# Mapping COBIT 5 and ITIL using Semantic Analysis

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**Abstract.** Enterprise Governance of Information Technology (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 services. Researchers agree that Control Objectives for Information and Related Technology (COBIT) and IT Infrastructure Library (ITIL) are among the most valuable and popular practices currently being adopted and adapted by organizations. In multi-framework environments, this situation is even higher since each framework defines its scope, structure, definitions, and terminology. To overcome this issue, this research intends to shed some light in this area by proposing an ontological approach for describing TIPA for ITIL Process Assessment Model (PAM) and COBIT PAM, using semantic similarity techniques to compare COBIT and ITIL process assessment core concepts.

**Keywords.** AgreementMakerLight, COBIT 5 PAM, METHONTOLOGY, Ontology Integration, Semantic Analysis, TIPA for ITIL

## 1. Introduction

In today's complex and competitive business environment, organizations need to react quickly and with the required flexibility to ensure the achievement of business goals and objectives [1] and so, they are heavily dependent on IT. To fully benefit from the advantages of IT processes, a variety of standards and frameworks are used as a reference to improve and to provide effective support for business/IT alignment.

EGIT can be defined as "an integral part of corporate governance that 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" [2].

COBIT and ITIL are currently some of the most valuable and popular EGIT frameworks adopted and adapted by organizations [3] [4] [5]. They are intended to facilitate effective EGIT [6] by providing a set of best practices that are often implemented according to the organization's needs.

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 practices to a renowned reference so that the current status of the 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. In turn, TIPA for ITIL 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 [7].

TIPA for ITIL PAM and COBIT PAM are based on ISO/IEC 15504 (ISO/IEC 15504-1, 2004; ISO/IEC 15504-2, 2003), which is a global reference for conducting process capability assessments.

The increasing demands of the different industries coupled with compliance requirements, have forced organizations to adopt multiple EGIT Frameworks [8] 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 [9] because each practice defines its own scope, definitions, and terminologies.

According to Textor et al. [10], ontology-based models satisfy the requirements of the need for formal meta-models flexible and expressive enough to allow both technical and non-technical domains to be modeled separately and connect the concepts of different models. In short, it is possible to say that an ontology describes a hierarchy of concepts related by subsumption relationships [11] and are meant to clarify the structure of knowledge of a domain [12], and formally represent all the knowledge of that domain [13].

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 evidence the overlapping between them and facilitate in this way the simultaneous assessment of these frameworks.

To achieve this goal, this research proposes an ontological approach for describing the PAMs of the TIPA for ITIL and COBIT PAM and also use semantic similarity techniques to compare COBIT and ITIL process assessment core concepts.

## 2. Problem

Currently, different frameworks, industry-specific standards, and methodologies of quality can be taken as references for the improvement of an organization's processes [14].

This situation allows organizations to select and complement their processes from the frameworks that better fits their context [14].

Moreover, considering the overlaps that exist between these EGIT frameworks, their independent adoption prevents organizations from asserting full IT management and governance because each one has limitations in its application to the management of specific IT areas [15].

The increasing demands of the different industries coupled with compliance requirements, have forced organizations to adopt multiple EGIT Frameworks [8].

Due to the lack of formal consensus on the terminology used, inconsistencies and conflicts arise when an organization decides to adopt and assess multiple frameworks making it difficult to understand the main concepts involved [9] [16].

Humans do not judge text relatedness merely at the level of text words. Words trigger reasoning at a much deeper level that manipulates concepts—the basic units of meaning that serve humans to organize and share their knowledge [17].

A fundamental operation performed while handling ontologies is the Alignment process, that takes two input ontologies and produces a set of relationships between concepts that match semantically with each other. To sum up, the problem that this research intends to help solve is the measureless degree of overlapping that prevents organizations to assess COBIT 5 and ITIL simultaneously.

Consequently, it is important for organizations to have a proposal that assists them in integrating multiple models, identifying and resolving their differences and similarities. When this occurs, an integrated solution is obtained, which takes advantage of the qualities of each model and maximizes them. In the Proposal Section, the authors explain how they tried to solve the problem described in this section.

## 3. State of the Art

### *3.1. COBIT 5*

According to ISACA [18], COBIT 5 provides a comprehensive practice that assists enterprises in achieving their objectives for the governance and management of enterprise IT helping enterprises to create optimal value for their stakeholders from IT by maintaining a balance between realizing benefits and optimizing risk levels and resource use.

Achieving IT-related goals requires the successful application and use of some enablers that include processes, organizational structures, and information - and then, for each enabler, a set of specific relevant goals can be defined in support of the IT-related goals. Processes are one of the enablers, and ISACA [18] provides a mapping between IT-related goals and the relevant COBIT 5 processes, which then contain related process goals.

Textor and Gheis [10] proposed an ontological meta-model, represented using Web Ontology Language (OWL), for the calculation of metric values with the goal of making better informed dynamic management decisions.

Goeken and Alter [19] and Souza Neto et al. [20] formalized COBIT 4.1 through a conceptual meta-model provided solely in human-readable format, an entity-relationship model.

### *3.2. ITIL*

ITIL is a set of comprehensive publications providing detailed guidance on the management of IT processes, functions, roles, and responsibilities related to IT Service Management (ITSM) [21]. ITIL focuses cycle of life, renewal and decommissioning of services, with a greater business-focused perspective [22]. 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 [23][24].

In the literature, several ontologies were proposed for describing ITIL. An ontology-based model for ITIL has been proposed by dos Santos et al. [25] with the goal of describing Configuration Items (CI) and the processes dependent on them.

Valiente et al. [26] proposed Onto-ITIL, an ontology based on the ITIL V3 Service Management Model that aims to achieve formalization of ITSM domain. Onto-ITIL provides a mechanism for managing interoperability, consistency checking and decision making, and can be used as a knowledge base for ITIL based process implementations, allowing IT service providers to add semantics and constraints to the data associated with the different ITIL-based processes [26].

#### *3.2.1. Integrating ITIL and COBIT 5*

A COBIT-ITIL Mapping ontology based on the mapping proposed by Glenfis [27] was referenced by Textor et al. [10] to explicit services on the proposal for a COBIT metamodel.

Cater-Steel and Toleman [28] promote this integration by stating that although ITIL provides good documentation of IT process flows and interactions, it is not a complete approach because of its absence of a measurement system for process improvement. With this in mind, organizations are urged to use COBIT to put their ITIL program in the context of a wider governance and control framework [28].

### *3.3. Process Assessment Models*

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 practices to a renowned reference so that the current status of the processes can be measured and appropriate suggestions for process improvement can be made.

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.

### *3.4. Ontology Integration*

The word integration can have multiple meanings in the ontology field, Pinto et al. [29] express the difficulty to use this word correctly, especially because of its abusive use. Different authors use different terms to refer to similar concepts, and, vice versa, sometimes different concepts are referred to by the same term [30]. The word integration can be presented with different meanings, which can be summarily described as [30]:

- **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.

### *3.5. METHONTOLOGY*

This methodology, developed by Férnandéz-Lopez et al. [31], aspires to produce ontologies at the knowledge level. During the ontology building process, is respected an on-

tology 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: the management activities, the development activities, and the support activities.

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 support activities fluctuate during the ontology's lifecycle and include knowledge acquisition, integration, evaluation, documentation and configuration management.

Regarding 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.

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

### *3.5.1. 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.

AgreementMaker [32] 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 (AML) [33], is an automated ontology matching framework based on element-level matching and focused on computational efficiency, designed to handle very large ontologies while preserving most of the flexibility and extensibility of the original AgreementMaker framework.

The 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. In this research, we used the AML framework since we were looking for an ontology mapping system that not only is flexible, efficient and reliable but also provides the possibility to map ontologies at different levels (Classes, Attributes, Relations and Individuals). AML is one of the few mapping systems that provide all the mentioned functionalities.

## 4. Proposal

To support the multi-framework adoption and facilitate the assessment of these frameworks in organizations, in this research, the authors propose an ontological integration of ITIL and COBIT 5 process assessment concepts (base practices, inputs/outputs and outcomes). The autors aim to achieve an alignment between these frameworks as defined by Amrouch et al. [34], focused on solving the semantic mismatches.

In order to increase the theoretical foundation of these frameworks, we first developed two ontologies: One for TIPA for ITIL and the other for COBIT 5 PAM. To support the development of the ontologies for each of these frameworks, we used the METHONTOLOGY methodology.

During the construction of both ontologies, on the specification activity, we defined the scope of the ontologies as "Process Assessment", emerging the need to translate the use of ITIL and COBIT 5 to TIPA for ITIL and COBIT 5 PAM respectively. Both ontologies aim to be used by auditors and assessors to help improve the management of the organizations IT services, infrastructures, and resources [7].

Since both ontologies have to be integrated, the ontological structures were designed with the efficiency of the matching process in mind. From the conceptualization phase of METHONTOLOGY, we present, in Table 1, a glossary of ontology concepts and their descriptions. It is important to note that both ontologies share the same structure.

**Table 1.** A Glossary of terms and concept dictionary

| Class Name | Description [18][7] | Class Attributes | Relations |
|---|---|---|---|
| Process | A structured set of activities designed to accomplish a specific structured set of activities designed to accomplish a specific objective. | process-name<br>purpose<br>lifecycle stage | hasObjective<br>isComposedBy<br>Uses<br>Produces |
| Work Product | Structured sets of data that make the process work and that are expected to be produced by the process. Inputs are gradually converted into outputs. | workproduct-name<br>workproduct-description<br>characteristics | isRelatedToAsOutput<br>isRelatedToAsInput<br>supportsAsInput<br>supportsAsOutput<br>isUsed<br>isProduced |
| Base Practice | A set of actions designed to achieve a particular result. Usually defined as part of processes or plans and are documented in procedures. | basepractice-name<br>basepractice-description | hasOutput<br>hasInput<br>helpAchieve<br>composes |
| Expected Result | The expected results required from a process, activity or organization to ensure that its purpose will be fulfilled. Expected results are usually expressed as measurable targets. | expectedresult-description | isSupportedByInput<br>isSupportedByOutput<br>achievedBy |

Moreover, TIPA for ITIL and COBIT 5 PAM are described in natural language. Therefore, they are prone to ambiguity and subjectivity. Since we developed an ontology to each of these frameworks, it is now possible to use knowledge-based measures to semantically to evaluate the relationship between their concepts. The system used to perform the ontological alignment needs to be flexible and reliable enough to provide us the possibility to map not only classes but also instances.

AML [33] meets our requirements and is one of the leading ontology matching system currently being used. It is derived from the original mapping system Agreement-

Maker [32]. There are others matching systems with similar characteristics, as presented by Ganzha et al. [35], but the majority are not apparently in active use neither support the ontology language used in this research. AML can calculate similarity scores resorting to external knowledge source, like WordNet [35].

This analysis focused on Service Operation (SO) life cycle stage of ITIL and the Deliver, Service and Support (DSS) domain of COBIT 5.

The matchers used to achieve the values here presented function at the element level, by analyzing concepts and instances in isolation, ignoring the relationships with other concepts or instances, and using only internal knowledge contained in the ontologies, in an all-against-all strategy, where all concepts are matched with each other. Using the threshold functionality of AML, it is possible to discard irrelevant values of similarity.

In our proposal we use the *HybridStringMatcher*, AML default matcher for instance matching) that combines a Lexical Matcher ( that finds literal full-name matches from the Lexicon, including labels, names, and synonyms), a String Matcher (that finds matches from Lexicon based on the ISub string similarity metric) and a Word Matcher (that finds matches from the Lexicon based on shared words - weighted Jaccard index); a *ValueStringMatcher* that is similar to the *HybridStringMatcher* but is based on the ValueMap instead of on the Lexicon (i.e. Property values) and also uses the ISub string similary metric; and a *Value2LexiconMatcher* that is similar to the previous two but compares the Lexicon to the *ValueMap*, to catch cases where one ontology has a property that goes to the Lexicon, but the other does not despite having a correspondence and uses WordNet.

## 5. Result Analysis

In this section, the authors present and discuss the results achieved in this research.

Humans have an innate ability to judge semantic relatedness of texts. Human judgments on a reference set of text pairs can thus be considered correct by definition, a kind of "gold standard" against which computer algorithms are evaluated [17]. Semantic measures are widely used today to compare units of language, concepts, instances or even resources indexed by them (e.g., documents, genes).

Therefore, in this research, the authors just semantically compared the instances from processes that according to ISACA [18] are related.

Due to space limitations, this analysis only deals with a subset of processes, namely the processes that belong to the SO lifecycle in ITIL and its related domain in COBIT 5 – the DSS domain.

The results comprise a total of 5749 values that represent the similarity mappings between 167 instances that belong to the DSS domain of COBIT 5 and the Service Operation life cycle stage of ITIL.

Also, in this proposal, we performed a direct evaluation, this means that the obtained measures are evaluated regarding their capacity to mimic human ratings of semantic similarity/relatedness. Detailed results are presented in Fig. 1. This figure presents the top 5 Base Practices with higher similarity. As one can see, the COBIT 5 DSS02-BP4 base practice and ITIL INCM-BP6 base practice achieved the highest degree of similarity with a score of 94.48%.

Since the similarity between instances is calculated taking into account all the attributes that compose the base practices (namely, the name and description), the results

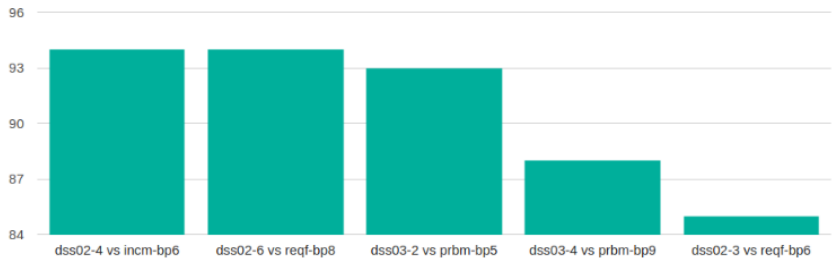


**Figure 1.** Top 5 comparisons between TIPA for ITIL and COBIT 5 PAM Base Practices.

are not unexpected. As presented in Table 2, the name of both base practices is rather similar, and their description has a higher level of coverage.

**Table 2.** Comparison of ITIL and COBIT correspondent instances

| Instance Name | basepractice-name | basepractice-description |
|---|---|---|
| DSS02-BP4 | Investigate, diagnose and allocate incidents. | Identify and record incident symptoms, determine possible causes, and allocate for resolution. |
| INCM-BP6 | Investigate and diagnose the incidents. | Analyze and investigate incidents by the appropriated support line(s) if first line support failed to restore service. |

However, it seems obvious that the description is a far more important attribute than the base practices name. Therefore, these results are likely to be biased. In order to avoid such a situation, the authors also semantically compare the base practices using the attributes separately.

The results are generically lower. In this specific scenario, the practices with the highest similarity are not the same. Taking into account the COBIT 5 DSS02-BP4 base practice and ITIL INCM-BP6 base practice, the previous value of 94.46% decreases to 75.58%.

## 6. Conclusion

At present, there is a wide range of solutions which can be applied as Process Reference Models (PRMs) to improve organizations' processes, some of the most applied solutions in organizations are COBIT 5 and ITIL. This gives the opportunity to support different needs through the benefits that each of them provides, but these frameworks are heterogeneous and present many differences in their scope, approach, processes structure, definitions and terminology, granularity or level of detail, amongst others. Therefore, organizations struggle with the complexity and difficulty of understanding and interpreting several models at the same time.

Efforts to address this issue have been performed without taking into account the definition of a common and consistent terminology which allows us to have an integrated point of view which allows to decrease the efforts during the assessment processes both in COBIT and ITIL when they are being installed, or they are instantiated at the same time in the same organization. Hence, a consistent terminology for assessment process based on COBIT and ITIL frameworks can provide an important instrument for under-

standing and support the right implementation of them in an organization, as well as for strengthening this research domain.

In consequence, in this research the main objective was to present an ontological mapping approach of TIPA for ITIL and COBIT 5 PAM through the semantic similarity evaluation of their core concepts, facilitating in this way the assessment of these frameworks in an integrated way.

From the proposal presented here, have emerged some additional research ideas that we want to address in future works, these are presented as follow:

1. First, although the ontology proposed here has been applied in COBIT 5 PAM and TIPA for ITIL, in the quest to cover a broader range of needs, we hope to extend it and include more terms and relationships of practices that can be related to other models/frameworks such us: ISO 20000 or ISO 33052.
2. Second, it should be said that our ontology has been used to instance the terms related to TIPA for ITIL and COBIT 5 PAM, which allowed us to identify relationships between them to support an assessment process in an integrated way. Therefore, it has shown that it can also be used as a basis for supporting the design and improvement of the organization's processes of both models in an aligned way through a software tool which can systematize the assessment of organizations' processes through our ontology.
3. Finally, the next step in this research project will focus on the development of algorithms which let us improve and extend the capability of the assessment process through the automation.

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