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Blockchain-based mobile application for traffic accident report's management

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***Abstract*—Nowadays, the proportion of traffic incidents is on the increase due to the rapid growth of vehicles, making it a persistent problem. Consequently, the number of amicable accident reports is unmeasurable. An effective management of accident information is a crucial element, especially in the absence of an information system for amicable accident report management. However, the use of traditional centralized systems is critical, as long as they fail to present secure, transparent, reliable, and trustworthy platforms for accident's report management. This paper provides an innovative solution. It's a use case study of developing a Blockchain and interplanetary file system (IPFS) protocol-based system for traffic report management, using a mobile application. This application could be used at the time of the traffic accident. By using the application, road users can fill out the accident report at the same time as the accident while maintaining data authenticity, integrity, and reliability, and without the need for a third trusted party. Furthermore, the application reflects the safety performance of insurance companies and allows them to put an end to oversights, inaccuracies, or incorrect information when completing the amicable accident report. A better understanding and streamlining the process of handling accident reports is an essential component to enhance emergency response, promote road safety, and mitigate the economic impacts of traffic incidents, for both users and insurance companies.**

***Index Terms*—Blockchain technology, Smart Contracts, amicable reports, traffic accidents, data security.**

I. Introduction

Traffic accidents present significant challenges worldwide, necessitating efficient and reliable management systems to streamline the reporting process. As a result, individuals frequently obtain car insurance to minimize their financial losses and receive compensation [1]. Despite that, the current process for filling traffic accident reports presents several issues, including instances of insurance fraud, challenges in efficiently tracking and transmitting insurance data, and complex procedures. In the case of traffic accidents, where there is no bodily harm, most of insurance companies rely on traditional processes of reporting. These methods present different problems such as delays, inconsistencies, and vulnerabilities that lead to inefficiencies in emergency response and insurance claim processing.

The basic solution to resolve this problem is the use of an information system to manage the accident report. However, centralized systems present several limitations, some of which are a lack of data security, integrity, and traceability without the need for a trusted third party. With this objective in mind, decentralized technologies like Blockchain have been recognized as a promising framework for enhancing the reliability, security, and transparency of data exchange within decentralized networks [2].

Numerous studies have suggested using Blockchain technology to collect, validate, and track metadata within a secure, immutable, and transparent infrastructure. An example is presented in [3]. As a work extension, authors in [4] suggested a novel architecture for secure data sharing among untrusted actors without the need for a third-party authority.

By creating transparency and trust, blockchain technology eliminates third parties and builds trust models [5]. It also allows people to share data simultaneously while recording blocks that must be validated by everyone on the network [6].

The goal of this paper is to present a use case study of developing a mobile application based on Blockchain technology and IPFS (Interplanetary file system) to manage traffic accident reports. The main goal of the proposed solution is

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to motivate road users to fill out the report from the accident zone, without the need for a trusted third party and to enhance the management of accident report, and finally to ensure that the data entered will not be altered by another person.

In section 2, we present an overview of the existing literature. In section 3, we describe the problem statement. In section 4, the proposed architecture, followed by preliminary results is presented. Finally, the conclusion is given along with future directions.

II. Related Works

Several studies have investigated the application of Blockchain in different domains, such as supply chain management, healthcare, and finance, demonstrating its potential to revolutionize data management practices. Below is a brief description of prior researches that has explored various methodologies for improving traffic accident information management, including decentralized architecture, mobile applications for accident detection, also Blockchain, smart contracts, and IPFS-based systems.

Authors in [7] implemented a Blockchain-based vehicle insurance management system that facilitates the exchange of policy details among stakeholders in the network. In [8], the authors proposed an approach that uses modern technology to develop a road accident detection and notification system that can detect accidents and notify emergency services immediately. Another research presented in [9] describes a new Blockchain-enabled certificate-based authentication scheme for vehicle accident detection and notification in Intelligent Transportation Systems (ITS). Authors in [10] presented a study to design and develop a new Blockchain-based system for decentralized monitoring and management of accident/incident information in the construction industry.

In a study presented in [11] the authors introduced an approach of a Blockchain-based file-sharing system for academic Paper Review that relies on Blockchain technology combined with IPFS to store large files in a distributed manner, in order to reduce storage requirements in the user side, also that's guarantee data decentralization, immutability, and auditability. In [12] authors confirmed that using a P2P file-sharing system contributes to reducing the cost of files stored and protected in a decentralized environment. The use of smart contracts plays a significant role in managing a Blockchain-based file-sharing system in a decentralized environment and deploying it in the Ethereum network [13].

With the growth of using smartphone devices, the mobile applications market is always changing, with new developments and trends emerging frequently [14] [15]. Intending to create safe, decentralized, and effective payment solutions, Blockchain technology has significantly impacted mobile applications especially, the applications designated for payment futures [16]. Furthermore, blockchain technology seamlessly integrates with Internet of Things (IoT) devices to address IoT-related challenges, including data security, trust, interoperability, and data provenance [17] [18].

Hence, Blockchain technology combined with IPFS and Smart Contracts has emerged as a promising solution to address the issues mentioned earlier, by providing a decentralized and tamper-proof ledger for recording and sharing accident-related information as well as a guarantee of data security, authenticity, and integrity.

III. Problem Statement

In this section, we provide a brief description of the current system limitations.

The proposed Blockchain-based mobile application for traffic accident report's management focuses on revolutionizing the current process of managing paper accident reports (Fig 1).

As presented in Fig 1, the current model is a paper-based report. As shown in the figure the document contains a lot of information to fill in and seems too complicated especially, in the case where the driver is a beginner in addition to that the risk of making mistakes is very high.

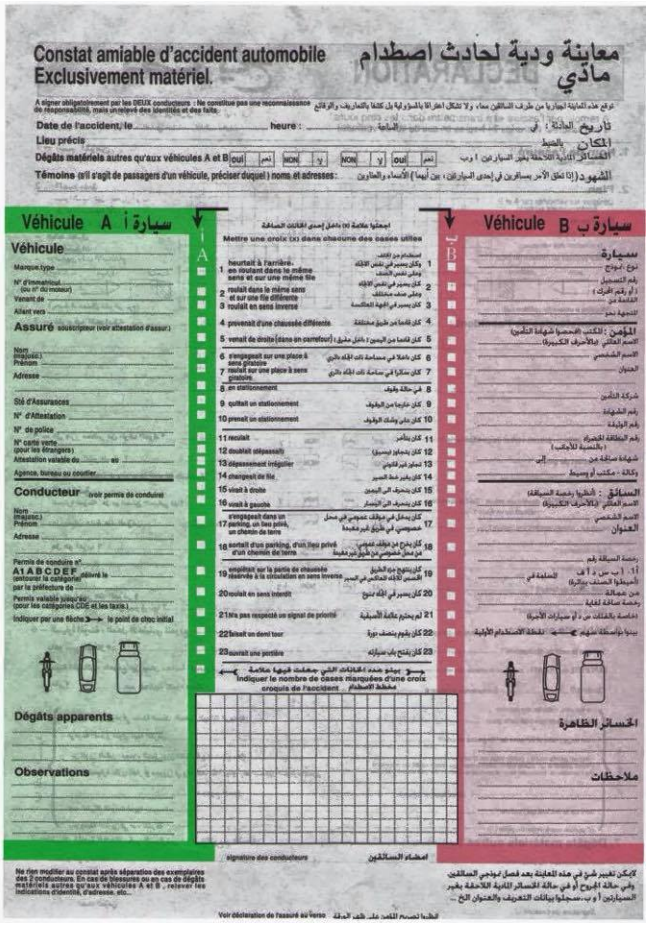

Fig. 1. Example of amicable traffic accident report used in case of car crash in the Moroccan country.

Moreover, written reports present several limitations such as:

- Error-prone: paper reports are susceptible to human error, including illegible handwriting, incomplete information, and data entry mistakes;
- Limited accessibility: paper reports may not be readily accessible to all relevant parties, such as insurance companies and law enforcement agencies, especially, if they are stored in physical files;
- Storage and retrieval challenges: storing and retrieving paper reports can be space-consuming, particularly when dealing with large amounts of reports over time;
- Susceptible to damage: paper reports are vulnerable to damage from environmental factors or even from loss, which can compromise the integrity and availability of the data;
- Lack of data security: Paper-based reporting is weak in terms of protecting sensitive information from unauthorized access, tampering, or theft;
- Time processing: generally, manual reporting leads to delays in data entry that could affect the time of response and resolution in emergency cases.

After all, the integration of Blockchain technology and IPFS into a mobile application will introduce a decentralized and immutable system that ensures trust, data integrity, data accountability, and data traceability, besides reducing the time of processing the accident report.

IV. Proposed Solution

In this section, a description of the proposed solution as well as the used technologies is presented.

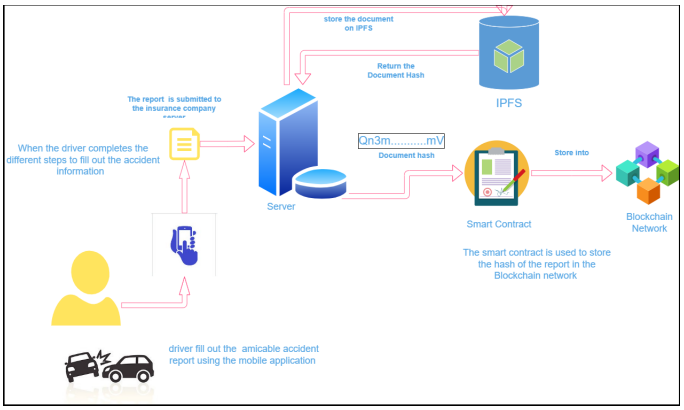

Fig. 2. Proposed architecture

As illustrated in Fig. 2, when a traffic accident occurs, the driver can easily complete the amicable accident report using the user interfaces of the mobile application. Once the necessary information is filled out and photos of the accident are taken and uploaded into the application, the driver can promptly submit the report to the insurance company.

The document is stored on IPFS, and then the document's hash is generated. The hash of the document is the key for document location on addressable content.

The IPFS guarantees non-duplication of a document, (unique ID, as it is cryptographically generated), and a tamper-proof document. When the document's hash is generated, it will be stored on the Blockchain network using a Smart Contract to allow traceability and authenticity.

In that case, we can have access to documents using the hash generated. If a user changes, one letter or character in that document a new hash will be generated and show that the original document has been altered. All of these functionalities will be described in the rest of this section.

A. Blockchain Technology

The Blockchain is a new technology where the data is structured on a Cryptographically linked list of blocks. Those blocks contain the list of transactions. In other words, the Blockchain could be considered a ledger of transactions that combine: a P2P network, consensus protocol, hashing algorithms, and decentralized system architecture. All of these technologies are combined together to ensure a secure environment to share or store data with the guarantee of transparency, immutability, consistency, equal rights, and availability [19].

B. Smart Contracts

To speed up transactions, Blockchain support smart contracts, which are computer programs written using a programming language called "solidity", are stored on the Ethereum Blockchain and executed automatically. Smart contracts are made up of various functions that can be accessed from outside of the Blockchain or from other smart contracts.

The combination of Blockchain and smart contract technology eliminates the need for a centralized system or an authorized third party between two transaction parties. Since smart contracts are stored on the Blockchain, all network participants have a copy [20].

C. Interplanetary File System (IPFS)

The Interplanetary file system is a protocol designed to store and access files in a peer-to-peer decentralized and distributed file system. Basically, IPFS is a peer-to-peer, open source, content addressable globally that can be used for storing and sharing large volumes of files with high throughput. So, if you want to check the integrity of a file, just recalculate its hash and compare it with the hash used as an Address [21].

D. Ethereum Blockchain

Ethereum, a leading decentralized platform, is responsible for the introduction of smart contracts. Also known as self-executing contracts where agreement terms are encoded in code. these contracts have revolutionized the processing of online financial transactions [22].

E. Ganache-cli

This tool will provide an instance of Ethereum Blockchain. It contains a log of all transactions and a console to inspect each one of the transactions and retrieve data related to it, (transaction hash, timestamp, location, input data) as well as the smart contract information. The Fig.3 represents the log of Ganache-cli. As seen in the figure the console contains information about the Ethereum node running in localhost, along with the transaction hash & timestamp.

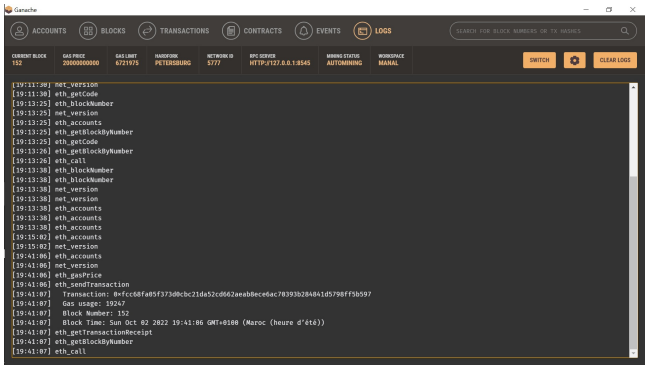

Fig. 3. Log of Ganache-cli environment

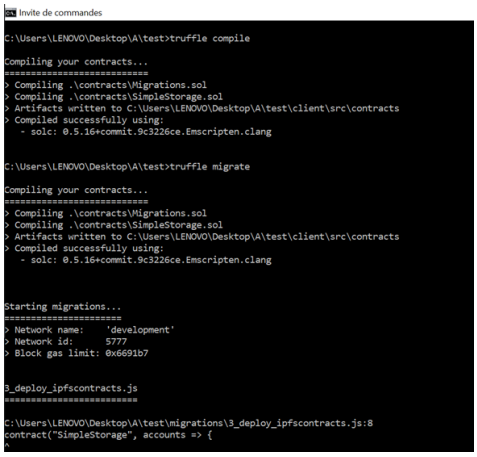

Fig. 4. Smart contract compilation and migration using truffle

F. Truffle

Truffle serves as a development environment, testing framework, and asset pipeline designed specifically for Ethereum. It's a front-end tool, used to deploy and compile smart contracts and insert them into the web application.

Fig.4 describes the process of deployment and migration of the smart contracts with truffle, via a CMD line command.

G. Android Studio

We used Android Studio, which is the official Integrated Development Environment (IDE) for developing Android apps, to create user interfaces.

Concerning the API integration, web3.js libraries were used to ensure the interactions between smart contracts and the Blockchain network with the mobile application.

Next Figures describe the smart contract coding and the code for IPFS Hash generating.

As seen in Fig.5, the function "createcontract" allows us to deploy smart contracts in the network and return the address of the contract. The function "processcontract" enables the use of the load function to apply the functions specified in the contract via its address.

In Fig.6, the code for generating an IPFS hash of the report is presented.

```
public String  createContract(String key) throws Exception {
    credentials = Credentials.create(key);
    Contract_Document contract = Contract_Document.deploy(web3j, credentials,DefaultGasProvider.GAS_PRICE, DefaultGasProvider.GAS_LIMIT).send();
    System.out.println("Contract :  "+contract.getContractAddress());

    return contract.getContractAddress();
}

public Contract_Document processContracts(String adress,String key) throws Exception {

     credentials = Credentials.create(key);

     Contract_Document contract = Contract_Document.load(adress, web3j, credentials,DefaultGasProvider.GAS_PRICE, DefaultGasProvider.GAS_LIMIT);
     System.out.println("Transaction fait avec succes");
    return contract;
}
```

Fig. 5. Smart contract deployment

```
//Send into Blockchain

Contract_Document contract;
IPFS ipfs = new IPFS("/dnsaddr/ipfs.infura.io/tcp/5001/https");
System.out.println("connected");
MerkleNode response = null;
HashMap<String, String> tmp = new HashMap<String, String>();

try {

    //Generer Hash IPFS
    byte[] bytes = file.getBytes();
    NamedStreamable.ByteArrayWrapper files = new NamedStreamable.ByteArrayWrapper(bytes);
    response = ipfs.add(files).get(0);
    System.out.println("Hash (base 58): " + response.name.get() + " - " +response.hash.toBase58());

    //Stock Contract
    contract = service.processContracts("0xc53623779DEE628674F21893A4b10b817488a5b6",key);
    TransactionReceipt tr = contract.set(response.hash.toBase58()).send();
    Block block = web3j.ethGetBlockByHash(tr.getBlockHash(), true).send().getBlock();
    Timestamp timestamp = new Timestamp((block.getTimestamp()).longValue() * 1000);
    Date date = new Date(timestamp.getTime());
```

Fig. 6. Generate IPFS Hash and store it in the Blockchain

V. Observation & Results

Ultimately, the preliminary testing of the application demonstrates its benefits in simplifying the accident report process. When an accident occurs, the driver can simply use the mobile application, and complete the steps for filling out the report of the accident.

The following is a scenario describing the different steps of using the application for report generation.

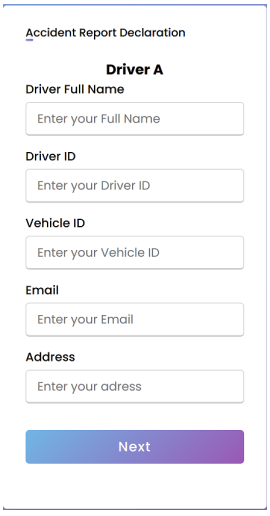

Fig. 7. Step1: the driver A details form

The first step is completing a form with essential information about the drivers and the vehicle ID (Fig.7). The same

Interface is used for the driver B. The next step is to select the car type from the existing list of cars (Fig.8, Fig.9).

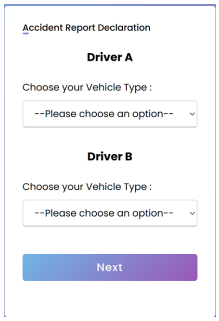

Fig. 8. Step3: Checking the vehicles type - 1

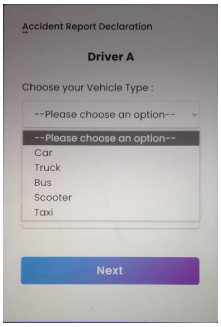

Fig. 9. Step3: Checking the vehicles type - 2

After that a checklist that includes details about the traffic accident, the position of the vehicles at the time of the crash, the various damages caused as well as determining the at-fault driver. The Drivers can easily select options from the list (Fig.10).

Fig. 10. Step4: Checking the accident information

The next step is taking photos of the accident (Fig.11).

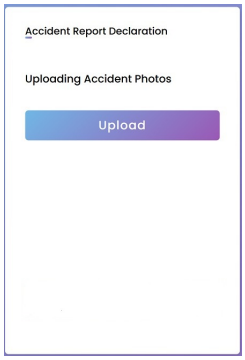

Fig. 11. Step5: Uploading real photos of the accident

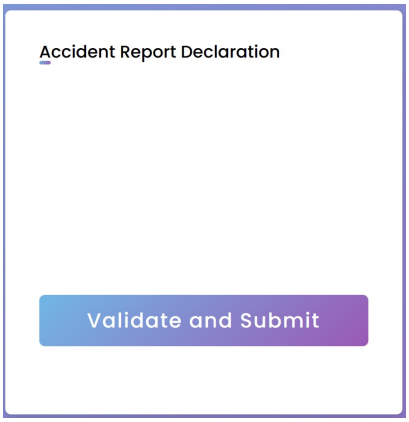

Fig. 12. Step6: Submitting the accident report

For more accuracy, the application gives the opportunity to include photos of the accident to be inserted into the report. Finally, the report is generated with all the necessary information for user verification and signing, and it can be submitted to the insurance company system (Fig.12).

VI. Discussion

Data sharing processes are often complex and lack of trust, particularly when managing documents manually. So, the use of centralized systems leads to a set of issues, especially a lack of trust, transparency, security, and confidentiality of data. The use of Blockchain technology, IPFS, and smart contracts in decentralized systems allows us to fix the mentioned issues and provide potential benefits and promises in different categories such as :

- transparency;
- reduction of corruption;
- unauthorized changes;
- data security;
- data privacy;
- easy data retrieval.

Certainly, the results of this study show that adopting this Blockchain-based application for accident report's management will be a prominent revolution for the insurance sector.

VII. Conclusion and Future Works

In conclusion, a Blockchain-based mobile application is used to manage the traffic accident report in this paper.

The integration of Blockchain technology into a mobile application combined with IPFS and Smart Contract offers a promising solution for improving traffic accident report management. By leveraging Blockchain's decentralized architecture and cryptographic principles, the proposed system enhances data integrity, transparency, and efficiency in accident-related processes.

Future directions of our work will focus on developing the capability to check the status of the accident report, and facilitate interactions with insurance company. Additionally, we aim to expand the functionality of the mobile application to support automated data exchange with relevant stakeholders, such as law enforcement agencies, and healthcare providers in case of accidents with injuries.

Lastly, the integration of emerging technologies such as Internet of Things(IoT), and artificial intelligence (AI) into our Blockchain-based application could unlock new capabilities and respond to the changing needs in this field.

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