A SYSTEMS-OF-INFORMATION IDENTIFICATION METHOD BASED ON BUSINESS PROCESS MODELS ANALYSIS

UM MÉTODO PARA IDENTIFICAÇÃO DE SISTEMAS DE INFORMAÇÃO BASEADO NA ANÁLISE DE MODELOS DE PROCESSOS DE NEGÓCIO

UN MÉTODO PARA IDENTIFICAR SISTEMAS DE INFORMACIÓN BASADO EN EL ANÁLISIS DE MODELOS DE PROCESOS DE NEGOCIO

Lucas da Silva Oliveira
Bacharel em Sistemas de Informação - Instituto Federal Fluminense
https://orcid.org/0000-0002-0290-7402

Aline Pires Vieira Vasconcelos
Professora do Programa de Mestrado Profissional em Sistemas Aplicados à Engenharia e Gestão - Instituto Federal Fluminense

Simone Vasconcelos Silva
Professora do Programa de Mestrado Profissional em Sistemas Aplicados à Engenharia e Gestão- Instituto Federal Fluminense

Rodrigo Pereira dos Santos
Professor do Programa de Pós-Graduação em Informática da UNIRIO
https://orcid.org/0000-0003-4749-2551

Scientific Editor: José Edson Lara
Organization Scientific Committee
Double Blind Review by SEER/OJS
Received on 17/12/2021
Approved on 10/10/2022

Abstract:
Objective: This study focuses on the mapping and understanding of an organization's business processes, allowing the identification of the different Information Systems (IS) that support them, as well as the interoperability needs between them.
Methodology: The proposed method was evaluated through a feasibility study, where it was performed in a real environment.
Relevance/originality: Organizations operated in a setting where different IS are needed to achieve their goals. Thus, the identification of an arrangement's systems and their interoperability needs help managers in decision-making, in IS management and in the execution of business processes. Thus, this research investigates the relationship between business processes and these IS arrangements, called Systems-of-Information Systems (SoIS), a recent topic and still little explored in academia.
Main results: It was possible to raise the automation or integration needs between the different IS that support the execution of processes. In addition, evidence was obtained that the method supports the detection of the need for integration between organizational IS. Evidence of traceability between the business and SoIS elements was also obtained, which supports the creation of a SoIS architecture based on business processes.
Theoretical contributions: The exposition of the relationship between SoIS and business processes.
Management contributions: The proposition of a method for analyzing business process models and identifying the IS that support them, as well as the tool to support their execution.

Keywords: Systems-of-Information Systems; Business Processes; Organizational Goals.

Resumo:
Objetivo do estudo: Este estudo foca no mapeamento e compreensão dos processos de negócio de uma organização, permitindo a identificação dos diferentes Sistemas de Informação (SI) que os suportam bem como as necessidades de interoperabilidade entre eles.
Metodologia: O método proposto foi avaliado por meio de um estudo de viabilidade, onde o mesmo foi executado em um ambiente real.
Relevância/originalidade: Organizações operaram em um cenário onde diferentes SI são necessários para atingir seus objetivos. Assim, a identificação dos sistemas de um arranjo e suas necessidades de interoperabilidade, auxilia os gestores na tomada de decisões, na gestão dos SI e na execução dos processos de negócio. Desta forma, esta pesquisa investiga a relação entre processos de negócios e esses arranjos de SI, denominados Sistemas-de-Sistemas de Informação (SoIS), um tema recente e ainda pouco explorado no meio acadêmico.
Principais resultados: Foi possível levantar as necessidades de automação ou integração entre os diferentes SI que suportam a execução dos processos. Além disso, obtiveram-se indícios de que o método suporta a detecção de necessidade de integração entre SI organizacionais. Também foram obtidos indícios de rastreabilidade entre os elementos de negócio e de SoIS, o que suporta a criação de uma arquitetura de SoIS baseada em processos de negócio.
Contribuições teóricas: A exposição da relação entre SoIS e processos de negócio.
Contribuições para a gestão: A proposição de um método para a análise de modelos de processos de negócio e identificação dos SI que os suportam, bem como a ferramenta de apoio à sua execução.

Palavras-Chave: Sistemas-de-Sistemas de Informação; Processos de Negócio; Metas Organizacionais.

Resumen
Objetivo del estudio: Este estudio se centra en el mapeo y comprensión de los procesos de negocio de una organización, permitiendo la identificación de los diferentes Sistemas de Información (SI) que los soportan, así como las necesidades de interoperabilidad entre ellos.
Metodología: El método propuesto se evaluó mediante un estudio de factibilidad, donde se realizó en un entorno real.
Relevancia / originalidad: Las organizaciones operan en un entorno donde se necesitan diferentes SI para lograr sus objetivos. Por lo tanto, la identificación de los sistemas de un acuerdo y sus necesidades de interoperabilidad ayuda a los gerentes en la toma de decisiones, la gestión de SI y la ejecución de los procesos comerciales. De esta manera, esta investigación investiga la relación entre los procesos de negocio y estos arreglos de SI, llamados Sistemas-de-Sistemas de Información (SoIS), un tema reciente y aún poco explorado en la academia.
Principales resultados: Se logró plantear las necesidades de automatización o integración entre los diferentes SI que soportan la ejecución de procesos. Además, se obtuvo evidencia de que el método apoya la detección de la necesidad de integración entre los SI organizacionales. También se obtuvo evidencia de trazabilidad entre el negocio y los elementos SoIS, lo que apoya la creación de una arquitectura SoIS basada en procesos de negocio.
Aportes teóricos: La exposición de la relación entre SoIS y los procesos de negocio.
Contribuciones a la gestión: La propuesta de un método para analizar los modelos de procesos de negocio e identificar los SI que los soportan, así como la herramienta para apoyar su ejecución.

Palabras clave: Sistemas-de-Sistemas de Información; Procesos de negocios; Metas organizacionales.

1. INTRODUCTION

A system is a group of entities and their interrelations brought together to form a whole greater than the sum of the parts (Boardman & Sauser, 2006). An information system (IS) is a set of components that dynamically interrelate to collect, store and process data and provide information and knowledge that support decision-making and control of an organization (Fernandes, Ferreira, Cordeiro, Neto, & Santos, 2019; Laudon & Laudon, 2016).

Being an interdisciplinary field, IS is supported by three dimensions - organizations/processes, people, and information technology – and prove to be an important tool for creating value for an organization (Laudon & Laudon, 2016). Seeking to meet the demands of users, IS are gradually becoming more complex (Saleh & Abel, 2015) and are requested to supply a plurality of information that may not be provided by a single IS. In this context, people require systems that can be integrated to meet their requirements, acting as a "single system" and bringing more than the information itself (Mendes, Loss, Cavalcante, Lopes, & Batista, 2018).

When formed by managerially and operationally independent IS, these arrangements have been called as System-of-Information Systems (SoIS), which is the result of several IS that work together to achieve common business goals (Majd, Marie-Hélène, & Alok, 2015; Saleh & Abel, 2015). As such, the importance of the relationships between these interoperable IS is due to the fact that companies can maintain themselves and generate more value if these relationships are better investigated and understood (Santos, Thom, Cota, & Fantinato, 2019).

Systems that operate in isolation prevent the automation of information delivery and synchronization, reduce the association and sharing of data between systems and obstruct communication between different sectors, causing an organization to end up offering inconsistent information to its customers (Fu, Song, Yu, & Chen, 2010; Kretser, Ogden, Colombi, & Hartman, 2016). In addition, the lack of IS integration increases operational and managerial/coordination costs (Georgantzas & Katsamakas, 2010). So, to effectively support organizations' business processes, existing IS must be integrated (Hasselbring, 2000).

Organizations strive to create value in their products and services by collaborating with each other to complement their mutual limitations and increase their influence and business advantages (Oliveira, Alves, & Valença, 2020). This collaboration extends to their technological infrastructure, including support through IS. Therefore, a SoIS can also be seen as the resulting set of interconnected and independent IS from different organizations (Fernandes *et al.*, 2019). The systems that make up a SoIS, called as constituents, have operational and managerial independence (Maier, 1998), being internally heterogeneous, which represents one of the main challenges for the development and implementation of SoIS (Mendes *et al.*, 2018). In this context, interoperability between constituents is a primary concern (Graciano Neto, Oquendo, & Nakagawa, 2017; Klein & Van Vliet, 2013), and a key aspect n the architecture (Emruli, Sandin, & Delsing, 2015).

The concept of SoIS originates from Systems-of-Systems (SoS), which represent an arrangement of interoperable systems designed to carry out a set of missions (high-level objectives). SoS arose as a result of the need for interoperability between individual software systems in order to create more robust applications, offering features that could not be delivered by any of these systems in isolation (Maier, 1998). SoS often support critical domains (intelligent traffic control, emergency and crisis management etc.), i.e., applications in which errors can cause threats to human integrity, loss of life, or environmental and financial losses (Graciano Neto, 2017). It is essential to ensure that SoS are software-based applications with reliable and robust operation.

In turn, SoIS have a predominantly business-oriented nature, making specific methodologies necessary to capture their characteristics, such as Business Process Modelling (BPM) (Graciano Neto, Cavalcante, El-Hachem, & Santos, 2017), which adopts the Business Process Modelling and Notation (BPMN). BPMN is a simple and expressive notation, based on a process-oriented approach, being widely used in academia and industry to represent knowledge about business processes (Moore, Benedict, Bilodeau, & Vitkus, 2013). It presents graphic elements based on flowchart techniques (Falcone, Garro, D'ambrogio, & Giglio, 2018), being a notation that is easy to understand, in addition to being better supported in terms of execution tools (Mendes *et al.*, 2018).

In this context, this article proposes a method for extracting knowledge from business process models to generate IS arrangements. This method aims to gather information about the IS of an organization and how they should be integrated to better meet the organizational objectives, taking into account, for this purpose, the possible formation of SoIS. The method involves the analysis of business processes of organizational units (i.e., sectors or other types of units that integrate the organization) and/or even different organizations that interact with each other during the execution of the processes, mapped via BPMN. The method is supported by a tool, aiming to identify the communication between actors and the organization’s sectors and then allowing to infer interoperability needs between its IS through the tasks performed. The method was evaluated through a feasibility study in a real environment, where it was possible to obtain some indications of the feasibility of its application.

Based on this introduction, the rest of the article is organized as follows: in Section 2, the background on SoIS and BPM is presented; Section 3 presents related work; in Section 4, the proposed method developed is described; Section 5 presents the tooling to support the execution of the method; Section 6 describes the feasibility study; in Section 7, we include results and discussion; and Section 8 presents conclusion and future work.

2. BACKGROUND

In this section, concepts related to SoIS and BPM are presented, which serve as a theoretical basis for this work.

2.1 Systems-of-Systems and System-of-Information Systems

In a context in which different IS need to interoperate to meet users' demands, SoS emerged and have been used to support the creation of new and sophisticated functions, taking advantage of the individual functionalities offered by each of its constituents (Graciano Neto *et al.*, 2018). According to Maier (1998), SoS are composed of a group of systems that individually present operational and managerial independence.

SoS constitute a class of large-scale and complex systems that originate from the interoperability of several systems called constituents (Lana *et al.*, 2016). However, the result of this interaction is considered to be greater than the sum of its parts (constituents) because it allows SoS to provide different functionalities that could not be offered by the individual systems (Silva, Batista, & Cavalcante, 2015; Dimario, 2006).

Similar to other classes of systems, SoS has its own objectives that can be described as missions. SoS missions are high-level objectives that, in order to be achieved, rely on interoperability between constituents and their individual functionalities. Missions are specified at the requirements level and are related both to the capabilities of the constituent systems and to the interactions between those systems that contribute to the achievement of the global objectives of the SoS. Such missions can be organized into two types: global, which refer to SoS, and individual, referring to constituents that may or may not be related or contribute to the fulfilment of a global mission (Silva *et al.*, 2015).

SoIS, in turn, represent a specific type of SoS composed of one or more information systems, being these are software intensive or not (Teixeira, Lopes, Santos, Kassab, & Neto, 2019). SoIS represent a class of SoS, composed of pre-existing IS. It consists of a dynamic network of different independent systems (mandatorily including IS) that concretizes an intra organizational junction to provide new services that could not be made available by any of the systems independently (Fernandes *et al*., 2019).

SoIS is the result of modernized business processes and a globalized world in which the IS is forced to interoperate with others so that they can provide services, enter into commercial partnerships with suppliers, comply with the laws, and deliver products in an agile and optimized way (Teixeira *et al.*, 2019). Once the SoIS are oriented to business processes, they meet business requirements (aligned to one or more processes), mapped to a main objective and secondary objectives related to SoIS and constituents (Fernandes *et al*., 2019). However, many individuals IS, even though they work efficiently as an independent system, fail when incorporated as components in a SoIS (Saleh, Abel, & Mishra, 2015).

2.2 Business Process Modelling

BPM is considered a managerial discipline that addresses the definition, engineering, control and continuous improvement of business processes, aiming to achieve the organization's objectives. Process modeling makes up the lifecycle of BPM and consists of building abstract representation models, with process design or its architecture, capable of facilitating the understanding and visualization of the same by the user, in addition to enabling improvements through analysis of the collaborators (ABPMP, 2020). BPMN, a standard created by the Object Management Group (OMG), consists of a model for different target audiences. Its acceptance has grown under several perspectives with its inclusion in the main modelling tools and presents a robust set of symbols for modelling different aspects of business processes (Moore *et al.*, 2013; Santos *et al.*, 2019).

The main objective of BPMN is to provide an easily readable notation by the different professionals involved in the management of business processes. It provides an intuitive notation for both business analysts and designers, who specify the business process, and for technical users, who frequently work with sophisticated process semantics and implement complex systems related to the specified process (Falcone, Garro, D'ambrogio, & Giglio, 2017).

3. RELATED WORK

Graciano Neto, Cavalcante, El-Hachem and Santos (2017a) discuss the potential of BPM to assist the specification of missions in the context of SoIS. The authors argue that, due to the business-oriented nature of SoIS, specific notations that can register the characteristics expressed by them are essential. They also claim that it is very relevant to have, in research related to SoIS, a harmonization between the idea of missions (an important characteristic for SoS) and the concept of business processes (an important characteristic for IS). Thus, BPM can assist in this activity by: (i) allowing the use of modelling, simulation, automation and monitoring tools for SoIS missions; (ii) bringing the possibility of converting BPM models to BPEL (Business Process Execution Language) format, which allows their processing and compilation; (iii) making available a BPM meta model, which allows conversion from one model to another, including code generation; and (iv) having well-established notations, facilitating learning and modelling missions in SoIS. Therefore, the authors' work aims to discuss the possibility of using BPM notations in the SoIS modelling process, while this work aims at the practical use of business process model analysis to identify possible IS arrangements as SoIS.

Falcone, Garro, D'ambrogio and Giglio (2018) present an integration between BPMN and HLA (High Level Architecture) standards for building SoS. In the authors' work, it is demonstrated how BPMN can be used by developers to: (i) create a bridge that reduces the difference between the activities carried out by a federated system and its concrete implementation; and (ii) model relations and communication flows between the federated systems that are being executed together in a distributed simulation. The work seeks to define a standardized graphical notation, based on the BPMN flowchart techniques, which allows developers to represent in a well-defined way, in terms of BPMN models, both a federated and an HLA federation. In contrast, in this work, we seek to define a method that allows extracting information from existing BPMN models.

The work of Fernandes, Ferreira, Cordeiro, Neto and Santos (2019) presents a conceptual model for SoIS that aims to satisfy the need for a more accurate characterization of SoIS, as well as the differentiation from other complex systems. To develop the model, the authors brought together the elements of a SoIS and their relationships from a literature review. Finally, they validated the model in the assessment of three contexts of different systems, where it was decided whether they were SoIS or not. The results presented show that the proposed model has the potential to assist managers of interorganizational projects and SoIS engineers in the recognition of SoIS elements and characteristics. On the other hand, the present work seeks to define a method that allows these managers to identify and extract from the BPMN models the elements and characteristics of SoIS related to business.

4. PROPOSED METHOD FOR THE IDENTIFICATION OF SOIS ARRANGEMENTS BASED ON THE ANALYSIS OF BUSINESS PROCESS MODELS

In order to investigate the feasibility of using business process models in BPMN to identify needs for IS integration and SoIS formation, different examples of business processes models were studied and analyzed and a feasibility study was carried out in the Academic Secretary sector (AS) of a campus of a University, whose processes were already modelled. In this study, it was observed that, from the analysis of the business process models in an organization, it is possible to obtain indications of interaction points and the need for integration between its organizational units and, consequently, among their different IS.

Given this context, this section presents a method developed to guide the process of extracting and analyzing the data present in the BPMN models, as well as necessary prerequisites for the models so that they can be submitted to analysis.

4.1 Prerequisites for the Analysis of BPMN Models in the Proposed Method

From the analyzed processes and the verification of the study’s results carried out with the person in charge of the AS sector, some problems and irregularities were identified, which can occur in different contexts, as follows: (i) actors who do not have any task in the processes; (ii) actors with different names and who play the same role in different processes; (iii) inconsistency in the grammar of the name of the same actor in different processes; (iv) grammatical errors in descriptions of BPMN elements (such as lanes, tasks etc.); (v) names of processes and tasks without verbs; and (vi) a high use of abstract tasks, which makes it difficult to perceive IS that may be related to them.

In order to obtain greater efficiency in extracting data from business process models in BPMN, the method presents a list of prerequisites that must be checked for its execution, as presented in Table 1. The set of prerequisites arose from the problems faced during the study and from the analysis of the good modelling practices imposed in the Guide for Business Process Management (Moore *et al.*, 2013).

4.2 Macro Process of the Proposed Method

A BPMN model of the method proposed in this work was developed in order to facilitate its understanding and serve as a guide for its application. The macro process of the method includes the steps shown in Figure 1. Initially, the Information Technology (IT) team or the person responsible for applying the method checks the existence of business process models in the organizational units involved in the study. If there are no previous models, a modelling tool is used to model the processes in BPMN, which must be performed by the Process Management Office or a corresponding sector responsible for strategic planning in the organization.

The processes' modelling must be done following the good modelling practices and the prerequisites defined by the method, presented in Table 1. After the models have been developed or if there are previous models, one proceeds to the checking task, in which the agreement of the models in relation to the prerequisites is verified. If the models do not meet the prerequisites of the method, one must return to the modelling task. In case the models meet the prerequisites, we move on to the sub-process of analyzing the relationships between actors, tasks and systems.

Table 1
List of prerequisites for the method's execution

ID	Prerequisite	Motivation
1	There should be no lanes without tasks on the models	Only the actors that are integrally part of the process should appear in its model to obtain a clear view of the functioning of the process.
2	There should not be two or more actors in different processes that play the same role	Standardization in the nomenclature of the actors in the domain is necessary to identify the number of interactions of each actor (intensity of interaction) and to identify the correct interaction between sectors and their systems. The composition of a sector, business or domain glossary can help in this regard.
3	There must be uniformity in relation to the names of the actors in all processes, i.e., the same actor must not have their name written with grammatical differences in different processes	Same as the previous item.
4	The use of abstract tasks in modelling should be avoided as much as possible	By knowing the type of task, it is possible to point out the need for interoperation between different systems or even the need for task automation.
5	Grammatical errors in element descriptions should be avoided	Differences in the grammar of the elements (occurring due to errors) can hinder the recognition of patterns and correspondences of the elements in different processes, because it makes the same element (which presents different grammars in different processes) be seen as if it was different elements. Again, using a glossary can be useful.
6	Good modelling practices should be followed	By following the good practices of BPMN modelling, a standard is maintained in the processes' models, making it easier for them to be analysed in a more reliable way, generating more accurate information.

Note. Source: Elaborated by the authors.

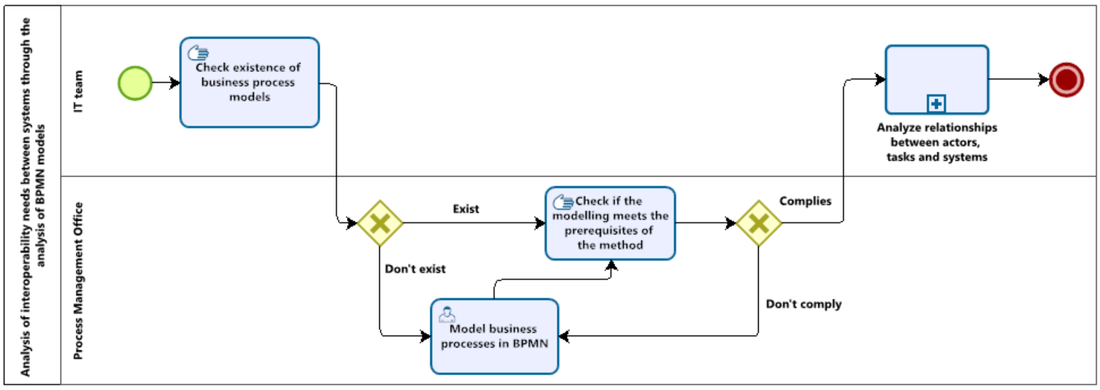

Figure 1. Macro process of the proposed method
Source: Elaborated by the authors.

4.3 Subprocess: Analyze Relationships Between Actors, Tasks and Systems

The subprocess for analyzing the relationships between actors, tasks and systems is illustrated in Figure 2. The subprocess is divided into four steps, as detailed below:

- **First step:** this step involves the analysis of business process models and the extraction of information about the actors and their related tasks. This activity is performed by the tool that was developed;
- **Second step:** after returning the results of the previous analysis, what was raised by the tool is verified with the stakeholders, represented by the management and employees of the organizational units involved, aiming at the following objectives: (i) to raise the actors external to the organization / organizational unit that interact with it based on the processes; and (ii) evaluate the intensity of the interaction of each external actor with the support of the tool, through the number of tasks that it performs in different processes. The intensity of interactions is an important parameter, as it allows visualizing with which external actors the organizational unit interacts and its relevance, being calculated using the following equation:

$$\text{interaction intensity} = \text{number of processes}^2 * \text{number of tasks}$$

  - Since participation in different processes tends to reflect a greater interaction from the actor, the number of processes in which the actor participates has a greater weight in the equation. This parameter is used to compare the external actors so that the higher the intensity value, the greater the participation of the actor in the processes and then the higher the priority of integration of the tasks performed by him/her and the IS that eventually support them;
  - In addition, the stakeholders responsible for management must validate that this intensity is in line with the priority tasks for meeting the organization's strategic objectives. Thus, it is possible to provide subsidies to support the decision of which interactions should be prioritized in the automation of tasks or integration of IS.

- **Third step:** tasks are related to the respective IS that support their execution. This step aims to gather all IS used during the execution of processes with the stakeholders. To do so, a user inserts descriptions of the tasks performed in the process and the organization's IS in the tool, which analyses these descriptions and presents a set of relationships that are then validated with the stakeholders. In this validation, the user can reject relationships that the tool wrongly suggested and/or present relationships that were not suggested.
- **Fourth step:** based on the analysis of the interaction intensity of the organization/organizational unit with external actors and the gathering of IS that support its tasks, the need for software development for tasks supported by manual IS and the needs of interoperation between IS that support the execution of automated or semi-automated tasks are evaluated.
    - This gathering should be carried out in joint meetings between the stakeholders of the organization/organizational unit management and the IT team, seeking to align with the strategic organizational objectives.

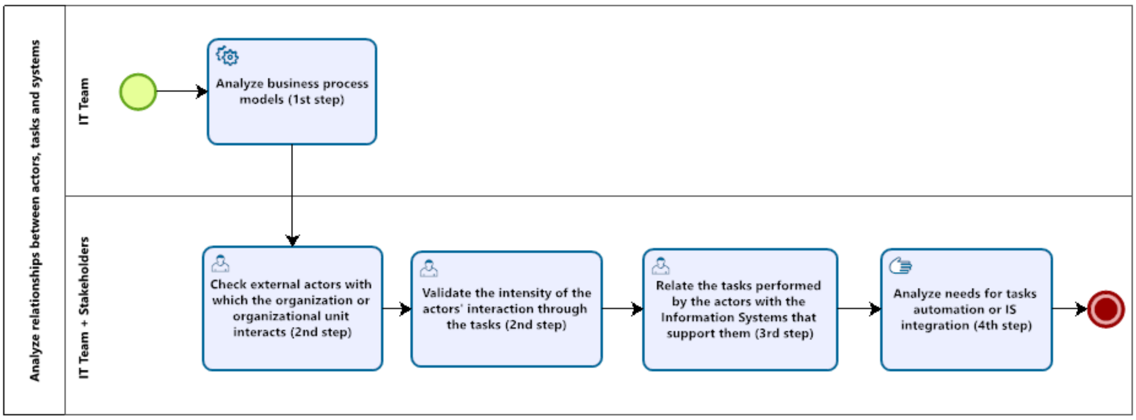

Figure 2. Subprocess: analyze relationships between actors, tasks and systems
Source: Elaborated by the authors.

In order to make the execution of the method scalable, a tool was developed to support it, which is presented in the following section.

5. TOOL FOR EXTRACTION AND ANALYSIS OF BPMN MODELS

In order to support the analysis of business process models in BPMN and to make this activity more scalable and reliable, a tool was developed. First, in order to allow the models to be analyzed in an automated way, it was necessary to export the BPMN diagrams to a format that could be read by programming languages. For that, the .bpmn format was chosen, i.e., a file standard similar to XML (Extensible Markup Language), in which the modelling elements are represented by different tags and their attributes. The programming language chosen for the development was Python, as it features the ElementTree library (etree), a library that allows the manipulation of XML files. Finally, the Django development framework was used to create a visual environment for the tool.

As such, the tool allows the reading and analysis of the models, in which it is possible to launch a number of process models that are analyzed and have their information extracted. The model elements of each process (such as lanes, tasks etc.) are saved in a database to be then crossed and compared. This is done to gather the general information contained in the models, providing an overview of the analyzed environment by identifying all the actors that integrate the processes with their respective tasks. Figure 3 shows the tool interface.

The tool's interface is divided into two areas: a main area where the files to be analyzed are uploaded and the data present in the models are presented (Figures 3, 4 and 5), and an area where the interaction occurs with the user (Figure 6). Figure 3, presents an overview of the main area of the tool. Figures 4 and 5 illustrate the region where the process information is exposed. This, in turn, is divided between a general listing of the sector's processes and their attributes (actors/lanes, tasks, gateways and subprocesses), illustrated in Figure 4, and a report of the actors, with the number of processes in which they appear and the tasks they perform in these respective processes, shown in Figure 5.

In the process listing area, each of the analyzed processes is presented, with a list of the actors participating in the process, a list of the tasks that are performed in the process (as well as the inputs, outputs, type and actor responsible for each one), a list of the gateways (decisions) that occur during the execution of the process, and a list of the subprocesses included. In the details' area, a report is displayed and identifies each of the actors showing their intensity of interaction, which is automatically calculated by the tool based on the equation presented above. Figure 6 shows the area where the tasks are associated with the IS that support them.

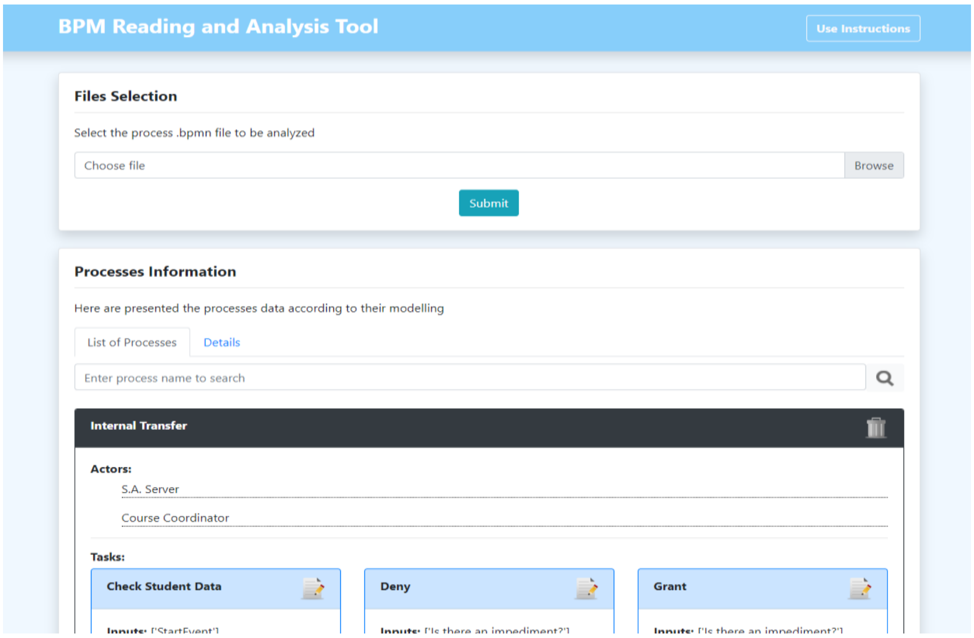

Figure 3. Tool's Interface: Main Area
Source: Elaborated by the authors.

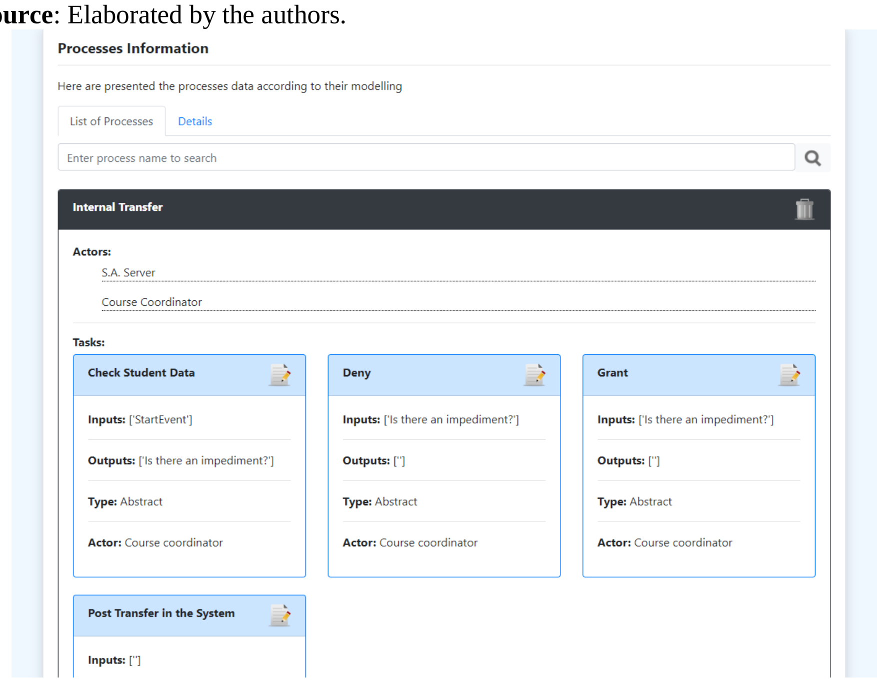

Figure 4. Tool's Interface: List of Processes
Source: Elaborated by the authors.

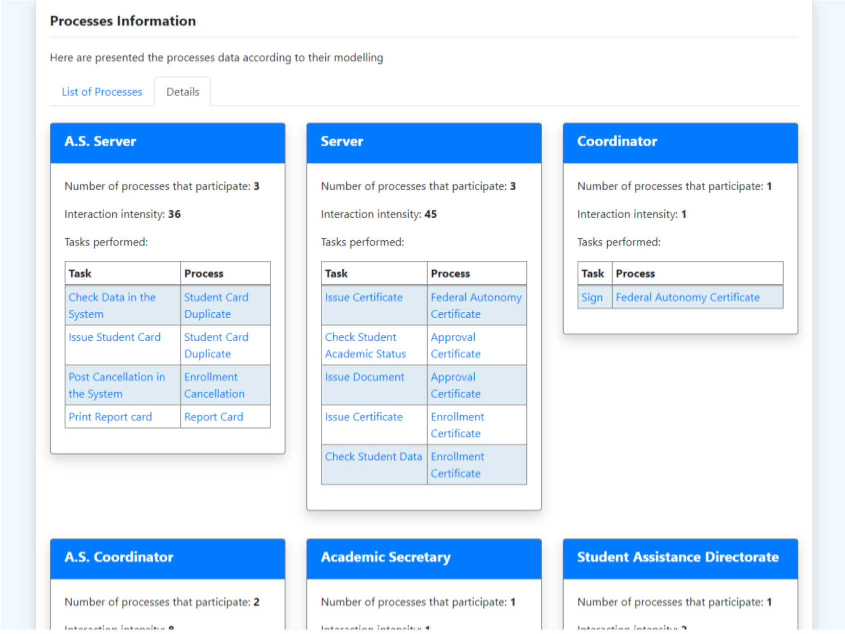

Figure 5. Tool's Interface: Details
Source: Elaborated by the authors.

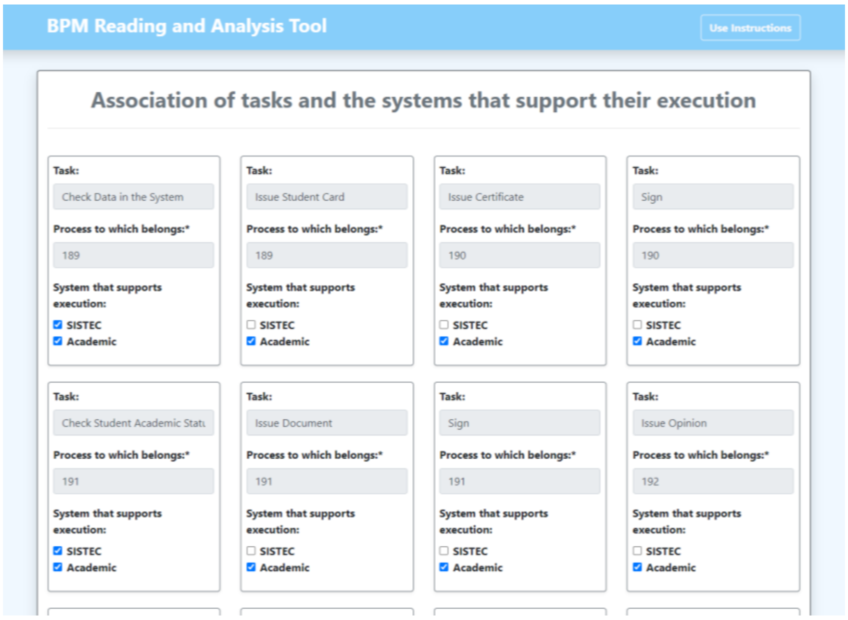

Figure 6. Tool's Interface: Association of tasks and systems
Source: Elaborated by the authors.

6. FEASIBILITY STUDY IN THE ACADEMIC SECRETARY SECTOR

While verifying the feasibility of using BPMN models to identify SoIS' formation needs, a study was carried out in the AS sector of a campus of a University. In this study, we analyzed the business process models of the sector, which manages the academic life of about 7,000 students distributed in 30 courses in different levels and teaching modalities.

The AS sector acts on all the processes that the student needs to deal with in the institution, requiring the interaction between different IS performing tasks in different sectors so that these processes can be carried out successfully. Such execution uses data distributed on different platforms, as well as internal and external IS. A list with the sector's process is presented in Table 2.

Table 2
Academic Secretary sector's Business Processes

Coordination	Business Processes
Basic Education	Federal Autonomy Certificate
	Course Completion Attestation
	LOA certificate
	Student Time Certificate
	High School Certificate
	External Transfer Guide
	Curriculum
	Internal Transfer
Higher Education	Program content
Both	Student's Requirement
	Student Card Duplicate
	Diploma Duplicate
	Graduation Anticipation
	Validate Studies
	Special Assistance to Students
	Approval Certificate
	Enrollment Certificate
	Report card

	Enrollment Cancellation
	Course Completion Certificate
	Graduation Ceremony
	Degree
	School Records
	Enrollment Reopening
	Course drop-out

Source: elaborated by the authors.

This process consists of the general procedure that occurs with the students' requirements, representing a macro process in which each request that the student has make (such as Enrolment Lock, Certificate of Completion of Course, Anticipation of Graduation etc.) represent subprocesses. Briefly, the process begins with the student filling out the requirement manually, and then proceeding to the Library where it will be checked whether the student has any pending issues. If there are no pending issues, the student must protocol the request at the reception of the AS, where the application is screened, directing it to the respective coordination of the student (Coordination AS Higher Education, or Coordination AS Technical Education). The respective coordination, in turn, identifies the request and executes the subprocess related to it. At the end of the execution of the subprocess, the application is filed in the student's folder until the student signs the receipt protocol. With the student's signature, the respective folder is thus archived, ending the process.

7. RESULTS AND DISCUSSION

During the study, the extracted data were being verified with the stakeholders. Different external actors that interact with the AS sector were identified. At the end, the following set of external actors was obtained, presented according to the order of their respective intensities of interaction: Requester, who represents the student, participates in all processes and 8 tasks; Library participates in all processes and 1 task; Course Coordination participates in 5 processes and 14 tasks; Discipline teacher participates in 1 process and 5 tasks; and Student Assistance Directorate participates in 2 processes and 4 tasks.

The Requester and the Library are counted as participants in all processes, because they are actors who perform the main tasks of the macro process illustrated in Figure 7 (Student's Requirement process). The graph in Figure 8 shows the final result of the number of processes and tasks of each actor present in the analyzed processes of the AS sector. From these data, the interaction intensities for each external actor were calculated, which are illustrated in the graph shown in Figure 9.

From the relationships of the tasks with the IS, it was found that the AS sector uses manual IS to support the tasks performed by the Student Assistance Directorate, such as “Identifying Motivation and Attempting to Reverse the Enrolment Lock” and by the Requester, as “Fill in Requirement". It was found that the Teacher is supported by a non-automated IS in the execution of manual tasks, such as "Applying an Assessment Instrument to Students in Special Care" and by the Academic System (automated) in the execution of automated tasks, such as "Correcting and Launching Notes".

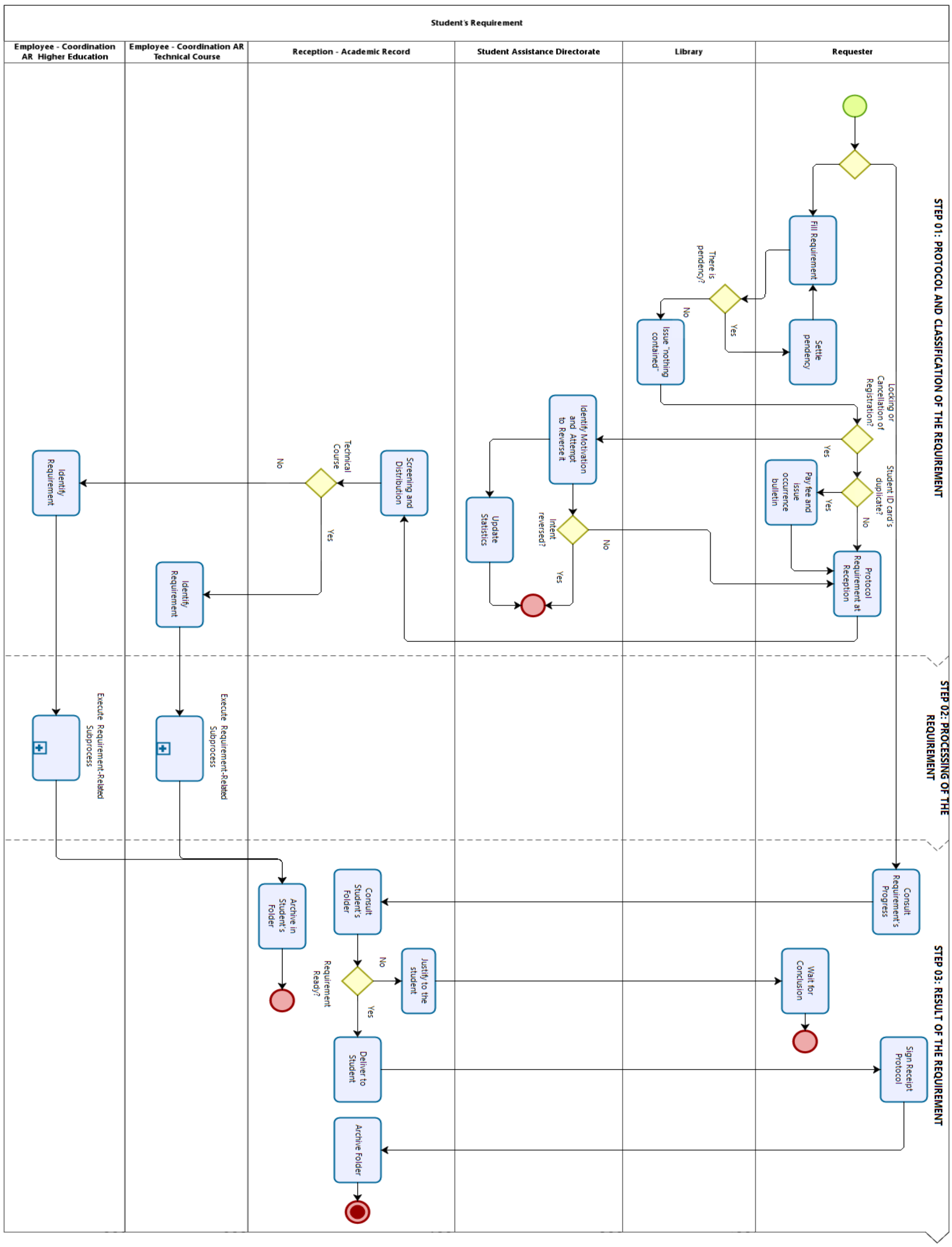

Figure 7. Student's requirement process
Source: Elaborated by the authors.

The gathering also showed that the Course's Coordination uses the Campus Administrative System, as well as the Academic System, to support its tasks. In addition, it was indicated that the Library makes use of the Administrative System for administrative tasks and its own automated IS to support queries in the task "Issue nothing contained".

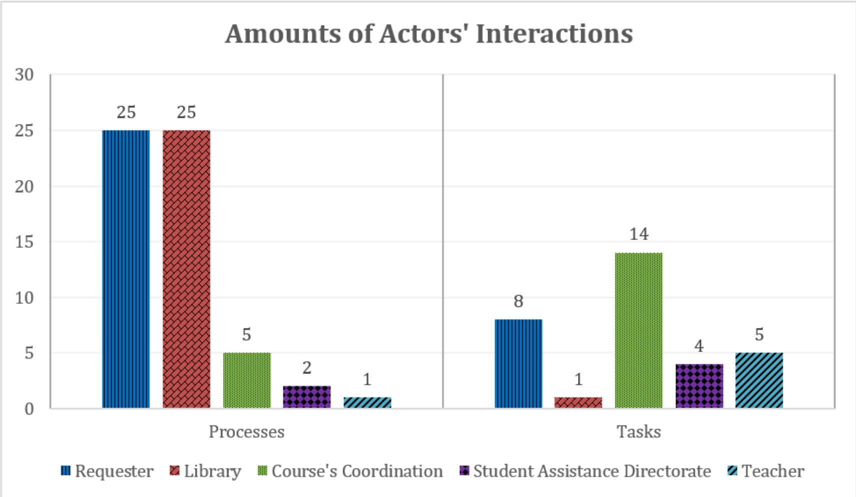

Figure 8. Amounts of actors' interactions
Source: Elaborated by the authors.

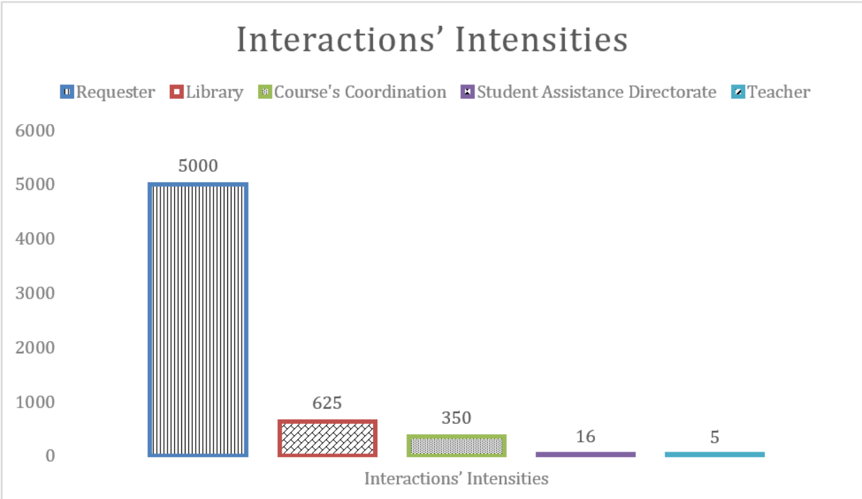

Figure 9. Interactions' intensities
Source: Elaborated by the authors.

During the assessment of software development needs and interoperation needs between existing IS, information was obtained from the Academic Directorate, responsible for the AS sector, that the priority strategic objectives involve more effective service to the student and the reduction of service overload in the reception desk, where currently the student fulfils the requirement on paper through a manual IS. Thus, based on the calculated interaction intensities and the identified organizational strategic objectives, there is a need to automate the student's requirement, in an integrated way with the systems already used by the AS sector and other external sectors, namely Academic System and the institution's Administrative System, as well as the system used by the Library. Table 3 presents the results of the study carried out, which was validated by the stakeholders, including the Academic Directorate.

Table 3
Results raised by the study

Actor External to AS Sector	Interaction's Intensity	Importance in meeting the strategic objectives	Need for automation / integration between IS
Requester (student)	25 processes; 8 tasks; intensity = 6.4%	Very important, allowing greater efficiency and comfort in attending the student and enabling greater efficiency in the reception desk's attending.	The task "Fill in Requirement" must be automated and integrated with the Academic System, which contains the student data, Administrative System and the Library system.
Library	25 processes; 1 task; intensity = 0,8%	Very important, since every requirement that the student makes in the Register requires the "nothing contained" of the Library.	Need to integrate the Student Requirement with the Library System.
Course's Coordination	5 processes; 14 tasks; intensity = 0,448%	Moderate importance, as only a few processes will require interaction with this sector.	Need for integration is not a priority.
Student Assistance Directorate	2 processes; 4 tasks; intensity = 0,01024%	Moderate importance, as only a few processes will require interaction with this sector.	Need for integration is not a priority.
Teacher	1 process; 5 tasks; intensity = 0,0064%	Moderate importance, as only a few processes will require interaction with this sector.	Need for integration is not a priority.

Source: elaborated by the authors.

8. CONCLUSION AND FUTURE WORK

This work aimed to identify the need for integration between an organization's IS, through the analysis of its business processes. The proposed method allows the semi-automated extraction of knowledge from business processes, being applicable in any organizational environment (academic, industrial etc.), as it only needs the modelling of the organization's processes in BPMN to be executed. The developed tool assists not only in the execution of the method, but also in the management and understanding of the processes. Once the modelled business processes will also involve external IS, it will be possible to detect the need for interorganizational integration.

Through the feasibility study in a real case, it was possible to obtain some indications that the method supports the detection of need for integration between organizational IS, generating possible SoIS. Since the formation of SoIS will take place based on the analysis of elements of the business (e.g., actors, tasks etc.), it can be possible to detect the traceability between these elements and the elements of SoIS, supporting the creation of a SoIS architecture based on the business, which is as an evolution of this work.

Moreover, from this work, some opportunities are pointed out as future work: (i) modularization of the tool so that other input file formats referring to business process models can be read; (ii) improvement of the tool for the extraction of other elements of the process modelling, as well as for the automation of all stages of the method; (iii) generation of SoIS architecture based on the results generated by the method; and (iv) conducting new studies in different business contexts and with greater scope.

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