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Title:

TOWARD A BLOCKCHAIN SOLUTION FOR DIGITAL TRANSFORMATION BASED ON BPMN

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Dedications

“

To my dear Parents, To my sisters, my brothers, To my Grandmother, and my maternal uncle ***Serraoui Laid****, who has helped me a lot with their patience and their prayers ... my dedications go tenderly to my dear educators from the university... To my colleagues in the computer vision team... To all my colleagues in the IT department... To all who love me and who I love. Thank you all.*

”

- Hinda

Acknowledgement

First of all, I thank our Almighty **God** who helped me and gave me the patience and courage during my years of study and to achieve this work. I would like to express my gratitude and appreciation to my Supervisor **Dr.Mourad Belhadj** for guidance, relevant remarks, discussions, careful reading, moral support, and encouragement throughout this work.

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Abstract

Digitization is the process of transforming information from a physical format to a digital format. Digitalization is the term used when this process is employed to improve business processes. Digital transformation is the term used to describe the results of this process.

Usually, when an organization decides to start a digital transformation, it needs Business process management (BPM), which is the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities. There are many programs that represent BPMN; this research relied on Bonitasoft.

It is necessary for any institution to protect its data. In this research, blockchain was proposed as a method of protection as a very powerful system due to its decentralization. And relied on caterpillar to convert BPMN to Blockchain.

Keywords : Digitalization, Digital transformation, BPM ,BPMN, Blockchain, Smart contract,Ph.D. contestes .

Résumé

La numérisation est le processus de transformation d'informations d'un format physique à un format numérique. La numérisation est le terme utilisé lorsque ce processus est utilisé pour améliorer les processus métier. La transformation numérique est le terme utilisé pour décrire les résultats de ce processus.

Habituellement, lorsqu'une organisation décide de démarrer une transformation numérique, elle a besoin de la gestion des processus métier (BPM) et il s'agit de l'art et de la science de superviser la façon dont le travail est effectué dans une organisation pour garantir des résultats cohérents et tirer parti des opportunités d'amélioration. de nombreux programmes qui représentent BPMN, dans cette recherche, on s'est appuyé sur Bonitasoft.

Il est nécessaire pour toute institution de protéger ses données. Dans cette recherche, la blockchain a été proposée comme méthode de protection en tant que système très puissant en raison de sa décentralisation. et s'est appuyée sur catrepiller pour convertir BPMN en Blockchain.

Mots clés : Digitalisation, transformation digitale, BPM, BPMN, blockchain, contrat intelligent, concours doctoral.

ملخص

الرقمنة هي عملية تحويل المعلومات من تنسيق مادي إلى تنسيق رقمي. الرقمنة هو المصطلح المستخدم عند استخدام هذه العملية لتحسين العمليات التجارية. التحول الرقمي هو المصطلح المستخدم لوصف نتائج هذه العملية.

عادة عندما تقرر منظمة بدء التحول الرقمي ، فإنها تحتاج إلى إدارة عمليات الأعمال (BPM) وهو فن وعلم الإشراف على كيفية تنفيذ العمل في المؤسسة لضمان نتائج متسقة والاستفادة من فرص التحسين.هناك العديد من البرامج التي تقوم بنمذجة عمليات الاعمال BPMN في هذا البحث تم الإعتماد على .Bonitasoft

من الضروري لأي مؤسسة حماية بياناتها ، وفي هذا البحث ، تم اقتراح blockchain كطريقة للحماية لانه نظام حماية قوي جدا بسبب لامركزيته ولتطبيق البلوكشين يتم تحويل BPMN الى بلوكشين في هذا البحث يتم استخدام Caterpillar لتحويل BPMN .

كلمات مفتاحية :

الرقمنة , التحول الرقمي ,ادارة عمليات الاعمال , البلوكتشين, مسابقة الدكتوراه,العقود الذكية.

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List of acronyms

DX	*Digital transformation*
BPR	*Business Process Reengenering*
AI	*Artificial Intelligence*
KPI	*Key Performance Indicator*
API	*Application Programming Interface*
IOT	*Internet Of Things*
BPM	*Business Process Management*
BPMN	*Business Process Modeling and Notation*
CSF	*Critical Success Factors*
POW	*Proof of work*
P2P	*Peer to Peer*
BDM	*Business Data Model*

General Introduction

Digital transformation is one of the most important drivers and catalysts for growth in major corporations and government departments, putting companies in a race to develop innovative solutions that ensure their survival in the competitive cycle.

Among the most important innovative solutions, we find BPM business process management, which is the art and science of supervision of how to perform work in the institution to ensure consistent results, as well as to forget one of the most important and prominent motives that stimulate digital transformation, which is the blockchain technology that has a great role in protecting data.

Many researchers have applied blockchain technology to BPM like (Orlenys López-Pintado) Who has developed an integrated environment Caterpiller to convert BPMN to Blockchain, which I also adopted in this research.

Digital transformation is necessary and very important for institutions to ensure adaptation to the requirements of their customers and markets. Therefore, it must be well studied and taken into consideration of its great importance in our time.

In this research, I studied a doctoral competition at university, and I wanted to implement the digital transformation in it, so I relied on BPM As a way to manage and represent business operations in this study. Then I applied blockchain technology on BPMN For a doctoral competition. Its aim of it is to make the system more protected because it is almost impossible to penetrate it.

Among the difficulties I faced was a significant shortage of blockchain search sources

Because it adopts modern technology that the majority has not adopted, but recently we see many companies accelerating their learning and adoption of their importance of them.

Finally, these steps that I adopted in my research:

01 A detailed view of digital transformation in chapter 01.

02 A detailed view of BPM and BPMN chapter 02.

03 A detailed view of BLOCKCHAIN in chapter 03.

04 Case study in chapter 04.

Chapter 1

Digital Transformation

1.1 Introduction

Shorter production times, reduced costs, increased flexibility and efficiency in the manufacturing process, and improved data processing and artificial intelligence capabilities will all be a result of the remarkable advancements in intelligent devices, machines, and systems. Without a doubt, these advancements will widen the area of development and change, culminating in extraordinary economic,cycle.[30]. In this chapter, I will explain the concepts related to digital transformation and the most important motives that motivate organizations to move to the digital world, as well as I will discuss some of the challenges facing these institutions in digital empowerment.

1.2 Definitions

In its most basic sense, digitization is the process of changing from analog to digital the form is also known as digital. In other words, it is the process of converting information from a physical format into a digital one.

Digitization is simply the process of creating a computerized representation of a printed

analog. There are numerous digitizing methods and media to be digitized.[30]

However, because texts and images are the primary objects in the digitization process, the main focus is on converting materials created in another format.

Technically, digitization is converting an analog image into numerical values.[30]

Exemples

Converting music from CD's to mp3s
Converting papers documents or books to pdf file on a computer by scanning or photographing it represents the process of digitization.

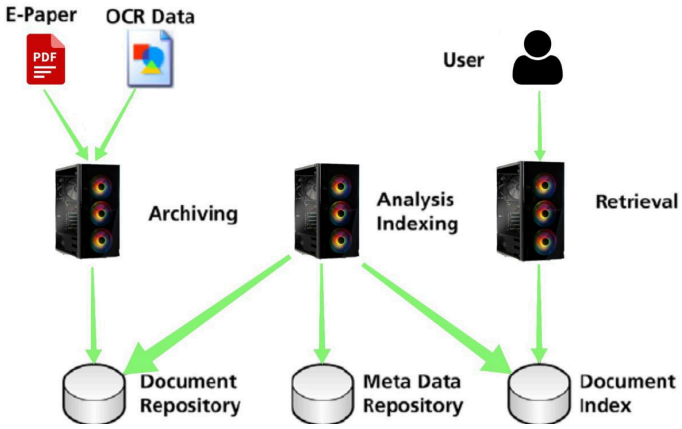

Figure 1.1: Example of digitization process [A]

1.2.1 Digitalization

The term "digitalization" was first used in a 1971 essay published in the North American Review (Brennan and Kreiss 2014). In terms of the limitations and potential of computer-aided research, Robert Machal discussed the "digitalization of society."[21]

"Digitalization means the use of digital technologies and of data (digitized and natively digital) in order to create revenue, improve business, replace ,transform business processes (not simply digitizing them) and create an environment for digital business, whereby digital

information is at the core." [21]

Example

To return to our example of converting paper documents to digital PDF files on a computer, a digitalization initiative could include uploading these files to the cloud to transform collaboration and reporting processes, as well as using analytical tools to generate insights and actionable knowledge to mitigate risk and promote efficiency on future projects.

1.2.2 Digital Transformation (DX)

Digital transformation is the impact of the digitalization process. It refers to the impact of digitalization on society. Defines digital transformation as the ongoing process by which enterprises adapt to or drive destructive changes in their customers and markets (external ecosystem) by leveraging digital competencies to innovate new business model products and services that seamlessly blend digital and physical, business and consumer experiences while improving operational efficiencies and organizational performance. In the organization, high-level leadership support is required.[28]

Comparison between Digitization,Digitalization and Digital transformation:

The following table shows a comparison between Digitization,Digitalization and Digital transformation :

	Digitization	Digitalization	Digital transformation
Focus	Data conversion	Information processing	Knowledge leaveraging
Goal	Change analog to digital format	Automate existing business operations and process	Change company's culture, the way it works and think
Activity	Convert paper documents , photos,micro films and VHS tapes to digital format	creation of completely digital work process	Creation of a new digital company transformation to a digital one
Tools	Computers and conversion /encoding equipment	IT systems and computer applications	Matrix of a new (currently disruptive) digital technologies
Challenges	Volume materiel	Price financial	Resistance human resource to change

Table 1.1: Digitization vs Digitalization vs Digital Transformation

1.3 Motives for transformation(key drivers):

1.3.1 Technologies

BigData

Digital transformation has assisted businesses in embracing change and remaining competitive in an increasingly digital world. The value of big data in digital transformation stems from an organization's ability to combine both in its efforts to enable digitization and automation of business operations. This digitization and automation are what drive efficiency, innovation, and the development of new business models.[19]

Internet Of Things(IOT)

Data is central to both digital transformation and IoT. IoT technology, when used correctly, collects source data from the physical world and converts it into useful information for the company.[15] The sensor generates internal source data. A software agent on the embedded system converts that data into a digital payload and then wraps it in protocols so it can be sent over the network. This is the edge of the IoT network, from which the data payload is collected and sent to the IT network via the operational technology network. The data is then transferred to the public cloud and stored in a database, where it can be processed by analytics software or artificial intelligence.[15]

Clouding

This new agile business world is built on the cloud. It's the platform that allows for agile application development. Cloud infrastructure is critical for providing flexible, on-demand access to the resources that underpin these new digital business offerings. It enables organizations to scale infrastructure as needed to support changing business priorities while lowering the risks of wasted IT resources, which have previously hampered investments in new digital services.[15]

Mobiles

Employees can connect to core processes and tasks even when they are not at their desks, thanks to enterprise mobility. Enterprise software that can be accessed via mobile devices enhances the employee experience and boosts team productivity. That is why an enterprise mobility strategy is such an important part of digital transformation. Mobile apps play a critical role in digital transformation.[9]

Social media

In the modern digital era, social media's broad reach and widespread use have become a reliable way to stimulate social conversation. There is a place where people can meet, talk, express themselves, and have fun. Although social media sites such as Twitter, Facebook, and others are becoming increasingly popular with individuals, can everyone is using them to benefit their businesses.[C]

Artificial Intelligence

When AI and machine learning became part of business strategy, digital transformation advanced significantly. Aside from increasing productivity, these technologies are critical because they enable better use of a company's data. Businesses can use user data to grow, improve their current products and services, and develop new strategies. [27]

API

Rapidly changing user expectations are driving digital transformation. The frequency of new releases is increasing, as is the need to connect an increasing number of applications and digital experiences. As a result, according to the State of API Integration Report.[31]

APIs (application programming interfaces) have recently gained a lot of clout in tech discussions. Building APIs first may improve internal reusability. APIs have evolved into a machine-readable standard for connecting partners. API startups are also in high demand, indicating that APIs are becoming products in their own right.

APIs are also facilitating change in large corporations.[31]

Security

Initially, the emphasis was on designing, developing, maintaining, and administering infrastructures and information systems housed in data centers. Traditionally, security was

organized around the fundamental technical components (e.g., data center facilities). The point was that an associated security activity was generally separated from a business context and carried out by technical personnel. Because computer terminologies were frequently used, other audiences did not fully comprehend security.[24]

When security elements (for example, logical access protocols used for identification, authentication, and authorization) were added to the financial statement audit, the context became clearer, and the audit was conducted for external auditors. However, the presented work result was not fully interpretable for these practitioners because it was primarily reported in Information Technology (IT) jargon and was not linked to the financial statement. With the introduction of the Sarbanes–Oxley Act (SOX) and the fundamental role of IT in its implementation, the security landscape changed dramatically. The audience grew as compliance, including security, became a top priority for many C-level executives.[24]

Blockchain

Blockchain, best known as the underlying technology that powers Bitcoin, is one of the most intriguing and powerful technologies of the digital age. Blockchain technology, like the Internet's impact on information distribution and availability, has the potential to drive digital transformation that disrupts multiple industries by making transactions and processes more efficient, secure, transparent, and democratic.[13]

If the blockchain realizes its full potential, it will be able to provide a secure decentralized information infrastructure conducive to efficient value chains and massive horizontal integration across traditional institutional boundaries. Maersk and Walmart, for example, use blockchain to reduce the rising administrative costs of supply chain management while improving tracking accuracy; and central banks hope to use blockchain beyond cryptocurrencies to provide more efficient digital currencies and secure global payment infrastructure.[13]

Blockchain has been identified as a revolutionary technology that can drive digital transformation by global organizations and governments, as well as startup companies and investors.[13]

1.3.2 The customer

Today, no industry is growing as quickly as eCommerce. It has completely transformed the retail industry. The customer is king here, so one must be customer-centric and understand his expectations. As customers, we all expect our online shopping experiences to be smooth and simple. Aside from that, if the app or website focuses on personalized service, the chances of conversion increase. Only by adapting to digital trends and working with customer data will this be possible.[22]
Customers expect better experiences from the businesses with which they do business, and companies must meet or exceed those expectations in order to be successful. Customers expect consistency in messaging and tone, as well as performance, responsiveness, authenticity, and authenticity. Companies that create better customer experiences than their competitors and are more in tune with how customers want to do business with them will win.[22] Businesses must understand where their customers want to interact with them, what needs they want to be met, and how they want to interact with the brand.

Customers save time by sharing context and customer data across all touchpoints, allowing them to define the experience they require and desire.[22]

1.3.3 The competition

Digital transformation has a positive impact on competition from an economic standpoint. Although the inherent characteristics of information goods, particularly network effects, favor the emergence of monopolies, cost reductions also lead to an increase in (international) competition.[2]

Aside from direct cost savings, digital transformation improves production and organizational processes, increasing overall economic efficiency. As the importance of innovation grows as a result of digital transformation, (economic) pressure on countries with weak institutions will increase, leading to international convergence.[2]

Cybercrime is a pressing issue that can ultimately only be addressed on a global scale.This endangers the existence of businesses and, as a result, the prosperity of a society.[2]

Because cybercrime is a global issue, international cooperation and the improvement of all prosecuting institutions are essential. As a result, both society and businesses must be aware of the trade-off between cost reduction and increased efficiency on the one hand, and data security and the need for constructive collaboration among all stakeholders on the other.[2]

In other words, for the digital transformation to be successful, pure competition must give way to cooperative competition (coopetition), in which even competitors who are fiercely competitive with one another cooperate in fundamental areas such as data protection or data security, as this is the only way to ensure the foundation for efficient and sustainable economic development.[2]

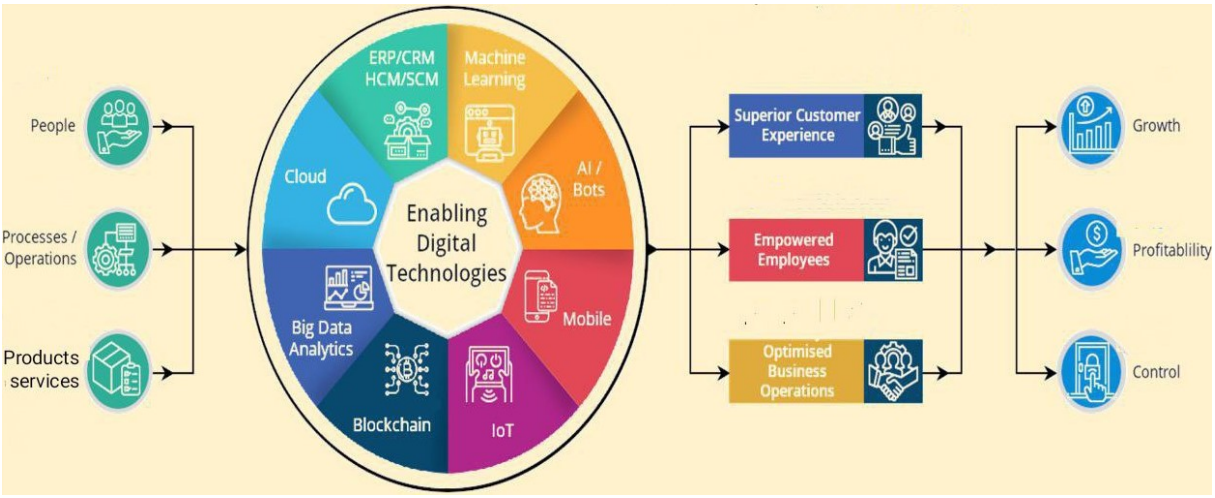

Figure 1.2: A comprehensive summary about digital transformation

1.4 Why Digital Transformation is important?

The way an organization operates changes as a result of digital transformation. This process includes systems, processes, workflow, and culture. This transformation affects every level of an organization and brings data from various areas together to help them work more effectively.

Benefits of digital transformation as below:

1.4.1 Improved Customer Engagement

The most significant advantage of digital transformation is an increase in customer engagement and experience. Through online channels and customer communication, businesses can learn about what their customers think, want, and how their decisions are influenced. These digital channels enable organizations to conduct online sales and marketing and connect with their customers.[1]

1.4.2 Improved Customer Satisfaction

While technology is being used not only for searching and educating but also for comparing products and services, it assists businesses in becoming digitally empowered. A company can improve customer satisfaction by transforming business activities through digital channels. Customer satisfaction is the only way businesses retain key customers, increase profitability, and achieve their goals.[1]

1.4.3 Improved Digital Traffic

When an organization conducts its business and activities through digital channels, its clients and customers will eventually begin to respond to it through these channels as well. For example, a website that properly showcases its products and services can receive high digital traffic and response rates. In addition, as consumers search for preferred products and services online, digital transformation can assist in attracting and retaining new and existing customers.[1]

1.4.4 Improved Lead Generatio

Another significant advantage of digital transformation is a significant improvement in lead generation. Lead generation is the process of generating consumer or customer interest in an investigation into a company's products and services. To reach a broad target audience, organizations must embrace digital mediums. Lead generation is critical for all businesses because it can lead to increased profits. This means that organizations must embrace and rigorously apply the concept of Digital Transformation.[1]

1.4.5 Improved Conversions

Customers visit many businesses' websites, but only a small percentage of them buy their services or products. This is due to their consumers' low conversion rate. This rate can be increased, resulting in more sales, by implementing Digital Transformation. It assists businesses in marketing their products to a specific audience and retaining their interest in a variety of ways.[1]

1.5 Challenges of digital transformation

Gartner estimates that by 2020, 75% of businesses will be digital or will be undergoing digital business transformations, but only 30% of those efforts will be successful (O'Connell, Delaney, Moriarty, 2015). The fundamental problem for companies founded before the digital age is change, and the real place to look for change is not on the Internet but inside your company - in the organizational culture and attitude toward change (Kanter, 2001).[3] The challenges that business organizations must overcome as part of their digital transformation can be divided into the following categories:

1. Consequences of the development of the IT sector and its impact on the strategies and business models of the remaining sectors;
2. The requirement for organizational structure modification in order to be suitable for digital business management;
3. The requirement for the development of specific processes, procedures, information systems, and computing models for processing large amounts of data in order to support Internet marketing;
4. Changes in key skills and abilities, management leadership style, and so on;
5. Creating shared values, channels, and approaches for interacting with customers, vendors, and partners;

1.6 Conclusion

Let's summarize what we understand from this chapter The process of converting information from a physical format to a digital format is known as digitization. When this process

is used to improve business processes, it is referred to as digitalization. The outcomes of this process are referred to as digital transformation.

Chapter 2

Business Process Management

2.1 Introduction

Companies need those who organize their business operations to facilitate their business administration. In this chapter, I will explain Business Process Management (BPM) and Business Process Modeling and Notation (BPMN). I explain how it started its importance and how to define it.

2.2 Business Process Management(BPM)

Business process management (BPM) is a systematic approach to capturing, designing, executing, documenting, measuring, monitoring , and controlling both automated and non-automated processes in order to achieve a company's objectives and business strategies. BPM is concerned with the deliberate, comprehensive, and increasingly technology-enabled definition, improvement, innovation, and maintenance of end-to-end processes. Companies achieve better results faster and more flexibly through systemic and conscious process management.[7] Processes can be aligned with the business strategy through BPM, and thus help to improve overall company performance through the optimization of pro-

cesses within business divisions or even beyond company borders.The term ”end-to-end process” refers to the entire process from beginning to end. The goal is to comprehend, assess, and improve an entire process, not just its components. This understanding is critical for successfully implementing BPM because it is rarely sufficient to improve only organizational procedures or supporting technologies; most of the time, we must improve both the procedures and the technology collaboratively.[7]

Business Process Management (BPM) is the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities.

Examples of Processes in Many Organizations

- Order-to-Cash
- Quote-to-Order
- Procure-to-Pay
- Issue-to-Resolution
- Application-to-Approval

2.2.1 Origins and History of BPM

The Functional Organization

The key idea of BPM is to focus on processes when organizing and managing work in an organization.

The birth of process thinking

Business Process Reengineering (BPR): The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as a cost, quality, service, and speed.

the Rise and Fall of BPR

BPM is revival of BPR as indeed BPM adopts the process-centered view on organizations.

2.2.2 Why We Need BPM?

BPM consultants say that new projects almost always involve one of the following three scenarios:

The client wants to improve a process using Information Technology (IT)

The first scenario is encountered the vast majority of the time: the client wants to improve a process with IT. The motivation is frequently a desire to improve efficiency, such as using software to eliminate manual keying or re-keying of data. A client might want to use IT to monitor and analyze routine processes based on key performance indicators (KPIs).[7]

The client wants current processes documented

The second scenario, documenting processes, occurs when the client requires documentation to guide the work of the people involved. Another reason is that the documentation is required by law or to obtain certification, such as ISO 9000.[7]

The client wants to introduce entirely new processes

The third scenario occurs the least frequently. When businesses want to implement completely new processes, it is usually because they need to adapt to changing market conditions, develop new channels of distribution, or launch new products.[7] Companies may make broad statements in public announcements, such as "we are interested in exploring BPM" or "we want to increase our process orientation." In practice, particularly in large organizations, the case for BPM is usually well-defined and specific, but it can take one of two forms:

1. Here's a compelling reason to use BPM. The project is about creating, improving, or documenting critical processes.[7]

2. BPM is used for strategic reasons. There will be no immediate or direct benefit, and the project was most likely initiated by a manager looking to advance his or her career.[7]

2.2.3 Business Process

A business process as a collection of inter-related events, activities, and decision points that involve a number of actors and objects, which collectively lead to an outcome that is of value to at least one customer.[6]

Relationship between processes

1- Sequence: this relationship describes that there is a logical sequence between tow processes.[6]
2- Decomposition: this relationship describes that there is a decomposition in which one specific process.[6]
3- Specialization: this relationship describes that there exist several variants of a generic process.[6]

2.2.4 BPM Lifecycle

Understanding how the typical BPM life cycle works is a good place to start.

Planning and strategic alignment

The first stage of the BPM life cycle entails developing a thorough understanding of how processes are linked to the value chain.[6] Typical activities at this stage may include:
Organization profiling
Identifying primary, management, and support processes
Noting key performance indicators (KPIs)
Preparing for process analysis(Process Categories)
Primary processes(Core Process)are the primary functions of a company. They directly provide value to customers. Primary processes include all processes involving the design, creation, and sale of products or services to customers.[6]
Secondary processes (Support Process)support the primary processes. Examples include human resources, IT management, procurement, office administration, and so on.[6]
Management processes involve monitoring primary and secondary processes to ensure that the organization is meeting overall financial and operational goals. These processes also involve activities to ensure compliance with regulatory guidelines.[6]

Process analysis

To get a complete picture, one must observe the process as it is currently practiced during the analysis stage. If effective changes are to be implemented, theym ust necessarily come before modeling.[6]
The method of analysis chosen may be qualitative or quantitative, depending on the nature of the processes. In general, however, the analysis includes interviewing process performers, analyzing available process documentation, and arriving at a complete picture of how processes are executed.[6]

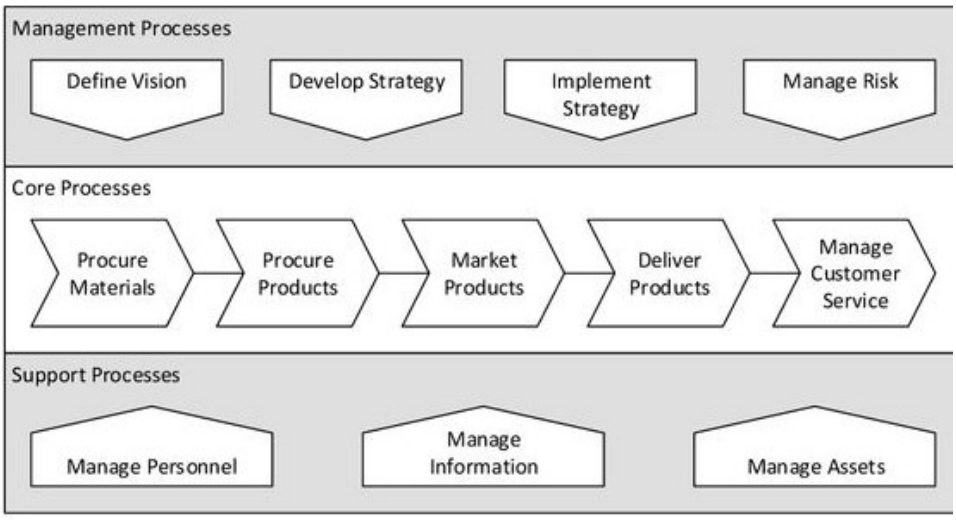

Figure 2.1: Process Categories [6]

Process design

Process analysis observations are used in the design stage. At this point, you should be fully aware of bottlenecks, lags, and delays.[6]
The key question is whether the process should be kept as is or redesigned to address the issues identified. You can approach it in one of two ways based on the response:

- Continuous process improvement wherein the process is accepted in its current structure and issues are corrected one after another.
- Redesign, wherein the entire process is remodeled in its entirety.

After the process modeling is completed, new procedures must be approved. A deployment plan is developed to ensure that relevant process performers are properly trained for the changes and that transitions are as smooth as possible.[6]

Implementing the process

There are two approaches to implementing the new process design: systemic and non-systemic implementation. The former implements using specific software or tools, whereas

the latter does not.[6]
The choice between the two types is determined by the nature of the business process and the organization's resources.
However, the goal remains the same–to put the workflow designed in the previous stage into action.

Process monitoring

At this stage, previously identified KPIs are monitored to ensure that the process is aligned with the overall goals of the organization. In this case, tracking, measuring, and controlling would be done on a continuous basis.[6]
Some common KPIs that are monitored include process duration, cost, capacity (how much the process can produce), and errors or issues that negatively impact customer satisfaction. The information gathered during process monitoring will assist you in determining whether the process requires any changes or tweaks and whether the redesigned process is meeting goals and objectives.

Process refinement

During the refinement stage, one makes an effort with carefully measured changes to close the gap between current performance and the modeled process.[6]
The concept of continuous process improvement underpins the BPM life cycle. The cycle is repeated as the organization strives to improve performance and accelerate growth.

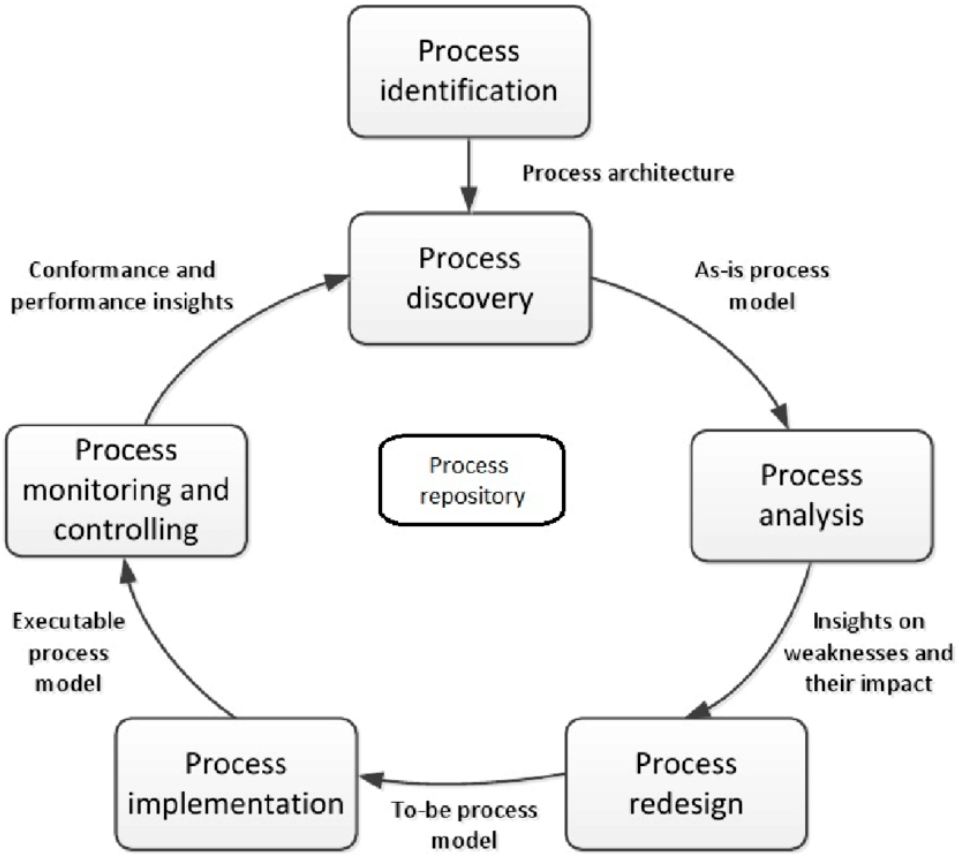

Figure 2.2: BPM Lifecycle [6]

The following picture shows an example of BPM

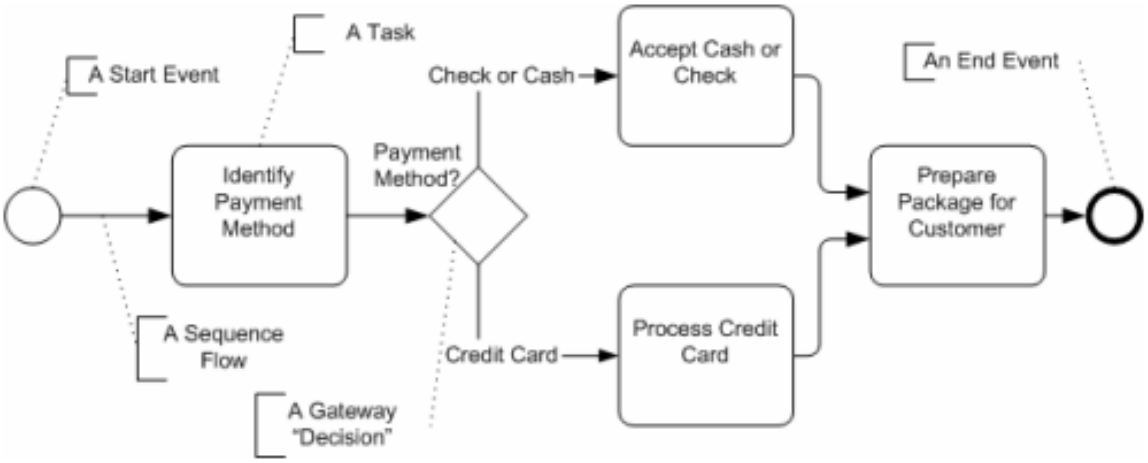

Figure 2.3: Example of Business Process Management BPM [29]

2.3 Business Process Modeling Notation(BPMN)

BPM: A business process model is a representation of an organization's processes. A model can be analyzed and improved.[25]
N: Notation consists of graphic symbols to represent action, flow, or behavior of a process.[25]
Developed by the Business Process Management Initiative (BPMI), and now maintained by the Object Management Group following their merger in 2005. Bridges the communication gap between business process design and implementation by assisting technical and business users with business process management.[11]

2.3.1 Process Modeling Methodologies

BPMN is intended to be methodology independent.

- Simple or complex diagrams can be created based on the chosen methodology.[29]
- Methodologies determine what information is captured about a process.[29]

Many different methodologies can be used for modeling with BPMN.[29]

- Some may require extended Artifacts.[29]

Examples of methodologies

- LOVeM, EPCs, RAD methodology, IDEF.
- Consulting organization methodologies.[29]

2.3.2 General Modeling Concepts

- A process is sequential. Accurate models should be oriented on a time line (generally, in sequence from left to right).[29]
- Processes typically begin with triggering events and progress to significant business outcomes.[29]
  - They can also represent smaller chunks of reused work.[29]
- All tasks or activities are assigned to roles that are important to the people who work in the company. Make certain that you have captured all relevant roles, which may occasionally be outside of the client's company.[29]
- A complete model should show how and where objects or data (or both) are transferred.[29]
- A process can be represented hierarchically (for example, with Sub-Processes).[29]
- The decisions that are made within a process determine which of all possible paths will be taken.[29]

2.3.3 General Modeling Guidelines

- Establish organization standards or guidelines for developing models and naming model elements, e.g.,[29]
  - Establish naming conventions for each type of modeling object.[29]
    For example, all activity names could have the following format.[29]

    - ∗ verb + (adjective/descriptor) + noun
    - ∗ example: “Verify Account”
  - Avoid redundancy in naming, e.g., do not include the word Process in the Process names or the words Task or Activity in Task names.[29]
  - To help with report outputs, names should be 32 characters or less.[29]
  - To help with readability, all words should be capitalized.[29]

- Establish a set of standard nouns, verbs, and acronyms that are used for naming objects.[29]

- Establish standards for versioning methods associated at the process model and artifact level to provide requirement traceability.[29]

2.3.4 Example For BPMN

The following image shows the most important elements in modeling 4.11

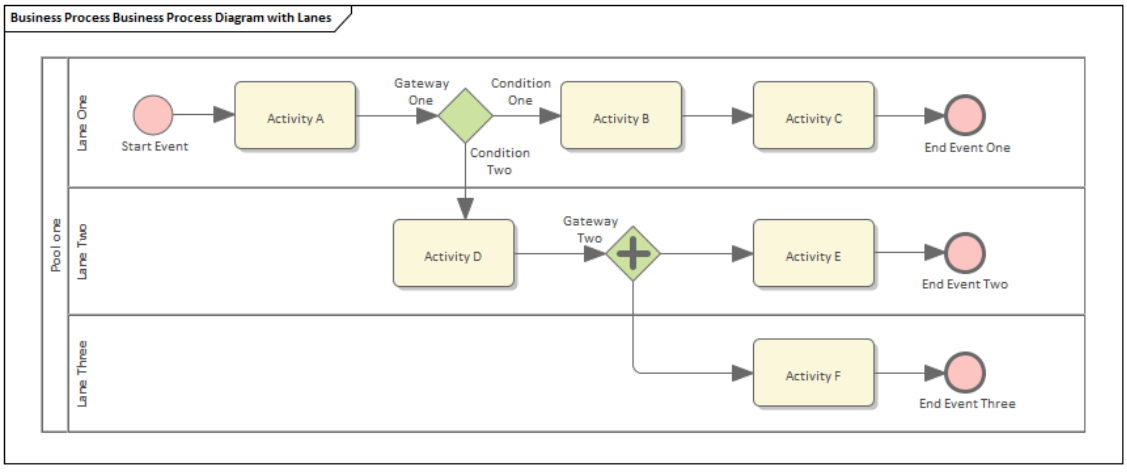

Figure 2.4: Process BPMN Template [B]

2.4 Key Performance indicator(KPI)

Continuous monitoring and reporting of the defined partial targets, i.e. strategic goals achieved, is one of the steps in HR scorecard implementation. KPIs are used to track the progress of the HR scorecard implementation phase.[8] KPIs must be connected to all partial goals in the strategy map. It is critical to assign the necessary strategic value that will have direct control over the level of organizational performance.[8]

2.5 Conclusion

Finally, using Business Process Management enables businesses to achieve their objectives faster, better, cheaper, and more efficiently. It offers a methodical approach to achieving these benefits.BPM aims to improve an organization's service quality by improving communication between people and systems, making better decisions, reducing waste, and increasing efficiency. The benefits are primarily realized in two ways: first, by providing visibility into how work is completed; and second, by automating tasks that can be automated. In other words, BPM enables organizations to make decisions about their operations based on data rather than intuition or experience.

Chapter 3

Blockchain

3.1 Introduction

In today's digital age, transactions are increasingly taking place in the virtual realm. Some people conduct all financial transactions online, while others refuse to consider this option because it is untrustworthy. Many technologies have already been tested in order to improve the reliability of online financial transactions.[10]

In this chapter, I will explain the blockchain technology and the most important concepts related to it, as well as an overview of how the blockchain works and its types.

3.2 Definition

A blockchain is a distributed database shared by computer network nodes. A blockchain, like a database, stores information electronically in digital form. Blockchains are best known for their critical role in cryptocurrency systems such as Bitcoin, where they keep a secure and decentralized record of transactions. A blockchain's innovation is that it ensures the fidelity and security of a data record and generates trust without the need for a trusted third party.[5]

3.3 Blockchain components

Blockchain technology may appear complex; however, by examining each component individually, it can be simplified. At its most basic, blockchain technology combines well-known computer science mechanisms and cryptographic primitives (such as cryptographic hash functions, digital signatures, and asymmetric-key cryptography) with record keeping concepts (such as append only ledgers). This section goes over each major component in detail, including cryptographic hash functions, transactions, asymmetric-key cryptography, addresses, ledgers, blocks, and how blocks are chained together.[30]

3.3.1 Smart Contracts

"Smart contracts" are computer programs that automatically execute all or parts of an agreement and are stored on a blockchain-based platform. As discussed further below, the code can either be the sole manifestation of the parties' agreement or it can supplement a traditional text-based contract by carrying out specific provisions, such as transferring funds from Party A to Party B. The code itself is replicated across multiple blockchain nodes and thus benefits from the security, permanence, and immutability that a blockchain provides.[14] That replication also implies that the code is executed as each new block is added to the blockchain. If the parties have indicated that certain parameters have been met by initiating a transaction, the code will execute the step triggered by those parameters. If no such transaction is initiated, the code will take no action. The majority of smart contracts are written in one of the programming languages designed specifically for such computer programs, such as Solidity.[14]

3.3.2 Cryptographic Hash Functions

The use of cryptographic hash functions for many operations is an important component of blockchain technology. Hashing is a method of applying a cryptographic hash function

to data, which produces a relatively unique output (known as a message digest, or simply digest) for nearly any size input (e.g., a file, text, or image). It enables individuals to independently take input data, hash that data, and derive the same result – demonstrating that the data did not change. Even minor changes to the input (for example, changing a single bit) result in a completely different output digest.[30]
Cryptographic hash functions have these important security properties:

- They are preimage resistantThis means that they are one-way; computing the correct input value given some output value is computationally infeasible (e.g., given a digest, find x such that hash(x) = digest).[30]

- They are resistant to second preimages. This means that it is impossible to find an input that hashes to a specific output. More specifically, cryptographic hash functions are designed in such a way that it is computationally impossible to find a second input that produces the same output given a specific input (e.g., given x, find y such that hash(x) = hash(y)).The only option is to search the input space exhaustively, which is computationally impossible to do with any chance of success.[30]

- They are resistant to collisions.This means that two inputs cannot hash to the same output. It is computationally impossible to find any two inputs that produce the same digest (e.g., find an x and y which hash(x) = hash(y)). [30]

The Secure Hash Algorithm (SHA), with an output size of 256 bits, is a specific cryptographic hash function used in many blockchain implementations (SHA-256).This algorithm is supported in hardware by many computers, making it fast to compute. SHA-256 produces 32 bytes (1 byte = 8 bits, 32 bytes = 256 bits), which is typically displayed as a 64-character hexadecimal string.

Input Text	SHA-256 Digest Value
1	0x6b86b273ff34fce19d6b804eff5a3f5747ada4eaa22f1d49c01e52ddb7875b4b
2	0xd4735e3a265e16eee03f59718b9b5d03019c07d8b6c51f90da3a666eec13ab35
Hello, World!	0xdffd6021bb2bd5b0af676290809ec3a53191dd81c7f70a4b28688a362182986f

Table 3.1: Examples of Input Text and Corresponding SHA-256 Digest Values.

Cryptographic Nonce

A cryptographic nonce is a random number that is used only once. A cryptographic nonce can be combined with data to generate unique hash digests:
hash (data + nonce) = digest
Changing only the nonce value allows for different digest values while keeping the same data. The proof of work consensus model employs this technique.

3.3.3 Transactions

A transaction is an interaction between two parties. In the case of cryptocurrencies, for example, a A transaction is a cryptocurrency transfer between blockchain network users. For In business-to-business scenarios, a transaction could be a method of recording activities that occur on the network. Physical or digital assets.[30]
A blockchain can have zero or more transactions in each block. A constant supply of new blocks (even with zero transactions) is critical for some blockchain implementations to maintain the security of the blockchain network; having a constant supply of new blocks published prevents malicious users from ever ”catching up” and manufacturing a longer, altered blockchain.[30]
The data that makes up a transaction varies depending on the blockchain implementation, but the mechanism for transacting is largely the same. A user of the blockchain network sends data to the blockchain network.The information sent may include the sender’s address (or another relevant identifier), the sender’s public key, a digital signature, transaction inputs and outputs, and so on.

3.3.4 Asymmetric-Key Cryptography

Blockchain technology employs asymmetric-key cryptography4 (also known as public key cryptography). Asymmetric-key cryptography employs a pair of keys: a public key and a private key that are mathematically related to one another. The public key is made public without jeopardizing the process's security, but the private key must remain secret if the data is to retain its cryptographic protection.Despite the fact that the two keys are related, the private key cannot be determined efficiently based on knowledge of the public key. Encrypting with a private key and decrypting with a public key is possible. You can also encrypt with a public key and then decrypt with a private key.[30] By providing a mechanism to verify the integrity and authenticity of transactions while allowing transactions to remain public, asymmetric-key cryptography enables a trust relationship between users who do not know or trust one another. The transactions are 'digitally signed' to accomplish this.[30] This means that a private key is used to encrypt a transaction, which anyone with access to the public key can decrypt. Because the public key is freely available, encrypting the transaction with the private key demonstrates that the transaction's signer has access to the private key. Alternatively, data can be encrypted with a user's public key and decrypted only by users who have access to the private key.[30]
Summary of the use of asymmetric-key cryptography in many blockchain networks:

- Private keys are used to digitally sign transactions.
- Public keys are used to derive addresses.
- Public keys are used to verify signatures generated with private keys.
- Asymmetric-key cryptography provides the ability to verify that the user transferring value to another user is in possession of the private key capable of signing the transaction.

3.3.5 Addresses and Address Derivation

Some blockchain networks employ an address, which is a short, alphanumeric string of characters derived from the blockchain network user's public key via a cryptographic hash function, as well as some additional data (e.g., version number, checksums). Addresses are used as the "to" and "from" endpoints in most blockchain implementations.[30] Addresses are not secret and are shorter than public keys. To generate an address, one method is to generate a public key, apply a cryptographic hash function to it, and convert the hash to text:

$$\text{public key} \rightarrow \text{cryptographic hash function} \rightarrow \text{address}.$$

Once a smart contract has been deployed within a blockchain network, a method of accessing it is required. Smart contracts in Ethereum are accessed through a special address known as a contract account. When a smart contract is deployed, this account address is generated (the address for a contract account is deterministically computed from the address of the smart contract creator). This contract account enables the contract to be executed whenever a transaction is received, as well as to create additional smart contracts in turn.[30]

3.4 Ledgers

A ledger is a record of all transactions. Pen and paper ledgers have been used throughout history to keep track of the exchange of goods and services.[30]

Ledgers are now digitally stored, frequently in large databases owned and operated by a centralized trusted third party (i.e., the owner of the ledger) on behalf of a community of users. These centralized ledgers can be implemented centralized or distributed (i.e., on a single server or a coordinating cluster of servers).[30]

3.5 Blocks

A block is a location in a blockchain where data is stored and encrypted. Long numbers are used to identify blocks, which include encrypted transaction information from previous blocks as well as new transaction information. Before new blocks can be created, a network must verify the blocks and the information contained within them. The first block is known as the Genesis block.[30] There are two parties involved:

3.5.1 Block Header

- The block number, also known as block height in some blockchain networks.[30]
- The previous block header's hash value.
- A hash representation of the block data (different methods can be used to accomplish this, such as a generating a Merkle tree (defined in Appendix B), and storing the root hash, or by utilizing a hash of all the combined block data).[30]
- A timestamp.
- The size of the block.[30]
- The nonce value. For blockchain networks which utilize mining, this is a number which is manipulated by the publishing node to solve the hash puzzle.[30]

3.5.2 Block Data

- A list of transactions and ledger events included within the block.[30]
- Other data may be present.[30]

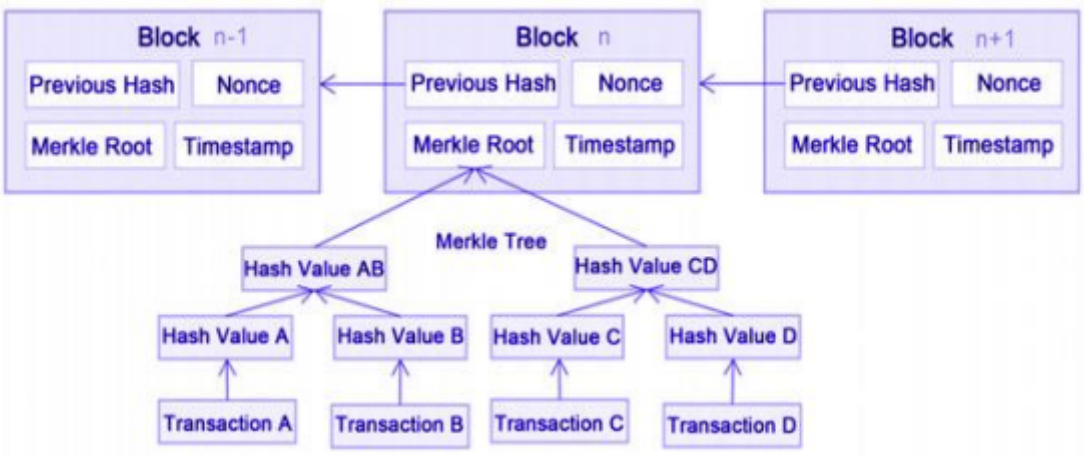

Figure 3.1: Structure of blockchain [12]

3.6 Longest chain Rule

Sometimes the blockchain might have a disagreement which produces a fork.where the chain splits into tow. Nodes always follow the longest chain to accept is as valid version of the Blockchain. the longest chain is the chain of blocks that took the most effort to build.[30]

3.7 The main features of blockchain technology

3.7.1 Distributed Ledger Technology

The blockchain has the structure of a distributed database, and this database is distributed among nodes. The blockchain's architectural structure enables participants to share a ledger created through peer-to-peer replication in each transaction.[13]

3.7.2 Consensus and Proof of Work (PoW)

Although the concept of Proof of Work has some value, it is a time and cost-intensive piece of data. The targeting of these data should be simple to control. In blockchain technology, this system is frequently used.[13]

For a partially synchronous system, the Byzantine-based consensus problem is examined. A partial synchronous system is an asynchronous system that ultimately transitions to synchronous mode. It's difficult to come up with a deterministic leader-free algorithm for a partially synchronous system.[4]

A leader-free algorithm, on the other hand, is made up of rounds in which all nodes communicate with each other. For partial synchronous systems, the consensus leader free algorithm for synchronous systems is extended. Each process generates a set of values, each of which represents a process element. Correct methods produce the same set of results. This algorithm can be improved,by parameterized consensus algorithm, which allows diverse failure models to agree.[4] There are more example of consensus algorithms like: PROOF-OF-WORK (POW), PROF-OF-STAKE (POS), PROF-OF-AUTHORITY (POA), PROF-OF-ELAPSED TIME (POET) and PROF-OF-CAPACITY (POC).

3.7.3 Decentralized

Transactions in this structure can be carried out in a distributed structure using the systematic infrastructure provided by blockchain technology, encrypted with cryptography only between the receiver and the transmitter, and independent of any authority.[13]

3.7.4 Peer to Peer (P2P) Network

Individual nodes enable data storage by transmitting data directly to each other in an end-to-end network, eliminating the need for a central system to connect the parties.[13]

3.8 How Blockchain work?

Blockchain technology is built on cryptography and a peer-to-peer (P2P) network of parties (or nodes) that distributes a blockchain ledger. Instead of a trusted intermediary managing a central ledger, each party in the network keeps its own copy of the ledger.[23] Timestamped and digitally signed transactions are stored in the ledger in cryptographically linked blocks made up of multiple ordered transactions, with each block containing the cryptographic hash of the previous block, hence the name blockchain ledger. The use of cryptography ensures that no single party can alter or add new (fraudulent) transactions to the ledger without invalidating it.

This ensures that transactions are immutable once stored and that non-repudiation by parties involved in the transaction, as identified by their respective digital signature, is ensured. To add a new transaction to the ledger, parties rely on a consensus mechanism through which network participants agree on the validity of transactions. A new block of transactions is added to the blockchain ledger only if a majority of the parties agree. A consensus protocol is in charge of determining the order of transactions within the consensus mechanism.[23]

The most well-known consensus protocol is proof-of-work. It takes computational effort to solve a cryptographic puzzle before a party can propose a new valid block of ordered transactions. The resulting delay makes it more difficult to double-spend a transaction because it would necessitate more computational power. Before appending the block proposal to their copy of the blockchain ledger, all other parties in the network validate it. In exchange, the party who proposed the block will be rewarded. This solves the problem of double spending because it is more advantageous for a party to act honestly than maliciously.[23]

The blockchain ledger cannot be altered without consensus, making transactions (and the information contained in these transactions) immutable. As a result, information, for example, in the form of documents, can be exchanged while the integrity of the exchanged

information is ensured.[23]

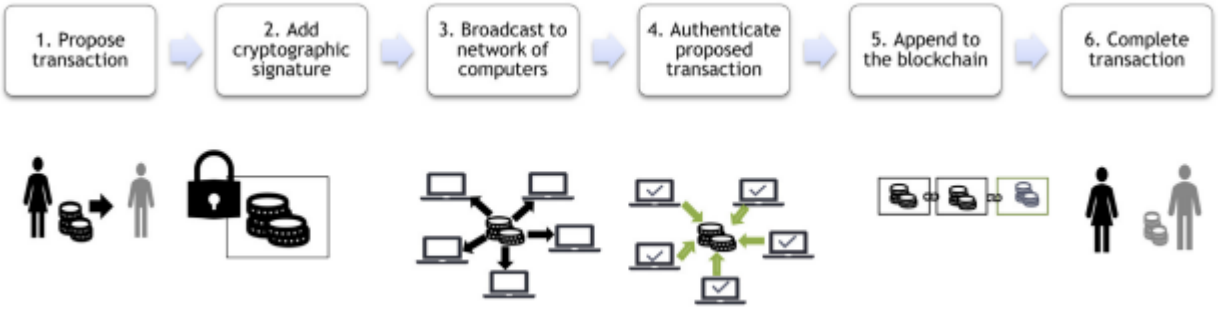

Figure 3.2: The six steps of asset exchange using blockchain.[20].

3.9 Types of blockchain

There are two types of technology blockchain:

3.9.1 Private blockchain

A private blockchain, on the other hand, gives the owner the sole authority over any changes that must be made. This could be compared to the existing infrastructure in that the owner (a centralized authority) would have the authority to change the rules, revert transactions, and so on as needed.This could be a concept that FIs and large corporations are very interested in. It could find use cases for proprietary systems, lowering costs while increasing efficiency.[12]

3.9.2 Public Blockchain

A public blockchain is a platform that allows anyone on the platform to read or write to the platform as long as they can demonstrate proof of work. There has been a lot of activity in this space because any technology in this space has a large number of potential users. A public blockchain is also considered a fully decentralized blockchain.[12]

3.9.3 Private blockchain VS Public blockchain

3.10 Related works

The following table shows some of the related works and the platforms used therein:

Title	Authors	Modeling by	Framework
CATERPILLAR: A Business Process Execution Engine on the Ethereum Blockchain	Orlenys López-Pintado, Luciano García-Bañuelos, Marlon Dumas, Ingo Weber, Alex Ponomarev	Commanda	Caterpiller[17]
Blockchain-based business process management (BPM) framework for service composition in industry 4.0	Z.M.Bi and Wattana Viriyasitavat	Not selected	QoS Blockchain [26]
Modelling Business Processes on a Blockchain Eco-System (BPMN)	Mariia Markovska	Commenda	not selected[18]
Caterpillar: A Blockchain-Based Business Process Management System	Orlenys L´opez-Pintado1 and Luciano Garc´ıa-Ba˜nuelos1 and Marlon Dumas1 and Ingo Weber2	Commenda	Caterpiller [16]

Table 3.2: Related works

3.11 Conclusion

Blockchain technology may be quite complementary in a future world possibility space that includes both centralized and decentralized models. The blockchain, like any new technology, is an idea that initially disrupts, but over time it may promote the development of a larger ecosystem that includes both the old and innovations. For example, the

introduction of the radio resulted in increased record sales, and readers such as the Kindle resulted in increased book sales. We now get our news from blogs, Twitter, and customized drone feeds. We consume media from major entertainment companies as well as YouTube. As a result, blockchain technology may eventually coexist in a larger ecosystem with both centralized and decentralized models.

Chapter 4

USE CSE (Ph.D Contests)

4.1 Introduction

In this chapter, I will explain the doctorate competition(PhD) and the most important tasks that take place from the beginning to the end. I relied on BPMN to represent the processes that take place in the competition, and then BPM is converted into Blockchain.

4.2 Requirement tools

4.2.1 Bonitasoft

Bonita is an open-source and extensible platform for business process automation and optimization.

The Bonita Platform speeds up the development, deployment, and maintenance of automation projects. While allowing users to perform tasks that affect their business data, it also integrates with existing information systems and orchestrates heterogeneous systems, some of which are soft robots. Through embedded end-user applications or Living applications built by the project team to perfectly fit the business needs, it provides deep

visibility of process execution across the organization.[D]

4.2.2 bonita structure

Bonita Studio for the development phase of the projects.

Bonita Runtime for the various runtime phases, running the BPM engine and the applications.

Bonita Continuous Delivery to ease the iterative deployment of the projects from environment to environment.

4.2.3 Caterpiller

Caterpillar is a Business Process Management System (BPMS) prototype that runs on top of Ethereum and that relies on the translation of process models into smart contracts. More specifically, Caterpillar accepts as input a process model specified in BPMN and generates a set of smart contracts that captures the underlying behavior. The smart contracts, written in Ethereum's Solidity language, can then be compiled and deployed to the public or any other private Ethereum network using standard tools. Moreover, Caterpillar exhibits a REST API that can be used to interact with running instances of the deployed process models.[E]

Use-Case Specification:<PhD Competition>

4.3 General Information

All information about the doctoral competition is taken from the note on the organization of the doctoral competition for the year 2021-2022.

4.3.1 Use-case description

4.4 Preconditions

4.4.1 Precondition one

4.4.2 Precondition two

4.4.3 Precondition three

4.4.4 Precondition four

4.4.5 Precondition five

4.4.6 Precondition six

4.5 Scenarios

4.5.1 Main Scenario

The main flow follows a step-by-step description of the use-case. This means that the main flow describes what the actor does and what the system does in response; i.e., it needs to be phrased in the form of a dialog between the actor and the system. In general, a scenario description explores:

- the use case starts when the candidate enters.
- When the use case interacts with the actors, and what data they: exchange
  - the use case interact with candidate he inter the code.
  - it interact with omissions committee they change the name by code

  - it interact with corrector he put the note of exam
  - it interact with university it put the result of exams

- the use case use data stored in the system when the candidate inter the code.and it store the notes of exams,codes replaced by names.
- the use case ends when the university announced the results.
- If a candidate has not been registered on the Ministry's website before he cannot pass the exam.
- the candidate must be present at the appointed time.

  Any case of fraud will prevent its owner from participating for a period of five years.

4.6 Postconditions

4.6.1 < Postcondition one >

According to article 15 of resolution 28 of 09 January 2022, the final order is arranged For candidates on the basis of merit and according to the specialization according to the final signs obtained in the written exams.

4.6.2 < Postcondition two >

In the case of equality, and in accordance with Article 15 of Resolution No. 28 of January 09, 2022, Candidates, successively, on the basis of the exam point in the specialization or the general average of the training track in The second phase or the general modifier of the formation path in the first phase.

4.6.3 < Postcondition three >

The final results of the competition can only be published after the approval of the qualified scientific bodies (Council The scientific council of the college/the scientific council of the institute at the university, the scientific council of the institute at the university center. The scientific committee of the school department.

4.6.4 < Postcondition four >

The announcement of the results must not exceed a maximum period of three (03) days after the date of the procedure Competition.

4.6.5 < Postcondition five >

The final, certified results cannot be subject to any amendment or appeal.

4.6.6 < Postcondition six >

According to Article 16 of Resolution No. 28 of January 9, 2022, successful candidates must begin the registration process within a deadline not exceeding 15 days, starting from the date of the announcement of the final results of the competition.

4.6.7 < Postcondition seven >

Registration in the doctoral stage is accepted only in one training and at the level of only one university institution.

4.6.8 < Postcondition eight >

Upon final registration, the successful candidate in the competition must submit the original copy of the master's certificate or the original copy of the foreign degree equivalency.

4.6.9 < Postcondition nine >

The directors of the concerned institutions must keep the documents related to the competition in order to use them when needed.

4.7 Use case application

4.7.1 Organization

In this use case, the Organization selected is the university.

4.7.2 Define Business Data Model(BDM)

In this phase, must define the columns of the database see figure 4.11

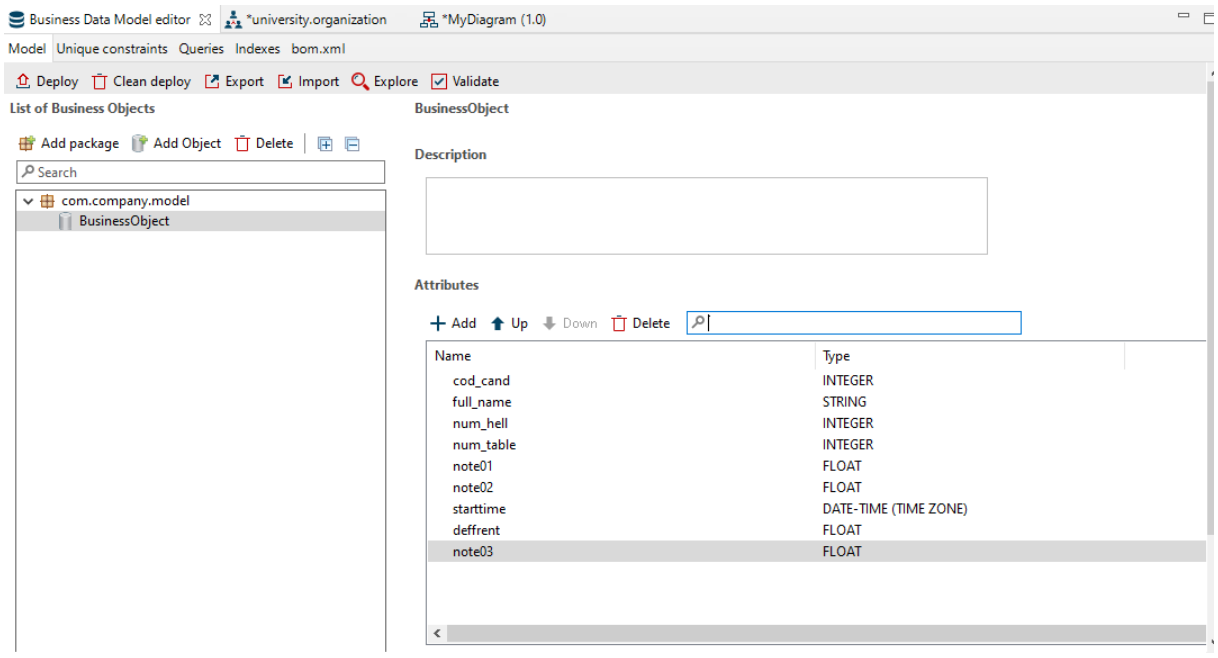

Figure 4.1: Business Data Model

4.7.3 Database

In this application, a simulated database has been set for the data that is stored in the PROGRESS platform after online registration.4.11

select *from inforcand;

COD_CND	FULL_NAME	NUM_HELL	NUM_TABLE
350001	CHIFA	2	1
350002	Maroi	2	2
350003	Hinda	1	1
350004	LILA	1	2

(4 rows, 4 ms)

Figure 4.2: Simulated Database

4.7.4 Actors

The following table 4.2 describe the Actors and their groups, roles and users:

Actor	Group	Role	User
Candidate	Candidate	Candidate	Chifa
Teacher	Teacher	teacher	Maroi
Organizer	Organizer	Organizer	Ahmed
Omission committee	Ommission	Codification	Salim
Corrector	Corrector	Correctorr	Ali
University	University	Manager	Hinda

Table 4.1: Description of Actors

The figure4.3 shows the roles and groups and users of actors in bonita application

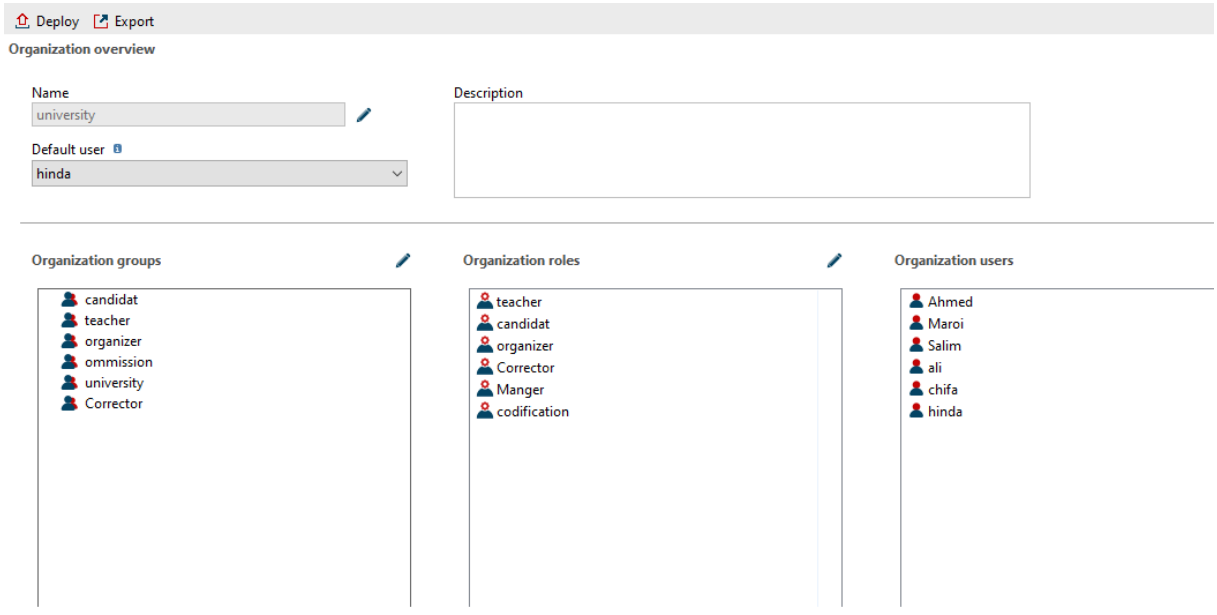

Figure 4.3: The roles and groups and users of university

[H]

4.7.5 process

Actors	Process	the input/output data
Candidate	Entry Candidate	in this process the candidate enter his code .
organizer	Directing the candidate to the hell Exam	in this process there is no input data but there is output data :full Name,Number of hell,Number of table
teacher	prepare exam	the input data is three exams
organizer	Shooing a random Voltaire	in this process the input data is boolean variable yes if process finish or no
teacher	Choosing Exam	in this process the input data is the number of exam chooses
organizer	Print papers	in this process the input date is yes or no
candidate	Doing the exam	in this process the input data is the start time of exam
teacher	sorting papers	in this process the input data is yes or no
ommission	Codification	in this process the input data is the name of candidate and the code of paper
Corrector	Corrector01	in this process the input data in the note01
corrector	corrector02	the input data is the note02
Ommission	compare result	the input data is the deference between note01 and note2
corrector	corrector03	the input data is note03
ommission	Deliberation without names	the input data is yes or no
ommission	Decodification	the input data is the code and the names of papers
ommission	deliberation with names	the input data in yes or no
University	announcement results	the input data is yes or no

Table 4.2: Description of process

The following image 4.11 shows the diagram of PhD competition:

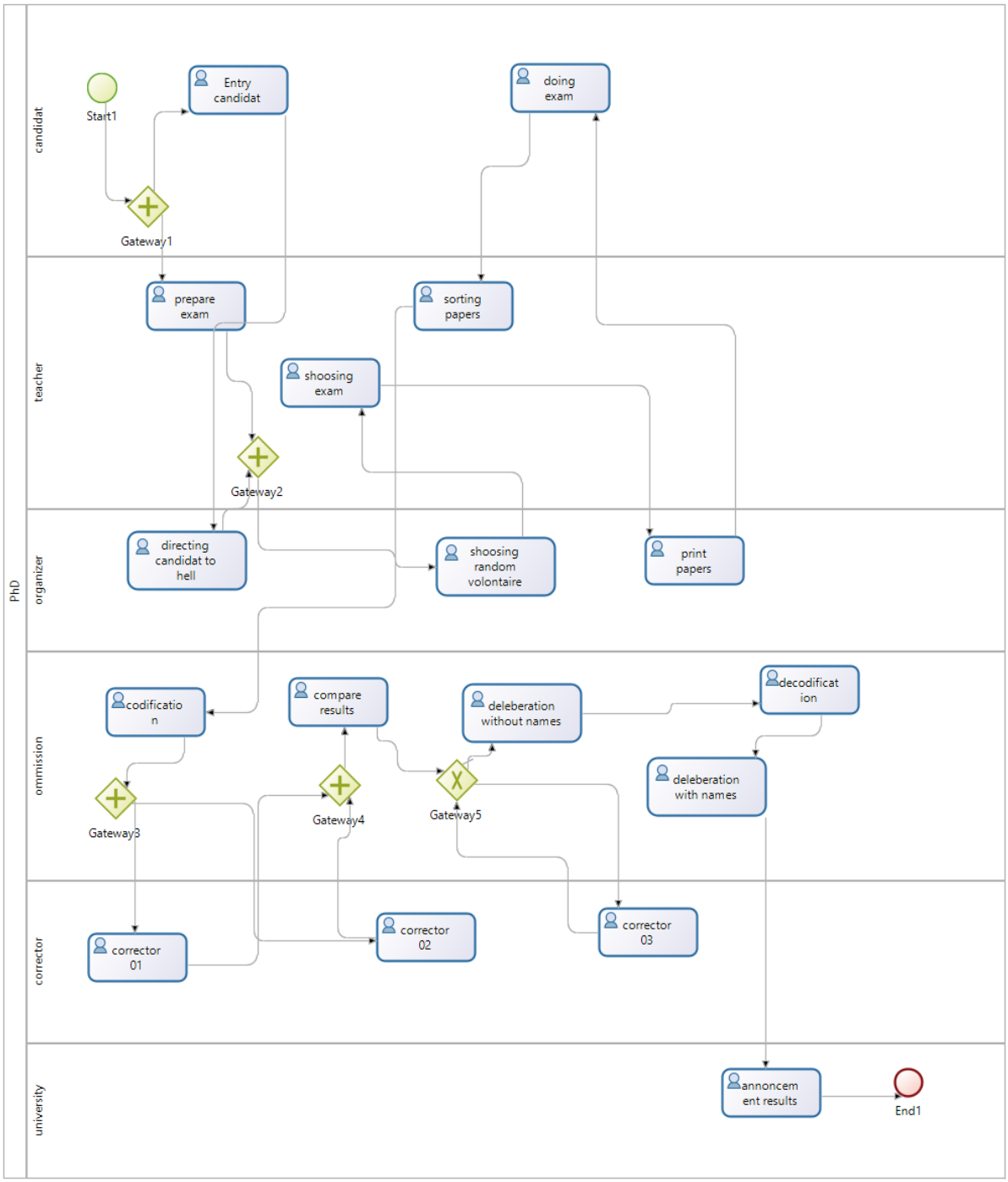

Figure 4.4: BPMN Diagram of PhD competition

4.7.6 Running the Diagram

In this page Signed in with one of the users defined in the organization.figure 4.11

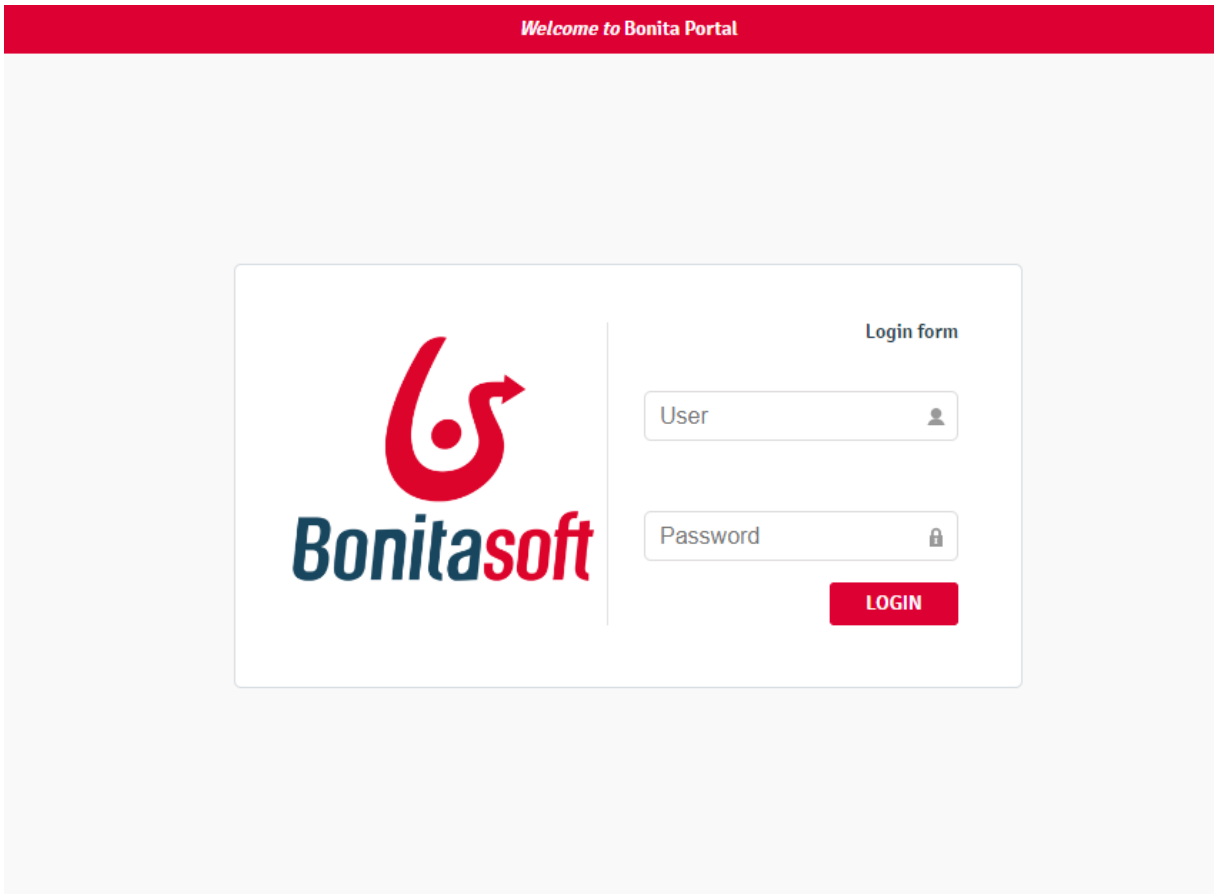

Figure 4.5: Login page

in this page after singed in the user startes the process.figure 4.11

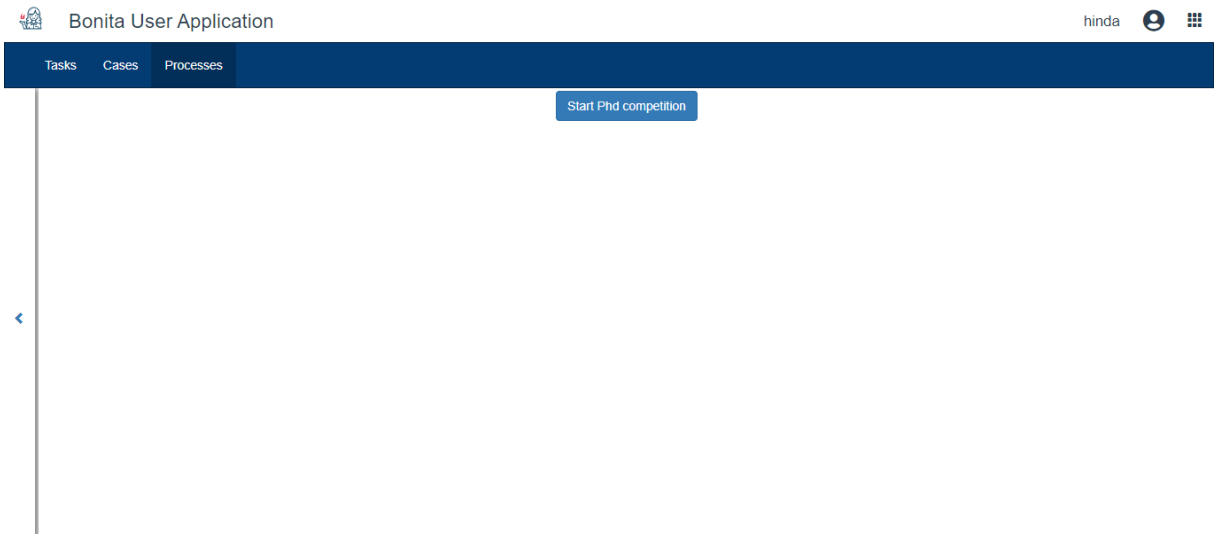

Figure 4.6: The start of Process

When the user starts the process starts first process.figure 4.11

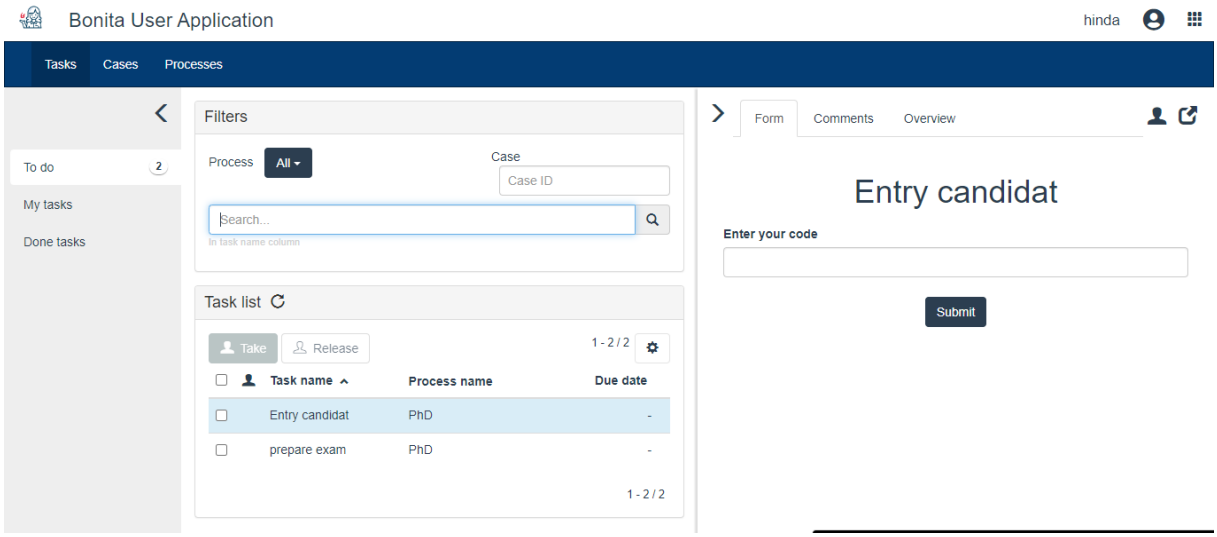

Figure 4.7: First Process

After the end of all process, the information stored in the BDM.figure 4.11

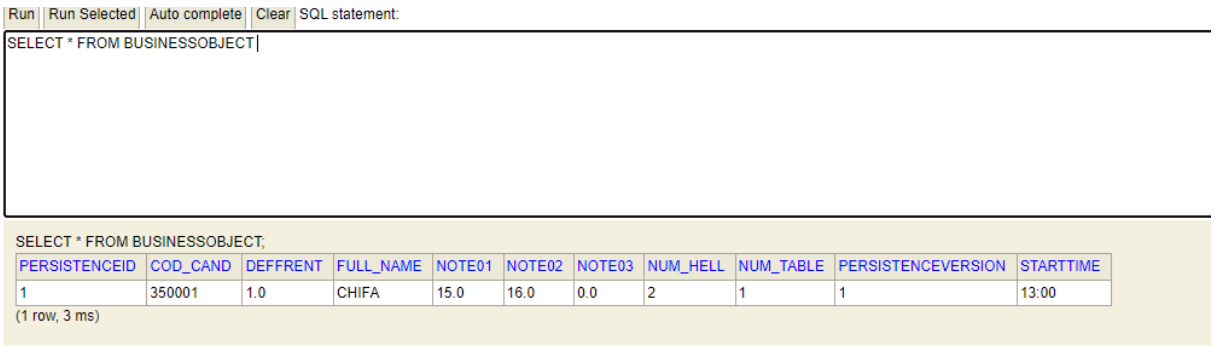

Figure 4.8: Information stored in BDM

4.8 Translate BPMN to Blockchain

4.8.1 Running the program

To run the program must follow the these steps:

Runing Ganache

By entering a command **ganache** in terminal.figure 4.11

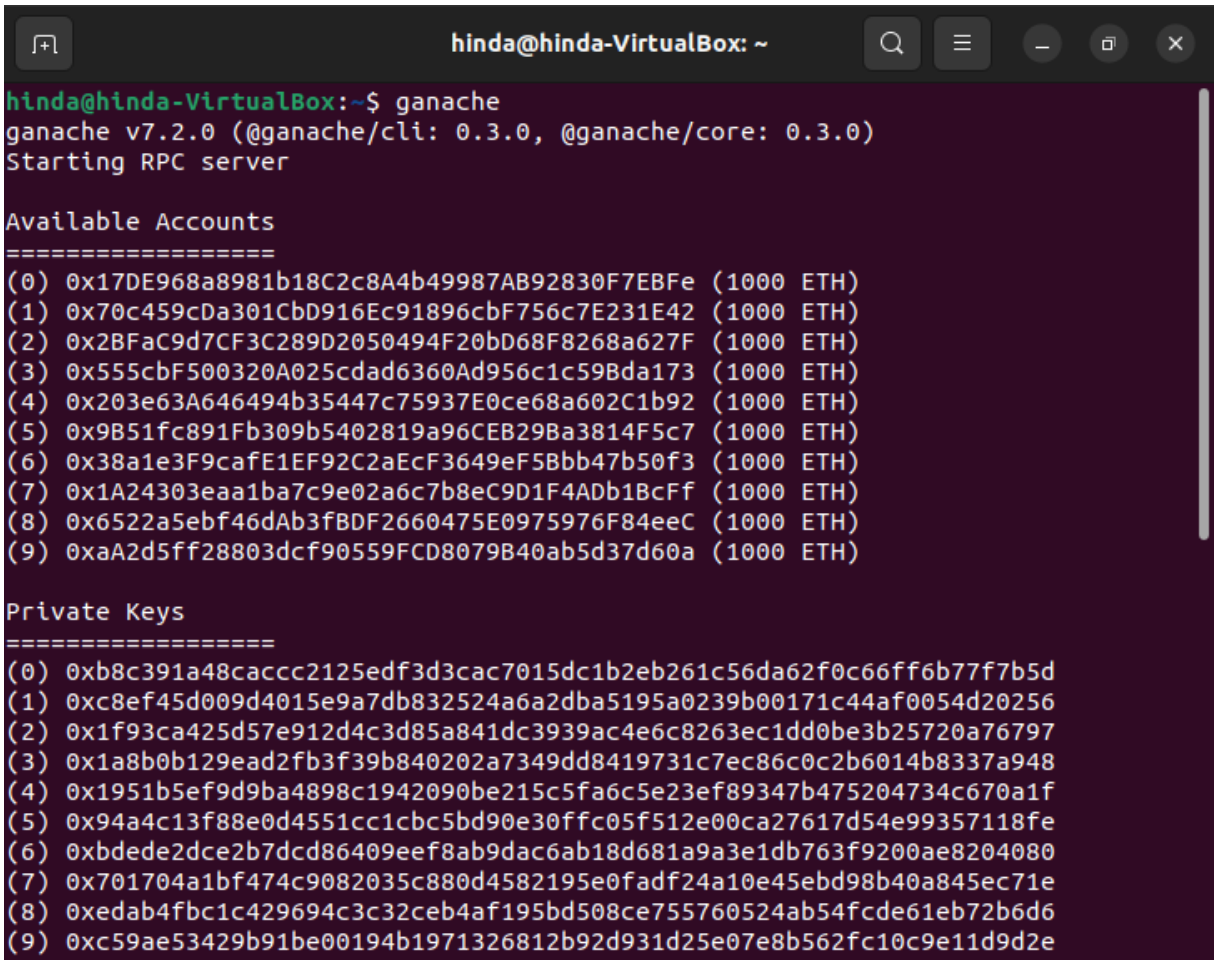

Figure 4.9: Runing ganache

Running Catrepiller

By entering a command **gulp** in terminal.figure 4.11

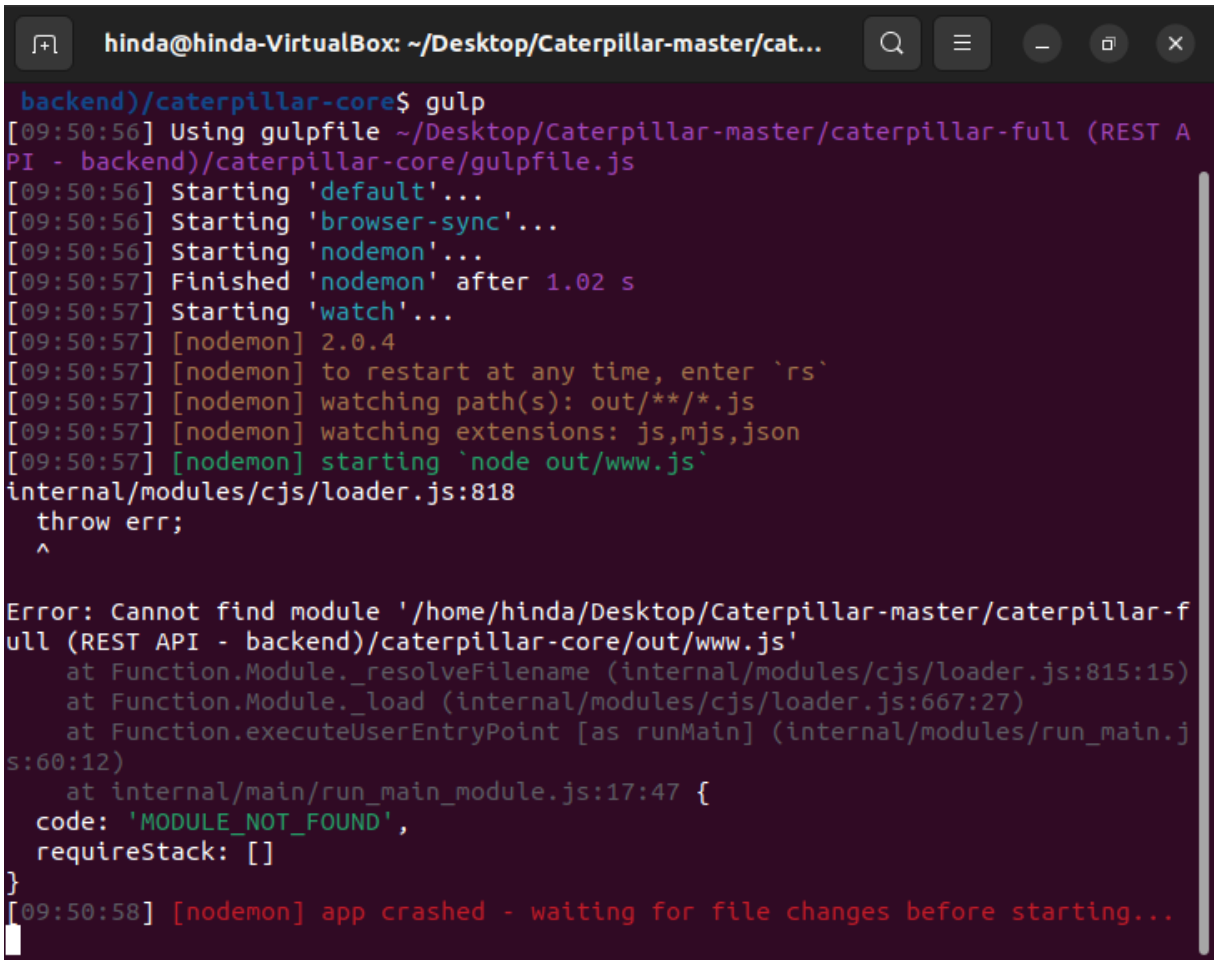

Figure 4.10: Runing Caterpiller

Unfortunately, we encountered some problems running it ,and we did not have enough time to search further, We will explain the steps that are after running the program:

After running command **gulp** By default the application runs on http://localhost:3000.

The application provides a REST API to interact with the core of Caterpillar. The following table summarizes the mapping of resource-related actions:

Verb	URI	Description
POST	/models	Registers a BPMN model (Triggers also code generation and compilation)
GET	/models	Retrieves the list of registered BPMN models
GET	/models/:mid	Retrieves a BPMN model and its compilation artifacts
POST	/models/:mid	Creates a new process instance from a given model
GET	/processes/	Retrieves the list of active process instances
GET	/processes/:pid	Retrieves the current state of a process instance
POST	/workitems/:wimid/:wiid	Checks-in a work item (i.e. user task)
POST	/workitems/:wimid/:evname	Forwards message event, delivered only if the event is enabled

Figure 4.11: Resource-related actions

From the caterpillar-core folder, it is possible to run the script:

node demo$_{r}unning_{e}xample_{t}est.js$

Which is provided only for the version v1.0, to register, create an instance and get the address of a sample process provided in the file demo-running-example.BPMN. For running the sampling process, it is also required to run first the application services manager and register the external services.

4.9 Results

- **The system facilitated the conduct of the Ph.D. competition for the university and the participants in the competition.**
- **The system minimized the effects of not having documentation of the actions to be taken.**
- **The system uses some of the activities and procedures implemented by the university administration in the doctoral competition in an accurate and easy-to-learn manner.**

4.10 conclusion

In this study, work was done on a system that organizes the doctoral competition using the Bonitasoft program. Among the difficulties that have been encountered is the continuous development of this program, where many things are changed in it, which makes you feel like you are using it for the first time. Caterpillar, converts the system into a blockchain, but we were unable to use it due to the scarcity of its resources and its many problems. And time is not in our favor, and it needs a deep study.

Conclusion

4.11 General conclusion

This research provided a detailed explanation of the application of blockchain technology in digital Transformation access by converting BPMN to a blockchain. During my research, I relied on the example of a Ph.D. competition in universities to prove to you that blockchain technology is not limited to digital currencies only, but rather it is a technology that can be adopted in companies and government institutions as well.

After reading this research, we will have a comprehensive knowledge of how institutions work and how they apply the digital transformation. Suppose we are the owner of an institution or we have the intention of forming our institution. In that case, this research will help us understand many points to form an institution compatible with digital transformation. I would also like to clarify that the technology of The blockchain is still in its infancy, and this is what makes its continuous development, so my research can be developed at any time.

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