SECURE CUSTOMER MANAGEMENT IN HYBRID BANKING USING IORT AND CYBER-PHYSICAL SYSTEMS

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ABSTRACT

In-person banking is still very important in the financial services industry worldwide. At hybrid bank offices, robotic service staff may boost output while reducing costs. An efficient autonomous Know-Your-Customer (KYC) system is necessary for hybrid banking. This study suggests a deep learning-based automated solution for interbank KYC in robot-based cyber-physical banking. A deep biometric architecture was used to model the customer's KYC and anonymise the collected visual data in order to preserve their privacy. The biometric data was sent and validated in a secure, decentralised way using the blockchain network and the symmetric-asymmetric encryption-decryption module. A high-capacity fragile watermarking method based on the integer-to-integer discrete wavelet transform in conjunction with the Z6 and A6 lattice vector quantisation is also recommended for the secure transmission and storage of in-person financial documents. The proposed framework for automated biometric-based bank check collection of handwritten checks from customers in accordance with COVID-19 pandemic safety guidelines was simulated and evaluated using a Pepper humanoid robot. The proposed framework is used to watermark and integrate bank customers' biometric information, including their name and fingerprint, into the appropriate bank documents. The results show that the proposed security protection framework can include more biometric information in bank documents than similar algorithms. Furthermore, the quality of the protected bank document is 20% higher than that of other proposed methods. The hierarchical visual information transmission and storage module, which hides people's identities in films collected by robots, may also satisfy the banks' privacy requirements. Taking everything into account, the proposed framework may provide a rapid, simple, and reasonably priced interbank solution for future in-person banking while adhering to security regulations and banking rules.

I. INTRODUCTION

Most banking services were made available online during the COVID-19 epidemic. However, in-person banking services are still required for typical paper-based financial procedures, such depositing and picking up handwritten bank checks. Elderly customers who are unable to utilise digital banking may also benefit from in-person banking services. Three main problems with bank branch services are that they are costly, they don't integrate effectively with internet banking, and their interactions aren't safe enough to utilise in the event of a pandemic. The creation of secure, effective, hybrid cyber-physical bank branches enabled by the Internet of Robotic Things (IORT) and humanoid service robots acting as tellers are potential remedies for these issues.

When adopting IORT-based cyber-physical banking, there are two key considerations. First things first: confirm that the purchasers are who they claim to be. Many financial organisations employ the Know-Your-Customer (KYC) [2] standards mandated by banking authorities to regularly authenticate an individual seeking a financial transaction. Bank employees personally verify the typical Know Your Customer documentation, which includes customer photos, driver's licenses, passports, and signatures. However, conventional know-your-

client procedures are time-consuming for clients and expensive for financial institutions. Know-your-customer (KYC) verification based on machine learning has the potential to greatly improve bank automation, save expenses, and speed up the provision of financial services. In terms of precision, speed, and resistance to fraud, automated biometric-based KYC outperforms conventional KYC papers like driver's licenses and passports.

Protecting our clients' privacy is our second top priority. One of the biggest challenges for automated KYC systems is protecting clients' personal information. The IoT edge nodes, or IORT agents, lack the processing capacity to perform the sophisticated machine-learning models needed for precise biometric verification. To get the validation results, this data must be sent to the bank's mainframe. Another problem with conventional KYC is that it requires each bank to individually confirm the identifying papers, which exposes consumers to both one-time and continuing KYC processes. Another significant problem with conventional in-person banking is the safe transmission, processing, and storage of physical financial documents.

This study suggests a blockchain-based architecture for IORT-enabled cyber-physical banking that use deep neural networks to assess different biometric-based data for KYC in order to allay these worries. "Automated Deep Decentralised KYC" is abbreviated as ADD-KYC. Humanoid robots serving as Modular Rapidly Deployable Service Agents (MORAD-SA) are included into the suggested design to collect biometric information from clients and provide them in-person financial services [1]. The secure and decentralised transmission and validation of KYC data is made possible by the use of smart contracts and the blockchain network. Customers' biometrics are verified using deep neural networks. Using a KYC token, a client may manage their KYC identification and share it with other banks as needed. The ADD-KYC may be used in interbank settings thanks to the suggested architecture. Additionally, client KYC information is added to actual banking papers using a high-capacity watermarking method. Additionally, a low-power watermarking technique using comparable Lattice Vector Quantisation (LVQ) sub-lattices for Z6 and A6 is suggested. This novel methodology is an improvement on the Z4 and A4 LVQ watermarking methods [4,5]. It is perfect because of its larger capacity and indiscernible size. Financial papers will stay safe during storage and transportation thanks to the water marking module.

Pepper, a humanoid robot from Softbank Robotics, is utilised for IORT-based biometric collecting and validation and offers a range of financial services. An automated system that obtains and processes client handwritten bank checks in compliance with COVID-19 safety regulations is implemented in the case study. Numerous scenarios are used, including greeting customers, confirming their identification, and delivering different financial services using service robots. A handwriting and signature verification module is used to study the issue of autonomous analysis and information extraction from bilingual Persian-English bank checks.

Lastly, building an intelligent automated bank branch that can employ robots to provide customers conventional paper-based services requires a sophisticated system that can handle a number of issues. These issues might be resolved in accordance with the suggested ADD-KYC model:

1. A workable hardware and software solution for robot-based banking security is required. This technology lowers the cost of human resources, expedites financial services, and complies with pandemic safety regulations. Significant software changes are required for the pre-programmed humanoid robots to do certain financial tasks to a high quality.

Second, to guarantee safe banking, a multi-biometric automated KYC system is needed. The interbank ecosystem should employ this

technology to accurately verify the identity of its clients.

3. A quick and large-capacity watermarking technique is needed to secure digitally transferred documents in the financial cloud. Using many biometric data sets, this technique ought to be able to encrypt financial documents.

Customers need a decentralised way to get their digital KYC identification in a cross-bank context without sacrificing security or privacy.

We suggest the Add-KYC framework, which has the following characteristics, to allay these worries:

1. Machine learning methods are used to remove the necessity for banks to gather KYC information. To guarantee the safe and private exchange of KYC data throughout the interbank ecosystem, a decentralised blockchain-based architecture is constructed.

2. The implementation of an automated biometric-based KYC system eliminates the requirement for falsifiable identifying papers. Third, a weak KYC watermarking technique is suggested to guarantee the security of in-person banking papers both during transmission and storage. It can include a significant quantity of Know Your Customer (KYC) data into financial papers because to its high Peak Signal-to-Noise Ratio (PSNR).

4. A hierarchical privacy-preserving module is suggested, which anonymises people in films that IORT agents gather from the banking environment for authorized-only access.

5. It is advised to use an IORT-based hybrid banking system to physically link bank clients to Banking as a Service (BAAS) in both routine and emergency situations. The abbreviations and their meanings as they occur in the text are shown in Table 1.

II. LITERATURE SURVEY

Cyber-Physical Customer Management (CPCM) for Internet of Robotic Things (IoRT) enabled banking is a new sector of financial services. This literature review looks at IoRT integration in banking, focussing on how cyber-physical systems (CPS) enhance customer management, automate processes, and provide seamless service delivery.

1. Overview of IoRT and Cyber-Physical Systems

Systems that combine networking, computer, and physical operations are referred to as cyber-physical systems (CPS). CPS bridges the gap between digital and face-to-face interactions by enabling real-time data processing and decision-making in banking.

Internet of Robotic Things (IoRT): IoRT builds upon the concept of the Internet of Things (IoT) by including robotic devices that are capable of autonomously interacting with their environment. IoRT devices used in the banking sector include service robots, automated kiosks, and intelligent ATMs.

Relevance to Banking: The banking sector aims to revolutionise customer management via the combination of CPS and IoRT by offering customised services, enhancing security, and improving operational performance.

2. In banking, Cyber-Physical Customer Management (CPCM)

Definition and Scope: CPCM is the use of CPS and IoRT to manage customer contacts across digital and physical channels. This involves combining information from several touchpoints, including branch visits, online banking, and IoRT devices, to provide a seamless customer experience.

CPCM components consist of:

The practice of integrating real-time client data from several sources to create a comprehensive customer profile is known as data integration.

Service automation is the practice of using Internet of Things (IoRT) devices, such robots and intelligent kiosks, to automate repetitive financial tasks, such as account management and customer enquiries.

Personalisation: Using AI and machine learning to modify services based on historical performance, consumer preferences, and behaviour.

Applications include automated advisory services providing real-time financial advice, user-adaptive ATMs, and personalised banking with robotic tellers.

3. Important Studies and Advancements

IoRT-Powered Financial Products:

Service Robots: AI-enabled robots can communicate with customers, help them with banking tasks, and provide specialised services. Research indicates that they are effective in reducing wait times and increasing customer satisfaction.

Intelligent ATMs: IoRT-enabled ATMs can perform complex transactions, provide personalised user interfaces, and enhance security with real-time threat detection and biometric authentication.

Making Data-Driven Decisions with CPS:

anticipated analytics: CPS enables banks to analyse consumer data in real-time by providing predictive insights for fraud detection, credit scoring, and personalised marketing.

Security and Privacy: Research shows that cybersecurity is essential to CPCM. IoRT devices must be protected from cyberattacks, and client privacy must be maintained by secure data transport and encryption.

4. Difficulties and Things to Take Into Account

Integration Complexity: Integrating CPS, IoRT, and conventional banking systems requires a significant amount of effort and funding. Strong integration frameworks and comparable standards are essential, according to research.

Cybersecurity Risks: Because IoRT devices are connected to the internet and the outside world, they are vulnerable to cyberattacks. Research suggests using multi-layered security measures and continuous monitoring to lessen risks.

Concerns about Ethics and Privacy: Large-scale consumer data collection and analysis raise ethical concerns around privacy, consent, and data ownership. Respecting legal frameworks like the GDPR is essential.

Customer Acceptance: Two important elements in the adoption of IoRT in banking are consumer trust and receptivity to engaging with robotic equipment. Open and honest communication with clients is necessary to increase acceptance, according to studies.

5. Prospects and Future Paths

Integration of AI and Machine Learning: More study is needed to examine the integration of state-of-the-art AI and machine learning models with IoRT in order to enhance customer service customisation and predictive capabilities. Edge Computing: IoRT-enabled banking may make use of edge computing to improve real-time decision-making, reduce latency, and enhance the overall customer experience.

Cross-Channel Synchronisation: Future developments should focus on the seamless synchronisation of digital and physical channels to ensure that customer interactions are consistent and unbroken across platforms. Standards and Regulatory Compliance: Establishing industry-wide standards and regulatory frameworks will be crucial to ensuring the ethical and secure deployment of IoRT in banking.

6. Final Thoughts on Banking:

CPCM for IoRT-enabled banking has the potential to revolutionise the customer experience by offering more effective, secure, and customised services. With the combination of CPS and IoRT, the future of banking is much closer.

Implications for Research: Interdisciplinary research that combines expertise in robotics, cybersecurity, artificial intelligence, and financial services is becoming more and more necessary to address the challenges and fully use CPCM in banking.

This literature study provides a comprehensive overview of the current and possible future paths of CPCM for IoRT-enabled banking. Although there are numerous chances for innovation in the quickly evolving area of cyber-physical systems in financial services, there are also disadvantages that need to be properly taken into account.

III. SYSTEM ANALYSIS

EXISTING SYSTEM

One crucial step in confirming a bank customer's identification is the Know Your Customer (KYC) check. Since it is an essential process in banking systems, international financial authorities often demand it for all financial transactions. The usual elements of the know-your-customer (KYC) process include a customer's home address, a current picture of themselves, a sample of their signature, and official identity credentials. The biometric-based Know Your Customer (KYC) check has also been used by several financial institutions worldwide [2]. The traditional approach depends on bank employees manually gathering and confirming KYC information. However, recent studies suggest that banks might save time and money by using service robots to answer consumer questions [3].

Achieving a balance between thoroughness and intrusiveness is crucial when doing KYC checks. Customer support representatives squander time and effort on pointless identification verification procedures. The outcomes of automated know-your-customer (KYC) systems that use a range of biometrics, including handwriting, signatures, palm veins, iris, voice, face, and fingerprints, have been promising. Because they are non-invasive, speech and facial biometrics are particularly well-suited to the banking industry. Recent studies have shown that deep neural networks are very effective in extracting biometric features [7]. A data fusion-based method for multi-modal biometrics customer verification for financial organisations was presented by Szczuko et al. [8]. Data fusion was achieved using the Dempster-Shafer method, and the results were precise enough for use in financial applications. Recent developments in deep learning systems for biometric applications were examined by the authors Almabdy and Elrefaei [7]. Deep neural networks may provide the degree of precision needed for human identity verification, according to a number of performance metrics. In order to protect financial applications against fraud and impersonation, Estrela et al. [9] presented a behavioural biometric user authentication technique. It obtained banking permission using biometrics with an accuracy of 97.05% in one setting and 90.68% in another. Hassan et al. [10] shown that these measurements have the potential to provide accuracy levels equivalent to traditional biometric measures in a variety of scenarios based on their analysis of several non-invasive, soft biometric evaluations.

The security of consumers' financial and personal information is another issue with automated biometrics. For the machine learning-based automatic biometric verification to work, robots and other edge nodes must provide visual and other sensory data to the bank servers. The need that each bank train its own biometric models exacerbates issues with consumer discontent, data security, privacy, and KYC costs. A KYC system built on the blockchain is one possible remedy for these issues. A Know Your Customer (KYC) strategy to online banking was presented by Laborde et al. [11] and makes use of identifying information provided by several organisations. To facilitate bank transfers, Jain et al. [12] developed a decentralised one-time KYC architecture. Yadav et al. [14] developed an Ethereum-based KYC model to increase customer happiness and save costs, whereas Biradar et al. [13] used Hyperledger Fabric as a blockchain-based KYC framework for same purpose. There are two categories of bank clients under this arrangement: those who are permanent and just need basic services, and those who are transient. A blockchain-based architecture for identity management and authorisation was presented by Esposito et al. [15] via integration with the Future-Internet-WARE (FIWARE) platform. Data security becomes a key problem since smart city applications need to be linked with the city's current information and communication technology infrastructures. Since the centralised system cannot satisfy the security requirements of these sites, a blockchain-based alternative is suggested. Research that is comparable to the techniques suggested in this work is shown in Table 2. Nonetheless, we discuss each pertinent

study's shortcomings using the ADD-KYC paradigm. Even though ADD-KYC is automated, based on a deep neural network, incorporates several biometrics, is intended for robotic banking, and provides hierarchical privacy protection, current frameworks only apply traditional KYC on the blockchain. Furthermore, the centralised, manual, document-based KYC validation procedures used by the banking sector today are expensive, time-consuming, and security-vulnerable.

Disadvantages

Banks want a hardware and software solution based on robotics that is safe and realistic. This technology improves the speed and accuracy of financial services, lowers the cost of human resources, and satisfies safety requirements during a pandemic. Significant software changes are required for the standard-bearer humanoid robots to execute certain financial services.

2. Without an automated multi-biometric KYC system, secure banking is impossible. This strategy should enable customers to get very precise identity verification via the interbank ecosystem.

3. A fast watermarking method with a large capacity is required to protect digitally transmitted documents in the financial cloud. It is anticipated that this approach will be able to store a variety of biometric information in financial documents.

4. In an interbank setting, customers want a decentralised solution that protects their confidentiality and privacy while enabling them to access their digital KYC identification.

PROPOSED SYSTEM

The system suggests a blockchain-based architecture for know-your-customer in IoRT-enabled cyber-physical banking, which uses deep neural networks to evaluate different biometrics-based data. "Automated Deep Decentralised KYC" is abbreviated as ADD-KYC. Humanoid robots serving as Modular Rapidly Deployable Service Agents (MORAD-SA) are included into the suggested design to collect biometric information from clients and provide them in-person financial services [1]. Know-your-customer (KYC) data is securely and decentrally sent after validation via the use of smart contracts and the blockchain network. Customers' biometrics are verified using deep neural networks. Using a KYC token, a client may manage their KYC identification and share it with other banks as needed. The ADD-KYC may be used in interbank settings thanks to the suggested architecture. Additionally, client KYC information is added to actual banking papers using a high-capacity watermarking method. Additionally, a low-power watermarking technique using comparable Lattice Vector Quantisation (LVQ) sub-lattices for Z6 and A6 is suggested. This novel methodology is an improvement on the Z4 and A4 LVQ watermarking methods [4,5]. It is perfect because of its larger capacity and indiscernible size. Financial papers will stay safe during storage and transportation thanks to the water marking module.

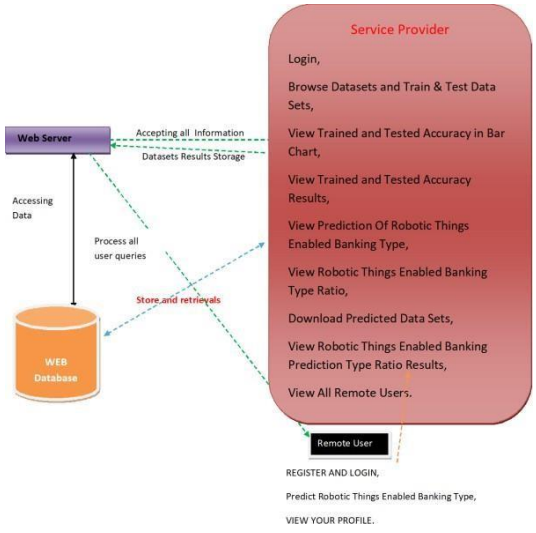
The use of the IoRT-based biometric collection and validation process is one of the several financial services that Pepper, a humanoid robot produced by Softbank Robotics, assists with. An automated system that obtains and processes client handwritten bank checks in compliance with COVID-19 safety regulations is implemented in the case study. Numerous scenarios are used, including greeting customers, confirming their identification, and delivering different financial services using service robots. Using a handwriting and signature verification module, we examine the issue of autonomous analysis and information extraction from multilingual Persian-English bank checks.

Advantages

1. To enable the secure and confidential sharing of know-your-customer (KYC) information across the interbank ecosystem, a decentralised framework built on blockchain technology is developed. It is proposed that machine learning models be used to eliminate the necessity to gather KYC data from many banks.

2. Instead of depending on vulnerable identification documents, we have developed an automated biometrics-based KYC solution.
3. To securely send and save in-person banking documents, we recommend a sensitive Know Your Customer watermarking solution. It may add a lot of Know Your Customer (KYC) information to bank documents and has a high Peak Signal-to-Noise Ratio (PSNR).
4. A privacy-preserving module that employs a hierarchical structure to conceal people's identities is proposed in order to guarantee that only authorised persons may see videos captured by IoRT agents in a banking environment.
5. Based on Internet of Things Radio Technology (IoRT), we propose a hybrid banking system that can link Banking as a Service (BaaS) with bank customers in both regular and emergency scenarios.

IV. SYSTEM ARCHITECTURE



V. SYSTEM IMPLEMENTATIONS

MODULES

Service Provider

The Service Provider must have a working account and password in order to access this module. After logging in successfully, he would be able to do tasks like viewing datasets and using them for training and testing. Robotics-enabled banking type prediction, robotics-enabled banking type ratio, trained and tested accuracy in a bar chart, trained and tested accuracy results, and more! Store Expected Data Sets, View the Total Remote User Count, and Robotics-Powered Banking Type of Prediction Ratio.

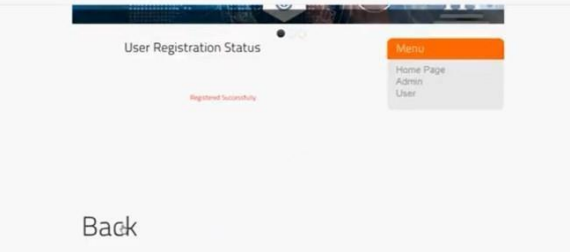
View and Authorize Users

In this part, the administrator has access to a comprehensive list of all registered users. The administrator may see the user's name, email address, and address here and allow them access.

Remote User

In all, this module has n users. It is necessary to register before beginning any operations. After a user registers, their information will be added to the database. After completing the registration process, he will need to log in using the approved username and password. Users will be able to do tasks like predicting which banking kinds are allowed by robotic devices after signing in. Create an account, get in, and check it out.

VI. SCREEN SHOTS


User Registration Status
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View All Datasets By Banking Type Blockchain !!!


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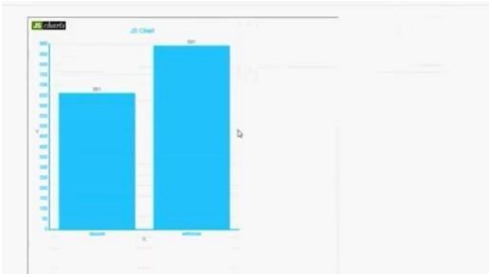

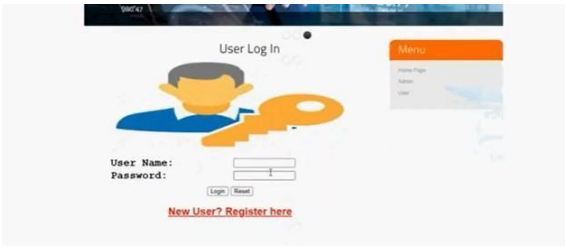
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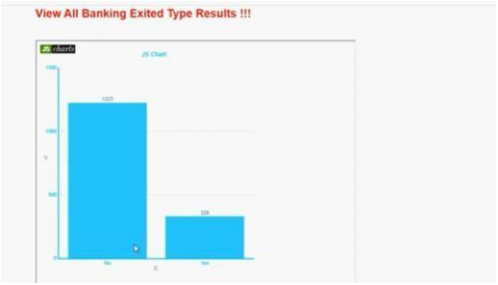
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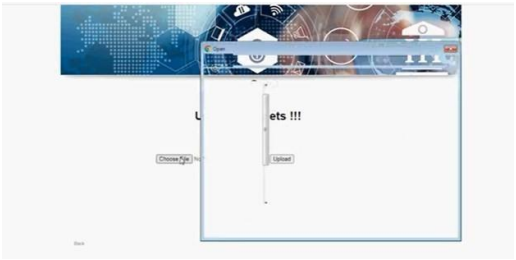
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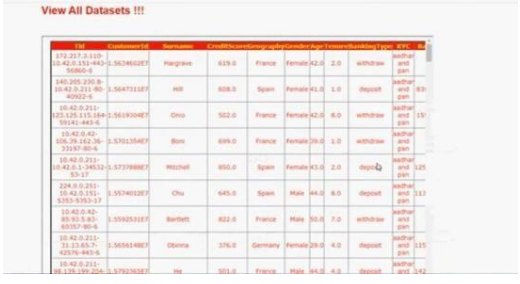
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VII. CONCLUSION

As a solution for cyber-physical banking in pandemic situations, Softbank Robotics' humanoid robot Pepper was used to build the suggested architecture. In the context of physical banking, it lowers expenses while improving client experience and efficiency since it is not obtrusive. We assessed the suggested watermarking algorithm's performance and contrasted the outcomes with those of a number of more contemporary methods that have been put out in the literature. The biometric security information used to watermark bank checks consists of the customer's fingerprint, the recipient's name, the check number, the customer's signature, the customer's photo, and the bank's logo. Compared to comparable techniques, the suggested methodology yielded PSNR values that were up to 5.1 dB higher. An average PSNR of 45.5 dB was obtained after embedding for photos of 100 checks, indicating little distortion in the images after watermarking. The simulations' outcomes demonstrated the suggested framework's high accuracy. The primary drawback of the suggested structure is that automated systems must constantly operate under human supervision since banking regulations demand complete client satisfaction. Additionally, the suggested framework's correctness is still restricted. More model training is necessary due to significant differences in consumer biometrics and bank environment circumstances. For the provision of financial services during the COVID-19 pandemic, the present method is suggested. Under these circumstances, using human personnel to provide routine KYC verification and paper-based banking services posed a health risk to both clients and employees. Under normal circumstances, determining how to enhance the client experience requires a thorough investigation of diverse banking contexts and cultures. Following deployment at many bank branches, extensive consumer feedback collecting and analysis are regarded as subsequent phases of this study. Future research projects are also being considered, including expanding the range of financial services offered and giving bank clients more authority in their interactions.

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