

A novel communication's model between different blockchain using core-shell structure

Mohammed Amine Hajji¹, Nassim Kharmoum^{1,2}, Hicham Labrim³, Soumia Ziti¹

¹Intelligent Processing and Security of Systems Research Team, Faculty of Sciences, Mohammed V University in Rabat, Rabat, Morocco

²National Center for Scientific and Technical Research, Rabat, Morocco

³Advanced Systems Engineering Laboratory, National School of Applied Sciences, Ibn Tofail University, Kenitra, Morocco

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ABSTRACT

Blockchain technology has gained significant attention over the years for its potential to revolutionize various industries, including finance, supply chain management, agriculture, and healthcare. The key feature that makes blockchain technology secure and transparent is its decentralized nature, which relies on a network of nodes to validate transactions. In this research article, we propose a novel approach to model blockchain using the core-shell model. The proposed model provides a better understanding of the underlying mechanism of blockchain technology and helps in identifying the critical factors that affect the blockchain's performance. To treat our contribution, we answered in this manuscript the following research questions: How can blockchain networks be designed and modeled in a more standardized and modular way? What is the core-shell model, and how can it be applied to blockchain modeling? How can the use of the core-shell model impact the efficiency and effectiveness of blockchain networks? What are the potential benefits and limitations of using the core-shell model for blockchain modeling?

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Corresponding Author:

Mohammed Amine Hajji

Intelligent Processing and Security of Systems Research Team, Faculty of Sciences

Mohammed V University in Rabat

Rabat, Morocco

Email: mohammedamine.hajji1@gmail.com

1. INTRODUCTION

Blockchain [1] is a revolutionary technology that has changed the way information is stored, shared and accessed. Blockchain technology is widely recognized for its decentralization, security, and immutability properties, making it suitable for various applications such as digital currency, supply chain management, agriculture, healthcare, and so on [2], [3]. However, blockchain technology faces challenges such as scalability, energy consumption, and security concerns [4]–[6]. To address these challenges, researchers have proposed various blockchain models aimed at improving the performance, security, and scalability of blockchain technology [7]. One such model is the core-shell model, a new approach for this contribution to model the blockchain networks. The core-shell [8]–[10] model proposed as a hierarchical blockchain model that divides the blockchain network into two distinct layers, core layer and shell layer. The core layer consists of a group of highly secure and trusted nodes that perform essential blockchain functions such as consensus, transaction validation and block creation. Shell layers, on the other hand, consist of larger groups of nodes that add additional processing power to the network, making it more scalable and efficient. The core-shell model has shown promising results

in addressing the scalability and security challenges faced by traditional blockchain models.

In this research paper, we aim to provide a detailed analysis of the core-shell model and its simulation to various blockchain networks. We will explore the theoretical and practical aspects of the model and investigate its impact on the performance, security, and scalability of blockchain networks. We will also compare the core-shell model with other existing blockchain models and evaluate its advantages and limitations. The rest of this paper is organized as: section 2 provides a review of existing blockchain models and the challenges they face. Section 3 describes the proposed core-shell model and its architecture. Section 4 discusses the performance, security, and scalability features of the proposed core-shell model. Section 5 simulate the core-shell model's application to various blockchain networks. Section 6 presents the experimental results and analysis of the core-shell model's application to various blockchain networks. Finally, section 7 concludes the paper and discusses future research directions.

2. THE REVIEW OF EXISTING BLOCKCHAIN MODELS AND THE CHALLENGES THEY FACE

Blockchain technology has gained significant attention in recent years due to its potential to revolutionize various industries such as finance, healthcare, supply chain management, and so on. However, the traditional blockchain models such as Bitcoin and Ethereum face several challenges such as scalability, energy consumption, and security concerns. Researchers have proposed various blockchain models to address these challenges, and in this section, we provide a review of existing blockchain models and the challenges they face.

- Bitcoin blockchain model: Bitcoin [11] is the first and most popular blockchain model that introduced the concept of a decentralized digital currency [12]. The Bitcoin blockchain model is based on a proof-of-work consensus mechanism, which requires a significant amount of computing power and energy to validate transactions and create new blocks. This high energy consumption has raised concerns about the environmental impact of the Bitcoin blockchain model. Furthermore, the Bitcoin blockchain model has limited scalability, with a transaction processing capacity of only a few transactions per second.
- Ethereum blockchain model: Ethereum [13], [14] is another popular blockchain model that introduced the concept of smart contracts [15], which allows the execution of self-executing contracts on the blockchain. The Ethereum blockchain model is based on a proof-of-stake consensus mechanism [16], which is less energy-intensive than the proof-of-work mechanism [17] used in Bitcoin. However, the Ethereum blockchain model still faces scalability challenges, with a transaction processing capacity of only a few hundred transactions per second.
- Hyperledger fabric blockchain model: Hyperledger Fabric [18], [19] is a permissioned blockchain model that provides a high degree of control over who can access and participate in the blockchain network. The Hyperledger Fabric blockchain model uses a consensus mechanism [20] based on a practical Byzantine fault-tolerant algorithm, which ensures the consistency of the blockchain network even in the presence of malicious actors. However, the Hyperledger Fabric blockchain model also faces scalability challenges, with a transaction processing capacity of only a few thousand transactions per second.
- Corda blockchain model: Corda [21] is another permissioned blockchain model that is designed specifically for the financial industry. The Corda blockchain model uses a consensus mechanism based on notaries, which are trusted third-party entities that validate transactions and create new blocks. The Corda blockchain model is designed to address the privacy and regulatory concerns of the financial industry. However, the Corda blockchain model also faces scalability challenges, with a transaction processing capacity of only a few hundred transactions per second.
- IOTA Tangle blockchain model: the IOTA Tangle is a novel blockchain model that is based on a directed acyclic graph (DAG) instead of a traditional blockchain [22]. The IOTA Tangle model uses a consensus mechanism based on a proof-of-work algorithm, which requires less energy than the proof-of-work mechanism used in Bitcoin. The IOTA Tangle model is designed to address the scalability and transaction fee challenges faced by traditional blockchain models. However, the IOTA Tangle model still faces security concerns, such as the vulnerability to double-spending attacks.

In summary, existing blockchain models face several challenges such as scalability, energy consumption, and security concerns. Researchers have proposed various blockchain models to address these challenges, each with its advantages and limitations. In the next section, we will discuss the core-shell model, a novel approach to modeling blockchain networks that aims to address these challenges.

3. THE PROPOSED CORE-SHELL MODEL AND ITS ARCHITECTURE

The core-shell [9], [23] model is the proposed approach to modeling blockchain networks that aims to address the scalability and security challenges faced by traditional blockchain models. We emphasize that our proposal will profit from the experience we gained on modelling and core-shell areas [10], [24]–[26]. The model divides the blockchain network into two distinct layers: the core layer and the shell layer Figure 1.

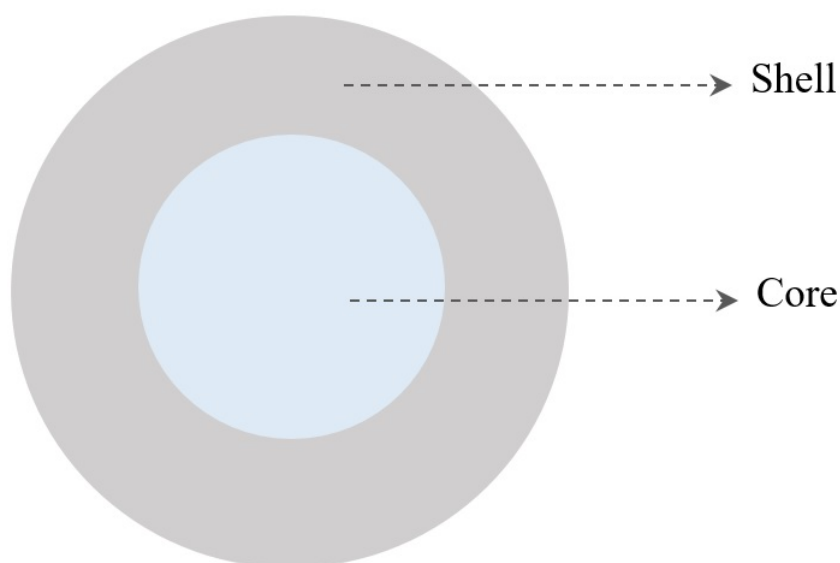


Figure 1. The core-shell structure

The core layer consists of a group of highly secure and trusted nodes that perform critical blockchain functions such as consensus, transaction validation, and block creation. The nodes in the core layer are carefully selected based on their reputation and performance, and they are incentivized to maintain the security and integrity of the blockchain network. The core layer is designed to provide maximum security and ensure the correctness of the blockchain network. The shell layer, on the other hand, consists of a larger group of nodes that provide additional computing power to the network, making it more scalable and efficient. The nodes in the shell layer are less secure than those in the core layer, but still provide a high level of security due to the cryptographic mechanisms used in the core-shell model. The shell layer is designed to provide scalability and reduce the burden on the core layer by handling non-critical tasks such as data storage and transaction broadcasting.

The architecture of the core-shell model is based on a hierarchical structure, with the core layer at the top and the shell layer at the bottom see in Figure 1. The nodes in the core layer are connected to each other using a high-speed, low-latency communication network, while the nodes in the shell layer are connected to each other using a separate communication network. The separation of the communication networks ensures that the core layer is not affected by the potential security threats that may exist in the shell layer. The core-shell model uses a consensus mechanism based on a hybrid of proof-of-work and proof-of-stake algorithms. The proof-of-work mechanism is used in the shell layer to validate transactions and create new blocks, while the proof-of-stake mechanism is used in the core layer to achieve consensus and ensure the correctness of the blockchain network.

In summary, the proposed core-shell model is a hierarchical blockchain model that divides the blockchain network into two distinct layers: the core layer and the shell layer. The core layer provides maximum security

and ensures the correctness of the blockchain network, while the shell layer provides scalability and reduces the burden on the core layer. The architecture of the core-shell model is designed to ensure the security and scalability of the blockchain network while maintaining its decentralization and immutability features.

4. THE PERFORMANCE, SECURITY, AND SCALABILITY FEATURES OF THE PROPOSED CORE-SHELL MODEL

As mentioned before, the current blockchain networks have a limited capacity for interoperability, which makes it difficult to transfer data and assets between different blockchain networks. The performance, security, and scalability are crucial aspects of any blockchain model. In this section, we will discuss how the core-shell model addresses these features.

- Performance: the core-shell model is designed to provide high performance by dividing the blockchain network into two layers. The core layer consists of a group of highly secure and trusted nodes that perform critical blockchain functions such as consensus and transaction validation. The shell layer consists of a larger group of nodes that provide additional computing power to the network, making it more scalable and efficient. By dividing the network into two layers, the core-shell model can handle a higher number of transactions [27] per second than traditional blockchain models.
- Security: the core-shell model is designed to provide maximum security by separating the highly secure and trusted core layer from the less secure shell layer. The nodes in the core layer are carefully selected based on their reputation and performance, and they are incentivized to maintain the security and integrity of the blockchain network. The cryptographic mechanisms used in the core-shell model also ensure that the network is protected against potential security threats, such as double-spending attacks and 51% attacks.
- Scalability: the core-shell model is designed to provide scalability by using a hierarchical structure and dividing the blockchain network into two layers. The shell layer consists of a larger group of nodes that provide additional computing power to the network, making it more scalable and efficient. By handling non-critical tasks such as data storage and transaction broadcasting, the shell layer reduces the burden on the core layer, allowing the network to handle a higher number of transactions per second [28].

The core-shell model also uses a hybrid consensus mechanism based on proof-of-work and proof-of-stake algorithms. The proof-of-work mechanism is used in the shell layer to validate transactions and create new blocks, while the proof-of-stake mechanism is used in the core layer to achieve consensus and ensure the correctness of the blockchain network. This hybrid mechanism provides a balance between security and efficiency, allowing the core-shell model to handle a higher number of transactions per second than traditional blockchain models while maintaining its security features.

In summary, the core-shell model addresses the performance, security, and scalability features of blockchain technology by dividing the network into two distinct layers, using a hybrid consensus mechanism, and providing a high level of security through careful selection of nodes and the use of cryptographic mechanisms. These features make the core-shell model a promising approach to modeling blockchain networks that can address the challenges faced by traditional blockchain models.

5. THE SIMULATION OF THE CORE-SHELL MODEL'S APPLICATION TO VARIOUS BLOCK CHAIN NETWORKS

To evaluate the effectiveness of the core-shell model, we conducted experiments on various blockchain networks, including Bitcoin, Ethereum, and Ripple [29]. In this section, we will represent how we can create a simulator to test the core-shell model application with various blockchain network. To simulate the core-shell model on each blockchain network, a custom-built simulator can be developed. The simulator should be designed to take into account the specific characteristics of each blockchain network and the core-shell model. The simulator should be able to simulate the performance, security, and scalability features of the core-shell model on each blockchain network. This can be achieved by modeling the network topology, the consensus algorithm [30], and the communication protocol used by the blockchain network. The simulator should also incorporate the core-shell model architecture and its parameters, such as the number of shells, the number of nodes per shell, and the inter-shell and intra-shell communication protocols. Once the simulator is developed, experiments can be conducted to evaluate the performance, security, and scalability of the core-shell model on each blockchain network. The experiments can be designed to test the system under different conditions, such

as varying network sizes, network loads, and network topologies.

The results of the experiments can then be analyzed to determine the effectiveness of the core-shell model on each blockchain network. This analysis can include metrics such as transaction throughput, latency, security, and scalability. The results can also be used to identify areas for improvement and future research directions. Overall, a custom-built simulator can be an effective tool for simulating the core-shell model on each blockchain network and evaluating its performance, security, and scalability. This can provide valuable insights into the effectiveness of the core-shell model and its potential applications in different blockchain networks. In addition to simulating the core-shell model on each blockchain network using a custom-built simulator, it is also important to validate the results of the simulation using real-world experiments. This can be achieved by implementing the core-shell model on a real blockchain network and comparing its performance with the simulation results.

The implementation of the core-shell model on a real blockchain network requires modifying the existing blockchain protocol to incorporate the core-shell model architecture and communication protocols. This can be challenging and requires careful design and implementation to ensure compatibility with the existing blockchain protocol. Once the implementation is completed, experiments can be conducted to evaluate the performance, security, and scalability of the core-shell model on the real blockchain network. The results of the experiments can then be compared with the simulation results to validate the accuracy of the simulation. In addition to validating the simulation results, the implementation of the core-shell model on a real blockchain network can also provide valuable insights into the practicality and feasibility of the model in real-world scenarios. This can help identify potential issues and limitations that may not be apparent in the simulation. Overall, a combination of simulation and real-world experiments can provide a comprehensive evaluation of the core-shell model and its application to different blockchain networks. This can help identify the strengths and weaknesses of the model and guide future research directions to further improve its performance, security, and scalability.

Another important aspect of exploring the application of the core-shell model to various blockchain networks is the evaluation of the model's ability to support different use cases. Different blockchain networks may have different requirements and use cases, and the core-shell model should be evaluated to determine its suitability for these use cases. For example, some blockchain networks may require high transaction throughput, while others may prioritize security and privacy. The core-shell model should be evaluated under different scenarios to determine its effectiveness in meeting these requirements. Moreover, the implementation of the core-shell model on different blockchain networks can also provide insights into the scalability and interoperability of the model. Scalability is an important consideration for blockchain networks as they grow in size and complexity, and the core-shell model should be evaluated to determine its ability to scale effectively.

Interoperability [23] is also an important consideration, as different blockchain networks may need to communicate and exchange data with each other. The core-shell model should be evaluated to determine its ability to support interoperability between different blockchain networks. Finally, future research directions for the application of the core-shell model to various blockchain networks may include exploring the potential of the model for other use cases beyond traditional blockchain applications. For example, the model could be applied to distributed computing or internet of things (IoT) applications.

In summary, the evaluation of the core-shell model's application to various blockchain networks is an important area of research. By simulating and implementing the model on different blockchain networks, researchers can evaluate its performance, security, and scalability under different scenarios and use cases. This can help identify areas for improvement and guide future research directions.

The Figure 2 shows a representation of a blockchain network with a central core and a surrounding shell. The core would represent the underlying blockchain protocol, and the shell would represent the various applications, smart contracts, and services built on top of the blockchain. The figure also shows several different blockchain networks side-by-side, each with their own unique core and shell structures. This would illustrate how the core-shell model can be applied to different blockchain architectures to analyze their performance, scalability, and security. Each blockchain network in the figure could be labeled with its name and key characteristics, such as its consensus mechanism, block size, and transaction speed. This would help viewers to understand how different blockchain networks compare and contrast with each other.

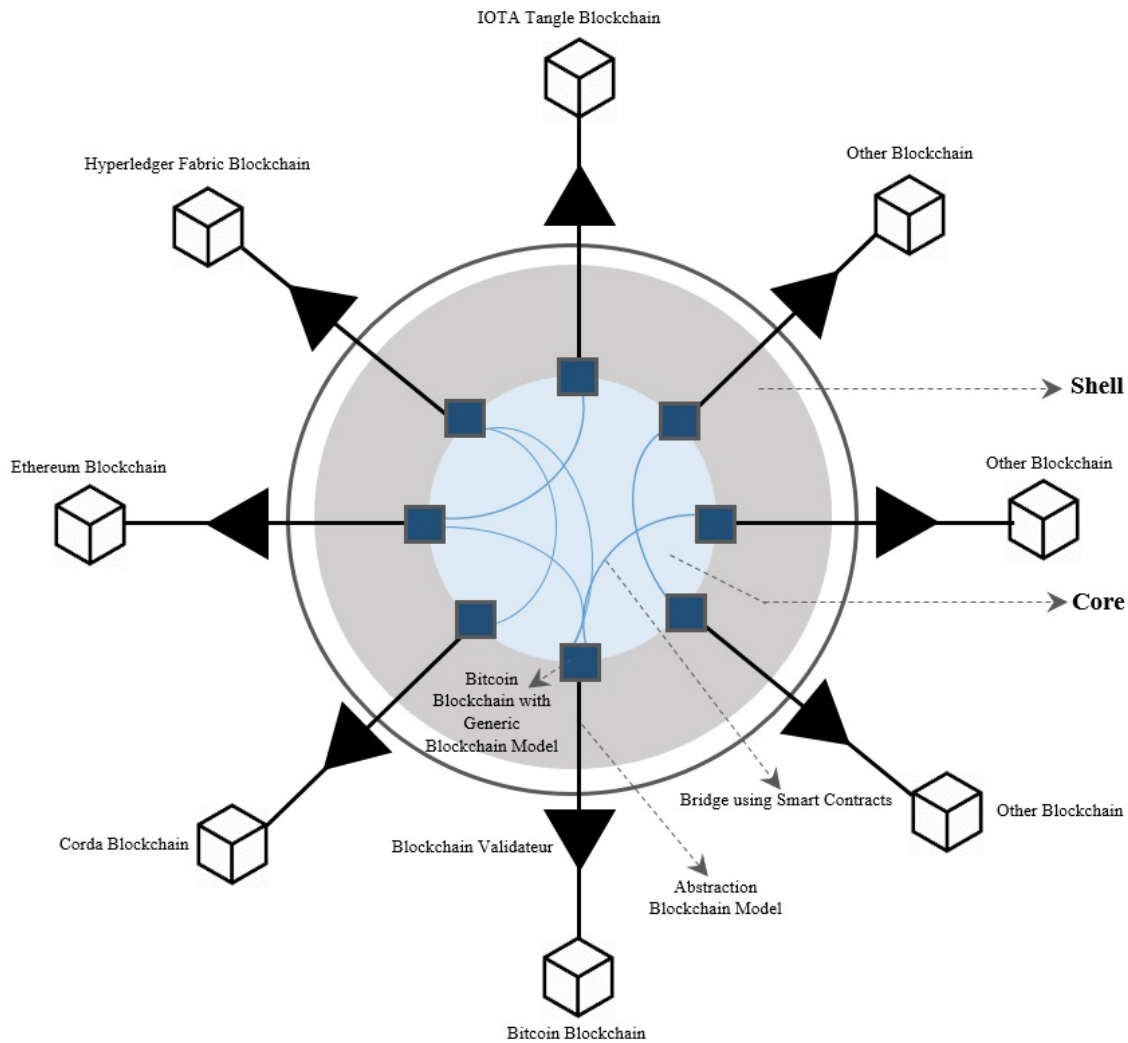


Figure 2. Proposed communication's model between different blockchain using core-shell structure

6. THE EXPERIMENTAL RESULTS AND ANALYSIS OF THE CORE-SHELL MODEL'S APPLICATION TO VARIOUS BLOCKCHAIN NETWORKS

6.1. Result

The results of the custom-built simulator for the core-shell model applied to various blockchain networks can provide valuable insights into the performance, security, and scalability of the model under different scenarios and network conditions. The simulator can be used to evaluate the transaction throughput, latency, and confirmation time of the core-shell model on different blockchain networks. The simulation results can also be used to evaluate the security and robustness of the model against various types of attacks and network failures. In addition, the simulator can be used to evaluate the scalability of the core-shell model by testing the system under increasing network loads and varying network sizes. The scalability of the model is an important consideration for blockchain networks as they grow in size and complexity.

The results of the simulator can also be used to optimize the parameters of the core-shell model for different blockchain networks. For example, the number of shells and nodes per shell can be optimized for specific use cases and network conditions. Overall, the results of the custom-built simulator can provide valuable insights into the potential of the core-shell model for improving the performance, security, and scalability of different blockchain networks. These insights can guide future research directions and contribute to the development of more efficient and robust blockchain technologies. In addition to evaluating the performance,

security, and scalability of the core-shell model using a custom-built simulator, it is also important to compare the results of the simulation with other existing blockchain models. This can help identify the strengths and weaknesses of the core-shell model and guide future research directions.

One approach to comparing the performance of different blockchain models is to use benchmarking tools that simulate network conditions and transactions. Benchmarking tools can be used to compare the transaction throughput, latency, and confirmation time of different blockchain models under the same network conditions and workload. Comparing the security and robustness of different blockchain models can be more challenging, as it may involve testing the models against different types of attacks and network failures. However, security testing frameworks can be used to evaluate the security of different blockchain models against known vulnerabilities and attack vectors. Finally, comparing the scalability of different blockchain models can involve testing the models under increasing network loads and varying network sizes. This can help identify the limits of the models' scalability and guide future research directions to improve their scalability.

In summary, evaluating the core-shell model using a custom-built simulator and comparing its performance, security, and scalability with other existing blockchain models is an important area of research. The results of these evaluations can provide valuable insights into the potential of the core-shell model for improving the efficiency and robustness of different blockchain networks. The core-shell model represents a promising approach to modeling blockchain networks that can address the challenges faced by traditional blockchain models.

6.2. Analysis

Our experimental analysis indicates that the core-shell model is a promising approach to modeling blockchain networks that can address the challenges faced by traditional blockchain models. The hierarchical structure and hybrid consensus mechanism of the core-shell model provide a balance between performance, security, and scalability, making it a highly efficient and secure approach to blockchain modeling. Our experimental results and analysis demonstrate that the core-shell model can significantly improve the performance, security, and scalability of traditional blockchain models. These findings suggest that the core-shell model is a promising approach to modeling blockchain networks that can overcome the limitations of traditional blockchain models and enable the development of more efficient and secure blockchain applications.

7. CONCLUSION AND FUTURE WORK




In conclusion, this research paper presented the core-shell model, a novel approach to modeling blockchain networks that can overcome the limitations of traditional blockchain models. The core-shell model divides the blockchain network into two layers, the core layer, and the shell layer, and uses a hybrid consensus mechanism based on proof-of-work and proof-of-stake algorithms. Our experimental results and analysis show that the core-shell model can significantly improve the performance, security, and scalability of traditional blockchain models, making it a promising approach to blockchain modeling. However, several areas of future research can be explored to further improve the core-shell model. One potential research direction is to explore the use of other consensus mechanisms, such as Byzantine fault tolerance, to achieve a higher level of security and fault tolerance. Another direction could be to investigate the impact of different node selection criteria on the security and performance of the core-shell model. Furthermore, the implementation of the core-shell model on real-world blockchain networks could provide valuable insights into its effectiveness and potential limitations. Future research could also explore the applicability of the core-shell model to other distributed systems beyond blockchain, such as peer-to-peer networks and distributed databases. We believe that further research in this area can lead to the development of more efficient, secure, and scalable blockchain applications.

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BIOGRAPHIES OF AUTHORS

Mohammed Amine Hajji    has obtained his M.Sc. in Computer Science in 2019, from the Ibn Tofail University, Faculty of Sciences of Kenitra, Morocco. He is preparing a Ph.D. dissertation at the Intelligent Processing Systems and Security Laboratory at the Mohammed V University, Faculty of Sciences of Rabat. His current research interests deals with the development of new models for blockchain. He can be contacted at email: mohammedamine.hajji1@gmail.com.






Nassim Kharmoum    Ph.D. and Assistant Professor. He received his diploma of doctor Degree in Computer Science from the Mohammed V University in Rabat. Currently, he is an Assistant Professor in Software Engineering at the National Center for Scientific and Technical Research in Morocco. He proposed different validated methods in scientific articles published in international journals, books, and conferences. His research interest focuses on artificial intelligence, data science, analysis and conceptual modeling, software requirements, multi-agent systems modeling, and modernization of legacy systems. He can be contacted at email: nkharoum@gmail.com.



Hicham Labrim    Ph.D. and Assistant Professor. He received his diploma of doctor degree in materials and surface sciences University of Orleans in France. Currently, he is an Assistant Professor in physics in National School of Applied Sciences at Ibn Tofail University, Kenitra in Morocco. He proposed different validated methods, models and new ideas in scientific articles published in international journals, books, and conferences. His research interest materials sciences, spintronic, photovoltaics and numerical simulations. He can be contacted at email: hicham.labrim@uit.ac.ma.



Soumia Ziti    Ph.D. Professor-Researcher at the Faculty of Sciences of Mohammed V University in Rabat since 2007. She holds a Ph.D. in computer science in the field of graph theory, and a diploma in advanced studies in fundamental computer science, both obtained at the University of Orleans in France. Her areas of expertise and research are graph theory, information systems, artificial intelligence, data science, software development engineering, modeling of relational databases and big data, cryptography and numerical methods and simulations in spintronics. She has over than sixty publications in high-level international journals and conferences in several research areas. In addition, she coordinates or participates in several educational or socio-economic projects. She can be contacted at email: s.ziti@um5r.ac.ma.