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Building a Recruitment System Based on Blockchain and Federated Learning

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***Abstract*—The problem of data privacy in Facial Recognition is one of the general public concerns. Facial recognition violates citizens' natural right to be constantly under government surveillance and to have their images stored without their permission. In addition, the issue of transparency in curriculum vitae is crucial. Some people are so desperate for a chance that they will do anything to increase their chances, even if it means lying on their resume about their experience. This study illustrates how Blockchain technology can be used to stop CVs from being false and how federated learning can shield user images from facial recognition. The outcome demonstrates that users are no longer able to fabricate information in their CVs about their experience because that information is now stored in the Blockchain and the user's raw images are kept on their storage devices. Our system uses a Ethereum's Smart contract to enhance the transparent of candidates' CV. While federated learning provides security in facial recognition process.**

***Index Terms*—Recruitment System, Facial Recognition, Blockchain, Ethereum , Federated Learning.**

I. Introduction

The two major issues with the hiring process at the moment are the transparency of the CV and the privacy of the face data if the business utilizes facial recognition technology to take attendance. However, building a personalized and secured system is a big challenge.

Generally, facial information being leaked may not be a serious problem. However, it should be considered when face recognition technology is more grown and popular. For example, user can unlock their smartphone with their face. There are some mechanisms that can trick and bypass the recognition system using face image in a 2D version, or more advanced, a 3D version with deep-fake. And we can get access to all services of the device. For applications in which security is even more essential such as smart homes, smart cars, etc., the attack can be more serious.

Regarding the transparency issue in the CV, if the candidate entered inaccurate information in the job experience section, it would be difficult for the employer to verify the candidate's honesty. To solve the above problems, the authors suggest building a facial recognition system based on Blockchain and Federated Learning technology. The Blockchain ensures CV transparency, while Federated Learning will preserve users' raw data images safely.

Our system contributions are summarized as follows:

- Design a recruitment system that combines Blockchain and Federated learning technology;
- Utilizing the token mechanism of the Blockchain to represent a user's employment status;
- Allow users to train facial data on their own devices by utilizing federated learning;
- Demonstrate and evaluate the proposed system on real hardware devices.

The rest of this paper is organized as follows: Section II introduces background and related works to Blockchain, federated learning technologies and recruitment system. Our system model is presented in Section III. After that, Section IV reports the evaluation of our proposal through two features: *i)* facial recognition performance and *ii)* blockchain fee . Section V ends the paper with our conclusions and future works.

II. Background and Related Works

This section introduces the recruitment system, and the previous works related to building the system. Beside that, blockchain and federated learning technologies are also mentioned at this part.

A. Blockchain - Ethereum

Blockchain is a public, trusted, shared ledger running on a peer-to-peer (P2P) network. The critical idea of the blockchain concept is its decentralization, which means data on the blockchain is not controlled by any single entity or location.

A cryptographically secured chain of blocks was introduced firstly by Stuart Haber and W Scott Stornetta in 1991. In 1998, the decentralised digital currency, namely "bit gold", was described Nick Szabo. These are two underlines for bitcoin [1] – the first cryptocurrency raised by Nakamoto in 2009. From this year to now, bitcoin has been one of the most interesting topics in science and currency. As the prediction from IHS Markit website, finance industry blockchain market reach to

$462 Billion by 2030. Figure 1 describes the business value in financial industry of blockchain.

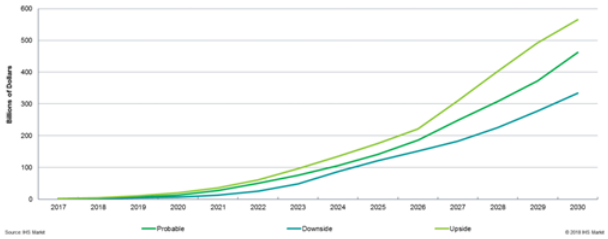

Fig. 1. The business value of blockchain in financial industry.

Difference to Bitcoin, Ethereum [2] was created as a public blockchain platform. It is an open-source, first proposed by Vitalik Buterin in 2013. Ethereum features Ether, a token (cryptocurrency) which can be used to pay for "gas", a unit of computation performed by smart contracts (scripts) which run on the Ethereum Virtual Machine (EVM). Ethereum supports a modified version of Nakamoto consensus (Bitcoin's consensus protocol). This platform is widely used for the development of Peer to Peer (P2P) Distributed (or Decentralized) Apps (Dapps).

B. The facial recognition systems

Facial recognition is progress includes collecting face images, training the model to learn these images and detecting who is in a new image or video. Marcelo Rovai's project [3] aims to build a facial recognition system based on Hacasscade[1]. Figure 2, 3 and 4 show the three above facial recognition process.

Firstly, User insert their facial data and identified to the dataset.

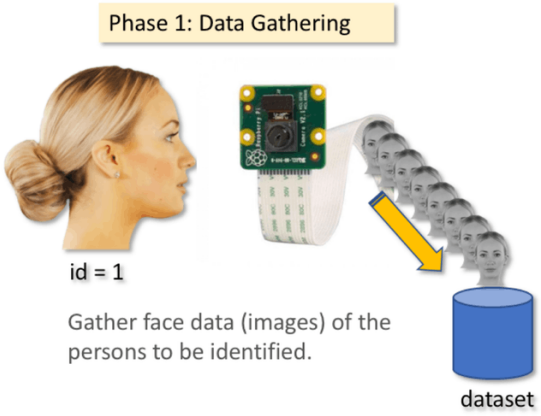

Fig. 2. Step 1-Collecting face data [3]

Secondly, the model is trained from dataset and ID (label) of each image.

Finally, when users insert a new image, the trained model detects who they are with the value of accuracy.

[1]https://docs.opencv.org/3.4/db/d28/tutorial cascade classifier.html

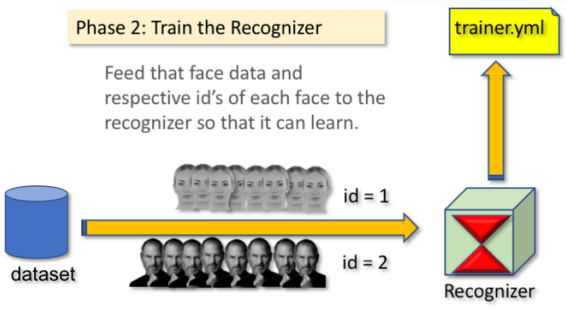

Fig. 3. Step 2-Training the model [3]

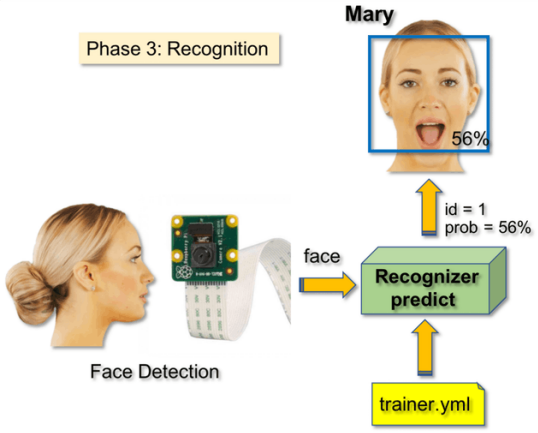

Fig. 4. Step 3-Recognition phase [3]

C. Federated learning technical

A machine learning paradigm known as federated learning [4] enables the cooperative training of machine learning models across many devices. Devices that store datasets and transmit trained weights to the server are referred to as client nodes in the FL architecture. The device that oversees overall model training is referred to as the server. A client's local data is never shared with other client nodes or the server thanks to the FL framework. Because of this, the FL framework is built to protect highly sensitive data and maintain the privacy of the participating clients' personal information.

D. Related works

Wu et al. [5] developed PerFit - a personalized federated learning framework in a cloud-edge architecture for intelligent IoT applications. The authors demonstrate a case study of IoT based human activity recognition to demonstrate the effectiveness of personalized federated learning for intelligent IoT applications. The result shows that the accuracy of federated transfer learning and federated distillation method are the same, while federated distillation communication size has significantly smaller than this criteria of federated transfer learning.

Y. Ruan et al. [6] proposed the framework applying federated learning to Optimize Client Recruitment. This

research aims to evaluate the data from candidates. The authors construct the system model to quantify the quality measures of federated learning, including training loss, the reliability and completion time of training, and the operating expense. The client recruitment is formulated as an NP-Hard problem and applied a provably optimal, tractable solution. The authors also demonstrate this framework by learning the higher accuracy and fewer client models via both synthetic and real-world data. The results show that recruiting more clients does not always improve the model, and intelligent client recruitment can greatly improve the accuracy of the trained model in constrained execution environments.

Yang et al. [7] enhanced the accuracy and time consumption of the face recognition system by balancing the workload between client and server. They also used CKKS homomorphic encryption method and reimplemented the similarity measurement function. The authors tested their work with verification task on LFW dataset. Their results showed that their work only took 2 seconds in Matching steps, while the other tasks such as Encoding, Decoding, Encryption, and Decryption required from 3 ms to around 436 ms. The space consumption for CKKS homomorphic encryption is 56 Bytes.

Facial emotion recognition is one of the trending techniques for understanding the emotions. Rupali Gill et al. [8] proposed Convolutional Neural Network based model for this purpose. The author tested their propose by LFW, The Extended Yale Face Database B, Google Facial expression to detect six discrete emotions including happy, sad, angry, surprise, bore, and disgust. Comparing to the other models, such as VGGNet16, MobileNet, RestNet50, MobileNetv2, their work had better performance in both accuracy and run time with 93% and 656 ms, respectively.

In the preview works, the authors only focuse on the accuracy of models as so as the time of execution. All of the data has to be collected, trained, tested and validated on systems. This is a weakness of the current face recognition systems. All users' data can be lost, and the thief can use them for not pure purposes, such as impersonation and stealing.

Rhemananda et al. [9] focused on developing the concept of blockchain technology in human resource management. This work can be applied for Small and medium-sized enterprises (SMEs) in the employee recruitment and selection process. The benefit of this work is in the selection and recruitment process through filtering the best candidates for each job position.

Dhanala et al. [10] proposed a Recruitment Management System supported by blockchain technology. This work aimed to reduce time consumption and cost and enhance the recruitment process's security. The author demonstrates the system by a Smart contract under the Ethereum platform and tests it via the Ganache tool[2].

III. Proposed system

A. System design

In this subsection, we introduce our recruitment system, which proposed to improve the transparency between candidates and companies and ensure candidates' privacy. This system is described in Figure 5. There are three factors who join to the system including candidates, companies, and Blockchain network.

- Users are candidates who want to find the new jobs.
- Companies are organizations have new work positions.
- Blockchain network is deployed for identifying and connecting Users and Companies

The Companies can create tokens and send to Users. Each user have 0 to 3 tokens from each Company. The state of each User is depending on their token number, as follows:

- Free – 0 token
- Applying – 1 token
- Working – 2 tokens

The primary benefit of using blockchain in this system is that all transaction information is kept Blockchain network, is entirely transparent, and cannot be changed. Therefore, it is possible to identify a candidate's job via a token holding method. In addition, Ethereum was chosen for this application system because it has a lengthy history with solid security, and ETH coins are simple to purchase on massive exchanges like Binance, Coinbase, and FTX... for transaction fees. The token created on Ethereum will be more secure and less likely to cause the blockchain nodes to crash thanks to the features listed above.

To mint tokens on Ethereum, the recruitment system will use some smart contracts. After minting the token, the company will name it, and it'll have a unique address. This token has no financial value and unlimited total supply because it is only used for governance purposes. Tokens will therefore be minted in this application system following ERC20 standards rather than standards like ERC721 or ERC1155.

The status of users will vary depending on how many tokens they own. There will be an endless supply of tokens, one for each company. To be able to start applying, candidates need to be whitelisted by the company (supported by a smart contract called Crowdsales). At this stage, the user must send their resume and their wallet address to the company via the system-provided email address. The company will provide an OTP code, which may be used both to create the dataset and obtain the token.

[2]https://trufflesuite.com/ganache/

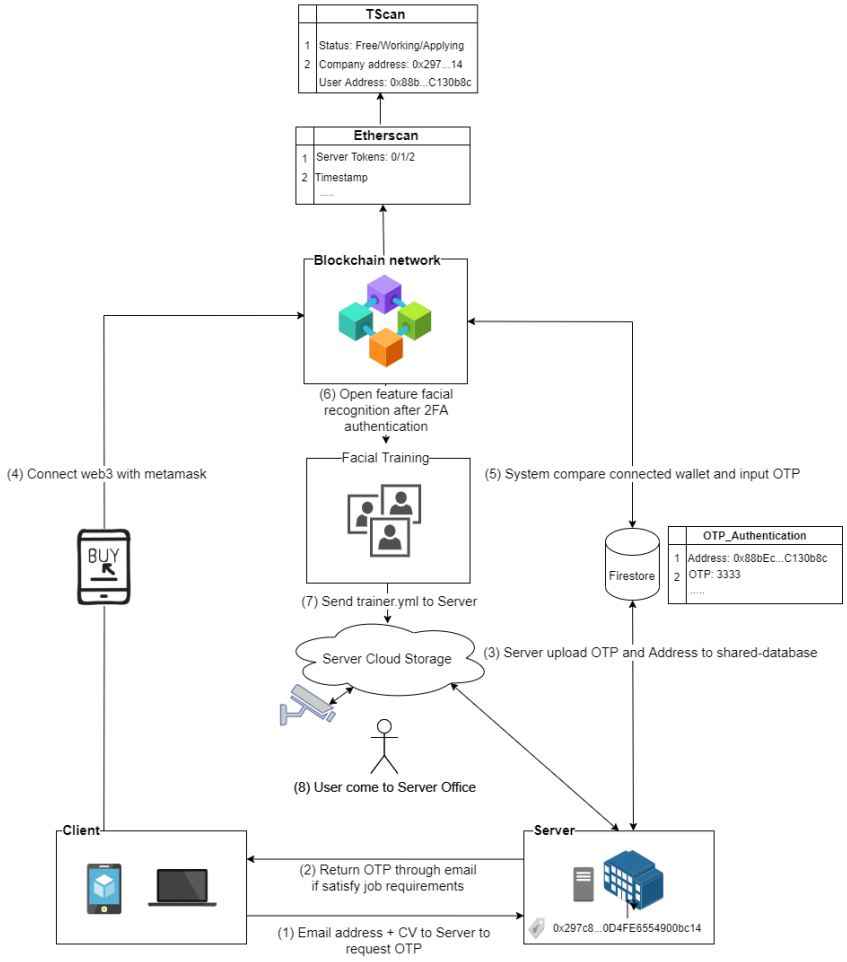

Fig. 5. Our System Design

After being successfully informed and given an OTP by the company through email, users will use that OTP to reaccess the application system's website (web3) to connect metamask wallet and obtain the first company token. With the aid of the token, the user can access the face data training feature on their device and change the state from "Free" to "Applying."

Training feature module based on Federated Learning enables customers to fully control their dataset without submitting it to the company to train faces for the recognition system. By using the webcam to take images and the candidate's device to train the face data, the training feature module will produce a dataset for the candidate during this procedure. However, to create their dataset, users must download the training feature module and enter their OTP code again. Additionally, the applicant will need to sign in to the email they used to send the company their CV to be able to send face data after training.

The operation of the system is described as follows:

- Init: Company's token = 0 and User's token = 0, User'state is **Free**
- Step 1: User submits his CV to Company's system
- Step 2a: If User's CV is suitable Company creates a OTP code and a token then sent to him.
- Step 2b: Company and User preform the interview
- Step 3: Company upload OTP (which sent to User) and Address to Firestore.
- Step 4: User connects to web3 with metamask by the received OTP
- Step 5: System compares connected wallet and input OTP
- Step 6: If User pass the interview, Company opens the facial recognition feature.
- Step 7: User creates face dataset and train model from OTP code, token and facial recognition model. Then User'state is **Applying**
- Step 8: User comes to the company and perform the identification process to enter the company. Next, company sends a new token to User and User'state is **Working** at this time
- If the user quits, he gives back company two tokens,

then his state is updated to **Free**

B. TScan website

Even though Etherscan is based on Ethereum, all transactions are visible to the public. If the applicant transfers the token they have been given at the company to another person, it will be quite confusing for the employer. To determine if the previous company's token was genuinely transferred to the user by the previous company or by a specific user, employers will need to examine many of the candidate's transactions. By using the website named TScan, this issue is resolved. The dashboard of TScan website is described at Figure 6.

The recruitment system will feature a website called TScan, which is in charge of just recording authorized transactions, if the number of tokens might be transferred from one person to another, misrepresenting information or impersonating an employee. Authorized transactions are valid transactions are from corporate wallet addresses to user wallet addresses and vice versa. All other transactions are invalidated, and even while Etherscan will still store them, TScan will not record them.

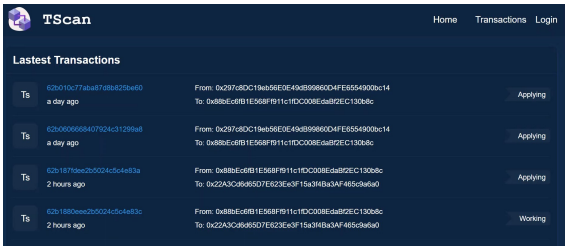

Fig. 6. TScan website dashboard

In summary, the recruitment system requires TScan since the number of company tokens shown in a user's wallet in Etherscan may not have been sent by the company itself. Rather, it may have been transferred to that user by another person who got the company token. Therefore, even if it is possible to check this by going through every transaction made to this wallet address, the employee will have to spend a lot of time and effort. Finding out what the actual company token that has been given to the candidate to change their status will be made much easier with the help of this website - TScan. This website might be considered the system's Etherscan filter.

C. Smart Contracts

Smart contracts are required for the implementation of this recruitment system. It assists the hiring process by assisting the company to mint tokens on Ethereum, adds people to the whitelist, and permits authorized users to get tokens. Numerous other smart contracts help the recruitment system with calculations and security checkpoints. Figure 7 shows the top 5 smart contracts in the system.

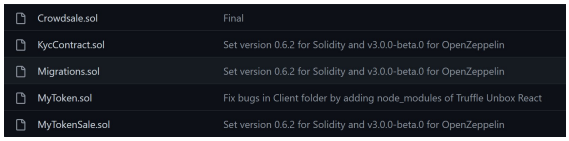

Fig. 7. Smart Contracts in recruitment system

All these smart contracts are supplied by OpenZeppelin [11] and customized for use with the recruitment system. In which the maximum number of tokens that users can obtain after being added to the whitelist is only one for the recruitment system to work effectively. This will prevent the candidate from obtaining an excessive amount of the company's tokens and transferring them to others to assume the identity of a company employee.

IV. Experimental Results

In this section, we'll go over the hardware and software that were incorporated into the above mentioned recruitment model to analyze the system's performance.

To evaluate the facial recognition feature, the authors deploy the feature on both PC and Jetson Nano. The parameters of two devices are described at the Table I.

TABLE I
HARDWARES

Parameters	**PC**	**Jetson Nano**
CPU	i5-8300H 3.9Ghz	Quad-core ARM A57 1.43 GHz
Memory	16GB	4GB
GPU	GTX 1050	Maxwell
Camera	onboard - webcam	Raspberry Pi Camera V2
No. trained images data	500	500

A. Facial Recognition

Our facial dataset is describes in Figure 8. These images are used to import to facial recognition model.

Fig. 8. The facial dataset

When the user visits the company's office to do identification after receiving 1 company token, the results

are showed at Figure 9. The performance of facial recognition feature is highlighted in Table II.

Fig. 9. The facial recognition performance

The results show that facial recognition feature has better performance when being run on PC in the number of FPS, delay and accuracy. The main reason is that Jetson Nano has limited performance, while we used high-resolution cameras during our testing. In addition, the screen recording software used during the experiment also partially affects the performance of Jetson Nano.

TABLE II
THE RESULT OF FACIAL RECOGNITION FEATURE

Parameters	PC	Jetson Nano
Average of FPS	13	5
Average of Delay	51 ms	85 ms
Average of Accuracy	65%	32%

B. Blockchain

The applicant and the business will have to pay a transaction fee to receive or transfer the token. The fees they pay will vary according to the volume of transactions and the state of blockchain system.

The cost to deploy smart contracts for the Ganache-powered blockchain-emulated recruiting system is shown in the Table III. These parameters are only for reference because the cost of implementation may differ based on the current status of the blockchain. The totally cost to perform whole process is around 0.05 ETH at the time we take the experiment.

TABLE III
BLOCKCHAIN COST OF THE RECRUITMENT SYSTEM

	Migrations	MyToken	KycContract	MyTokenSale
Gas used	164391 (0x28227)	1091501 (0x10a7ad)	521896 (0x7f6a8)	884242 (0xd7e12)
Gas Price *(gwei)*	20	20	20	20
sent fee *(ETH)*	0	0	0	0
Cost *(ETH)*	0.00328782	0.02183002	0.01043792	0.01768484
Total cost *(ETH)*	**0.0532406**			

V. CONCLUSIONS

The major objective of this system is to create a secure and transparent recruiting process. The user's job experience information is transparent and it can not tamper. The users' face images can be kept on their devices. The authors use three technologies to develop their system: Blockchain, Federated learning, and Facial Recognition. Additionally, the system has a filter for legitimate transactions called TScan display candidates status by the number of tokens kept in the wallet. The experimental result shows that the candidates take only 0.05 ETH to use the system.

In the future, we will deploy this system in a realistic environment to evaluate performance. Moreover, the face recognition feature also needs to be improved to increase the quality of FPS as well as reduce the delay in recognition.

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