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How can FLOSS Support COBIT 2019? Coverage Analysis and a Conceptual Framework

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Abstract

This paper assesses the supportive role of free/libre and open source software (FLOSS) in Information Technology (IT) Governance. The result is a conceptual framework emerging from design science research conducted in cooperation with a private non-profit organization in the third sector. Our selection of 35 FLOSS solutions distributed across twenty-one categories can be adopted for nearly 95% of COBIT 2019 management activities. The results are encouraging to companies interested in improving their IT Governance based on FLOSS infrastructure. For theory, we present a pioneering analysis of the FLOSS market for IT Governance using the lenses of COBIT 2019. For practice, we offer artifacts for FLOSS selection and initial recommendations to increase FLOSS adoption for IT Governance. The growing expansion of FLOSS adoption requires new tools to guide IT Governance auditors and integrate FLOSS solutions within the entire governance lifecycle from early planning, execution, and performance evaluation to more mature stages of continuous improvement.

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1. Introduction

Information technology (IT) investments represent a significant percentage of the firms' budget for executing digital transformation strategies, requiring effective measurement of business benefits [11]. The diversity of IT portfolios and their essential role in supporting innovation in turbulent markets [20] are additional reasons to implement structures, processes, and relational mechanisms to steer IT adoption at different levels of the organization. Therefore, IT Governance can be defined as “a process by which decisions are made around IT investments. How decisions are made, who makes the decisions, who is held accountable, and how the results of decisions are measured and monitored are all parts of IT governance” [17]. IT Governance can be guided by frameworks like Control Objectives for Information and related Technologies (COBIT®) [10], one of the most relevant and top priorities for enterprise information systems research [15].

Free/libre/open-source software (FLOSS) is increasingly adopted to support particular aspects of IT Governance [6]. For example, network/communication security, risk analysis, or document management. The FLOSS benefits are well known, including enhanced autonomy in technology development, supplier independence, and the four freedoms of FLOSS [5,22]: freedom to run, understand how the system operates, redistribute, and improve the software. FLOSS adoption can also promote the social inclusion of a significant portion of the population, improving accessibility and supporting IT training. Finally, the benefit of zero licensing cost in many FLOSS solutions [16] is a viable strategy for cost reduction, especially for small and medium enterprises, due to the limited resources available for selecting and adopting a new software system [16,20].

Several studies addressed the governance of FLOSS [4,8]. Conversely, there is a shortcoming of contributions on how FLOSS can support IT Governance, and none focus on the most recent version of the influential framework COBIT 2019. COBIT 2019 was selected for its relevance to enterprise information systems research [15]. Moreover, it is a comprehensive guide, adopted worldwide, including other frameworks and standards in its structure [11,12]. The importance of FLOSS for IT Governance and the lack of empirical studies detailing how synergies can be obtained with COBIT 2019 led to the formulation of the following research objectives:

- *ROI: Assess how FLOSS can support COBIT 2019 lifecycle adoption, from the early stages of IT Governance planning to more advanced stages of auditing and continuous improvement;*
- *RO2: Propose a conceptual framework for FLOSS-enabled COBIT 2019.*

The rest of this paper is structured as follows. The next section reviews foundational literature on IT Governance, FLOSS, and a recent trend in the literature looking for their synergies. Subsequently, the design science research approach is explained. The following section details our results of the FLOSS assessment vis a vis COBIT 2019 requirements and introduces the framework. The discussion is then included, and the paper closes by summarizing the main conclusions, limitations, and opportunities for future research.

Nomenclature

COBIT	Control Objectives for Information and related Technologies
FLOSS	Free/Libre and Open Source Software
PDCA	Plan, Do, Check, and Act

2. Background

2.1. COBIT 2019: A reference for modern IT Governance

COBIT [10] was developed in 1996 by the Information Systems Audit and Control Association (ISACA). It is a prominent framework for providing control mechanisms over the information technology domain [2], incorporating other IT standards, for example, ISO 17799, ISO/IEC 38500, Information Technology Infrastructure Library (ITIL), and Capability Maturity Model Integration (CMMI) [11,12]. On the one hand, COBIT defines the components to

create and sustain a governance system and guidelines that the enterprise should consider to build the best-fit governance system. On the other hand, COBIT should not be considered a complete description of the whole IT environment or a framework to organize business processes and does not make or prescribe any IT-related decisions. COBIT 2019 is the latest version [12], extending the previous releases with focus areas and design factors for additional guidance on how to “tailor” the governance system to the enterprise’s needs [10].

COBIT 2019 includes an extensive list of governance activities, organized into 40 governance and management objectives and five domains, namely [10], Evaluate, Direct and Monitor (EDM) related to strategic options and monitoring, and the four management-related domains: Align, Plan and Organize (APO) addressing IT organization; Build, Acquire and Implement (BAI) steering the acquisition of IT and the continuous integration in the organizational practice; Deliver, Service and Support (DSS), comprising the IT service management (and the vital aspect of security); and Monitor, Evaluate and Assess (MEA) for performance management and control (e.g., compliance). The forty objectives address the entire IT sourcing lifecycle from the preliminary stages of planning to more advanced testing and process improvement phases. The level of detail of COBIT 2019 makes it particularly suited for IT auditing and state-of-the-art governance performance in the most demanding economic sectors. Security is a central concern in COBIT 2019, and some authors suggested the importance of analyzing the lifecycle, for example, adopting the PDCA [23]. The popular PDCA-Plan, Do, Check, and Act was proposed by [14] for quality management and provides an interesting lens to continuously improve IT Governance.

2.2. Free/Libre and Open Source Software and the quest for users' freedom

The concept of open source software appeared in different computer science departments (e.g., Stanford, Berkeley, Carnegie Mellon, and MIT) in the 1960s and 1970s. A critical mark was set by Richard Stallman and some colleagues when they announced the GNU project (an acronym for ‘GNU’s Not Unix’), aiming to deploy the complete software of the free GNU operating system Unix-compatible. This initiative in 1983 aimed to bring back a cooperative spirit in the computing community [18]. In that decade, the Free Software Foundation (FSF) was founded to raise funds and created the GNU General Public License (GPL), which is still commonly used [5].

FLOSS reinforces the users’ freedom to run, copy, distribute, study, change, and improve the software, beyond gratuitousness [5,22]. According to [16], FLOSS has numerous advantages. For example, (1) technological autonomy, (2) safety and security, (3) supplier independence, (4) the “four freedoms”, (5) digital inclusion, and (6) zero cost in many solutions. Conversely, FLOSS may also face problems like the lack of support for new users, the need for better training of technical staff, adapting to other platforms, and resistance to change [5,7,16]. Therefore, FLOSS and IT Governance are deeply interrelated. The scientific literature reveals many advances in FLOSS governance, as is the case of [6,7]. Several authors point to the importance of using a framework to adopt FLOSS [1], supporting FLOSS governance [7]. This trend in research has started due to the increasing complexity of FLOSS products and the need to create a coherent strategy for deploying them in organizations. Using open source components internally [8] is evolving side-by-side with the open source community software governance, describing how decisions are made within the community [21]. Interestingly, most studies focus on the problem of governing FLOSS adoption, lacking guidance on the other side: how FLOSS enables IT Governance.

3. Research approach

Our study follows the design science research (DSR) paradigm, aiming to produce knowledge contributions by designing new models, frameworks, methods, or instantiations [9,13]. The work started after contacting a Portuguese institution operating in the third sector. They recently made significant investments to improve their offer, including education to young children, social support, healthcare, and cultural services, which are relevant goals of the social economy. IT Governance is essential to this type of organization, dealing with personal data, privacy requirements, disclosure of information to third parties, and requiring strict cost control. They found the idea of increasing FLOSS adoption for governance very appealing, and the work started with a literature review and analysis of related FLOSS offers. It was surprising to see the lack of contributions addressing how FLOSS can support IT Governance, despite the numerous works explaining the governance of FLOSS portfolio (e.g., [6,7]).

DSR can evolve in a cyclic nature, building, evaluating, theorizing, and justifying the results obtained in each cycle [13]. This paper reports the first complete DSR cycle aiming to design a conceptual framework to guide organizations in their FLOSS-enabled governance practices. Fig. 1 summarizes our DSR according to the grid proposed by [3].

<p style="text-align: center;">Problem</p> <p>How FLOSS supports the different domains, practices, and activities of IT Governance is understudied. Lack of tools to assist companies in FLOSS selection</p>	<p style="text-align: center;">Research Process</p> <p>Initial DSR cycle to evaluate the potential FLOSS for IT Governance and map them with the list of COBIT 2019 activities. Create a framework to assist FLOSS selection and evaluate its utility</p>	<p style="text-align: center;">Solution</p> <p>FLOSS categorization and a guiding framework to support FLOSS selection within continuous improvement lifecycles of IT governance using COBIT 2019</p>
<p style="text-align: center;">Input Knowledge</p> <p>IT Governance, FLOSS, PDCA cycle for continuous improvement</p>	<p style="text-align: center;">Concepts</p> <p>COBIT 2019 framework, Enterprise information systems market</p>	<p style="text-align: center;">Output Knowledge</p> <p>IT Governance coverage by FLOSS, categorization, and FLOSS quadrant with examples for COBIT 2019</p>

Fig.1. DSR presentation.

The fieldwork proceeded as follows. We started with a detailed analysis of COBIT 2019 domains (5), practices (40), and over one thousand activities. COBIT 2019 provided an additional governance focus, identifying key concepts (e.g., risk management, security, and IT service management) that must be addressed during governance framework implementation. [24,19] The FLOSS selection followed an iterative process. First, we looked for FLOSS projects/applications (e.g., [24,19]) matching each of the 40 COBIT 2019 management objectives and the more specific practices and activities. For example, in the case of BAI01—Managed Programs (management objective) and BAI01.06 Monitor, control, and report on the program outcomes (practice), we found examples like Zabbix created for infrastructure performance monitoring and addressing activities like “4. Monitor and control IT services, assets and resources (...)”. Therefore, Zabbix was added to our list, and then we checked for other COBIT 2019 activities supported by this system. Second, we searched FLOSS portals for IT Governance categories (e.g., security) and then evaluated if that solution supported any COBIT 2019 activities. The criteria were the selection of FLOSS supporting at least one COBIT 2019 activity.

Our stop criteria were reached when all 40 governance and management objectives were linked to at least one FLOSS. The results of this critical step, including the analysis of FLOSS adoption opportunities for the largest possible extension of COBIT 2019 compliance, and the framework that will support the subsequent DSR cycles (implementing and auditing IT Governance with the new infrastructure), are presented in the next section.

4. Results and discussion

This section starts with a summary of the COBIT 2019 coverage conducted during the iterative selection and analysis of 35 FLOSS. When reaching our stopping criteria, the team proceeded to categorize FLOSS. The conceptual framework proposal and discussion are included in section 4.2.

4.1. Evaluating how “free” is the support to COBIT 2019

Table 1 presents the results for the five governance domains. Only a minor percentage of COBIT 2019 activities are not addressed by any of the 35 FLOSS. All cases are above 89% coverage (right column). An example of those rare activities is to encourage innovative ideas from customers, suppliers, and business partners.

Table 1. Domain's coverage by FLOSS.

Governance and Management Domains in COBIT 2019	Coverage of activities by FLOSS (%)
Evaluate, Direct and Monitor (EDM)	97,67
Align, Plan and Organize (APO)	91,31
Build, Acquire and Implement (BAI)	89,11
Deliver, Service and Support (DSS)	97,71
Monitor, Evaluate and Assess (MEA)	99,08

Inspired by the Gartner Magic Quadrant presentation, Fig. 2 includes the names of FLOSS solutions evaluated and illustrates how they are distributed according to COBIT 2019 objectives and activities. Two additional solutions, Eramba and GLPI (not included because they can address 604 and 636 activities, respectively), complete the full list of the 35 FLOSS. These two solutions were built for governance-related tasks, risks, and IT service management. Therefore, reaching a much higher number of activities (nearly 60% of the overall COBIT 2019 activities).

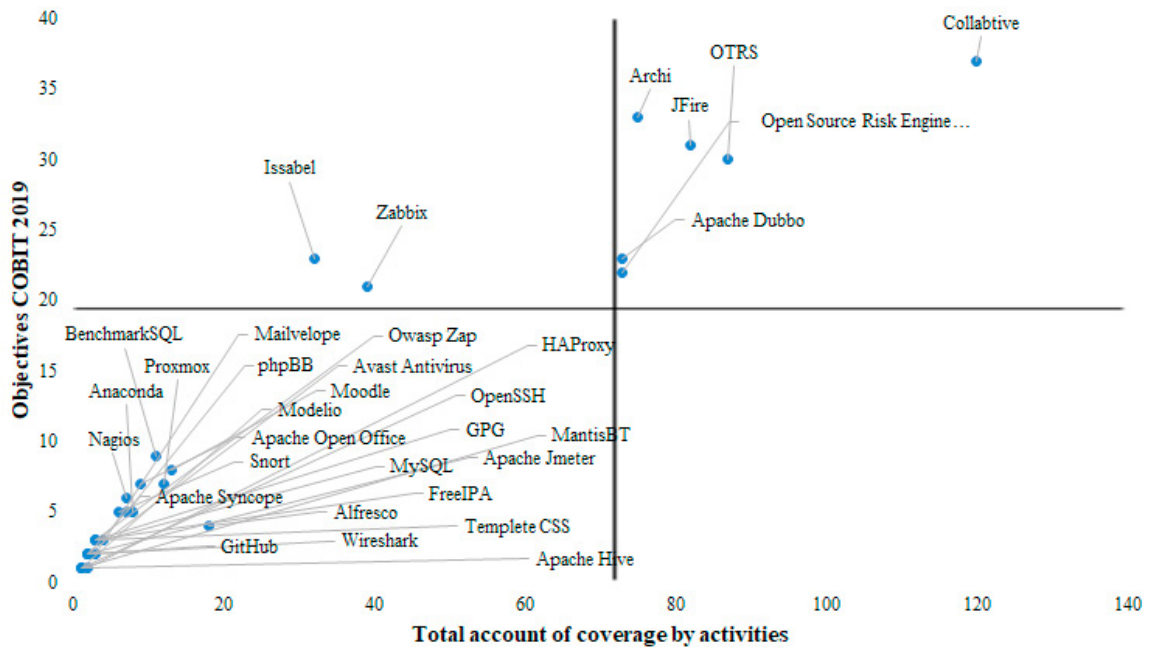


Fig. 2. FLOSS-enabled IT Governance quadrant.

The Y axis in Fig. 2 represents the 40 governance and management objectives defined in COBIT 2019. The Higher the FLOSS is located more governance and management objectives are covered. The X-axis represents the activities supported by the FLOSS. The top right quadrant includes six FLOSS solutions (> 50% of objectives and a minimum of 70 activities). Two FLOSS (Issabel; Zabbix) are above 50% of the objectives covered but with less depth in activities. 71,42% of FLOSS pertain to the bottom left quadrant.

FLOSS can support the entire PDCA [23] life cycle of IT Governance. Most FLOSS solutions assessed in this research are adopted for IT Governance execution (Do). The Act is also well represented in 16 FLOSS, while solutions addressing the Check (e.g., performance assessment, log analysis) are scarce (1 solution). Only a few in our sample helps the practitioners in planning activities.

Fig. 3. depicts FLOSS prevalence among the multiple IT Governance categories.

(e.g., Snort, HAProxy, Mailvelope, GPG, OpenSSH, Owasp Zap & Avast Antivirus)	(e.g., Issabel, GitHub & phpBB)	(e.g., Apache Syncope & FreeIPA)	(e.g., GLPI & OTRS)	(e.g., Apache Dubbo)	(e.g., Proxmox)	(e.g., Apache Jmeter)	
				Remote Procedure Call, 1	Infrastructure, 1	Testing, 1	
	Communication, 3	(e.g., Zabbix, Nagios & Wireshark)	(e.g., Apache Hive & BenchmarkSQL)	IT management, 2	(e.g., Apache Open Office)	(e.g., Collabtive)	(e.g., Eramba)
					Office, 1	Project management, 1	Governance, Risk and Compliance, 1
					(e.g., Alfresco)	(e.g., Jfire)	(e.g., Moodle)
	Security, 7	Infrastructure monitoring, 3	Risk, 2	Data Science, 1	Customer Satisfaction Survey, 1	Enterprise Resource Planning, 1	Knowledge management, 1
					(e.g., Anaconda)	(e.g., ArchiMate)	(e.g., Modelio)
				Architecture, 1	Business Process Management, 1	Database management, 1	

Fig. 3. Identification of FLOSS solutions for each IT Governance category.

The categorization of FLOSS used in Fig. 3 was done according to the information available online for each product and trials conducted by the team to more complex solutions (e.g., Security (HAProxy, Mailvelope, and Snort) or infrastructure monitoring (Nagios, Wireshark, and Zabbix)). The matrix presents the number of FLOSS per category (e.g., security on the left with 7 FLOSS solutions) and the identification of solutions on the top of each treemap cell.

4.2. A guiding framework to adopt COBIT 2019 with FLOSS

We could not find a FLOSS architecture to implement 100 % of COBIT 2019 activities at this research stage. The number of activities covered is very high (above 90%) but would require the integration of multiple FLOSS, depending on the organization's business. Nevertheless, solutions for risks, compliance, and IT service management reach an interesting level of COBIT 2019 support for nearly 55% of the required activities. Many other cases address less than 10% of activities, supporting particular niches. Therefore, FLOSS strategic planning is critical.

The range of processes relevant to IT Governance is extensive. For example, in the scope of the IT department, FLOSS can be adopted for infrastructure deployment, performance monitoring, and emerging concerns in security and intelligent data processing. Moreover, company operations (e.g., business process management) and external interfaces (e.g., customer management and satisfaction) can also find relevant FLOSS features for governance.

The entire PDCA lifecycle is also on the agenda of FLOSS, particularly for the execution (Do). However, in the perspective of processes and continuous improvement lifecycles like the PDCA, interoperability and capabilities development (e.g., training) must be evaluated by design.

A use case example can be presented for a company aiming to improve its DSS domains according to COBIT 2019. First, using the framework proposed in Fig. 4, the organization can identify the most relevant categories (e.g., IT management) and then identify examples of FLOSS available using the treemap presented in Fig. 3 (for the selected example, GLPI or OTRS would be an option). The categories are associated with COBIT 2019 domain and PDCA stage, ensuring that the selection can contribute to increasing their IT Governance maturity. We decided to separate the concrete FLOSS solutions into a different artifact (Fig. 3) to simplify the framework presentation, including only FLOSS categories relevant to each domain and PDCA lifecycle in Fig. 4.

Evaluate, Direct and Monitor	Align, Plan and Organize	Build, Acquire and Implement	Deliver, Service and Support	Monitor, Evaluate and Assess
Plan • IT management • Monitoring	Plan • IT management • Monitoring	Plan • IT management • Monitoring	Plan • IT management • Monitoring	Plan • IT management • Monitoring
Do • Architecture • Enterprise Resource Planning • Governance, Risk and Compliance • IT management • Monitoring • Office • Project management • Risk • Security	Do • Architecture • Communication • Customer Satisfaction Surveys • Database Management • Data management • Enterprise Resource Planning • Identity management • IT management • Knowledge management • Monitoring • Office • Project management • Risk • Remote Procedure Call • Security	Do • Communication • Content management • Database Management • Governance, Risk and Compliance • Identity management • IT management • Knowledge management • Monitoring • Office • Project management • Risk • Security	Do • Communication • Customer Satisfaction Surveys • Governance, Risk and Compliance • Identity management • Infrastructure • IT management • Knowledge management • Monitoring • Risk • Security	Do • Content management • Data management • Data Science • Enterprise Resource Planning • Governance, Risk and Compliance • Identity management • IT management • Monitoring • Office • Risk • Security
Check • Enterprise Resource Planning • Risk	Check • Data management • Risk	Check • Risk • Testing	Check • Infrastructure • Risk	Check • Data management • Enterprise Resource Planning • Risk
Act • Governance, Risk and Compliance • Security	Act • Database management • Data Science • Governance, Risk and Compliance • Identity management	Act • Communication • Database Management • Identity management • Security	Act • Communication • Governance, Risk and Compliance • Identity management • Security	Act • Data Science • Security

Fig. 4. FLOSS-enabled IT Governance – a guiding framework.

Fig. 4. reveals the categories of FLOSS available for each COBIT 2019 domain (on the top). The analysis was carried out according to the respective PDCA steps, making it easier to identify available FLOSS solutions. There are two main uses for the proposed artifacts. On the one hand, companies can start with the identification of the governance categories they aim to improve using the framework presented in Fig.4. Next, identify the possible FLOSS solutions for those categories in Fig. 3. On the other hand, auditors may follow the framework categories to look for evidence of COBIT 2019 compliance in the organization or suggest specific FLOSS. For example, companies may find potential business process modeling solutions (e.g., Modelio identified in Fig. 3). for planning tasks related to DSS domain. If there are compliance difficulties in APO, and risk checking activities, the Open Source Risk Engine (ORE) solution may be an option. The 35 FLOSS presented in Fig. 3 for each category are not exclusive. We are creating a table of options (e.g., the solution OpenOffice has the alternatives LibreOffice or Polaris Office, among others) to improve the FLOSS selection process, but the framework is dynamic.

5. Conclusions

This paper presented a typology of FLOSS solutions to support IT Governance according to COBIT 2019. Design Science Research [3,9] was used to search the market, assess how 35 FLOSS features address COBIT 2019, and propose a conceptual framework to assist companies in their FLOSS deployment strategy.

Several limitations must be stated. The FLOSS sample selection for testing adopted a snowballing approach. Therefore, other solutions may emerge using different sources and keywords. Our conclusions are restricted to the COBIT 2019 framework. Finally, we have followed a specific definition of FLOSS [15,16] in our work relevant to decision support in information systems implementation. This paper valued “L-libre” as part of free strategic choices instead of a strict vision of “no cost”.

Several opportunities for future work are identified. The next DSR iteration will test the framework in a real organization adopting COBIT 2019 to develop a corporate governance handbook, FLOSS infrastructure instantiation, and the framework for auditing COBIT 2019 compliance. However, the most promising future steps are related to our contribution to FLOSS advances. Our findings offer a starting point for FLOSS developers to select features relevant to IT Governance. Moreover, future FLOSS evaluation can increase companies' awareness of these solutions.

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