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جامعة مولاي الطاهر، سعيدة
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Project title: project evaluation using Monte Carlo simulation case study: a platform for exchanging items using AI

LOGO of project	Brand Name
Bedeli	**Bedel-i**

Presented by:

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Thank you to everyone the teachers who taught us and the administrators

we thank everyone who helped me directly or indirectly with a gesture, a word or

Wise advice.

Thank you all….

Houari Ines

Abidi Maissa

Abstract:

In light of the economic challenges and the desire to enhance sustainability, this research presents an integrated study of the Bedel-i digital platform project for the exchange of traditional and ceremonial gowns and dresses, focusing on two main aspects: the technical aspect related to the design and development of the platform, and the financial aspect, which is based on evaluating the feasibility of the project using advanced quantitative methodologies

Where the technical part represents the technical side of the platform Bedel-i was developed using modern web technologies such as HTML and PHP to build interfaces and core functions, while integrating AI algorithms with Python to create a smart recommendation system. This system is based on product similarity analysis to provide personalized suggestions to users, which improves the exchange experience and increases its efficiency. The basic idea is to enable users to exchange traditional and ceremonial gowns and dresses and luxury clothing that are mostly disposable, reducing waste and promoting the concept of a 'circular economy

From the financial side, the feasibility of the project was evaluated using the Monte Carlo simulation method, which is considered one of the effective quantitative tools in analyzing projects under conditions of uncertainty and risk. The simulation results showed that the project has a high profitability rate, which confirms the high economic feasibility of the project and its ability to succeed in the market

Keywords: artificial intelligence, recommendation system, web development, similarity calculation, commodity exchange platform, Monte Carlo simulation, project evaluation, net present value, risk and uncertainty,Decision Making

الملخص:

في ظل التحديات الاقتصادية والرغبة في تعزيز الاستدامة، تقدم هذه الدراسة عرضًا متكاملًا لمشروع المنصة الرقمية "بدلي "لتبادل الفساتين التقليدية والاحتفالية، مع التركيز على جانبين رئيسيين: الجانب التقني المتعلق بتصميم وتطوير المنصة، والجانب المالي القائم على تقييم جدوى المشروع باستخدام منهجيات كمية متقدمة.

يمثل الجزء التقني البنية الفنية للمنصة، حيث تم تطوير "بدلي" باستخدام تقنيات الويب الحديثة مثل HTMLو PHPلبناء الواجهات والوظائف الأساسية، مع دمج خوارزميات الذكاء الاصطناعي بلغة Pythonلإنشاء نظام توصية ذكي. يعتمد هذا النظام على حساب التشابه بين المنتجات لتقديم اقتراحات مخصصة للمستخدمين، مما يُحسن تجربة التبادل ويزيد من فعاليتها. وتقوم الفكرة الأساسية على تمكين المستخدمين من تبادل فساتين الأعراس والملابس الفاخرة التي غالبًا ما تُستخدم مرة واحدة فقط، مما يُقلل من النفايات ويُعزز مفهوم "الاقتصاد الدائري."

أما من الجانب المالي، فقد تم تقييم جدوى المشروع باستخدام طريقة محاكاة مونت كارلو، التي تُعد من الأدوات الكمية الفعالة لتحليل المشاريع في ظل ظروف عدم اليقين والمخاطرة. وأظهرت نتائج المحاكاة أن المشروع يتمتع بنسبة ربحية مرتفعة، مما يُؤكد الجدوى الاقتصادية العالية له وقدرته على النجاح في السوق.

الكلمات المفتاحية:

الذكاء الاصطناعي، نظام التوصية، تطوير الويب، حساب التشابه، منصة تبادل السلع، محاكاة مونت كارلو، تقييم المشروع، القيمة الحالية الصافية، المخاطر وعدم اليقين ,اتخاذ القرار

Résumé :

Face aux défis économiques et dans un souci de promouvoir la durabilité, cette recherche propose une étude intégrée du projet de plateforme numérique **« Badel-i »**, dédiée à l'échange de robes traditionnelles et cérémonielles. Elle met l'accent sur deux volets principaux : l'aspect technique relatif à la conception et au développement de la plateforme, et l'aspect financier basé sur l'évaluation de la faisabilité du projet à l'aide de méthodologies quantitatives avancées.

Sur le plan technique, « Badel-i » a été développée à l'aide de technologies web modernes telles que **HTML** et **PHP** pour la création des interfaces et des fonctions principales, en intégrant des algorithmes d'intelligence artificielle via **Python** afin de mettre en place un **système de recommandation intelligent**. Ce système repose sur le **calcul de similarité** entre les produits pour proposer des suggestions personnalisées aux utilisateurs, améliorant ainsi l'expérience d'échange et son efficacité. L'idée de base consiste à permettre aux utilisateurs d'échanger des robes de mariage et des vêtements de luxe généralement peu utilisés, réduisant ainsi les déchets et favorisant le concept d'**économie circulaire**.

Sur le plan financier, la faisabilité du projet a été évaluée en utilisant la méthode de **simulation de Monte Carlo**, l'un des outils quantitatifs les plus efficaces pour analyser les projets dans des conditions d'incertitude et de risque. Les résultats de la simulation ont montré que le projet présente un taux de rentabilité élevé, ce qui confirme sa forte viabilité économique et son potentiel de réussite sur le marché.

Mots-clés :

intelligence artificielle, système de recommandation, développement web, calcul de similarité, plateforme d'échange de biens, simulation de Monte Carlo, évaluation de projet, valeur actuelle nette, risque et incertitude, **Prise de décision**

Summary

Chapter Two:

Analysis and design of the Bedeli application

Chapter three:

Recommendation system development environment and application presentation

Chapter four:

Project Evaluation of the (trade name of the project Bedel-i)Wedding Dresses Exchange PLATFORM under Uncertainty Using Monte Carlo Simulation

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Introduction

Sustainability is no longer just an option in our time, but a necessary requirement to face a complex environmental and economic reality that requires non-traditional solutions. Many entrepreneurial initiatives are adopting innovative models that invest in digital technologies and artificial intelligence to deliver services that are based on efficiency, while reducing environmental impact.

Bedel-i is an entrepreneurial idea that seeks to transform the way society treats luxury limited-use clothing, such as wedding and event dresses. The project provides an electronic platform designed to facilitate the exchange of these clothes between individuals in a smart and organized manner, taking advantage of advanced recommendation algorithms that contribute to improving the matching between offers and requests.

This project is not limited to the technical aspect, but also includes a rigorous assessment of financial feasibility using quantitative analysis tools such as the Monte Carlo simulation, which allows measuring the probability of success in an uncertain environment.

In this memorandum, Bedel-i's project will be analyzed in two ways: technical, which reviews the architecture of the smart system used, and financial, based on the results of predictive computational models, with the aim of providing a comprehensive vision of the realism of the implementation of this initiative and its economic and social return. From the above, the problem can be raised in the main question : **How can Monte Carlo simulation be used as an advanced quantitative tool to assess financial feasibility and predict the risks of an AI-based digital platform for exchange?**

Research Significance:

The significance of this research lies in its contribution to the growing field of digital entrepreneurship, which combines technological innovation with environmental and economic sustainability. Through the case study of the "Bedel-i" platform, the research demonstrates how modern analytical tools such as Monte Carlo simulation can enhance strategic decision-making for startups operating in uncertain environments. Furthermore, the integration of artificial intelligence within a circular economy model provides valuable insights into scalable and responsible business practices in emerging markets.

Research Objectives:

1. To design and describe the technical architecture of a digital platform that uses artificial intelligence to facilitate the exchange.
2. To apply Monte Carlo simulation as a methodology for evaluating the financial feasibility of the project.
3. To analyze the potential risks and uncertainties related to user behavior, revenue variability, and operating costs.
4. To provide recommendations for improving the decision-making process for entrepreneurs adopting AI in sustainable digital business models.

5. To assess the contribution of this platform to environmental sustainability and consumer behavior change.

Initial Hypotheses:

- Monte Carlo simulation indicates that the platform can achieve **high profitability** (>90%) despite market uncertainty.
- The most influential variable on financial success is the number of active users, followed by the customer retention rate.
- Artificial intelligence enhances operational efficiency and reduces long-term costs.

Research Methodology:

This study adopts a **mixed-method approach** combining **descriptive analytical** and **quantitative probabilistic** methodologies:

1. **Descriptive Analytical Method:**

   This method is used to analyze the technical architecture of the "Bedel-i" platform. It includes an in-depth review of the technologies employed—HTML, PHP for the frontend and backend, and Python for implementing the AI-based recommendation engine. The analysis focuses on how these technologies are integrated to facilitate efficient and intelligent product exchange.

2. **Quantitative Probabilistic Method:**

   To assess the financial viability of the project, the study uses **Monte Carlo simulation**, a robust statistical tool for modeling risk and uncertainty. This simulation is applied to forecast the Net Present Value (NPV) of the project over a defined time horizon, accounting for possible fluctuations in key variables such as active users, revenues, and operational costs. By running thousands of iterations, this method provides a probability distribution of outcomes, enabling more informed strategic decisions.

3. **Tools and Software:**

   The financial simulations were carried out using **Microsoft Excel** and **MATLAB**, which provided the computational environment to apply Monte Carlo simulations effectively.

The project Definition

The project, named "Badel-i", is a web-based platform developed out of a desire to combine technology, sustainability, and social innovation. It aims to facilitate the exchange of women's traditional and ceremonial gowns, accessories, and other rarely used items in an innovative and efficient way. This initiative addresses a real issue faced by many women, especially those with limited income, due to the high cost of wedding dresses, which are often worn only once, making them an unnecessary financial burden The concept is based on empowering users to extend the life cycle of valuable but infrequently used products by promoting responsible and collaborative consumption through a circular economy model.

The platform targets women interested in sustainable fashion and offers an innovative solution that allows users to exchange dresses directly without the need for purchase or rental, thus fostering an interactive community based on trust and collaboration

Developed using modern web development technologies such as HTML and PHP for designing interfaces and building the platform’s core functionalities, and Python for implementing artificial intelligence algorithms, Badel-i integrates a smart recommendation system. This system analyzes product similarity to provide personalized suggestions, thus enhancing the exchange experience and better matching users' needs.

The exchange process begins with Person A registering and uploading a picture of the dress or item intended for exchange. Then, Person B browses the listed items and, if both parties express mutual interest, the exchange is confirmed with their consent. Person A sends the item to our designated office for inspection and verification, paying an agreed delivery fee. After verifying that the item matches the uploaded picture and meets quality standards, a service fee of 100 Algerian Dinars is charged as a commission for this mediation and verification service. The item is then shipped to Party B. The same procedure is applied to Party B to ensure a successful exchange for both sides.

Chapter One:

Theoretical Framework for Project Evaluation and Monte Carlo Simulation

1.Section One: Project Evaluation and Its Role in Decision-Making

1.1 Subsection One: Concepts and Methods of Project Evaluation

1.1.1 The Concept of a Project:

- **Association for Project Management (APM) Definition:**

  « A project is a set of interrelated, non-routine activities with defined start and end dates, executed by an individual or organization to achieve specific performance and objectives within cost, time, and quality constraints (MOUAYED EL FADL, 2005)

- **Project Management Institute (PMI) Definition:** A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists.

Examples of product include: Construction, financial statements or software. Think "tangible".

Examples of service include: Employee assistance program, comprehensive training program or claims service. Think "intangible".

Examples of result include: Documentation of an on-boarding process. Think "outcome".

A project charter is a link between the operation and the project. An operation has initiating, planning, executing, and monitoring and controlling process group, but the project has one more process group which is closing.

Projects have been with us from the beginning of the history. The pyramids and the Great Wall of China were, in their day, of roughly the same dimensions as the Apollo Project to send men to the moon. We use the term project frequently in our daily conversations. A husband, for example, may tell his wife, "My main project for this weekend is to straighten out the garage." Going hunting, building pyramids, and fixing faucets all share certain features that make the projects.

Projects are temporary. They are not an everyday business process and have definitive start dates and end dates (Global, 2024 ،16 SEPTEMBRE)

- **PMI Methodology:**

  A project is a temporary effort aimed at creating a unique product, service, or resuLT (Al-Muhimmed, 2017, p. 12)

- **International Organization for Standardization (ISO) Definition:**

  A project is a unique process consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve a specific objective according to

specified requirements, including time, cost, and resource constraints (SADIK, 2003, p. 45)

- Based on the above definitions, a comprehensive and concise definition can be derived: A project is a planned endeavor comprising a set of activities designed to achieve specific results within a defined budget and timeframe**.**

1.1.2 Concept of Evaluation

Evaluation, as a concept, refers to the analysis and review based on a systematic scientific approach aimed at providing an understanding of the studied subject to identify any positive or negative changes within it. Evaluation serves as the foundational basis for many scientific and research studies, including economic feasibility studies for projects and activities of various organizations, whether production or service-oriented. The primary objectives of evaluation are:

- Identifying all negative elements within the subject being evaluated.
- Identifying all positive elements desired by decision-makers.

Evaluation can pertain to a production or service project proposed for approval or establishment at a specific location. It may also address a particular issue being assessed in preparation for finding appropriate solutions. Evaluation is related to projects—whether production or service—that are associated with business organizations or individuals in one way or another. Therefore, the term "project evaluation" is adopted in this context, which involves analyzing the economic, social, industrial, and environmental realities of a project to identify all its negative and positive elements.

This process necessitates the adoption of a set of analytical tools and methods, with quantitative tools and methods—collectively known as quantitative methods—being among the most important. (Il-FadIl, 2005, pp. 13–14)

1.1.3. Types of Evaluation:

Two primary types of evaluation are utilized in projects

- Formative Evaluation: Conducted during the project's lifecycle, this type of evaluation provides information aimed at guiding corrective actions.
- Summative Evaluation: Summative evaluation is an assessment of the overall impact of a program or initiative, conducted at the end of the project. It is used to determine whether the project or program has met its intended objectives and goals, and to identify areas for improvement. Summative evaluation is often contrasted with formative evaluation, which is conducted throughout the project to monitor progress and make adjustments as necessary.

1.1.4. Project Evaluation Methods:

Decision-making is a complex process that doesn't occur in isolation. It considers the nature of the environment in which an organization operates or where a proposed project is to be established. Experts distinguish between environments characterized by risk and those that are

stable and certain. This environmental diversity stems from internal or external factors, necessitating the use of various quantitative methods. Accordingly, decisions are made under two types of environmental conditions: certainty and uncertainty.

Based on this, project evaluation methods are divided into two categories:

- Evaluation Methods for Investment Projects under Certainty:
- Evaluation Methods for Investment Projects under Uncertainty or Risk

1.2. Project Evaluation Methods under Certainty:

There are several criteria used to evaluate projects under conditions of certainty. Some take the time value of money into account, while others ignore the effect of time on cash flows. Therefore, we divide them into two categories:

- Project evaluation methods that ignore the time value of money (i.e., traditional methods)
- Proposal evaluation methods that consider the time value of money (i.e., dynamic methods)

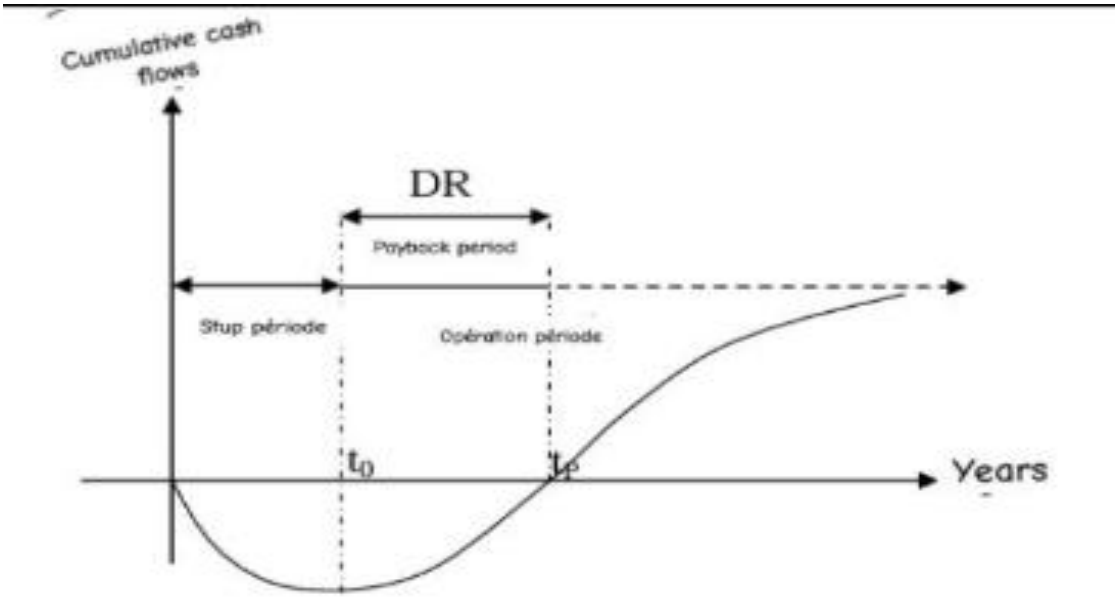
1.2.1. Traditional Methods:

1.2.1.1. Payback Period:

Concept of Payback Period: It is defined as the number of years required to recover the investment value, meaning the period it takes for the project to cover its initial costs. The objective is to make investment decisions, either accepting or rejecting the project, based on this time frame.

The payback method can be represented as follows**.**

Figure (1) : The curve represents the cash flows and the initial investment cost



Source : Damodaran, A. (2010), ***Applied Corporate Finance*** **(3rd ed.). Wiley**.

Decision Rule:

The decision rule is based on evaluating the project in two scenarios:

In the Case of a Single Project:

The decision to accept or reject a single project depends on the comparison between the project's payback period and the standard payback period.

- The project is accepted if the calculated payback period is shorter than the standard payback period.
- The project is rejected if the calculated payback period is longer than the standard payback period.

In the Case of Comparing Multiple Projects:

The project with the shortest payback period is accepted, or they are ranked according to preference. The arithmetic mean method can also be relied upon in case the annual cash flows are not equal.

- The payback period criterion varies depending on the net annual cash flows, which are divided into equal and unequal cash flows.

Case 1: Equal Net Annual Cash Flows

When the net annual cash flows of the project are equal throughout its economic life, the payback period is calculated as follows:

$$\textbf{The payback period} = \frac{\textbf{the investment cost of the project}}{\textbf{the net annual cash flows}}$$

Case 2 : of Unequal Net Cash Flows

In this case, the project's net cash flows vary from year to year throughout its economic life. The payback period is calculated by cumulatively adding the annual net cash flows until their total equals the initial investment cost of the project. At that point, the payback period is determined.

There are two possible scenarios:

- In the first scenario, the payback period occurs at the end of a specific year, in which case the payback period is that full year.

- In the second scenario, the payback period occurs between two years. In this case, the payback period is calculated using the following formula:

Payback Period = Number of full years before complete recovery + Remaining months during the final year

Remaining Months = (12 months / Net Cash Flow after Payback) × (Difference between the Investment Cost and the Last Accumulated Cash Flow before Payback)

Advantages and Disadvantages of Using the Payback Period Method:

First – Advantages of Using the Payback Period Method:

- The payback period method provides a quick and preliminary indication of whether a project is worth further study and investigation. It attempts to address the uncertainty problem by favoring projects that recover their capital as quickly as possible. This method is one of the most widely used due to its **simplicity and ease of calculation**.
- This criterion is particularly important for projects that involve **rapid technological advancements** and **technical progress**, which require quick decision-making. Therefore, such projects tend to prefer a shorter payback period.
- Additionally, this method is very relevant for businesses subject to **seasonal fluctuations**, as it helps in recovering the invested funds during a typical operating period. It is also crucial for companies experiencing **liquidity problems**, as they are highly interested in quickly recovering their invested capital in order to reinvest it in other areas.

Disadvantages of the Payback Period Method:

Despite its advantages, this method has been subject to various criticisms, which can be summarized as follows:

- One major criticism is that the **payback period method ignores the time value of money**, as it considers cash flows at their nominal value during the calculation. This can lead to misleading investment decisions.
- The payback period measures the **time required to recover the invested funds**, not the **profitability** of the investment. This conflicts with the main objective of most projects, which is to **maximize profitability**.

1.2.1.2. Accounting Rate of Return (ARR)

The concept of the Accounting Rate of Return is based on accounting profit. This method takes into account all expected profits over the useful life of the project to determine the average return on the invested capita (Dumont, (1995), p. 24)**.** l. It is called the "Accounting" Rate of Return because it relies on accounting data.

$$\textbf{Accounting Rate of Return (ARR)} = \left(\frac{\textbf{Average Annual Profi}}{\textbf{Initial Investment}}\right) \times \textbf{100}$$

Calculate the Accounting Rate of Return (ARR):

Divide the average annual profit by the initial investment and multiply the result by 100 to convert it into a percentage.

ARR = (Average Annual Profit / Initial Investment) × 100

Analyze the Results:

After calculating the Accounting Rate of Return, the result can be used to make an investment decision. If the ARR is high and exceeds the company's required rate of return, this suggests that the project may be financially viable. On the other hand, if the ARR is very low, it indicates that the project may not be financially worthwhile.

It is important to note that the ARR relies on certain estimates and assumptions, and it does not account for the time value of money. Therefore, ARR should be compared with other financial indicators and used as part of a broader investment analysis process.

Decision Rule:

If There Is Only One Project:

When evaluating a single project, the project's accounting rate of return (ARR) should be compared to a benchmark rate of return:

- If the project's ARR is **greater** than the benchmark rate, the project is **accepted**.
- If the project's ARR is **less** than the benchmark rate, the project is **rejected**.

If There Are Multiple Projects:

Projects are ranked and compared based on their nature, as follows:

- **Mutually Exclusive Projects**: Accept the project with the **highest accounting rate of return** and reject the others.
- **Independent Projects**: Rank the projects by preference, giving priority to those with the **highest accounting rate of return**.

Advantages and Disadvantages of the Accounting Rate of Return (ARR) Method

The ARR method has several advantages, the most important of which include:

- It is **simple to calculate** and **easy to understand**, with quick access to the data needed for its computation.
- It provides a **quick indication of a project's profitability**, and it takes into account the **residual value** of the project.

However, this method also has some disadvantages:

- It **does not consider the time value of money**, which can lead to less accurate evaluations.
- Due to **differences in accounting methods** used from one institution to another, the results obtained using this criterion can vary significantly.

1.2.2 .Modern Methods

Many criticisms have been directed at the traditional evaluation criteria; one of the most important is their failure to take into account the **time value of money**. Since a sound project evaluation process should not overlook this fact, it becomes necessary to adjust the project's cash flows—both outflows and inflows—as if they were spent or received **at the moment the investment decision is made**.

This is expressed through the **present value**, which indicates that **the value of one dinar today is greater than its value in the future**. The present value of an amount is calculated using the following formula:

Present Value Formula

Where: $$A = \frac{S}{(1 + I)^n}$$

- A: Present Value
- S: Future Amount
- I: Interest Rate (as a decimal)
- n: Time Period (in years)

The Time Value of Money (TVM):

The time value of money is the cornerstone of modern finance. In simple terms, it means that money has a time-based value; for example, $1,000 today is not equal to $1,000 one year from now. A rational person would prefer to receive $1,000 today rather than in the future.

This preference is explained by the potential to invest the $1,000 today at an interest rate of 10%, earning an additional $100 over the year. Thus, $1,000 today is equivalent to $1,100 in one year if the interest rate is 10% (mohammed, 2006, p. 20)

This demonstrates that the value of money varies depending on when it is received. Money received in the future is worth less than money received today due to several reasons, such as:

- The impact of the **discount rate** on the value of money.
- The **timing mismatch** between cash inflows and outflows, as cash flows typically extend over several years.

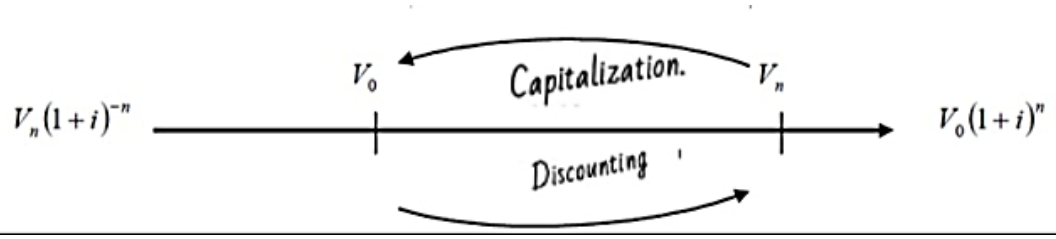
To overcome these issues, we **discount the expected future cash flows** of a project over its economic life back to **year zero**—the year of capital investment (Ehrhardt, 2016).

1.2.2.1.Net Present Value (NPV):

Net Present Value (NPV) Criterion:

The Net Present Value is defined as the difference between the present value of cash inflows and the invested capital. The present value of cash inflows refers to the amounts that will be received in the future, but whose value is known today — i.e., calculated based on the chosen discount rate at time zero.

Figure (2) :Relationship Between Present Value and Future Value Using Discounting and Capitalization



Source: Brealey, R. A., Myers, S. C., & Allen, F. (2020)*Principles of Corporate Finance* (13th ed.). McGraw-Hill Education.

NPV for future payments is calculated using a discount rate and is based on a simple idea:

The value of money today is greater than its value in the future.

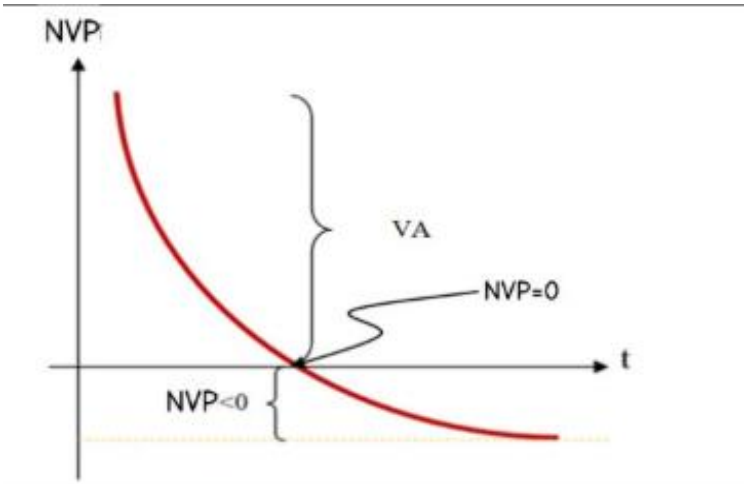
The NPV is calculated as follows: **NPV = ∑CFi=1…n (1+t) -i**

In the case of equal cash flows, the following formula is used:

Where: **NPV = CF [1-(1+t) -n) /t] -I0**

- **I0** : is the initial investment cost,
- **CF**: is the net cash flow,
- **R**: is the discount rate,
- **N** : is the project's useful life (production period).

Figure (3):NPV Sensitivity Curve with Respect to the Discount Rate"



Source : Brealey, R. A., Myers, S. C., & Allen, F. (2020). *Principles of Corporate Finance* (13th ed.). McGraw-Hill Education.

- If the NPV is **positive**, meaning the present value of incoming cash flows exceeds the present value of outgoing cash flows, then the investment project is considered **profitable**.
- Conversely, if the NPV is **negative**, the project is not profitable.
- When comparing a group of investment alternatives, the project that generates the **highest Net Present Value** should be selected.

Decision Rule:

- **First Case:** When the Net Present Value (NPV) is greater than zero, it means that the net cash flows cover the investment expenses and result in a surplus or profit. In this case, the project is accepted if it is being evaluated individually. However, if a comparison is being made between multiple projects, the one with the highest positive NPV is accepted.
- **Second Case:** When the Net Present Value equals zero, it means that the present value of net cash flows is equal to the investment expenditure, resulting in neither profit nor loss. Therefore, the investment is not accepted.
- **The third case**

  If you would like to present the three cases in a separate paragraph or summarize them in a table, I can assist you with that as well

Table (01) Advantages and disadvantages of the NPV method,

advantages of the Net Present Value (NPV)	**disadvantages of the NPV method**,
It accounts for the time value of money and considers changes in the value of annual revenue costs. (CHKIRI NOURI MOUSSA, 2016)	When projects have different investment durations, it becomes difficult to compare them, since naturally, the longer the investment duration, the higher the NPV. For this reason, the Net Present Value method is often complemented by time-weighted approaches.
It takes into consideration the cash gains generated by the project throughout its entire useful life.	It does not provide a proper ranking of projects when the initial investment values differ.
It is preferred when cash flows alternate between positive and negative values.	It requires determining an appropriate discount rate in advance
It reflects the value of the investment decision using a discount rate that represents the cost of capital or the cost of funds.	

Source: Prepared by the author.

1.2.2.2. Profitability Index (PI):

Also known as the Benefit-Cost Ratio, the Profitability Index is a measure that evaluates or assesses the ability of an investment project to generate profit. It is the ratio of the net present value of cash inflows to the initial costs of the project. This index reflects the relationship between the total present value of cash inflows and the total present value of cash outflows. (ABD ALSETAR MOHAMMED ALI, 1987)

formula $$IP=1+(NPV/I_{\circ})$$

Applying this criterion results in three possible cases:

- If the Profitability Index is greater than one, it means the project is profitable and financially viable, and therefore, it is accepted.
- If the Profitability Index is less than one, it means the project is not profitable and has no financial viability, thus it is rejected.
- If the Profitability Index equals one, it means the project neither gains nor loses profit, so it has no financial viability, and the decision is to reject it.

1.2.2.3Internal Rate of Return (IRR):

Definition of the Internal Rate of Return:

The internal rate of return (IRR) is defined as the discount rate that makes the net present value (NPV) of an investment equal to zero. In other words, it is the rate at which the present value of expected cash inflows equals the initial investment cost at the beginning of the period. This criterion is based on the concept of finding the discount rate at which the present value of investment costs equals the present value of future cash inflows over the project's lifespan. The higher the discount rate, the lower the NPV, and vice versa. (Boughba, 1998)

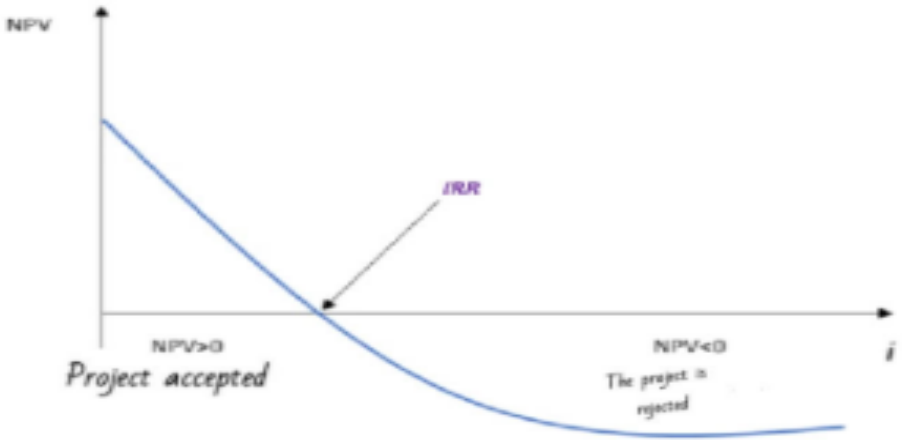
The IRR is considered one of the most important criteria used to compare different investment projects. It is currently used by the World Bank in all types of financial and economic analyses of projects. It is also adopted by most international financial institutions when deciding whether to accept or reject projects submitted for funding.

Decision Rule:

The internal rate of return represents the maximum rate of return an investor can earn, and it leads to the following cases:

- **If the IRR equals the minimum required rate of return**, the investment project yields neither a profit nor a loss; therefore, the project is **rejected**.
- **If the IRR is less than the minimum required rate of return**, the investment project incurs a **loss** because the discount rate exceeds the IRR, leading to a deterioration in the institution's overall profitability. Thus, the project is **rejected**.
- **If the IRR is greater than the minimum required rate of return**, the investment project yields a **profit**, as the internal rate of return exceeds the discount rate. Hence, the proposed project is **accepted** for implementation

Figure (04): The Relationship Between a Project's Net Present Value (NPV) and Internal Rate of Return (IRR)



Source: Nathalie Taverdet, Popiolek, 2006, Investment Decision Guide, EYROLLES Group edition.

The net present value (NPV) is considered the benchmark criterion for comparing investment projects. While the internal rate of return (IRR) is not a suitable criterion for selecting between projects, it does help indicate whether a project is profitable by comparing the IRR of each project to the discount rate.

When comparing two investment alternatives, it is not always wise to select the one with the higher IRR. In practice, investment decisions often depend on different situations that require evaluating both the NPV and the IRR.

1.3.Methods for Project Evaluation Under Risk Conditions

Risk is considered one of the most critical issues that significantly impact projects. Therefore, it is essential to understand and define the concept of "risk" scientifically, as increasing risk may turn into a major problem.

1.3.1.Definition of Risk:

Risk is anything that can potentially cause harm, such as exposed electrical wires, hazardous chemicals, high places, noise, electrical regulations, work pressure, and similar hazards. In the context of business, *risk* is a term used to describe and clarify the causal relationship that may lead to loss or injury. Risk is any situation with the potential to cause harm. For instance, work pressure in a company is considered a risk that can lead to employee fatigue and stress.

1.3.2.Definition of Risk Exposure (Uncertainty):

Risk exposure can be defined as the probability of an event occurring or damage resulting from exposure to risk. In project management, it refers to uncertain events that could have a positive or negative impact on one or more project objectives—such as scope, schedule, cost, or quality—if they occur.

1.3.3.Difference Between Risk and Risk Exposure:

The terms *risk* and *risk exposure* are often confused, though they are different. Risk is the cause or source of potential harm, while risk exposure is the likelihood of that harm occurring due to exposure to the risk.
For example, working from a high place, such as cleaning skyscraper windows, represents a risk; the chance of falling while performing the cleaning task is the risk exposure.

All Projects Are Exposed to Risk:

However, through practical analysis, we can categorize and identify these risks more accurately as follows:

- Some risks are simple and fade away without affecting the project’s progress.
- Some risks escalate into problems with broader impacts and require a remediation plan.
- A portion of unmanaged risks may develop into crises that threaten the entire project.

The purpose of risk management is to ensure that the third type of risk (potential crises) can be completely avoided through proper planning by the risk management team.

1.3.4.Criteria for Evaluating Investment Projects Under Risk Conditions

Risk conditions can be defined as situations in which it is possible to estimate certain probabilities for random events related to the future. The main criteria used under such conditions are:

- Expected Value (E(X))
- Standard Deviation (δ)

These criteria are calculated for the previous evaluation indicators based on given probabilities.

Criterion E(x): The Role of Expected Value in Project Evaluation

The **expected value** (E(x)) allows for the mathematical evaluation of a project's profitability. It involves calculating the expected values for both the Net Present Value (NPV or VAN) and the Profitability Index (PI or IP) under conditions of uncertainty.

1.3.4.1.Expected Net Present Value – E(VAN)

The expected value of the NPV (E(VAN)) refers to the anticipated value of a project's net present value, based on future scenarios each assigned a certain probability. The calculation steps are as follows:

1. Identify the possible future scenarios, usually categorized as:
    - Optimistic scenario
    - Most likely (moderate) scenario
    - Pessimistic scenario
2. Assign a probability to each scenario, ensuring that the total adds up to 1.
3. Determine the net present value (NPV) for each scenario.
4. Calculate the expected value by multiplying each scenario's NPV by its probability, summing the results, and subtracting the initial investment (I):

$$E(NPV) = \sum(NPV \times P) - I$$

Note: If the available data includes only the probabilities of different NPV outcomes (rather than the expected cash flows), the expected NPV can be calculated directly by multiplying each possible NPV by its probability and summing the products**.**

Decision Rule Based on E(VAN)

There are two cases:

Case 1: Single Project

- Accept the project if E(NPV)>0
- Reject the project if E(NPV)<0

Case 2: Multiple Projects

- Select the project with the highest expected NPV.

1.3.4.2.Standard Deviation as a Decision Criterion (δ)

The standard deviation is a measure of dispersion. In project evaluation, it is used to assess the degree of variability of a project's returns from their expected value. In this context, the standard deviation can be calculated for both the Net Present Value (δ(NPV)) and the Profitability Index (δ(PI)).

Standard Deviation of the Net Present Value (δ(NPV))

The standard deviation of the Net Present Value refers to the degree of fluctuation in the expected returns from investments. The greater the variation in future returns, the higher the risk.

Steps to Calculate δ(NPV):
- Calculate the expected value of NPV, E(NPV), and square it.
- Calculate the expected value of squared NPV, $E(NPV^2)$.
- Determine the variance using:
  Variance = $E(NPV^2) - (E(NPV))^2$
- Calculate the standard deviation by taking the square root of the variance.

Illustrative Formula:

$$\delta(NPV) = \sqrt{[\ E(NPV^2) - (E(NPV))^2\ ]}$$

Decision Rule for δ(NPV):
- If the investor is risk-seeking, they may choose the project with the higher standard deviation, since it implies greater potential for high returns.
- If the investor is risk-averse, they will prefer the project with the lower standard deviation, as it indicates lower risk.

Standard Deviation of the Profitability Index (δ(PI))

The standard deviation of the Profitability Index indicates how much the project's PI deviates from its expected value.

Steps to Calculate δ(PI):

- Compute the expected value E(PI) and square it.

- Compute the expected value of PI^2, denoted $E(PI^2)$.

- Use the variance formula:

  Variance = $E(PI^2) - (E(PI))^2$

- Find the standard deviation by taking the square root of the variance.

Illustrative Formula:

$$\delta(PI) = \sqrt{[\ E(PI^2) - (E(PI))^2\ ]}$$

Decision Rule for δ(PI):

- If the investor is not afraid of risk, they may select the project with the higher δ(PI) to pursue a potentially higher profitability index.

- If the investor is risk-averse, they will favor the project with the lower δ(PI), even if it means accepting a lower profitability index.

Table(2): Relationship Between Risk Preference and Standard Deviation

Investor Type	Decision Criteria	Project Chosen
Risk-Seeking	Highest standard deviation	High potential returns
Risk-Averse	Lowest standard deviation	Lower risk

Source **: Prepared by the Student**

1.4.Project Evaluation under Uncertainty

The state of uncertainty refers to natural situations in which future events cannot be predicted and which significantly affect project evaluation and, consequently, decision-making. Under such conditions, it is impossible to forecast probability distributions. Therefore, subjective judgment by the decision-maker is used, which depends on their insight and expectations about the future — whether they are optimistic or pessimistic.

The main difference between risk conditions and uncertainty conditions lies in the way probability distributions of cash flows are established. Under risk conditions, estimates are based on objective probabilities derived from frequency or historical data. In contrast, under uncertainty conditions, estimates are based on the personal judgment of the decision-maker.

There are several models used to handle uncertainty, including:

- Sensitivity Analysis
- Scenario Analysis
- Game Theory and Decision Tree

and others that we will now explore.

1.4.1.Sensitivity Analysis

Sensitivity analysis refers to assessing how the proposed project responds to changes in one or more of the variables or factors used in its evaluation — that is, how sensitive the project is to changes in the various elements that influence it (salam, Economic Feasibility Studies and Project Evaluation., 1998, p. 193) .

In other words, this technique is used to measure the impact of changes on the main components of both the cash inflows and cash outflows, and thus determine the final effects on the net cash flows throughout the project's lifetime.

The decision-maker can determine how sensitive the project's returns are to possible variations in the value of any given variable. If the Net Present Value (NPV) or the Internal Rate of Return (IRR) is significantly affected, this suggests that the project is highly sensitive to uncertainty (salam, Economic Feasibility Studies and Project Evaluation, 1998, pp. 181,182)

Key Considerations When Applying Sensitivity Analysis: (touhami, 1981, p. 235)

- Identify the main variables that significantly affect the evaluation criterion or criteria.

- Compute the evaluation indicators under conditions of uncertainty.

- Focus on estimating the most optimistic and most pessimistic values for specific key variables rather than exploring all possible probabilities.

Typical Questions a Decision-Maker Might Ask:

- What happens if the unit selling price decreases?

- What is the expected outcome in the base case?

- What happens if the variable cost per unit increases beyond expectations?

- What happens if the initial investment cost exceeds the anticipated estimate?

Key Variables Affecting Sensitivity Analysis

The variables that influence the project and can be used in conducting sensitivity analysis include:

1. Various cash outflows (e.g., fixed costs, operating costs, initial investment).

2. Various cash inflows (e.g., revenue from sales, additional income).

3. Factors affecting both inflows and outflows, such as:

   - Environmental changes

   - Global economic shifts

   - Exchange rate fluctuations

   - Inflation and regulatory changes

Sensitivity Index Formula:

The sensitivity index for any element is calculated as:

Sensitivity Index = Change in the evaluation criterion / Relative change in the influencing factor

Where the relative change in the influencing factor is calculated as:

Relative Change = (New value - Original value) / Original value

The higher the sensitivity index, the more sensitive the chosen evaluation criterion is to changes in that element — and consequently, the greater the risk level in the project.

1.4.2. Scenario Analysis

Scenario Analysis is a process to ascertain and analyze possible events that can take place in the future. This is an important tool in the world of finance and economics, and is used extensively to make projections for the future. (web)

1.4.3.Game Theory:

The **Game Theory criterion** is used under **conditions of uncertainty**, where there is no reliable information to assign probabilities to future cash flows. In such cases, subjective but logical probabilities must be established, based on the reasoning of the decision-maker.

Game theory includes several classical and modern decision-making criteria, which are applied to assess and select among investment projects under uncertainty. These criteria include:

- Maximax Criterion (Optimistic Approach)
- Maximin Criterion or Wald's Criterion (Pessimistic Approach)
- Laplace Criterion (Equal Probability Assumption)
- Hurwicz Criterion (Coefficient of Optimism)
- Savage Criterion or Minimax Regret

Projects are ranked based on the chosen criterion and the specific conditions or preferences of the decision-maker.

1.4.3.1.Optimism Criterion – Maximum of Maximum Payoffs (Maximax)

This is the **criterion of the optimistic investor**, who is **risk-seeking** and prioritizes **profit over safety**. According to this approach, the investor chooses the project that provides the **highest economic value under the best possible conditions**.

The steps followed are:

- Identify the **maximum payoff** for each alternative (project).
- Select the highest of these maximum payoffs among all alternatives.
- Choose the investment project that achieves this maximum value.
- A **decision tree** is often drawn to represent the choices and outcomes.

1.4.3.2.Maximin Regret Criterion (Wald Criterion)

The Maximin regret criterion, also known as the Wald Criterion, reflects the mindset of a relatively cautious investor. It is used to minimize the potential regret an investor might feel for missing out on profits that could have been achieved had they chosen a different investment alternative.

In this case, it is necessary to construct a **regret matrix** by calculating the losses (regrets) associated with each alternative in each possible state of nature. These regrets are calculated by comparing the actual return of a given alternative with the **best possible return** that could have been achieved under the same scenario.

The decision is then made **based on the alternative that yields the least maximum regret** (i.e., the smallest of the worst regrets across all alternatives).

Regret Formula:

To compute the regret for each alternative under each state: regret =max(RJ)-Rig

Where:

- Rig: is the return of alternative in state
- max(RJ) : is the maximum return achievable in state

1.4.3.3.Laplace Criterion (Equal Probability Assumption

The Laplace Criterion, also known as the criterion of equal probabilities (khadija, p. 33), is a method used in decision-making under uncertainty, where no prior information is available about the probabilities of different outcomes. This criterion is attributed to the French mathematician Pierre-Simon Laplace, who made significant contributions to probability theory, especially through the Principle of Insufficient Reason. This principle states that in the absence of distinguishing information between possible outcomes, all outcomes should be assumed equally probable.

Steps for Applying the Laplace Criterion:

1. Identify possible states: Determine all possible states or scenarios that might occur.
2. Assume equal probabilities: Since there is no information about the probability of each state, assume all states are equally probable.
3. Calculate the expected return: For each alternative or option, calculate the expected return by summing all possible returns and dividing by the number of states.
4. Choose the optimal alternative: Select the alternative that yields the highest expected return**.**

Suitability of the Criterion:

The Laplace Criterion is suitable for investors who adopt a neutral stance towards risk, meaning they neither favor nor avoid risk. This criterion is used when there is a lack of information about the probabilities of different states, making it a useful tool under complete uncertainty.

1.4.3.4.Hurwicz Criterion

The Hurwicz Criterion is named after the American economist Leonid Hurwicz. It is also referred to as the Realism Criterion, as it represents a compromise between the optimism (Maximax) and pessimism (Maximin) criteria. According to this approach, the decision-maker does not solely adopt an optimistic or a pessimistic view of the future.

Main Idea

In this method, the decision-maker identifies the maximum and minimum possible outcomes (payoffs) for each alternative. Then, the expected value for each alternative is calculated using a weighted average, where a coefficient of optimism (α) is introduced.

The formula used is:

$$H = \alpha \times (\text{maximum payoff}) + (1 - \alpha) \times (\text{minimum payoff})$$

Where:
- α = coefficient of optimism (between 0 and 1)
- H = weighted expected payoff

The alternative with the highest value of H is selected.

1.4.3.5.Savage Criterion

This criterion is named after the American economist Leonard Jimmie Savage. It is also known as the Regret Criterion.

Main Idea

This approach is based on the principle that a decision-maker might choose an alternative that does not yield the best possible payoff, which leads to regret when comparing the result with what could have been obtained from other choices.

According to this criterion, a Regret Matrix is constructed by comparing each actual payoff to the best possible payoff in each state of nature. The decision-maker then selects the alternative with the smallest maximum regret.

Steps for Application

1. Identify the possible payoffs for each alternative under every state of nature.
2. Determine the best payoff for each state.
3. Calculate the regret for each alternative in each state: Regret = Best Payoff − Actual Payoff

4. Find the maximum regret for each alternative.
5. Select the alternative with the lowest maximum regret.

Objective

To minimize potential regret as much as possible—making a decision that leaves the decision-maker with the least amount of disappointment after execution.

1.4.3.6.A decision tree

is a flowchart-like structure in which each internal node represents a test on an attribute (e.g. whether a coin flip comes up heads or tails), each branch represents the outcome of the test, and each leaf node represents a class label (decision taken after computing all attributes). The paths from root to leaf represent classification rules.

In decision analysis, a decision tree and the closely related influence diagram are used as a visual and analytical decision support tool, where the expected values (or expected utility) of competing alternatives are calculated.

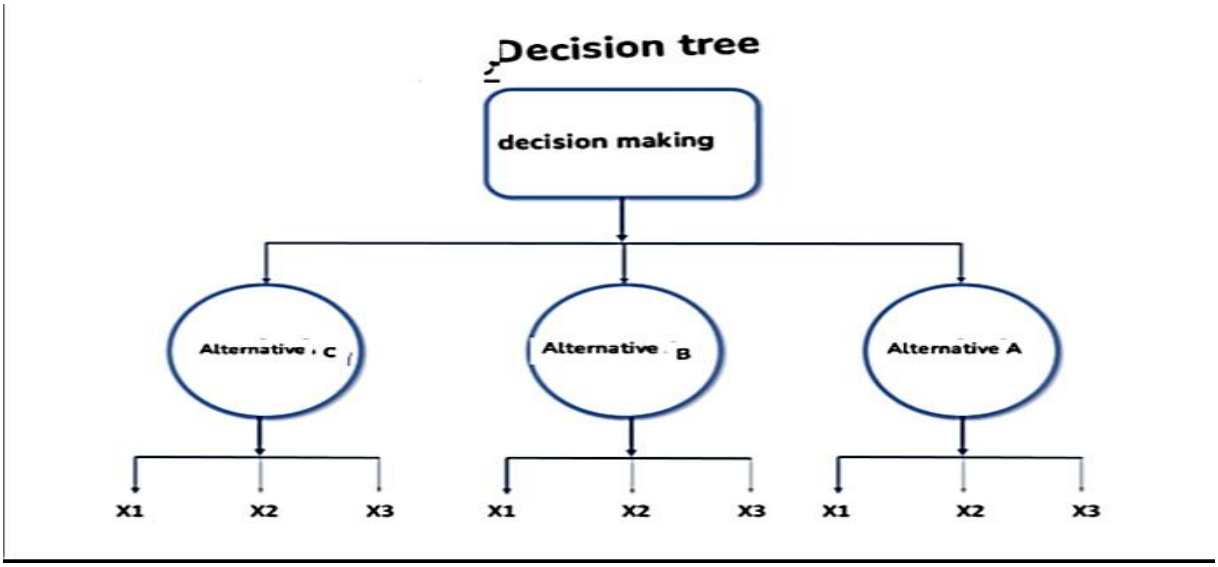
A decision tree consists of three types of nodes: (A framework for sensitivity analysis of decision tree, 2017)

1. Decision nodes – typically represented by squares
2. Chance nodes – typically represented by circles
3. End nodes – typically represented by triangles

Decision trees are commonly used in operations research and operations management. If, in practice, decisions have to be taken online with no recall under incomplete knowledge, a decision tree should be paralleled by a probability model as a best choice model or online selection model algorithm.] Another use of decision trees is as a descriptive means for calculating conditional probabilities.

Decision trees, influence diagrams, utility functions, and other decision analysis tools and methods are taught to undergraduate students in schools of business, health economics, and public health, and are examples of operations research or management science methods. These tools are also used to predict decisions of householders in normal and emergency scenarios

Figure (05) : DECISION TREE



Source: Robert Woudaier, 1989, Financial Evaluation of Projects Investment. Economica

2.Section Two: The Importance of Project Evaluation

2.1.Importance of Project Evaluation

Project evaluation means determining the optimal project among several other projects by calculating returns and comparing them with costs. Meanwhile, the term "economic feasibility study" refers to a set of studies, not just one, that cover all aspects of the environment, legal, marketing, technical, financial, commercial, and economic factors of the proposed project. It is a process of establishing the necessary criteria through which one can reach the appropriate alternative or project from several proposed alternatives that guarantee achieving specific goals based on practical foundations.

The importance of project evaluation can be attributed to two main factors:

1. **The first factor:** The scarcity of economic resources, especially capital, due to the diversity of fields and activities in which these resources can be used.
2. **The second factor:** Scientific and technological progress, which has provided many alternatives in the field of production means, production alternatives, or production methods, in addition to the rapid transfer of information through the communications and information revolution.

The importance of project evaluation continues as follows:

1. **Optimal specialization of economic resources:** labor, land, capital, technology, and their profitable use. Through project evaluation, unproductive projects that represent a waste of economic resources are filtered out.

2. **Ensuring the reduction of investment-related risks:** through the evaluation process, the degree of risk, certainty, and uncertainty is taken into account, thus excluding projects involving high risks.
3. **Determining the optimal structure of project costs** between fixed and variable costs.
4. **Determining the preferred production methods** used in the production process.
5. **Providing a source of information** for many local economic actors such as banks, and international ones such as the World Bank and the International Finance Corporation.
6. **Achieving the optimal use of available resources:** to do so, the project evaluation process must ensure the interconnected relationships between the proposed project and existing projects.
7. **Helping to reduce the level of risk** for invested funds.
8. **Helping to direct the investment funds** to the area that guarantees achieving the specified objectives.
9. **Helping to rationalize investment relations.**

2.2.Project comparison includes the following

1. Comparison between expanding existing projects or establishing new projects.
2. Comparison between producing certain types of goods.
3. Comparison between production methods to ultimately choose the appropriate method.
4. Comparison between projects based on specific goals for each project.
5. Comparison between alternative locations for the proposed projects.
6. Comparison between technological alternatives.

3. Section Three: Monte Carlo Simulation

The Monte Carlo simulation method is considered one of the techniques that can play a significant role in risk forecasting and prediction. Simulation is an approach used in analysis and risk management, involving the construction of a mathematical model that attempts to represent the real situation in reality. This model aims to incorporate important variables and their interrelated relationships in a way that enables the study of impactful managerial changes.

3.1.Section One: Concepts, Definitions, and Principles of Monte Carlo Simulation

3.1.1. Origins of Monte Carlo Simulation

The origin of Monte Carlo simulation can be traced back to the scientist and mathematician Stanisław Ulam, who was working on the Manhattan Project during World War II. Ulam developed this technique as a tool to solve complex statistical problems related to the design of nuclear bombs and to evaluate the probabilities of their success. The technique was named

"Monte Carlo" after the famous casino city of Monte Carlo, Monaco, where gambling and betting scenarios symbolized the potential outcomes of statistical experiments (McLeish, 2017, p. 03).

3.1.2. The Concept of Simulation Using the Monte Carlo Method

The definition of Monte Carlo simulation varies from one specialist to another. For example, Dmugoversh and Maron, in their book *Foundations of Computational Mathematics*, define it as solving mathematical and physical problems using repetitive random experiments. Meanwhile, Koveman and Kriyoun, in their book *Waiting Matrix and Its Applications*, mention that the Monte Carlo method is based on probabilistic laws and can therefore be described as a statistical experimentation method that expresses the simulation approach using samples. Instead of drawing samples from a real population, samples are drawn from a theoretical, identical population where the distribution is defined using random numbers as a basis.

- The Monte Carlo simulation technique allows the modeling of the behavior of studied systems as realistically as possible. However, its efficiency increases with the number of specific events. Hence, analytical methods and simulation are not interchangeable but rather complementary, with each being well-suited to specific types of problems. With the advancement of computers, evaluation problems increasingly require simulation.
- As we will see later, Monte Carlo simulation always provides a confidence level for the results obtained—something that is rarely the case with analytical methods, where it is often difficult, if not impossible, to assess the impact of the estimates made in reaching a particular result.

The Monte Carlo method is considered a numerical method that offers a non-deterministic algorithm to solve probabilistic problems. It uses random draws to estimate probabilities and represents a rich application of the law of large numbers. However, these methods tend to follow a specific pattern:

1. Define the input probability distribution.
2. Perform random draws from the probability distribution and apply probability calculations to them.
3. Aggregate the results of the various calculations to obtain the final outcome.

3.1.3. Components of the Monte Carlo Simulation

Monte Carlo analysis consists of input variables, output variables, and a mathematical model. A computer system feeds independent variables into a mathematical model, simulates them, and produces dependent variables.

1. **Input Variables:**

Input variables are random values that affect the outcome of the Monte Carlo simulation. For example, manufacturing quality and temperature are considered input variables that impact the

durability of a smartphone. Input variables can be expressed as a set of randomly sampled values. Therefore, Monte Carlo methods simulate outcomes using random input values.

2. **Output Variables:**

An output variable is the result of Monte Carlo analysis. For instance, the expected lifespan of an electronic device is an output variable, which might range from 6 months to 2 years. The Monte Carlo simulation software displays the output variable in a histogram or a graph that distributes the result across a continuous range on the horizontal axis.

3. **Mathematical Model:**

The mathematical model is an equation that describes the relationship between output variables and input variables in mathematical terms. For example, a profitability model may be expressed as:

Profit = Revenues – Expenses.

The Monte Carlo program replaces revenues and expenses with possible values based on the probability distribution type. It then repeats the simulation to obtain a highly accurate result.

3.1.4. Applications of the Monte Carlo Simulatio

There are **three main application areas** for the Monte Carlo method:

1. **Deterministic Non-Probabilistic Problems:**

   The Monte Carlo method can be applied to non-probabilistic problems. As previously mentioned, the first to use this technique in solving deterministic problems were the scientists **John von Neumann** and **Stanislaw Ulam** in the late 20th century.

2. **Model Sampling:**

   This refers to a sampling technique based on a random process to regenerate the nature of a probability distribution. It is done through multiple attempts that allow the estimation of the shape of the probability distribution, which is often difficult to define using traditional statistical methods. On this basis, **model sampling** utilizes the Monte Carlo method, also known as **random sampling from a probability distribution**.

3. **Simulation:**
   Most simulation studies rely on the use of random numbers. In principle, the simulation technique is used to solve both **probabilistic and non-probabilistic problems**, by selecting a random sample from a given probability distribution (Kroese, 2014)

3.1.5.Principle of Monte Carlo Simulation:

This principle involves replacing analytical computation with statistical computation by conducting a large number of trials using random number generation. Through simulating these random numbers, the studied system is explored in all possible directions. As the number of trials increases, events with the highest probabilities start to appear first. This enables obtaining a realistic picture of the likelihood of various scenarios occurring. This method provides a

deeper understanding of the behavior of complex systems without relying solely on analytical processing.

3.2. Building a Monte Carlo Simulation Model for Project Evaluation

The phase of building a simulation model aimed at project evaluation is considered one of the most crucial stages in simulation studies. This section clarifies its components as follows:

3.2.1. Nature of Variables and Factors Entering the Model

The key variables and factors influencing the value of an investment project can be divided into three primary groups:

- **Market Analysis Variables:** These variables can be combined to estimate specific influential factors affecting the investment project's revenue throughout its economic life. The most significant variables include market size, market growth rate, company market share, and sales prices.) Richard A. Brealey(2020 ،
- **Operating Cost Variables:** This group includes variable operating costs per unit and fixed annual operating costs.) Damodaran(2012 ،
- **Investment Cost Variables:** This category encompasses original and initial investment costs, depreciation of fixed assets, and the project's economic life. The first group relates to estimating internal cash flows (revenues), while the second and third relate to calculating external cash flows (investment and operating costs) (Rubinstein R. Y., 2017)

3.2.2. General Simulation Model for Investment Evaluation

The simulation model for evaluating investment projects consists of essential components and elements, detailed as follows:

- **Constants and Model Parameters:** These are input measures that decision-makers can specify and control during estimation. Such elements take the form of point estimates and remain constant throughout simulation cycles. Key parameters include depreciation rate, unit sale price, risk-free rate, and the number of simulation cycles.
- **External Variables:** These are stochastic variables that decision-makers cannot control or specify except through probabilistic distributions. Potential scenarios are defined along with their probabilities. Examples include market growth rate, initial market size, company market share, required initial investment, economic project life, and fixed and variable operating costs.
- **Internal Variables:** These represent outputs or performance variables, also called dependent variables. They describe and determine system operations and how effectively the system achieves various objectives under random events and conditions. While external variables are independent, internal variables are dependent. Examples include sales units generated by the project, total revenues, depreciation, total variable costs, net income after taxes, net cash flow, internal rate of return, and payback period during simulation cycles.

3.2.3.Advantages and Capabilities of Using the Monte Carlo Simulation Method in Project Evaluation

The Monte Carlo simulation method is considered one of the best quantitative techniques that can be used in evaluating investment projects. This is due to the numerous capabilities and advantages it offers in dealing with uncertainty, complexity, and the interdependencies among variables and factors affecting the value of the investment project. The advantages and capabilities of the Monte Carlo simulation method in project evaluation can be summarized as follows:

1. The Monte Carlo simulation method is characterized by its strong ability to handle complex problems. It possesses several features, such as the presence of many external variables whose values cannot be determined by a single fixed number but are estimated as variables that must be taken into account when making investment decisions. Based on this, the simulation method is used to express the relationships among these variables)Glasserman(2003 ،.

2. The Monte Carlo simulation method relies on probabilistic analysis to evaluate investment projects under conditions of uncertainty, which provides many benefits, including:
   a. The ability to utilize all available information regarding possible future conditions that affect the project's value, along with the probability of these values occurring.
   b. The method allows the incorporation of all relevant expert knowledge when evaluating the investment project, as it requires the participation of experts to prepare the necessary estimates to obtain the probability distribution for each element of the project's value.
   c. The method increases confidence in the estimates, since the project's planning is expressed as a probability distribution encompassing the various possible values the project can achieve. (Mun, 2015)

3. A strong aspect of this method is the way the model handles temporal correlations among variables. It can automatically consider these correlations during project evaluation, meaning that the estimated value of a particular element in one period depends on its value in previous periods.

4. The Monte Carlo simulation model acts as an analytical model of the project; it is like a management laboratory where experiments can be conducted and studied to explore the feasibility of performing these experiments under uncertainty.

5. Using the Monte Carlo simulation method in evaluating investment projects provides highly valuable information to management, as this information is based on balancing the expected return against the risks involved. The simulation method serves as a tool for balancing return and risk surrounding the investment project. (Kendrick, 2006)

6. Applying the Monte Carlo simulation method is relatively inexpensive compared to other techniques and methods used in project evaluation.

3.3. Monte Carlo Simulation: Conditions and Fundamentals

Monte Carlo Simulation is a technique that relies on random number generation to analyze complex systems that are difficult to handle using traditional analytical methods. This method is widely used in financial project evaluation, risk analysis, and engineering and natural sciences. To obtain accurate and reliable results from a Monte Carlo Simulation, certain application conditions must be observed, and a solid understanding of supporting mathematical and statistical principles is necessary.

3.3.1.Ergodic Conditions for Application

Ergodic conditions are fundamental requirements ensuring that the distribution of states visited by the system during simulation accurately reflects the true probabilistic distribution of the system at equilibrium. In other words, for a Monte Carlo Simulation to correctly represent system behavior, the system must be:

- **Ergodic:** The system must be able to reach every possible state in the state space, ensuring that time averages or averages over many trials approximate the theoretical probabilistic average) Dirk P. Kroese(2011 ،.
- **Long-term Stability:** The statistics derived from the simulation must stabilize after a sufficient number of trials, ensuring that the results are not influenced by initial conditions.

Meeting these conditions guarantees that the outcomes of the Monte Carlo Simulation are a faithful representation of reality.

3.3.2.Random Number Generation

Random number generation lies at the core of Monte Carlo Simulation, as the method depends on producing sequences of numbers that follow specific probability distributions (such as normal, exponential, or uniform distributions). These numbers are used to simulate the random variables of the system under study (Averill M. Law, 2015).

- **Random Number Generators:** Techniques such as Linear Congruential Generators are used to produce numbers that appear sufficiently random.
- **Quality Testing:** These generators must be tested to ensure the absence of patterns or repetitions that would hinder accurate simulation.

3.3.3.Law of Large Numbers

This law states that as the number of independent random experiments increases, the arithmetic mean of the obtained results converges to the expected value (theoretical mean).

This implies that increasing the number of repetitions in a Monte Carlo Simulation enhances the accuracy and reliability of results, as random errors from small sample sizes are minimized (Billingsley, 1995)

3.3.4.Central Limit Theorem

This theorem asserts that the sum or average of a large number of independent and identically distributed random variables tends to follow a normal distribution (Gaussian), regardless of the original distribution of the variables.

This allows the use of statistical techniques based on the normal distribution, such as confidence interval estimation and hypothesis testing, when analyzing the results of a Monte Carlo Simulation.

3.3.5.Other Key Fundamentals

- **Probability Distributions:** A suitable probability distribution must be assigned to each random variable in the model to accurately reflect real-world conditions.
- **Statistical Convergence:** It is essential to ensure that the results converge to a stable distribution (stationarity), meaning the statistics remain consistent as the simulation progresses.
- **Error Estimation:** The margin of error or standard deviation of the results should be calculated to assess their accuracy.
- **Computational Efficiency:** While increasing the number of simulations improves accuracy, it also requires more computational resources. Thus, balancing precision and computational time is crucial.
- Monte Carlo Simulation relies primarily on the principle of random generation and experiment repetition to analyze the behavior of complex systems. Conditions like ergodicity (Ergodic method) ensure that the results accurately represent reality. The method is supported by the Law of Large Numbers and the Central Limit Theorem, which ensure result accuracy and stability. These fundamentals, along with appropriate probability distribution modeling and statistical verification, make Monte Carlo Simulation a powerful and reliable tool for evaluation and risk analysis.

Summary of Chapter One

Chapter One highlights the significant importance of evaluating investment projects as a fundamental step in making well-informed and effective investment decisions. This process serves as a key tool for analyzing the feasibility of a project from various aspects, especially in environments characterized by uncertainty and risk. The chapter discusses different evaluation methods depending on the nature of the available information, as the adopted criteria vary between situations of complete certainty and those dominated by uncertainty. In this context, the **Monte Carlo simulation** method emerges as a powerful and effective mathematical tool for evaluating projects under risk. It achieves this by modeling various future scenarios based on the probabilistic distribution of influential variables, thus providing more accurate and comprehensive results that support decision-makers in adopting optimal choices.

Chapter Two:

Analysis and design of the Bedeli application

1. Introduction

Once the structure of the application framework is understood, this chapter introduces the idea of application analysis and design. The goal is to anticipate, identify, and gather system data to integrate into the article exchange process. We use UML (Unified Modeling Language) to illustrate diagrams, reduce uncertainty, and design applications (from an object-oriented perspective) using Modelio.

2. Unified Modeling Language (UML)

2.1 Definition:

UML stands for "Unified Modeling Language." It is a visual language made up of a set of diagrams, each providing a different view of the project. UML provides diagrams to represent the software being developed : its functioning, setup, possible actions, etc (Booch, G., Rumbaugh, J., & Jacobson, I. , 2005).

2.2 Advantages and Disadvantages of UML

Advantages :

- **UML is a formal and standardized language**: it ensures accuracy, encourages the use of tools, and offers stability.
- **UML is an effective communication tool:** it frames the analysis and facilitates understanding of complex abstract representations. Its versatility and flexibility make it a universal language.

Disadvantages :

- Using UML requires learning and adaptation.
- The process (not covered by UML) is another key to project success. Integrating UML into a process is not trivial, and improving a process is a complex and lengthy task.
- UML's creators are aware of the importance of process, but industrial acceptance of object modeling starts with the availability of an analysis language.

3. Modelio

Modelio, the successor to Objecteering, is a UML modeling software available for Windows and Linux. It also includes BPMN modeling, as well as support for modeling requirements, glossaries, business rules, and goals.

Modelio offers a range of tools, including MDA (Model Driven Architecture) support.It fully supports the UML 2.3 standard.

Modelio allows real-time accuracy checks on models using configurable consistency checks. It also facilitates sharing models with other tools through the XMI exchange format. (Arlow, J., & Neustadt, I. , 2005).

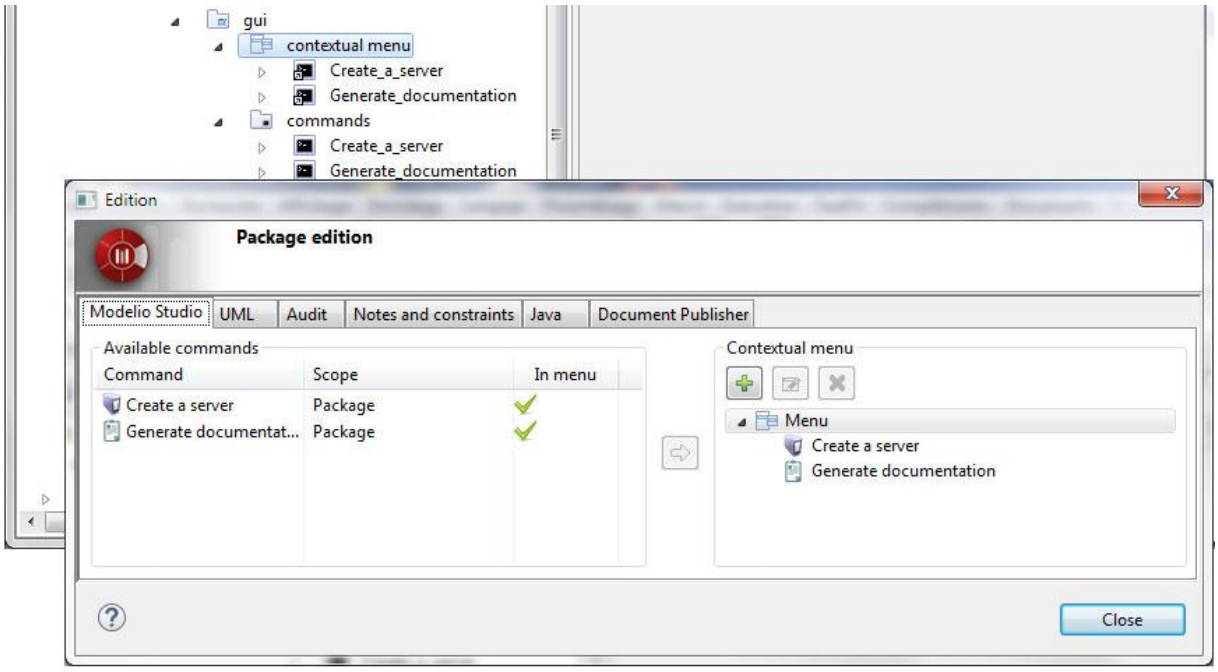


Figure 6: Modelio Modeling Software Window « Modelio »

4. Design of Our Application

4.1 Identifying Needs

Functional Requirements

These are the needs that lead to the development of use cases.

- Each user has a unique name, email address, and password to log in to the application.
- A database is required to store articles.
- Management and updating of the database.
- The administrator can add or delete data and manage users.

Non-Functional Requirements

These define the system's requirements for proper operation.

- Ensuring the security of user information by encrypting passwords.
- Role-based access (user or administrator).
- Exchanges should never be lost or deleted without validation.
- The interface must be user-friendly, clear, and intuitive — even for inexperienced users.

4.2 Needs Analysis

This section covers the functional analysis of our project. First, we identify the involved actors, then we specify the application's use cases.

Identification of Actors

Actors in the use case diagram include:

- ✓ **Website Administrator**: responsible for managing the application from design to maintenance.
- ✓ **Users**: registered users who are logged in.
- ✓ **Delivery Company**: oversees item exchanges between users at its office.

4.3 Use Case Identification

Use Case Diagram

Use case diagrams (UCDs) are UML diagrams used to represent a system's functional behavior. They're useful for presentations to stakeholders, though actual development relies more on detailed use cases. (Larman, C. , 2004).

Use Case Diagram « Admin »

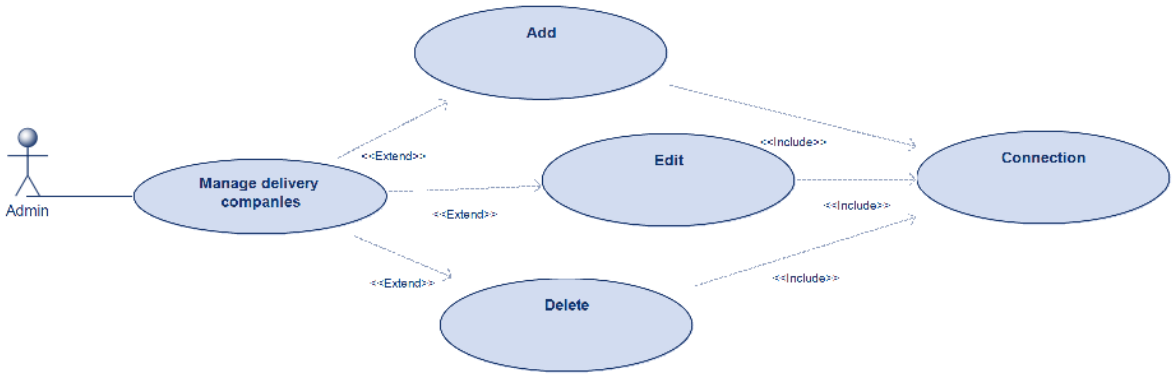


Figure 7: Use Case Diagram «Admin »

Use Case Diagram « User»

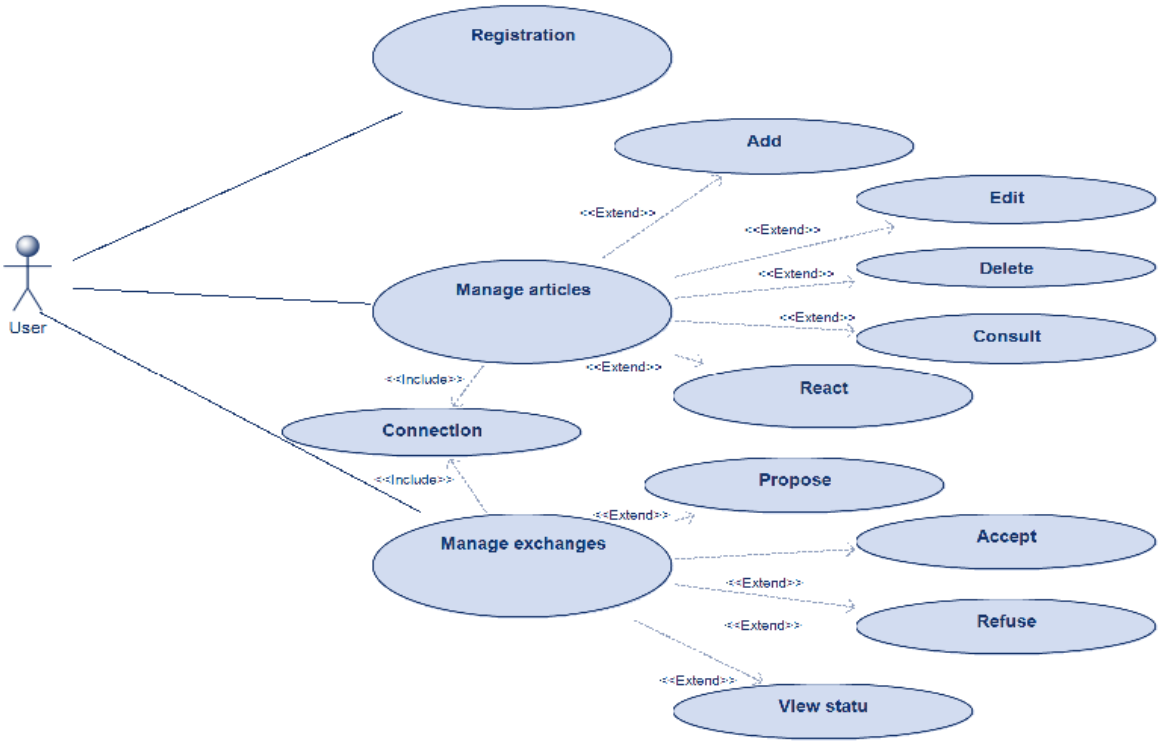


Figure 8: Use Case Diagram «User»

Use Case Diagram « Delivery Company»

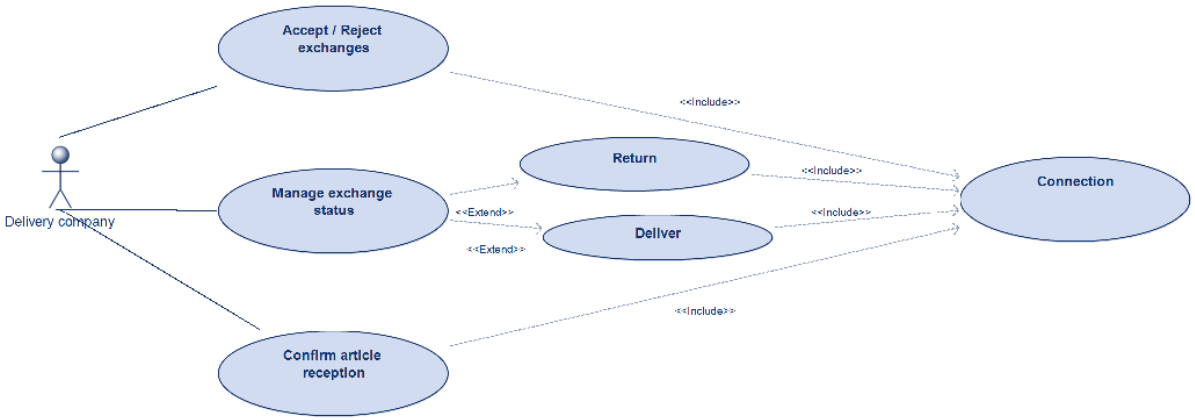


Figure 9: Use Case Diagram « Delivery Company»

Sequence Diagrams

The sequence diagram is a behavioral (dynamic) UML diagram that shows interactions between objects and actors over time. Unless the system is very simple, it's better to create multiple sequence diagrams for each sub-function, typically to illustrate a use case. (Fowler, M. , 2004)

Sequence Diagram « Registration»

Objective: Allow a new user to register on the website.

Pre-condition: The user does not yet have an account.

Post-condition: The user account is created.

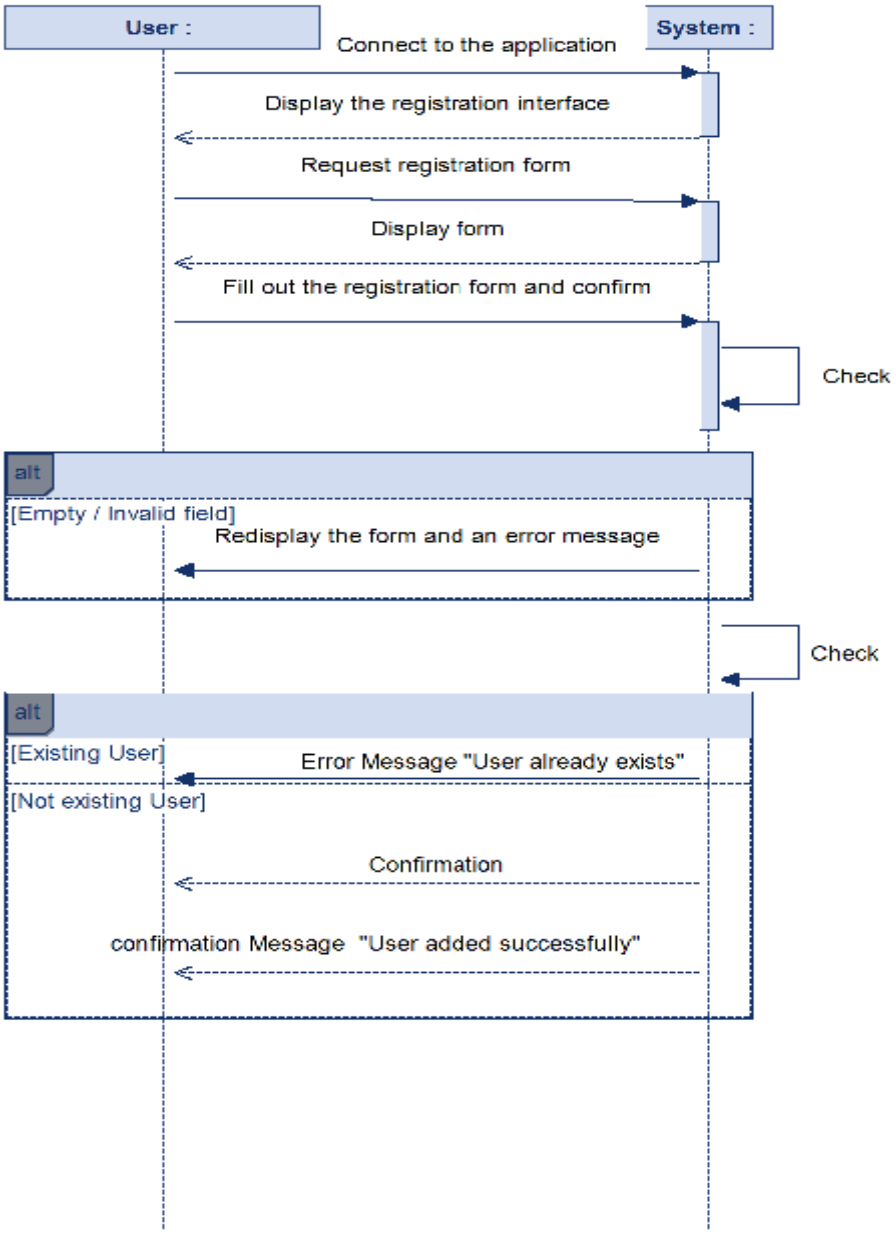


Figure 10: Sequence Diagram « Registration »

Sequence Diagram « Connection »

Objective: Allow a user to access the site.

Pre-condition: The user is already registered.

Post-condition : The user is directed to the homepage.

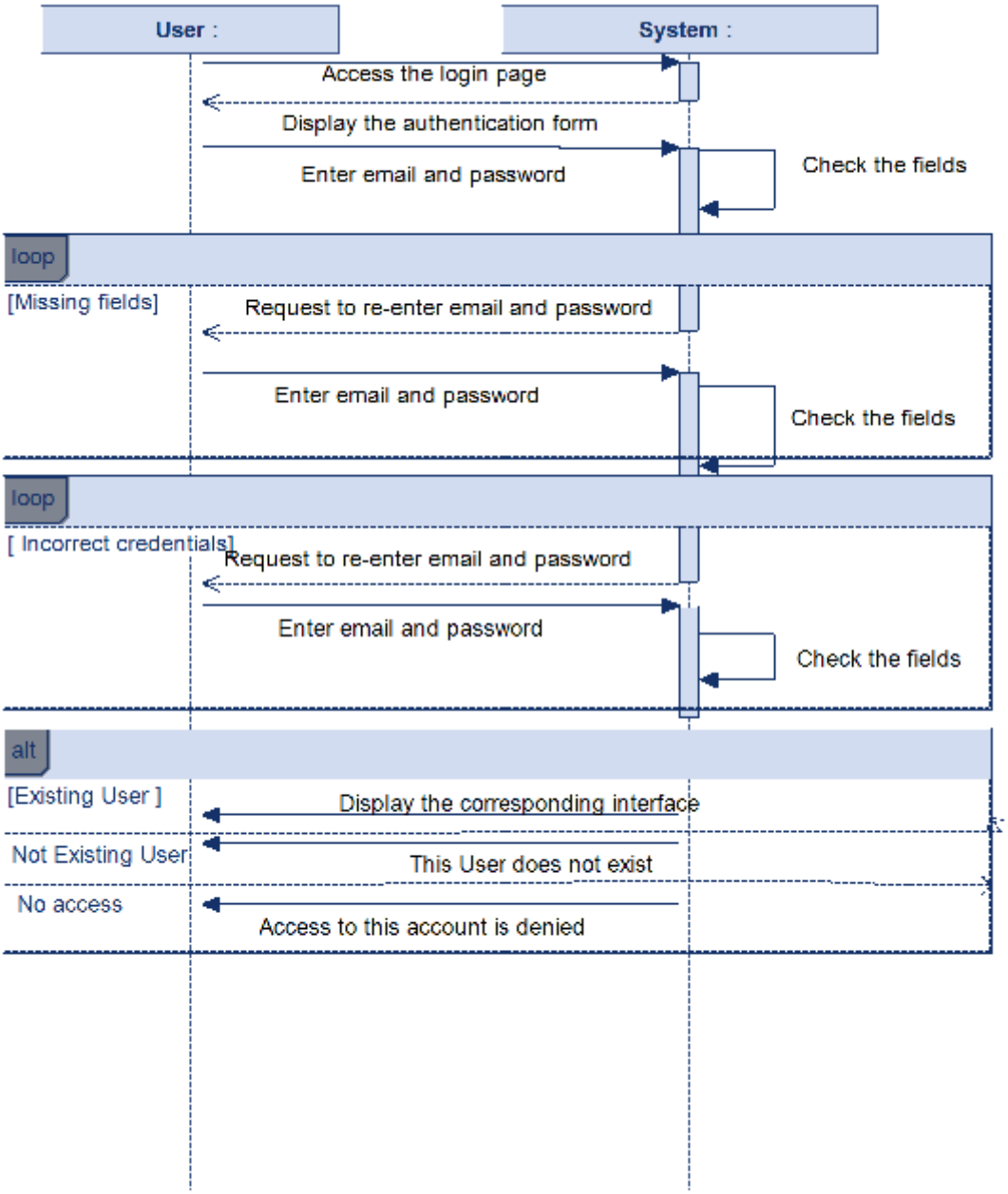


Figure 11: Sequence Diagram « Login »

Sequence Diagram « Add Article »

Objective: Allow a user to submit an article for exchange.

Pre-condition: The user is connected.

Post-condition: The article is saved and visible on their profile or the article list.

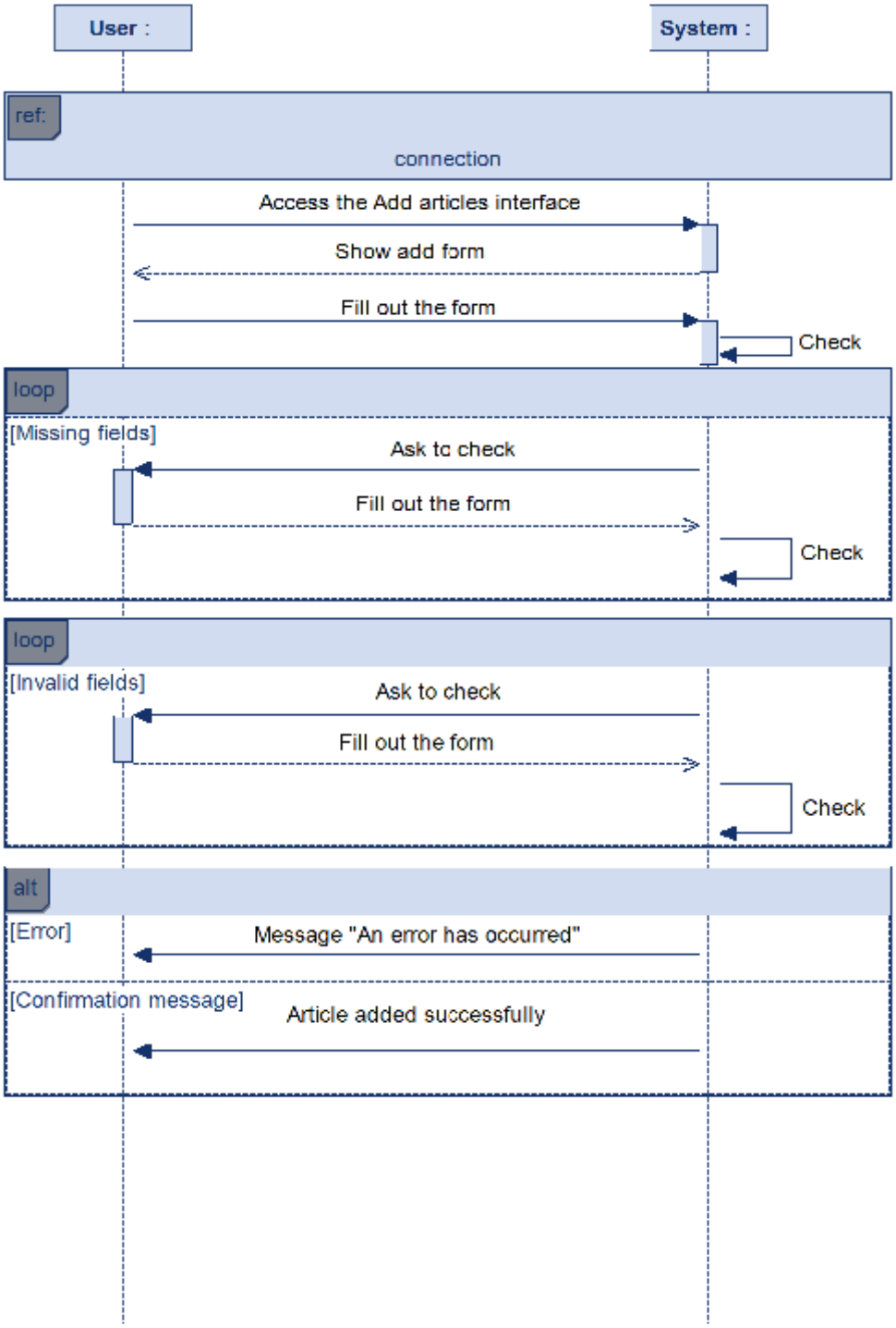


Figure 12: Sequence Diagram « Add Article »

Sequence Diagram « View Available Articles»

Objective: Allow the user to browse articles posted by others.

Pre-condition: Other users must have already uploaded articles.

Post-condition: A selection of articles with descriptions is displayed.

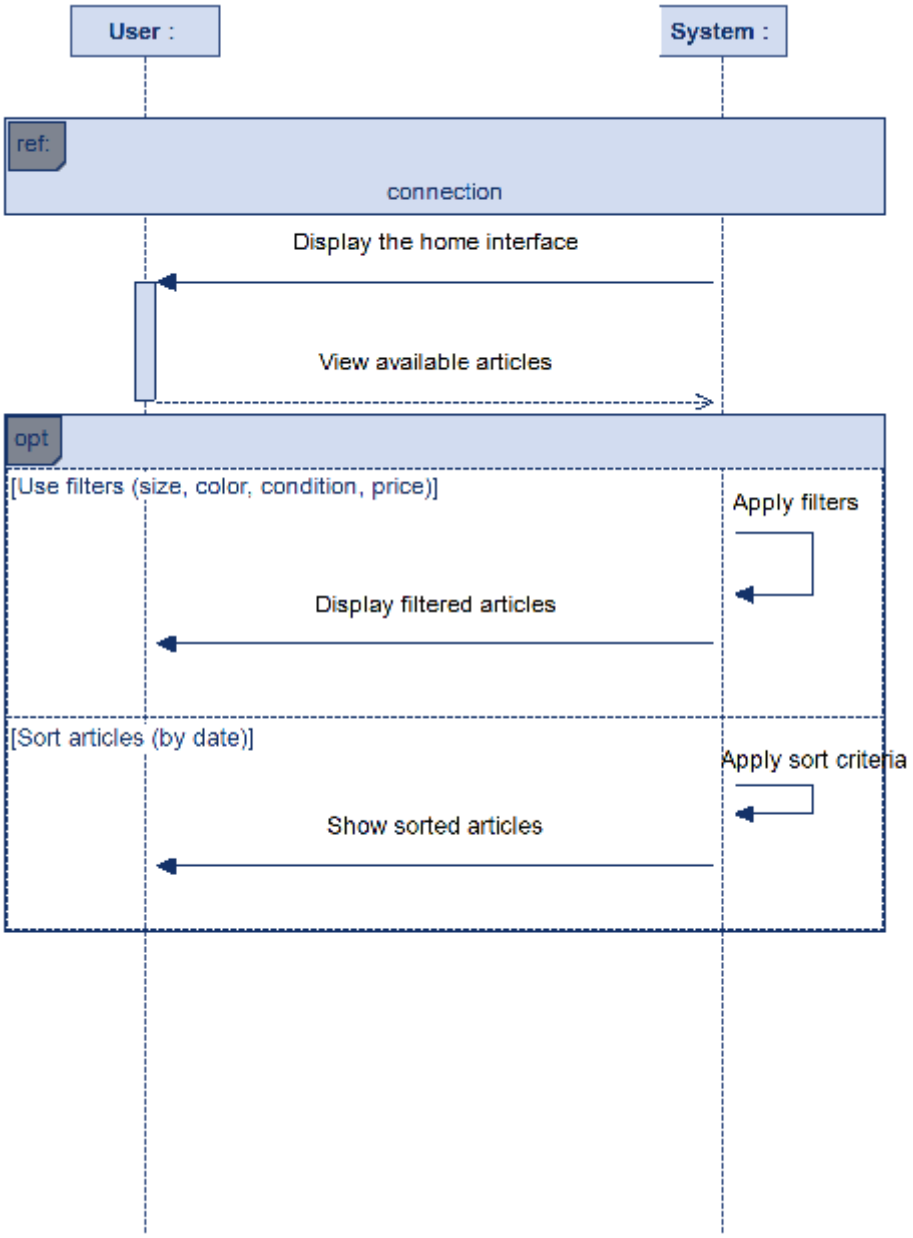


Figure 13: Sequence Diagram « View Available Items »

Sequence Diagram « Search Article »

Objective: Find articles matching specific criteria.

Pre -condition : The user is connected.

Post-condition : A list of articles matching the criteria is shown.

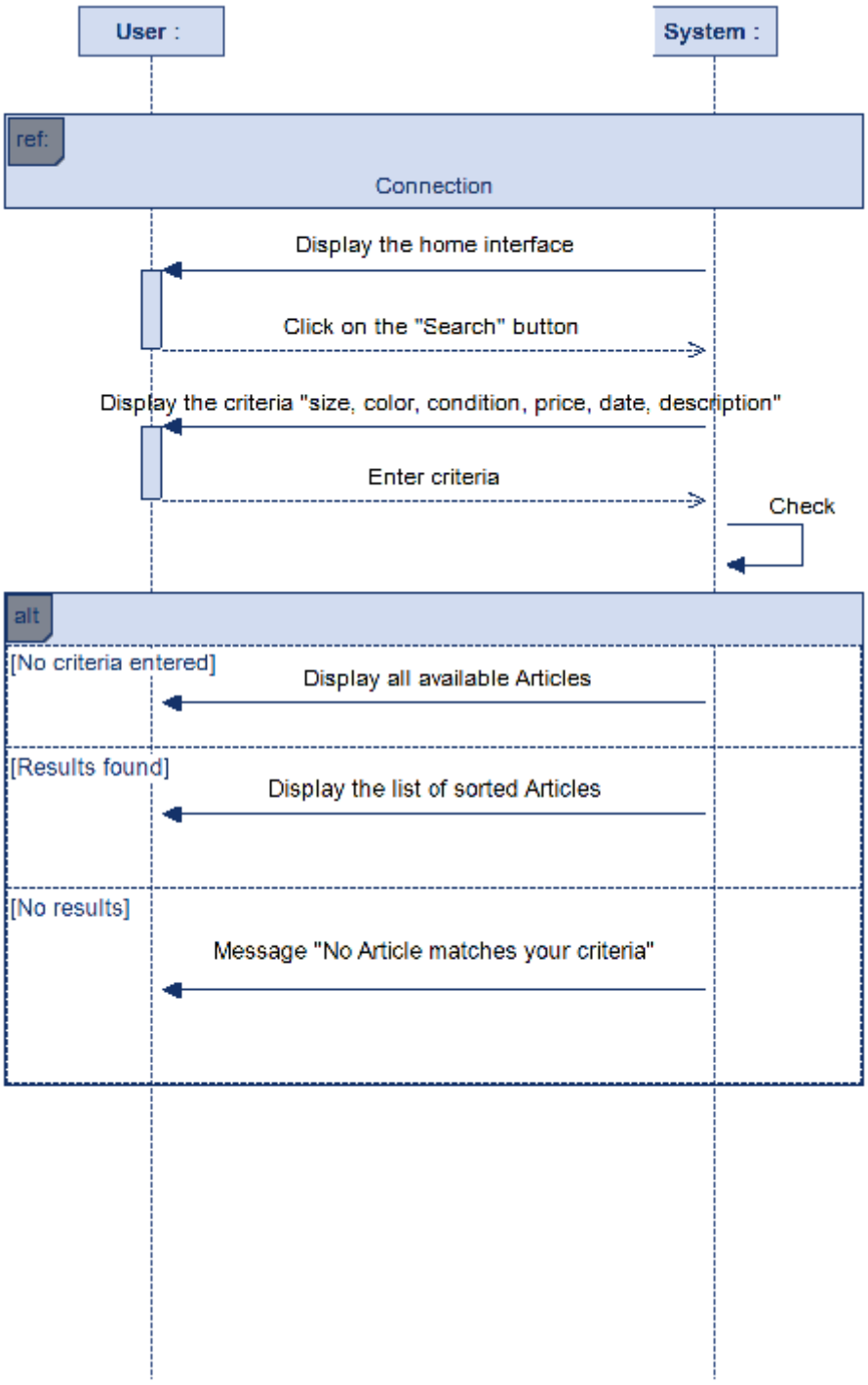


Figure 14 : Sequence Diagram « Search Item »

Sequence Diagram « Propose Exchange »

Objective: Allow a user to propose an exchange between one of their articles and another user's article.

Pre -condition : The user is connected and has at least one article listed.

Post-condition : The other user is notified, and the proposing user can track the status.

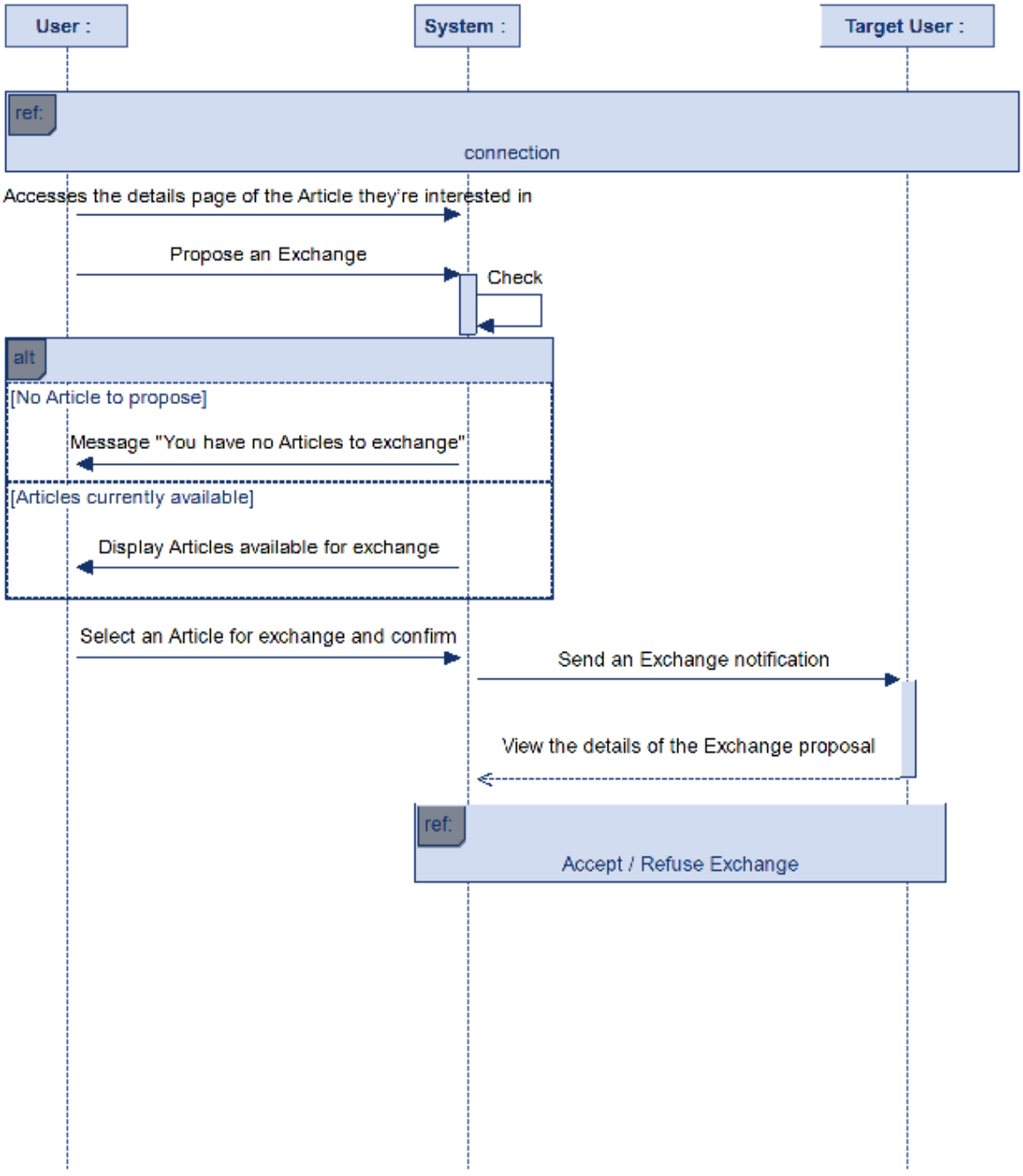


Figure 15 : Sequence Diagram « Propose Exchange»

Sequence Diagram « Accept/Refuse Exchange »

Objective: Let a user decide whether to accept or refuse an exchange proposal.

Pre -condition : The user is connected and has received a proposal for one of their listed articles (which is still available).

Post-condition : The proposal status is updated (Accepted/Refused), and both users are notified.

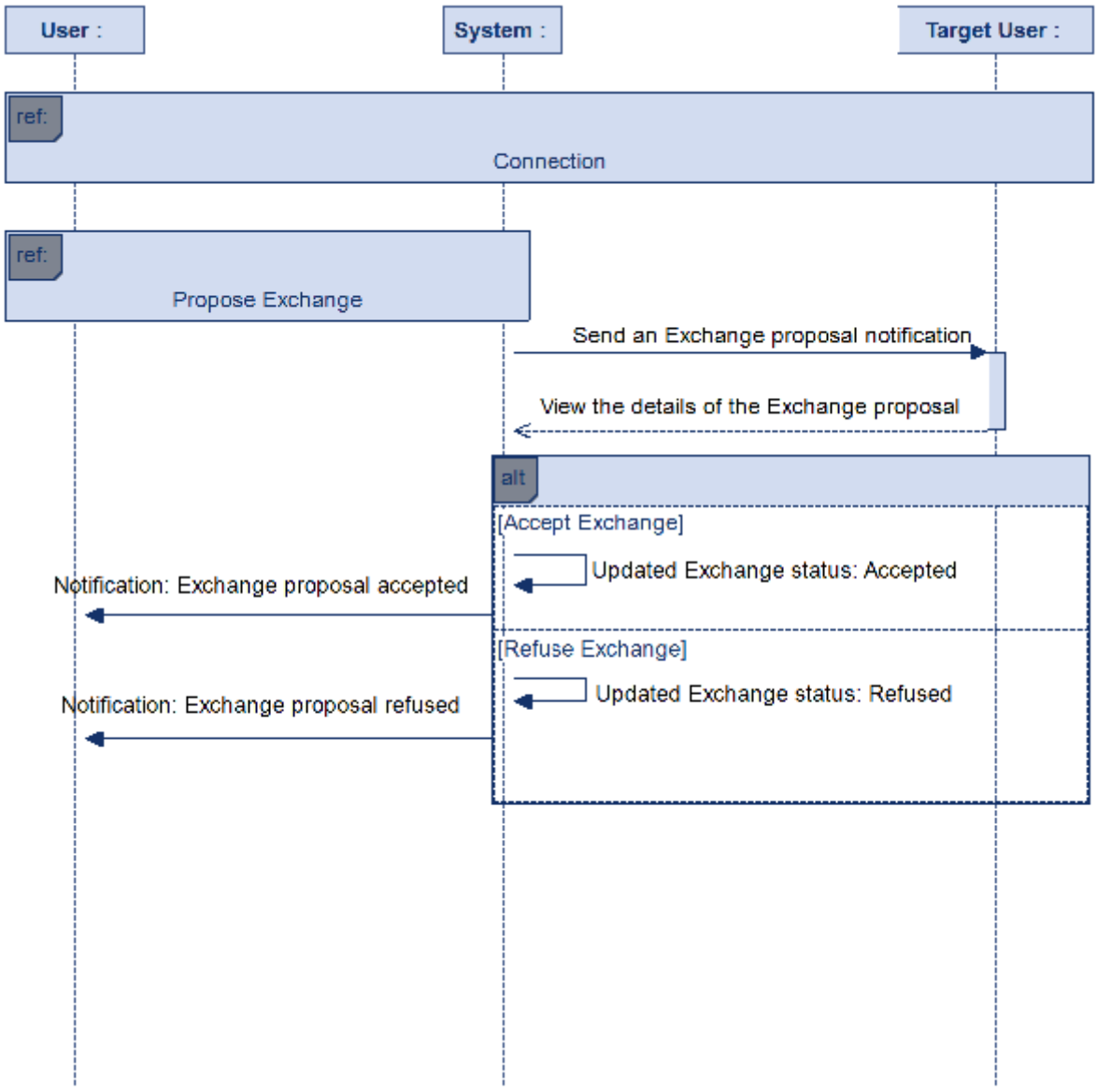


Figure 16 : Sequence Diagram « Accept/Refuse Exchange »

Activity Diagrams

An activity diagram provides a view of system behavior by describing the sequence of actions in a process. They resemble information processing flowcharts by showing action flows (Reynaud, C., 2005).

Activity Diagram « Registration »

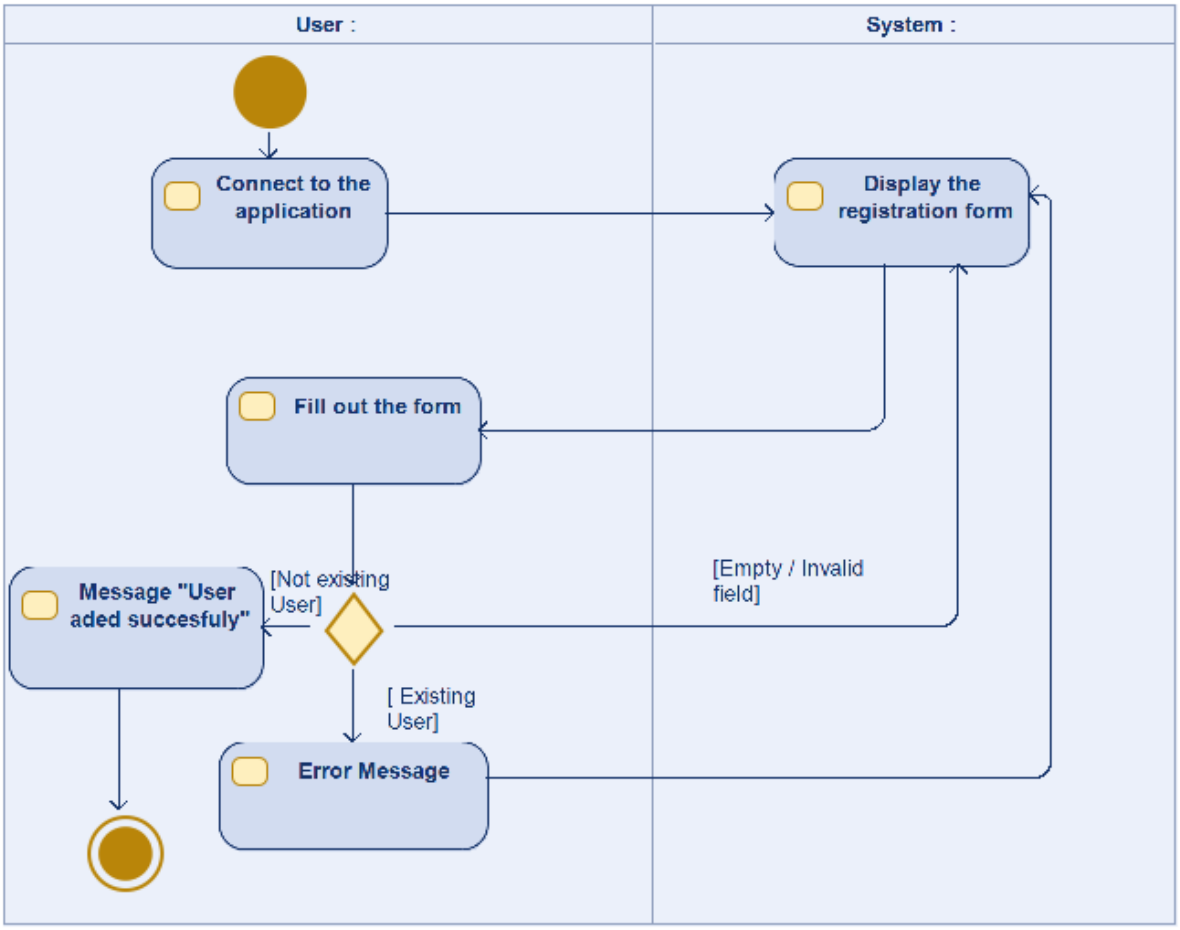


Figure 17 : Activity Diagram « Registration »

Activity Diagram « Connection »

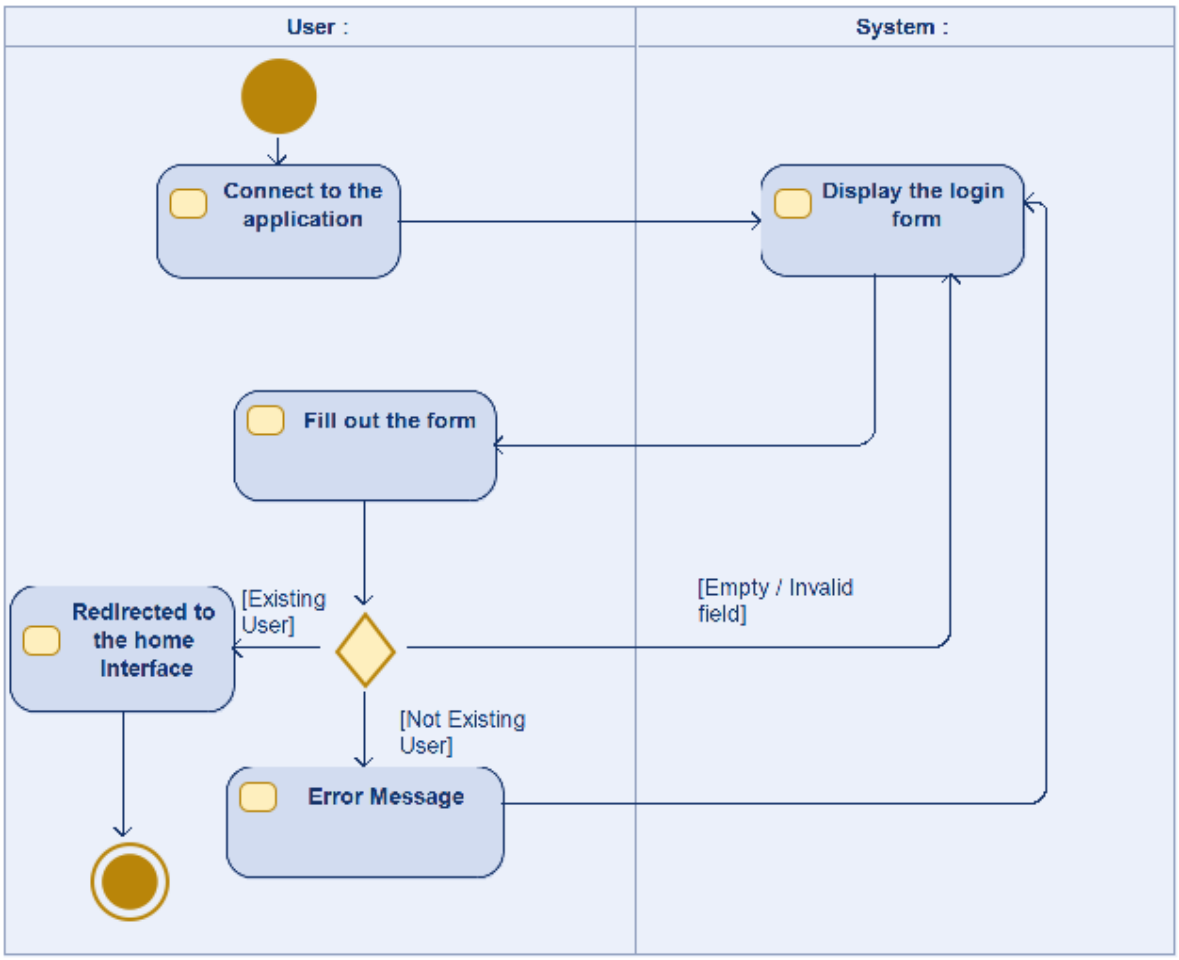


Figure 18 : Activity Diagram « Connection»

Activity Diagram « Add Article »

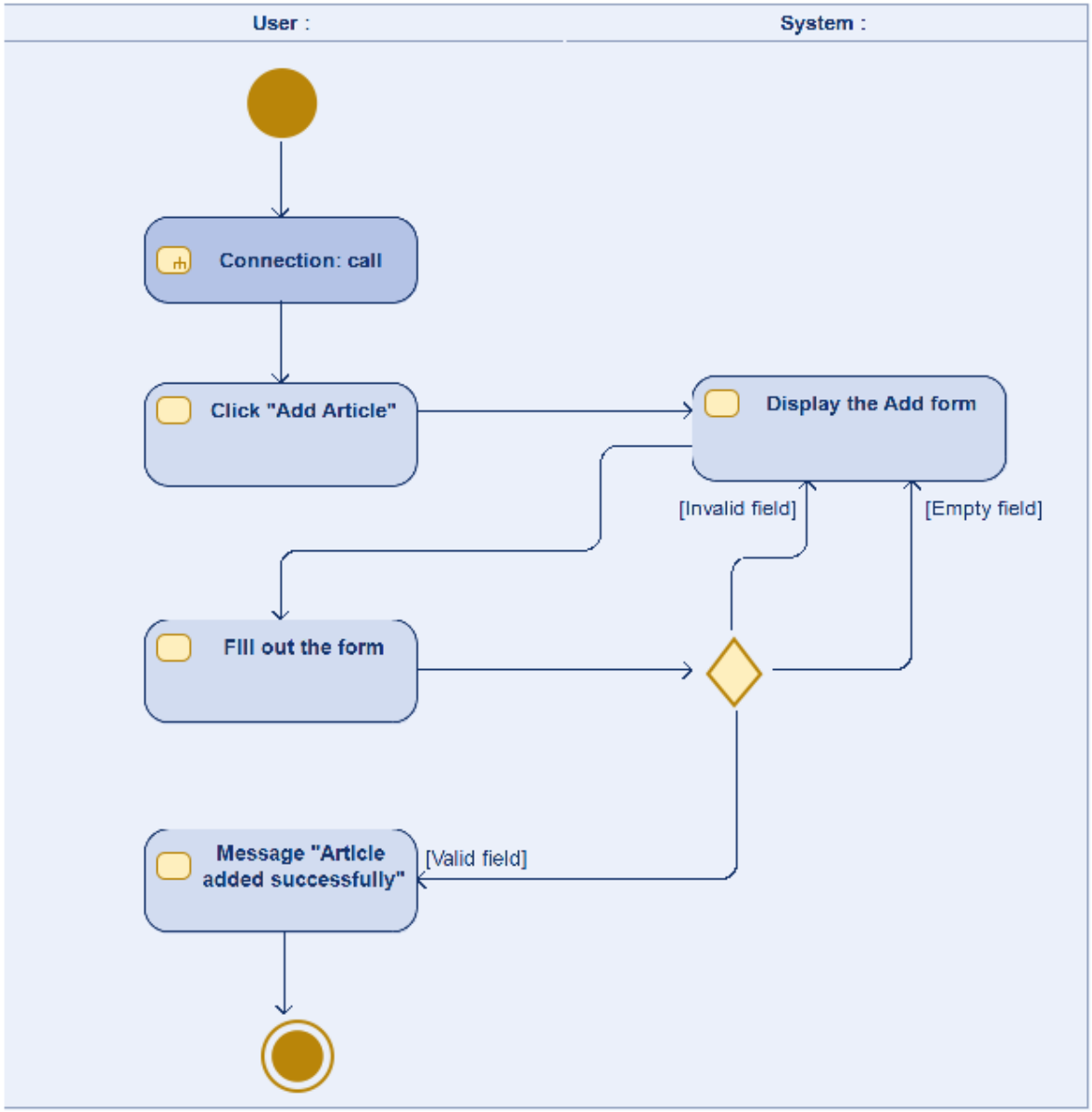


Figure 19 : Activity Diagram « Add Article »

Activity Diagram « View Available Articles »

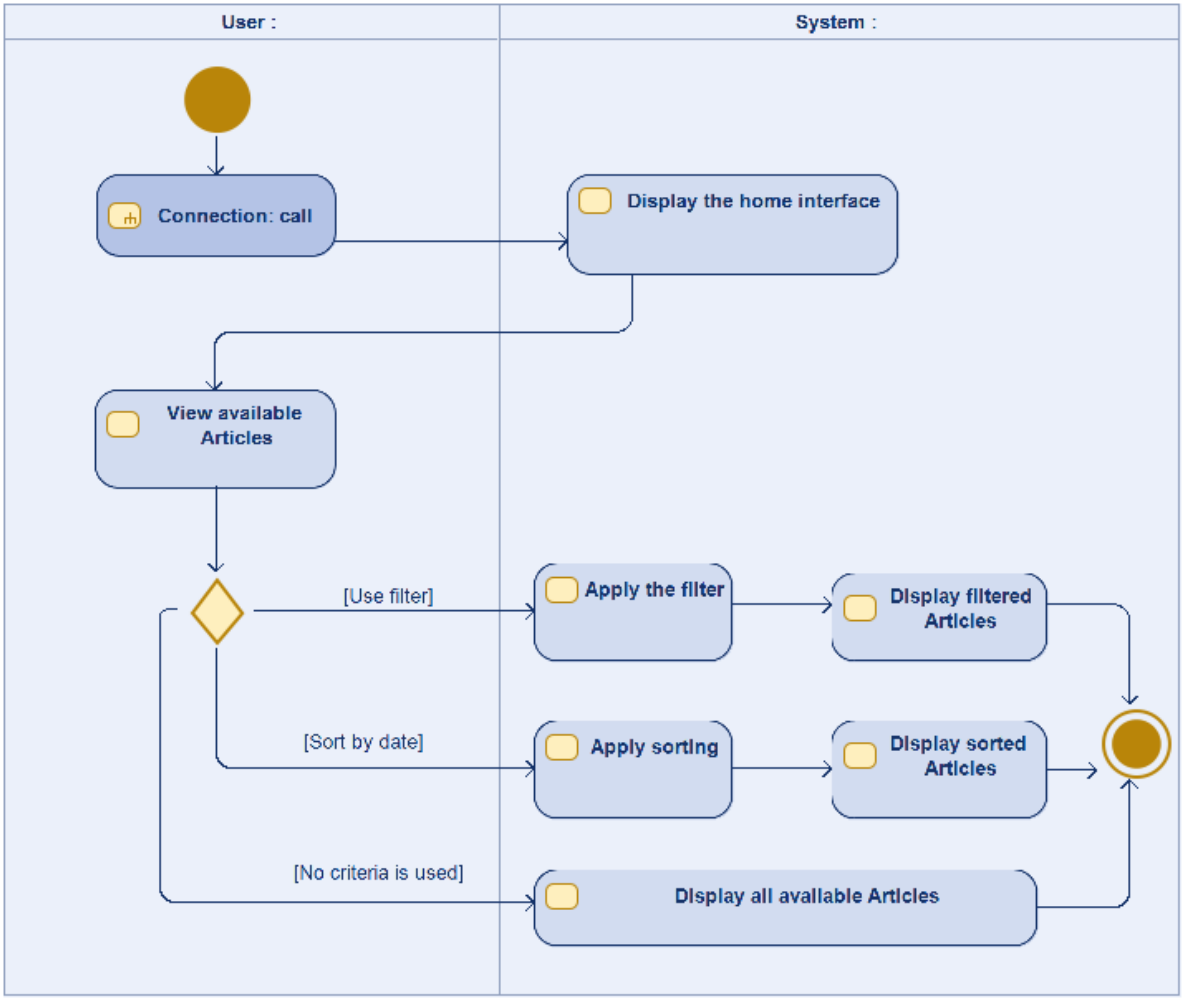


Figure 20 : Activity Diagram « View Available Articles »

Activity Diagram « Search Article »

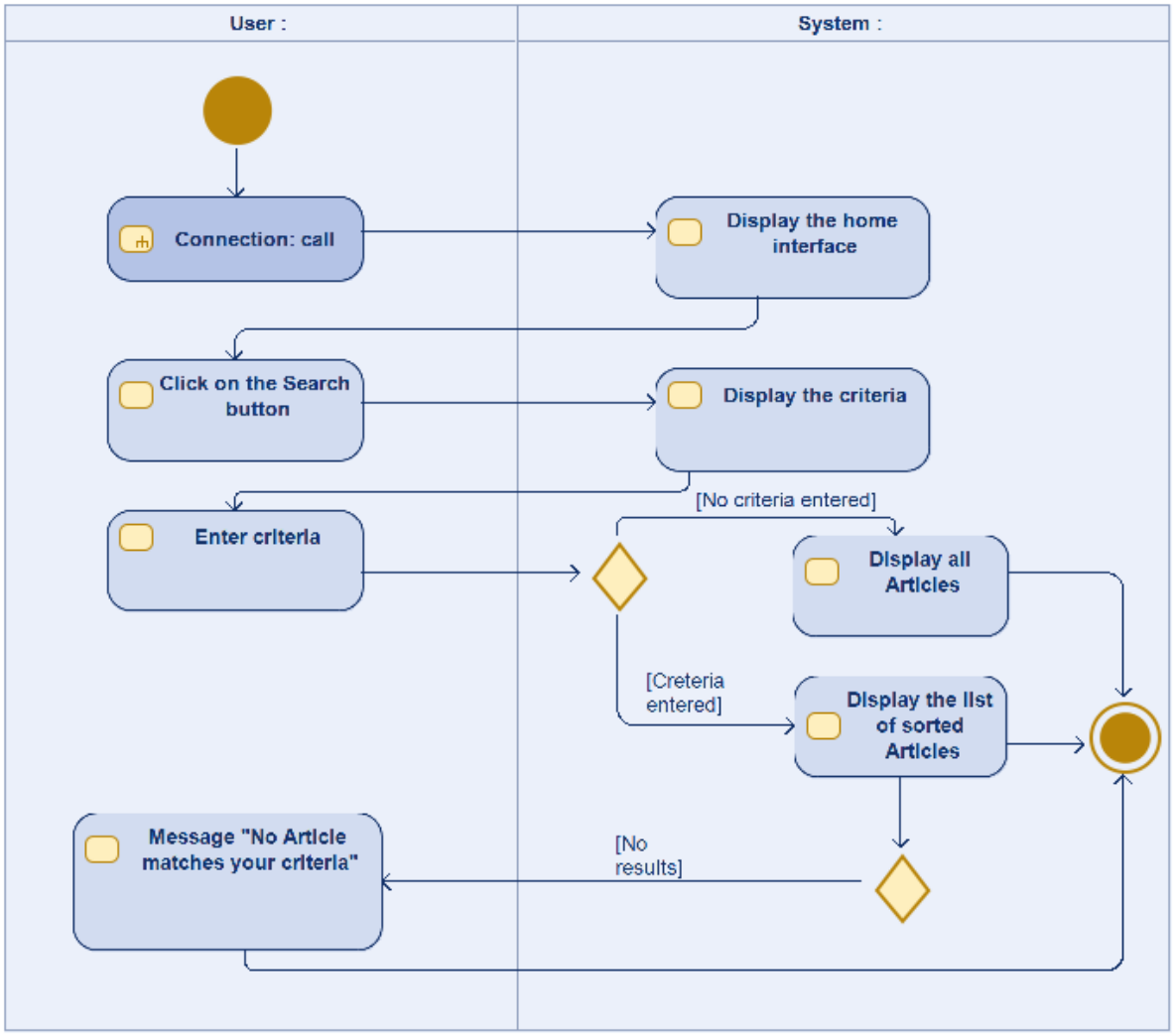


Figure 21 : Activity Diagram « Search Article »

Activity Diagram « Propose Exchange »

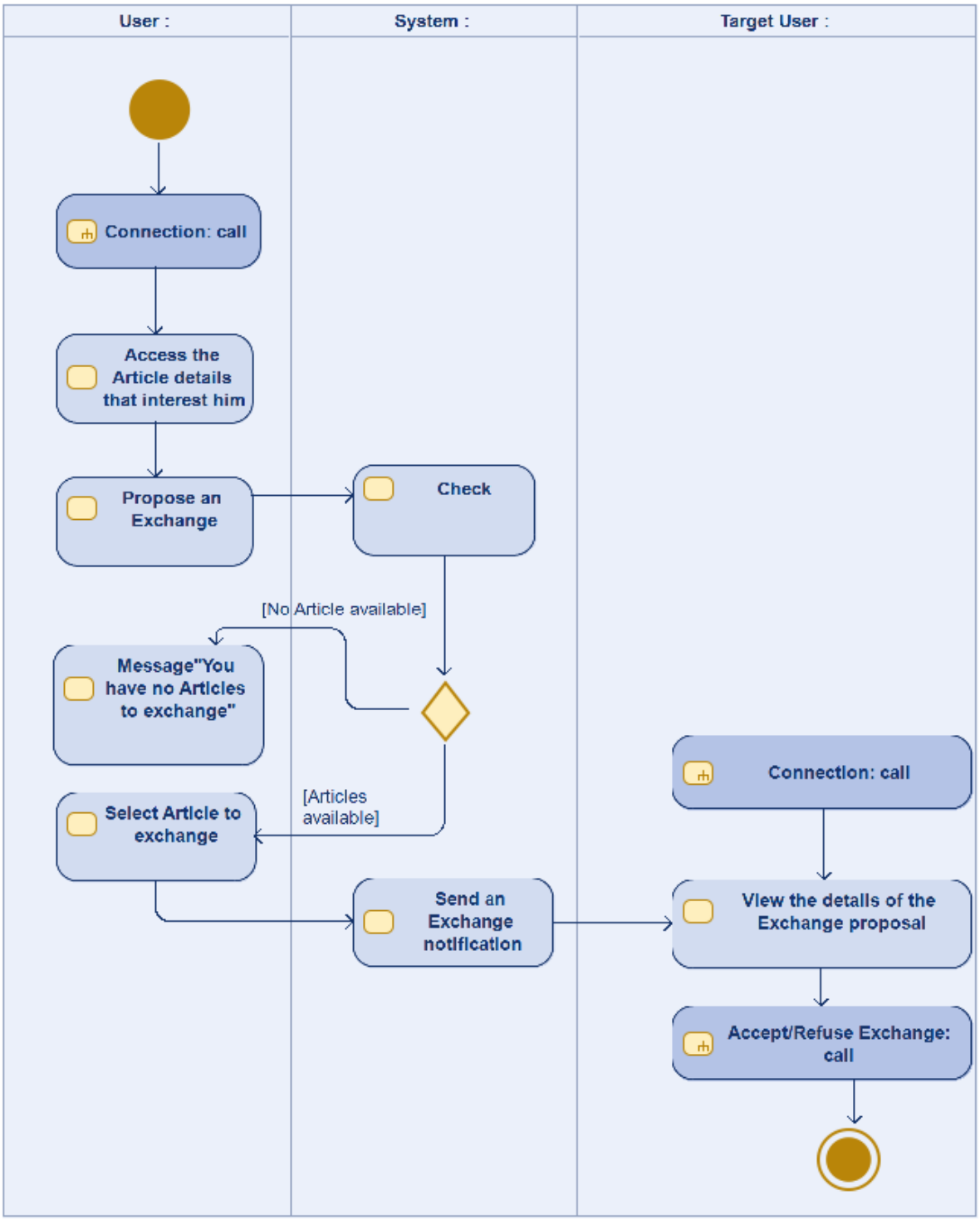


Figure 22 : Activity Diagram « Propose Exchange »

Activity Diagram « Accept/Refuse Proposal »

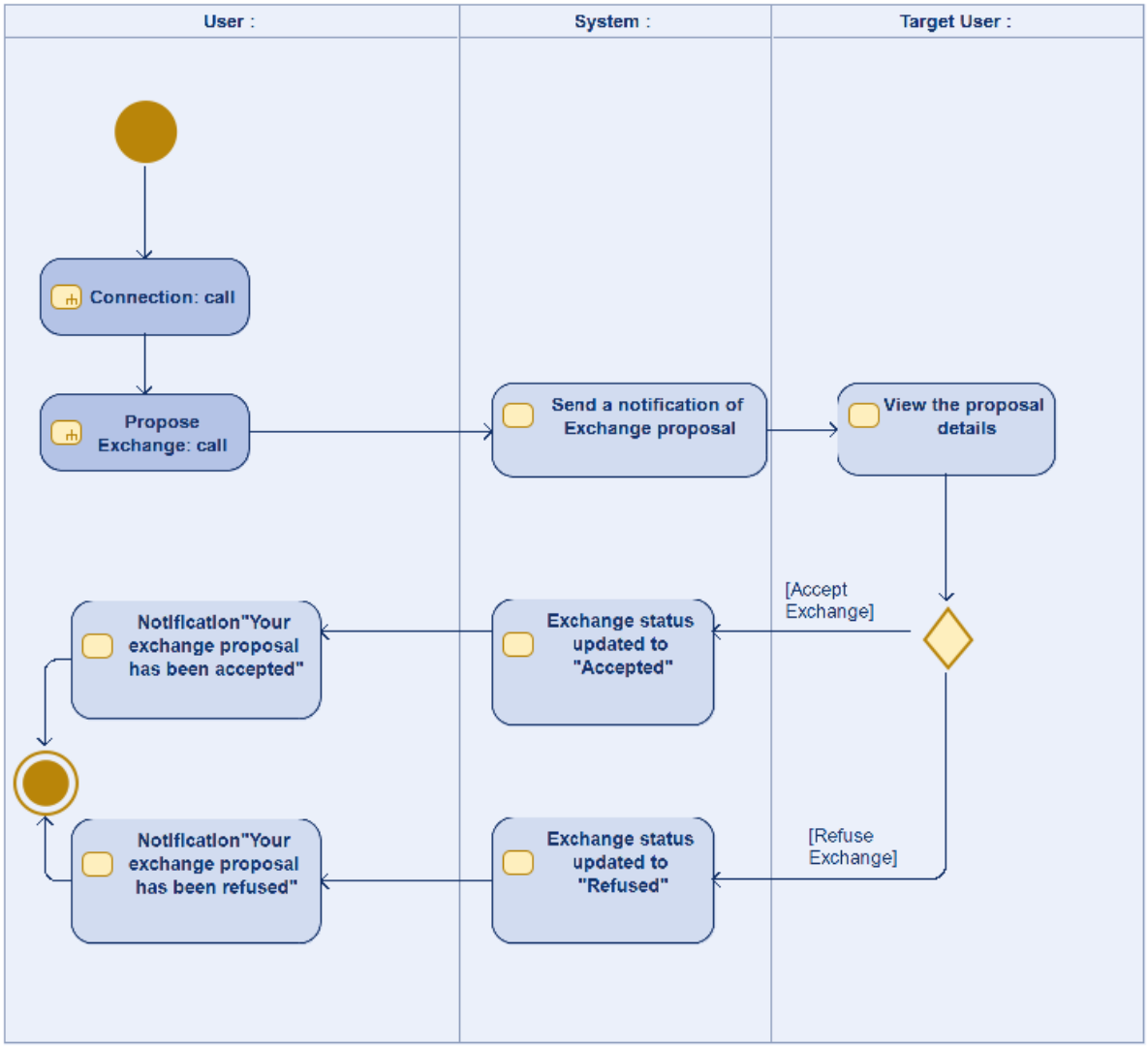


Figure 23 : Activity Diagram « Accept/Refuse Proposal »

Class Diagram

A class describes a set of objects sharing the same attributes, operations, relationships, and semantics. All objects are modeled as classes, each with a unique name. An attribute is a named property describing a set of values its instances can take.

Visibility and type are always defined, even if not shown explicitly: + public (default), - private (protected) (Fuentes-Fernández, L., & Vallecillo-Moreno, A. , 2004).

Global Class Diagram

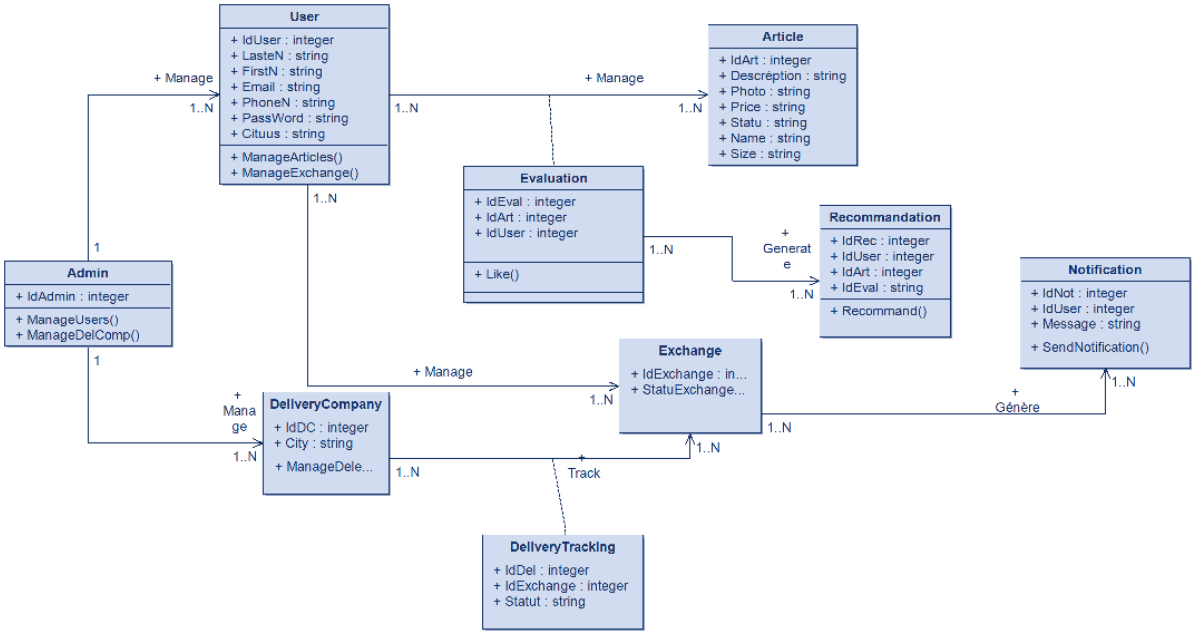


Figure 24 : Global Class Diagram

5 Conclusion

After exploring the various diagrams, we now clearly understand how our web application functions and the interactions between its users and the system. The goal of this analysis and design phase is to prepare for the implementation phase, which will be addressed in the next chapter.

Chapter three:

Recommendation system development environment and application presentation

1. Introduction

In this final chapter, we will explain the principle of article recommendation, which is useful for the various users of our application. We will then present the development environment and the tools used to build the application. We will conclude by showcasing its functionalities through its different interfaces.

2. Recommendation approaches in an article exchange application

In our article exchange platform between users, various recommendation systems were implemented to enhance the user experience:

a. Collaborative Filtering

a. User-Based Collaborative Filtering

This method relies on the preferences of users with similar behavior.

Example: If two users liked the same items, the system may suggest to one user articles viewed or Exchanged by the other.

Advantage: No need to understand the articles themselves, only user interactions.

Limitation: Struggles with the "cold start" problem (lack of data for new users or items).

b. Item-Based Collaborative Filtering

The system recommends items similar to those already liked by the user, based on other user's behaviors.

Exemple : « Users who traded this t-shirt also traded this pair of pants. »

Advantage: More stable than user-based filtering.

Limitation: Less personalized when user history is limited.

b. Content-Based Filtering

Recommendations are generated based on product attributes (color, size, name, condition) and the user's preferences, explicit or implicit.

Exemple : « You liked a modern red traditional dress? Here are other similar options. »

Advantages:

- ✓ Works well even with few users.
- ✓ Easier to explain recommendations.

Limitations:

- ✓ Less diversity ("filter bubble" effect).
- ✓ Requires well-structured metadata.

c. Hybrid Recommendation

To overcome the limitations of each method, multiple strategies are combined (typically collaborative content-based).

Example on our platform: Uses both click history and product features to offer precise suggestions.

Hybrid Combination types :

- o Weighted: Scores are merged with weights.
- o Cascade: One method filters, the other refines.
- o Ensemble: Results from several systems are combined.

Advantage: Increases accuracy and reduces bias.
Limitation: More complex to implement.

d. Image Similarity-Based Systems

Uses computer vision (AI) to analyze item images and suggest visually similar articles.

Exemple : " Here are articles visually similar to the one you viewed."

3. Definition of Artificial Intelligence (AI):

Artificial Intelligence is the process of mimicking human intelligence using powerful algorithms, enabling machines to think and act like humans.

It requires:

- Computer systems
- Data with management systems
- Advanced AI algorithms (code)

AI needs large datasets and high processing power to emulate human behaviour (Russell, S. J., & Norvig, P. , 2020).

4. AI in Article Exchange Platforms

Artificial intelligence plays a key role in optimizing user experience on an article exchange platform.
By leveraging computer vision and natural language processing algorithms, AI is capable of analyzing item images as well as their names and descriptions to suggest similar articles based on user preferences. It also facilitates the automatic detection of categories, colors, and styles, thereby improving the relevance of search results. Furthermore, AI can identify exchange behavior patterns to personalize suggestions and ensure the quality of the published articles.

a. Image Similarity Computation

We calculate similarity between two images using vector representations from the CLIP model and cosine similarity.

CLIP (Contrastive Language–Image Pretraining)

CLIP is an artificial intelligence model developed by OpenAI.

It was trained on over 400 million image-text pairs. Its goal is to link the visual content of an image to a linguistic meaning, allowing it to understand what an image represents from a semantic perspective (e.g., “a red dress,” “a mobile phone,” “a white cat”) (Hugging Face., 2023).

CLIP Architecture Overview

CLIP consists of **two main encoders** trained jointly using a **contrastive learning objective** (Alammar, J., 2021)

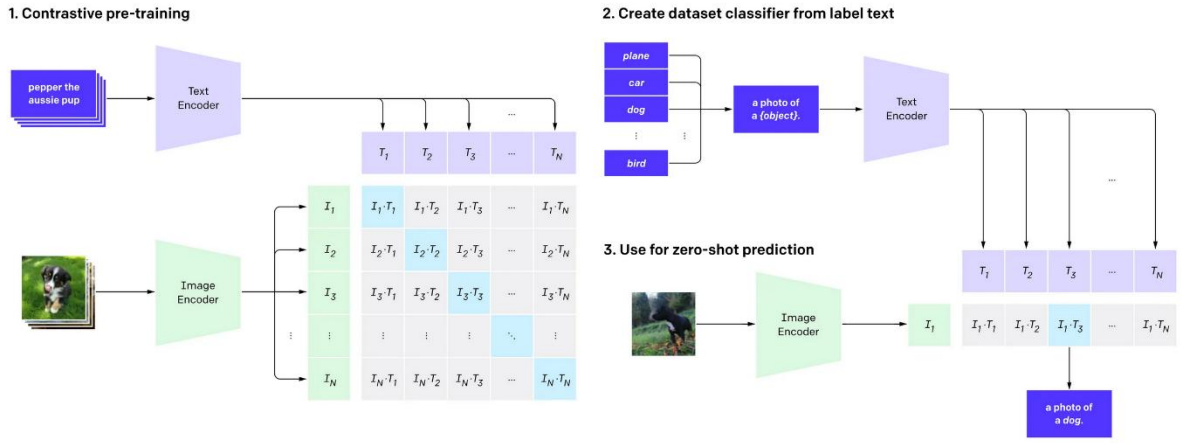


Figure 25 : CLIP Architecture Overview (Palucha, S. , 2021)

1. **Two-Tower Architecture :** CLIP has a dual-encoder (two-tower) architecture :

Image Encoder

- Usually a **Vision Transformer (ViT)** or **ResNet.**
- Takes a raw image as input.
- Encodes the image into a **fixed-size feature vector**.

Text Encoder

- Usually a **Transformer-based model** (like a variant of GPT).
- Takes a **text prompt** (e.g., "a photo of a cat") as input.
- Encodes the text into a **fixed-size feature vector** (same dimension as the image vector).

2. Contrastive Training Objective

- During training, CLIP is given **a batch of images and corresponding text descriptions.**
- The model **projects both image and text embeddings** into a shared space.
- It is trained to **maximize the similarity between matching image-text pairs** and **minimize the similarity of mismatched pairs**.
- Uses a **contrastive loss function** (like InfoNCE) over all image-text combinations in the batch.

3. Zero-Shot Inference : After training, CLIP can:

- Encode any image and any piece of text into the same latent space.
- Match images to descriptions **without any task-specific fine-tuning**.
- Enable **zero-shot classification** by comparing an image to a set of label descriptions (e.g., "a dog", "a cat") and choosing the most similar one.

How CLIP Works:

CLIP functions by integrating visual (image) and linguistic (text) analysis, giving it a unique capability for tasks involving semantic image comparison. Below is a more detailed breakdown of its steps (OpenAI. , 2021):

1. **Data Preparation**: Before any analysis, the image is resized to 224×224 pixels to standardize the model input. It is then centered to focus on the main subject, followed by RGB color normalization based on the mean and standard deviation from the model's training dataset (typically ImageNet).
2. **Patch Division**: The scaled image is divided into 196 segments (patches) of 16×16 pixels. Each patch represents a small localized area of the image, allowing the model to analyze specific regions while maintaining an overall view.
3. **Patch Embedding**: Each patch is converted into a numerical vector (embedding) through a linear layer. This vector contains data about shapes, textures, and visual patterns present in the patch.
4. **Positional Encoding**: Since Transformers do not inherently account for sequence order, a positional encoding is added to each vector to indicate its location within the image. This helps preserve the spatial arrangement of the image.
5. **Transformer Usage**: The set of position-augmented patch vectors is fed into a Transformer model. It learns to understand the relationships between different areas of the image (e.g., the connection between a dress sleeve and its collar), enabling a coherent and comprehensive interpretation of the visual content.
6. **Image Vector Generation** : The Transformer produces a unique 512-dimensional vector known as the image embedding. This vector summarizes all the visual characteristics of the image within a semantic space shared with textual representations. Images with similar meanings will have embeddings that are close to each other. This vector thus becomes a mathematical representation of the image's overall visual meaning.

$$\vec{v}_{\text{i}}=\text{CLIP\_ImageEncoder(I)}$$

7. **Vector Normalization** : Each vector is normalized to have a unit norm (i.e., its length is set to 1) :

$$\vec{v}_{\text{norm}} = \frac{\vec{v}}{\| \vec{v} \|}$$

8. ***Cosine Similarity Calculation :*** At the core of the visual recommendation system lies the computation of similarity between item images using cosine similarity.

$$\text{Sim}(\vec{A}, \vec{B}) = \vec{A}_{\text{norm}} \cdot \vec{B}_{\text{norm}} = \sum_{i=1}^{512} a_i \, b_i$$

Similarity is a real number between -1 and 1:

- **Close to 1**: images are very similar
- **Close to 0**: little or no relation
- **Close to -1**: opposite concepts

However, in the case of CLIP and item images, the similarity score generally ranges from **0 (no similarity) to 1 (visually identical)**.

The closer the score is to 1, the more visually similar the items are. This method effectively enables the recommendation of visually similar articles, even if they are described differently or in another language.

9. ***Generalization (Similarity Matrix)*** *:* To compare multiple images, their vectors are stacked into a matrix **E**, and then the pairwise similarities are computed :

$$S = E \cdot E^{\top}$$

Each element S_{ij} represents the similarity between image *i* and image *j*.

Recommendation of Similar Articles on Our Website

Here is a simplified overview of the automated suggestion process using CLIP (Radford, 2021):

1. The user views an image → the item is displayed on the product page.
2. CLIP generates a vector (embedding) for this image.
3. The vector is compared with all other embeddings stored in the database.
4. Cosine similarity is calculated for each pair.
5. Items with a similarity score above a certain threshold (e.g., 0.8) are filtered.
6. Similar articles are dynamically displayed in a dedicated section ("You may also like").

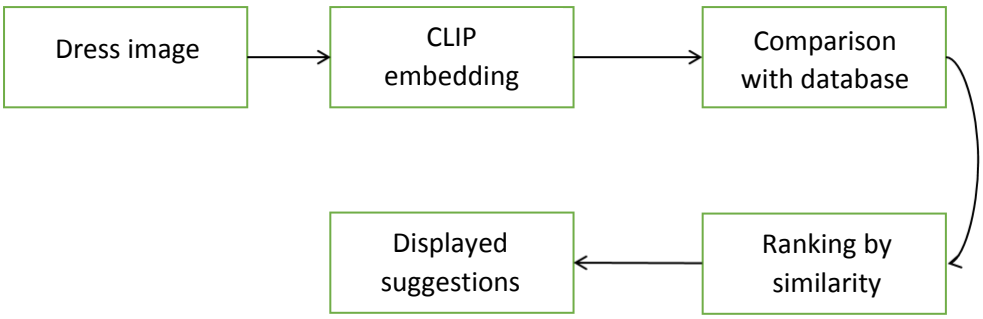


Figure 26: Flowchart of Similar Article Recommendation on Our Website

By following these steps, we can calculate the similarity between two images using artificial intelligence models like CLIP and cosine similarity, as well as the similarity between two filters (such as name, condition, size, etc.) using the previously described recommendation system approaches. This enables us to efficiently compare items in the context of article recommendation.

b. Strengths of the CLIP Model

- **Semantic understanding**: CLIP comprend le sens de l'image au lieu de simplement analyser les couleurs ou les contours.
- **Tolérance aux variations**: petit changement de lumière, de position ou de fond n'altère pas fortement la comparaison.

- **Adaptabilité** : peut détecter des similitudes même si les objets sont partiellement visibles ou légèrement transformés.
- **Haute précision mathématique** : grace à l'utilisation de la Similarité Cosinus et des embeddings normalisés.
- **Facilité d'usage** : modèle pré-entraîné, facile à intégrer avec PyTorch, adapté à de nombreuses applications (e-commerce, recherche visuelle, clustering, etc.).

i. Limitations

- **Struggles with abstract or systematic tasks :** Like Counting the number of objects in an image.
- **Performs poorly on complex tasks**: Estimating how close the nearest car is in a photo.
- **Highly sensitive to wording and phrasing**: Performance depends on the exact wording of the prompt.
- **Only slightly better than random guessing on specific datasets**: On two tested datasets, zero-shot CLIP performs only marginally better than chance.

5. Evaluation of Visual Similarity Results

To test and validate our recommendation system based on visual similarity, we compiled a set of images representing different styles of traditional dresses. These images were intentionally selected to include noticeable variations. The goal is to evaluate CLIP's ability to extract consistent representations despite these visual differences.

Figure 27: Set of Dresses for Evaluation

As part of our recommendation system, we applied cosine similarity calculations between the vector representations of images of different items. These vectors were generated using the CLIP model. To interpret the results, we defined the following threshold:

- If the similarity is ≥ **0.80**, the articles are considered **similar**.
- If the similarity is < **0.80**, they are considered **not similar**.

A particularly significant example is the comparison between *blouza.jpg* and *blouza_zoom.jpg*. Despite a notable difference in visible form, closer framing, and different lighting conditions, our system successfully captured the essential common features. The resulting similarity score was **0.84**, classifying them as similar. This demonstrates the robustness of the CLIP model, which can perform visual abstraction beyond superficial variations.

In contrast, the comparison between *blouza.jpg* and *chedda.jpg* yielded a score of **0.77**, below the threshold, indicating a real difference in style and visual features.

The following figure presents several examples of compared dresses along with their similarity scores, illustrating the system's ability to recognize visual resemblance even in the presence of variations.

image1,image2,similarity	résultats
blouza.jpg,bouza_zoom.jpg,0.8401669859886169	Similaire
blouza.jpg,chedda.jpg,0.7771635055541992	Non similaire
blouza.jpg,chedda1.jpg,0.7053322792053223	Non similaire
chedda.jpg,chedda1.jpg,0.8372193574905396	similaire
chedda.jpg,koftan.jpg,0.7167872190475464	Non similaire

Figure 28: Visual Similarity Results

6. Development Environment and Tools

To successfully develop our application, we selected specific tools, which are detailed below.

PHP (Personal Home Page)

PHP (PHP: Hypertext Preprocessor) is a widely used programming language in web development. It can be used to create interactive and dynamic web pages. PHP works well with HTML as it can be embedded directly into HTML code (Ullman, L. , 2017).

HTML (HyperText Markup Language)

HTML was used to structure the various web pages of the application, including the data entry interface, model selection, and result display. It serves as the foundational language for creating web pages and defines the content structure using specific elements and attributes (Duckett, J., 2011).

CSS (CASCADINGSTYLESHEETS)

CSS (Cascading Style Sheets) is used to control the presentation of a web page. It allows the creation of styling and layout rules, including the positioning of elements, alignment, fonts, colors, margins and spacing, borders, background images, and more. The main purpose of CSS is to separate the structure of an HTML document from its visual presentation (Duckett, J., 2011).

Bootstrap

Bootstrap is a framework developed by the team behind the social network Twitter. Offered as open source (under the MIT license), this framework uses HTML, CSS, and JavaScript to provide developers with tools for easily creating websites. It is designed to build responsive websites that adapt to any screen size, with a primary focus on smartphones. Bootstrap includes pre-styled components for typography, buttons, navigation interfaces, and much more. This type of framework is known as a "Front-End Framework." (Matsinopoulos, P. , 2020).

AJAX

AJAX refers to a software architecture that enables the creation of web pages and applications capable of interacting with the user and/or other applications without needing to reload the page in the user's web browser. AJAX relies on technologies available in most web browsers, including JavaScript (JS) and XML, which are part of the acronym AJAX: "Asynchronous JavaScript and XML." AJAX itself does not introduce new technologies, as most of them have existed for years. However, it provides a method to use these technologies together to create dynamic applications executed directly in browsers (Brooks, D. R , 2007).

Javascript

JavaScript is a programming language that allows the implementation of advanced operations within web pages. It enhances HTML by enabling commands to be executed on the client side (i.e., in the browser rather than on the web server). As such, JavaScript is highly dependent on the browser that loads the web page containing the script. However, it has the advantage of not requiring a compiler .

The application was developed using a web development platform on Windows, specifically the XAMPP package version 3.3.0 (2.2), which includes:

Windows : A tool that runs on Windows XP and Windows 7.

Apache (2.2.21) : It is a web server and one of the most essential components. Its role is to deliver web pages to visitors. However, Apache only handles static websites, so it must be complemented with other programs to manage dynamic content.

MYSQL(5.5.16) It is the database management system (DBMS).

PHP(5.3.8) It is a plug-in for Apache that enables it to process dynamic web pages.

David R Brooks. An introduction to html and javascript for scientists and engineers.

7. Database Implementation

We implemented our database using the SQL environment for its creation.

SQL

SQL (Structured Query Language) is a language used to query databases in a straightforward manner. It follows a specific syntax that must be respected to ensure effective communication with the database. Its success is largely due to its simplicity and the fact that it allows users to express queries while leaving the execution strategy to the DBMS (Harris, A , 2003).

8. Application Interfaces

Registration Interface

Allows a new visitor to create an account in order to publish articles, propose exchanges, and interact with other members. It also enables a new delivery company manager to accept or reject exchanges, and to deliver or return items submitted for exchange.

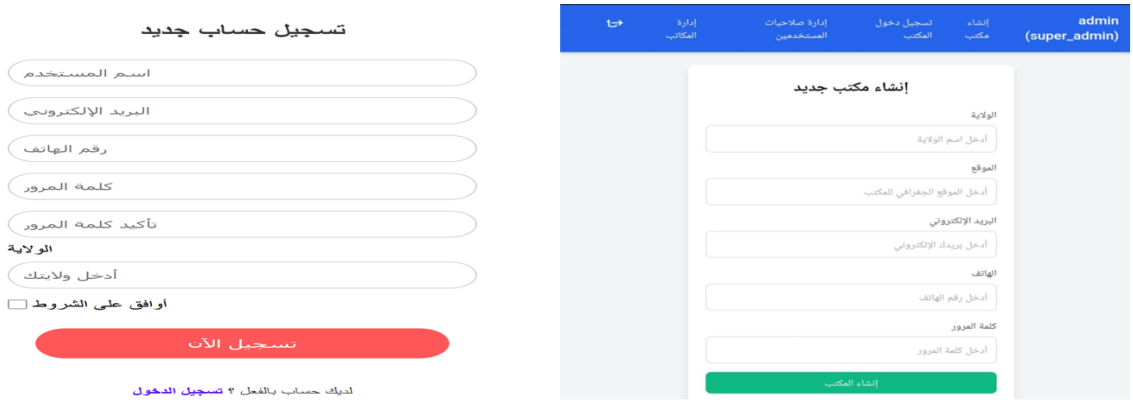


Figure 29: Registration Interface

Login Interface

Allows registered users and delivery company managers to log into their accounts and access the main features of the website.

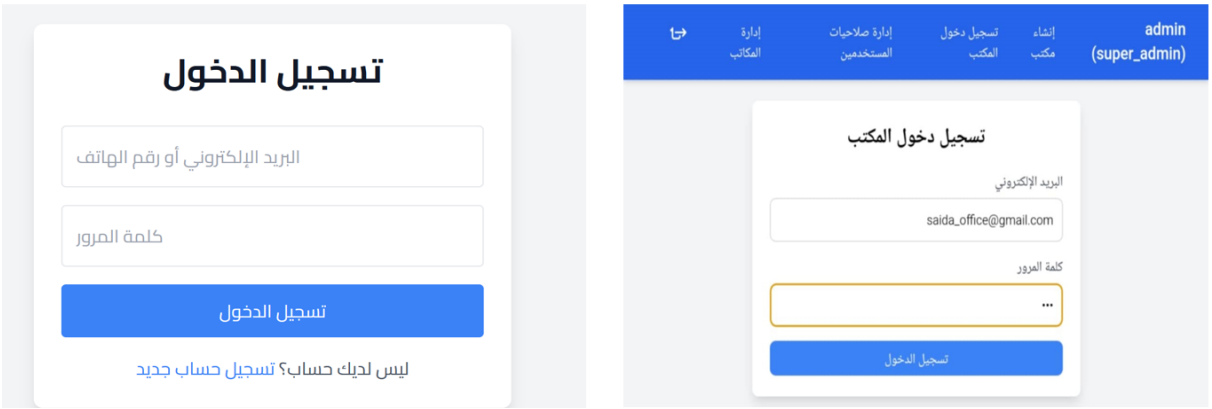


Figure 30: Login Interface

User Home Interface

Displays to the logged-in user the complete list of available items on the site, with the ability to view, sort, initiate exchanges, and receive personalized article recommendations

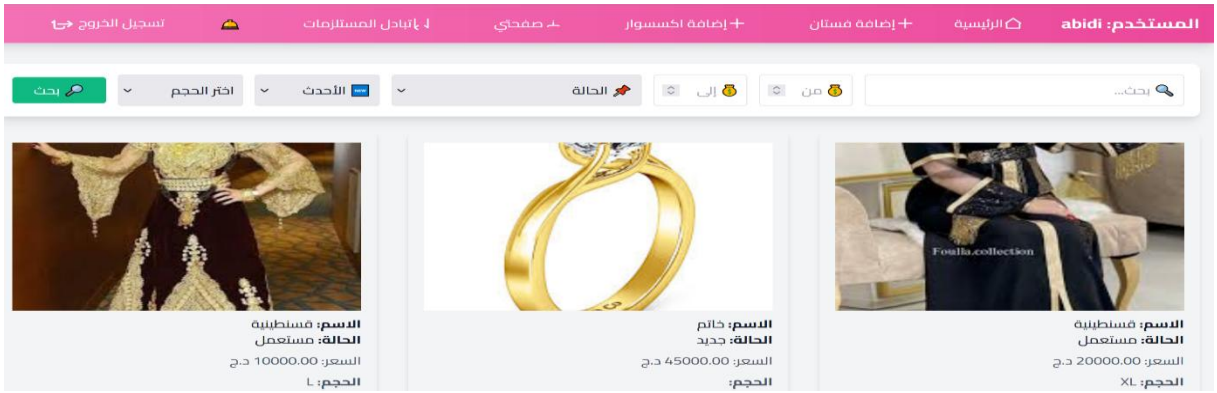


Figure 31: User Home Interface

Search and Filter Interface for Articles

Allows the logged-in user to search for items available for exchange based on several relevant criteria such as size, condition, estimated price, color, etc

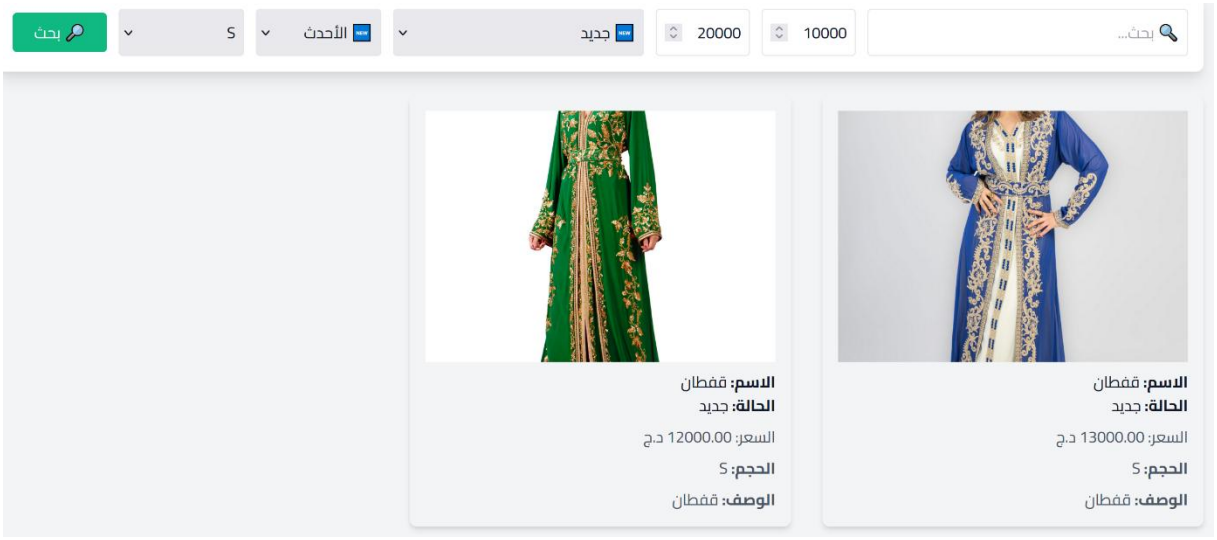


Figure 32: Search and Filter Interface for Articles

User Dashboard Interface

Provides the user with a personal space where they can manage their articles, track their exchanges, access their history, and more.

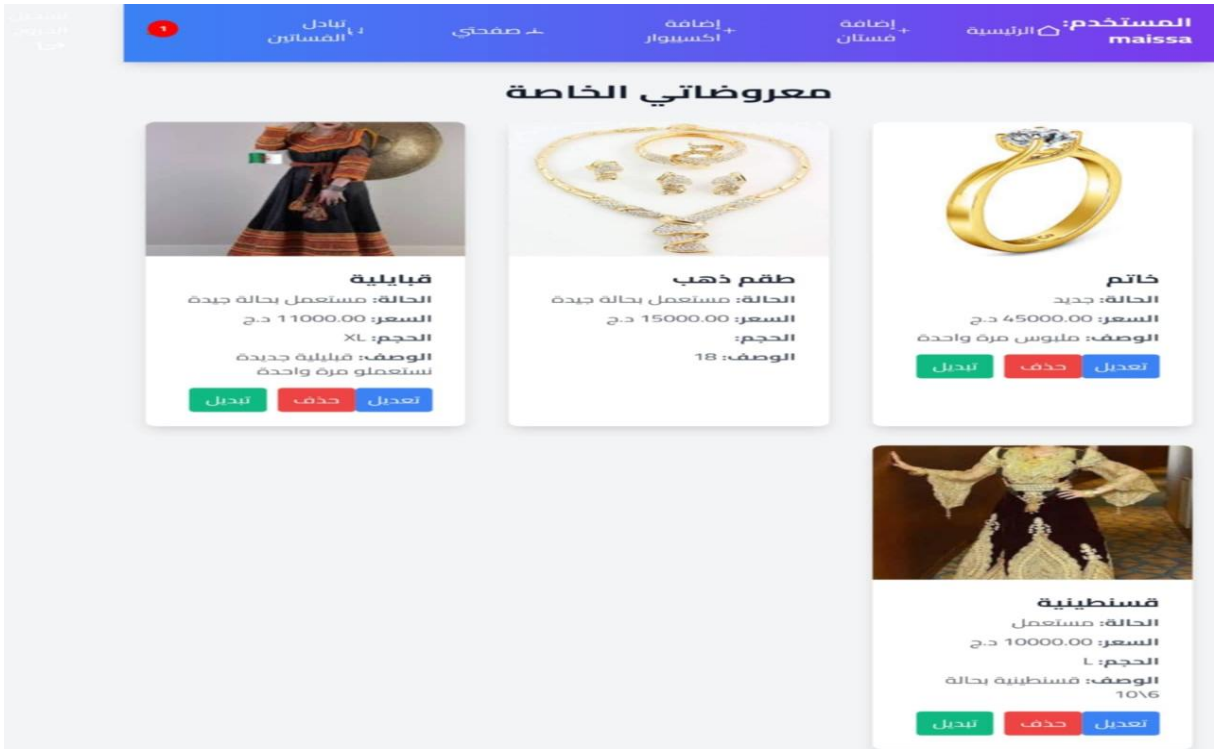


Figure 33: User Dashboard Interface

Exchange Request Interface

Allows a user to send an exchange request to another user by offering one of their own articles, and triggers a notification to be sent to the recipient.

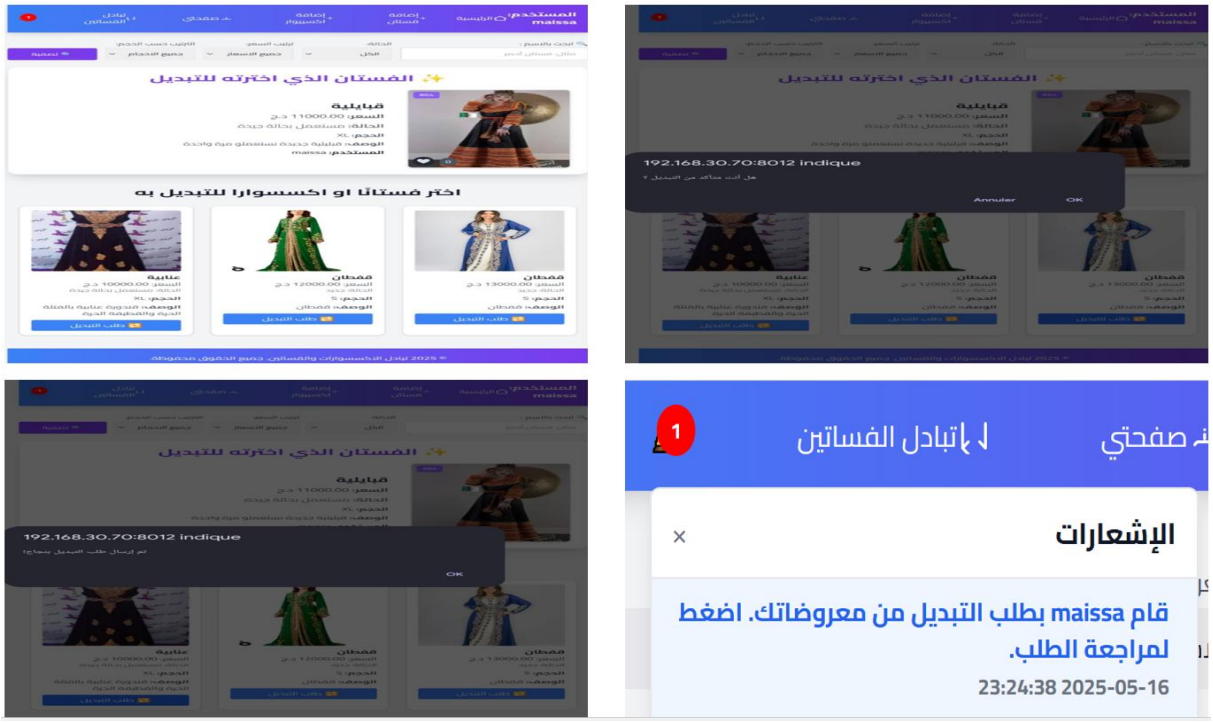


Figure 34: Exchange Request Interface

Received Requests Management Interface

Allows the owner of an item to view a received request, accept or reject it, and notify the requester with a deposit message for the item.

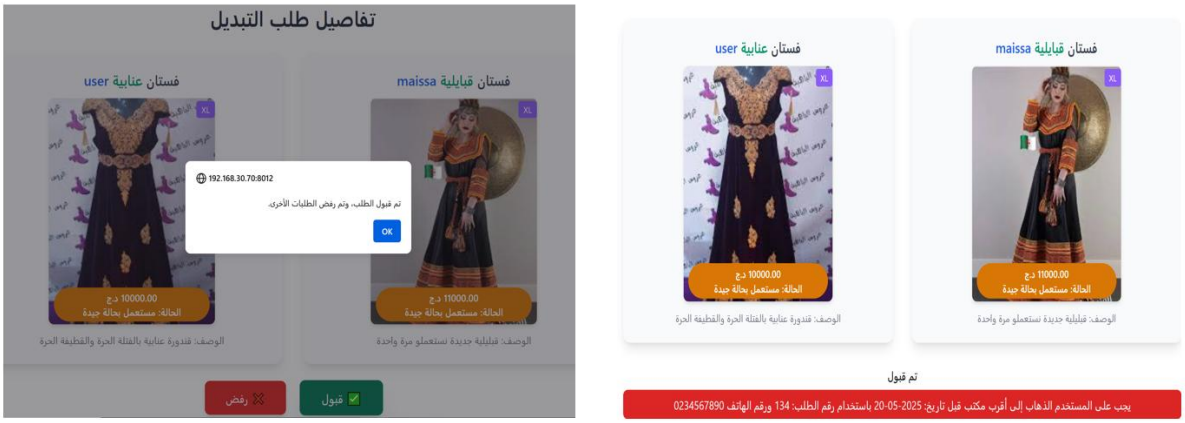


Figure 35 : Interface de gestion des demandes reçues

User Deposit Validation Interface (Delivery Company Side)

Allows the delivery company manager to enter the deposit number provided by the user, verify the identity and the item, validate or reject the deposit, and then automatically generate a notification to the recipient of the exchange.

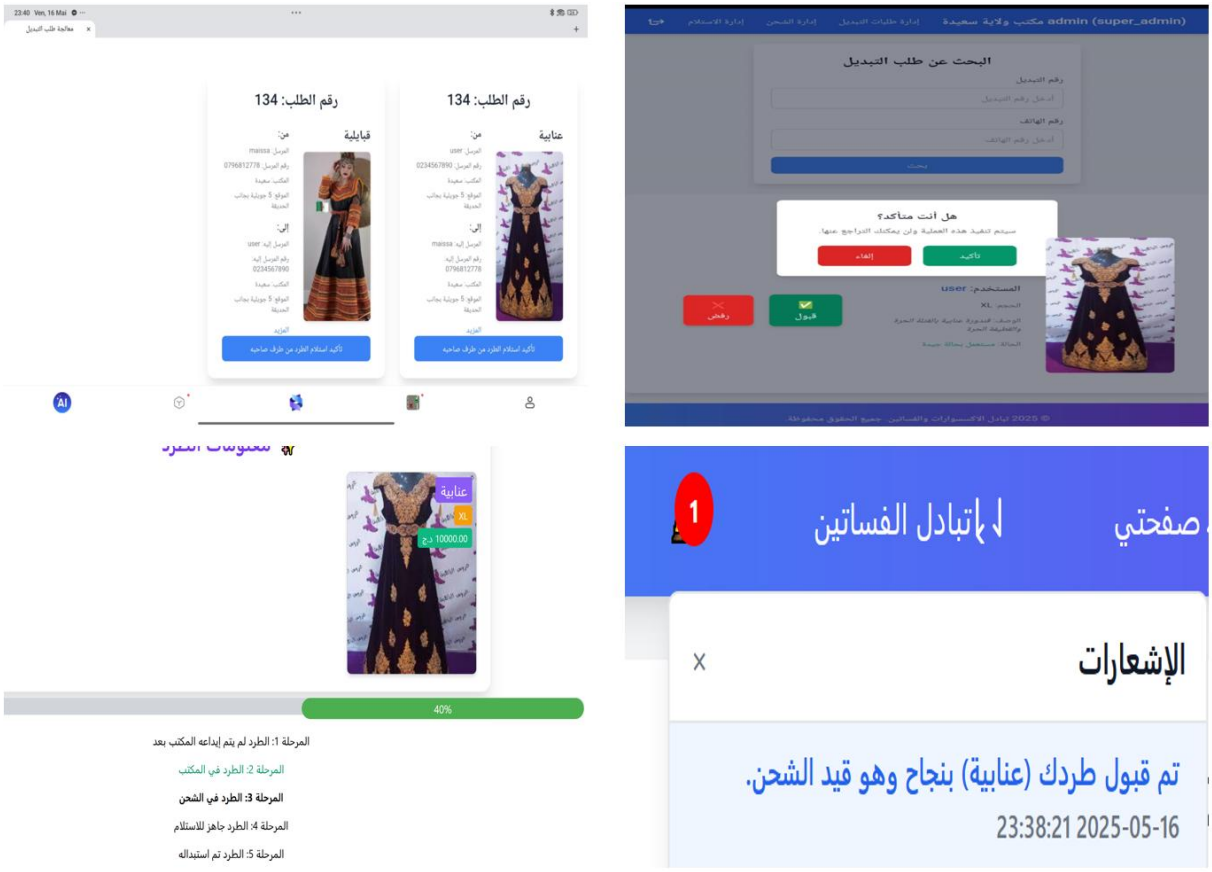


Figure 36: User Deposit Validation Interface (Delivery Company Side)

End-of-Deposit Process Interface

Allows the delivery company manager to: confirm that both exchanged items have been received, initiate the delivery process, notify both users that their items are ready for pickup, and finally mark the exchange as completed.

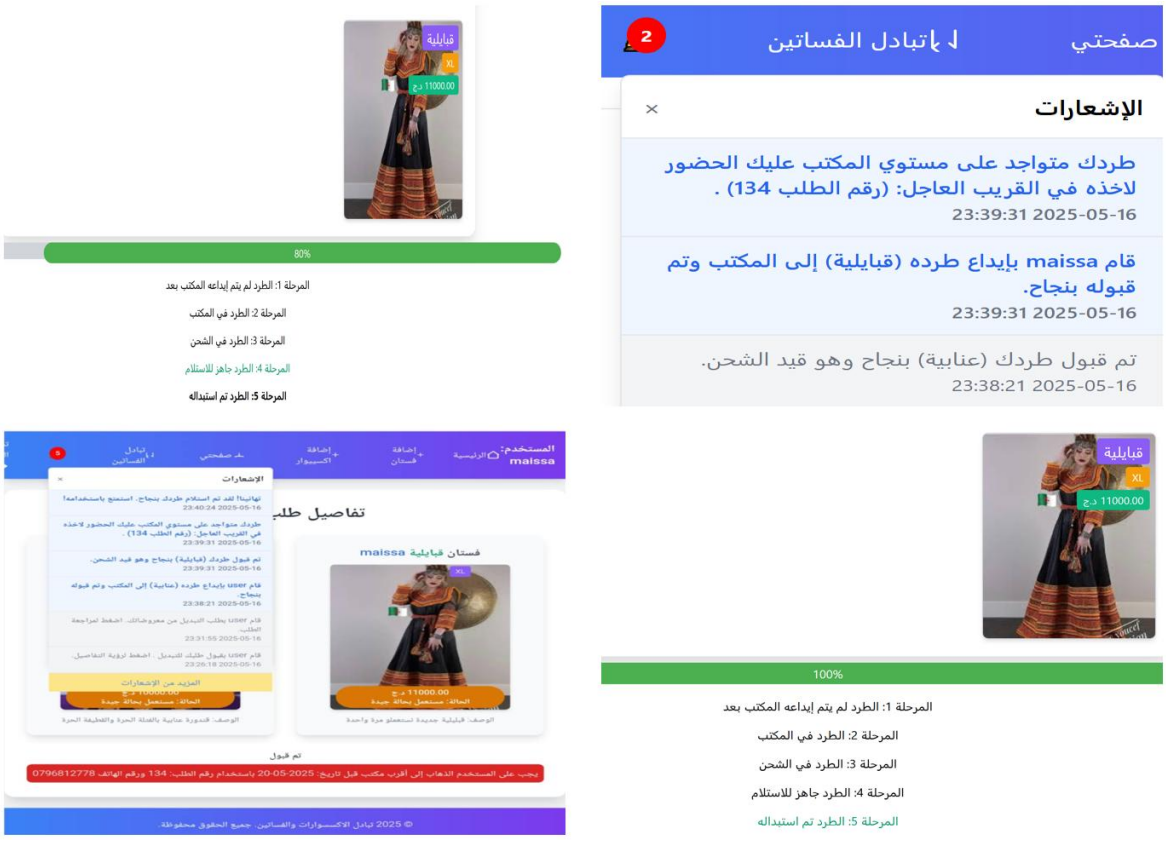


Figure 37: End-of-Deposit Process Interface

9. Conclusion

This chapter described the tools we used to develop our application. We then explained how it functions by presenting its various interfaces, along with the different operations available to each type of user.

Chapter four:

Project Evaluation of the (trade name of the project Bedel-i)Wedding Dresses Exchange PLATFORM under Uncertainty Using Monte Carlo Simulation

1. The depreciation

This project is categorized as a startup initiative. The business will rely on its own equipment and infrastructure — such as office space, furnished rooms, computers, and other tools — which are considered project assets. These are not included in the current operational costs but are recorded in the Income Statement (Compte de Résultat) and classified under depreciation (amortization).

Table (3) : represents the depreciation of the equipment.

element	value/DA	YEARS	DEPRECIATION/ZEARS
computer	70000	5	14000
phone	40000	5	8000
pinter	10000	7	1429
office funiture	20000	4	5000
total			28429

Source: Prepared by the student.

2. Full Process of the Monte Carlo Simulation Model for the wedding dresses Exchange Project

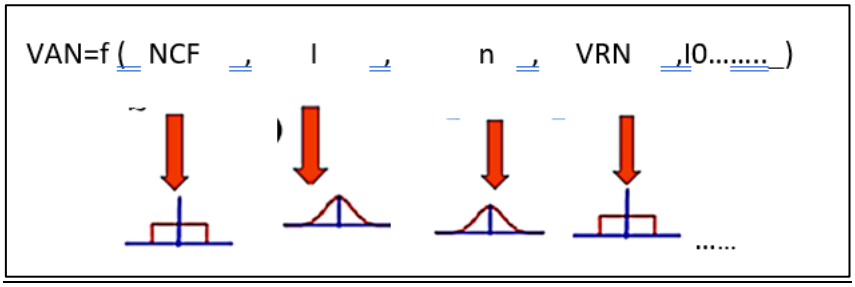
The Monte Carlo simulation process for the women's clothing exchange project can be summarized in three main steps as follows:

- **First**: Identifying the Variables and Determining Their Probability Distributions In this initial stage, it is essential to identify all key economic variables and risk factors. Then, establish the appropriate probability distributions for each variable based on available data, expert opinion, or historical performance.

Determining the Net Present Value (NPV) Formula of the Project**:**

$$\mathbf{NVP} = \sum_{j\_1}^{n} \boldsymbol{NCF}\ \mathbf{(1+i)(1+i)^{-j} + vrn(1+i)^{-j}\ \_I0}$$

The distribution of the variables must be determined.



- S**econd**,. conducting experiments on the mathematical model. This involves repeatedly running simulations for a specified number of iterations—usually ranging between one thousand and five thousand cycles—in order to generate the resulting probability distribution.
- **Third** recording the simulation results. This includes documenting the distribution of the expected net present value (NPV) and its variance using the complete Monte Carlo simulation process. The required software is used to carry out these simulations efficiently.

3. The project's technical data sheet

3.1.Project Title:

A APLICATION NEMED BEDELI for Exchanging Women's traditional and ceremonial gowns and dresses (karakou, KOFTAN ,mensouj , …….-)

3.2.Project Summary:

This project aims to develop a digital platform specifically designed for the exchange of Women's traditional and ceremonial gowns and dresses (karakou, KOFTAN ,mensouj , ….-)

and related accessories. It addresses a real problem faced by many women—the high cost of purchasing Women's traditional and ceremonial gowns and dresses that are typically worn onlyone time , making them an unnecessary financial burden. Theplatforme targets a segment of women looking for economical and sustainable solutions, particularly those with limited income or those interested in sustainable fashion. The platform offers an innovative solution by enabling users to exchange dresses directly with one another, without the need for buying or renting, thereby fostering an interactive community built on trust and collaboration. The application is expected to have a significant social and economic impact by promoting a culture of exchange, reducing waste, and strengthening solidarity among women.

3.3.Market Analysis:

1. **the main target customers**

   The primary target customers for this project are women, particularly:

   - Brides who do not wish to spend large amounts of money on dresses worn only once.
   - Women with limited income.
   - Women interested in sustainable fashion and collaborative economy.
   - Mothers and sisters who wish to support other women within a trustworthy exchange network.

2. **The specific needs, desires, or problems**

   - Reducing the high costs associated with wedding dresses.
   - Finding an alternative to buying or renting.

- Getting rid of unused dresses in a useful way.
- Contributing to waste reduction and promoting reuse.
- The desire to be part of a supportive and empowering women's community.

3. **the early adopters been identified. And the characteristics**

   early adopters can be identified as follows:

   - Women active in Facebook groups dedicated to weddings and second-hand fashion.
   - Users already familiar with second-hand or exchange platforms like wad elkniss online marketplaces.
   - Young university students or young working women from the middle class.
   - Open to trying new ideas based on trust and community.

4. **Is the Dproject defined** as **B to C** (Business to Consumer) or **B to B** (Business to Business) or **B to G** (Business to Government)?

   The project is classified as **B2C** (Business to Consumer), as it directly targets individual women users of the application.

3.4.Financial analysis

1. This project revolves around the development of a mobile application **statistics on the number of potential customers and market size .and sources.**

   based on national statistics:

   - Women represent approximately 49.5% of the Algerian population, meaning more than 22 million women(Only women of all age groups :Any female of all ages, including minors, not just adult women) (World Bank/Global Economy)
   - According to marriage reports about 300,000 weddings are registered annually in Algeria. (Civil Registry Data (ONS)

- In this part of the project, we present a preliminary estimate of the costs required to implement the idea and transform it into an effective digital platform. These costs are categorized into fixed costs and variable costs

3.4.1.Fixed costs list

Tabe (4) : approximate values of fixed costs."

Nature of costs in (DA)	month	year1	YEARS2	years3	years4	years5	years6	years7	years8	years9	years10
workers' salaries.	24000	288000	288000	288000	288000	3E+05	288000	288000	288000	288000	288000
website hosting	10000	120000	120000	120000	120000	1E+05	120000	120000	288000	120000	120000
bills	5000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
insurance costs	5000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
total fixed costs	44000	528000	528000	528000	528000	5E+05	528000	528000	528000	528000	528000

Source: Prepared by the student"

Nature of costs

- Workers' salaries : First member (founder or technical/administrative officer): manages the application, follows up on content, coordinates with the developer, and addresses technical and organizational aspects. ; Second Member (Support and Marketing Officer): Oversees user interaction, order processing, and social media digital marketing campaigns ;

This prototype represents a flexible distribution of tasks that takes into account the specificity of startups and can be developed later by including specialized cadres as the scope of work expands.

- Website hosting
- Bills such as electricity, gas, and internet bills.
- Insurance costs including the Corporate Liability Insurance ,Digital Data Insurance,Employee Social Insurance

3.4.2. VARIABLE COSTS

Table(5) List variable costs

nature of the	quantity	unit price	montly cost	years cost
technical ma	1	6,740	6,740	80880
service prov	1	45,000	45,000	540000
			total	620880

Source: Prepared by the student"

Nature of costs

1. technical material**:**

- Domain Name
- Cloud Database

- Design and programming tools

2. Services provided **:**

- App developer fee
- Digital marketing services
- Technical support service

Assuming an annual increase in variable costs of 10%, we will create this table for 10 years

Table (6) of variable cost results

years	1	2	3	4	5	6	7	8	9	10
variables cos	620880	682968	751264.8	826391.28	909030.408	999933.449	1099926.79	1209919.47	1330911.42	1464002.56

Source: Prepared by the student"

3.4.3.Revenues

Table(7) presents project revenue

years	Visitors	work/year	customers	price OF SERVICE	exchanges /years	rvn/excheges	rvn/advertising	total revenue
1	15	310	8	100 (DA_)	2480	248000	50000	298000
2	20	310	17	100 (DA_)	5270	527000	100000	627000
3	35	310	26	100 (DA_)	8060	806000	150000	956000
4	55	310	35	100 (DA_)	10850	1085000	200000	1285000
5	50	310	44	100 (DA_)	13640	1364000	250000	1614000
6	65	310	53	100 (DA_)	16430	1633000	300000	1933000
7	72	310	62	100 (DA_)	19220	1922000	350000	2272000
8	89	310	71	100 (DA_)	22010	2201000	400000	2601000
9	96	310	80	100 (DA_)	24800	2480000	450000	2930000
10	145	310	100	100 (DA_)	31000	3100000	500000	3600000
							total	18116000

Source: Prepared by the student"

- Years: The table presents revenue forecasts over a 10-year period, starting from year 1 to year 10.
- Visitors: This represents the projected number of people who will visit the " Badel-i " application each year. The number increases progressively due to marketing efforts and word-of-mouth growth.
- Customers: Out of the total visitors, a portion becomes actual users who perform exchanges. The customer count rises steadily each year, reflecting improved user engagement and platform credibility.
- Exchanges: The number of successful clothing exchange transactions completed by users each year. This figure is calculated based on the growing number of customers and their average transaction activity.

- Revenue per Exchange (revenue /exchange): For every successful exchange, the platform charges a fixed service fee of 100 Algerian Dinars. The total annual revenue from exchanges is calculated by multiplying the number of exchanges by 100 DZD.
- Revenue from Advertising (revenue/advertising): As user traffic increases, the app generates additional revenue from in-app advertisements. This revenue is projected to grow annually as the app gains visibility and popularity.
- Total Revenue: This is the sum of revenues generated from both exchange fees and advertising. It provides a full picture of the application's annual financial performance.
- Total (10 Years): Over the span of 10 years, the projected cumulative revenue reaches 18,116,000 Algerian Dinars, highlighting the financial potential and sustainability of the "Badel-i" startup project.

4.Monte carlo simulation application to the project

4.1.Project data

The project we propose to evaluate under conditions of uncertainty and risk is a platform for the exchange of women's clothing among themselves. The choice of this project is justified by the fact that investment in the field of exchange services is attracting interest among women.

Table(8) presents preject data

cutmrs/dat	8		fixed cost	528000	update rat	10%
work/year	310		depreciation	28429	tax	17%
prg life	10				investment a	700000

years	1	2	3	4	5	6	7	8	9	10
cutmrs/dat	8	17	26	35	44	53	62	71	80	100
work/year	310	310	310	310	310	310	310	310	310	310
nmb of exchg/yea	2480	5270	8060	10850	13640	16430	19220	22010	24800	31000
unit price	100	100	100	100	100	100	100	100	100	100
CA	298000	627000	956000	1285000	1614000	1933000	2272000	2601000	2930000	3600000
CV	620880	682968	751264.8	826391.28	909030.408	999933.449	1099926.79	1209919.47	1330911.42	1464002.56
M/CV	-322880	-55968	204735.2	458608.72	704969.592	933066.551	1172073.21	1391080.53	1599088.58	2135997.44
CF	528000	528000	528000	528000	528000	528000	528000	528000	528000	528000
DEPRECIATIO	28429	28429	28429	28429	28429	28429	28429	28429	28429	28429
overall rslt	-879309	-612397	-351693.8	-97820.28	148540.592	376637.551	615644.21	834651.53	1042659.58	1579568.44
tax	##########	#########	######	######	25251.9006	64028.3837	104659.516	141890.76	177252.129	268526.635
net profit	-879309	-612397	-351693.8	-97820.28	123288.691	312609.167	510984.694	692760.77	865407.451	1311041.81
DEPRECIATIO	28429	28429	28429	28429	28429	28429	28429	28429	28429	28429
CAF	-850880	-583968	-323264.8	-69391.28	151717.691	341038.167	539413.694	721189.77	893836.451	1339470.81
update rat	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386

Source: Prepared by the student

4.2.Required rate of return

The required rate of return is the minimum return that the project must achieve to cover the cost of capital and the associated risks. This rate is used as a specific benchmark in the evaluation of financial indicators such as Net Present Value (NPV) and Internal Rate of Return (IRR). Given the specificity of the project and the fact that it is a relatively new activity

4.3 Steps to Apply Monte Carlo Simulation

To achieve an effective simulation using the Monte Carlo model, the following steps must be followed:

Step 1: Preparing the Data Sheet

- After estimating the initial data in the previous section, an Excel sheet is created containing all the information, with the Net Present Value (NPV) formula clearly included.

Step 2: Defining the Parameters of Variables and Their Probability Distributions

- Defining the parameters of the random variables depends on the operational environment of the project**.**
- We assume there are three main parameters, for example:
    - The number of customers per day, which we will name y
    - The total annual revenues realized, which we will name x
    - The investment costs, which we will denote by z

Step 3: Determining the Probability Distribution for Each Variable

- To determine the appropriate probability distribution for each variable

1. As for the first variable **y** it's following the a triangular distribution

Table (9) : Probability Distribution for variables y

years	min	mod	max
1	6	8	10
2	14	17	20
3	22	26	30
4	30	35	40
5	38	44	50
6	47	53	59
7	56	62	68
8	65	71	77
9	74	80	86
10	90	100	101

Source: Prepared by the student

2. For the second variables variables **X** it's follows the **normal distribution**

Table (10) Probability Distribution for variables x

AVERAGE	1811600
Standard deviation	1056289.02

Source: Prepared by the student

3. The total investment cost variable which include both fixed and Variable cost over 10 years was a represented using aJ **triangular distribution** as it is suitable for modeling the variables

Table (11) : Probability Distribution for variables y

Min	9380905.38
Mod	10423228.2
Max	11465550.99

Source: Prepared by the student

Step 4: Random Number Generation in Monte Carlo Simulation

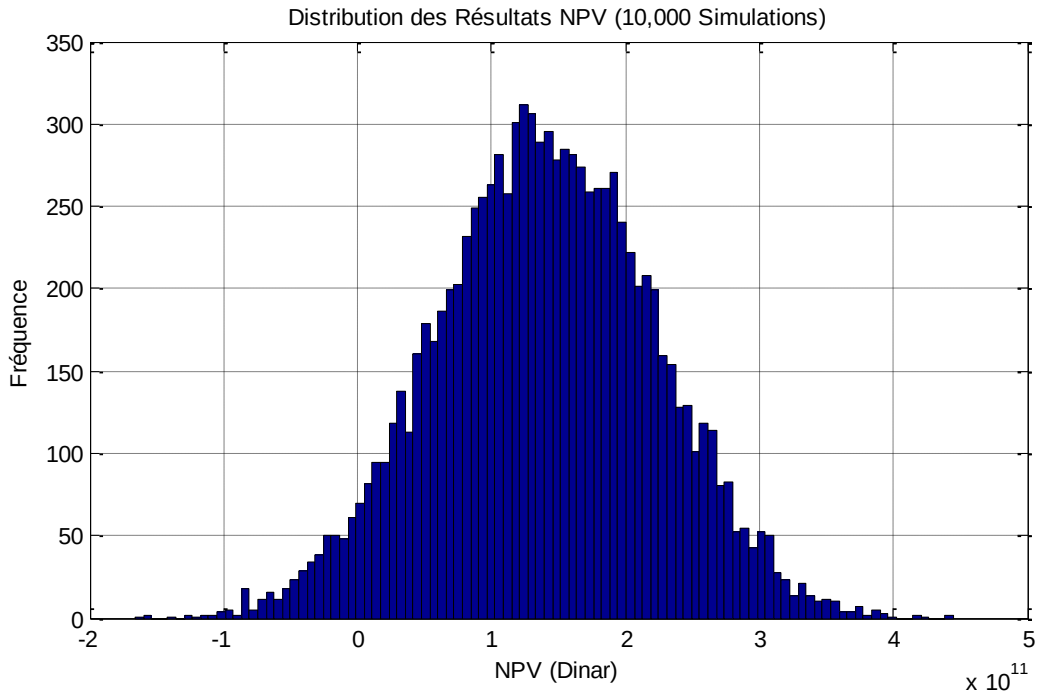
The random number generation phase is a critical step in implementing Monte Carlo simulation. A high-quality random number generator is required to ensure the accuracy and realism of the results. After defining the appropriate probability distributions for input variables (such as revenues, costs, number of customers, etc.) in the software used—such as MATLAB—the simulation settings are configured by selecting the number of iterations, which should ideally be large enough to reduce the margin of error and stabilize the statistical results. Consequently, **n = 100,000** is often adopted as a suitable number of iterations in this type of model.

Next, the system begins generating a series of random numbers according to the previously defined probability distributions. Each set of generated values represents one simulation run, which ultimately allows for the calculation of target financial indicators—such as the **expected net present value (NPV)**—within an environment of uncertainty and risk.

- The number of iterations is chosen using a relatively simple method. We start by entering the number 10,000 initially and observe the evolution of the parameter, i.e., the Net Present Value (NPV). Then, we increase the number of iterations to monitor how this parameter develops, as shown in the following results, until we reach 100,000 iterations, which is the final number retained for analysis.

As shown in the following results

Figure 38: Histogram of Simulated Net Present Value (NPV) – Monte Carlo Simulation with 10,000 Iteration



Source: Prepared by the student

Average NPV: 139903038016.65 DZ

Standard deviation of the VPS: 81816754944.09 DZ

NPV Minimum: -166186431766.03 DZ

NPV Maximum: 444917229901.88 DZ

Probability of Profit: 95.56%

Analysis of Monte Carlo Simulation Results (10,000 Iterations):

1. Mean Net Present Value (NPV Mean):

- 139,903,038,016.65 Algerian Dinars

  This indicates that the average expected Net Present Value (NPV) of the project after 10,000 random trials is approximately 140 billion DZD, which is a highly positive result, suggesting that the project is profitable on average.

2. Standard Deviation of NPV:

- 81,816,754,944.09 Algerian Dinars

The high standard deviation reflects a significant variability in the simulation outcomes, highlighting a clear level of risk. However, this risk may not be critical if the profitability probability remains high.

3. Minimum NPV:

- -166,186,431,766.03 Algerian Dinars

This value suggests that in the worst-case scenarios, the project could incur a loss of more than 166 billion DZD. While rare, such scenarios are important for assessing potential downside risk.

4. Maximum NPV:

- 444,917,229,901.88 Algerian Dinars

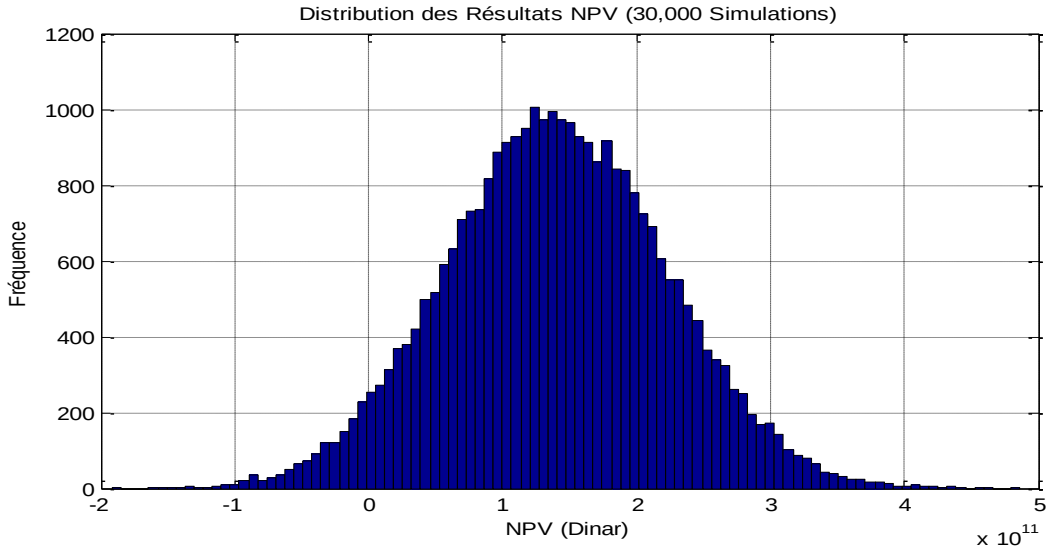
In the best-case scenario, the project could generate up to 444 billion DZD, reflecting high potential profitability under favorable conditions.

5. Probability of Profitability:

- 95.56%

One of the most important results: there is a 95.56% probability that the project will be profitable (NPV > 0). This is a strong indicator of the project's viability despite the uncertainty.

Figure 39: Histogram of Simulated Net Present Value (NPV) – Monte Carlo Simulation with 30,000 Iteration



Source: Prepared by the student

Medium NPV: 140241278992.62 DZ

Standard deviation of the VPS: 82210315613.72 DZ

NPV Minimum: -191310067703.32 DZ

NPV Maximum: 486206920120.46 DZ

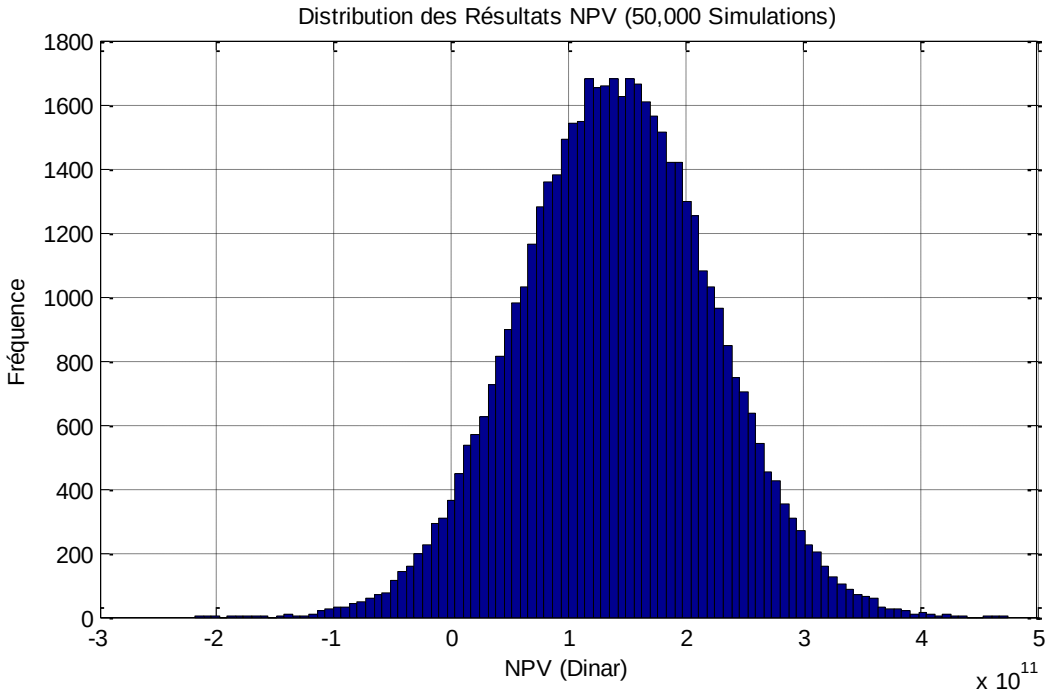
Probability of Profit: 95.61%

Analysis of Monte Carlo Simulation Results (30,000 Iterations)

Simulation Results:

- Mean Net Present Value (NPV):
  140,241,278,992.62 Algerian Dinars
  → The project's average expected NPV after 30,000 simulations is approximately 140.24 billion DZD, indicating strong average profitability.
- **Standard Deviation of NPV:**
  82,210,315,613.72 Algerian Dinars
  → A relatively high standard deviation shows that there is some variability in the outcomes, reflecting moderate risk.
- **Minimum NPV:**
  -191,310,067,703.32 Algerian Dinars
  → In the worst-case scenarios, the project might incur a maximum loss of about 191.31 billion DZD.
- **Maximum NPV:**
  486,206,920,120.46 Algerian Dinars
  → In the best-case scenarios, the project may reach a profit up to 486.2 billion DZD.
- **Probability of Profitability:**
  95.61%
  → This result means that in 95.61% of the simulations, the project's NPV was greater than zero, confirming a high likelihood of profitability**.**

Figure 40: Histogram of Simulated Net Present Value (NPV) – Monte Carlo Simulation with 50,000 Iteration



Source: Prepared by the student

Average NPV: 140728967021.39DZ

NPV Standard Deviation: 81718083054.82 DZ

NPV Minimum: -218679269430.70 DZ

NPV Maximum: 474775274569.61 DZ

Probability of Profit: 95.84%

Simulation Results of Net Present Value (NPV) – Monte Carlo with 50,000 Iterations

Detailed Results:

- **Mean Net Present Value (NPV):**
  140,728,967,021.39 Algerian Dinars
  → This result suggests that the average expected profitability of the project is very high. The mean NPV exceeds 140.7 billion DZD, which reinforces the attractiveness of the project.

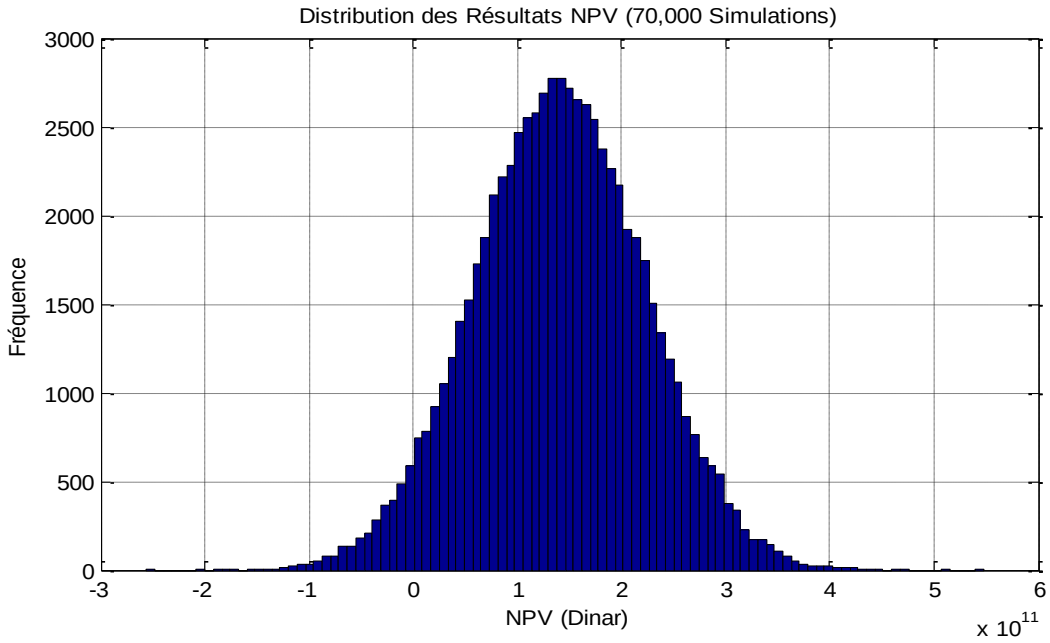
- **Standard Deviation of NPV:**
  81,718,083,054.82 Algerian Dinars
  → The standard deviation remains high, reflecting a notable level of uncertainty and risk, but still within manageable limits given the strong average profitability**.**

- **Minimum NPV:**
  -218,679,269,430.70 Algerian Dinars
  → In extreme worst-case scenarios, the project may result in losses exceeding 218.6 billion DZD. These scenarios, while rare, must be taken into account in the risk assessment process.

- **Maximum NPV:**
  474,775,274,569.61 Algerian Dinars
  → The highest observed NPV in the simulation reaches nearly 475 billion DZD, indicating a very high potential upside under favorable conditions**.**

- **Probability of Profitability:**
  95.84%
  → This key indicator confirms that 95.84% of the scenarios resulted in a positive NPV, making the project highly likely to succeed financially, despite the presence of some risk**.**

Figure 41: Histogram of Simulated Net Present Value (NPV) – Monte Carlo Simulation with 70,000 Iteration



Source: Prepared by the student

Average NPV: 140591318151.26 DZ

NPV Standard Deviation: 81915291235.36 DZ

NPV Minimum: -256221541683.76 DZ

NPV Maximum: 547788959866.04 DZ

Probability of Profit: 95.67

Simulation Results of Net Present Value (NPV) – Monte Carlo with 70,000 Iterations

Detailed Results:

- **Mean Net Present Value (NPV):**
  140,591,318,151.26 Algerian Dinars
  → The average expected profitability of the project remains **very high**, with a mean NPV of approximately **140.59 billion DZD**, confirming the financial attractiveness of your project.

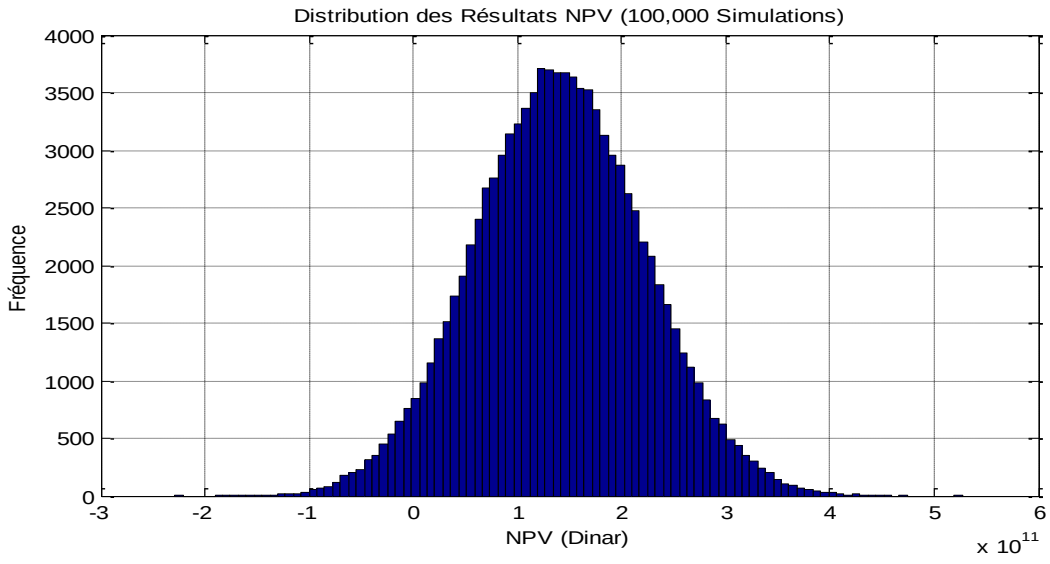
- **Standard Deviation of NPV:**
  81,915,291,235.36 Algerian Dinars
  → This indicates a **moderate level of variability** around the mean. Although the project is generally profitable, there are some risks involved, as expected in entrepreneurial ventures.

- **Minimum NPV:**
  -256,221,541,683.76 Algerian Dinars
  → The **worst-case scenario** shows a possible loss of up to **256.22 billion DZD**, which highlights the importance of risk mitigation strategies.

- **Maximum NPV:**
  547,788,959,866.04 Algerian Dinars
  → The **best-case scenario** predicts a potential gain of nearly **547.79 billion DZD**, showing the strong upside potential if conditions are highly favorable.

- **Probability of Profitability:**
  95.67%
  → This excellent result means that **95.67% of the simulations resulted in a positive NPV**, reinforcing the project's viability and financial strength.

Figure 42: Histogram of Simulated Net Present Value (NPV) – Monte Carlo Simulation with 100,000 Iteration



Source: Prepared by the student

Average NPV: 140459659688.43DZ

NPV Standard Deviation: 81804799514.89 DZ

NPV Minimum: -228371974869.36 DZ

NPV Maximum: 527110776793.91 DZ

Probability OF profit: 95.72%

Simulation Results of Net Present Value (NPV) – Monte Carlo with 100,000 Iterations

Detailed Results:

- **Mean Net Present Value (NPV):**

  140,459,659,688.43 Algerian Dinars
  → This average NPV remains very strong and stable, confirming that your project maintains high profitability expectations even with a large number of simulations.

- **Standard Deviation of NPV:**

  81,804,799,514.89 Algerian Dinars

  → The level of risk and variability remains within reasonable limits. Although fluctuations exist, the magnitude of the average return compensates for them.

- **Minimum NPV:**

  -228,371,974,869.36 Algerian Dinars

  → The worst-case scenario indicates a potential loss of over 228.37 billion DZD, which justifies the importance of planning risk responses and financial buffers**.**

- **Maximum NPV:**
  527,110,776,793.91 Algerian Dinars

  → The best-case scenario projects a gain of more than 527.11 billion DZD, which reflects a high potential return under optimal conditions.

- **Probability of Profitability:**
  95.72%
  → An excellent 95.72% of the iterations resulted in a positive NPV, reinforcing that your project is highly likely to generate profits under uncertainty.

Determining the probability distribution of the Net Present Value (NPV)

After completing the random number generation program, there will be a series of resulting Net Present Value (NPV) values. Then, we need to construct a probability distribution, as illustrated in the following graph

--- NPV Statistics---

Average NPV: 140818073208.34 dinars

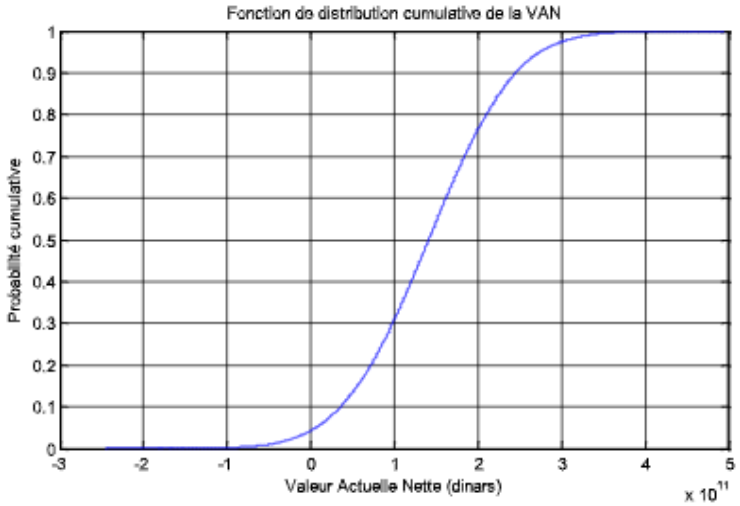
NPV Standard Deviation: 81810392793.47 dinars

Minimum NPV value: -244592272455.34 dinars

Maximum NPV value: 495067931538.08 dinars

Probability of Profit: 95.76%

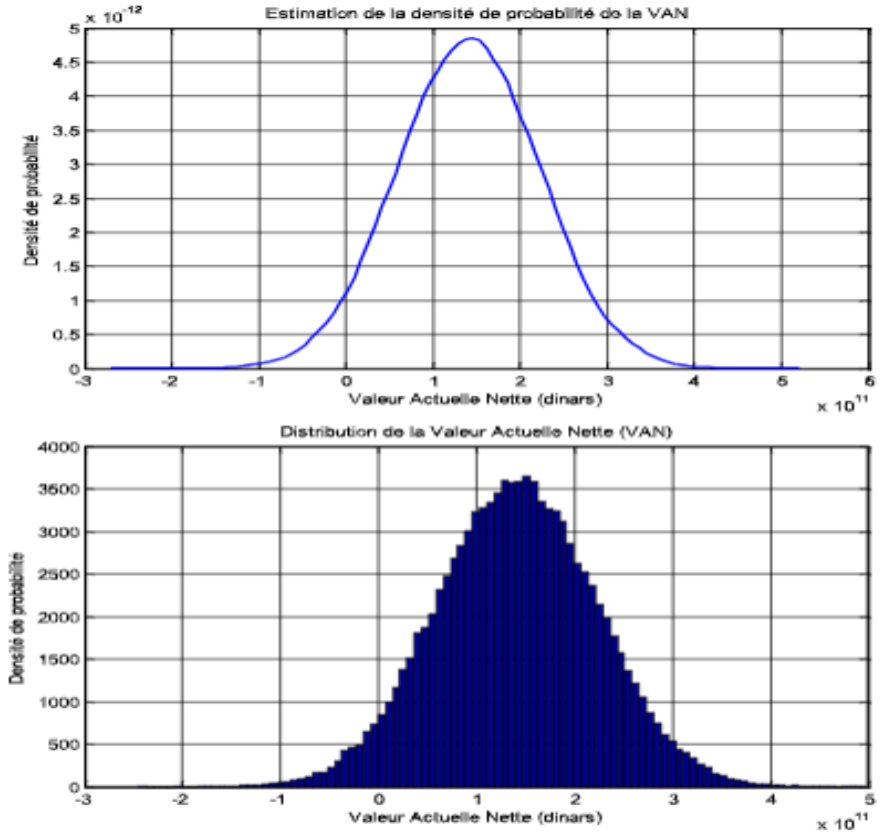
Figure 43: The graph represents Cumulative Distribution Function (CDF



Source: Prepared by the student

The S-shaped curve is typical for normal distributions. This curve is the best tool to confirm **"Probability of Profit: 95.76%".** If you look at the point where the NVP intersects zero (0 dinars) on the horizontal axis, you will find that the corresponding cumulative probability value on the vertical axis is very low (less than 0.05). This means that the probability that the VAN is less than or equal to zero (i.e. a loss or break-even point) is about 1−0.9576=0.0424 or 4.24%. Thus, the probability that the NVP is greater than zero (i.e. make a profit) is 0.9576 or 95.76%, which exactly matches the given value. Range: The curve shows that NVP can range from very large negative values to very large positive values, as shown in Minimum NPV value: -244592272455.34 dinars and Maximum NPV value: 495067931538.08 dinars.

Figure 44: The graph represents the Probability Density Function (PDF) and the histogram."



Source: Prepared by the student

The upper curve and bottom histogram show a bell-like shape (normal distribution), indicating that the majority of net present value (NVP) values are clustered around a certain central value.

The peak distribution is clearly centered in the positive region of the horizontal axis (values in dinars). This exactly matches the **Average NPV : 140818073208.34 dinars,** which means that the project's expected average net present value of the project is a very positive and significant value (about 140.8 billion dinars).

The curve and histogram show a reasonable spread around the mean, reflecting the standard deviation**. NPV Standard Deviation: 81810392793.47 dinars** indicates that there is considerable volatility in possible outcomes, but most of this volatility falls within the positive range of the NVP

Although most of the distribution is in the positive region, there is a small "tail" extending to the negative region of the horizontal axis. This corresponds to **Minimum NPV value: -244592272455.34 dinars,** confirming that there is a possibility, albeit small, that the net present value is negative and reaches this minimum (loss).

To sum up the final: These powerful results from the Monte Carlo simulation confirm that the project: Very high profitability: With an average net present value of more than 140 billion dinars and a profit probability of more than 95%, the project is very attractive from a financial

point of view. Involves limited risk of loss: Although there is a probability of negative NP, this probability is very small (approximately 4.24%). It is characterized by large fluctuations in potential returns: a high standard deviation suggests that results can vary significantly around the average, but more importantly most of this range is in positive territory. It has the potential to generate exceptional returns: the maximum value of THE NVP (495 billion dinars) shows that the project has the potential to generate huge profits in the most optimistic scenarios. Overall, these analyses indicate that this project has a solid financial foundation, with manageable risks and highly attractive expected returns.

Conclusion

Monte Carlo simulation proved to be a highly effective tool in assessing the financial feasibility of the Bedel-i digital platform. By simulating thousands of possible outcomes, it confirmed that the platform has a strong probability of profitability exceeding 90%, even under uncertain market conditions. The analysis also highlighted that the most critical factors influencing financial success are the number of active users and the retention rate. Furthermore, the integration of artificial intelligence significantly improves operational efficiency and contributes to long-term cost reduction. These results support the viability of the platform as a sustainable and scalable business model driven by data-informed decision-making.

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