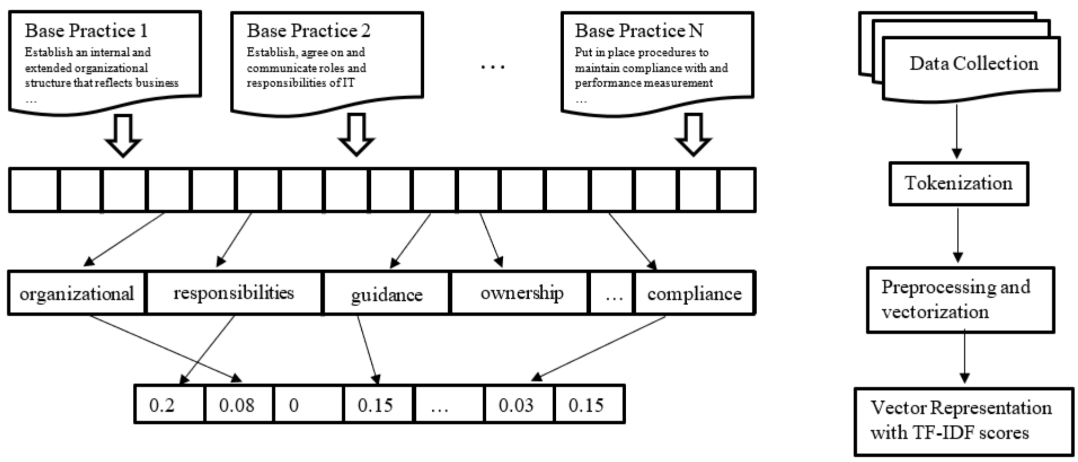


Figure 6.1: Vector Representation Diagram

As mentioned earlier, three core concepts of COBIT 5 PAM and TIPA for ITIL PAM were considered. After the calculation of the different scores of each core concept, we realized that the results for the Work Product concept were very high or very low. This is normal since, usually, the Work Product instances are just described using two or three words, so the words are rather similar or different. The Expected

Results/Outcomes instances also are short descriptions, but not as short as the Work Products one. So the similarity results were not as extremes as the results of the Work Products. This can be justified by the fact that the description of the Outcomes is longer than the description of the Work Products.

Therefore, to calculate the process similarity score, we decided to use just the similarity between the Base Practices and Outcomes, using the following formula:

$$PS = BPs \times \frac{7}{10} + Os \times \frac{3}{10} \tag{6.1}$$

Similarity measures are likely to perform poorly given if the number of words to compare with is small. Thus, it was assigned different weights to each core concept considered. The Base Practices' core concepts have a higher weight since they are composed of long descriptions.

In this step, the performance of different similarity and distance metrics were evaluated. The weighting metric used was TF-IDF. Then it was tested the best average performance between different text similarity metrics. However, the best accuracy results were achieved using cosine similarity. This methodology not only had the best overall average efficiency but each process pair resulted in a similarity value closest to the reference mapping study presented in [4]. The results of our approach are presented in fig. 6.2 for the processes of two COBIT domains: DSS and BAI.

	Access Management	Availability Management	Business Relationship Management	Capacity Management	Change Evaluation	Change Management	Demand Management	Event Management	Incident Management	Information Security Management	IT Service Continuity Management	IT Service Financial Management	IT Service Strategy Management	Knowledge Management	Problem Management	Release and Deployment Management	Request Fulfilment	Service Asset and Configuratio	Service Catalogue Management	Service Design Coordination	Service Level Management	Service Portfolio Management	Seven-Step Improvement	Supplier Management	Service Validation and Testing	Transition Planning and Support
BAI01 Manage Programmes and Projects	13%	16%	12%	16%	24%	14%	17%	16%	13%	15%	19%	15%	24%	19%	13%	16%	12%	16%	17%	30%	12%	30%	17%	24%	24%	33%
BAI02 Manage Requirements Definition	19%	21%	17%	17%	15%	16%	19%	26%	12%	27%	21%	13%	16%	15%	16%	12%	7%	9%	16%	20%	12%	26%	16%	22%	13%	24%
BAI03 Manage Solutions Identification and Build	14%	25%	35%	23%	26%	34%	26%	27%	24%	25%	33%	25%	36%	15%	13%	34%	14%	24%	41%	51%	42%	44%	20%	23%	37%	53%
BAI04 Manage Availability and Capacity	10%	49%	28%	38%	23%	20%	31%	12%	29%	16%	28%	17%	22%	13%	16%	19%	12%	14%	34%	26%	20%	23%	30%	19%	19%	19%
BAI05 Manage Organisational Change	9%	20%	25%	20%	47%	53%	15%	28%	14%	15%	18%	22%	22%	15%	19%	22%	6%	15%	15%	20%	13%	26%	12%	18%	20%	25%
BAI06 Manage Changes	14%	25%	29%	24%	46%	51%	14%	29%	20%	20%	23%	17%	21%	10%	21%	14%	20%	19%	18%	21%	11%	29%	8%	11%	14%	20%
BAI07 Manage Change Acceptance and	18%	28%	22%	18%	20%	30%	30%	22%	26%	23%	39%	17%	18%	15%	15%	26%	9%	13%	18%	14%	23%	34%	17%	14%	52%	20%
BAI08 Manage Knowledge	25%	16%	10%	19%	12%	16%	20%	13%	19%	25%	16%	19%	23%	63%	24%	24%	17%	24%	25%	18%	13%	17%	23%	11%	13%	14%
BAI09 Manage Assets	10%	30%	24%	22%	7%	21%	17%	17%	16%	19%	16%	22%	26%	18%	16%	38%	13%	28%	26%	14%	13%	19%	24%	14%	14%	12%
BAI10 Manage Configuration	14%	23%	20%	24%	20%	36%	11%	30%	8%	17%	14%	13%	33%	10%	14%	40%	12%	49%	33%	18%	18%	30%	13%	17%	19%	18%
DSS01 Manage Operations	8%	21%	20%	20%	14%	12%	16%	20%	23%	18%	16%	15%	24%	13%	14%	25%	9%	12%	25%	23%	24%	26%	15%	15%	16%	27%
DSS02 Manage Service Requests and Incidents	50%	28%	16%	20%	14%	48%	25%	27%	56%	21%	34%	25%	20%	18%	32%	24%	64%	22%	35%	21%	26%	35%	24%	15%	30%	20%
DSS03 Manage Problems	22%	16%	11%	14%	26%	27%	12%	41%	24%	11%	18%	13%	14%	9%	55%	16%	20%	20%	17%	11%	18%	15%	14%	10%	19%	13%
DSS04 Manage Continuity	24%	43%	22%	18%	25%	19%	27%	13%	31%	25%	43%	23%	19%	21%	19%	37%	13%	17%	32%	22%	27%	26%	28%	16%	21%	22%
DSS05 Manage Security Services	45%	32%	15%	20%	10%	10%	22%	43%	14%	45%	18%	15%	22%	21%	11%	25%	18%	26%	26%	8%	19%	14%	13%	11%	9%	8%
DSS06 Manage Business Process	20%	16%	21%	21%	19%	12%	20%	23%	18%	24%	14%	17%	13%	26%	27%	15%	18%	23%	26%	21%	22%	17%	24%	18%	23%	19%

Figure 6.2: Result of text similarity between the process of domains BAI and DSS from COBIT 5 PAM and TIPA for ITIL PAM

7

Evaluation

Contents

This chapter corresponds to the fifth activity of DSRM: evaluation. The main goal is to observe and measure the adequacy of the artifact to a solution to the problem. This requires knowledge of relevant metrics and analysis techniques to compare the results observed to the objectives of a solution.

Reasoning about the similarity of natural language texts is regularly performed by humans but remains a challenge for computers [82]. When evaluating the relatedness between texts, humans do not judge relatedness merely at the level of text words, but at a much deeper level that manipulates concepts. Their interpretation of a document is far from their background knowledge and experience. Humans have an innate ability to judge the relatedness of texts. Therefore, human judgment on a set of text pairs can thus be considered correct by definition, a kind of "gold standard" against which computer algorithms are evaluated [82].

In this specific research, the authors compared the results obtained in this research with a benchmark proposed in [4]. It is important to remark that the benchmark was performed for an overall process comparison so, it did not go into the details of the respective PAMs. Nevertheless, it is a relevant mapping that contributes to a broader discussion of the similarities between COBIT 5 and ITIL processes.

Similarity is a complex concept that has been widely discussed in the linguistic, philosophical, and information theory communities. For the current task, the similarity between two text units is defined as a sense share, i.e., both text units share concepts above a predefined threshold. In this case, and based on the rating scale of both the COBIT 5 PAM and the TIPA for ITL PAM, we defined the following thresholds:

- 0%-15% - Not similar
- 16%-50% - Partially similar
- 51%-85% - Largely similar
- 86%-100% - Fully similar

We are only presenting the COBIT 5 processes that have more than a 50% similarity score with at least one ITIL process. This decision is based on the fact that higher results give us a high level of confidence regarding the semantic similarity between different processes.

Some remarks regarding figure 7.1 should be highlighted:

- We just present the 8 COBIT 5 processes that have a semantic similarity score higher than 50% with at least one ITIL process. This means that, in principle, these are the COBIT 5 processes that are largely or fully similar to the ITIL processes.
- It is possible to conclude that the vast majority of the processes (7 out of 8) belong to the sometimes called primary processes (BAI and DSS domains)

	Access Management	Availability Management	Business Relationship Management	Capacity Management	Change Evaluation	Change Management	Demand Management	Event Management	Incident Management	Information Security Management	IT Service Continuity Management	IT Service Financial Management	IT Service Strategy Management
APO09 Manage Service Agreements	24%	27%	36%	28%	25%	14%	39%	20%	33%	12%	35%	30%	46%
BAI03 Manage Solutions Identification and Build	14%	25%	35%	23%	26%	34%	26%	27%	24%	25%	33%	25%	36%
BAI05 Manage Organisational Change Enablement	9%	20%	25%	20%	47%	53%	15%	28%	14%	15%	18%	22%	22%
BAI06 Manage Changes	14%	25%	29%	24%	46%	51%	14%	29%	20%	20%	23%	17%	21%
BAI07 Manage Change Acceptance and Transitioning	18%	28%	22%	18%	20%	30%	30%	22%	26%	23%	39%	17%	18%
BAI08 Manage Knowledge	25%	16%	10%	19%	12%	16%	20%	13%	19%	25%	16%	19%	23%
DSS02 Manage Service Requests and Incidents	50%	28%	16%	20%	14%	48%	25%	27%	56%	21%	34%	25%	20%
DSS03 Manage Problems	22%	16%	11%	14%	26%	27%	12%	41%	24%	11%	18%	13%	14%

	Knowledge Management	Problem Management	Release and Deployment Management	Request Fulfilment	Service Asset and Configuration Management	Service Catalogue Management	Service Design Coordination	Service Level Management	Service Portfolio Management	Seven-Step Improvement	Supplier Management	Service Validation and Testing	Transition Planning and Support
APO09 Manage Service Agreements	21%	25%	38%	21%	33%	55%	44%	46%	53%	40%	34%	33%	51%
BAI03 Manage Solutions Identification and Build	15%	13%	34%	14%	24%	41%	51%	42%	44%	20%	23%	37%	53%
BAI05 Manage Organisational Change Enablement	15%	19%	22%	6%	15%	15%	20%	13%	26%	12%	18%	20%	25%
BAI06 Manage Changes	10%	21%	14%	20%	19%	18%	21%	11%	29%	8%	11%	14%	20%
BAI07 Manage Change Acceptance and Transitioning	15%	15%	26%	9%	13%	18%	14%	23%	34%	17%	14%	52%	20%
BAI08 Manage Knowledge	63%	24%	24%	17%	24%	25%	18%	13%	17%	23%	11%	13%	14%
DSS02 Manage Service Requests and Incidents	18%	32%	24%	64%	22%	35%	21%	26%	35%	24%	15%	30%	20%
DSS03 Manage Problems	9%	55%	16%	20%	20%	17%	11%	18%	15%	14%	10%	19%	13%

Figure 7.1: Result of text similarity between process of COBIT and ITIL

- The processes with the highest degree of similarity are the DSS02 - Manage Service Requests and Request Fulfilment processes with a score of 64%
- From these 12 processes with results above 50%, 8 are in agreement with the benchmark
- There are some false positives regarding the following processes: APO09 Manage Service Agreements, BAI03 Manage Solutions Identification and Build, BAI05 Manage Organisational Change Enablement. The similarity score is higher than it should have been according to the specialists' mapping. According to the specialists, these processes do not have any related ITIL process, and so, a lower result was expected
- On the other hand, the processes APO09 Manage Service Agreements, BAI03 Manage Solutions Identification and Build, BAI05 Manage Organisational Change Enablement, BAI06 Manage Changes, and BAI07 Manage Change Acceptance and Transitioning are a false negative. This means that some results are below expected. For example, BAI07 Manage Change Acceptance and Transitioning corresponds to 5 ITIL processes, accordingly to the experts' mapping. Meanwhile, our solution only had a high result for one ITIL process.
- Most of the presented processes belong to and based on the specialists' mapping, our approach allows us to conclude that the more operational processes have higher results. This is normal, since ITIL is a more operational model than COBIT 5, and so, the overlap in these domains is higher. Therefore, we can argue that the interoperability between COBIT PAM and TIPA for ITIL is higher in this kind of processes

Overall, the results are in line with the specialists' opinion presented. However, the specialists' mappings are just a binary scale (0 or 1). So the level of granularity is not equivalent to our proposal.

7.1 Interview with experts

To evaluate our proposal, we gathered data through an online survey that was sent to 8 COBIT and ITIL experts. Due to time limitations, we are not able to inquire about all the COBIT and ITIL processes. So, we chose the COBIT 5 DSS domain. This choice is based on the fact that initial focus on any process assessment would be the core (sometimes called primary) processes, which are primarily part of the DSS domain.

To design the survey, we started by making a table with processes that belong to the DSS domain of COBIT 5 and the Service Operation domain of ITIL. The main idea was to evaluate the similarity between the processes in a 4-point rating scale, and based on the rating scale of both the COBIT 5 PAM and the TIPA for ITIL PAM, where:

- 1 - Not similar
- 2 - Partially similar
- 3 - Largely similar
- 4 - Fully similar

We decided to use this scale since it is similar to a process assessment scale, and therefore is easier to grasp. It is important to note that similarity is a very broad and ambiguous concept. There may be some variance in the results. This survey allowed us to gather quantitative data about the experts' opinions regarding the similarity between processes. This survey was written and administered using Google Sheets.

Below, in table 7.1, we present the similarity scores for all the processes belonging to the Deliver, Service, and Support (DSS) domain of COBIT 5, which are compared with the ITIL processes that belong to the service operation domain.

Table 7.2 presents the average rating regarding the similarity of each process that results from the experts' survey. The practitioners' answers vary a lot form one another. This is a relevant mapping that contributes to a broader discussion of the similarities between COBIT 5 and ITIL processes. The green cells signify the experts confirm our results. On contrary, the red ones contradicted our results.

Some remarks regarding the obtained results are presented below:

- The processes that were considered by the respondents largely similar or fully similar were the ones with higher results in the automatic similarity analysis
- From the presented processes, 18 out of 30 fell into the same similarity level
- The processes with the highest similarity is the pair DSS02 Manage Service Requests and Incidents Request Fulfilment with a score of 64% (largely similar). This result is consistent with the

Table 7.1: Process Similarity Scores

	Event Management	Incident Management	Request Fulfillment	Problem Management	Access Management
DSS01 – Manage Operations	20%	23%	9%	14%	8%
DSS02 – Manage Service Requests and Incidents	27%	56%	64%	32%	50%
DSS03 – Manage Problems	41%	24%	20%	55%	22%
DSS04 – Manage Continuity	13%	31%	13%	19%	24%
DSS05 – Manage Security Services	43%	14%	18%	11%	45%
DSS06 – Manage Business Process Controls	23%	18%	18%	27%	20%

experts' opinions. Also, the COBIT process is divided into 2 ITIL processes, which were the ones that obtained the highest similarity scores

- Although the similarity between DSS03 – Manage Problems and Problem Management is high (55%), experts considered that these two processes are fully similar, assigning it a similarity level of 4.

Table 7.2: Average similarity score from the surveys

	Event Management	Incident Management	Request Fulfillment	Problem Management	Access Management
DSS01 – Manage Operations	2	2	2	2	2
DSS02 – Manage Service Requests and Incidents	2	3	3	2	1
DSS03 – Manage Problems	2	2	1	4	1
DSS04 – Manage Continuity	2	1	1	2	1
DSS05 – Manage Security Services	2	2	1	1	2
DSS06 – Manage Business Process Controls	2	2	2	2	2

Following the preliminary survey, we conducted a face-to-face interview with 2 experts, one from Portugal and one from Brazil. Table 7.3 shows some information regarding the two practitioners.

The interview allowed us to understand some of the reasoning behind their answers to the survey. Both experts mentioned that the similarity scores are influenced by each expert's background and

Table 7.3: Respondents Profile

ID	Country	Experience	Certifications	Industry
1	Portugal	30	Cobit Foundation, CRISC, CISA CGEIT, ISO 27000	IT consulting Regulation
2	Brazil	+30	COBIT 2019, ITIL, PMI, CISA, CRISC CGEIT, ISO 27000	Education IT consulting

knowledge (for example, if they came from the ITIL ‘world’ or the COBIT ‘world’).

Both respondents highlighted that COBIT is a broader model that combines several areas, while ITIL is focused on IT service management. This means that not every process will have a match or will have a high similarity at a low-level spectrum, in spite of being similar at a high-level spectrum.

8

Conclusion

Contents

To conduct this research, we followed the DSRM process that consists of 6 phases of development.

Organizations needing to comply with multiple regulations are struggling to meet audits each year with a large number of business/IT resources being spent specifically to demonstrate the organization's compliance against well-known EGIT models. The problem this research targets is the lack of a comprehensive approach to understanding and identifying the similarities between core process concepts of similar models, thus current approaches are ineffective and inefficient in multi-model environments. Our main objective is to facilitate the simultaneous assessment of different EGIT models by identifying the similarities between process core concepts. To address this problem, and to automate the implementation as much as possible, we decided to use NLP techniques to measure the similarity between processes.

Through literature review, we identify the different approaches that have been proposed to address this issue. However, the existing interoperability approaches to EGIT models are mainly done manually as demonstrated in this research.

Following this, the proposal presents a new methodology that combines text analysis and data mining in order to automatically identify the similarities between EGIT models. The models were converted into computer readable objects. Then, the similarity results were automatically calculated using different measures. The most efficient measure was the cosine similarity to calculate the similarity score.

To assess the proposed artifact, two evaluations were made. In the first, we compared our results with a benchmark mapping provided by specialists [4]. In the second, we conducted an online survey to ITIL and COBIT experts. Then, we compared our results with the experts' opinions. From the evaluations, it becomes clear that our approach had positive results, especially for the more operational processes.

Regarding the other process domains, the results are not so clear. However, it seems that high-level processes are not so related. It is important to highlight that every organization must be aware that even though these EGIT models are compatible, they still work from different points of view in the myriad of possible organizational scenarios. Therefore, it is imperative to know each of these in depth, so the important and critical facts are known, and no unwanted outcomes result when using the proposed techniques.

Therefore, we can state that NLP similarity techniques can have a high impact when addressing more operational processes i.e., these techniques can facilitate a simultaneous assessment. We believe that this is an important conclusion since operational processes are the most valuable and most frequently used processes in any organization.

The developed artifact and the results were communicated to proper audiences through the presentation and submission of a paper in the International Journal of Human Capital and Information Technology Professionals.

However, it is important to mention that our intention is not to automate all tasks and activities involved in an assessment. The main intention is to help auditors and stakeholders automate the more cumbersome and tedious steps in order to assess an organization's processes when multi-models are present.

8.1 Contributions

The main contribution of this thesis is a mapping of TIPA for ITIL PAM and COBIT 5 PAM core concepts. The similarity scores obtained with the proposed artifact allowed us to conclude that there exists some overlap between these models. It can also be considered as a starting point to facilitate and automatize simultaneous assessments.

8.2 Limitations

The limitations found during the development of this thesis are:

- The artifact is strongly dependent on the three main overlapping concepts of COBIT 5 PAM and TIPA for ITIL PAM: Base Practices, Outcomes, and Work Products. The proposed artifact can be adapted to other EGIT models, but adaptions should be made with caution.
- NLP is an ongoing research field that remains dependent on large corpora. Since the Base Practices, Outcomes, and Work Products concept descriptions are worded concisely, it is sometimes difficult to calculate the similarity between them.
- The vocabulary used in EGIT models. The processes in EGIT models are described using very formal language and include jargon. This makes it harder for the computer to identify the similarities.
- Experts interviews were only used to evaluate the final proposal. We believe the artifact would have benefited from interviews in the beginning to obtain information such as what should have had more weight in computing the similarity score.

8.3 Communication

Communicating the problem, the solution, and the results to the scientific community is the last step of the DSR methodology.

During the writing of this thesis, we were able to produce one paper which we submitted. The information about this paper can be found in table 8.1. The paper was already accepted and will be published in 2020.

Table 8.1: Submitted Papers

Papers	
Title	Integrating COBIT 5 PAM and TIPA for ITIL Using Ontology Matching System
Authors	Almeida, R., Gonçalves, P., Percheiro, I., Mira da Silva, M., Pardo, C.
Journal	International Journal of Human Capital and Information Technology Professionals (IJHCITP)
State	Accepted

8.4 Future Work

Regarding the results of this thesis, there are several opportunities that can be addressed for future work:

- Improving the proposed artifact by trying different weighting techniques such as Chi-square or Information Gain weighting metric instead of TF-IDF.
- Demonstrating and evaluating the proposed artifact for mapping different IT governance models (ex: CMMI, ASPICE, etc.).
- Creating a specific dictionary with terms used in these models. The idea behind this is to apply different weights to more important terms. Additionally, it is also possible to replace terms by its meaning. That way, if different terms have the same meaning, this would increase the similarity score.
- Integrating fuzzy logic to the proposal. This logic is the science that makes a computer understand and think the way humans do. That would help the computer to better understand the meaning of each process.
- Developing algorithms that let us improve and extend the capability of the assessment process through automation.

Bibliography

[1] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, "A design science research methodology for information systems research," *J. of Management Information Systems*, vol. 24, pp. 45–77, 2007.

[2] J. J. Tambotoh, R. Kosala, B. Ranti, H. Prabowo, S. H. Supangkat, S. M. Isa, and B. W. Pudjianto, "A conceptual model for creating effective public value through key practices in information technology governance mechanisms," *2017 International Conference on Information Management and Technology (ICIMTech)*, pp. 128–132, 2017.

[3] ISACA, *A Business Framework for the Governance and Management of Enterprise IT*, 2013.

[4] ——, *Cobit 5 Enabling Processes*, 2012.

[5] S. D. Haes and W. V. Grembergen, *Enterprise Governance of Information Technology: Achieving Alignment and Value, Featuring COBIT 5*, 2nd ed. Springer Publishing Company, Incorporated, 2016.

[6] I. G. Institute, *Board Briefing for IT Governance*. Information Systems Audit and Control Association, 2003.

[7] N. Melville, K. Kraemer, and V. Gurbaxani, "Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value," *MIS Quarterly*, vol. 28, pp. 283–322, 06 2004.

[8] W. Van Grembergen, "Introduction to the Minitrack IT Governance and Its Mechanisms," 02 2007, pp. 233 – 233.

[9] N. V. Patel, "Global Ebusiness IT Governance: Radical Re-directions," in *HICSS*, 2002.

[10] S. D. Haes, W. V. Grembergen, and R. S. Debreceny, "COBIT 5 and Enterprise Governance of Information Technology: Building Blocks and Research Opportunities," *J. Information Systems*, vol. 27, pp. 307–324, 2013.

[11] M. F. I. Othman, T. Chan, E. Foo, K. Nelson, and G. Timbrell, "Barriers to information technology governance adoption : a preliminary empirical investigation," 08 2011.

[12] M. Sharifi, M. Ayat, A. A. Rahman, and S. Sahibudin, "Lessons learned in ITIL implementation failure," *2008 International Symposium on Information Technology*, vol. 1, pp. 1–4, 2008.

[13] M. Nicho, R. F. Gordon, and S. Muamaar, "Towards a Taxonomy of Challenges in an Integrated IT Governance Framework Implementation," 2016.

[14] P. Calvache, F. Pino, F. Garcia, M. Piattini, and M. Baldassarre, "An ontology for the harmonization of multiple standards and models," *Computer Standards & Interfaces*, vol. 34, pp. 48–59, 01 2012.

[15] M. Gehrmann, "Combining ITIL COBIT and ISO/IEC 27002 for structuring comprehensive information technology for management in organizations," *Navus: Revista de Gestão e Tecnologia*, vol. 2, 09 2012.

[16] S. Weiss, N. Indurkhya, T. Zhang, and F. J. Damerau, *Text Mining: Predictive Methods for Analyzing Unstructured Information*, 01 2004.

[17] F. S. Gharehchopogh and Z. A. Khalifelu, "Analysis and evaluation of unstructured data: text mining versus natural language processing," *2011 5th International Conference on Application of Information and Communication Technologies (AICT)*, pp. 1–4, 2011.

[18] A. Hevner, A. R, S. March, S. T, P. , J. Park, R. , and S. , "Design science in information systems research," *Management Information Systems Quarterly*, vol. 28, pp. 75–, 03 2004.

[19] P. Calvache, F. Pino, F. Garcia, M. Baldassarre, and M. Piattini, "From chaos to the systematic harmonization of multiple reference models: A harmonization framework applied in two case studies," *Journal of Systems and Software*, vol. 86, pp. 125–143, 01 2013.

[20] E. J. Oud, *The Value to IT of Using International Standards*. Information Systems Control Journal, 2005.

[21] A. Cater-Steel, W.-G. Tan, and M. Toleman, "Challenge of adopting multiple process improvement frameworks," 01 2006, pp. 1375–1386.

[22] J. Moore, "An integrated collection of software engineering standards," *IEEE Software*, vol. 16, 12 1999.

[23] C. Pardo, "A Framework to Support the Harmonization between Multiple Models and Standards," Ph.D. dissertation, 07 2012.

[24] C. J. P. Calvache, F. J. Pino, F. Garcia, M. T. Baldassarre, and M. Piattini, "From chaos to the systematic harmonization of multiple reference models: A harmonization framework applied in two case studies," *Journal of Systems and Software*, vol. 86, pp. 125–143, 2013.

[25] L. Liao and H. K. N. Leung, "A Software Process Ontology and Its Application," in *Semantic Web Enabled Software Engineering*, 2014.

[26] I. Aaen, "Software process improvement: Blueprints versus recipes," *Software, IEEE*, vol. 20, pp. 86 – 93, 10 2003.

[27] I. G. Institute, *Global Status Report on the Governance of Enterprise IT (GEIT)*, 2011.

[28] S. Biffl, D. Winkler, R. H, and H. Wetzel, "Software Process Improvement in Europe: Potential of the New V-Modell XT and Research Issues Practice Section," 07 2019.

[29] T. Coleman and A. T. Chatfield, "Promises And Successful Practice In IT Governance: A Survey Of Australian Senior IT Managers," in *PACIS*, 2011.

[30] M. Marrone and M. Hammerle, "Relevant Research Areas in IT Service Management: An Examination of Academic and Practitioner Literatures," *Communications of the Association for Information Systems*, vol. 41, pp. 517–543, 01 2017.

[31] J. Bhattacharjya and V. Chang, "Australasian (ACIS) 2006 Adoption and Implementation of IT Governance : Cases from Australian Higher Education," 2007.

[32] M. Ula, Z. Ismail, and Z. M. Sidek, "A Framework for the Governance of Information Security in Banking System," 2011.

[33] A. L. Ferreira, R. J. Machado, and M. C. Paulk, "Supporting Audits and Assessments in Multi-model Environments," in *PROFES*, 2011.

[34] A. K. Y. Wong, F. Yip, P. R. Kumar, and N. Paramesh, "Towards Semantic Interoperability for IT Governance: An Ontological Approach," *Computing and Informatics*, vol. 27, pp. 131–155, 2008.

[35] K. Haufe, R. Colomo-Palacios, S. Dzombeta, K. Brandis, and V. Stantchev, "Security management standards: A mapping," *Procedia Computer Science*, vol. 100, pp. 755–761, 10 2016.

[36] S. Sahibuddin, M. Sharifi, and M. Ayat, "Combining ITIL, COBIT and ISO/IEC 27002 in Order to Design a Comprehensive IT Framework in Organizations," *2008 Second Asia International Conference on Modelling & Simulation (AMS)*, pp. 749–753, 2008.

[37] S. Karkosková and G. Feuerlicht, "Extending MBI Model using ITIL and COBIT Processes," 2015.

[38] ISACA, *Getting started with governance of enterprise IT (GEIT)*, 2011.

[39] W. Van Grembergen, “From IT Governance to Enterprise Governance of IT: A Journey for Creating Business Value Out of IT,” 11 2010, p. 3.

[40] S. D. Haes and W. V. Grembergen, “An Exploratory Study into the Design of an IT Governance Minimum Baseline through Delphi Research,” *CAIS*, vol. 22, p. 24, 2008.

[41] W. Van Grembergen and S. De Haes, *Enterprise governance of information technology: Achieving strategic alignment and value*, 01 2009.

[42] E. Wessels and J. van Loggerenberg, “IT governance: theory and practice,” 06 2019.

[43] J. Etzler, “IT Governance according to COBIT,” Master’s thesis, 2007.

[44] ISACA, *Process Assessment Model (PAM): Using COBIT 5*, 2013.

[45] M. Marrone and L. M. Kolbe, “Impact of IT Service Management Frameworks on the IT Organization,” *Business and Information Systems Engineering*, vol. 3, pp. 5–18, 02 2011.

[46] M. Marrone and L. Kolbe, “ITIL and the Creation of Benefits: An Empirical Study on Benefits, Challenges and Processes,” in *ECIS*, 2010.

[47] C. F. Gomes, *Gestão da cadeia de suprimentos integrada à tecnologia da informação*, 07 2014.

[48] V. Strahonja, “Definition Metamodel of ITIL,” in *ISD*, 2007.

[49] B. Barafort, B. D. Renzo, and O. Merlan, “Benefits Resulting from the Combined Use of ISO/IEC 15504 with the Information Technology Infrastructure Library (ITIL),” in *PROFES*, 2002.

[50] S. Cortina, B. Barafort, A. Renault, M. Picard, V. Betry, M. St-Jean, and O. Valdés, *ITSM Process Assessment Supporting ITIL - Using TIPA to Assess and Improve Your Processes With Iso 15504 and Prepare for Iso 20000 Certification*, 2009.

[51] D. Jurafsky and J. H. Martin, *Speech and Language Processing (2Nd Edition)*. Upper Saddle River, NJ, USA: Prentice-Hall, Inc., 2009.

[52] D. Roth, “Learning to resolve natural language ambiguities: A unified approach,” in *AAAI/IAAI*, 1998.

[53] G. Salton, “Automatic text processing,” 1988.

[54] G. Sidorov, A. F. Gelbukh, H. Gómez-Adorno, and D. Pinto, “Soft similarity and soft cosine measure: Similarity of features in vector space model,” *Computación y Sistemas*, vol. 18, 2014.

[55] Z. Karaffy and K. Balla, “Text analyses - combining text analyses, data mining and machine learning to support process oriented multimodel approaches,” 2015.

[56] C. D. Manning, P. Raghavan, and H. Schütze, *Introduction to Information Retrieval*. New York, NY, USA: Cambridge University Press, 2008.

[57] F. Sebastiani, "Machine learning in automated text categorization," *ACM Comput. Surv.*, vol. 34, no. 1, pp. 1–47, Mar. 2002. [Online]. Available: http://doi.acm.org/10.1145/505282.505283

[58] B. Das and S. Chakraborty, "An Improved Text Sentiment Classification Model Using TF-IDF and Next Word Negation," *ArXiv*, vol. abs/1806.06407, 2018.

[59] P. Achananuparp, X. Hu, and X. Shen, "The evaluation of sentence similarity measures," in *DaWaK*, 2008.

[60] H. J. Wang and S. Deng, "A paper-text perspective: Studies on the influence of feature granularity for chinese short-text-classification in the big data era," *The Electronic Library*, vol. 35, pp. 689–708, 2017.

[61] T. Wang, Y. Cai, H. fung Leung, Z. Cai, and H. Min, "Entropy-based term weighting schemes for text categorization in vsm," *2015 IEEE 27th International Conference on Tools with Artificial Intelligence (ICTAI)*, pp. 325–332, 2015.

[62] C. Corley and R. Mihalcea, "Measuring the semantic similarity of texts," in *EMSEEACL*, 2005.

[63] A. Y.-Q. Huang, "Similarity measures for text document clustering," 2008.

[64] B. Larsen and C. Aone, "Fast and effective text mining using linear-time document clustering," in *KDD*, 1999.

[65] J. Han, M. Kamber, and J. Pei, "Getting to know your data," 2012.

[66] N. Kakabadse and A. Kakabadse, "IS/IT Governance: Need for an Integrated Model," *Corporate Governance*, vol. 1, pp. 9–11, 12 2001.

[67] F. Tugas, "Assessing the level of information technology (IT) processes performance and capability maturity in the Philippine food, beverage, and tobacco (fbt) industry using the Cobit framework," *Academy of Information & Management Sciences*, vol. 13, pp. 45–68, 01 2010.

[68] P. Willson and C. Pollard, "Exploring IT Governance in Theory and Practice in a Large Multi-National Organisation in Australia," *IS Management*, vol. 26, pp. 98–109, 04 2009.

[69] A. Calder and S. Moir, *IT Governance: Implementing Frameworks and Standards for the Corporate Governance of IT*, ser. It Governance Series. IT Governance Limited, 2009.

[70] J. Heschl, "Cobit in relation to other international standards," *Information systems control journal*, pp. 37–40, 2014.

[71] P. Năstase, F. Năstase, and C. Ionescu, "Challenges generated by the implementation of the it standards cobit 4.1, ITIL v3 and ISO/IEC 27002 in enterprises," *Economic computation and economic cybernetics studies and research / Academy of Economic Studies*, vol. 3, 01 2009.

[72] R. Sheikhpour and N. Modiri, "An approach to map cobit processes to iso/iec 27001 information security management controls," 2012.

[73] K. Haufe, R. Colomo-Palacios, S. Dzombeta, K. Brandis, and V. Stantchev, "Security management standards: A mapping," 2016.

[74] R. Almeida, P. Pinto, and M. Mira da Silva, "Using archimate to integrate cobit 5 and coso metamodels," 06 2016.

[75] R. Almeida, P. L. Pinto, and M. M. da Silva, "Using archimate to assess cobit 5 and itil implementations," in *ISD*, 2016.

[76] D. Milicevic and M. Goeken, "Ontology-based evaluation of iso 27001," in *I3E*, 2010.

[77] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing," *Int. J. Hum.-Comput. Stud.*, vol. 43, pp. 907–928, 1993.

[78] I. Percheiro, "Mapping COBIT 5 and ITIL using Semantic Analysis," Master's thesis, 2018.

[79] F. Sebastiani, "Machine learning in automated text categorization," *ACM Computing Surveys*, vol. 34, pp. 1–47, 04 2001.

[80] B. Borges, "Comparison of COBIT 5 and ITIL V3 using Semantic Analysis," Master's thesis, 2018.

[81] Z. Karaffy and K. Balla, "Applying text analyses and data mining to support process oriented multi-model approaches," in *EuroSPI*, 2015.

[82] E. Gabrilovich and S. Markovitch, "Computing semantic relatedness using wikipedia-based explicit semantic analysis," in *IJCAI*, 2007.

A

COBIT 5 PAM and TIPA for ITIL Mapping

	Access Management	Availability Management	Business Relationship Management	Capacity Management	Change Evaluation	Change Management	Demand Management	Event Management	Incident Management	Information Security Management	IT Service Continuity Management	IT Service Financial Management	IT Service Strategy Management	Knowledge Management	Problem Management	Release and Deployment Management	Request Fulfilment	Service Asset and Configuration Management	Service Catalogue Management	Service Design Coordination	Service Level Management	Service Portfolio Management	Seven-Step Improvement	Supplier Management	Service Validation and Testing	Transition Planning and Support
APO01 Manage the IT Management Framework	14%	14%	13%	16%	18%	20%	15%	11%	17%	14%	13%	17%	17%	37%	11%	20%	14%	26%	16%	20%	24%	20%	21%	15%	10%	11%
APO02 Manage Strategy	10%	16%	18%	23%	20%	16%	18%	10%	19%	13%	20%	22%	27%	16%	12%	19%	9%	12%	22%	14%	20%	26%	22%	24%	18%	16%
APO03 Manage Enterprise Architecture	13%	14%	17%	14%	15%	22%	18%	11%	10%	12%	28%	13%	20%	28%	8%	19%	7%	11%	16%	27%	13%	21%	19%	15%	9%	25%
APO04 Manage Innovation	12%	15%	16%	9%	11%	15%	12%	8%	11%	9%	12%	16%	19%	13%	8%	14%	5%	12%	7%	9%	11%	18%	11%	12%	21%	11%
APO05 Manage Portfolio	12%	15%	20%	18%	22%	18%	17%	10%	9%	11%	22%	25%	29%	17%	9%	23%	18%	18%	22%	22%	17%	43%	26%	33%	17%	21%
APO06 Manage Budget and Costs	15%	23%	14%	25%	17%	16%	23%	10%	12%	18%	22%	44%	24%	17%	13%	22%	16%	20%	29%	21%	24%	33%	20%	17%	18%	23%
APO07 Manage Human Resources	15%	17%	16%	21%	13%	21%	23%	8%	12%	13%	20%	16%	13%	35%	13%	21%	10%	18%	10%	14%	16%	11%	16%	36%	12%	18%
APO08 Manage Relationships	9%	22%	40%	24%	20%	22%	21%	10%	20%	16%	18%	26%	31%	15%	10%	20%	10%	24%	27%	19%	20%	26%	29%	18%	13%	20%
APO09 Manage Service Agreements	24%	27%	36%	28%	25%	14%	39%	20%	33%	12%	35%	30%	46%	21%	25%	38%	21%	33%	55%	44%	46%	53%	40%	34%	33%	51%
APO10 Manage Suppliers	12%	20%	29%	16%	16%	11%	15%	29%	17%	31%	21%	18%	17%	11%	12%	17%	17%	19%	14%	18%	20%	20%	16%	47%	14%	23%
APO11 Manage Quality	13%	13%	29%	19%	19%	7%	15%	10%	17%	9%	17%	20%	24%	18%	10%	18%	9%	17%	27%	20%	23%	21%	39%	7%	10%	18%
APO12 Manage Risk	13%	20%	13%	25%	37%	22%	24%	34%	16%	36%	28%	23%	31%	22%	12%	19%	11%	23%	11%	22%	12%	23%	24%	20%	10%	31%
APO13 Manage Security	21%	13%	11%	14%	11%	14%	9%	9%	10%	47%	16%	8%	16%	16%	8%	10%	7%	14%	23%	13%	15%	12%	24%	10%	9%	14%
BAI01 Manage Programmes and Projects	13%	16%	12%	16%	24%	14%	17%	16%	13%	15%	19%	15%	24%	19%	13%	16%	12%	16%	17%	30%	12%	30%	17%	24%	24%	33%
BAI02 Manage Requirements Definition	19%	21%	17%	17%	15%	16%	19%	26%	12%	27%	21%	13%	16%	15%	16%	12%	7%	9%	16%	20%	12%	26%	16%	22%	13%	24%
BAI03 Manage Solutions Identification and Build	14%	25%	35%	23%	26%	34%	26%	27%	24%	25%	33%	25%	36%	15%	13%	34%	14%	24%	41%	51%	42%	44%	20%	23%	37%	53%
BAI04 Manage Availability and Capacity	10%	49%	28%	38%	23%	20%	31%	12%	29%	16%	28%	17%	22%	13%	16%	19%	12%	14%	34%	26%	20%	23%	30%	19%	19%	19%
BAI05 Manage Organisational Change Enablement	9%	20%	25%	20%	47%	53%	15%	28%	14%	15%	18%	22%	22%	15%	19%	22%	6%	15%	15%	20%	13%	26%	12%	18%	20%	25%
BAI06 Manage Changes	14%	25%	29%	24%	46%	51%	14%	29%	20%	20%	23%	17%	21%	10%	21%	14%	20%	19%	18%	21%	11%	29%	8%	11%	14%	20%

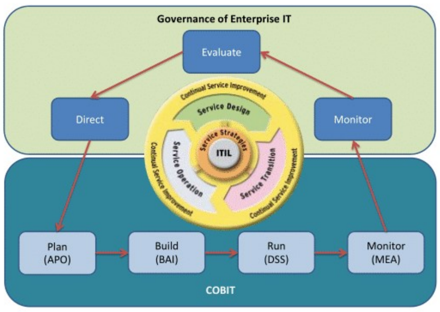
Figure A.1: Similarity scores of mapping COBIT 5 PAM and TIPA for ITIL (part 1)

	Access Management	Availability Management	Business Relationship Management	Capacity Management	Change Evaluation	Change Management	Demand Management	Event Management	Incident Management	Information Security Management	IT Service Continuity Management	IT Service Financial Management	IT Service Strategy Management	Knowledge Management	Problem Management	Release and Deployment Management	Request Fulfilment	Service Asset and Configuration Management	Service Catalogue Management	Service Design Coordination	Service Level Management	Service Portfolio Management	Seven-Step Improvement	Supplier Management	Service Validation and Testing	Transition Planning and Support
BAI07 Manage Change Acceptance and Transitioning	18%	28%	22%	18%	20%	30%	30%	22%	26%	23%	39%	17%	18%	15%	15%	26%	9%	13%	18%	14%	23%	34%	17%	14%	52%	20%
BAI08 Manage Knowledge	25%	16%	10%	19%	12%	16%	20%	13%	19%	25%	16%	19%	23%	63%	24%	24%	17%	24%	25%	18%	13%	17%	23%	11%	13%	14%
BAI09 Manage Assets	10%	30%	24%	22%	7%	21%	17%	17%	16%	19%	16%	22%	26%	18%	16%	38%	13%	28%	26%	14%	13%	19%	24%	14%	14%	12%
BAI10 Manage Configuration	14%	23%	20%	24%	20%	36%	11%	30%	8%	17%	14%	13%	33%	10%	14%	40%	12%	49%	33%	18%	18%	30%	13%	17%	19%	18%
DSS01 Manage Operations	8%	21%	20%	20%	14%	12%	16%	20%	23%	18%	16%	15%	24%	13%	14%	25%	9%	12%	25%	23%	24%	26%	15%	15%	16%	27%
DSS02 Manage Service Requests and Incidents	50%	28%	16%	20%	14%	48%	25%	27%	56%	21%	34%	25%	20%	18%	32%	24%	64%	22%	35%	21%	26%	35%	24%	15%	30%	20%
DSS03 Manage Problems	22%	16%	11%	14%	26%	27%	12%	41%	24%	11%	18%	13%	14%	9%	55%	16%	20%	20%	17%	11%	18%	15%	14%	10%	19%	13%
DSS04 Manage Continuity	24%	43%	22%	18%	25%	19%	27%	13%	31%	25%	43%	23%	19%	21%	19%	37%	13%	17%	32%	22%	27%	26%	28%	16%	21%	22%
DSS05 Manage Security Services	45%	32%	15%	20%	10%	10%	22%	43%	14%	45%	18%	15%	22%	21%	11%	25%	18%	26%	26%	8%	19%	14%	13%	11%	9%	8%
DSS06 Manage Business Process Controls	20%	16%	21%	21%	19%	12%	20%	23%	18%	24%	14%	17%	13%	26%	27%	15%	18%	23%	26%	21%	22%	17%	24%	18%	23%	19%
EDM01 Ensure Governance Framework Setting and Maintenance	12%	19%	12%	14%	18%	19%	10%	4%	18%	7%	6%	11%	13%	23%	3%	8%	13%	11%	8%	23%	16%	16%	17%	9%	14%	14%
EDM02 Ensure Benefits Delivery	11%	15%	18%	15%	15%	13%	12%	16%	9%	10%	17%	18%	23%	12%	7%	16%	6%	17%	17%	16%	16%	32%	14%	17%	17%	13%
EDM03 Ensure Risk Optimisation	8%	18%	13%	12%	36%	21%	7%	13%	3%	29%	34%	9%	17%	9%	33%	11%	9%	13%	7%	25%	6%	9%	9%	19%	13%	33%
EDM04 Ensure Resource Optimisation	7%	20%	10%	26%	5%	18%	21%	11%	12%	18%	9%	5%	17%	14%	31%	15%	5%	13%	8%	14%	8%	7%	16%	10%	8%	14%
EDM05 Ensure Stakeholder Transparency	10%	30%	8%	8%	11%	6%	9%	3%	6%	11%	5%	8%	12%	11%	0%	10%	3%	12%	6%	7%	7%	12%	21%	6%	6%	10%
MEA01 Monitor, Evaluate and Assess Performance and Conformance	12%	21%	17%	20%	22%	9%	11%	9%	9%	7%	14%	13%	18%	13%	9%	16%	8%	17%	15%	16%	24%	12%	19%	25%	9%	21%
MEA02 Monitor, Evaluate and Assess the System of Internal Control	9%	27%	10%	28%	15%	13%	16%	7%	10%	29%	17%	11%	21%	20%	20%	21%	22%	20%	11%	11%	18%	16%	20%	15%	14%	15%
MEA03 Monitor, Evaluate and Assess Compliance with External Requirements	8%	12%	11%	12%	15%	19%	9%	8%	4%	21%	11%	8%	14%	6%	9%	6%	4%	9%	3%	10%	12%	19%	6%	12%	6%	10%

Figure A.2: Similarity scores of mapping COBIT 5 PAM and TIPA for ITIL (part 2)

B

COBIT ITIL Mapping from specialists



ITIL© Edition 2011 - COBIT© *5* Mapping		Service Strategy					Service Design								Service Transition							Service Operation					CSI	
		Strategy management for IT services	Service portfolio management	Financial management for IT services	Demand management	Business relationship management	Design coordination	Service catalogue management	Service Level Mgmt	Availability management	Capacity management	IT service continuity management	Information security management	Supplier management	Transition planning and support	Change management	Service asset and configuration management	Release and deployment management	Service validation and testing	Change evaluation	Knowledge management	Event management	Incident management	Request fulfilment	Problem management	Access management	Service Reporting	The seven-step improvement process
EDM	***Evaluate, Direct and Monitor***																											
EDM01	Ensure Governance Framework Setting and Maintenance																											
EDM02	Ensure Benefits Delivery		x																									
EDM03	Ensure Risk Optimisation																											
EDM04	Ensure Resource Optimisation				x																							
EDM05	Ensure Stakeholder Transparency					x																						
APO	***Align, Plan and Organise***																											
APO01	Manage the IT Management Framework																											x
APO02	Manage Strategy	x																										
APO03	Manage Enterprise Architecture																											
APO04	Manage Innovation																											
APO05	Manage Portfolio		x					x																				
APO06	Manage Budget and Costs			x																								
APO07	Manage Human Resources										x																	
APO08	Manage Relationships				x	x																						
APO09	Manage Service Agreements		x		x			x	x																		x	
APO10	Manage Suppliers													x														
APO11	Manage Quality																											x
APO12	Manage Risk												x															
APO13	Manage Security												x															
BAI	***Build, Acquire and Implement***																											
BAI01	Manage Programmes and Projects						x																					
BAI02	Manage Requirements Definition								x																			
BAI03	Manage Solutions Identification and Build																											
BAI04	Manage Availability and Capacity									x	x																	
BAI05	Manage Organisational Change Enablement																											
BAI06	Manage Changes															x												
BAI07	Manage Change Acceptance and Transitioning						x								x			x	x	x								
BAI08	Manage Knowledge																				x							
BAI09	Manage Assets																x											
BAI10	Manage Configuration																x											
DSS	***Deliver, Service and Support***																											
DSS01	Manage Operations																					x						
DSS02	Manage Service Requests and Incidents																						x	x				
DSS03	Manage Problems																								x			
DSS04	Manage Continuity											x																
DSS05	Manage Security Services												x															
DSS06	Manage Business Process Controls																									x		
MEA	***Monitor, Evaluate and Assess***																											
MEA01	Monitor, Evaluate and Assess Performance and Conformance																										x	
MEA02	Monitor, Evaluate and Assess the System of Internal Control																											x
MEA03	Monitor, Evaluate and Assess Compliance with External Requirements																											x

Figure B.1: COBIT ITIL mapping [4]

C

Experts’ answers

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS02 Manage Problems	DSS03 Manage Continuity	DSS04 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	2	2	1	2	2
Incident management	2	3	2	1	2	2
Request fulfillment	2	3	1	1	1	2
Problem management	3	2	4	2	2	2
Access management	2	2	1	1	3	2

Figure C.1: Expert 1 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS02 Manage Problems	DSS03 Manage Continuity	DSS04 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	1	1	1	1	2
Incident management	2	4	1	1	1	2
Request fulfillment	2	2	1	1	1	2
Problem management	2	1	4	1	1	2
Access management	2	1	1	1	1	2

Figure C.2: Expert 2 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS02 Manage Problems	DSS03 Manage Continuity	DSS04 Manage Security Services	DSS06 Manage Business Process Controls
Event management	3	2	2	2	2	1
Incident management	2	4	2	2	2	2
Request fulfillment	2	4	2	1	1	2
Problem management	2	2	4	2	1	2
Access management	1	1	1	1	2	2

Figure C.3: Expert 3 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS02 Manage Problems	DSS03 Manage Continuity	DSS04 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	2	2	2	2	1
Incident management	2	3	2	1	1	1
Request fulfillment	1	3	1	1	1	1
Problem management	2	2	3	1	1	1
Access management	1	1	1	1	2	1

Figure C.4: Expert 4 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS02 Manage Problems	DSS03 Manage Continuity	DSS04 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	2	2	2	2	2
Incident management	2	3	2	1	2	1
Request fulfillment	2	3	1	1	1	1
Problem management	1	2	3	2	1	1
Access management	1	2	1	2	2	2

Figure C.5: Expert 5 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS03 Manage Problems	DSS04 Manage Continuity	DSS05 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	1	1	1	1	2
Incident management	2	5	1	1	1	2
Request fulfillment	2	3	1	1	1	2
Problem management	2	1	5	1	1	2
Access management	2	1	1	1	1	2

Figure C.6: Expert 6 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS03 Manage Problems	DSS04 Manage Continuity	DSS05 Manage Security Services	DSS06 Manage Business Process Controls
Event management	2	1	1	1	2	2
Incident management	1	3	1	1	1	2
Request fulfillment	1	3	1	1	1	2
Problem management	1	1	3	1	1	2
Access management	1	1	1	1	2	2

Figure C.7: Expert 7 score result

	DSS01 Manage Operations	DSS02 Manage Service Requests and Incidents	DSS03 Manage Problems	DSS04 Manage Continuity	DSS05 Manage Security Services	DSS06 Manage Business Process Controls
Event management	3	4	2	2	2	2
Incident management	3	4	2	3	3	4
Request fulfillment	3	4	1	1	1	1
Problem management	2	2	5	3	3	3
Access management	4	1	1	1	2	2

Figure C.8: Expert 8 score result