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РАЗРАБОТКА МОДЕЛИ БЛОКЧЕЙН МЕХАНИЗМА ДЛЯ АВТОМАТИЗАЦИИ ОПОВЕЩЕНИЯ О ДТП С ЦЕЛЬЮ ОКАЗАНИЯ ПЕРВОЙ ПОМОЩИ ПОСТРАДАВШИМ

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Автоматизация оповещения о дорожно-транспортных происшествиях (ДТП) и предоставление первой помощи пострадавшим – важные аспекты общественной безопасности. В данной статье представлена разработка модели блокчейн механизма, который направлен на улучшение эффективности и скорости реагирования на ДТП с целью оказания первой помощи пострадавшим. Модель предлагает инновационный подход к автоматизации процесса оповещения о ДТП, основанный на использовании технологии блокчейн. Система предусматривает создание децентрализованной сети, в которой информация о происшествиях фиксируется и доступна для мгновенного обмена между участниками. Это позволяет сократить время реагирования служб экстренной помощи и улучшить координацию действий на месте происшествия. В рамках статьи рассматриваются технические аспекты разработки модели, включая структуру блокчейн сети, протоколы обмена данных и механизмы безопасности. Обсуждаются потенциальные выгоды и препятствия внедрения предложенной системы. Кроме того, данная модель блокчейн механизма способствует улучшению взаимодействия между участниками системы, включая медицинский персонал, службы экстренной помощи и органы правопорядка, что повышает координацию и эффективность помощи на месте ДТП. Исследование также обращает внимание на важность обучения и информирования общественности о возможностях и преимуществах использования таких технологий в повседневной жизни для повышения безопасности дорожного движения.

Ключевые слова: Блокчейн, Умная дорога, Умное здравоохранение, Умные контракты, Цифровизация, Транзакция.

DEVELOPMENT OF A BLOCKCHAIN MECHANISM MODEL FOR AUTOMATING TRAFFIC ACCIDENT NOTIFICATION FOR THE PURPOSE OF PROVIDING FIRST AID TO VICTIMS

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Automating road traffic accident (RTA) notification and providing first aid to victims are important aspects of public safety. This paper presents the development of a blockchain mechanism model that aims to improve the efficiency and speed of road accident response to provide first aid to victims. The model proposes an innovative approach to automate the process of traffic accident notification based on the use of blockchain technology. The system involves the creation of a decentralized network where incident information is captured and available for instant sharing among participants. This reduces the response time of emergency services and improves coordination at the scene of an accident. The paper discusses the technical aspects of model development, including the blockchain network structure, data exchange protocols and security mechanisms. The potential benefits and obstacles of implementing the proposed system are discussed. In addition, this blockchain model facilitates better communication between system participants, including medical personnel, emergency services, and law enforcement, which enhances the coordination and efficiency of assistance at the accident scene. The study also

draws attention to the importance of educating and informing the public about the possibilities and benefits of using such technologies in everyday life to improve road safety.

Keywords: Blockchain, Smart Road, Smart Health, Smart Contracts, Digitalization, Transaction.

Introduction

Globally, road traffic accidents pose a significant public health challenge, leading to substantial casualties and economic burdens [1]. With millions of lives lost or injured each year, there's an urgent need for innovative solutions to streamline emergency response processes and reduce the impact of these incidents. In the context of the Republic of Kazakhstan, which has witnessed a concerning increase in road accidents, the integration of advanced technologies holds promise for improving accident notification and first aid delivery [2].

Blockchain technology has emerged as a transformative tool in various sectors, including Smart City initiatives aimed at enhancing urban infrastructure and services. In recent years, research and development efforts have explored the potential of blockchain in improving traffic management, emergency response, and public safety [3]. By leveraging blockchain's decentralized ledger and secure data exchange capabilities, cities can optimize resource allocation, enhance transparency, and facilitate seamless collaboration among stakeholders [4].

Several countries have embarked on initiatives to integrate blockchain technology into their urban infrastructure, with promising results. For example, Singapore has implemented blockchain-based solutions for traffic management, enabling real-time data sharing between vehicles and infrastructure [5]. Similarly, Dubai has launched the Dubai Blockchain Strategy, aimed at enhancing government efficiency and transparency across various sectors, including transportation and emergency services [6].

While specific initiatives related to blockchain integration in traffic accident notification systems may be limited in Kazakhstan, the country has shown interest in adopting blockchain technology in various sectors. For instance, the Astana International Financial Center (AIFC) has established a Blockchain and Cryptocurrency Center to promote blockchain adoption and innovation in finance, logistics, and other industries [7]. Additionally, Kazakhstan's Digital Kazakhstan Strategy emphasizes the importance of emerging technologies like blockchain in driving digital transformation and innovation across the country's economy [8].

Recent studies have ventured into pioneering solutions harnessing blockchain technology to fortify traffic accident notification systems, with the overarching goal of augmenting the efficiency of emergency response operations and bolstering the delivery of critical first aid. Let’s journey through some noteworthy examples:

First up is the brainchild of Farooq et al., aptly christened DrunkChain: a Blockchain-Based IoT System engineered to combat drunk driving-related traffic accidents. The researchers recognized the sobering reality that drunk driving is a significant contributor to fatal accidents. Existing methods for assessing driver alcohol consumption, however, are fraught with vulnerabilities. The proposed solution intertwines the Internet of Things (IoT) with blockchain technology, presenting a device-based dashboard that vigilantly monitors the driver’s blood alcohol concentration (BAC) and vehicle stability. Integrated blockchain transactions seamlessly transmit data directly to a centralized police account, circumventing the need for a central server and ensuring the immutable integrity of data [9].

Next on our radar is the Blockchain-Based Framework for Traffic Event Verification in Smart Vehicles, meticulously outlined by Pujol. Though not explicitly tailored for accidents, this framework serves as a beacon illuminating the potential of blockchain in fortifying road safety. The system, anchored in blockchain transactions, stands as a staunch guardian of event data integrity, furnishing a reliable record of incidents [10].

Hamid et al. make a compelling case with their Accident Alert System Using Blockchain Technology, a paradigm-shifting endeavor championing privacy preservation and non-repudiation. This system swiftly furnishes crucial information to emergency responders, leveraging the potent fusion of blockchain and an incentive mechanism to foster enhanced communication and coordination in accident scenarios [11].

Hamza et al. present an intriguing divergence with their AI-Enabled Accident Detection and Alert System, ingeniously employing IoT and deep learning to discern car accidents through smartphone-based sensors. While not directly reliant on blockchain, this endeavor underscores the pivotal role of IoT sensors in the realm of accident detection [12].

Rounding off our exploration is the visionary proposition by proponents advocating for the Integration of IoT and Blockchain for Ensuring Road Safety. As the landscape of intelligent transportation systems continues to evolve, the fusion of IoT and blockchain emerges as a formidable ally in fortifying accident reporting and response mechanisms [13].

In essence, these groundbreaking initiatives underscore the transformative potential of blockchain technology in redefining traffic accident notification systems, propelling emergency responses towards unprecedented efficiency and reliability. As researchers continue to chart new frontiers, the horizon brims with promise, heralding an era where road safety stands as an unwavering beacon of progress and innovation.

The integration of blockchain technology in traffic accident notification systems holds significant potential for the Republic of Kazakhstan. With the country experiencing a rise in road accidents and fatalities, leveraging advanced technologies like blockchain could enhance the efficiency and effectiveness of emergency response efforts [4]. By automating accident reporting, improving data accuracy, and enabling real-time communication between stakeholders, blockchain-based solutions could help reduce response times and save lives.

In conclusion, the integration of blockchain technology in traffic accident notification systems represents a promising approach to enhancing emergency response processes in the Republic of Kazakhstan and other regions globally. By leveraging blockchain's decentralized architecture and secure data exchange capabilities, cities can improve the accuracy, speed, and coordination of accident reporting and first aid delivery efforts. Continued research and collaboration are essential to further explore the potential applications of blockchain in improving public safety and urban resilience.

Methods and materials

Blockchain technology

Blockchain (BC) is a decentralized digital ledger that provides a secure and transparent record of transactions. It is a distributed database that maintains an ever-growing list of records, called blocks, that are linked and secured using cryptography.

Smart contracts are self-executing contracts with the terms of the agreement directly written into code. They run on blockchain platforms like Ethereum and automatically execute actions when predefined conditions are met. Smart contracts enable trustless and automated transactions, reducing the need for intermediaries and the risk of fraud. They have applications in various fields, including finance, supply chain, real estate, and more, where parties want to ensure trust and automate processes without relying on traditional intermediaries.[14]

Suppose a patient needs to share their medical history with different healthcare providers:

- *Blockchain*: The patient's electronic health records are stored on a blockchain, ensuring security and immutability.
- *Smart Contracts*: Smart contracts control access to these records. When a healthcare provider requests access, the smart contract verifies the request and, upon approval, grants temporary access to the specific records needed.
- *Data Sharing*: With the patient's consent, the healthcare provider can access the necessary medical data instantly and securely from the blockchain. Once the access time expires, the data is no longer accessible.

This example demonstrates how blockchain and smart contracts can improve the security and efficiency of managing electronic health records while ensuring patient privacy and control.

2.2 System design and architecture:

Using vision computing based technology, it can send real-time signals via server to the blockchain system. Whereas, server sends the proper arguments, blockchain mechanism procedure the data and link it to the smart contract that holds the tracked intel. Initially, vision computed mechanism fires the data through the blockchain, handling information on smart road smart-contract, keeping data to be emitted to third-party block - Medicinal center smart-contract. Thus, smart health smart-contract, by virtue of real-time responding event, perceive exact location of the accident by filtering passed event from local database. After resolving the incident, server sends request to smart road blockchain mechanism, instruct that car accident is resolved. Meantime, server using automatized device, help treat the injured people via blockchain system (see Figure 1).

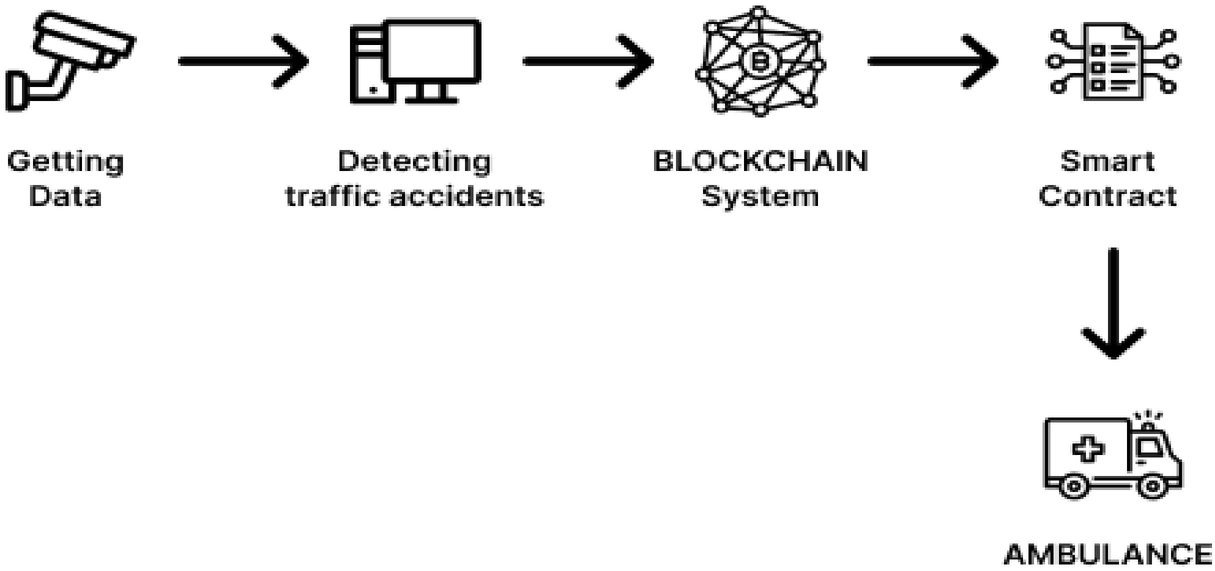

Figure 1 – System Architecture

In this scenario, the relationship between cameras and medical centers is streamlined to facilitate seamless emergency response. Here's how it works:

- *Smart Contracts for cameras*: Every camera along the smart road network is associated with a specific smart contract. These smart contracts continuously monitor their respective road sections for any events or incidents.
- *Medical Centers*: Medical centers, strategically located throughout the smart road system, are equipped with servers connected to the blockchain network. These centers act as hubs for coordinating emergency responses.
- *Emergency Event Detection*: When an emergency event occurs at an road sections, such as a traffic accident or a medical emergency reported by sensors or eyewitnesses, the corresponding smart contract is triggered.
- *Smart Contract Actions*: The smart contract at the road sections promptly executes predefined actions. In the case of a medical emergency, it initiates a call to the nearest medical center's server.
- *Server Response*: Upon receiving the emergency call from the smart contract, the medical center's server quickly assesses the situation and dispatches the appropriate response team, such as an ambulance or a rapid response unit, to the location of the road sections.
- *Efficiency and Rapid Response*: This automated process significantly reduces response times, optimizing resource allocation and ultimately saving lives. The load on individual servers is managed efficiently, ensuring that emergency calls do not overwhelm any single medical center.

To implement blockchain in projects, it is possible to use the Solidity language to write self-executing contracts for the Ethereum platform. Below is an example of a Solidity smart contract (see Figure 2).

```
function connectToMedpoint(
        string calldata cameraLongtitude,
        string calldata cameraLatitude
    ) external {
        this.setAccidentCount(Location(cameraLongtitude, cameraLatitude), 1);
        emit AccidentLocated(cameraLongtitude, cameraLatitude);
    }

function getAccidentCountByLocation(
        Location calldata key
    ) external view returns (uint256) {
        bytes32 hash = keccak256(abi.encode(key));
        return accidentsByLocation[hash];
    }

mapping(address => Location) public medpointsByCameras;
mapping(address => Location) public cameras;
mapping(bytes32 => uint256) public accidentsByLocation;

event AccidentLocated(string longtitude, string latitude);
```

Figure 2 – Code snippet

At the heart of this innovation lies the utilization of blockchain technology and smart contracts. Each intersection on the smart road network is represented by a dedicated smart contract. These smart contracts serve as autonomous entities capable of executing predefined actions when specific conditions are met. Additionally, each medical center is equipped with a server that connects to the blockchain network. This infrastructure helps distribute the load and ensures a rapid response to emergencies without overburdening individual servers.

2.3 Blockchain algorithms usage

Blockchain transactions between the two senders can be represented by the several formulas that show how functionality handles data transmission. Mainly, there are two of them: SHA-256 and Merkle Root.

SHA-256 (Secure Hash Algorithm 256-bit) is a cryptographic hash function that takes an input message of any length and produces a fixed-size output hash value of 256 bits. SHA-256 Algorithm often used by ciphering the block data, unique IDs in order to avoid revealing secret keys. Here's a simplified explanation of how SHA-256 works along with a high-level formula:

H - Block hash
SHA-256 - algorithm (secure hash algorithm)

$$H = SHA256(SHA256(Version + Previous\ Block\ Hash + Merkle\ Root + Timestamp + Difficulty\ Target + Nonce))$$

Formula 1.

Version: A version number that indicates the protocol version being used.
Previous Block Hash: The hash of the previous block's header, linking the current block to the previous one in the blockchain.
Merkle Root: The Merkle root hash of all the transactions included in the block.
Timestamp: A timestamp representing the time when the block was created.

Difficulty Target: A value that indicates the difficulty of the proof-of-work algorithm.
Nonce: A number that miners increment during the mining process to find a valid block hash.

Where:

- Message: The input message.
- Compression_Function: The compression function applied to each block.
- Block_N: Each 512-bit block of the padded message.
- Initial_Hash_Values: The initial hash values used for the first iteration.

Merkle Root Calculation:

Given a set of data blocks (D1, D2, ..., Dn), the Merkle root (R) can be calculated using a recursive process:

1. Begin with the data blocks as the leaves of the Merkle tree.
2. Compute the hash value (H) of each data block.
3. Pair adjacent hash values and concatenate them.
4. Hash each concatenated pair to produce a new hash value.
5. Repeat steps 3-4 until only one hash value remains - this is the Merkle root.

The formula can be represented recursively as follows:

$$D = [d_1, d_2, d_3, \dots, d_n]$$
$$M(D) = H(D_i)$$
$$M(D) = H(M(DL)) + M(DR))$$

Formula 2.

Where:

- D1, D2, ..., Dn are the data blocks.
- H () represents the hash function.
- DL - data left (first data)
- DR - data right (end)

The Merkle root (R) obtained from this process is a compact representation of all the data blocks and serves as a single cryptographic proof of the integrity of the entire data set. This root is then stored in the blockchain header along with other metadata.

Results and Discussion.

The transaction data in *Table 1* confirms the smooth execution of the blockchain mechanism model in automating traffic accident notification and enabling communication with the Medpoint system. Each transaction signifies a seamless interaction among various entities within the blockchain network, thereby enhancing the overall efficiency and efficacy of emergency response processes.

The "Success" status of each transaction indicates error-free execution of the connect-to-Medpoint method, validating the reliability and robustness of the implemented smart contracts. These contracts play a pivotal role in orchestrating accident notification and facilitating timely provision of first aid, thereby ensuring prompt responses to road-related emergencies.

The inclusion of block numbers and timestamps in each transaction offers valuable insights into the temporal dynamics of transaction execution, shedding light on the real-time nature of accident notification and response coordination facilitated by the blockchain mechanism model.

The involvement of transaction parties, including sender and recipient addresses, illustrates the seamless communication and collaboration among different stakeholders, such as smart road infrastructure, medical centers, and emergency response teams. This interoperability is crucial for optimizing resource allocation and enhancing coordination during emergency situations.

Additionally, the minimal transaction fees associated with each transaction underscore the cost-effectiveness of employing blockchain technology for automating traffic accident notification. These nominal fees contribute to the sustainability and scalability of the blockchain mechanism model, ensuring its long-term viability in real-world scenarios.

In essence, the transaction data reaffirms the effectiveness and reliability of the developed blockchain mechanism model in enhancing emergency response processes and bolstering public safety on the roads. Through the utilization of blockchain technology and smart contracts, the model simplifies accident notification, minimizes response times, and ultimately saves lives during critical situations.

This discussion underscores the significance of continuous research and innovation in leveraging emerging technologies like blockchain to tackle pressing challenges in urban environments, particularly in the realm of road safety and emergency response.

This thorough analysis of transaction data highlights the transformative potential of blockchain technology in enhancing emergency response processes and bolstering public safety in urban settings.

Conclusion

The integration of blockchain technology and smart contracts into smart road systems has the potential to revolutionize emergency response procedures. By establishing a network of smart contracts for intersections and well-connected medical centers, the system can rapidly and efficiently respond to accidents and medical emergencies, enhancing road safety and saving valuable time in critical situations. This innovative approach represents a significant step toward safer and more responsive smart road networks in modern urban environments.

In conclusion, the development of a blockchain mechanism model for automating traffic accident notification marks a significant stride towards enhancing public safety, particularly in the critical domain of providing timely first aid to accident victims. By leveraging blockchain technology, this model offers a streamlined approach to accident reporting and fosters seamless communication among key stakeholders, including medical professionals, emergency responders, and law enforcement agencies.

Overall, the findings from this study reaffirm the efficacy and reliability of the blockchain mechanism model in optimizing emergency response efforts and mitigating the adverse impacts of road accidents. Through the integration of blockchain technology and smart contracts, the model not only reduces response times but also plays a pivotal role in saving lives during critical situations.

Looking ahead, it is imperative to continue exploring innovative solutions and advancing research in the realm of emerging technologies like blockchain. By fostering collaboration and promoting the adoption of such technologies, we can further bolster public safety measures and create more resilient communities, not only in Kazakhstan but also on a global scale.

Table 1 – Transaction Data for Connect-to-Medpoint Method

Transaction Hash	Status	Method	Blockno	DateTime (UTC)	From	To	Value	Txn Fee
0x351068f4ce441cebec5b72f38dfb6566350724d2fe4fc1efbeb3d1c8ec956436	Success	Connect To Medpoint	39989226	2024-05-02 20:19:22	0xdAcCe3cFd67E9f466469440534C1128db68e3F6A	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.000177
0x877b2743eaea2e2b93ce05949e3b4298c6d93812350b0aa1e771824b931fcb87	Success	Connect To Medpoint	39989225	2024-05-02 20:19:19	0xdAcCe3cFd67E9f466469440534C1128db68e3F6A	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.000177
0x8b81d5dfd680a087708809f26bbda67338b46b38eb3c729851fdf7dc5854e7fe	Success	Connect To Medpoint	39989223	2024-05-02 20:19:13	0xdAcCe3cFd67E9f466469440534C1128db68e3F6A	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.0002625
0xd7eedd03ad9299919e33a828aa0619be8a60acff1e97da610f1eed4b60150dbb	Success	Connect To Medpoint	39989217	2024-05-02 20:18:55	0x14543dcFeAc3725c15991B87388A7d11E39AA12D	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.0002625
0x81d549e76ffb929c0a87407e8812180303a4e2f611a49407485d64d1e9128a0a	Success	Connect To Medpoint	39989210	2024-05-02 20:18:34	0x9d02adec1dE5Af14eeAebC4D6f5dF8107A641199	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.000177
0xa81d2a076f7419cae049373daae9c8dc662599937fed5b2597ea2a623991b6fc	Success	Connect To Medpoint	39989205	2024-05-02 20:18:19	0x9d02adec1dE5Af14eeAebC4D6f5dF8107A641199	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.0002625
0x6e911c99f45856726e70966ed475185cbf8f936e9e64b553da63689319d01c25	Success	Connect To Medpoint	39989196	2024-05-02 20:17:52	0xbA4c09F68eAd6e81c9391A4A2480e83AC0218aC6	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.000177
0x59a68d277a86c6d3af734cc8f859d435c7c4033e9bc5a3f9e32122472d8ba4ad	Success	Connect To Medpoint	39989175	2024-05-02 20:16:49	0xbA4c09F68eAd6e81c9391A4A2480e83AC0218aC6	0xfb5ed4f23fe5B07e9AEDD0f71319b330794bad5a	0 BNB	0.0002625
0x18ff79df2ce483b886f1128e88d7f2928c211a2de719cf67ad852391a79af2d4	Success	60806040	39989155	2024-05-02 20:15:49	0xbA4c09F68eAd6e81c9391A4A2480e83AC0218aC6	Contract Creation	0 BNB	0.00761416

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