Research on the Application of Blockchain Technology in Subway Construction Safety Management

Dongzhu Zhu

Hubei No. 3 People's Hospital of Jianghan University, Wuhan, China

13647206181@163.com

Abstract. There are a large number of safety hazards in the construction process of subway projects, which are difficult to eliminate from the source. Currently, security risks identified based on rules often require assistance in addressing challenges such as time consumption, poor authority, poor traceability, or lack of real-time information. To address these issues, this study developed a new blockchain based subway construction safety hazard regulation storage system (SHRSS) and constructed a safety hazard regulation database, standardized regulations, and stored them on a block basis.

Keywords: Safety Hazard; Metro construction; Data storage; Blockchain; Safety Hazard Regulation Storage System.

1 Introduction

The subway provides various benefits, including large transportation capacity, fast transportation, minimal energy use, and convenience [1,2]. The Statistical Analysis Report on Urban Rail Transit in 2021 pointed out that by the end of 2021, there were 50 cities in Chinese Mainland operating urban rail transit, with 283 lines and 9206.8 kilometers in length. However, risks based on personnel, machinery, environment, and management greatly increase the likelihood of risk occurrence[3].

During the subway construction phase, safety hazards can lead to accidents. It is necessary to exchange and transmit information on hazards (such as project type and scale, construction technology, safety management processes, weather, and site conditions) among all parties involved in monitoring[4]. However, without formal understanding of the danger, information sharing and communication among all parties may pose significant obstacles.

A blockchain storage system is information about subway construction and regulations, including improper operations by builders, interactions between structures and their surrounding environment, as well as construction equipment and management controls. Most safety hazards in subway construction are related to these engineering data, and skilled engineers can identify problems and risk factors by reading blockchain models. Therefore, this article will combine blockchain technology to establish a formal and comprehensive knowledge base of subway construction safety hazards. The focus

P. Liu et al. (eds.), *Proceedings of the 2024 5th International Conference on Civil, Architecture and Disaster Prevention and Control (CADPC 2024)*, Atlantis Highlights in Engineering 31,
https://doi.org/10.2991/978-94-6463-435-8_25

of research on building storage systems based on blockchain technology is to extract standard regulations with security regulations and store these regulations in the blockchain.

2 The SHRSS construction

2.1 The classification of the safety hazard regulations

The quality specification "Urban metro Transit Engineering Quality and Safety Inspection Guide" is an example in this document and is divided according to the types of safety hazards involved in the metro construction process[5]. According to this Guide, we divided the metro construction process safety risks into 21 categories. In order, security introductory management class, civilized construction class, fastener steel scaffolding, bowl buckle steel scaffolding, plate steel scaffold, complete scaffolding, formwork engineering, construction safety, safety protection, tower crane safety, gantry safety, material elevator management, lifting, construction machinery management, foundation pit support, shield tunnel construction, mining tunnel construction, metro construction management, unique climate construction, artificial digging, and bridge machine safety inspection.

After the first-level hazard classification, determine the second-level hazard standard according to the category's standard content. The third-level classification catalog of metro construction hazards mainly refers to the specific inspection catalog of each second-level catalog[6]. Take the security introductory management class as an example, as shown in Tables 1.

Currently, the potential safety risks of metro transit have been relatively mature in the industry. Nevertheless, no relevant literature makes statistics on the causes of these dangers. Therefore, it is necessary to establish a more practical type database of metro construction hazards and form a governance basis for investigating them. According to the characteristics of each type of safety hazard, this paper divides it into four following specific categories[7]:

1)personnel(P) refers to the mistakes of personnel, which may lead to the destruction of other control measures, resulting in the unintentional release of energy or hazardous materials and initiating accidents.

2)Machine(M) refers to the failure of the object, which the phenomenon function can not realize because of the low performance. The inability of things or direct cause measures to restrain, limit the quantity, or harmful substances failure, resulting in accidents.

3)Environment(E) refers to the physical environment of the system operation, the peaceful environment of enterprises and society, and the poor system construction environment.

4)Administration(A) refers to the organizational factors that are not safe, including the managerial procedures, corporate culture, rules, systems, and the unsafe behaviors of the managers.

Table 1. Example of three-level hazards of metro construction

Second-level hazard	Third-level hazard	Classification
Unit Qualification and Personnel Qualification	The project manager has not obtained the safety license	P
	No security management organization on the project	A
	No clear quality and safety management standardization self-assessment department	A
	The monitors' equipment was not meet the standard	M
	The driver of the shield machine failed the operation assessment(construction unit) before working	P
	No safety inspection system	A
	No accident hidden investigation management system	A
	No regular safety checking	A
	No security inspection file	A

2.2 How to standardize the safety regulations?

The correctness of risk knowledge description and the simplicity of knowledge acquisition influences the accuracy and efficiency of SHRSS.

The standardization and formalization of safety risk knowledge in metro construction are implemented in this study using the Miyoung Uhm technology, which is based on the specifics of the risk identification of metro construction and its practical application significance[8]. This will enable sharing and reusing risk knowledge from this particular domain to assist in identifying risks in metro construction projects[9].

To translate natural language into a machine-readable and executable format, that is, to extract the rules of metro safety hazard regulations syntax. Firstly, the python Jieba function is needed to mark the segmentation and annotation of security hazard regulations and utilize General Architecture for Text Engineering (GATE） for knowledge extraction.

Secondly, this study used context-free grammar (CFG) in natural language processing. It classified morphemes into four categories: object(noun), method(verb), and strictness(modal), allowing us to translate them into things later, methods, degrees of strictness, and properties. Adjectives and adjective phrases were also examined and later translated into properties or qualities of an object.

Thirdly, the morphemes generated by CFG decomposition are detailed and used to build object (morpheme) libraries and method libraries. Standardized specified the final rules in SWRL(Semantic Web Rule Language)[10]. About half of the methods are Boolean type. Returns True if the condition is met and False if not met. Thus, the

specification regulations can be expressed in syntax and identified in the blockchain hash algorithm.

2.3 The storage mechanism of the safety hazard regulations

Blockchain, as a kind of decentralized, non-tamable, traceable, and distributed data jointly maintained by various parties, can establish trustworthiness among multiple parties without mutual understanding. Without the coordination of third-party intermediaries, dependable data sharing and transmission of point-to-point value are realized in an epoch-making way.

To achieve the immutability of data, Blockchain introduces a chain structure in blocks. The block structure comprises a header and body, similar to the blockchain's generally used block structure. The block body has data from volume transactions saved in it. The following details are in the block header:(1) Hash of the block for verification. (2) Merkle root tracks a group of transactions for each block. (3) Nonce value is a number generated by the consensus process to produce a hash value below the specified difficulty level. (4) Timestamp is when the block was created. The data structure of the Blockchain is shown in Fig. 1.

Typically, blockchain does not save the original data or transaction records directly. The data gets encoded into the blockchain as a precise string of numbers and letters, but it still contains the hash function result. The NSA developed the SHA-256 algorithm, which is used in this work. The SHA-256 generates a 256 bit or 64 character long hash from input data and outputs a fixed-length output of 265 bits.

A Blockchain is created by connecting isolated blocks using a forward hash based on the previous block's content. Volume transactions for the current block and transactions produced during the confirmed block formation process are included.

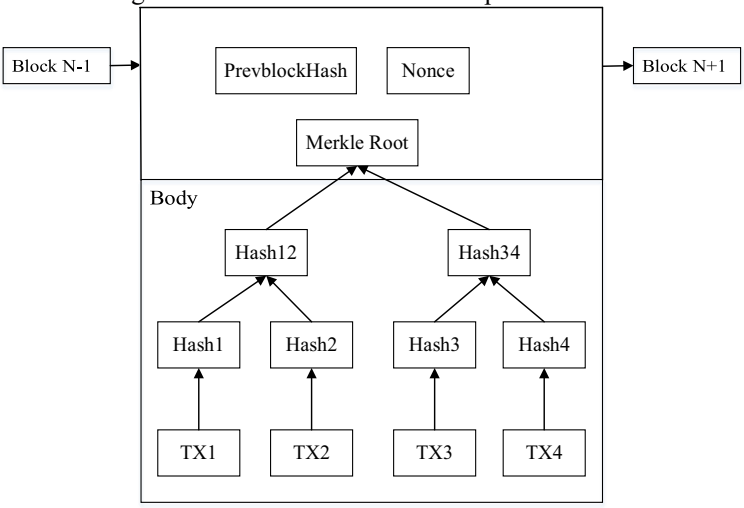

Fig. 1. The Data Structure of the Blockchain

The storage system based on blockchain technology changes the traditional regulation identification mode and improves the efficiency of risk identification. The block construction method of the metro hazard regulations stores the number, content, and classification of the third-level hazard in the nodes corresponding to the second-level hazard, and the information of the second-level hazard is stored in the block where the first-level hazard is located. The information embodied by each node is a data block, which identifies the block and its contents as a unique code using an SHA-256 code. The hashing process linked to the Merkle roots is kept in the block, ensuring it can trace every piece of data. Meanwhile, due to the unidirectional and conflict resistance of the hash algorithm. This provides that the data cannot be tampered with, and the reliability of the safety hazard regulations is improved. Specific stored procedures are in Fig. 2.

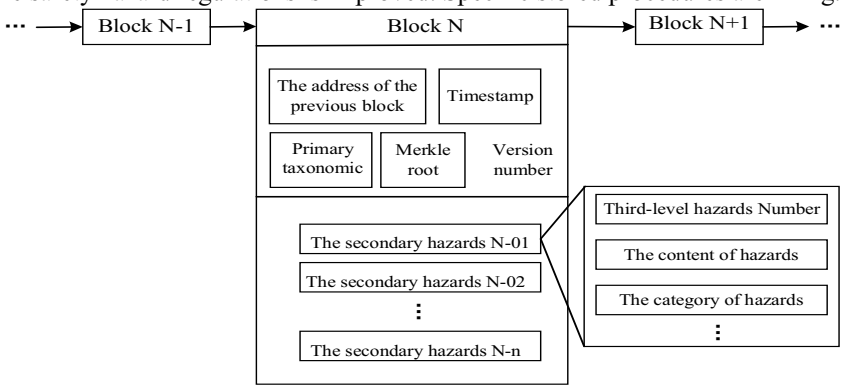

Fig. 2. The Block construction process of metro safety hazard regulations

3 Conclusions

For metro construction management, it is crucial to store safety hazard regulations. The advantages of SHRSS over conventional methods are as follows: (1) The blockchain-based storage of security hazard laws assures immutability while saving time and labor costs. (2) The construction of a security hazard regulations database. This paper selects the "Urban Metro Traffic Engineering Quality and Safety Inspection Guide" quality standard. The four categories of personnel, machinery, environment and administration are used to categorize and significantly standardize the safety hazard rules database. (3) Standardization of safety hazard laws. Make security hazard regulations rules that computers can recognize, reducing reliance on regulations with different ways of expression. Past safety hazard regulations are randomly stored on third-party tools. The use of blockchain technology can reduce dependence on third-party tools and facilitate the sharing of hazards among participants and field experts.

References

1. Xinggao Li, Chen X 2012: Using Grouting of Shield Tunneling to Reduce Settlements of Overlying Tunnels: Case Study in Shenzhen Metro Construction. Journal of Construction Engineering and Management 138, 574-584. http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0000455.
2. Ding Lieyun, Zhang Limao, Wu Xianguo, Skibniewski MJ, Qunzhou Y 2014: Safety management in tunnel construction: Case study of Wuhan metro construction in China. Safety Science 62, 8-15. http://dx.doi.org/10.1016/j.ssci.2013.07.021.
3. Yoo C, Jeon Y-W, Choi B-S 2006: IT-based tunnelling risk management system (IT-TURISK) – Development and implementation. Tunnelling and Underground Space Technology 21, 190-202. http://dx.doi.org/10.1016/j.tust.2005.05.002.
4. Teizer J 2016: Right-time vs real-time pro-active con- struction safety and health system architecture. Construction Innovation 16, 253-280. http://dx.doi.org/10.1108/CI-10-2015-0049.
5. McFeat-Smith I, Harman KW 2004: IMS risk evaluation system for financing and insuring tunnel projects. Tunnelling and Underground Space Technology 19. http: //dx. doi. org/ 10.1016/j.tust.2004.01.030
6. Meng Li, Hongliang Yua, Hongyu Jinb, Liua P 2018: Methodologies of safety risk control for China's metro construction based on BIM. Safety Science 110, 418-416. http://dx.doi.org/10.1016/j.ssci.2018.03.026.
7. Hunhevicz JJ, Hall DM 2020: Do you need a blockchain in construction? Use case categories and decision framework for DLT design options. Advanced Engineering Informatics 45. http://dx.doi.org/10.1016/j.aei.2020.101094.
8. CAO Yang, SU Zhenmin, Na L 2019: Research on System Architecture of the Information Sharing Management of Construction Supply Chain Based on Blockchain. CONSTRUCTION ECONOMY 40, 69-74. http://dx.doi.org/10.14181/j.cnki.1002-851x.201905069.
9. Perera S, Nanayakkara S, Rodrigo MNN, Senaratne S, Weinand R 2020: Blockchain technology: Is it hype or real in the construction industry? Journal of Industrial Information Integration 17. http://dx.doi.org/10.1016/j.jii.2020.100125.
10. Laurie Hughesa, Yogesh K. Dwivedia, Santosh K. Misrab, Nripendra P. Ranaa, Vishnupriya Raghavanc, Akellad V 2019: Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. International Journal of Information Management 49, 114-129. http://dx.doi.org/10.1016/j.ijinfomgt.2019.02.005.