TÉCNICO LISBOA

Comparison of COBIT 5 and ITIL V3 Using Semantic Analysis

Bruno Sony Lopes Borges

Thesis to obtain the Master of Science Degree in

Information Systems and Computer Engineering

Supervisors: Prof. Miguel Leitão Bignolas Mira da Silva
Prof. Rúben Filipe de Sousa Pereira

Examination Committee

Chairperson: Prof. Paolo Romano
Supervisor: Prof. Miguel Leitão Bignolas Mira da Silva
Member of the Committee: Prof. Mário Jorge Costa Gaspar da Silva

October 2018

Acknowledgments

First and foremost, I would like to thank my mother and my sister for their encouragement and support over all these years without whom this project would not be possible.

I would also like to thank Prof. Miguel Mira da Silva, Prof. Rúben Pereira, and also to Ph.D. student Rafael Almeida for their insight, support, motivation and sharing of knowledge that has made this Thesis possible.

Sincere thanks to all my friends for their support, motivation and funny moments.

Abstract

Enterprise Governance of IT (EGIT) is defined as a means to achieve business/Information Technology (IT) alignment. Organizations can benefit from this alignment by implementing and assessing new or improved processes defined by EGIT frameworks to become more competitive and produce high-quality products and services.

Control Objectives for Information and Related Technology (COBIT) and Information Technology Infrastructure Library (ITIL) are two well-known Process Reference Models (PRMs) that are widely adopted and adapted by organizations. PRMs are always related to a Process Assessment Model (PAM) which holds all details to determine the capability of the processes of the reference model. COBIT supports the alignment of IT with Enterprise Governance while ITIL provides detailed guidance on the management of IT processes, functions, roles, and responsibilities related to IT service management. However, in multi-framework environments, organizations struggle in the adoption and assessing these frameworks since each framework defines its own scope, structure, definitions, and terminology.

There are not many proven attempts to provide an explicit and systematic solution that would allow stakeholders to better align multiple frameworks in organizations. In order to overcome this issue, the authors propose an approach that through a semantic similarity comparison between COBIT and ITIL core concepts defines the semantic similarity between those terms/concepts so that stakeholders can be aware of the overlaps that exist between these frameworks.

Keywords

COBIT; EGIT; ITIL; PRM; Semantic similarity;

Resumo

A *EGIT* é definida como um meio para alcançar o alinhamento de negócios / *IT*. As organizações podem se beneficiar desse alinhamento implementando e avaliando processos novos ou aprimorados definidos pelas estruturas da *EGIT* para se tornarem mais competitivas e produzirem produtos e serviços de alta qualidade.

COBIT e *ITIL* são dois *PRMs* bem conhecidos que são amplamente adotados e adaptados pelas organizações. Os *PRMs* estão sempre relacionados a *PAM* que contém todos os detalhes para determinar a capacidade dos processos do modelo de referência. *COBIT* suporta o alinhamento de *IT* com a governança corporativa, enquanto o *ITIL* fornece orientações detalhadas sobre a gestão de processos, funções e responsabilidades de *IT* relacionadas com a gestão de serviços de *IT*. No entanto, em ambientes multi-framework, as organizações têm dificuldades na adoção e avaliação dessas frameworks, uma vez que cada framework define seu próprio escopo, estrutura, definição e terminologia.

Não há muitas tentativas comprovadas de fornecer uma solução explícita e sistemática que permita às partes interessadas alinhar melhor várias frameworks nas organizações. Para superar essa questão, os autores propõem uma abordagem que, por meio da comparação da similaridade semântica entre os conceitos centrais do *COBIT* e do *ITIL*, define a distância entre esses termos / conceitos para que os stakeholders possam estar cientes das sobreposições existentes entre esses frameworks.

Palavras Chave

COBIT; EGIT; ITIL; PRM; Similaridade semântica;

Contents

List of Figures

List of Tables

Acronyms

AML AgreementMakerLight

BAI Build, Aquire and Implement

BSM Business Service Management

COBIT Control Objectives for Information and Related Technology

CMDB Configuration Management Database

CMMI Capability Maturity Model Integration

DSS Deliver, Service and Support

DSRM Design Science Research Methodology

EA Enterprise Architecture

EGIT Enterprise Governance of IT

FP False Positive

ISO 9001 international standard that specifies requirements for a quality management system (QMS)

IT Information Technology

ITIL Information Technology Infrastructure Library

ITSM Information Technology Service Management

LCS Longest Common SubString

MBI Management of Business Informatics

NLP Natural Language Processing

PAM Process Assessment Model

PRM	Process Reference Model
PRMs	Process Reference Models
SO	Service Operation

1

Introduction

Contents

The awareness that business involvement is crucial in the governance of IT initiated a shift in the definition of IT Governance toward EGIT [6].

EGIT can be defined as ”an integral part of corporate governance which 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” [7].

Several authors argue that organizations should implement EGIT over the use of frameworks, best practices, and ISO standards (due to readability reasons, hereafter called EGIT Frameworks) [8]. Moore [9] identified approximately 315 EGIT frameworks, and the number of EGIT frameworks has now increased, as have their application areas, since some of these EGIT frameworks only cover a specific aspect of IT, such as information security, service management, quality, among others.

This situation allows organizations to select and complement their processes from the EGIT frameworks which better fit their contexts [10]. Researchers agree that Control Objectives for Information and Related Technologies COBIT, Information Technology Infrastructure Library ITIL and ISO 27000 family are the most valuable and popular EGIT frameworks currently being adopted [11], [12]. Research also indicates that organizations are widely adopting COBIT in practice [6], [12], [13].

COBIT, now in its fifth edition, is a Process Reference Model (PRM) that provides a comprehensive practice that assists enterprises in achieving their objectives for the governance and management of enterprise IT [14]. In turn, ITIL is a PRM that provides descriptive guidance on the management of IT processes, functions, roles, and responsibilities related to Information Technology Service Management (ITSM) [15]. Because of its high-level, broad coverage, COBIT can act as an integrator and can be mapped to other EGIT frameworks that cover specific areas in more detail such as ITIL [16].

For COBIT and ITIL, as PRMs, process management requires each process to be controlled to remain compliant with the objectives of both IT and business [17]. Therefore, PRMs are always related to a PAM which holds all details to determine the capability of the processes of the reference model [18]. A process assessment is conducted to get a clear view of the current practices in an organization in a particular domain. The goal is to compare these EGIT frameworks to a renowned reference so that the current status of the processes can be measured and appropriate suggestions for process improvement can be made.

TIPA for ITIL PAM and COBIT PAM are two well-known PAMs. They are based on ISO/IEC 15504 [19], [20], which is a global reference for conducting process capability assessments. From an assessment perspective, both TIPA for ITIL and COBIT 5 PAM break down each process into Base Practices specific to each process and take into account generic practices, which are not restricted to any particular process.

Nowadays, the increasing demands of the different industries coupled with compliance requirements, have forced organizations to adopt multiple EGIT frameworks [21], which add even more complexity to the field, since organizations struggle with the perceived complexity and difficulty of understanding and adopting several frameworks at the same time [22].

Complexity, in general, can be defined as "property of a language [representation] expression which makes it difficult to formulate its overall behavior, even when given almost complete information about its atomic components and their inter-relations." [23]. Choosing this generic and overarching definition enables the adoption to various fields of application and incorporates specific complexity theories, views, and paradigms [24].

Complex systems can be understood as a heterogeneous amount of elements with diverse inter-relations and dependencies [25], [26], [27]. In this context, complexity can be divided into multiple dimensions. Namely, these are task related complexity, structural complexity and time-related complexity/dynamics [21], [28]. While structural complexity can be quantitatively measured [29], the remaining dimensions often depend on the subjective reception of an object by the observer [30], [31]. This observation leads to differentiation between real or structural complexity and perceived complexity [32], [33], which is the type related to EGIT frameworks implementation.

At a time when organizations strive to be efficient and effective, it seems counterintuitive to be wasting resources by having different organizational departments handling both approaches independently [34]. However, the literature lacks a proposal that can assist and guide organizations in assessing different frameworks in a multi-framework environment [4]. Identifying differences, similarities and reducing issues related to the overlapping [35] can be a good start to optimize the costs and risks in the process assessment.

Semantic similarity defines the relatedness between texts based on the likeness of their meaning [36]. Therefore, Semantic Similarity Measures can calculate and present the distance between terms and concepts so that stakeholders can be aware of the overlaps that may exist between different EGIT frameworks.

To sum up, the problem this research intends to help solve is: **The terminological disparities between ITIL V3 2011 and COBIT 5 makes best professional judgment the only approach currently available to understand the overlapping between COBIT 5 and ITIL, hindering their simultaneous assessment**.

1.1 Research Objective

The objective of this research is to perform a comparison, based on a semantic evaluation, of COBIT and ITIL process assessment core concepts (base practices, inputs/outputs, outcomes/expected results) in order to highlight the overlapping between these concepts and, in a certain way, facilitate the simultaneous assessment of these EGIT frameworks by identifying common aspects of both frameworks. It is important to highlight that in the process assessment model those core concepts are all considered in the assess of maturity level 1.

1.2 Research Methodology

This research follows the Design Science Research Methodology (DSRM). DSRM involves a rigorous process to design artifacts to solve observed problems, to make research contributions, to evaluate the designs, and to communicate the results to appropriate audiences [1]. Walls et al. [37] argue that the widespread adoption of DSRM within the field of Information Systems research will have more impact on management practice as a result of closer ties between researchers and practitioners. Hence, [38] posits academics should conduct design science research more regularly. Unfortunately, the application of design science research within the context of EGIT remains relatively low [39].

DSRM is appropriated for research that seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifact [40]. DSRM differentiates from other research paradigms because it tries to develop and reach artifacts that can be proven effective in real-world scenarios [1]. A methodology can be seen as a system of principles, practices, and procedures applied to a specific branch of knowledge. According to [1], a methodology for design science research would include three elements: conceptual principles to define what is meant by design science research, practice rules, and a process for carrying out and presenting the research. The process model consisting of six iterative activities is described next:

- **Problem Identification and Motivation:** The terminological disparities between ITIL V3 2011 and COBIT 5 makes best professional judgment the only approach currently available to understand the overlapping between COBIT 5 and ITIL, hindering their simultaneous assessment.
- **Definition of the objectives for the solution:** To perform an integration, based on a semantic evaluation, of COBIT and ITIL process assessment core concepts (base practices, inputs/outputs, outcomes and expected results) in order to highlight the overlapping between these concepts and, in a certain way, facilitate the simultaneous assessment of these EGIT frameworks by identifying common aspects of both frameworks.
- **Design and Development:** Use of the spaCy library and AgreementMakerLight framework for evaluating COBIT 5 PAM and TIPA for ITIL similarity.
- **Demonstration:** Semantic Similarity between TIPA for ITIL and COBIT PAM.
- **Evaluation:** Compare the accuracy of the results against a benchmark proposed by a group of human experts.

- **Communication:** Submission to the 52nd Hawaii International Conference on System Sciences (HICSS) conference. Dissertation.

In Figure 1.1 the authors adapted the DSRM methodology process to the research activities.

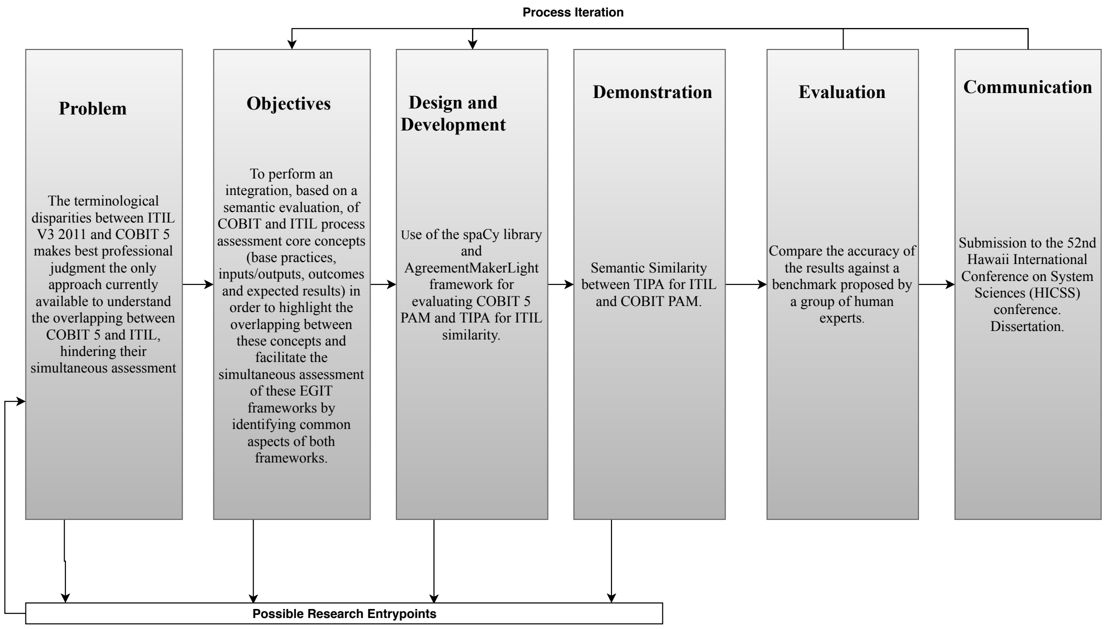

Figure 1.1: Mapping of research activities with DSRM. Adapted from [1].

1.3 Thesis Outline

In Table 1.1 the authors present the structure of this document, which is strongly influenced by the methodology used to conduct this research.

Chapters	Description
2. Research Problem	Statement of the research problem and motivation for this work.
3. Theoretical Background	State of art of the main concepts addressed in this research.
4. Related Work	Critical analysis of the main concepts and solutions related to this thesis context.
5. Research Proposal	Detailed description of the research proposal.
6. Demonstration	Demonstration of the results of this research.
6. Evaluation	Evaluation of the research results.
6. Discussion	Discussion of the results and considerations.
7. Conclusion	Final conclusions, research limitations, communication and future work.

Table 1.1: Thesis Outline.

2

Research Problem

Organizations, due to excessive complexity and high cost associated with the implementation and operation of EGIT frameworks [5], have yet to adopt frameworks such as COBIT and ITIL [41]. There is still confusion in IT organizations when it comes to their correct use and implementation [16].

COBIT requires expert knowledge [42] to deal with its level of complexity [43], lack of detail [44] and abundance of generality. ITIL on the other hand requires organizations to spend much time to perceive process diagrams and to achieve results due to the lack of work instructions and failure to maintain momentum [45].

Cater-Steel et al. [2] used the results from a survey conducted at the 2005 IT Service Management Forum (ITSMF) conference to highlight multiple framework adoption. The scope of the study was restricted to ITIL, COBIT, Capability Maturity Model Integration (CMMI) and ISO 9001. To explore the extent of multiple frameworks adoption, an analysis was conducted to determine which organization was implementing how many of those four frameworks. The result is presented in Figure 2.1.

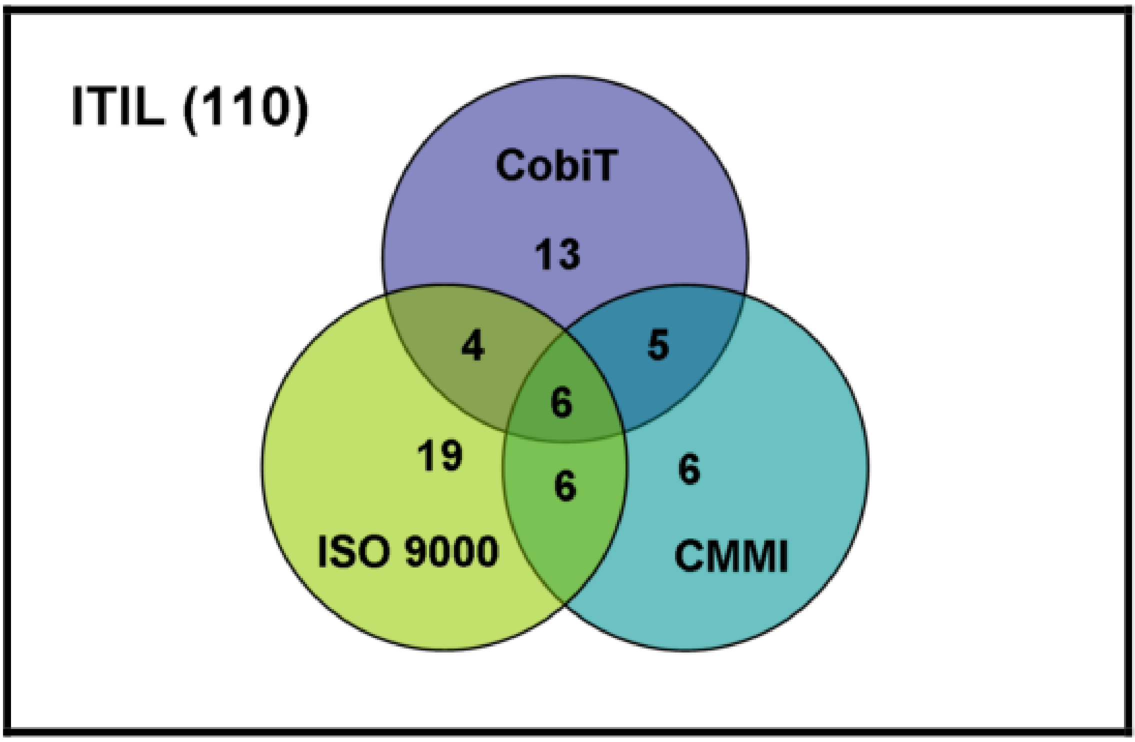

Figure 2.1: Number of organizations adopting ITIL, COBIT, CMMI and ISO 9001. From [2].

For some IT Managers, adopting multiple frameworks is a matter of legal compliance. For others, a risk management strategy, a cost-saving measure, or a means to satisfy customers more effectively [2]. The decentralization and liberalization of markets and economy are also putting IT departments and organizations under pressure to comply with internationally recognized process improvement frameworks [2].

However, the literature lacks a proposal that can assist and guide organizations in assessing different frameworks in a multi-framework environment [4]. Identifying differences, similarities and reducing issues related to the overlapping [35] can be a good start to optimize the costs and risks in the process assessment

The problem this research intends to help solve is: 'The terminological disparities between ITIL V3 2011 and COBIT 5 makes best professional judgment the only approach currently available to understand the overlapping between COBIT 5 and ITIL, hindering their simultaneous assessment'. Therefore, the primary objective of this research is to perform an integration, based on a semantic evaluation, of COBIT and ITIL process assessment core concepts (base practices, inputs/outputs, outcomes and expected results) in order to highlight the overlapping between these concepts and, in a certain way, facilitate the simultaneous assessment of these EGIT frameworks by identifying common aspects of both frameworks.

3

Theoretical Background

Contents

3.1 EGIT

EGIT is about defining and embedding processes and structures in the organization that enable both business and IT people to execute their responsibilities in creating value from IT-enabled business investments [7]. It is defined as ”an integral part of corporate governance which addresses the definition and implementation of processes, structures and relational mechanisms in the organization that enable both business and Information Technology IT people to execute their responsibilities in support of business/IT alignment and the creation of business value from IT-enabled business investments” [7].

Enterprises are increasingly making investments in improving EGIT by drawing upon the practical relevance of generally accepted good-practice frameworks [43]. Researchers agree that COBIT, ITIL, and ISO 27000 family are the most valuable and popular practices (frameworks and standards) currently being adopted [11], [12]. Research also indicates that organizations are widely adopting COBIT in practice [12], [6], [13].

The perceived benefits from implementing EGIT are enormous [46]. Among them include efficiency and control of IT functions, clear allocation of roles and responsibilities for IT functions, effective management of IT, increase IT control and standards, prioritization of IT initiatives, alignment between business and IT, return on investment and competitive advantage [46]. However, organizations have yet to adopt EGIT practices although they recognize those advantages [46]. There are several factors identified in the literature [46] that organizations face in the adoption process, such as, resistance to change, complexity, organizational politics, lack of knowledge and skills [46].

3.2 COBIT 5

COBIT, now in its fifth edition, provides a comprehensive framework that assists enterprises in achieving their objectives for the governance and management of enterprise IT [14]. COBIT 5 is based on five principles: meeting stakeholder needs; covering the enterprise end-to-end; applying a single, integrated framework; enabling a holistic approach; and separating governance from management [14]. Together these principles would allow enterprises to assemble and deploy an effective EGIT and management practice and thus support an outstanding balance between benefits realization, risk management and resources [16]. COBIT 5 unified ISACA's three frameworks: Val IT, a value delivery focused framework; Risk IT, a risk management focused framework and previous COBIT versions. Hence, this allowed COBIT 5 to cover the life-cycle of governance and management within the scope of enterprise IT [6].

3.3 ITIL

ITIL is a set of comprehensive publications providing detailed guidance on the management of IT processes, functions, roles, and responsibilities related to ITSM [18]. ITIL focuses life-cycles, renewal and decommissioning of services, with a greater business-focused perspective [47]. Its benefits have been addressed from a few relevant academic researchers, that frequently evidenced the following benefits: improvement of Service Quality, improvement of Customer Satisfaction, improvement of Return on Investment [48], [49]. ITIL seeks to provide a comprehensive and cohesive set of templates and best practices for core IT operational processes [2].

Strahonja et al. in [50], address some weaknesses regarding ITIL:

- Lack of holistic visibility and traceability from the theory (specifications, glossary, guidelines, manuals, amongst others) to its implementations and software applications;
- It focus on the logical level of processes, instructing what should be done but not how;
- Poorly definition of the information models corresponding to process description;

ITIL is currently administrated by the UK Office of Government Commerce and its best-practice processes are supported by the British Standards Institutes BS 15000 Standard for IT Service Management [2].

3.4 Process Assessment Models

To get a clear view of the current EGIT practices implemented, organizations apply what is called process assessment in particular domains.

The goal is to compare organization's processes to renowned references so that the current status of the organization's processes can be measured and appropriate suggestions for process improvement can be made. COBIT 5 PAM is a model that aims at assessing the capability of a COBIT 5 process. It scales six process capability levels defined on an ordinal scale, which starts from incomplete to optimizing processes. Process maturity has been a core component of COBIT for more than a decade [51].

TIPA is the result of more than ten years of research work, including experimentation on how to combine ITIL with the ISO/IEC 15504 [52]. TIPA uses the generic approach for process assessment published by the ISO in ISO/IEC 15504-2 – Process Assessment (now ISO/IEC 33000) (ISO/IEC 15504-1/2, ISO/IEC 33000). TIPA is a standards-based approach to ITIL (v2, v3 and v3 2011) 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 [53]. TIPA for ITIL PAM and COBIT PAM are based on ISO/IEC 15504 (ISO/IEC 15504-1, 2004; ISO/IEC

15504-2, 2003). It means that they both rely on the same foundation (ISO/IEC 15504), which is a global reference for conducting process capability assessments.

From an assessment perspective, both TIPA for ITIL and COBIT 5 PAM break down each process into base practices specific to each process and take into account generic practices, which are not restricted to any particular process.COBIT 5 PAM base practices are specific to COBIT processes and ensure proper governance and management of Enterprise IT while TIPA for ITIL base practices are specific to ITIL and guarantee the proper execution of the process to support the service delivery in line with customer needs.

3.5 Ontology Engineering

Ontologies are sets of concepts of a given domain [54]. Gruber et al. [55] defines ontology 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. Philosophically an ontology denotes a system of categories accounted for a particular vision of the world [56]. It can provide semantic context by adding semantic information to models [57]. Ontologies are evaluated through verification and validation, where the correct process of ontology building and the representation of the domain of disclosure are assessed [58] [59].

3.6 Ontology Integration

There is no clear consensus in the meaning of ontology integration. Pinto et al. in [60] expresses this difficulty. Different authors use different terms to refer to similar concepts [61]. The word integration can be presented with different meanings, which can be summarily described as [61]:

- **Matching:** the process of finding relationships or correspondences between entities of different ontologies.
- **Alignment:** a set of correspondences between two or more ontologies. The alignment is the output of the matching process.
- **Mapping:** the oriented, or directed, version of an alignment, it maps the entities of one ontology to at most one entity of another ontology.
- **Merging:** the creation of a new ontology from two, possibly overlapping, source ontologies.

Amrouch et al. [62] identifies three types of mismatches in the ontology integration:

- **Syntactic mismatches:** occurs when two ontologies are represented through different representation languages, resulting in syntactically heterogeneity;
- **Lexical mismatches:** are heterogeneities between names of entities, instances, properties or relations;
- **Semantic mismatches:** relates to the content of the input ontologies.

3.7 Methontology Methodology

The methodology, developed by Fernandez-Lopez et al. [3], aspires to produce ontologies at the knowledge level. During the ontology building process, is respected an ontology life cycle based on evolving prototypes. For each ontology's prototype, the first activity performed is the schedule activity where all the tasks to be performed are identified, arranged and a survey of the needed resources is done. During the ontology's life cycle three different types of activities are performed in parallel carrying an intra-dependency relationship, as shown in Figure 3.1: **management**, **development** and **support** activities.

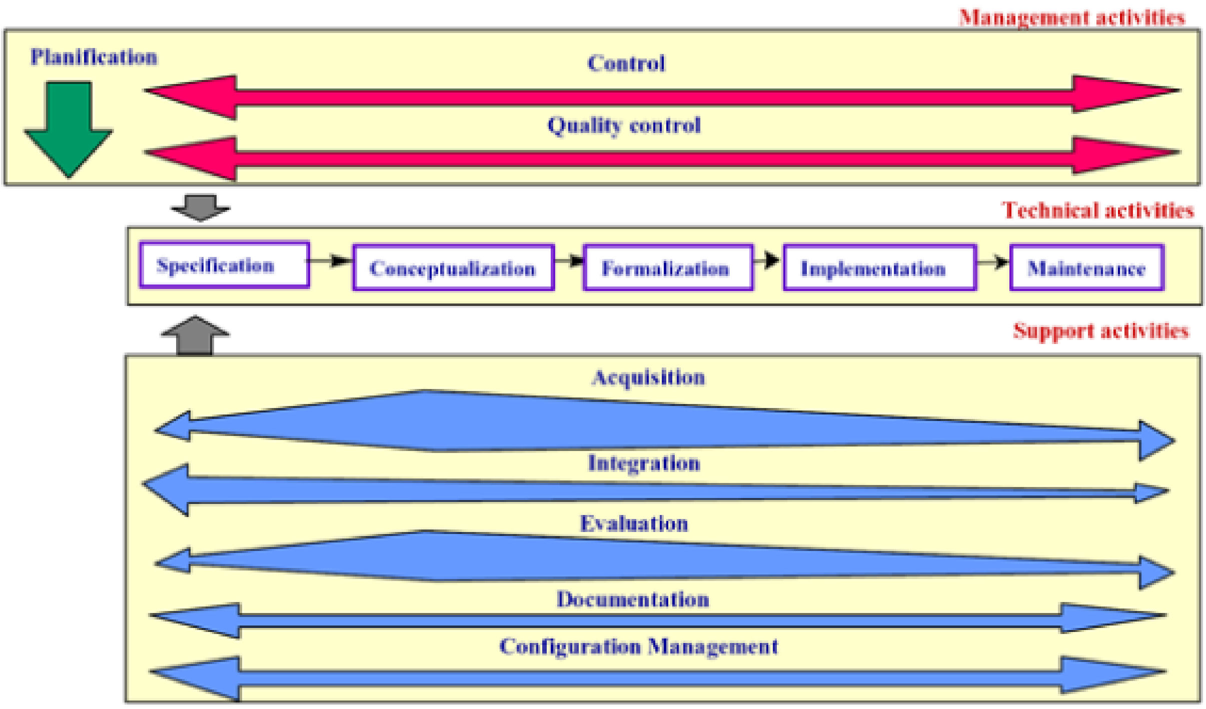

Figure 3.1: Methontology life cycle. From [3].

In the management activities, the control activity guarantees that the tasks to be performed meet the performance requirements and the quality assurance activity ensures the quality of every output of the ontology development process.

The development activities, the first activity, named Specification, is where a prototype is established and is stated the ontology significance, its intended uses and who the end users are. The Conceptualization activity is crucial for the rest of the ontology development, note that the knowledge acquisition and evaluation activities from the support activities are more significant in this phase. All the knowledge gathered will be, during the Conceptualization activity, structured and organized. This methodology proposes to firstly build a conceptual model and then formalize it to be implemented later in an ontology implementation language.

Finally, the support activities fluctuate during the ontology's life-cycle and include knowledge acquisition, integration, evaluation, documentation and configuration management.

In this methodology, the Conceptualization activity includes a set of tasks that aim to structure knowledge, concerning the primary ontology components.

3.7.1 Ontology Matching Systems

Ontology matching provides a mean to link concepts from different ontologies. It can be viewed as a process that takes as input two ontologies and outputs a set of correspondences between semantically related ontology concepts. Several matching algorithms, called matchers, are used to assign a numerical value to each mapping. This numerical value reflects the semantic similarity between different terms. There are different levels upon how those matchers can work, including the element level and the structural level. Element level matchers analyze concepts or their instances in isolation, ignoring their relations with other concepts or instances. Structure level techniques compare ontology concepts or their instances based on their relationships with other concepts or instances.

AgreementMaker [63] is one of the leading ontology matching systems, that combines flexibility and extensibility with a comprehensive user interface that enables alignment, visualization, and manual editing. Its derivative, **AgreementMakerLight** [64], is an automated ontology matching framework based on element-level matching and focused on computational efficiency, while designed to handle very large ontologies while preserving most of the flexibility and extensibility of the original AgreementMaker framework.

The AgreementMakerLight (AML) framework includes three key data structures: The **Lexicon**, the **Relationship Map**, and the **Alignment**. The first two data structures are the main components of Ontology Objects, i.e., representations of ontologies used in AML to support the matching process. As their names suggest, the Lexicon stores the lexical information of an ontology (i.e., the labels and synonyms of each term) and the Relationship Map stores the structural information of an ontology (i.e., the relationships between all terms). The Alignment stores the set of mappings between two ontologies produced by one or more matching algorithms.

AML implements six matchers that range from simple (label similarity) to complex (so-called, structural matcher), as well as three filters (e.g., cardinality filter). Each matcher is configurable, e.g., the string matcher has a choice of four similarity measures [65]. AML can calculate similarity scores resorting to external knowledge source, such as WordNet [65].

3.8 Natural Language Processing

Natural Language Processing (NLP) can be viewed as a pipeline with various stages, to extract as much knowledge as possible [66]. A range of computational techniques are used together with similarity measures for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis to achieve human-like language processing for a range of tasks or applications [66]. Typical stages are for example, Sentence Splitting and Tokenization, Removal of Stop words, Stemming,Parts-of-Speech Tagging and Lowercased tokens.

- **Sentence Splitting and Tokenization** is the process of chopping the sentences into pieces, called tokens and at the same time throw away certain pieces, such as punctuation [66].
- **Stop words** are common words which would appear to be of little value in helping select documents or sentence matching. Some example of Stop words are 'the', 'is', 'at' and 'on'.
- **Stemming** is a mechanism for transforming words in a way that if they represent the same meaning they are captured by the same token [66].
- **Parts-of-speech Tagging** relates to the large amount of information that tags give about a word and its neighbors [66]. Rule-based approaches generally involve a large dictionary and use hand-crafted rules to tag a text. Usually, there are two main steps: (1) with the help of a dictionary, one tags each word with all its possible labels, and (2) with the help of a set of (disambiguation) rules, one disambiguates these labels into a single one. These rules can specify, for instance, that a word following a determiner and an adjective must be a noun. The set of rules must be properly written and checked by human experts [66].

3.9 Sentences Similarity

There is extensive literature regarding the measure of the similarity between documents and sentences. It is broadly used in different fields such as NLP, artificial intelligence, and data mining [67]. An effective similarity measure should be able to determine whether two sentences are semantically equivalent, considering the variability of natural language expression [68]. Several similarity measures could be considered when measuring sentences and words:

- **String similarity** measures operate on string sequences and character composition. A string metric is a metric that measures similarity or dissimilarity (distance) between two text strings for approximate string matching or comparison [69].

- **Knowledge-Based** measures determine the degree of similarity between words using information derived from semantic networks [69].

- **Corpus-Based** measures determine the similarity between words according to information gained from large corpora. A Corpus is an extensive collection of written or spoken texts that are used for language research [69].

3.9.1 String-Based Measures

String-Based measures can be partitioned into two types of measures: character-based and term-based measures [69]. Character-based measures operate on the chars of the strings being measured [69]. There are several character-based measures as, for example, Longest Common SubString (LCS), N-gram, Damerau-Levenshtein, Jaro, among others. On the other hand, Term-based similarity measures operate over concepts. There are also several term-based similarity measures such as Cosine distance, Euclidean Measures, Jaccard similarity, among others [69].

Following there is a description of some of the string based similarity measures.

- **Longest Common Subsequence** (LCS) is the distance between the text and the hypothesis. The value is clamped between 0 and 1 by dividing the size of the LCS by the sentence with the longer length [66].

- **Edit Distance** is the size of the minimum edit distance between the text and the hypothesis [66].

- **Length** is the absolute length between the text and the hypothesis. Also, the maximum and minimum length are considered as separately features [66].

- **Jaccard Similarity** between the text and the hypothesis. The return value is a real number between 0 and 1, where 1 means equal, and 0 totally different [66]. The Jaccard similarity between two sets of words A and B is defined as follows:

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} \tag{3.1}$$

- **Jaccard Distance** measures dissimilarity between sample sets, is complementary to the Jaccard coefficient and is obtained by subtracting the Jaccard coefficient from 3.1 [66].

$$1 - J(A,B) \tag{3.2}$$

- **Cosine Similarity** computes the similarity between two documents d1 and d2 by their vector representations V(d1) and V(d2). The formula is described in equation 3.3. The return value is a real number between 0 and 1. The higher the value, the more identical is the text-hypothesis pair [66].

$$sim(d1, d2) = \frac{\vec{V}(d1).\vec{V}(d2)}{||\vec{V}(d1)|| * ||\vec{V}(d2)||} \tag{3.3}$$

- **Soft TF-IDF** similarity metric measures between vector-based representations of the sentences, but considering an internal similarity metric for finding equivalent words. The Jaro-Winkler similarity metric between words with a threshold of 0.9, as the internal similarity metric [66].

$$dj = \begin{cases} 0, & \text{if } m = 0 \\ \frac{1}{3} * (\frac{m}{|s1|} + \frac{m}{|s2|} + \frac{m}{|s2|} + \frac{m-t}{|m|}) & \text{otherwise} \end{cases} \tag{3.4}$$

- **N-Gram** a contiguous sequence of n items from a given sequence of text or speech. An n-gram of size 1 is referred to as a ”unigram”; size 2 is a ”bigram” [66].

- **Sorensen-Dice coefficient** Similar to Jaccard index, but this time the similarity is computed as [66]:

$$QS = \frac{2|A \cap B|}{|A| + |B|} \tag{3.5}$$

- **Optimal String Alignment** The Optimal String Alignment variant of Damerau–Levenshtein (sometimes called the restricted edit distance) computes the number of edit operations needed to make the strings equal under the condition that no substring is edited more than once [66].

- **Levenshtein Distance** is the minimum number of single-character edits (insertions, deletions or substitutions) required to change one word into the other [66].

- **Normalized Levenshtein** This distance is computed as Levenshtein distance divided by the length of the longest string [66].

- **Weighted Levenshtein** An implementation of Levenshtein that allows to define different weights for different character substitutions [66].

3.9.2 Knowledge-Based Measures

Knowledge-based similarity measures can be divided into two groups, more specifically, measures of semantic similarity and measures of semantic relatedness. Semantically similar concepts are deemed to be related based on their likeness. Semantic relatedness covers a broad range of relatedness between words such as is-a-kind-of, is-a-part-of kind or is-the-opposite-of [69].

3.9.3 Corpus-Based Measures

Corpus-based semantic representations exploit statistical properties of textual structure to embed words in a vector space. In this space, terms with similar meanings tend to be located closer to each other. These methods rely on the idea that words with similar meanings tend to occur in similar contexts [70].

Well-known methods in corpus-based similarity are the Latent Semantic Analysis (LSA) and the Hyperspace Analogues to Language (HAL) model [69]. In LSA, a set of representative words needs to be identified from a large number of contexts (each described by a corpus). A word by context matrix is formed based on the presence of words in that contexts and through the process of decomposition and reconstruction, LSA acquires word knowledge that spreads in contexts [71].

When the LSA method is used to compute sentence similarity, a vector for each sentence is formed in the reduced dimension space, and then the similarity is measured by computing the similarity of these two vectors using, for example, a distance metric such as Cosine distance. Like other methods, LSA ignores any syntactic information from the two sentences being compared. HAL is closely related to LSA, and they both capture the meaning of a word or text using lexical co-occurrence information. Unlike LSA, which builds an information matrix of words by text units of paragraphs or documents, HAL builds a word-by-word matrix based on word co-occurrences within a moving window of a predefined width [71].

More recently, neural-network language embeddings have received an increasing attention leaving aside classical word representation methods such as LSA. In particular, Word2vec models have become especially popular in embedding generations [70]. These models are trained to reconstruct linguistic contexts of words. Word2vec takes as input a large corpus of text and produces a vector space with each unique word in the corpus being assigned to a corresponding vector in the space. Word2vec methods have an advantage in handling large datasets since they do not consume as much memory as some classic methods like LSA.

It is important to state that in this research, the authors useed both, string based measures as well as corpus based measures. Taking advantage of the extensive study in the field of string based measures and the practicality and simplicity of implementation of those measures, the authors tested all the string similarity measures above presented. However, as the research evolved it became clear that the limitations of those measures, such as the fact that they only compare string and ignore variability of the words in contexts would compromise the results. Therefore, the authors decided to search and apply other techniques more suitable for this research purpose. After considering the two measures left, Knowledge and Corpus, the authors decided to take advantage of the extensive work that has been done in the field of corpus based similarity measures.

4

Related Work

Contents

There are a number of proposals which have been defined and that are in current existence, related to the combination of multiple EGIT practices. On that subject, the authors are going to highlight the most important aspects of some related works and the differences between them and this research proposal with highlight in the combination of COBIT and ITIL.

4.1 Harmonization of multiple reference models

Pardo et al. in [4] presented a framework called HFramework, illustrated in Figure 4.1, to support harmonization of multiple reference models. The aim is to present a model, framework independent, that can be used to harmonize different reference models and not only a specific set, e.g., Capability Maturity Model Integration (CMMI), ITIL and ISO 9001.

The document presents a framework that defines elements needed to support the harmonization of multiple reference models, a process, which is the backbone and way of integrating all the elements defined in the framework thus allowing the implementation of a harmonization project to be guided systematically, harmonizing multiple models through the configuration of a harmonization strategy, and a set of methods, which allows us to know "what to do", as well as "how to put" two or more models in consonance with each other.

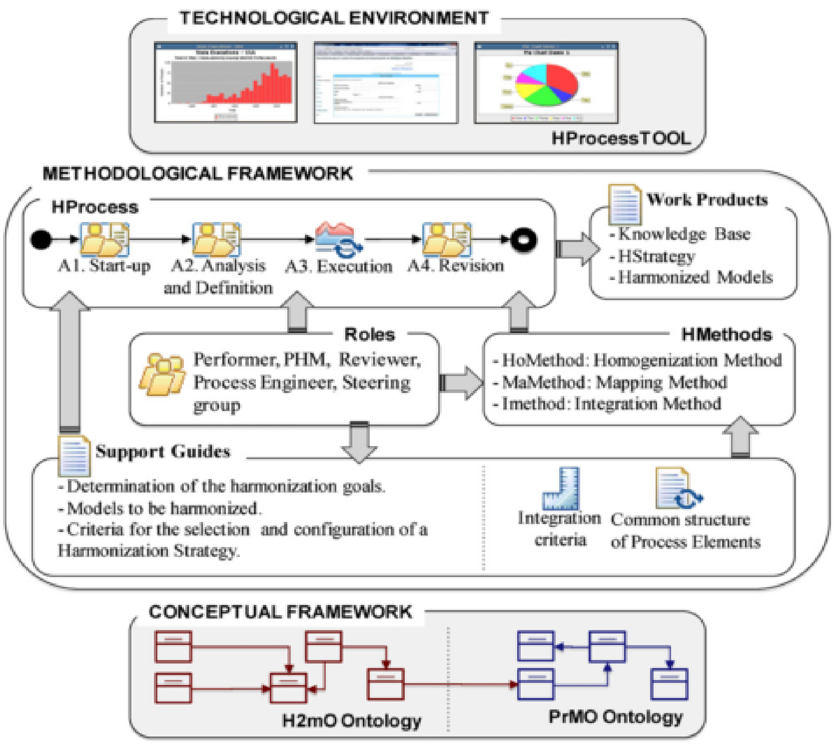

Figure 4.1: Framework for supporting harmonization of multiple reference models. From [4].

4.2 Combining COBIT and ITIL

Hill and Turbitt in [16] combine ITIL and COBIT to meet business challenges. The document presents an overview of COBIT and ITIL, describes how they are complementary, discusses the need to use systems-based solutions to ensure success in implementing these frameworks, and finally presents criteria that these solutions should meet.

ITIL is becoming a de facto worldwide standard as organizations adopt it as their guideline for establishing ITSM processes. COBIT 4.1, because of its high level broad coverage and because it is based on many existing practices, can be viewed as an integrator that brings different practices under one practice and helps link those practices to strategic business objectives.

Business Service Management (BSM) results from the combination of COBIT and ITIL to help organizations manage IT from a business perspective. ITIL focuses mainly on the best practice of ITSM processes geared toward aligning of IT with the business. COBIT, besides of offering an effective mechanism for managing and measuring progress in implementing ITIL processes it also helps the organization shape ITIL processes to the business needs and goals.

Due to the complexity of combining COBIT and ITIL, some requirements that ITSM solutions should meet to help organizations speed up the adoption are proposed. It should be comprehensive and integrated, business oriented, underpinned by a Configuration Management Database (CMDB) and provide support for ITIL and COBIT.

4.3 Challenge of Adopting Multiple Process Improvement Frameworks

Cater-Steel and Toleman in [2] describes the processes included in ITIL, COBIT, CMMI and ISO 9001 and their increasing international diffusion throughout the Information Technology community. The document also presents the possible motivation, significance and implications of multiple process frameworks adoption.

This study summarize current research on multiple concurrent process framework implementations, and provides survey and case study evidence indicating that many organizations are in fact at various stages of adoption of various frameworks. It provides answers to ”why are IT managers adopting multiple frameworks?” and ”what are the implications of this practice?”.

Organizations have been urged to adopt multiple frameworks. Managers are advised that IT service management and governance frameworks are not mutually exclusive, and when combined provide powerful IT governance, control and best practice in IT service management. Although ITIL provides good documentation of IT process flows and interactions, it is not a complete approach in that it lacks a specific measurement system for process improvement. Organizations are urged to use COBIT to put their ITIL program into the context of a wider governance and control framework.

However, Implementation of the frameworks for some can be seen as either as bureaucratic overkill, ”flavor of the month” or as certification hunting by individuals and organizations. Furthermore, another issue arises related to the optimal sequence of implementing the processes within each framework. This problem is exacerbated with multiple frameworks, in particular due to the inter-relationships and process overlaps.

4.4 Extending MBI Model using ITIL and COBIT Processes

Karkoskova et al. [5] proposed extensions to the Management of Business Informatics (MBI) to incorporate IT Performance Management and a Capability Maturity Model. TheMBI framework defines objects that describe processes for the management of enterprise IT. To analyze the relationship between MBI, ITIL and COBIT, a map between MBI tasks to ITIL and COBIT processes was made.

ITIL V3 2011, and COBIT 5 differentiate between IT governance and IT management. COBIT defines a clear distinction between the company management (governance) and the executive management (management) [5]. ITIL does not emphasize the need for the separation of IT governance and IT management, but has separate publications that cover governance and management [5].

Figure 4.2 is an excerpt of the mapping between COBIT 5 processes and ITIL v3 processes. Full image can be found in [5].

	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 Management	Information Security Management	Supplier Management	The seven-step improvement process	IT service continuity management	Event management	Incident Management	Request Fulfilment	Problem management	Access management
APO Align, Plan adn Organize																	
APO01 Manage the IT mangement Framework											■						
APO02 Manage Strategy	■																
APO05 Manage Portfolio		■															
APO6 Manage Budget and Costs			■														
APO08 Manage Relationships			■	■													
APO09 Manage Service Agreements			■	■			■	■									
APO10 Manage Suppliers										■							
APO13 Manage Security																	
DSS Deliver, Service and Support																	
DSS01 Manage Operations													■				
DSS02 Manage Service Requests and Incidents														■	■		
DSS03 Manage Problems																■	
DSS04 Manage Continuity												■					
DSS05 Manage Security Services																	■

Figure 4.2: Mapping of COBIT and ITIL processes. Adapted from [5].

4.5 Towards Conceptual Meta-Modeling of ITIL V3 and COBIT 5

ArchiMate is an Enterprise Architecture (EA) modeling language [72]. It provides an architectural approach to describe and visualize different concepts of the types: active structure, behavior, and objects, as well as it defines their relations. Based on specializations of the core concepts, the language defines three main layers: Business, Application and Technology.

Percheiro et al. in [73] discussed and presented a way to represent ITIL meta-model in ArchiMate, as well as its integration with the COBIT meta-model. Furthermore, presented an approach for the integrating of these EGIT frameworks in a conceptual way.

4.6 Combining ITIL, COBIT and ISO/IEC 27002

Gehrmann et al. in [74] analyzed ITIL, COBIT, and ISO/IEC 27002 practices through a bibliographic review, highlighting their similarities and differences. From that, proposed a general structure for the combination of those practices which can be used by any organization as a broader solution for the management and support of IT.

4.7 Integrating COBIT 5 PAM and TIPA for ITIL Using an Ontology Matching System

The following work is a result of the research where the main author of this research, Bruno Borges, collaborates with his colleague, Inês Percheiro, and it is presented in the Percheiro's dissertation document [75].

Percheiro et al. in [75] proposes an ontological approach for describing ITIL's and COBIT's PAMs and through semantic mismatches between their process assessment core concepts (base practices, inputs/outputs, outcomes and expected results) achieve an alignment between those PAMs.

Ontologies are disseminating in Computer Science, and its importance is being recognized especially in information modeling and information integration. It describes a hierarchy of concepts related by subsumption relationships, (Is-a), and are meant to clarify, and formally represent the structure and knowledge of a domain. Ontology mapping, is one of the fundamental ontology operations. It is performed by taking two or more ontologies as input and presents a set of semantic similarity relations between those ontologies concepts.

The authors developed two ontologies, one of TIPA for ITIL and the other of COBIT 5 PAM. The methodology used in the development of the ontologies was the Methontology methodology.

To align the two ontologies, TIPA for ITIL and COBIT 5 PAM, based on the semantic comparison between their concepts the authors used AML. AML is one of the leading ontology matching system currently used. It is derived from the original ontology matching system The AgreementMaker [63].

The authors presented two alignments. One based on the combination of the names and the descriptions of the base practices of TIPA for ITIL and COBIT 5 PAM. The other one based only on the description of the base practices.

This research only focused within a subset of processes, namely the processes that belong to the Service Operation (SO) life-cycle of ITIL and its related domain in COBIT 5 – the Deliver, Service and Support (DSS) domain. These processes were chosen because, according to ISACA, the initial focus on any process assessment would be the core (sometimes called primary) processes, which are primarily part of the Build, Aquire and Implement (BAI) and DSS domains.

Figure 4.3 is the top 5 result of the comparison between the base practices of the two PAMs based on the name and description attribute. While the Figure 4.4 is the top 5 result of the comparison based only in the description attribute.

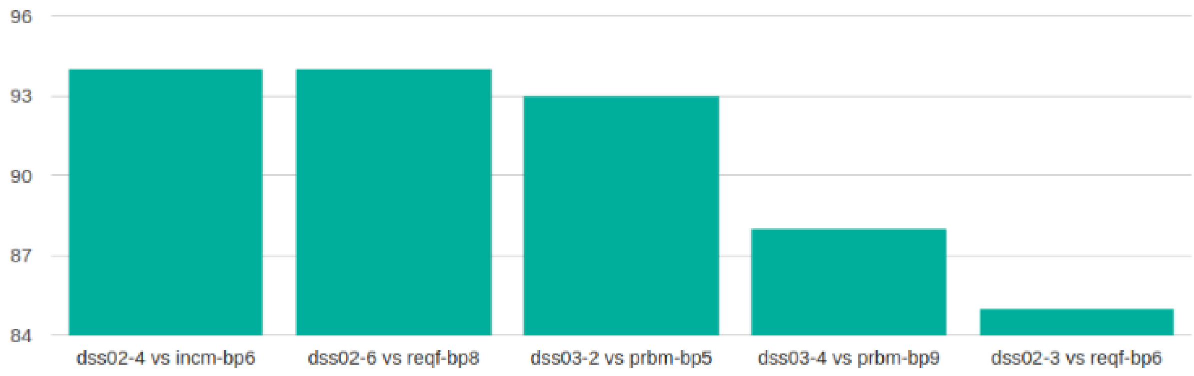

Figure 4.3: Top 5 comparisons between TIPA for ITIL and COBIT 5 PAM Base Practices.

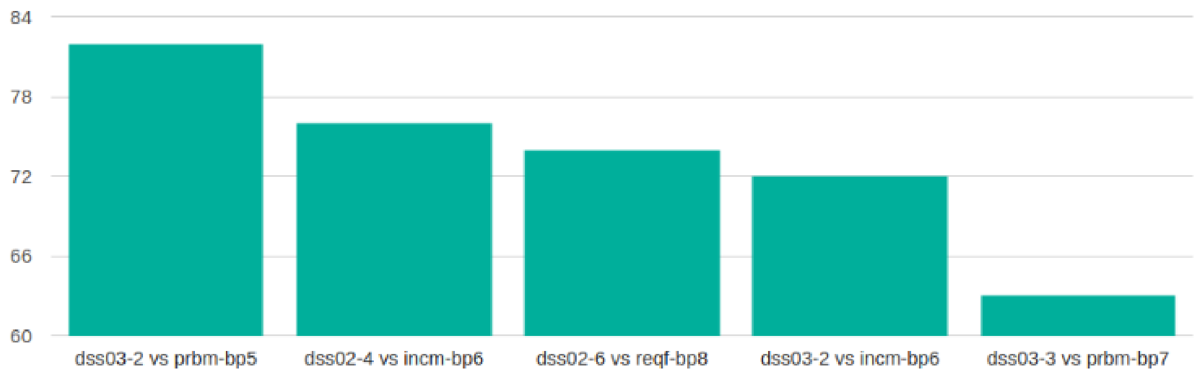

Figure 4.4: Top 5 comparisons between TIPA for ITIL and COBIT 5 PAM Base Practices with only the basepractice-description being evaluated.

The authors argue that the results were not what was expected. When the base practices names and descriptions were considered in the comparison, the results were not consistent with the results when the name of the base practices was omitted.

Taking for example the comparison between the COBIT 5 DSS02-BP4 base practice and ITIL INCM-BP6 base practice. When the name and description attributes were considered in the calculation of the similarity it achieved the highest degree of similarity between base practices with a score of 94%. But when the name was omitted the higher score of similarity was 82% and for different base practices, the COBIT 5 DSS03-BP2 base practice and ITIL PRBM-BP5 base practice.

Since the descriptions have a higher level of coverage, it was expected that the descriptions would have more importance in the calculation of the similarity results. Therefore, these results were likely to be biased.

In this research the authors used an ontology matching system to align COBIT 5 PAM and TIPA for ITIL core concepts. There are some challenges to be considered when using ontology matching systems [76]. Ontology matching errors such as false positives (where irrelevant matching between concepts is found as relevant) and false negatives (where relevant matching between concepts is found as irrelevant) is one of the reasons for the low performance of the ontology matching systems. If false positives are high, then precision becomes low. If false negatives are high, then the recall becomes low. Precision can be 1.0 if False Positive (FP) becomes zero. Precision share the reliability of match predictions. Recall calculates the real matches. If precision becomes high but recall becomes very low, then overall performance becomes very low. To handle this problem Anam et al. in [76] proposed to increase the value of recall. The authors of this research didn't considered the values of the precision and recalls so there are no way to determine the degree of performance of the matchings.

Selecting matchers is not feasible if the users do not have proper knowledge about the systems [76]. To avoid the matchers' selection, users try to use the default combination. In the largely differing matching problems of diverse domains, the default configuration is not appropriate [76]. The authors of this research used the default matchers.

Furthermore, it is important to state that, there where large amount of data to be processed. Creating an ontology for all the data can be very time consuming. There are alternative systems such as relational database systems. One fundamental difference between ontology and relational database system is that databases are created as effective data warehouses, whereas ontologies are formed for better communication, interoperability, and as the communication bridge between a human and a machine [77].

4.8 Analysis

Following are the main characteristics of the related works here presented:

- Works where only two process reference models where combined.
- Works that combines two or more reference models.
- Works that proposes new models.
- Works that provide analysis of multiple models or related concepts.
- Works that uses ontology matching system to combine two reference models.

Currently however, the software engineering community has shown an ever increasing interest in harmonizing multiple frameworks [4]. Organizations may currently need more than one framework to support and achieve the organization's strategic goals. There are some works on the field [4]. However, these works have limitations, such as, addressing specific set of frameworks, e.g. CMMI, ITIL and international standard that specifies requirements for a quality management system (QMS) (ISO 9001). Therefore, there is a lack of proposals and it is necessary to define more elements and tools which make it possible to address different needs which have not been taken into account within a multi-framework viewpoint. An example of this would be the need to reconcile the structural differences found between frameworks first, before carrying out their comparison and/or integration. There should be integration criteria to support the definition of multi-framework processes and a definition of combination solutions from the business needs of organizations [4].

Considering all that has been said, the authors proposed an novel approach based on relational database mechanism to store the information regarding the frameworks and use NLP techniques to combine multiple frameworks in a web based application and present their similarity results.

5

Research Proposal

Contents

In this section, the authors explain how they used semantic similarity techniques to compare COBIT 5 PAM and TIPA for ITIL v3.

5.1 Description

In order to fulfill the previously mentioned objective and solve the research problem, the authors applied several sentences similarity measures and NLP techniques to make the comparison between COBIT 5 PAM and TIPA for ITIL core concepts.

The authors started by implementing and testing String-based measures such as Longest Common SubString (LCS), the Cosine and the Jaccard Distance measures together with a range of computational techniques that are normally used for analyzing and representing naturally occurring texts such as Sentence Splitting and Tokenization, Removal of Stop words, Stemming, Parts-of-Speech Tagging and Lowercased tokens. The Wordnet was also used as a lexical reference system.

However, these similarity measures and techniques have some limitations when used in certain contexts. They typically exclude similarity features beyond content per se, thereby implying that similarity can be computed by comparing text content exclusively, leaving out any other text characteristics. For example, the variability of natural language expression and word context in sentences are ignored when evaluating sentences similarity. Compromising in that way the semantic meaning of the sentences.

Therefore, more advanced techniques and measures were considered to increase the robustness of this proposal. Due to their strong dependence on the availability of an ontology [78], which falls out of the scope of this research, the authors did not apply Knowledge-based measures. Corpus-Based measures was then the right measure to follow.

Recently, neural-network language embeddings have received increasing attention [70]. So, the authors searched for embedding models to apply in this research. From the research the authors discovered spaCy. spaCy is an open source software library for advanced Natural Language Processing. The library is published under the MIT license and currently offers statistical neural network models for several languages such as English, German, French, and various others. The similarity between sentences is calculated by comparing word vectors or ”word embeddings” that are multi-dimensional meaning representations of a word. When processing natural language, spaCy starts by tokenizing the text to produce a Doc object. The Doc is then processed in several different steps called ‘processing pipeline’. The pipeline used mainly consists of a tagger, a parser, and an entity recognizer.

- **Tagger** assigns part-of-speech tags, which is the process of marking up a word in a text as corresponding to a particular part-of-speech (noun, verb, etc.) based on its definition and context.

- **Parser** assigns dependency labels.

- **Named Entity Recognition** (NER) detects and labels named entities, that seeks to locate and classify named entities in text into pre-defined categories such as the names of persons, organizations, locations, and so forth.

Figure 5.1 describes the spaCy processing pipeline.

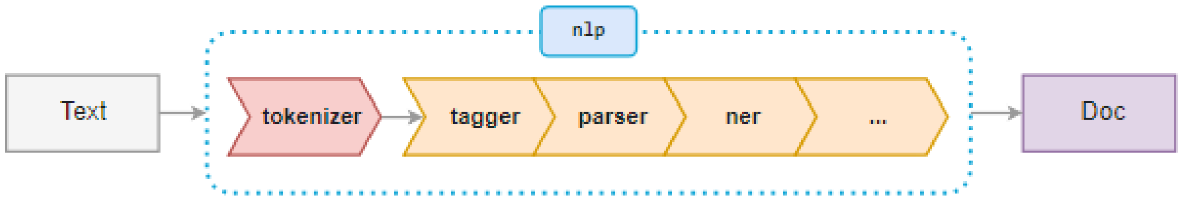

Figure 5.1: spaCy Processing Pipeline

The sentences to be evaluated are all written in the English language. Therefore, the authors used spaCy English models to calculate the semantic similarity between sentences. Several English models are offering different techniques for natural language processing. spaCy *en_core_web_sm* is the simplest and the smallest model. It uses context vectors in the pipeline processing to generate vectors by locally clustering the context for each word. It is very efficient and fast.

However, according to the spaCy documentation, the results are better with larger models since in larger models each individual token has assigned vectors and they provide a larger vocabulary with more vectors. Therefore, the authors used a larger model (*en_core_web_md*) in the sentence semantic similarity calculation to improve the results. The main issue with a larger model is the fact that it is very time consuming taking several hours to compute the results here presented.

The individual processes of each practice is described regarding the process name, purpose, and outcomes. The process dimension of the process assessment model provides information in the form of:

- Base practices (BPs) for the process, defining the tasks and activities needed to accomplish the process purpose and fulfill the process outcomes. Each BP is explicitly associated with a process outcome.

- Input and output work products (WPs) associated with each process and related to one or more of its outcomes.

- Characteristics associated with each WP.

5.2 Design and Development

We begin this research by implementing a web application that through selection of COBIT and ITIL processes, shows the result of the evaluation of semantic similarity between the core concepts of those frameworks.

Figure 5.2 describes the main page of the web application developed. In this page, the stakeholders can select one or several processes from COBIT and ITIL frameworks and measure the semantic similarity between those processes core concepts, base practices, inputs and outputs/work products and outcomes.

Figure 5.2: Selection of the COBIT process DSS02 and ITIL process INCM to evaluate the semantic similarity between their core concepts.

However, as this research progressed and the requirements evolved, we decided to go further and proposed a new and novel way of measuring the similarity between each COBIT and ITIL process based on the results of the similarity previously calculated. The main architecture of this proposal is presented as a bottom-up approach shown in Figure 5.3.

For the calculation of the similarity scores between base practices, outcomes, and work products, the authors adopted a pairwise similarity comparison between sentences. Pairwise comparison is defined as a process of comparing entities in pairs. Therefore, the authors compared these three core concepts of COBIT 5 PAM and TIPA for ITIL.

The similarity score for each core concept (base practice, outcomes, and work product) is calculated by the average of the similarity scores between the highest similarity score of each concept instantiation. An example of this situation is illustrated in Figure 5.4. This means that, in a hypothetical case, the sim-

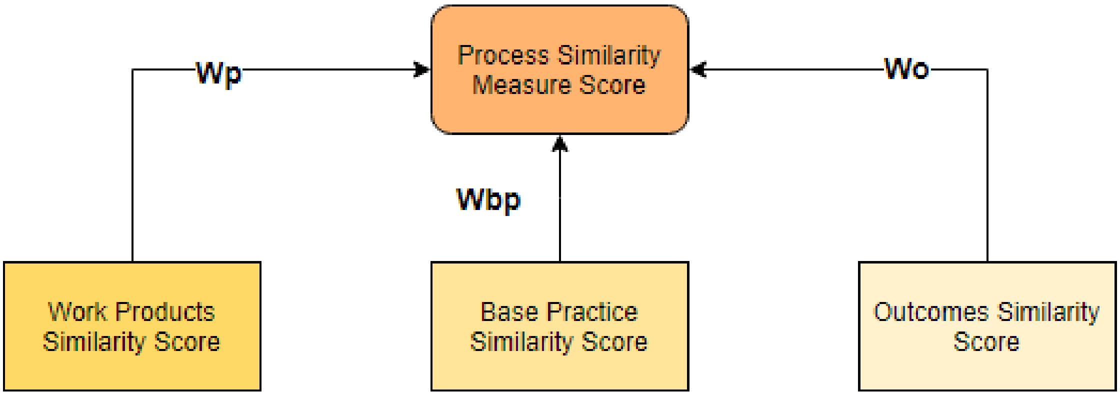

Figure 5.3: Bottom-up approach to the calculation of the processes overall similarity.

ilarity score for the Base Practices concept can be the average of the similarity between Base Practice A → Base Practice' A + Base Practice A → Base Practice' B + Base Practice A → Base Practice' C + Base Practice A → Base Practice' D + Base Practice A → Base Practice' E since Base Practice A is the one that has the highest similarity scores with all the Base Practices'.

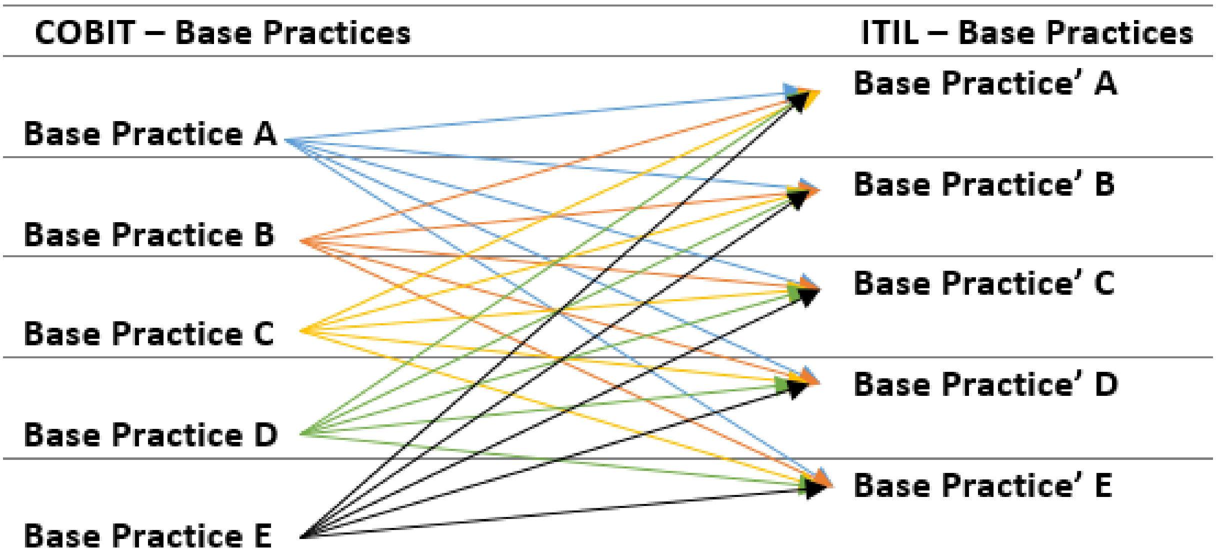

Figure 5.4: Pair comparison combinations between concepts.

The overall similarity score for the processes is then calculated as described in the equation 5.1, where *PS* is the process similarity score, *WPS* is the work product similarity score, *BPS* is the base practice similarity score and *OS* is the outcome similarity score. In this research, the authors considered that all the core concepts have the same weight (1/3).

$$PS = WPS * \frac{1}{3} + BPS * \frac{1}{3} + OS * \frac{1}{3} \tag{5.1}$$

Sentences with similar meanings should score near 100 percent, and sentences with different meanings should score near to 0 percent. Hence, PS value close to 100 percent means the process being compared have similar meanings while value close to 0 means have different semantic meanings.

5.3 Demonstration

Figures 5.5, 5.6 and 5.7 are the results of the three core concepts, base practice, inputs and outcomes respectively, evaluated from the previous selection of process in the Figure 5.2. The similarity is calculated by measuring of the similarity between all the sentences from core concepts of the processes been evaluated. The processes selected in this demonstration are the COBIT DSS02 Manage Service Requests and Incidents and its related (according to the ISACA publication) ITIL Incident Management process. These processes were chosen because, according to ISACA [14], the initial focus on any process assessment should be the core (sometimes called primary) processes, which are primarily part of the Deliver, Service and Support (DSS) and Build, Acquire and Implement (BAI).

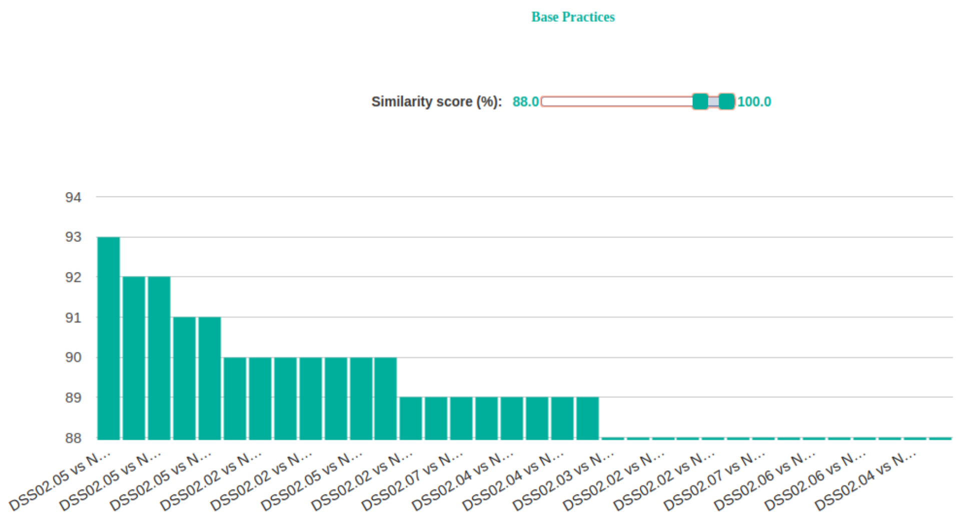

Figure 5.5: Base practices sentences comparison results.

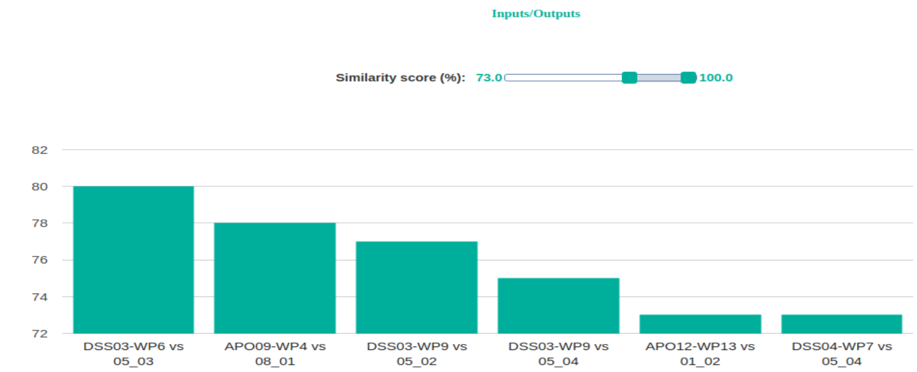

Figure 5.6: Work product sentences comparison results.

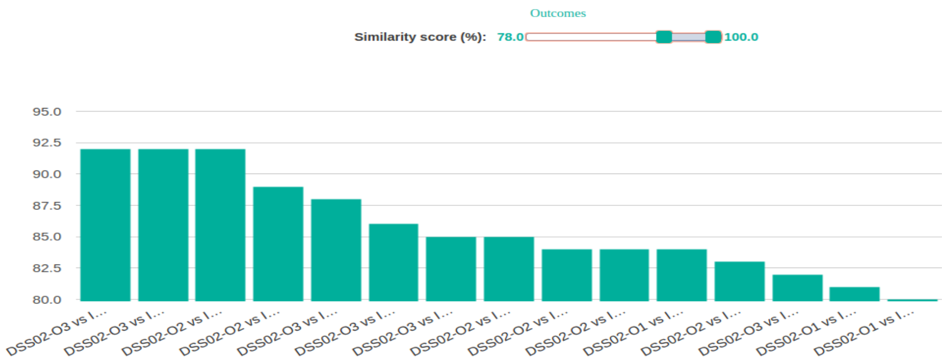

Figure 5.7: Outcome sentences comparison results.

5.4 Evaluation

Reasoning about the semantic relatedness of natural language expressions is regularly performed by humans but remains a challenge for computers [79]. 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. Thus, human's interpretation of a word in a document is far from their background knowledge and experience [38]. Humans have an innate ability to judge semantic 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 [79].

Figures 5.8, 5.9 and 5.10 presents the results using the spaCy library. Each cell represents the result of the semantic similarity between the two process being evaluated applying the equation described in 5.1. In each row, the highest similarity values are highlighted with three colors, yellow, green and red. The yellow cells represents the cells whose value should have been higher for that row, according to the ISACA benchmark in Figure A.1, but failed to do so. In such cases, the red cells represents the higher similarity scores for those rows. Finally, the green cells represents the cells whose similarity values are higher for that row and matches to the human benchmark. The results presented are from the COBIT and ITIL domains with more matching between processes according to the ISACA benchmark.

	Service Transition						
	Transition Planning and Support	Change Management	Service Asset and Configuration Management	Release and Deployment Management	Service Validation and Testing	Change Evaluation	Knowledge Management
Build, Aquire and Implement							
Manage Programmes and Projects	85.70%	84.90%	81.90%	84.68%	83.40%	83.6%	83.30%
Manage Requirements Definition	83.30%	82.80%	80.90%	82.9%	82.70%	81.89%	81.90%
Manage Solution Identifications and Build	85.00%	85.2%	82.55%	85.0%	84.40%	83.30%	83.79%
Manage Availability and Capacity	80.89%	80.56%	78.29%	81.4%	80.84%	79.26%	79.97%
Manage Organisational Change Enablement	83.93%	84.05%	83.49%	84.54%	83.40%	81.90%	83.70%
Manage Changes	86.14%	87.30%	83.49%	86.46%	84.90%	86.80%	83.70%
Manage Change Acceptance and Transitioning	84.82%	86.65%	80.98%	84.61%	85.30%	83.70%	82.58%
Manage Knowledge	82.82%	82.93%	83.359%	84.42%	83.43%	81.60%	85.65%
Manage Assets	81.7%	80.6%	82.94%	83.25%	81.50%	79.70%	81.30%
Manage Configuration	79.55%	81.97%	85.28%	81.13%	80.80%	79.75%	80.53%

Figure 5.8: Result of semantic similarity between process of domains Build, Aquire and Implement from COBIT and Service Transition from ITIL.

From Figure 5.8 one can observe that the correlation with the human mappings presented in Figure A.1 is:

- 87.30% (Manage Changes → Change Management);
- 84.82% (Manage Change Acceptance and Transitioning → Transition Planning Support);
- 84.61% (Manage Change Acceptance and Transitioning → Release and Deployment Management);
- 85.30% (Manage Change Acceptance and Transitioning → Service Validation and Testing);
- 83.70% (Manage Change Acceptance and Transitioning → Change Evaluation);
- 85.65% (Manage Knowledge → Knowledge Management);
- 80.6% (Manage Assets → Change Management);
- 81.97% (Manage Configuration → Change Management);

	Service Operation				
	Event Management	Incidente Management	Request Fulfilment	Problem Management	Access Management
Deliver, Service and Operation					
Manage Operation	79.60%	78.40%	77.30%	76.00%	79.96%
Manage Service Requests and Incidents	82.20%	81.80%	82.50%	80.60%	83.58%
Manage Problems	81.50%	80.50%	78.88%	83.20%	81.40%
Manage Security Services	80.60%	79.36%	80.30%	77.00%	83.80%
Manage Business Process Controls	82.60%	81.80%	82.38%	79.20%	84.00%

Figure 5.9: Result of semantic similarity between process of domains Deliver, Service and Operation from COBIT and Service Operation from ITIL.

From Figure 5.9 one can observe that the correlation to the human mappings presented in Figure A.1 is:

- 79.60% (Manage Operation → Access Management);
- 81.80% (Manage Service Requests and Incidents → Incident Management);
- 82.50% (Manage Service Requests and Incidents → Request Fulfillment);
- 83.20% (Manage Problems → Problem Management);
- 83.80% (Manage Security Services → Access Management);
- 84.00% (Manage Business Process Controls → Access Management);

	Service Strategy				
	Business Relationship Management	Demand Management	IT Service Financial Management	IT Service Strategy Management	Service Portfolio Management
Align, Plan and Organize					
Manage the IT Management Framework	84.38%	85.80%	85.30%	85.96%	85.69%
Manage Strategy	85.24%	85.75%	85.75%	86.60%	86.24%
Manage Enterprise Architecture	83.00%	83.30%	83.28%	83.25%	84.62%
Manage Innovation	84.86%	85.19%	85.50%	85.38%	85.70%
Manage Portfolio	84.59%	84.89%	85.84%	85.06%	85.87%

Figure 5.10: Result of semantic similarity between process of domains Align, Plan and Organize COBIT and Service Strategy from ITIL.

From Figure 5.10 one can observe that the correlation with the human mappings presented in Figure A.1 is:

- 85.24% (Manage Strategy → Business Relationship Management);
- 84.89% (Manage Portfolio → Demand Management);

6

Conclusion

Contents

6.1 Lessons Learned

As previously mentioned, human judgment is considered by definition a kind of “gold standard”. From the Figure 5.9, 4/6 of the mappings are in line with the experts’ opinion. In Figure 5.8 2/8 of the mappings are in line and finally in Figure 5.10 the result is not conclusive since only 1/3 of the COBIT processes were evaluated.

From the Figure 5.9, just the Manage Operation → Access Management mapping and the Manage Service Requests and Incidents → Incident Management mapping are not in line with the experts’ opinion. The results are quite similar, even when talking about different processes. This is not strange since we are talking about processes of the same domain that use similar language to describe their base practices, outcomes, and work products. This means that just a few words change in the descriptions (however, these changes have a clear impact on the meaning but are not enough when using semantic similarity techniques). Therefore, the language used to describe and explain these concepts should be thoroughly reviewed by experts to facilitate the understanding and, in that way, the differentiation of the processes by the practitioners. Also, a larger dataset is needed to refine the results. Therefore, one should create an “IT Governance” dictionary that will take into account some particularities of the EGIT field in order to improve the results.

6.2 Discussion

In this research, the authors proposed a novel approach to the EGIT field by proposing the use of semantic similarity techniques to address the terminological disparities between ITIL V3 2011 and COBIT 5 that makes best professional judgment the only approach currently available to understand the overlapping between them. The semantic similarity techniques are broadly used in different fields such as natural language processing, artificial intelligence, and data mining. However, it is rather unusual to use these techniques in the EGIT field. The results were then compared against a benchmark proposed by human experts. The results are quite good for some domains such as the Deliver Service and Operation from COBIT and Service Operation from ITIL since 4/6 of the mappings are in line with the experts’ opinion. This means that the techniques used during this research hit 2/3 of the mappings from that domain proposed by the specialists. Taking into account the subjectivity of the field, one can argue that the results are encouraging signs that can allow us to, in the near future, map different EGIT frameworks using semantic similarity techniques rather than human working groups.

6.3 Limitation

This research also has some limitations. First of all, not all domains were analyzed. Therefore, more work should be done regarding other processes. Also, since the approach proposed in this paper is relatively new in the EGIT field, there is a lack of the semantic similarity techniques concerning the EGIT terminologies so it is difficult to evaluate the results and find the techniques that better fits the domains in study.

6.4 Communication

This section presents the communication activities to relevant audiences with interests in this research problem.

Throughout the course of this research, the authors submitted two papers, the first one in partnership with a colleague Inês Percheiro concerning the results from the AgreementMakerLight [64], and the second one focused in the results previously presented on Figures 5.8, 5.9 and 5.10. The first one was submitted in the International Conference on Formal Ontology in Information Systems and the second one to The Hawaii International Conference on System Sciences. Unfortunately they were both reject but the authors intend to take the inputs from those conferences and submit again the papers in the near future to new conferences.

6.5 Future Work

Regarding future work, it should include several directions such as (a) improving and extending the dataset, this means, analyze other COBIT 5 domains, and (b) improving the proposed approach via investigating other techniques and algorithms. Also, it would be interesting to analyze the evolution of the results by giving different weights to the core concepts. For example, one can assign a $\frac{1}{2}$ weight for the outcome concept and $\frac{1}{4}$ for the base practices and work products concepts. Finally, a focus group to extract qualitative information about the obtained results would be an interesting work to do to evaluate the results.

Bibliography

[1] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, “A Design Science Research Methodology for Information Systems Research,” *Journal of Management Information Systems*, vol. 24, no. 3, pp. 45–77, 2007. [Online]. Available: http://www.tandfonline.com/doi/full/10.2753/MIS0742-1222240302

[2] A. Cater-Steel, W.-G. Tan, and M. Toleman, “Challenge of Adopting Multiple Process Improvement Frameworks,” *Ecis*, no. 2006, pp. 1–12, 2006. [Online]. Available: http://is2.lse.ac.uk/asp/aspecis/20060118.pdf

[3] M. Fernández-López, A. Gómez-Pérez, and N. Juristo, “METHONTOLOGY: From Ontological Art Towards Ontological Engineering,” *AAAI-97 Spring Symposium Series*, vol. SS-97-06, pp. 33–40, 1997. [Online]. Available: http://oa.upm.es/5484/

[4] C. Pardo, 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, no. 1, pp. 125–143, 2013. [Online]. Available: http://dx.doi.org/10.1016/j.jss.2012.07.072

[5] S. Karkoskova and G. Feuerlicht, “Extending MBI Model using ITIL and COBIT Processes,” *Journal of Systems Integration*, vol. 5, pp. 29–44, 2015. [Online]. Available: http://www.si-journal.org/index.php/JSI/article/view/244

[6] S. de Haes and W. van Grembergen, “An Exploratory Study into IT Governance Implementations and its Impact on Business/IT Alignment,” *Information Systems Management*, vol. 26, no. 2, pp. 123–137, 2009.

[7] W. Grembergen and S. Haes, *Enterprise Governance of Information Technology*, 2015.

[8] P. Weill and J. W. Ross, “How Top Performers Manage IT Decisions Rights for Superior Results,” *IT Governance*, no. Harvard Business School Press Boston, Massachusetts, pp. 1–10, 2004.

[9] J. W. Moore, “Integrated collection of software engineering standards,” *IEEE Software*, vol. 16, no. 6, pp. 51–57, 1999.

[10] C. Pardo, F. J. Pino, F. García, M. Piattini, and M. T. Baldassarre, “An ontology for the harmonization of multiple standards and models,” *Computer Standards and Interfaces*, vol. 34, no. 1, pp. 48–59, 2012. [Online]. Available: http://dx.doi.org/10.1016/j.csi.2011.05.005

[11] A. Chatfield and T. Coleman, “Promises and successful practice in IT governance: a survey of Australian senior IT managers,” *PACIS 2011 Proceedings*, vol. 2011, pp. 1–15, 2011. [Online]. Available: http://aisel.aisnet.org/pacis2011/49{%}5Cnhttp://ro.uow.edu.au/infopapers/1529/

[12] G. Debreceny, R.S. Gray, “IT-governance-and-process-maturity-A-multinational-field-study_2013_Journal-of-Information-Systems,” *Journal of Information Systems*, vol. Volume 27, no. Issue 1, pp. Pages 157–188, 2013.

[13] Isaca, “COBIT ® 5 Design Paper Exposure Draft,” *Information Systems Journal*, pp. 1–16, 2010. [Online]. Available: http://www.isaca.org/Knowledge-Center/Research/Documents/COBIT5{_}Design{_}Exposure{_}18Mar2010.pdf

[14] ISACA, *COBIT 5 Framework*, 2012.

[15] L. Lema, J. A. Calvo-Manzano, R. Colomo-Palacios, and M. Arcilla, “ITIL in small to medium-sized enterprises software companies: Towards an implementation sequence,” *Journal of Software: Evolution and Process*, vol. 27, no. 8, pp. 528–538, 2015.

[16] B. P. Hill, I. T. G. Network, K. Turbitt, B. Practices, and B. M. C. Software, “Combine ITIL and COBIT to Meet Business Challenges,” *BMC Software*, p. 16, 2006.

[17] G. Case, G. Spalding, and S. Taylor, “Continual Service Improvement ITIL v3,” *Service Management*, vol. 5, p. 221, 2007.

[18] J. Ivanyos, “Implementing Process Assessment Model of Internal Financial Control,” *Small*, no. August, pp. 1–11, 2006. [Online]. Available: http://project2005-07.ia-manager.org/files/Implementing{_}Process{_}Assessment{_}Model{_}of{_}Internal{_}Financia.pdf

[19] L. Raichel, K. Brannon, W. Fumy, M. D. Soete, E. J. Humphreys, K. Naemura, and M. Ohlin, “International Standard Iso / Iec,” vol. 2011, no. 117101, 2005.

[20] I. E. Commission, “Software engineering — Process assessment — Part 2 : Performing an assessment Information technology — Process assessment — Part 2 : Performing an assessment Information technology — Process assessment — Part 2 : Performing an assessment,” vol. 2004, pp. 2003–2004, 2004.

[21] M. Nicho and S. Muamaar, "Towards a Taxonomy of Challenges in an Integrated IT Governance Framework Implementation." *Journal of International Technology & Information Management*, vol. 25, no. 2, pp. 1–31, 2016. [Online]. Available: http://search.ebscohost.com/login.aspx?direct=true{&}db=bsu{&}AN=122416561{&}lang=es

[22] C. Jesús and P. Calvache, "A Framework to Support the Harmonization between Multiple Models and Standards," p. 219, 2012.

[23] B. Edmonds, "What is Complexity? - The philosophy of complexity per se with application to some examples in evolution," 1995. [Online]. Available: http://cogprints.org/357/

[24] Y. Bartens, S. D. Haes, Y. Lamoen, F. Schulte, and S. Voß, "On the Way to a Minimum Baseline in IT Governance: Using Expert Views for Selective Implementation of COBIT 5," *2015 48th Hawaii International Conference on System Sciences*, pp. 4554–4563, 2015.

[25] B. Morel and R. Ramanujam, "Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems," *Organization Science*, vol. 10, no. 3, pp. 278–293, 1999. [Online]. Available: http://pubsonline.informs.org/doi/abs/10.1287/orsc.10.3.278

[26] J. R. Blau and W. McKinley, "Ideas , Complexity , and Innovation," *Administrative Science Quarterly*, vol. 24, no. 2, pp. 200–219, 1979.

[27] S. C. Sommer and C. H. Loch, "Selectionism and Learning in Projects with Complexity and Unforeseeable Uncertainty," *Management Science*, vol. 50, no. 10, pp. 1334–1347, 2004. [Online]. Available: http://pubsonline.informs.org/doi/abs/10.1287/mnsc.1040.0274

[28] M. T. Pich, C. H. Loch, and A. D. Meyer, "On Uncertainty, Ambiguity, and Complexity in Project Management," *Management Science*, vol. 48, no. 8, pp. 1008–1023, 2002. [Online]. Available: http://pubsonline.informs.org/doi/abs/10.1287/mnsc.48.8.1008.163

[29] B. Shalit, "Structural ambiguity and limits to coping," *Journal of Human Stress*, vol. 3, no. 4, pp. 32–45, 1992.

[30] P. Checkland, *Systems Thinking, Systems Practice*, 1999.

[31] W. J. Orlikowski and D. Robey, "Information technology and the structuring of organizations," *Information Systems Research*, vol. 2, no. 2, pp. 143–169, 1991.

[32] S. L. Schlindwein and R. Ison, "Human Knowing and Perceived Complexity: Implications for Systems Practice," *Emergence: Complexity & Organization*, vol. 6, no. 3, pp. 27–32, 2004. [Online]. Available: http://search.epnet.com/login.aspx?direct=true{&}db=buh{&}an=16459105

[33] B. Hasan, "Examining the Effects of Computer Self-Efficacy and System Complexity on Technology Acceptance," *Information Resources Management Journal*, vol. 20, no. 3, pp. 76–88, 2007. [Online]. Available: http://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/irmj.2007070106

[34] M. Vicente, N. Gama, and M. M. D. Silva, "Using archimate to represent ITIL metamodel," in *Proceedings - 2013 IEEE International Conference on Business Informatics, IEEE CBI 2013*, 2013, pp. 270–275.

[35] E. a. Marks, *Service-oriented architecture governance for the services driven enterprise*, 2008.

[36] C. More, M. Kulkarni, and V. Bhandekar, "Text Analytic Tools for Semantic Similarity," *Imperial Journal of Interdisciplinary Research*, vol. 2, no. 5, pp. 2454–1362, 2016. [Online]. Available: http://www.onlinejournal.in

[37] J. J. G. Walls, G. R. Widmeyer, and O. A. El Sawy, "Assessing information system design theory in perspective: How useful was our 1992 initial rendition," *Journal of Information Technology Theory & Application*, vol. 6, pp. 43–58, 2004. [Online]. Available: http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1126{&}context=jitta{%}5Cnhttp://iris.nyit.edu/{~}kkhoo/Spring2008/Topics/DS/DtheoryAssessing{_}JITTA2004.pdf

[38] A. G. L. Romme, "Making a Difference: Organization as Design," *Organization Science*, vol. 14, no. 5, pp. 558–573, 2003. [Online]. Available: http://pubsonline.informs.org/doi/abs/10.1287/orsc.14.5.558.16769

[39] S. Jarvela, S. Volet, and H. Jarvenoja, "Proceedings of the 9th European Conference on Research Methods in Business and Management," 2010.

[40] S. Y. R. Esearch, B. A. R. Hevner, S. T. March, J. Park, and S. Ram, "D Esign S Cience in I Nformation," *MIS Quarterly*, vol. 28, no. 1, pp. 75–105, 2004.

[41] ITGI, "Global Status Report on the Governance of Enterprise It (GEIt)—2011," *Governance An International Journal Of Policy And Administration*, p. 70, 2011. [Online]. Available: http://www.isaca.org/Knowledge-Center/Research/Documents/Global-Status-Report-GEIT-10Jan2011-Research.pdf

[42] R. Pereira and M. M. da Silva, "A Literature Review: Guidelines and Contingency Factors for IT Governance," *European, Mediterranean & Middle Eastern Conference on Information Systems*, vol. 2012, pp. 342–360, 2012.

[43] Steven De Haes, Wim Van Grembergen and R. S. Debreceny, "COBIT 5 and Enterprise Governance of Information Technology: Building Blocks and Research Opportunities,"

Spring 2013, Vol. 27, No. 1, pp. 307-324, vol. Vol 27, 2013. [Online]. Available: http://www.aaajournals.org/doi/abs/10.2308/isys-50422?code=aaan-site

[44] T. Mataracioglu and S. Ozkan, "Governing Information Security in Conjunction With Cobit and Iso 27001," pp. 1–11, 2011.

[45] M. Sharifi, M. Ayat, A. A. Rahman, and S. Sahibudin, "Lessons learned in ITIL implementation failure," *Proceedings - International Symposium on Information Technology 2008, ITSim*, vol. 1, pp. 8–11, 2008.

[46] M. F. I. Othman and T. Chan, "Barriers to formal IT Governance practice - Insights from a qualitative study," *Proceedings of the Annual Hawaii International Conference on System Sciences*, pp. 4415–4424, 2013.

[47] T. van Sante and J. Ermers, "TOGAF™ 9 and ITIL® V3 Two Frameworks Whitepaper," *OGC*, no. September, pp. 1–16, 2009. [Online]. Available: http://www.best-management-practice.com/gempdf/White{_}Paper{_}TOGAF{_}9{_}ITIL{_}V3{_}Sept09.pdf

[48] C. F. S. GOMES, *Gestão da Cadeia de Suprimentos integrada à Tecnologia da Informação*. Pioneira Thomson Learning, 2004. [Online]. Available: https://books.google.pt/books?id=B06QoZ8jB8IC

[49] M. Marrone and L. Kolbe, "ITIL and the Creation of Benefits: An Empirical Study on Benefits, Challenges and Processes," *Business Information Systems Engineering*, vol. 3, pp. 1–14, 2010. [Online]. Available: http://aisel.aisnet.org/bise/vol3/iss1/3

[50] V. Strahonja, *Definition Metamodel of ITIL*. Boston, MA: Springer US, 2009, pp. 1081–1092. [Online]. Available: https://doi.org/10.1007/978-0-387-78578-3{_}39

[51] ISACA, "COBIT ® Process Assessment Model (PAM): Using COBIT ® 5," p. 144, 2013.

[52] B. Barafort, B. Di Renzo, and O. Merlan, "Benefits resulting from the combined use of ISO/IEC 15504 with the Information Technology Infrastructure Library (ITIL)," *Product Focused Software Process Improvement, Proceedings*, vol. 2559, pp. 314–325, 2002.

[53] V. H. Publishing, *ITSM Process Assessment Supporting ITIL (TIPA)*, 1st ed. Van Haren Publishing, 2009.

[54] D. Milicevic, M. Goeken, D. Milicevic, M. Goeken, O.-b. Evaluation, I. S. O. Wojciech, E. Estevez, S. Services, and I. Ad, "Ontology-Based Evaluation of ISO 27001 To cite this version :," pp. 93–102, 2014.

[55] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing," *International Journal of Human - Computer Studies*, 1995.

[56] N. Guarino, "Formal Ontology and Information Systems," *Proceedings of the first international conference*, 1998.

[57] M. C. Valiente, E. Garcia-Barriocanal, and M. A. Sicilia, "Applying an ontology approach to IT service management for business-IT integration," *Knowledge-Based Systems*, 2012.

[58] G. Antunes and M. Bakhshandeh, "Using Ontologies for Enterprise Architecture Integration and Analysis," *Complex Systems Informatics and Modeling Quarterly*, vol. Mar. 2014, no. RTU Press, pp. 1–23, 2014. [Online]. Available: http://www.ifs.tuwien.ac.at/{~}mayer/publications/pdf/ant{_}csimq14.pdf

[59] A. Gómez-pérez, "Criteria to Verify Knowledge Sharing Technology," pp. 1–17, 1867.

[60] H. S. Pinto, A. Gómez-Pérez, and J. P. Martins, "Some Issues on Ontology Integration," *Praxis*, vol. 18, no. Borst 1997, pp. 1–12, 1999. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.67.7066{&}rep=rep1{&}type=pdf

[61] J. Euzenat and P. Shvaiko, *Ontology matching*, 2007.

[62] S. Amrouch and S. Mostefai, "Survey on the literature of ontology mapping, alignment and merging," in *2012 International Conference on Information Technology and e-Services, ICITeS 2012*, 2012.

[63] I. F. Cruz, "AgreementMaker : Efficient Matching for Large Real-World Schemas and Ontologies," *Pvldb*, vol. 2, no. 2, pp. 1586–1589, 2009.

[64] D. Faria, C. Pesquita, E. Santos, M. Palmonari, I. F. Cruz, and F. M. Couto, "The AgreementMakerLight ontology matching system," *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 8185 LNCS, pp. 527–541, 2013.

[65] M. Ganzha, M. Paprzycki, W. Pawłowski, P. Szmeja, K. Wasielewska, and G. Fortino, "Tools for ontology matching—practical considerations from INTER-IoT perspective," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 9864 LNCS, 2016, pp. 296–307.

[66] R. J. S, "Detecting Contradictions in News Quotations Thesis to obtain the degree : Master in Information Systems and Computer Engineering Examination Committee October 2015," no. October 2015.

[67] Y. Li, D. McLean, Z. A. Bandar, J. D. O'Shea, and K. Crockett, "Sentence similarity based on semantic nets and corpus statistics," *IEEE Transactions on Knowledge and Data Engineering*, vol. 18, no. 8, pp. 1138–1150, 2006.

[68] P. Achananuparp, X. Hu, and X. Shen, "The evaluation of sentence similarity measures," *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 5182 LNCS, pp. 305–316, 2008.

[69] W. H.Gomaa and A. A. Fahmy, "A Survey of Text Similarity Approaches," *International Journal of Computer Applications*, vol. 68, no. 13, pp. 13–18, 2013. [Online]. Available: http://research.ijcaonline.org/volume68/number13/pxc3887118.pdf

[70] E. Altszyler, M. Sigman, S. Ribeiro, and D. F. Slezak, "Comparative study of LSA vs Word2vec embeddings in small corpora: a case study in dreams database," pp. 1–14, 2016. [Online]. Available: http://arxiv.org/abs/1610.01520

[71] T. Slimani, "Description and Evaluation of Semantic Similarity Measures Approaches," *International Journal of Computer Applications*, vol. 80, no. 10, pp. 25–33, 2013. [Online]. Available: http://research.ijcaonline.org/volume80/number10/pxc3891851.pdf

[72] J. Zdravkovic, J. Stirna, and J. Grabis, "A Comparative Analysis of Using the Capability Notion for Congruent Business and Information Systems Engineering," *Complex Systems Informatics and Modeling Quarterly*, no. 10, pp. 1–20, 2017. [Online]. Available: https://csimq-journals.rtu.lv/article/view/csimq.2017-10.01

[73] B. Percheiro, R. Almeida, P. L. Pinto, and M. Mira, "Information Systems," vol. 299, pp. 478–491, 2017. [Online]. Available: http://link.springer.com/10.1007/978-3-319-65930-5

[74] M. Gehrmann, "Combining ITIL , COBIT and ISO / IEC 27002 for structuring comprehensive information technology for management in organizations," *Navus - Revista de Gestao e Tecnologia.*, vol. 2, pp. 66–77, 2012.

[75] I. Percheiro, M. M. da Silva, and C. Mendes, "Mapping COBIT 5 and ITIL Using Semantic Analysis," no. May, 2018.

[76] S. Anam, Y. S. Kim, B. H. Kang, and Q. Liu, "Review of Ontology Matching Approaches and Challenges," *International journal of Computer Science & Network Solutions*, vol. 3, no. 3, 2015. [Online]. Available: http://www.ijcsns.com/March.2015-Volume.3-No.3//Article01.pdf

[77] M. Sir, Z. Bradac, and P. Fiedler, "Ontology versus Database," *IFAC-PapersOnLine*, vol. 28, no. 4, pp. 220–225, 2015. [Online]. Available: http://dx.doi.org/10.1016/j.ifacol.2015.07.036

[78] S. Harispe, S. Ranwez, S. Janaqi, and J. Montmain, "Semantic Similarity from Natural Language and Ontology Analysis," 2017. [Online]. Available: http://arxiv.org/abs/1704.05295{%}0Ahttp://dx.doi.org/10.2200/S00639ED1V01Y201504HLT027

[79] E. Gabrilovich and S. Markovitch, "Computing semantic relatedness using wikipedia-based explicit semantic analysis," *IJCAI International Joint Conference on Artificial Intelligence*, pp. 1606–1611, 2007.

A

Appendix A

Mapping of COBIT and ITIL processes from ISACA

		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	The seven-step improvement process
EDM	***Evaluate, Direct and Monitor***																										
EDM01	Ensure Governance Framework Setting and Maintenance																										
EDM02	Ensure Benefits Delivery																										
EDM03	Ensure Risk Optimisation																										
EDM04	Ensure Resource Optimisation																										
EDM05	Ensure Stakeholder Transparency																										
APO	***Align, Plan and Organise***																										
APO01	Manage the IT Management Framework																										■
APO02	Manage Strategy	■																									
APO03	Manage Enterprise Architecture																										
APO04	Manage Innovation																										
APO05	Manage Portfolio		■																								
APO06	Manage Budget and Costs			■																							
APO07	Manage Human Resources																										
APO08	Manage Relationships				■	■																					
APO09	Manage Service Agreements		■		■			■	■																		
APO10	Manage Suppliers													■													
APO11	Manage Quality																										
APO12	Manage Risk																										
APO13	Manage Security												■														
BAI	***Build, Acquire and Implement***																										
BAI01	Manage Programmes and Projects																										
BAI02	Manage Requirements Definition						■																				
BAI03	Manage Solutions Identification and Build																										
BAI04	Manage Availability and Capacity									■	■																
BAI05	Manage Organisational Change Enablement																										
BAI06	Manage Changes															■											
BAI07	Manage Change Acceptance and Transitioning														■			■	■	■							
BAI08	Manage Knowledge																				■						
BAI09	Manage Assets																■										
BAI10	Manage Configuration																■										
DSS	***Deliver, Service and Support***																										
DSS01	Manage Operations																					■					
DSS02	Manage Service Requests and Incidents																						■	■			
DSS03	Manage Problems																								■		
DSS04	Manage Continuity											■															
DSS05	Manage Security Services																									■	
DSS06	Manage Business Process Controls																									■	
MEA	***Monitor, Evaluate and Assess***																										
MEA01	Monitor, Evaluate and Assess Performance and Conformance																										■
MEA02	Monitor, Evaluate and Assess the System of Internal Control																										
MEA03	Monitor, Evaluate and Assess Compliance with External Requirements																										

Figure A.1: Mapping of COBIT and ITIL processes. From [5].