

An innovative blockchain-based system for human resources digitalization with traceable relationship management

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Abstract. Small and Midsize Enterprises (SMEs) have faced innovative changes in their organizational structure, especially in human resources (HR) and employee management: these digital structural changes have transformed their business practices and strategies. The employees with new technical skills have also been impactful in this digitalization. The HR departments in SMEs have become increasingly pivotal in recruiting new employees and supporting existing employees throughout the organization. ITSvil in Salerno (Italy) has developed the Easywork project based on the “Fenice” microservices architecture. This system supports the HR departments in efficiently managing HR activities through digitalization. The first step in acquiring new resources is formulating the employment contract, which is essential for stipulating agreements on specific job requirements. Blockchain technology and smart contracts are among recent technological innovations impacting this process. Writing contracts in digital codes to simplify and effectively manage the legal relationship involving bureaucratic tasks and cost management is now possible. The new digital system makes employment contract processing transparent, traceable, and reliable. This research presents the design and development of a new microservice compatible and integrable process with the “Fenice” system based on blockchain technology. The proposed digital system aims to make HR management activities more transparent and traceable.

1 Introduction

The growing interest of business organizations in human resources (HR) has reached impressive heights. In today's competitive landscape, the quality and expertise of the HR department have emerged as pivotal competitive advantages across diverse industry sectors [1]. Over the past decade, the domain of business companies has navigated through profound technological revolutions, leading to changes in professional roles' demand. In particular, the development of IT skills has become crucial for a company's value. This

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requires changes and improvements in how human resources are managed within the company [11]. Addressing this evolving landscape, the adoption of blockchain technology [9] has emerged as a pivotal solution. This is proving instrumental in resolving pertinent challenges. This includes the validation and certification of candidates' skills and qualifications, the identification of optimal profiles, and the programmatic management of contracts [20]. These applications extend to initiatives such as incentivizing exceptional candidates through Token-based retention plans, Token options, vouchers, or NFTs [15]. Through the secure and transparent recording of data, the blockchain ecosystem ensures unparalleled security, making the database impervious to hacking attempts [12]. One of the most important moments in the hiring process is during the formulation of the employment contract [19]. Here the idea of smart legal contracts emerges, which are executed as blockchain-based smart contracts [10]. Smart legal contracts facilitate the automatic execution of predefined actions exclusively when all conditions specified within the agreement are fulfilled. In doing so, these contracts guarantee clarity of terms, streamline document signing procedures, authorize the onboarding process for new employees, and enable seamless and instantaneous remuneration for completed tasks, contingent on specific predefined criteria. It is crucial to recognize that technological innovations wield a multifaceted influence on the realm of work. The emergence of new technologies has sparked debates about their impact on the job market. Some believe that these innovations may replace human workers with machines, while others argue that they are valuable tools that simplify tasks that were once tedious and repetitive. In this digitally driven context, the imperatives of data security and confidentiality, coupled with the demand for swiftness and transactional certainty, stand as central concerns. As the journey towards work digitization gathers momentum, the dual challenges of data protection and transactional efficiency command unwavering attention.

1.1 Problem Statement

The domain of blockchain and smart contracts is often predominantly associated with supply chain management [14] and emerging digital consumption models [13]. While this perspective focuses on tracking the production phases of goods, it can be extended to encompass the entire spectrum of recruitment and employment phases. This novel "lifecycle" approach could serve as the foundation for recording comprehensive employee information, from their initial engagement with the company to their potential resignation. The initial step in onboarding new talented individuals involves formulating the employment contract, a critical component for establishing sector-specific and occupational agreements. Subsequently, throughout an employee's career journey, there are performance assessments, training opportunities, career advancements, and a constant pursuit of new goals. This intricate process leads to interaction across various segments of the organization, without any interruption. This is precisely where blockchain technology emerges as a potential solution, capable of streamlining HR operations.

1.2 Related Works

The pervasive influence of technological advancement manifests in the widespread integration of blockchain technology and the implementation of smart contracts. The scholarly community has extensively delved into this phenomenon, proposing a plethora of innovative solutions within the realm of HR management. These innovations encompass pioneering mechanisms founded on blockchain technology, aiming to imbue the company's human resource management system with accuracy, efficiency, openness, and transparency [21].

The spectrum of applications for this technology spans systems orchestrating core processes, facilitating a more strategic approach in a traceable manner [3]. A comprehensive examination reveals that blockchain for human resource management can revolutionize systems spanning from the hiring process to employee payment interactions. In doing so, it enhances and traces every stage of the employment lifecycle [2]. The technology finds particularly robust usage in systems dedicated to candidate selection for organizations. The implementation of smart human resource management systems has significantly truncated the time needed for candidate selection processes, concurrently predicting employee performance [5]. Furthermore, leveraging smart contracts enables the development of personalized spaces for employees to showcase their skills and expertise, effectively constructing an inter-organizational network that catalogues achievements and tracks performance [6]. This mechanism proves invaluable for enabling precise job allocation, securely sharing HR management data across organizations, and validating all transactions and tasks executed. Consequently, the HR department can streamline and expedite the recruitment strategy, which was previously marred by time-consuming processes [7].

The use of blockchain technology addresses traditional human resource management challenges related to employee personal information verification, task information evaluation, task feedback efficiency, and salary incentive fairness. This mechanism promotes transparency, fairness, and openness in human resource management while ensuring rapid information updates and feedback without significant third-party interference. Furthermore, exploring smart contract integration and resolving token issues within the consensus mechanism represents promising future research directions for human resource management scenarios [21]. The growth of smart device usage and internet technology has heightened the importance of the authenticity of human resource information, such as the system of certification [16]. HR department must be aware of risks caused by information asymmetry constantly brings economic loss. By instituting a model based on BC, it provides cost-efficient, third-party independent assistance for decision-making, diminishing risks related to data authenticity, improving data differentiation, and enhancing the efficiency and effectiveness of human resource management information [18]. Numerous studies have tackled HR management's complex decision-making challenges. As this innovative approach moved from early adopters to early majorities, it gained momentum, and blockchain has become essential for adapting to the new normal. Recent research will confidently encourage managers to adopt this innovation in their company's operations [17].

Undoubtedly, the role of smart contracts in contemporary enterprise management systems is of paramount significance. Their deployment within systems fostering the interaction of contractual processes across multiple organizations is particularly remarkable. Such an approach capitalizes on a blockchain-adaptive contract management system that orchestrates and interconnects intricate contracts, thereby enhancing mechanisms like dispute resolution among contracting parties [8]. In the ever-evolving landscape of HR management, the fusion of blockchain technology and smart contracts stands as a hallmark of innovation, heralding a paradigm shift towards streamlined, transparent, and efficient practices. This symbiotic relationship has the potential to redefine the trajectory of HR practices, enhancing collaboration, data security, and strategic decision-making across organizational boundaries.

1.3 Context Analysis

The literature review highlights the pervasive influence of technological advancement, specifically focusing on the integration of blockchain technology and the implementation of

smart contracts in the field of human resource management (HRM). It is evident how the adoption of blockchain technology in HRM achieves accuracy, efficiency, openness, and transparency. In the context of our analysis, it becomes crucial the need of human resources to implement strategic internal processes, such as the selection of candidates with specific hard skills, employee payment transactions, and the overall employment lifecycle management. As indicated by the spectrum of applications, blockchain technology emerges as a promising candidate to optimize these processes, covering a broad range of activities from core processes to strategic approaches. The technology is particularly robust in candidate selection, reducing time and predicting employee performance. Implementation of smart HR management systems is highlighted, showcasing the role of smart contracts in expediting, and streamlining recruitment strategies. The need for personalized spaces for employees is created, forming an inter-organizational network that catalogues achievements and tracks performance. Blockchain technology is applied to address challenges related to employee personal information verification, task information evaluation, task feedback efficiency, and salary incentive fairness. The mechanism promotes transparency, fairness, and openness while ensuring rapid information updates and feedback without significant third-party interference. The literature recognizes the paramount significance of smart contracts in contemporary enterprise management systems. Smart contracts are deployed to foster interaction among contractual processes across multiple organizations, with a focus on enhancing mechanisms like dispute resolution among contracting parties. In this way is possible to create personalized spaces for employees, forming an inter-organizational network that catalogs achievements and tracks performance. This work aims to analyze the design of a novel microservice, named “Mithra”, which is compatible and integrable with the existing Fenice system. Built upon blockchain technology, the primary objective of Mithra is twofold: firstly, to simplify the recruitment and management activities; and secondly, to establish traceability of the entire employment relationship, encompassing all its phases. In particular, the phases that evolved in Mithra architecture are first the data verification of identities, qualifications, credentials, and experiences. Also, using Smart Contracts for employment contract drafting is pivotal in the context analyzed. Finally, a crucial capability involves the collection of employee information and tracking activities throughout their employment.

2 Fenice Architecture

The architecture of Fenice is microservices-oriented and developed by ITSvil company (based in Salerno). The name is derived from the myth of the phoenix rising from its ashes and this represents a metaphor for technological rebirth. The microservices implemented for the architecture are defined as follows (see Fig. 1):

- **Prophet** represents the *API Gateway* of the architecture to protect the APIs of the various microservices and it is the single access point.
 - **Ganesha** represents the *Service Discovery* of the architecture. Each microservice registers with Ganesha by communicating its physical address.
 - **Ammit** is the *Identity Manager* and manages the authentication/authorisation of applications and users that want to use the services of the architecture.
 - **Lakshmi** manages user profiling for each application through roles, functions and features.
 - **Chirone** implements the *API Composition Pattern* between microservices, which aggregates responses between responses from Ammit and Lakshmi.
- Heimdallr** implements the services required to manage the sending of e-mails and PUSH notifications.

The technologies used for the development of the architecture are Spring Boot (<https://spring.io/projects/spring-boot>), PostgreSQL (<https://www.postgresql.org>), OAuth2 (<https://oauth.net/2>) with JWT (<https://jwt.io>).

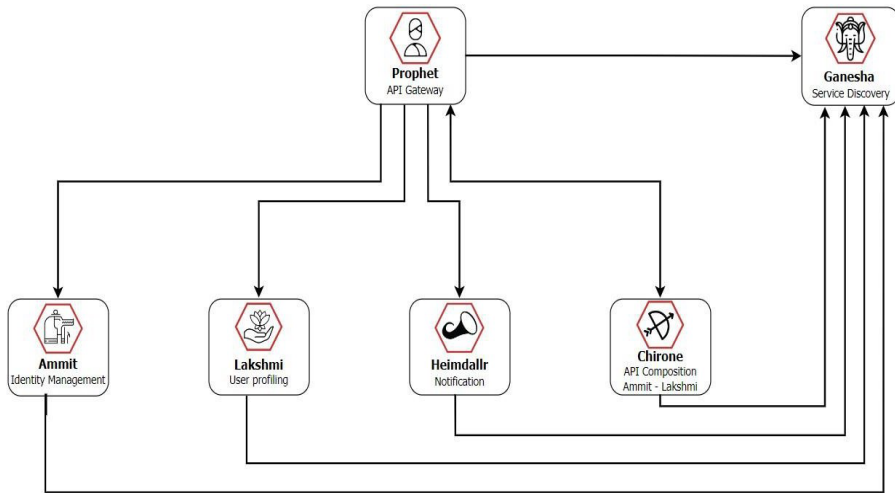


Fig. 1. Fenice's microservices-oriented architecture

2.1 Easywork

The Easywork (EW) project was born to support HR management. It uses the functionalities offered by Fenice. This system allows, firstly, the start of the cycle from the new candidates' hiring to their employment. Also, it concerns the personal information section creation by registering the soft and hard skills of each employee to manage its economic categorization. Through the job posting management, the candidates can submit their applications. The HR department will be notified via email to process the request. In the end, this system can perform the management of tasks assigned to specific individuals within the company to welcome a candidate who has been hired and becomes an employee.

2.2 Mithra Microservice

The new microservice has been called Mithra. It is responsible for managing the interactions between the users, the smart contract and the blockchain. Additionally, it provides functionality for contract workflow management, contract creation, digital signature, and contract status visualization. To integrate Mithra into Fenice's architecture, a few steps need to be described. EW, for an employment new hire, requires the services offered by Mithra. Therefore, it needs to interact with the Prophet, who will query Ammit to authorize access to the services. Once authorization is granted, the Prophet invokes Ganesha to obtain Mithra's physical address. With the obtained address, the Prophet proceeds to invoke the requested service from EW on Mithra. Mithra processes the service request and returns the appropriate results to Prophet. Finally, Prophet forwards the results to EW, completing the interaction. In this way, EW can benefit from Mithra's services by following a defined workflow involving architectural components such as Prophet, Ammit, Ganesha, and Mithra.

2.3 Colour illustrations

You are free to use colour illustrations for the online version of the proceedings but any print version will be printed in black and white unless special arrangements have been made with the conference organiser. Please check whether or not this is the case. If the print version will be black and white only, you should check your figure captions carefully and remove any reference to colour in the illustration and text. In addition, some colour figures will degrade or suffer loss of information when converted to black and white, and this should be taken into account when preparing them.

3 Solution Proposal

The microservice architecture is based on the Hyperledger Fabric technology (<https://www.hyperledger.org/use/fabric>), which provides a framework for developing permissioned blockchains. The blockchain infrastructure will consist of a network composed of peers, a Certification Authority organization, an Ordering Service organization and a shared channel among the involved parties. For the application of employment contracts, a smart contract will be developed using the Hyperledger Fabric Chaincode programming language and it will contain the business logic for the creation, management, and execution of employment contracts (see Fig.2).

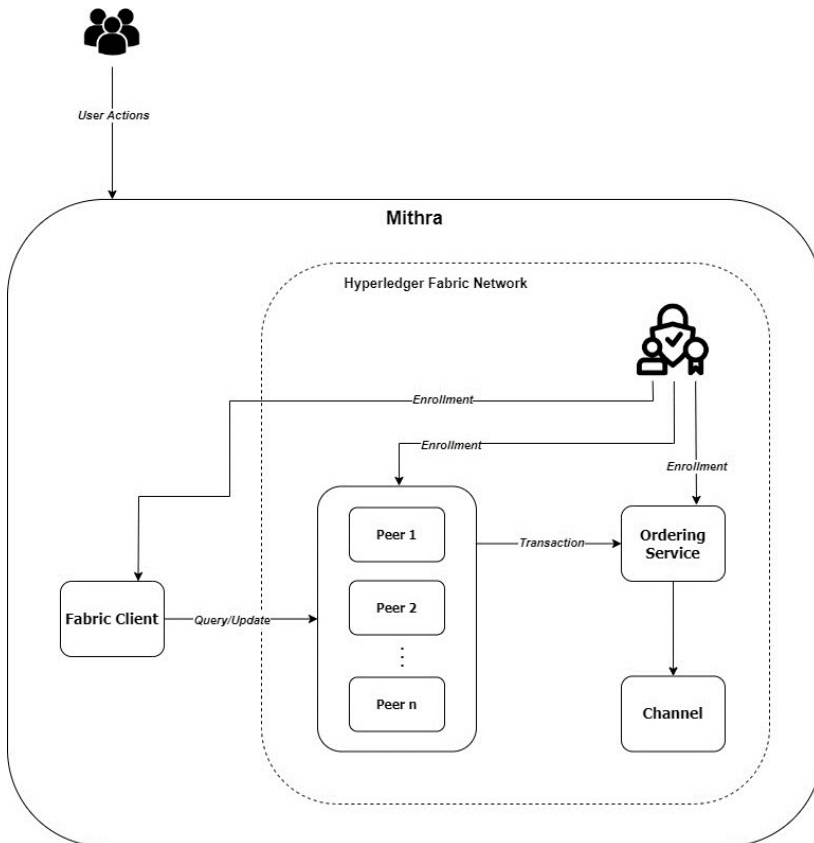


Fig. 2. Mithra's architecture

One of the functionalities of Mithra will be to ensure a certified signature system on the new employment contract and record it immutably in the blockchain ledger. When a user wants to digitally sign a contract, the microservice can provide a user interface that allows the user to input the necessary signing data, such as the contract ID and their private key. Once the user provides the information, the microservice can use cryptographic libraries such as Bouncy Castle (<https://www.bouncycastle.org>) to generate a digital signature based on the private key provided by the user. Once the digital signature is generated, the microservice can prepare a transaction that includes the contract details and the signature itself. Within the smart contract on the blockchain, the logic for verifying digital signatures will be included. Using Hyperledger Fabric's Chaincode, the microservice can define a function that takes as input the contract details, the digital signature, and the public key corresponding to the private key used for signing. The verification function in the smart contract will utilize cryptographic algorithms to verify the validity of the signature. After submitting the transaction containing the digital signature to the smart contract, the microservice waits for a response from the blockchain. The blockchain executes the signature verification logic within the smart contract and returns a response to the microservice. The microservice can then interpret the response to determine whether the digital signature is valid or not. Based on the result of the digital signature verification, the microservice can take appropriate actions. For example, if the signature is valid, the microservice can record that the contract has been successfully signed and update the contract's status on the blockchain. Conversely, if the signature is not valid, the microservice can log a signature error and take necessary steps, such as requesting a new signature or issuing a warning.

3.1 Example of Application

The ITsvil organization needs to be defined in the blockchain network: the configuration file is defined, specifying its name, digital certificates, network service URLs, and other relevant information. The first peer which we have defined as the CEO peer, is the entity that will interact as one of the parts. It will generate the cryptographic materials for the CEO peer, including its certificate and private key. After defining the CEO peer's identity, it will be associated with the ITsvil organization in the network configuration file. Fig.3 shows the sequence diagram of the use cases proposed. In detail, suppose a new employee needs to be hired at ITsvil, and the signing of the contract between the employee and the CEO needs to take place. The following workflow will occur within the blockchain network (see Fig. 3):

1. The CEO initiates the contract creation process on the blockchain system. Then the contract is generated in a digital form and stored on the blockchain, and a unique address is created for the new employee within the blockchain.
2. which CEO sends a notification to the new employee, providing the contract address and signing instructions.
3. The new employee carefully reads the contract and, if in agreement with the terms, proceeds with the digital signature, which is encrypted and added to the contract on the blockchain.
4. The signed contract is permanently stored on the blockchain, ensuring the integrity and immutability of the information.
5. Once the signature is verified, the CEO officially confirms the new employee's hiring.
6. Then the CEO receives the notification of the new employee's digital signature and verifies the authenticity of the signature on the blockchain.

The hiring details, including the signed contract and the new employee's personal information, are securely recorded on the blockchain and the hiring process is completed: the new employee becomes an official part of ITSvil.

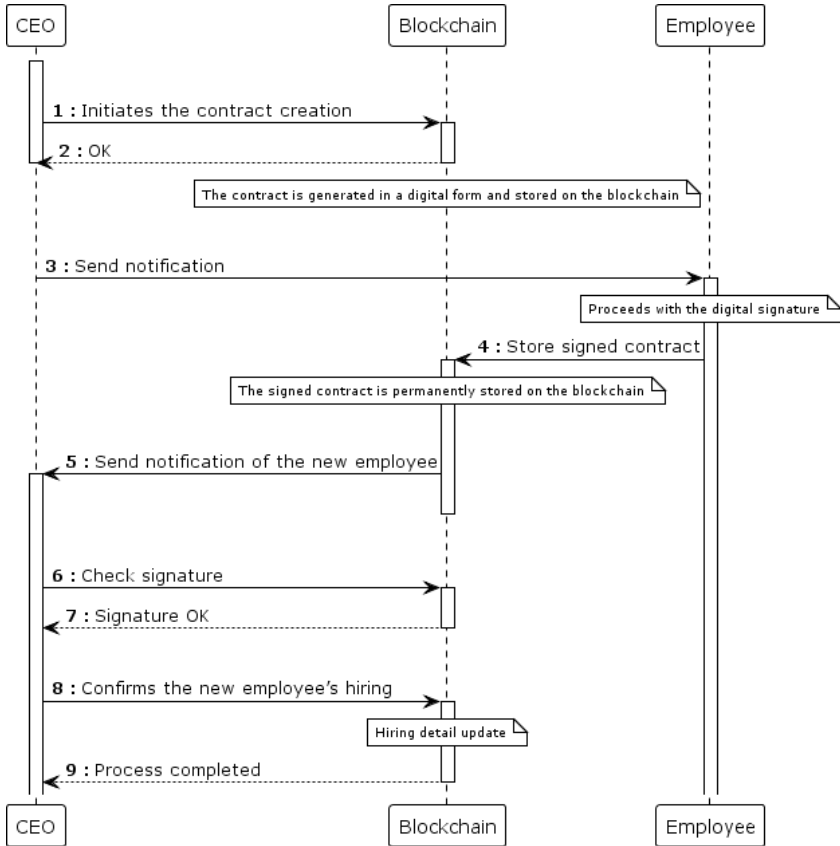


Fig. 3. Mithra sequence diagram

4 Results and Discussion

In this section, we discuss the results of implementing the proposed blockchain-based system for human resources digitalization, named Mithra, and discuss its implications for HR management in Small and Midsize Enterprises (SMEs). The Mithra microservice was successfully integrated into the existing Fenice architecture. The integration involved Hyperledger Fabric technology for developing a permissioned blockchain, ensuring security and permission control in the network. A key success lies in Mithra's ability to proficiently manage the contract workflow and facilitate digital signatures for employment contracts. Through cryptographic libraries and smart contracts, Mithra ensures a certified signature system, recording signed contracts immutably on the blockchain ledger. The entire employment relationship, from contract creation to digital signature and confirmation, is recorded on the blockchain. This ensures a transparent and traceable history of each employee's journey within the organization. The integration of blockchain technology in HR processes brings several advantages. The use of smart contracts automates and streamlines tasks, reducing the risk of errors and fraud. The immutability of

the blockchain ensures data integrity, providing a reliable source of information for HR activities. The proposed system addresses the challenges faced by SMEs in managing human resources efficiently. It simplifies the recruitment process, making it more transparent and traceable. The digitalization of employment contracts through smart contracts minimizes bureaucratic tasks and enhances cost management. Moreover, the secure and transparent recording of data on the blockchain mitigates concerns related to data security and confidentiality. The use of cryptographic techniques ensures the authenticity of digital signatures, adding an extra layer of security to the employment contract process. The implemented system enhances traceability and transparency in HR processes.

5 Conclusions

The of blockchain in enterprises for hiring processes through smart contracts offers a significant improvement. It is clear how they lead to the automation of critical tasks such as qualification verification and salary management, reducing the risk of errors and fraud. Furthermore, the immutable record on the blockchain ensures data integrity and transaction traceability, providing companies with a reliable tool to optimize their recruitment and personnel management operations. We have presented a novel architecture to assist the HR Department in new employment activity, using the power of smart contracts to simplify the recruitment and relationship management activity and to make the performance of the employment relationship traceable in all its phases. The solution as designed is well-ready to be applied not only for ITSvil but in different business contexts. In this blockchain network workflow, the contract is generated, digitally signed, and securely stored on the blockchain, ensuring transparency, immutability, and information security. In this way, the employment contract is transparent, traceable and reliable between all parties. Mithra can be used to track each kind of event transparently by publishing them on the blockchain or to automatize simple or complex operations based on smart contract conditions. Furthermore, by technically adopting a micro-service architecture, each service provided as an API could be used and integrated by third-party platforms or applications to implement new use cases or more services. As future improvements, the Mithra architecture's flexibility allows the management of employee payments and optimizing work teams based on skills and workload. This adaptability positions the system as a scalable solution for evolving HR management needs.

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