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The optimization of business processes in Moroccan public sector based on AI,COBIT and Blockchain: case of Purchasing Business Process in public universities

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of the requirements for the degree of
PhD in computer science

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Abstract

Business process management has received more attention in the private sector literature, such as industrial engineering and management. The public sector in turn has been given less attention. As a result, managers in public sector are perplexed about how Business Process Management concepts should be implemented, and how should public organizations reorganize to accommodate business process management.This research work try to provide answers in this context, and aims to reduce the complexity around business process management implementation and optimization in the public sector.to do so, we study and demonstrate the impart of information technologies and standards such as Artificial Intelligence , Blockchain and COBIT 2019 on Business Process Management in public sector. For a better mastering of the issue we reduced the spectrum of our proposal to the Purchasing Business Process PBP in the context of Moroccan public universities. The Purchasing Business Process was chosen as use case, because of it's great financial stake, and also it's organizational challenges. In fact,The Moroccan Court of Accounts often highlights the Purchasing Business Process in the public sector as a budgetary loophole because of many organizational issues. Accordingly, we propose a new approach for the organization and execution of the Purchasing Business Process in Moroccan public universities. This approach aims to establish a system of transparency and governance best practices to minimize financial wastes and overcomes organizational issues. Our proposal approaches the problem from tow axes: The first one is enhancing the actual purchasing business process with COBIT 2019 guidelines, and Artificial Intelligence techniques. COBIT 2019 aligns the Purchasing Business Process with conventional regulations and best practices in IT governance. Based on these guidelines, an intelligent recommendation system is proposed to generate an optimal and reliable purchasing order. The second axe focus on the interactions between the Purchasing Business Process stakeholders. This axe appeals the concept of Blockchain technology to create a platform where stakeholders can exchange sensitive and financial information in a secure and trusted way.The intelligent recommendation system and the Blockchain platform are experimented trough a prototype software we have developed and entitled : Blockchain Intelligent System for Business Process Execution BIS-BPE. The BIS-BPE was experimented on the purchasing of IT products (hardware, gear, etc.) in our faculty. Experimental results demonstrate that our approach contributes to limiting financial wastage, optimize organizational issues and promotes transparency in this business process.

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This work could not have been successfully accomplished without the help of many people.

Thanks to Professor Pr. Aaroud Abdessadek for the excellent supervision and support. It has been a pleasure working with him, especially because of his constant support in all of my endeavours throughout my studies and also for his enlightened orientations.I have learned a lot from him in both research and personal levels.

Thanks to Dr. Akodadi Khalid, Dr. Sabiri Khadija and my colleague Ait Bennacer Sara , for all the help and teaching, especially for mathematical optimization and Blockchain technology implementation. I have definitely enjoyed working with the ELITES Lab members, and I look forward to collaborating with them even after graduation.

Thanks to my family and friends for their full support on all of my endeavours. Thank you for helping me during my hard-times Thanks for making me believe in my ambitions and go all the way to make them.

Chapter 1

Introduction and Literature Review

1.1 Introduction

This research work fits in a global research project initiated in the ELITES Lab by Pr Aaroud Abdessadek. This research project is an e-governance centred project Figure 1.1. And it aims to address governance challenges in Moroccan public sector trough the integration of Information and Communication Technology (ICT). The project initiated for now four thesis topics in different business domains such as public health, urban planing and education. In the current work we study one of the most important pillar of governance which is the Business Process Management BPM. In fact, Business Process Management is one of the effective performance methodologies used in the management and governance of process-oriented organizations [1] such as public institutions. Therefor we orient the study in this research work on the BPM and we demonstrate it's integration we new ICT enhance the ability of managers in public sector to address the governance challenges and overcome many limitations. The business domain we have chosen to demonstrate our proposal is the public university for tow reasons : first, due to the experience and knowledge of the research supervisor and lab-mates in public university governance challenges and problems, and second because of the growing demands both within the university and the government authorities to makes the administrative business process traceable, efficient and transparent.

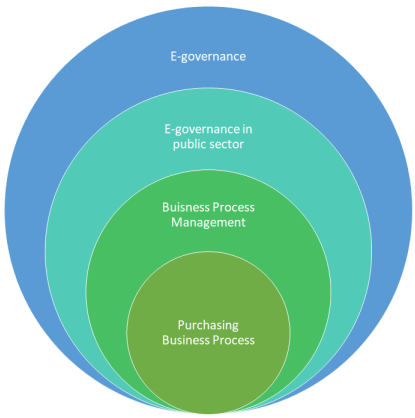

Figure 1.1: Initial Requirements

Therefore, in order to reduce the complexity around Business Process Management in public sector, we study and demonstrate the impart of information technologies and standards such as Artificial Intelligence, Blockchain and COBIT 2019 on Business Process Management. These study covers the modeling, implementation and optimization of BPM in in the public sector. For a better mastering of the issue we reduced the spectrum of our proposal to the Purchasing Business Process PBP in the context of Moroccan public universities. Purchasing Business Process was chosen as use case because it's a very impacting and problematic Business Process in Moroccan public sector, especially because of it's great financial stake. In fact, The Moroccan Court of Accounts often highlights the Purchasing Business Process in the public sector as a budgetary and organizational loophole.

We propose a new approach for the organization and execution of the Purchasing Business Process in Moroccan public universities. This approach aims to establish a system of transparency and governance best practices to minimize financial wastes and overcomes organizational issues. Our proposal approaches the problem from tow axes: The first one is enhancing the actual purchasing business process with COBIT 2019 guidelines, and Artificial Intelligence techniques. COBIT 2019 aligns the Purchasing Business Process with conventional regulations and best practices in IT governance. Based on these guidelines, an intelligent recommendation system is proposed to generate an optimal and reliable purchasing order. The second axe focus on the interactions between the Purchasing Business Process stakeholders. This axe appeals the concept of Blockchain technology to create a platform where stakeholders can exchange sensitive and financial information in a secure and trusted way.

The intelligent recommendation system and the Blockchain platform are experimented trough a prototype software we have developed and entitled : Blockchain Intelligent System for Business Process Execution BIS-BPE. The BIS-BPE was experimented on the purchasing of IT products (hardware, gear, etc.) in our faculty. Experimental results demonstrate that our approach contributes to limiting financial wastage, optimize organizational issues and promotes transparency in this business process.

Owing to the COVID-19 pandemic, the World Bank estimated that most major economies will lose at least 2.5 percent of their gross domestic product (GDP) value [2]. In developing countries like Morocco, the impact may be even more prominent, and the government will inevitably find loans to overcome the economic damage. This necessarily implies an increase in external debt, which places the country in a vicious circle that delays economic development. To limit external borrowing, the government must optimize internal expenses and optimally limit waste linked to bad governance. Our current research fits this endeavor. We propose a new approach to the organization and execution of the purchasing business process at Moroccan public universities. In fact, the Moroccan Court of Accounts often highlights the purchasing business process in the public sector in general and public universities, particularly as a budgetary loophole. Thus, the proposed approach aims to establish a system of transparency and governance best practices in this business process.

Our proposed approach enhances the actual purchasing business process with Control Objectives for Information and Related Technology (COBIT) 2019 guidelines and artificial intelligence techniques. COBIT 2019 aims to align purchasing business process with conventional regulations and best practices in IT governance. Artificial intelligence techniques are used to establish an intelligent recommenda-

tion system. This recommendation system takes purchasing preferences as technical features as input and then executes a series of filters on local and crawled data to propose suitable products in quality and cost. Hence, the final output of the recommendation system is the optimal purchasing order. Actual state regulations on purchasing business processes stipulate that the optimal purchasing order is chosen according to lowest bidder principal. This approach does not guarantee compliance with average market costs. Purchasing order can be excessive, despite proposing lowest price. Hence, the proposed recommendation system proposes an alternate approach that defines optimal purchasing order based on utility theory [3].

The intelligent recommendation system is experimented on the purchasing of IT products and gears, and the purchasing scenario is established in our computer science department. Experimental results demonstrated that our approach contributes to limiting financial and time waste and promotes more transparency in the purchasing business process.

We aim to answer the following key research question: How can we promote transparency, limit financial wastes, and reduces execution time in the purchasing business process of Moroccan public universities? To gather the answers, we first studied the current purchasing business process. This process is then formalized to analyze and highlight its weaknesses. This analysis enabled us to approach the "to-be" purchasing business process. We then propose a recommendation system that constitutes an execution framework for this business process. We have conceived this recommendation system as an organizational tool and as a vector to governance best prices to answer the previous research question.

The paper is structured as follows:

- Section 2 presents the research methodology.
- Section 3 discusses related works and contributions and positions the current paper.
- Section 4 presents and models the purchasing business process in Moroccan public universities.
- Section 5 overviews the motivation scenario and the theoretical background of our proposition
- Section 6 presents the intelligent recommendation system and its components and workflow
- Section 7 presents the implementation of the intelligent recommendation system. A prototype is developed and tested on a real purchasing use case in computer science department.
- Section 8 discusses the results
- Section 9 anticipates the perspectives of our future works

Business Process Management (BPM) refers to the design, execution, monitoring and improvement of a set of sequential tasks, which are essentially business processes performed within or between organisations by various participants or stakeholders.BPM has undergone significant and sustained improvements thanks to the evolution of information and organisational systems over time. This improvement has been supported by the implementation of new technologies (Internet, distributed

systems, web applications, etc.) and innovative modeling standards such as PBMN [4].

In general, BPM is about getting a group of participants (people and/or organisation) to work together within a regulated framework to achieve business goals. This includes task automation and supervision and a centralised controlling entity to manage it all. Despite the ambition of the approach, BPM still faces many challenges.In fact, the diversity of shareholder roles and the distributed execution of business processes raises the problem of transparency and consistency within these transactions. This lack of trust is partly due to the risk of unfair control within the business process itself, and also to security vulnerabilities and malicious access.

Blockchain technology has demonstrated its ability to address these issues. First, Blockchain can provide a high level of security for BPM through its private/public key authentication and powerful cryptographic algorithms.Second, in terms of data processing, management and storage, Blockchain applications propose innovative and trust-building methods, particularly through Smart Contracts. Therefore, Blockchain technology has the potential to take business process management to a new level of security, traceability, trust and decentralisation. The aim of this paper is to examine the main issues of BPM, in particular, the Purchasing Business Process. This paper also tries to outline the potential of Blockchain technology in relation to these issues, and how Blockchain technology can unlock them in the case of Purchasing Business Process.

This paper will be organised as follows

- Introduction : in this section, we will present the general context and the motivations behind this research work.

- Blockchain and Business Process Management : in this section, we will define each of the concepts in order to state the research problem.

- Related works : in this section we will present four research works dealing with same research question

- Hypothesis and Proposal : in this section we will present the theoretical framework of our proposal.

- Reflections and perspectives: in this section we will discuss the potential limitations and perspectives of our proposal.

1.2 Business Process Management BPM

1.3 Business Process Management in public sector

1.4 Purchasing Business Process in Moroccan Public University

1.5 Research questions

1.5.1 Problem Statement

1.5.2 Research Objectives

Main Objective

Specific Objectives

1.6 Literature Review

Chapter 2

Research Methodology and adopted approaches

2.1 Overview

2.2 Experimental Method

2.3 Simulation Method

2.4 Model Driven Architecture

2.5 Design Science Research methodology (DSR)

Chapter 3

Intelligent Recommendation System for PBP

3.1 Introduction

Owing to the COVID-19 pandemic, the World Bank estimated that most major economies will lose at least 2.5 percent of their gross domestic product (GDP) value [2]. In developing countries like Morocco, the impact may be even more prominent, and the government will inevitably find loans to overcome the economic damage. This necessarily implies an increase in external debt, which places the country in a vicious circle that delays economic development. To limit external borrowing, the government must optimize internal expenses and optimally limit waste linked to bad governance. Our current research fits this endeavor. We propose a new approach to the organization and execution of the purchasing business process at Moroccan public universities. In fact, the Moroccan Court of Accounts often highlights the purchasing business process in the public sector in general and public universities, particularly as a budgetary loophole. Thus, the proposed approach aims to establish a system of transparency and governance best practices in this business process.

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3.2 Related works

We have chosen the following research works as they share with our proposal the recommendation of products to users based on initial data or metadata. We analyzed these related works based on eight axes: graphic user interface, use of review dataset, product information filtering, product review filtering, criteria ponderation, proposal of similar products, use of sentiment analysis for review classification, and finally the classification algorithm used in the sentiment analysis process.

In [5], the authors proposed a system that extends item-based collaborative filtering algorithm. In terms of data, this system combines "online product click data" (metadata) and offline product sale data. This combination represents the customers' online and offline preferences. These preferences were traced over time. The recommendation system aims to offer substitute and complementary products by exploring product category information based on a scoring system. This field of study focuses on fashion products, and the proposed system was adapted into this domain's characteristics. First, preferences for fashion products appear using

online click and purchase data to generate recommendations. Second, preference for fashion products decreases over time. Finally, the product that the customer wishes to purchase replaces or supplements the product that the customer prefers before.

Authors in [6] also propose a product recommendation system. Unstructured data have the potential to be transformed into information that companies and users can employ using appropriate processing and analyses. However, existing systems do not reflect the detailed information they collect (e.g., user characteristics, purchase preferences, or purchase priorities) while analyzing review data. Therefore, providing customized recommendations to various users is challenging. Therefore, in this study, we have developed a product recommendation system that considers the user's priority, which they select, when searching for and purchasing a product. The recommendation system then displays the results to the user by processing and analyzing their preferences. Because the user's preference is considered, the user can obtain more relevant results.

Research work proposed in [7] adheres to the emergence of data marketplaces as an alternative to traditional data commerce as they provide appropriate online environments for data offering and purchasing. Nevertheless, as the number of available purchase datasets increases, the task of buying appropriate offers is often challenging. In this sense, we propose an intelligent decision support system to help buyers purchase data offers based on multiple-criteria decision analysis. Experimental results show that our approach provides an interactive way to address buyers' needs, allowing them to state and easily refine their preferences, without any specific order, via a series of dataset recommendations.

Research work in [8] propose a recommendation system that suggests product alternatives. This study highlights the limitations of traditional recommendation systems that cannot recommend alternative products when existing product reviews are negative about a specific product (e.g., price, battery). Hence, this study proposes a purchasing recommendation system that focuses on review data. In fact, two types of reviews are analyzed from comments on e-commerce websites: complaint information and satisfaction information. The recommended alternative products are those that solve product complaint information. Complaint information is extracted based on product review analysis. This separation is performed by extracting negative and positive information from product reviews. Subsequently, a review analysis outputs the higher-rated products that will be used to propose alternative products by solving complaints.

The following table (Table 3.1) summarizes the comparison between these related works and our proposal, according to the previously mentioned axes.

Research Work	GUI	Dataset	Product Information	Product reviews	Critaria ponderation	Similar products	Sentiment analysis	Classification Algorithms
Recommendation system development for fashion retail e-commerce	Console	Offline Online	Yes	No	No	Yes	No	-
Product Recommendation System based on User Purchase Priority	Console	Online	No	Yes	Yes	No	Yes	Morphological Analysis
Intelligent decision support for data purchase	Console	Offline	Yes	No	Yes	Yes	No	SOM
A Product Recommendation System Based on User Complaint Analysis Using Product Reviews	Console	Online	No	Yes	No	Yes	Yes	-
Current Work	Web	Offline Online	Yes	Yes	Yes	Yes	Yes	SOM SVM

Table 3.1: Comparative table of the related work

3.3 Purchasing Business Process in Moroccan public universities

3.3.1 Presentation

Purchasing in the public sector is quite different and more challenging compared to the private sector. In the public sector, the purchasing operation must satisfy specific state regulations and laws, and money must be spent prudently and cleverly. Therefore, purchasing services and staff are pressured to make efficient procurement decisions, and delivery time is more efficient.

In Moroccan public universities, purchasing business process create and execute an obligation that entails an expense to be paid by the authorizing officer to meet the university's needs. This process applies to all acts of engagement (markets, purchase order, contract, agreement); normative references for this process are as follows:

- Decree n ° 02-06-388 of the 16 Moharrem 1428 (05-02-2007) bearing the regulation of the public markets
- Order No. 2-2471 of May 17, 2005 concerning the financial and accounting organization of universities
- Law 69.00 on state financial control of public enterprises and other sectors
- Dahir n ° 01-02-25 of the 03 April 2002 promulgating the law n ° 61-99 relating to the responsibility of the authorizing officers, controllers, and public accountants
- Note 2-2471 DE / SPC of the DEPP concerning the financial and accounting organization of universities.
- Law 21-00 on the opening date and the closing date of the accounting years of universities.

- Decree 2-89-61 of 10 RABIA II 1410 (November 10, 1989) setting the rules applicable to the accounting of public institutions. (OO No 4023 of 6 December 1989).

- Royal Decree No. 330-66 of 10 March 1387 (April 21, 1967) on the General Regulation of Public Accounting. (Official Bulletin No. 2843 of April 26, 1967)

- Code of Obligations and Contracts (DOC)

- Paying Treasurer's Guide

- C.C.A.G.T

- General Accounting Standards Code (CGNC)

- C.C.A.G. MO

3.3.2 BPMN modeling of the purchasing business process

Based on previous normative references, we established the PBMN model [9] of the purchasing business process, where BPMN stands for business process model and notation. BPMN is an ISO-certified standard (ISO/IEC 19510:2013) for describing business process semantics as its notation is generally easy to comprehend and is highly understandable for business and technical personnel [10]. BPMN provides businesses and organizations with the capability to understand their internal business processes in a graphical notation to analyze and communicate these business processes in a standard manner.

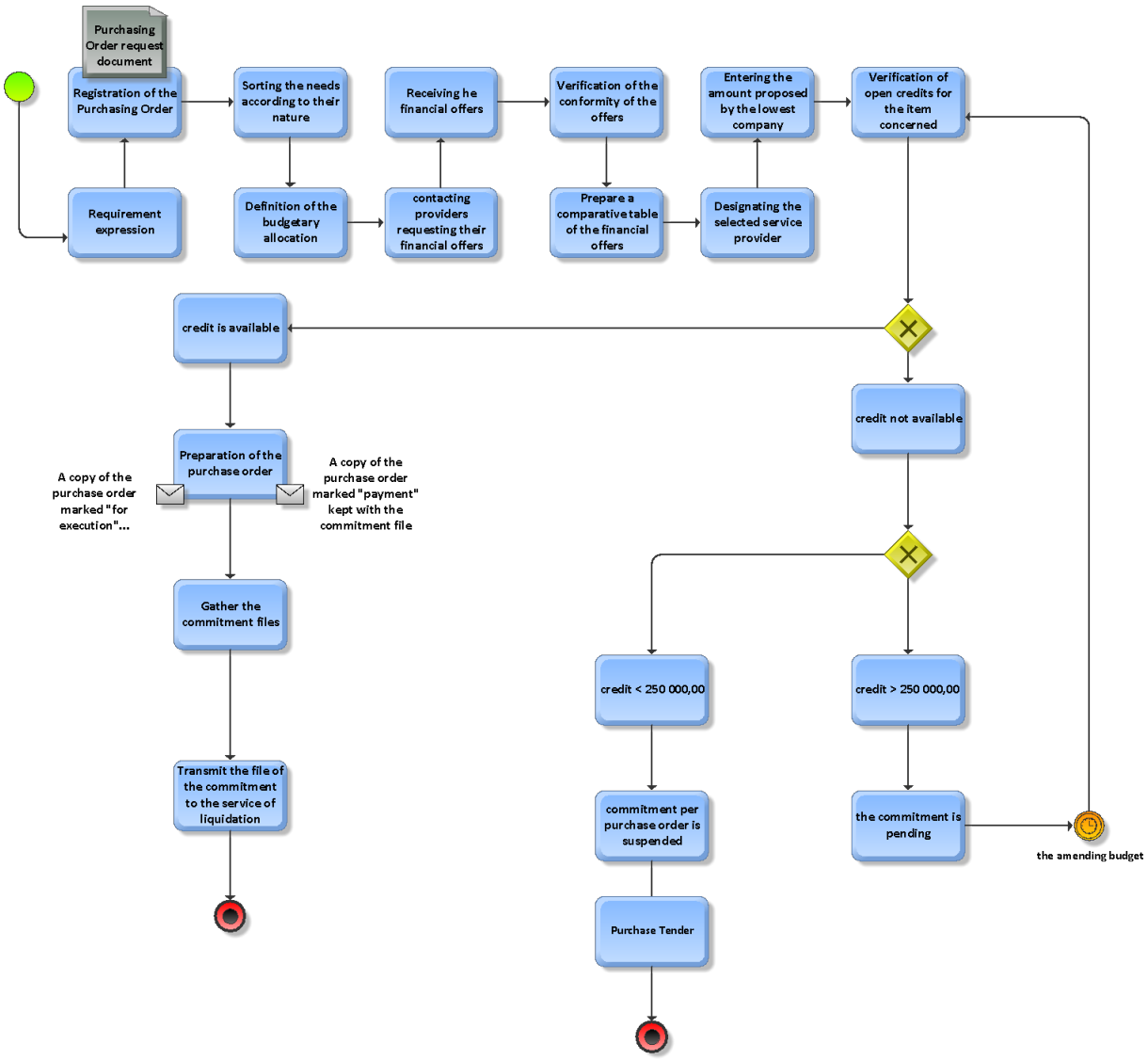

Figure 3.1: BPMN representation of the purchasing business process

3.4 Problem statement and proposal objectives

3.4.1 Motivation scenario

In this motivation scenario, we consider purchasing order in a computer science department. Purchasing order in this scenario expresses the need for a powerful computer to run heavy AI calculations. Here, we will not describe the execution of the entire purchasing business process. We will focus on three steps: "requirements expression, " ""purchasing order registration," and "designating the selected service provider" (figure 3.1). Processing in these steps constitutes the core of our proposition.

Professor X is beginning a project on the implementation machine learning technique on big data. He identified the need for a new laptop workstation with the following technical features:

- Graphics (GPU): NVIDIA GTX 1050 GPU with 4GB RAM

- Processing (CPU): 2.8GHz Intel Core i7-7700HQ
- RAM: 32GB 2400MHz DDR4 RAM
- Storage: 1TB SSD

A purchasing order of two Dell XPS 15 9560 laptops is established and communicated to the department head. Purchase order was then sent to the three vendors to receive financial offers. **Vendor A**, **Vendor B**,**Vendor C**, responds, respectively, with 1750$, 1.800$ and 1910$. Purchasing order finds its way through the purchasing business process, and **Vendor A** will be selected as it is the lowest bidder.

In fact, even if **Vendor A** has the lowest financial proposition, the proposed price exceeds average price of the same product in Amazon by 250$. The actual business process does not cover this use case for two reasons: first, the lowest bidder rule, and, second, the absence of a formal mechanism to assess how reasonable the prices are.

In addition to the financial side, quality of purchased reference is not assessed. Moreover, possible technical problems and failures that may occur after some time of use have not been verified. In this case, an alternative product with minor differences from the initial requirements may be proposed. Finally, from an optimization perspective, the purchasing business process does not involve checking the local IT equipment stock to identify computers that meet approximately the initial criterion and requires only a maintenance effort.

3.4.2 Diagnosis of the current challenges

To diagnose the current limitations and position our proposition, we will take a fragment of the purchasing business process BPMN model figure 3.2:

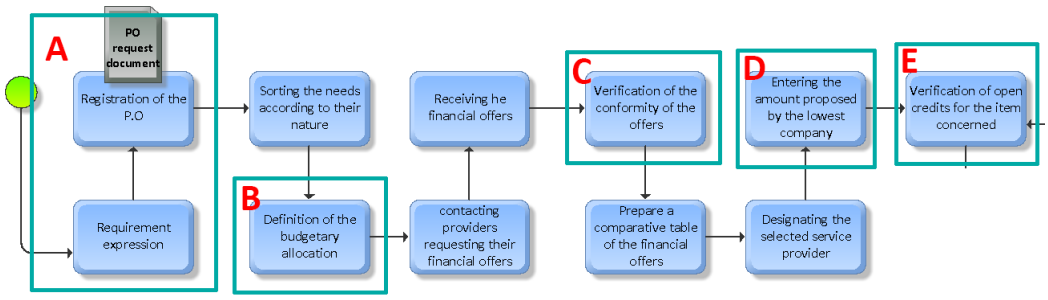

Figure 3.2: Diagnosis of current challenges in the current purchasing business process

(A) The user expresses the needs through technical specifications without any visibility about the future material and the expected budget compared with the market. Conversely, the user cannot consult the available products in the local IT equipment stock of the university.

(B) Budgetary allocation is defined without a clear visibility about the actual prices in the market.

(C) The verification of conformity is done comparing to initial requirements without consulting a formal technical repository for validation, and the preparation

(D) The lowest bidder is selected. And as previously stated, his offer is a good deal technically and financially.

(E) Verification of the open credit is done after consultation with vendors. If the open credit is not sufficient, the purchasing order is blocked or reported while we have gone through several step and spends considerable time.

3.4.3 Positioning of the proposed solution

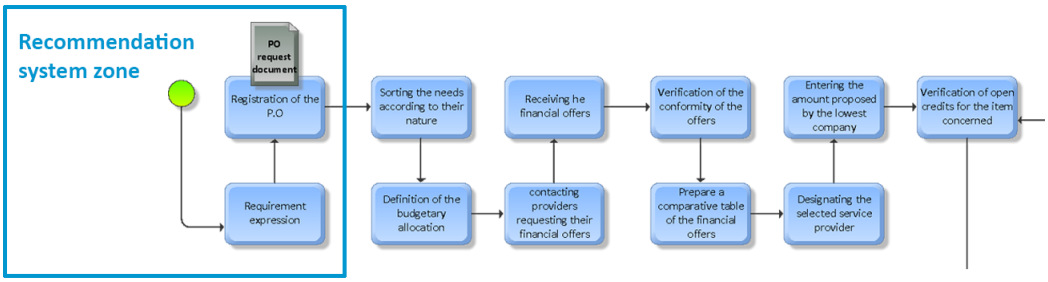

Figure 3.3: Recommendation system operating zone

Figure 3.3 shows that the recommendation system operates at the beginning of the process when the user expresses the initial requirements. Its role is to establish an optimal purchasing order. The recommendation system aims to overcome challenges A, B, C, D, and E, as follows:

(A) The recommendation system provides the user with accurate and updated information on the future product. These information concerns the technical characteristics and reviews representing previous user's feedback. Moreover, the recommendation system proposes the available products on local storage to check if a matching product exists.

(B) The recommendation system provides the user with the actual market prices. Defined budgetary allocation should be reasonable and close to market costs.

(C) The recommendation system verifies conformity according to initial requirements and propose alternative products by consulting online e-commerce data for technical characteristics and products reviews.

(D) The recommendation system enhances the "lowest bidder"-based decision making using a new feature. In addition to proposing the lowest offer, lowest bidder is also evaluated – in an objective and independent way – comparing to the market offer in terms of technical specifications and cost.

(E) As the recommendation system provides the user with actual market prices, the user can verify budgetary allocation according to open credit without waiting for vendors' offers. This approach adds another layer of transparency as the vendors must align to the user budgetary allocation and not the opposite.

3.5 Theoretical background

3.5.1 Process optimization

Business process optimization is the improvement of business processes using predefined performance measures. These measures represent optimization objectives [11]. Business process optimization aims to redesign business processes and

generate various instances based on the same initial process specification. These instances were then assessed according to predefined performance measures. Given its organizational aspect, the implementation of business process optimization is a managerial act. However, it involves technological and technical engineering to meet automation needs. Generally, there is a need for a wider use of information and communications technology (ICT) in business process contexts, especially decision support systems based on artificial intelligence and expert systems [12]. ICT can support business process optimization as an automation tool, as stated before and through simulation and modeling tools and standards to represent and optimize the design of the business process.

Our current research work fits in this perspective using artificial intelligence as a decision support and PBMN models to design and optimize the purchasing business process.

3.5.2 Utility theory in artificial intelligence

Utility theory studies and theorizes the choices of individuals and their decision-making process based on initial preferences. Utility here reflects a subjective conception of opinion quality and goodness compared to other options. Standard neoclassical economic theory describes utility as a set of internally consistent assumptions about options to maximize utility [3]. Utility theory has been leveraged as one of the most dominant theories in economics, underpinning rational choice and game theory.

Utility theory is an essential element of artificial intelligence. Artificial intelligence is the design of artificial agents that perceive their environment and make decisions to maximize the chances of achieving a goal [13]. Hence, AI-based systems involve a utility function that must be maximized by a rational agent.

In our proposition, the intelligent recommendation system aims to mimic human behavior by maximizing a purchasing utility function.

3.5.3 COBIT 2019

Information Technology Governance (ITG) can be defined as the system by which current and future use of IT is directed and controlled [14]. ITG involves evaluating and directing IT use to support the organization and monitoring this use to achieve plans and includes the strategy and policies for using IT within an organization. ITG and its frameworks provide managers with the structures considered necessary to facilitate IT services for academic and business processes [15].

The overall aim of ITG is to purify business processes and provide justifiable road map to organization strategies. COBIT 2019 [16] is an ITG framework intended for this purpose. The first principle of COBIT is that all IT-related activities should support the generation of value for the enterprise. The COBIT 2019 core model in figure 3.4 illustrates that the five domains covered by the COBIT 2019 code model are [17]:

- Direct and Monitor (EDM): governing body evaluates strategic options, directs senior management on the chosen strategic options, and monitors the achievement of the strategy.

- Align, Plan, and Organize (APO): addresses the overall organization, strategy and supporting activities for IT

- Build, Acquire, and Implement (BAI): treats the definition, acquisition and implementation of IT solutions and their integration in business processes.
- Deliver, Service, and Support (DSS): addresses the operational delivery and support of IT services, including security.
- Monitor, Evaluate, and Assess (MEA): addresses performance monitoring and conformance of IT with internal performance targets, internal control objectives, and external requirements.

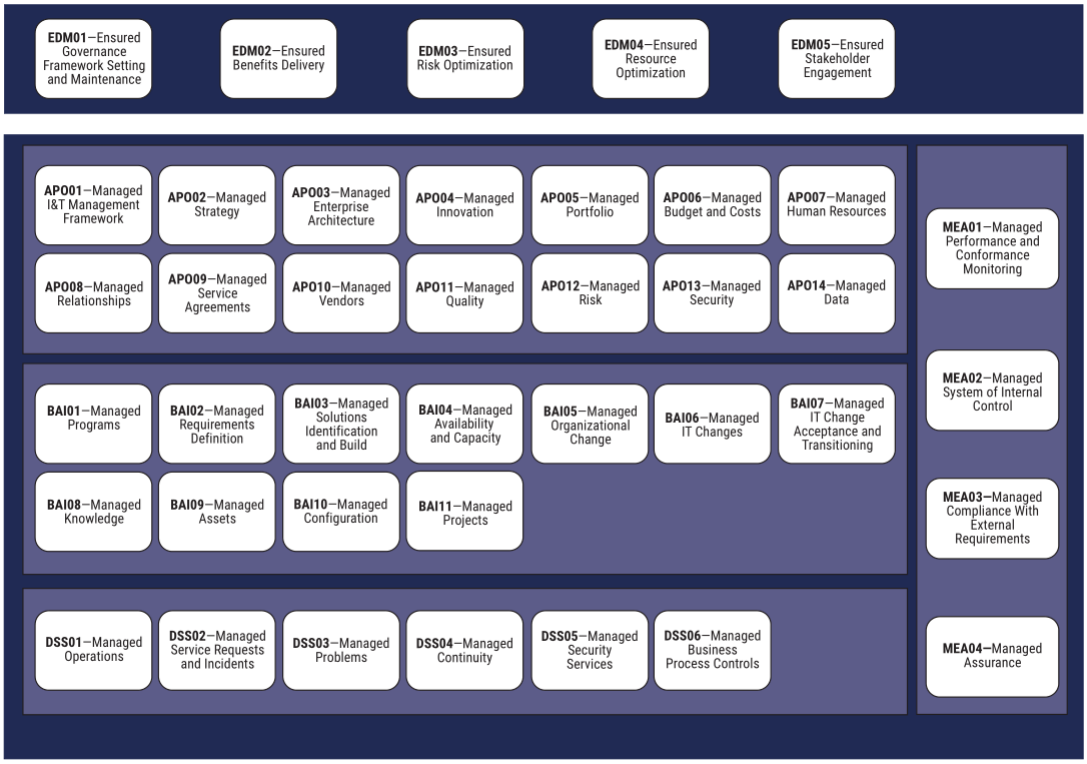

Figure 3.4: COBIT 2019 code model

Our research work fits in the first domain (APO) and uses more GMO which are in direct relation of this paper purpose these two GMO are:

- APO06 (Budget and Cost Management): Foster a partnership between IT and enterprise stakeholders to enable the effective and efficient use of IT-related resources and provide transparency and accountability of the cost and business value of solutions and services. Enable the enterprise to make informed decisions on the use of IT solutions and services.
- APO10 (Managed Vendors): Optimize available IT capabilities to support the IT strategy and road map, minimize risk associated with nonperforming or noncompliant vendors, and ensure competitive pricing.

For each guideline suggested by APO06 and APO10, recommendations are translated into the proposed recommendation system as follows:

- APO06.01 Manage finance and accounting: The recommendation system proposed offers a transparent context to manage and account for IT-related costs.

Moreover, it offers a visibility on the future investments through the purchasing orders and their impact on the financial systems and accounts.

- APO06.02 Prioritize resource allocation: The recommendation system implements a decision-making workflow that favors prioritizing the recycling and reuse of resources (local database) but also considers the recourse to external actors.
- APO06.04 Model and allocate costs : The cost is modeled based on the utility theory. Hence the decision-making process enables the analysis and benchmarking of the allocated cost.
- APO06.05 Manage costs: The recommendation system enables the user to explore similar and alternatives products (SOM analysis) to guarantee a certain level of quality while respecting budget. In fact, this approach allows the user to monitor the costs and adjust withing the purchasing order.
- APO10.02 Select vendors : The recommendation system provides the user with reliable and realistic costs. This costs much the average prices in the market for a given product. Based on this information, vendor choice could be done in a pragmatic and transparent way.

3.6 Design of the intelligent recommendation system

3.6.1 BPMN workflow of the recommendation system

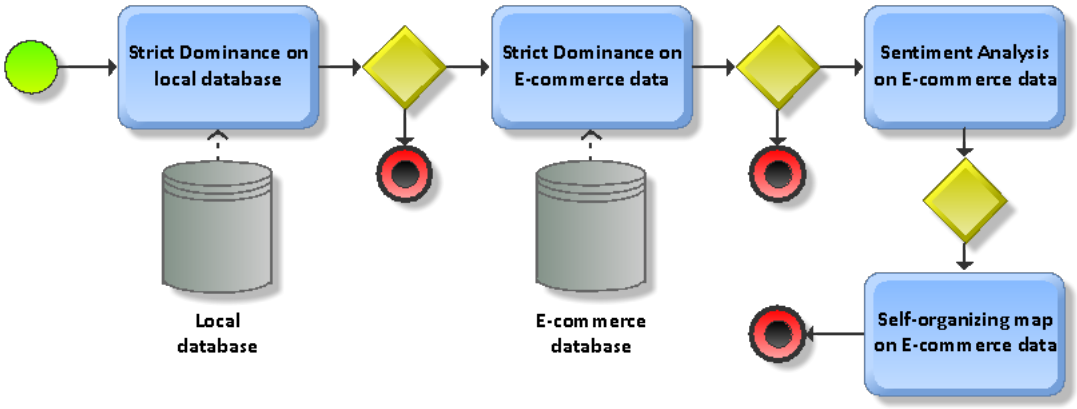

Figure 3.5: workflow of the recommendation system

The workflow in figure 3.5 illustrated in this BPMN model presents the filtering process executed by the recommendation system:

1. The workflow is triggered when the user provides the initial requirements.
2. Based on the initial requirements, a strict dominance filtering is performed on a local database. The resulting products are presented to the user, and if the user is satisfied, the workflow is aborted. Otherwise, the user moves to Step 3.

3. Based on the initial requirements, E-commerce data are crawled, and a strict dominance filtering is performed this time on scraped data. The resulting products are presented to the user, and if the user is satisfied, the workflow. Otherwise, the user moves to Step 4.

4. The E-commerce data are subject to a sentiment analysis to reclassify them based on users' reviews, and the resulting products are presented to the user. If the user is satisfied, the workflow is aborted. Otherwise, the user moves to Step 5.

5. The resulting products from step 4 are processed by self-organizing map classifier and provides the user with a matrix to explore the similarities between products to select the suitable product. Finally, the workflow is aborted.

3.6.2 UML modeling of the recommendation system

UML sequence diagram

The sequencing of actions to interact with the intelligent recommendation system are illustrated through the sequence diagram in figure 3.6 :

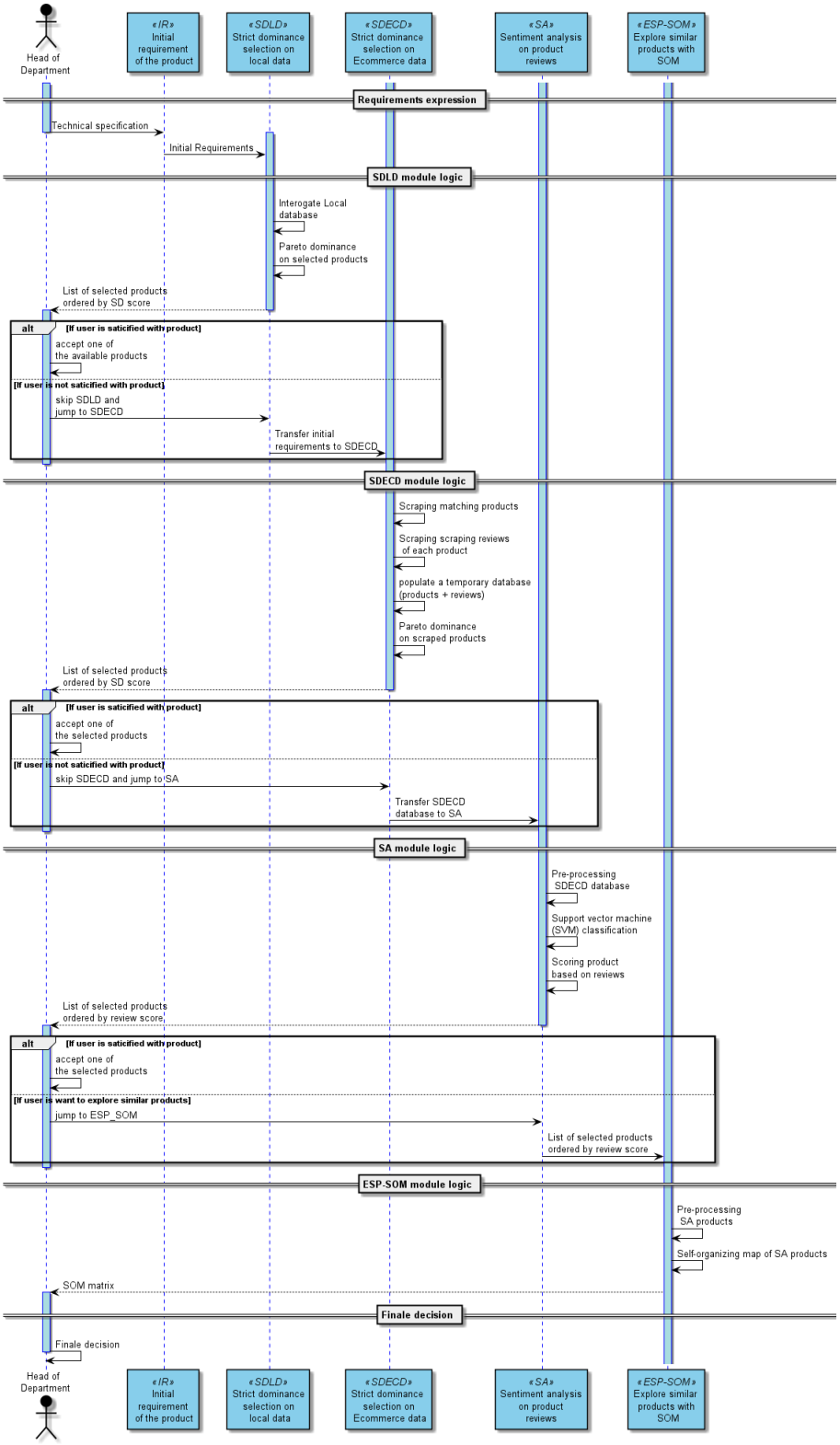

Figure 3.6: Sequence diagram of the Intelligent recommendation system

UML component diagram

The components of the the intelligent recommendation system are illustrated through the component diagram in figure 3.7 :

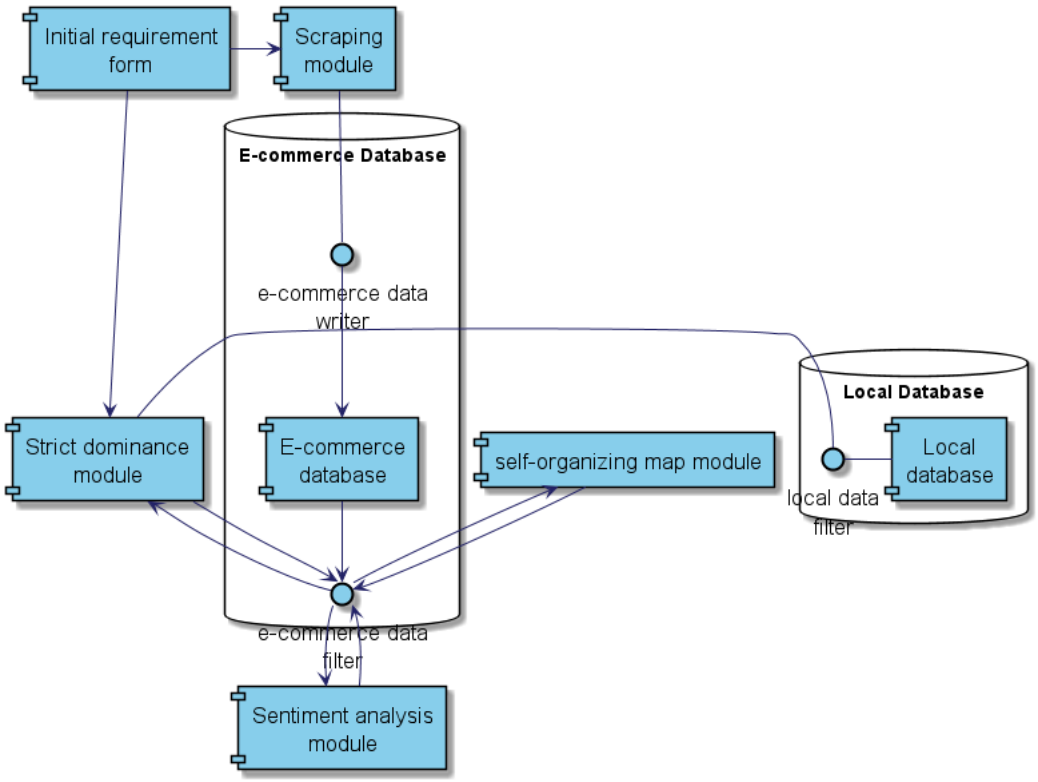

Figure 3.7: Component diagram of the Intelligent recommendation system

3.6.3 System components presentation

Initial requirements

Initial requirements represent user preferences expressed as technical features (e.g., Processor generation and RAM capacity ...). These purchasing criteria are considered top priority for the final product. For more flexibility and to explore similar products at the end of the process, the entered values of the criteria are allowed a margin of maneuver. For example, the user expresses that minimum RAM capacity is 16 GB, which allows the recommendation system to propose a product with RAM higher then 16Gb and balancing with other technical features.

Strict dominance module

This module performs data refinement and selection using the strict dominance concept in game theory. This module primarily aims to calculate a strict dominance score for each product given as input and then classify them based on this score. In the recommendation process, we call this module twice, first to classify products issued from the local database and then to classify products issued from scraped data from the e-commerce website. In both cases, this module selects products based on the initial requirements. The products are then refined using strict dominance logic.

In game theory, a strategy is considered strictly dominant when it is better than all other strategies. By contrast, a strategy is strictly dominated when all other strategies are better [18]. In our proposition, we use the notion of dominance to calculate a dominance score for classifying our products. This means that products with lower values for all attributes than all others will be given a low score and vice versa. Essentially, strict dominance is used to narrow down the field of choice for real candidates.

To implement the concept of strict dominance, we relied on pareto dominance algorithm. Pareto dominance enables the comparison of candidates based on two or more criteria and provides a proper candidate optimal scheme for decision makers [19].

Let Up be the utility functions of the product. The utility function Up represents the preferences between products based on criteria p pertaining to the preference set P:

A product X is dominated by product Y if the two following conditions are satisfied:

- Y is better than X in every criterion, meaning $\forall p \in P, \quad Up(X) \geq Up(Y)$
- a product is considered pareto-optimal if it is not dominated by any other product in the selected list.

Local database

This database constitutes an inventory of the "out of service" IT equipment. This database centralizes maintenance information and facilitates the follow-up of maintenance processes.

E-commerce database

This database is filled using web scraping technique [20] on predefined e-commerce websites. Based on the initial requirements, a URL representing the search pattern was constructed for each e-commerce website.

Upstream, we have developed a middle-ware for each website that enable the browsing of its DOM and the extraction of product's information from its HTML tree. The crawled information is stored in two different tables. First, the technical features of each product are stored in the corresponding table. Subsequently, for every product, a set of rows representing its reviews is created and stored in the corresponding table with reference to its parent product. For sentiment analysis efficiency, only products with more than 10 reviews were selected.

Sentiment analysis module

In the natural language processing (NLP), sentiment analysis (SA) has become one of the many fields of computational studies [21]. Sentiment analysis was used to calculate the appreciation score for each product. The appreciation score was calculated through the categorization of positive and negative customer reviews of the product. The polarization of positive and negative reviews was performed using the mean of the supervised learning model. The model was trained on one of the most reliable and large datasets used in this field, which is an Amazon review dataset.

In fact, Amazon is one of the largest e-commerce sites as there are numerous number of reviews that can be seen. We used Amazon product data provided by [22]. Current data include reviews from May 1996 to October 2018. The dataset reviews included ratings, text, helpful votes, product description, category information, price, brand, and image features. The dataset is unlabeled and widely used to analyze users positive and negative sentiments toward products.

In our analysis, we have used two subsets of global data: "Electronics" and "Office Products." The total number of reviews in the principal dataset for these two subsets was 26, 575, 666. In our prototype, we used portions of the "small subsets" offered by [22] for experimentation purposes. Hence, total review were used to train the

sentiment analysis module is 1,539,947 reviews. A typical JSON object of a review of Amazon product data is illustrated in figure 3.8:

```
{
  "reviewerID": "ID of the reviewer",
  "asin": "ID of the product,",
  "reviewerName": "name of the reviewer",
  "vote": 5,
  "style": {
    //a disctionary of the product metadata
    "key1": "values1",
    "key2": "value2"
  },
  "reviewText": "text of the review",
  "overall": "rating of the product from 0 to 5",
  "summary": "summary of the review",
  "reviewTime": "time of the review"
}
```

Figure 3.8: Json structure of review object

To implement the sentiment analysis workflow on our subset, we have adopted the methodologies used in similar works [23], [24], [25], [26]. The workflow contains four steps (figure 3.9).

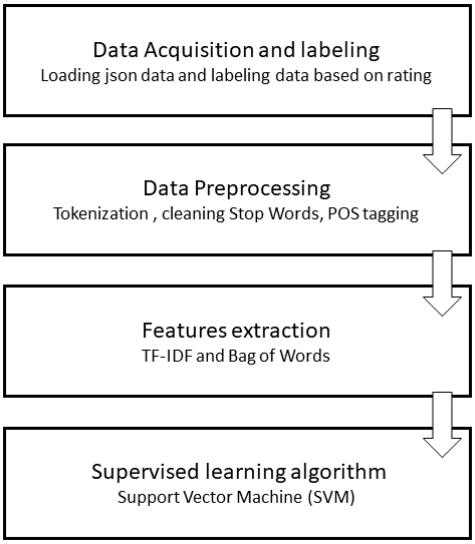

Figure 3.9: Sentiment analysis workflow

- Data acquisition: As stated before, we have acquired our data from 2 subsets, with each subset in the Json format. Regarding the important number of reviews, labelling data manually was very difficult. Hence, data were labeled by an algorithm based on Amazon reviews rating. This rating is represented by a 1 to 5 rating. A rating of 1 or 2 stars is considered negative, while a rating of 4 or 5 is considered positive, 3 stars rating are considered neutral hence not processed in the labeling.

- Data pre-processing: This step was performed through three stages. First, tokenization, which consists on untying a string sequence into separates entities called tokens. Tokens can be individual words, phrases, and sentences. Second, the Stop Words elimination consists of removing punctuation and all unnecessary text mining strings. This will enhance the accuracy and performance analysis. Finally, the POS tagging helps the model understand the grammatical function of words [27].
- Feature extraction: This step performed through Bag of words and TF-IDF techniques. The bag of word is created from nouns and adjectives selected based on the previous the POS tagging. The bag of word is then used to generates term frequency as text characterization feature. This feature will then be used as input in TF-IDF stage. TF-IDF in turn will weighs the extracted term frequency and also inverse document frequency. TF and IDF scores are then calculated for each word as well as the TF*IDF weight for each word. The value TF*IDF weight determine the rarity of words, lower TF*IDF value means o high frequency of the word.
- Support vector machine (SVM): SVM is a machine learning method that has become exceedingly popular for neuro-imaging analysis in recent years. Owing to their relative simplicity and flexibility for addressing a range of classification problems, SVMs distinctively afford balanced predictive performance, even in studies where sample sizes may be limited [28]. SVM has also proven its accuracy in sentiment analysis classification especially when trained over the amazon reviews dataset. In [29] and [30] the accuracy of SVM has being demonstrated comparing to other supervised learning algorithm.

SOM analysis module

The Self-Organizing Map (SOM), with its variants, is the most popular artificial neural network algorithm in the unsupervised learning category [31]. It provides topology-preserving mapping from high-dimensional space to map units. Map units or neurons usually form a two-dimensional lattice; thus, mapping is a mapping from a high-dimensional space onto a plane. [32]. Each unit has a set of weights that are compared to the input data to find the nearest unit (commonly measured with Euclidean distance) to the input data, which is called the best matching unit (BMU). The weights of the BMU and its neighbors were adjusted. At the end of the training phase, A topological map (commonly a 2D map) was established. The topological neighborhood of the units reflects the similarities in the input data that activate them. Figure 3.10 illustrates the concept of the competitive learning algorithm [33].

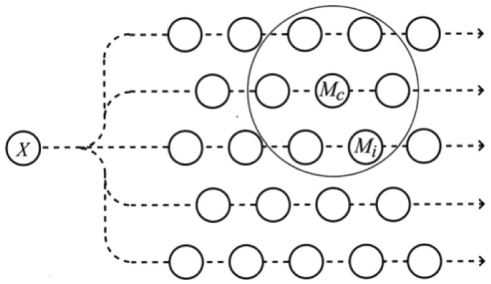

Figure 3.10: Illustration of a self-organizing map. An input data item X is broadcast to a set of models M i , of which M c matches best with X. All models that lie in the neighborhood (larger circle) of M c in the grid match better with X than with the rest [34]

The SOM has been used as a purchase decision-making support in many studies [35] [7] [36] [37]. From this perspective, we use SOM in our recommendation system to provide users with more purchasing options by exploring new opportunities. In fact, at the end of sentiment analysis of primary data, the user has a first classification of selected products based on technical features and review score. The purchasing order can then be established based on this classification. Otherwise, the user can have a deeper discrimination of the classification by discovering similarities between the selected products using SOM analysis. For example, the product X rank is 5/10; however, in the SOM 2D grid, this product is located near product A, which ranks 1/10 and is located in the same cluster. Hence, the choice of Product X may present a potential benefit.

3.7 Implementation of the simulation scenario

3.7.1 Presentation of the simulation data

Implementation scenario of the proposal simulates a purchasing of computers in our computer science department. Simulation data are then composed of local and e-commerce data.

Local database

To prepare our demonstration, we did an inventory in our computer science department to list and identify the existing desktop computers and laptops. Using this inventory, we built a local database (figure 3.11) that references the technical specifications of each product and its operating state. Here, we mean, by operating state, whether the product is functional or not. If a product is out of service, the required level of maintenance is identified.

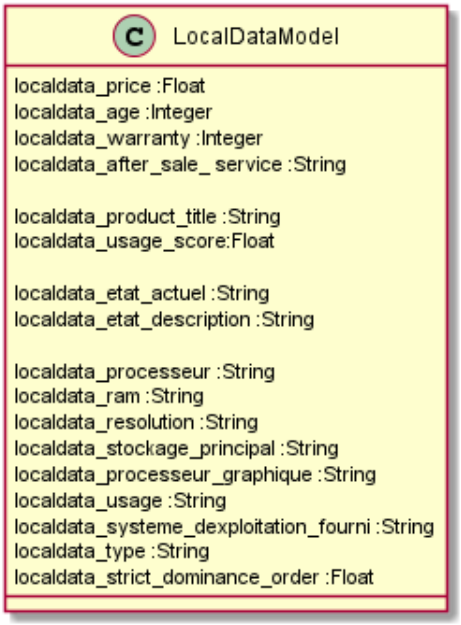

Figure 3.11: Local database structure

E-commerce scraped database

Leveraging data from the web presents both researchers and practitioners with big challenges as well. Apart from the need to learn and deploy new tools and technologies capable of accommodating big data, researchers and practitioners intending to use web scraping in their research projects must comply with a number of legal and ethical requirements [38]. Our scraping module is developed with respect to the following ethical requirements:

- Terms of Use: Respect to the website we used
- Purpose of Web Scraping: none profit usage
- Damage to the Website: respect the time out and amount of data
- Individual Privacy: we don't scrap any personal information
- Organizational Privacy and Trade Secrets: we don't scrape o have access to any privacy or thread secrets

Data enhancement

Due to a technical constraint, the reviews of each data are enhanced by external reviews from the amazon review database. In fact, when accessing the detailed page of the product only the first ten products are displayed, and to access other reviews, manual navigation must be performed.

3.7.2 Technical specification

The implementation prototype was developed with Django framework. Django is a high-level Python web framework that encourages rapid/clean development and pragmatic design [39]. Django is based on the MVC design pattern [40] and enable a fluent integration with a large number of python libraries. The following table (table 3.2) resume the technical specification and the used libraries.

Computer	• 15" Laptop • CPU-Intel i7-8650U vPro 8th Generation • 16G RAM based
Operating System	Windows 10 pro 64bit
Programming language	Python 3.6

Crawling	Beautiful Soup 4.9.0
Natural Language Processing	Spacy 2.3.5
Self-organizing Map	MiniSom
Feature Scaling	sklearn
Others	numpy, matplotlib, pandas

Table 3.2: Technical specification

3.7.3 Experimental use case

Initial requirements

In this step (figure 3.12), the user fills the minimum required preferences and the approximate budget allocated. Further information is also provided about the purchasing order, namely the subject, and a short description of the purpose of the future purchasing order.

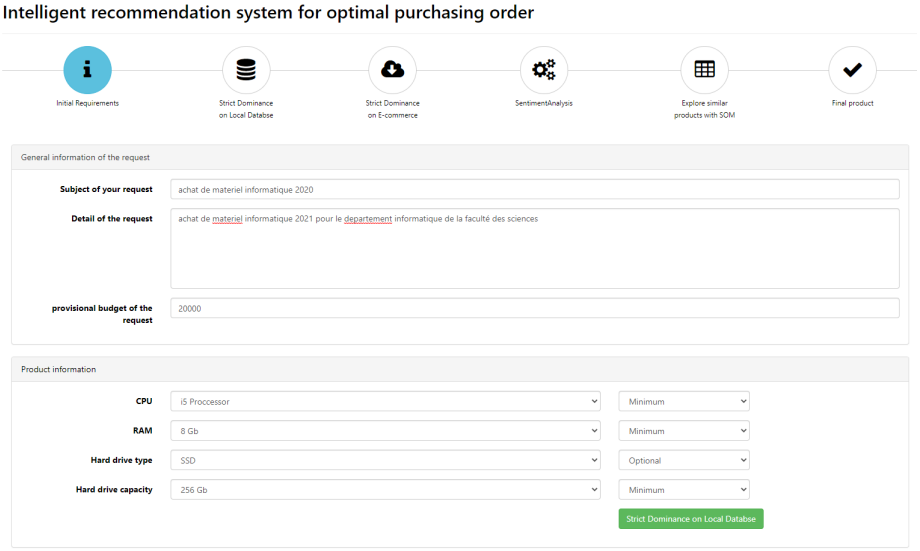

Figure 3.12: Initial Requirements

Strict dominance on local database

In this step (figure 3.13) a selection query is performed based on the initial requirement data entered by the user. Hence, the filter is composed of the desired technical specifications and weighting of each specification. A strict dominance score was then calculated, and the selected products were classified based on this score. The top ten products were then presented to the user.

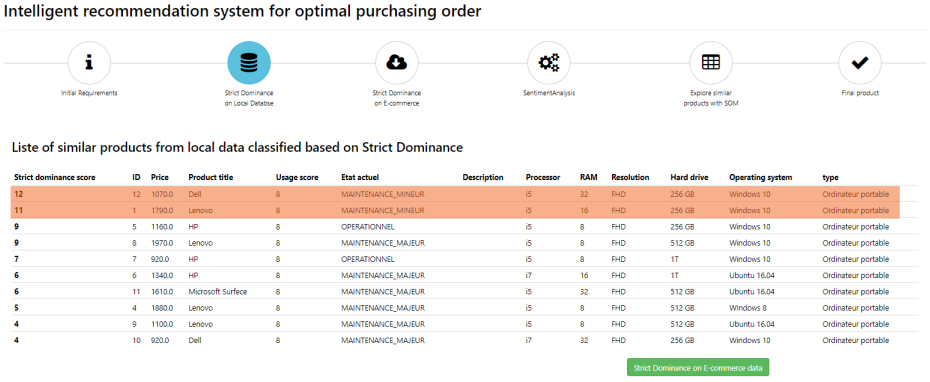

Figure 3.13: Strict Dominance on local database results

If the user is satisfied with the result, he will communicate the product ID to the administration to get the product through a recovery procedure. To browse the

other step of the demonstration, we considered that the user would go through all the steps. The next issue is the strict dominance of e-commerce data.

Strict dominance on e-commerce data

In this step (figure 3.14) the initial requirement data entered by the user are used as entree for a scarping. This scraping module uses technical specifications and their weights to scrape data from an e-commerce website. A strict dominance score was calculated for the selected products from the scraping module.

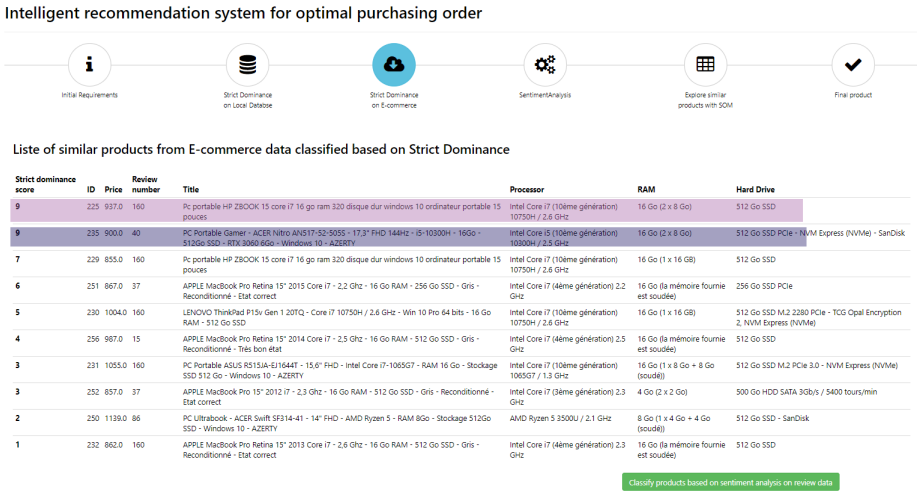

Figure 3.14: Strict Dominance on e-commerce data results

For each product scraping module import available product reviews and store them to be in the next step.

Sentiment analysis

For each product the sentiment analysis module perform a NLP on each one for the previously selected products. This analysis calculates the sentiment analysis score and orders products based on this score.The results of this step are highlighted in figure 3.15.

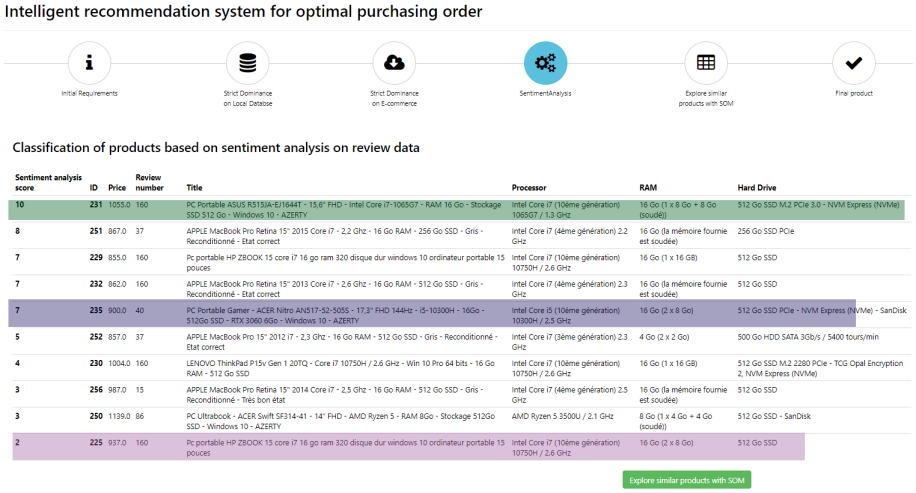

Figure 3.15: Sentiment analysis results

Explore similar products using SOM analysis

In this step (figure 3.16) a SOM map is presented to the user with nods representing products IDs. For each product, the nearby counterparts are more similar than those that are further away. This enables the user to explore similar products and check more details each time by entering the ID of the product in the appropriate form.

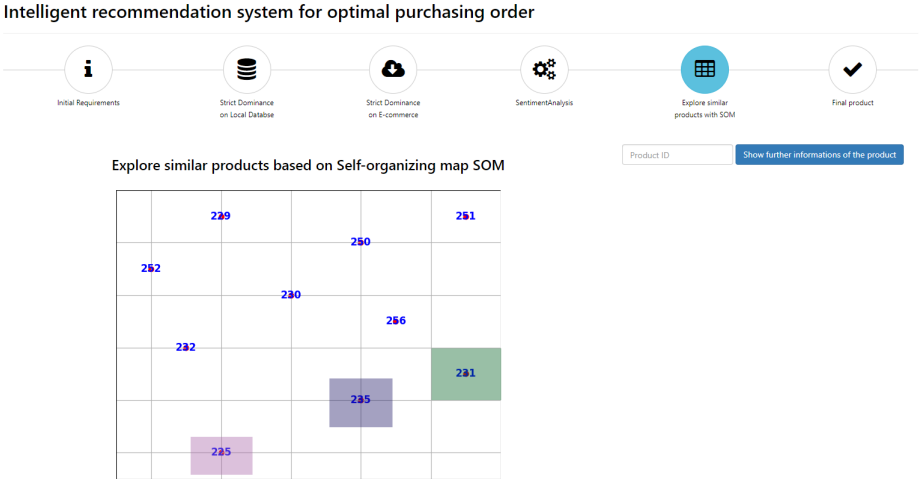

Figure 3.16: SOM map of the selected products from sentiment analysis step

Final product

The final product selected by the user (figure 3.17). In the next section, the process leading to this choice is explored and discussed.

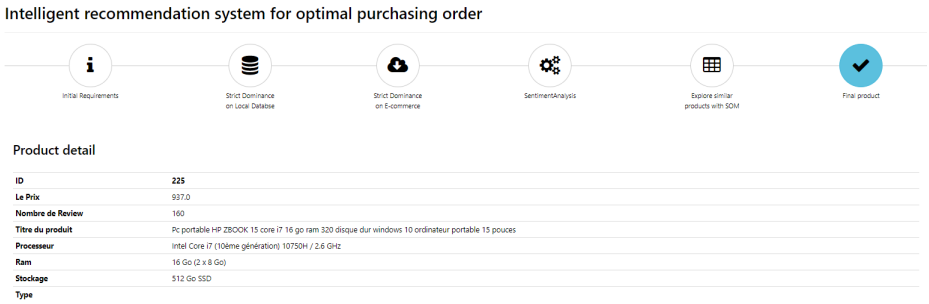

Figure 3.17: Final product information

3.8 Results and discussion

To analyze the efficacy of our intelligent recommendation system, we simulated a recommendation request of the computer science head department above. The recommendation system involves efficient laptops for developing new internal applications. We discuss the execution and results of each step of the recommendation process:

3.8.1 Initial requirements

The initial requirements entered by the user are:

Criteria	Value	Ponderation	Description
CPU	i5	Minimum	At least an i5 processor can be i7
RAM	8 Gb	Minimum	At least 8 Gb of RAM
Hard drive	SSD	Optional	Can be DDR
Capacity	256 Gb	Minimum	At least 256 Gb

Table 3.3: Initial requirements

3.8.2 Strict dominance on local database

When performing the strict dominance on local data, the algorithm favors products with miner maintenance with respect to the i5 minimum processor value and maximizing the RAM value. The weighting of the price is neutralized because the products are already purchased and available internally. The top-scoring products are Product 12 and Product 1 of the database.

3.8.3 Strict dominance on E-commerce data

The scraped data are then object to a strict dominance processing, as demonstrated before the algorithm give a score of 9 to products 225 and 235.Product 225 has an i7 processor and 16 Gb in RAM at a price of 937.0, which seems to be a good deal because it has a good configuration and reasonable price. Product 235 is relatively cheaper than 225, but only for an i5 processor.

3.8.4 Sentiment analysis

The sentiment analysis on the scraped product gives a quite different result from the previous one. Remarkably, product 225 descended in ranking with a sentiment analysis score of 2. Product 235 maintained a good ranking with a score of 7. It's if clear that from a user's reviews perspective the product 231 is a good deal with a score of 10 extracted from 160 review.

3.8.5 Explore similar products using SOM analysis

When exploring SOM map, we can see that the product 225 is relatively far from other products. If we combine this information with sentiment analysis results, we can conclude that product 225 represents a good deal in terms of technical specification and user's reviews. We can also notice that products 235 and 232 are the closest to 225, which means that they are a potential choice, especially 235, which was recommended by strict dominance.

Chapter 4

Blockchain based system for PBP execution

Chapter 5

Discussion and future works

As initially stated in this paper, the main goal of the current research work relies in the optimization of the purchasing business process in Moroccan public university in terms of transparency and budgetary optimization. To achieve this goal, we used a functional-technical approach leading to the development of an intelligent recommendation system that supports the choice of optimal IT equipment for decision makers. All this, in total alignment with Moroccan normative laws, and with COBIT's guidelines in information system governance.

The recommendation system proposes a technical solution based on three concepts: the first one is the strict dominance which belong to utility theory, the second and third belong to artificial intelligence world and are, respectively, sentiment analysis and self-organizing maps. Beyond this technical aspect, we proposed a PBMN model for purchasing business processes. We plan to extend this model to all the business processes of our university to implement a global business process repository. We also used COBIT as an organizational reference to implement the recommendation system with respect to COBIT's guidelines.

Moreover, the purchasing process of computer equipment is in constant height demand and must follow the technical evolution while providing the possibility to reuse available equipment in stock and those out of service.

Hence, the major contribution proposed in the current paper can be summarized as follows:

- The modeling of business processes in public university is established using BPMN in accordance with official regulations. The set of BPMN models constitute a powerful repository for business process execution but also for further optimization.
- Governance generally aims to reduce budgetary wastes, and our recommendation system demonstrates a technical and methodological approach enabling this feature.
- Implementation of artificial intelligence techniques can bring great value in terms of transparency and fluidity in purchasing business process execution

Potential limitations can be considered as business limitations and technical limitations:

- Business limitations: First, the proposed system was modeled to handle one type products, which are computer-related equipment. Hence, we intend to

extends our model to other type of products in future works. Conversely, the system proposes optimal purchasing order and assumes that decision makers will rely on this optimal purchasing order to choose between offers. In fact, as perspective, we plan to work on a complete automation of the workflow to also include vendors selection and offers validation.

- Technical limitations: NLP is a widely used sentiment analysis technique that enabled us to validate our proposed system. Even working on samples of datasets, we noticed NLP dependency on huge computing power. We intend to experiment with learning and knowledge-based sentiment analysis and assess its computing power consumption and its accuracy compared to NLP. Another technical limitation is related to the web scraping technique, in fact, the users' reviews are crucial for our system. To guarantee timeliness and reliable reviews, the system has to look automatically in websites, which confront us with the limitations of the web scraping like the permanent changing of website structure and scraping restrictions.

This paper highlighted the challenges related to Business Process Management. Then we presented the key features of the Blockchain technology. The integration of Blockchain in the Business Process Management in general and Purchasing Business Process in particular have a potential that can overcame the challenges. The Blockchain integration can improve business processes transparency, security and trust. As continuity of this research work, we intend to study and propose a Smart Contracts based implementation.This implementation will aim to demonstrate the added value of Blockchain technology the PBM in general and Puchasing Business Process in particular.

Appendix A

Other Supplementary Figures

Appendix B

Source Codes

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