Knowledge Requirements for Sustainable Smart Service Design

Jesus Mario Verdugo Cedeño[a], Lea Hannola[b] and Ville Ojanen[c]
School of Engineering Science, Department of Industrial Engineering and Management, LUT University, Yliopistonkatu 34, Lappeenranta, Finland

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Abstract: Recent research have addressed the topic of smart services from distinct angles, covering both technical and business aspects. However, a holistic approach in development processes of such services have yet to be fully covered. Therefore, this paper proposes an elicitation of requirements process as the initial step of a smart service design approach. The process takes information and knowledge needs as its core element for development, also considering customer centricity, service lifecycle, and sustainability concerns. A text mining tool was used to discover the unknown knowledge requirements from different text-data sources presented in a case ecosystem. After a co-occurrence analysis performed by our text mining software, we extracted the most relevant natural linguistic elements, which are expressed as knowledge requirements. The proposed elicitation process aims to lay the foundations for further propositions with a holistic point of view. Future research could aim the application of other technologies and methods for service design, as well as a broader approach in business processes and interdisciplinary cooperation.

1 INTRODUCTION

The more connected world and accessibility of resources have driven a seamless spread of ideas and information in a globalized market. It is leading into a relative easiness in imitation of product design, resulting in a commoditization of tangible goods (Stickdorn et al., 2018). This challenge creates a need for innovation for organizations, guiding them to turn their vision into services (Lüftenegger et al., 2017). Value co-creation is hardly conceived without the consideration of collaborative partnering interactions between stakeholders from different organizations (Lempinen and Rajala, 2014). Such collaborations are known as service ecosystems, which are considered as dynamic systems of connected actors interacting each other through value co-creation, with the ability of self-reconfiguring continuously (Vargo and Lusch, 2011, Lusch and Nambisan, 2015). Finally, a service platform serves as the means to integrate actors and resources of a service ecosystem for service exchange (Hein et al., 2018).

Service design can be defined as a "*human-centered, collaborative, interdisciplinary and iterative approach to create experiences that meets stakeholders needs"* (Stickdorn et al., 2018, p. 20), usually through the approach of design thinking. Design thinking is a collaborative approach of cross-functional teams integrated by members from different backgrounds (Lim et al., 2018). It concentrates most of the attention on customer centricity, utilizing tools such as customer journeys and service blueprints (Bitner et al., 2008). Despite being a proven approach for service design, it is not clear how design thinking considers the design process from a lifecycle point of view, where "sustainability (environment, social, economic) value" (Orellano et al., 2018) is approached, most known as lifecycle thinking (Bauer et al., 2008). On the other hand, lifecycle perspectives lack customer centricity on their frameworks (Antikainen and Valkokari, 2016, Orellano et al., 2018). Therefore, an integrated process which considers both customer centricity and sustainability matters should be researched more in detail.

[a] https://orcid.org/0000-0001-5394-9568
[b] https://orcid.org/0000-0002-9079-7839
[c] https://orcid.org/0000-0001-8124-5082

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The concept of "Smart Services" has gained attention in recent years due to the digitalization of industries. Several authors have defined the term to refer data-driven services (Kim et al., 2018, Lim et al., 2018, Neuhüttler et al., 2018). However, there is not an official definition. Data is considered the raw material or input needed to develop Smart Services. Hence, it is fundamental to understand the methods, technologies, and processes required to achieve the collection and analysis required to transform raw data to actual knowledge (Fayyad et al., 1996). There are several approaches to convert data into knowledge, for both qualitative and quantitative data. One of the qualitative ones is text mining, which is a knowledge discovery process to obtain unknown insights from data contained in texts (Bird et al., 2009). According to Lim and Maglio (2018), using text mining could enhance the data collection and analysis of keywords from different sources and related to the characteristics (features, needs, pain points, requirements, experiences) of a given service.

The present study aims to utilize text mining as the means to determine the unknown knowledge requirements from the data generated by stakeholders' service interactions. The purpose of this paper is to present a requirements elicitation process for the initial phases of a smart service design method, considering the customer centricity and service lifecycle. The organization of this paper is presented as follows: Section 2 presents a literature review of the relevant theory related to smart services design and applicability of text mining tools. As well as a brief description of text data mining and its role on determining service keywords; Section 3 illustrates in detail the requirements elicitation process proposition, the justification of the chosen approach and the gaps filled through its application; Section 4 describes the utilized research method of case study to demonstrate and justify the applicability of text mining for requirements discovery; Section 5 discusses the results of the case study and the requirements elicitation process; and Section 6 concludes with the limitations, practical and theoretical contributions, as well as its future research approaches of the study.

2 LITERATURE REVIEW

2.1 Smart Service Design

The most novel approaches for service design surged to the field with a strong focus on data, human centricity, collaboration, user experience, sustainability, lifecycle, and ecosystems. For this paper, the main focus of study are the service offerings which take data as their raw material and outcome, best known as smart services. Such services are defines by Neuhüttler et al. (2018) as a self-configurable bundle of digital and physical services based on data collected from different sources.

Recently, authors have proposed tools, method and frameworks covering the novel approaches mentioned above. First, there is the method suggested by Kim et al. (2018), which address the data collection gap of interviews, surveys, and experiments by collecting customer and business data from electronic sources. Second, Stickdorn et al. (2018) aim to deliver a service design based on customer experiences, with roots in collaborative design thinking and an ecosystem point of view. Third, Orellano et al. (2018) propose a framework for PSS offerings with a lifecycle and sustainable perspective. It contemplates all the phases of PSS lifecycle: Beginning of Life (BOL), Middle of Life (MOL) and End of Life (BOL) (Orellano et al., 2018). BOL phases consider PSS design, production and distribution; MOL phases the PSS use, repair and maintenance; and finally EOL phases involve disposal and backtracking processes. Such framework utilizes the lifecycle thinking method, which is defined by the "*ability to decouple the lifecycle of any offer into sub-processes*" (Orellano et al., 2018, p. 293), translating them into environmental and societal requirements.

All the approaches follow the current trends of service design separately. However, there is a significant research gap of proposing a framework, method, approach or a process for smart service design, which considers and integrates the aspects covered by the previous authors.

2.2 Text Mining as a Tool to Obtain Knowledge Requirements

As suggested by Kim et al. (2018) the service design process consists of the following five steps: (1) Definition of service objectives. A multidisciplinary agreement is required in order to define the market trends and constraints, as well as a precise definition of stakeholders' objectives. (2) Data collection of customers' data sources. The common methods usually utilize traditional tools for data collection, such as surveys, or experiments. However, recent studies have been using data collection from electronic sources to overcome the bias and trends from previous sources, e.g., text documents, social media, data from sensors, emails, and so on (Ordenes et al., 2014). (3) Analysis of data collection using both quantitative and qualitative methods, as well as IT related tools such as big data analytics and machine learning for requirements elicitation. For example, the study presented by Mankad et al. (2016), aims the utilization of automated text analysis tools for understanding customers' reviews. (4) Idea generation for service propositions. This step also considers the multidisciplinary approach to reach an agreement of what are the options that best meet the requirements of customers. (5) Concept generation. In this final step, the ideas that best suit the customers' demands from the previous step are selected for prototyping and market test.

For Stickdorn et al. (2018) data collection task should include different types of data outputs in order to get a more plentiful and comprehensive researcher's findings, known as *Data Triangulation*. The terms refers to the principle of combining distinct data sources, such as text in the form of documents, transcripts, interviews, audio translations, notes; images, photos and pictures; audios, videos; artifacts in the form of brochures, flyers; tickets and finally quantitative data such as statistics, tables, numbers, and so on. One of the most common processes for working with qualitative data is the Qualitative Content Analysis (Hsieh, 2005), which interprets and codifies data from text sources to find patterns and meanings from them. A regular challenge of text data is its lack of structure, given its degree of difficulty of analysis and interpretation (Orellano et al., 2018, Ordenes et al., 2014). Meanwhile, structured data in the form of numbers have been a convenient path of organizations to evaluate a product or service by giving numerical ponderations to their attributes, being questionnaires the most traditional method for customer feedback (Macdonald, 2011).

Text mining or text data mining is the process to discover unknown knowledge by the analysis of textual information, finding its structure and hidden meaning (Mikroyannidis, 2006, Bird et al., 2009). It is a continually evolving technology which integrates machine learning algorithms, data mining, natural language processing and knowledge management (Yu, 2011, Lim and Maglio, 2018). For structuring text data, data mining utilizes a processing method to extract the so-called *concepts*, which are words or complete sentences explaining a general interpretation of a text (Mikroyannidis, 2006).

Several studies have used the text mining methods to identify customer feedback, reviews, opinions and informative documents (Jansen, 2009, Ordenes et al., 2014, Mankad et al., 2016). However, no study presents the integration of diverse interactions among several members of an ecosystem in a systematic approach, either analyse the whole lifecycle perspective of such interactions.

3 PROPOSED KNOWLEDGE REQUIREMENTS ELICITATION PROCESS

The elicitation process suggested in this paper considers business related aspects, such as system mapping, customer centricity and service lifecycle; as well as technical related aspects, such as text data mining analysis. The elicitation proposition adheres to the service design process explained above, focusing on the three first steps of it. The reason why the elicitation process is developed in such way lies in two arguments: (1) the need of practical studies that consider a holistic approach of identifying, collecting and analysing different data sources presented in a service ecosystem and in each phase of service lifecycle, and (2) the applicability of text data mining tools to discover knowledge insights from non-structured natural language sources. In industry, there is a saturation of quantitative structured data with a wide offer of technological and managerial developments able to reach a high level of automation in decision making.

The first step of the process consist in the use of the system map tool proposed by Stickdorn et al. (2018) in their collaborative service design approach as a reference to present the relationships between members of a product-service ecosystem. It represents the value exchanges (money, goods, services, and information) among such members. The adaptations of the Stickdorn et al. (2018) system map for our process consisted in solely two aspects. The first one is the simplification of the value representation. While the original map considers four forms of value exchange, this proposed process only contemplates the information exchanges and interactions, since knowledge (information) is the primary resource for creating smart services. The second one is the integration of a lifecycle approach into the system map. Namely, the process also maps information exchanges and interactions between ecosystem members through the whole service lifecycle as shown in Figure 1.

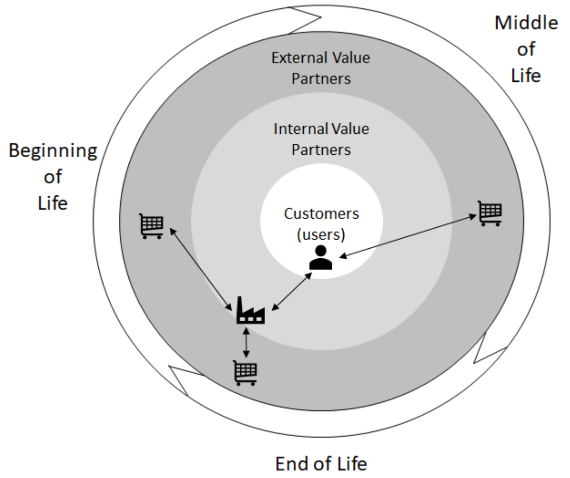

Figure 1: Service ecosystem value exchange (information) mapping from a customer-centric and lifecycle approach (adapted from (Stickdorn et al. 2018).

The purpose of the lifecycle approach is to give deserving importance to the middle and last phases of the lifecycle. In such a way, we cannot ignore the environmental and social aspects, i.e., sustainability issues. The system mapping is necessary at the beginning to understand all the information interactions between value partners in the ecosystem, for later identify the data sources of such value exchanges. In fact, the initial step of the process is to identify and describe the sources of data collection presented on every phase of the service lifecycle, which can be presented in the form of text content, reviews, interviews, brochures, flyers, reports and so on. The further step consists of the data collection, text data mining analysis and report of the analysis results by presenting the most common and usual

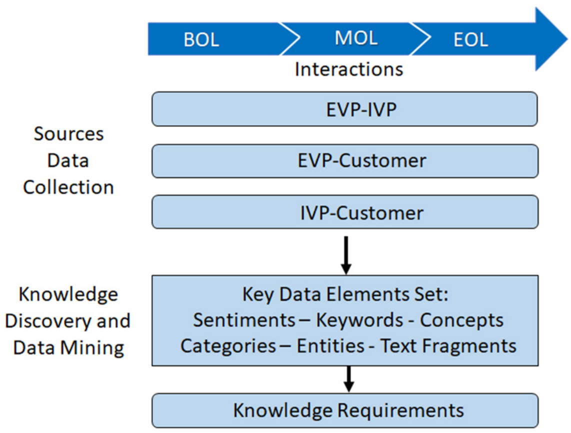

Figure 2: Framework for determining Knowledge Requirements for Sustainable Smart Service Design.

keywords obtained from such data sources. In the particular case of our study, we decided to utilize the data elements (sentiments, keywords, concepts, categories, entities and text fragments) offered by our text mining software enrichments. Data enrichment is defined as an algorithm that process unstructured text data from different sources to find insights that were not referenced explicitly in the text, interpreting the data into the context of other information sources and simplifying the definitions of specific topics (Hasan et al., 2011, IBM). A data enrichment utilizes a linguistic approach which considers the natural language contained in the data sources, identifying the domain (topic) predominant for effective analysis (Ordenes et al., 2014). The data enrichment algorithm used by the software employed in this study removes the irrelevant elements and performs interdependency analysis to bring the key or most relevant element set on the members' interaction. The elements that present a higher co-occurrence are considered as knowledge requirements. The whole requirement elicitation process is illustrated in Figure 2.

4 CASE STUDY: OIL LUBRICANT AND ADDITIVE MANUFACTURER ECOSYSTEM

An empirical study was used to apply and test the elicitation process previously presented. The members involved in the study were a car lubricant and additive manufacturer and one of its main customers, a fuel stations group providing full-service offerings to its customers. The manufacturer supplies several customers segments in its value chain. Their customer segments are car workshops, spare parts stores, retail stores, and its main customer fuel stations. The fuel stations group provide full-service offerings to its customers, including gasoline and diesel filling, express car washing and car liquid level checking, serving both consumers and corporate clients. The optimal scope of this study would be the full integration of all the members involved in the manufacturer's ecosystem. However, due to the extension limitations of our work, we will consider the system integrated by the manufacturer and the service station group, including its members and regulators, defined as the micro-ecosystem.

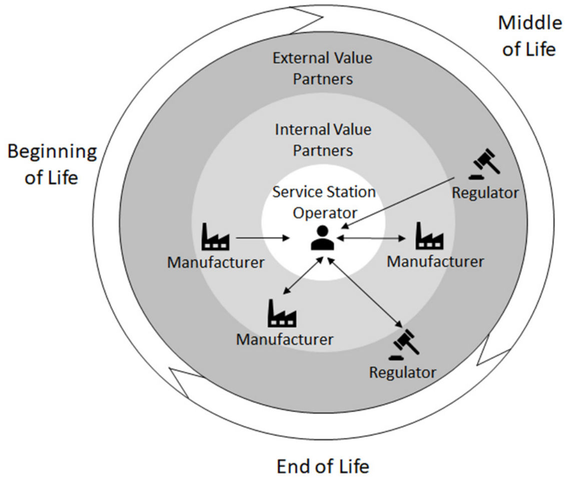

Figure 3: Service ecosystem value exchange (information) mapping among members of case study.

The study began with two interviews made to the Operations Managers from both companies. The purpose of such meetings was to identify the data sources presented in each interaction, considering the whole service lifecycle. The members involved within the manufacturers ‘side were sales representatives, training leaders, technical representatives and operations managers. From the fuel stations group side, the members involved were service operators, sales and operations managers. Finally, the regulator´s side was represented by governmental institutions and private quality assurance entities. The value (information) exchanges between members are graphically represented in the system map shown in Figure 3.

The managers from both companies provided the data sources resulting from the previously mentioned interactions. As shown in figure 4, several data sources were identified for the different members interactions across the whole service lifecycle, representing the first part of our elicitation process. Diverse areas involving the performance, customer feedbacks, safety issues and product handling were found. According to our interviews and employees´ recommendations, we selectively categorized four areas or fields for our analysis: Safety, Regulations, Performance and Disposal. The next step was to perform the text mining analysis. The software used for this study was IBM Watson Discovery, a cloud-based solution which uses algorithms to process text data from diverse sources, transforming raw unstructured data into explicit and implicit findings. We proceed to upload all the text documents previously into the software cloud in order to carry out the text mining process and knowledge discovery. After the text mining process was finished and data enrichment analysis was performed, the software brought us outputs composed of multiple key elements. The chosen elements were selected based on their co-occurrence, which are the elements with

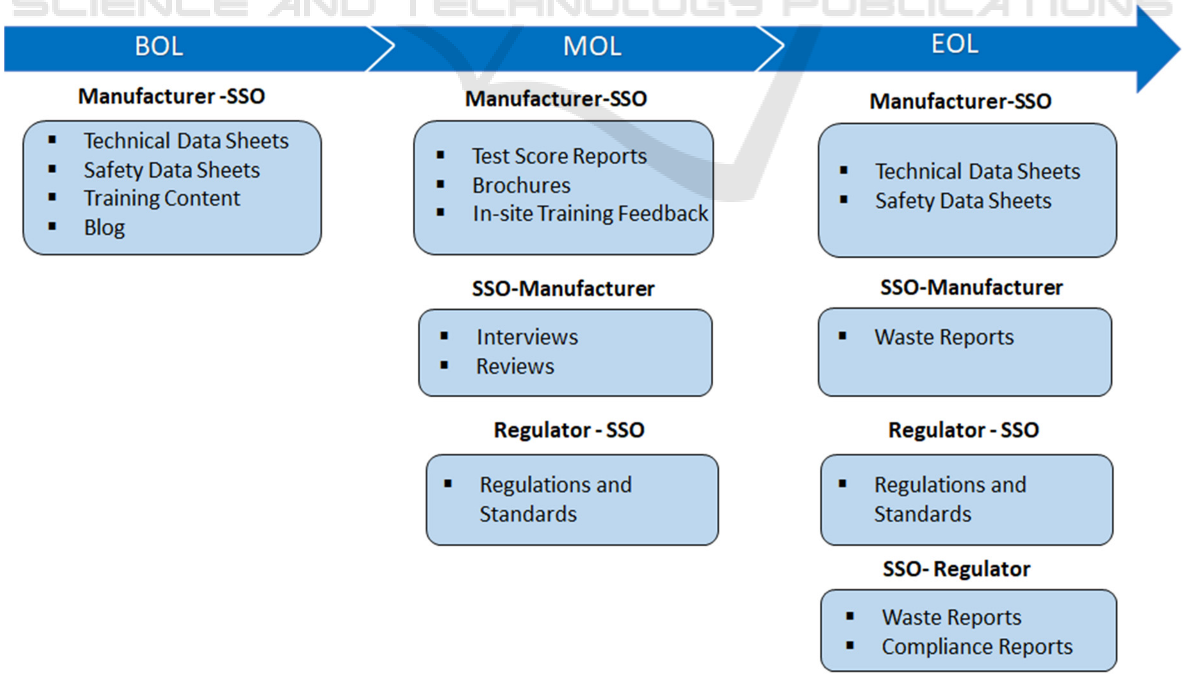

Figure 4: Sources of data collection through the phases of service lifecycle.

more interdependency with each other once the software eliminates irrelevant elements and performs the statistical analysis for term frequency. The last one is an automate process that brings the most common and used keywords presented in the documents. As shown in Table 1, we organized the key elements (outputs) presented according to the areas previously described and the three phases of service lifecycle as illustrated in Figure 4. Finally, once the key element set is obtained and organized, it is utilized as the main input to construct the whole knowledge requirements elicitation process, necessary for further smart service design process steps, which are object of study for future research.

5 RESULTS AND DISCUSSION

In order to describe the results obtained and illustrated in Table 1, the following lines will explain the origin and application of the key elements discovered, henceforth expressed as knowledge requirements. We begin presenting the keywords output brought by the statistical analysis for term frequency, which is one of the previous analysis before obtaining the key elements by co-occurrence or interdependency. The most frequent terms by study area are: (1) Safety keywords related to health hazards and risks that the handling of lubricant and additives can cause to human health, such as *Inhalation, Skin, Toxicity, Breathing* and *Irritation*; (2) Regulations keywords with strong emphasis on the compliance and environmental preservation fields, such as *Pollution, Carbon Monoxide, Hazards, and ISO and OSHA* standards; (3) Performance keywords aiming the knowledge of the recommended product to use in each car and situation, such as *Application, Benefits, Applications, 100000 Km, Transmission, Corrosion, Viscosity Index, Synthetic*; (4) Disposal keywords related to waste management and handling of liquid and solid hazardous waste, such as *Residues, Collectors, Spills, Environment, Containers, Lifecycle and Transportation.*

As we can observe, the keywords brought by the term frequency statistical analysis only provide single words without any natural linguistic-based outcomes involving the syntax, grammar and interdependency of elements. The resulted keywords are important to understand the repeatability in words an identify certain parameters. However, the analysis concerned to this study involves the more complex process involved after the software eliminates irrelevant elements and brings term frequency, the linguistics-based co-occurrence analysis, which bring us key data elements in form of composed keywords.

As shown in Table 1, we can identify several key elements that illustrate the knowledge requirements in a structured way after the co-occurrence analysis. It reveals us the exact knowledge need presented in each phase of the service lifecycle. Firstly, at the Beginning of Life phase we can find elements related to the information of the properties, characteristics and classification and disposal of the product. It interesting in this case that the main requirements are not service concerned, rather product orientated. Makes sense in the way fuel stations operators and managers demand all the crucial knowledge needed to perform an optimal service, keeping the customers and employees in the safest condition before their activities begin. Elements such as *Toxicological Information, Component Information, Oils and Additives Classification and Uses*, and *Confined Spaces* confirm us the concerns. Currently, employees do not have the technological tools to extract the most important information from data sources, given the fact that such information is contained in hundreds of electronic or paper documents in form of technical data sheets, safety sheets, training presentations, and so on. Making the request of single query a very challenging and time-consuming task to be done. Therefore, even when employees are constantly trained, some valuable knowledge is still hidden within the document pages. Secondly, at the Middle of Life phase we observe a transition towards the performance of the service per se. In the performance area, the elements of *Recommended Applications* and *Car Condition Determination* explain us the need of recognizing the diverse conditions a car could face. As we previously observed in the frequent keywords, information regarding the condition of the transmission, high-kilometrage engines, corrosion and many more car states are concerns to determine the correct product and service offering. However, nowadays service providers are guided on their previous experience, traditional training and colleague advise, guiding them to offer a service susceptible to errors. In the Safety and Regulations areas, we notice the interest to preserve human integrity while providing the service. The elements *Security Practices, Risk Control Procedures* and *Chemical Substance Practice* are related to the protocols the employees must follow in order to mitigate risks and the way they respond to possible emergencies when handling chemical products in the service activities. In the Disposal area, the elements of *Product Spills* and *Cleaning Methods* clearly describe the need to know the procedures in

Table 1: Knowledge discovery of key data elements for requirements elicitation.

Fields	BOL	MOL	EOL
Safety	Hazard Communication	Security Practices	
	Toxicological Information	Risk Control Procedures	
Regulations	Component Information	Chemical Substance Handling	Appropriate Containers
Performance	Product Classification	Recommended Applications	
	Product Uses	Car Condition Determination	
Disposal	Confined Spaces	Product Spills	Dangerous Residues
	Contractor Competence	Cleaning Methods	Waste Collection

case the product leaks in certain surfaces when giving the service, causing an environmental damage and potential hazards. Finally, at the End of Life phase, naturally the areas of Disposal and Regulations are presented. The elements of *Appropriate Containers*, *Dangerous Residues* and *Waste Collection* provide us a convinced idea that the main knowledge requirements are related to processes and regulations in storage, transportation and confinement of residues for sustainable and safety purposes.

6 CONCLUSIONS

The practical contribution of this paper is to bring us an understanding of the main knowledge needs from the people involved in the operational and customer service processes every day. Which is one of the pillar steps in the development of the smart worker or the so-called Operator 4.0, also presented at service and retail industries. Previous research mainly focuses on the development of the smart worker within purely manufacturing environments, without mentioning the opportunities on their peripheric ecosystem members. Two main novel tools contributed to the development of the proposed process. First, the use of the system mapping tool to understand the information value flows and data sources needed, considering all the phases of the service proposition and all the members involved within the ecosystem. Second, the application of text data mining from the data sources allows us to comprehend the key elements presented in different ecosystem process, identifying the information or knowledge needs for the further smart service design phases.

We identified three main limitations to our study that can be tackled for future research. First, our results depend on the analysis of the given data sources documents from case companies. We infer that the quality and amount of information contained on the documents provided by the managers from the two companies were adequate. However, the information contained on the documents can change overtime and the amount naturally will raise. That could be an opportunity to address a more complex analysis and better algorithm training. Second, the study did not describe in detail each business process involved within the ecosystem members. For general purposes, this the scope of this study was appropriate. However, future research may address the analysis of business processes in a systematic way to comprehend the pain points and needs involved. Third, this study employed tool IBM Knowledge Discovery for text data mining. Which is a software with a high degree of process automation, making easier to non-field experts in the data science area to perform high-quality analyses. However, future research could focus on providing more specialized data analysis performed by experts as collaborators of further works, who could exploit state-of-the-art methods. Since the study involves both managerial, business and technical work, it would be necessary to achieve a collaborative and multidisciplinary environment, integrated by field experts, operators, managers, regulators, and other members presented in the ecosystem.

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