Design of a Mine Supervision and Law Enforcement System

Desheng Zhang[a,b,c], Tiantian Shao[*a,b,c]

[a]China Coal Research Institute, Beijing, China 100013
[b]Coal Mine Emergency Avoidance Technology and Equipment Engineering Research, Center, Beijing, China 100013
[c]Beijing Coal Mine Safety Engineering Technology Research Center, Beijing, China 100013

*Corresponding author:shaotiantian@ccrise.cn

Abstract. In view of the problems of low standardization of mine safety production supervision and law enforcement process, lack of information means and low credibility of law enforcement information, a mine supervision and law enforcement system is designed, which can realize online Safety signs traceability of mine law enforcement and reliable solidification of data. The experimental results show that the system can effectively improve the work efficiency of law enforcement personnel, improve the efficiency, objectivity and scientificity of supervision and law enforcement, and achieve accurate law enforcement underground.

Keywords: Law enforcement; traceability of safety standards; trusted solidification

1   Introduction

In recent years, China has made great progress in the supervision and supervision of mining safety production, establishing a "network" for coal mine safety risk monitoring, achieving full coverage of supervision and law enforcement business, user and data aggregation. However, there are still certain shortcomings in precise law enforcement [1-4]. In the administrative law enforcement process of coal mines, there are generally problems such as outdated regulatory methods and equipment, discontinuous evidence collection process, and subjective experience judgment as the main method. The lack of automatic identification technology and equipment has led to some hidden dangers in coal mine production not being discovered in a timely manner[1,4-8].At the same time, safety production accidents occur from time to time in the coal mine production process [9], and the hidden safety hazards at the mine site are strong, with many hidden danger investigation points, outdated technical level of existing law enforcement equipment, and a large workload of on-site supervision and law enforcement [10-11]; The existing law enforcement process has a low degree of standardization, with problems such as spatiotemporal discontinuity, empirical evaluation as the main method, and high consumption of administrative resources; And

the security of law enforcement data is low, there is a possibility of tampering, and the credibility is not high[10-12]. The relevant policy documents such as the "14th Five Year Plan for the Construction of Safety Production Supervision and Supervision Capacity of Emergency Management Departments and Mine Safety Supervision Institutions" clearly propose policy requirements to strengthen law enforcement guarantee capabilities, accelerate innovation in safety production supervision and supervision methods, strengthen precise law enforcement, and increase the application of advanced intelligent and lightweight law enforcement equipment[13].

This article uses a text semantic understanding algorithm based on multi head bidirectional attention mechanism to achieve online safety labeling traceability of underground equipment; By using public key asymmetric encryption technology, timestamp and electronic signature electronic evidence chain synchronization and trusted solidification technology, a law enforcement information security guarantee system is constructed to solve problems such as law enforcement data falsification, secure access to law enforcement terminals, and reliable transmission of law enforcement information, ensuring the trustworthiness of law enforcement data.

2   Overall design

The system consists of law enforcement terminals and law enforcement platforms, as shown in Figure 1. The law enforcement terminal can receive law enforcement tasks issued by the law enforcement platform, and has functions such as environmental parameter detection, photography and recording, and safety label traceability. It can conduct business navigation through voice interaction, and can also achieve wireless uploading of law enforcement data; The law enforcement platform has functions such as issuing law enforcement tasks, managing law enforcement data, generating law enforcement reports, and displaying law enforcement processes. The specific law enforcement process is as follows:

(1) The law enforcement platform issues law enforcement tasks to the law enforcement terminal, and law enforcement personnel carry the law enforcement terminal to the corresponding underground places for law enforcement inspections;

(2) After law enforcement personnel arrive at the underground law enforcement site, they trigger the law enforcement terminal to enter the business navigation interface through voice input, including law enforcement items, inspection methods, result judgment, etc., to guide law enforcement personnel to conduct law enforcement inspections;

(3) After the law enforcement inspection is completed, law enforcement documents will be automatically generated and uploaded to the underground law enforcement platform through the underground wireless network.
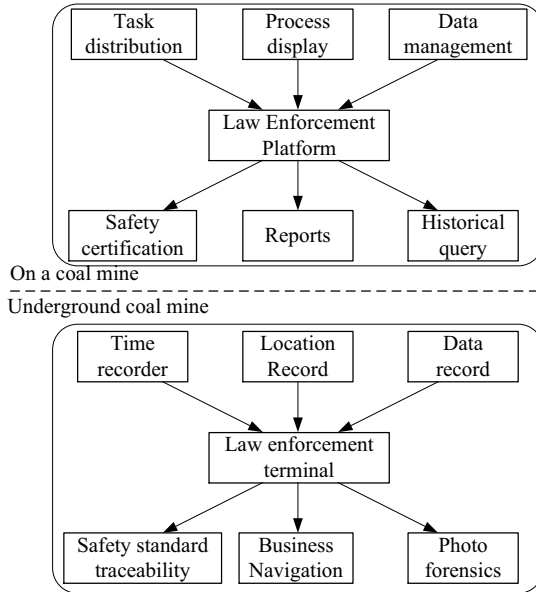
Fig. 1. Block diagram of mine supervision and law enforcement system.

3 Key technology

3.1 Standard traceability technology based on multi-head bidirectional attention model

In order to trace the safety effectiveness of downhole equipment, information extraction method is used to identify the safety mark number of the product, and the main information such as the manufacturer of the equipment and the validity period of the safety mark is obtained by comparing with the database of the safety center. In the process of recognition, the information items in the nameplate image are extracted by combining the layout information and the text recognition result information in the nameplate image.

According to the different rules of nameplate printing by different manufacturers, there may be different forms of "security mark number", "security certificate number", "security number" and so on. Therefore, a machine reading understanding model based on multi-head bidirectional attention mechanism is adopted, and an end-to-end neural multi-head bidirectional attention encoder structure is applied to understand the complex dependency between query and context. The multi-head bidirectional attention mechanism focuses on querying relevant information between U and context H.

d_{model} represents the dimension represented by query U and context H, N represents the number of all feature points in the bidirectional attention layer, d_p is the dimension of the attention mechanism, and $d_p \leq d_{model}$, then:

$$d_{model} = Nd_p \tag{1}$$

We artificially choose a dimension equal to one dimension at the time of projection, and let the model choose to handle the context and query relationship at each feature point. Finally, these noticed features are fed back to the multiple attention layers. Note that the input of the layer is the feature vector and the query vector of the context, and the output is the concatenation representing the context of each query term. In this way, all the detected characters are recognized, the characteristic characters that may appear in all the characters are extracted, and whether the recognition result meets the requirements of 3 letters and 6 digits is determined. If the conditions are met, the result is output.

3.2   Data synchronization and trusted curing technology

In order to ensure the credibility of law enforcement data, a data synchronization and trusted solidification module is designed, which is composed of forensics law enforcement terminal, law enforcement platform and time stamp issuance management system. The forensics law enforcement terminal is responsible for the collection and acquisition of evidence, encrypts all kinds of electronic evidence obtained, and uploads the results to the time stamp issuing management system for time stamp stamping. The law enforcement platform is mainly responsible for verifying law enforcement data and providing storage services for electronic physical evidence documents; The time stamp issuing management system provides the time stamp stamping service to the electronic material evidence, and proves the uniqueness of the electronic material evidence through the uniqueness and irreversibility of the legal time parameters.

Figure 2 shows the process of data synchronization and trusted solidification, with the specific implementation process as follows:

(1) The law enforcement terminal collects information such as law enforcement scene environmental parameters, equipment operating status, and calibration effectiveness to form law enforcement evidence, and hashes the law enforcement evidence to obtain information summaries;

(2) Based on asymmetric encryption algorithm, the private key is used to digitally sign the information summary of law enforcement evidence;

(3) The information digest of law enforcement evidence is time-stamped and solidified through the time-stamped authentication interface of the national Timing Center;

The law enforcement platform is based on asymmetric encryption algorithm and uses public key to verify the digital signature to ensure the credibility of data.
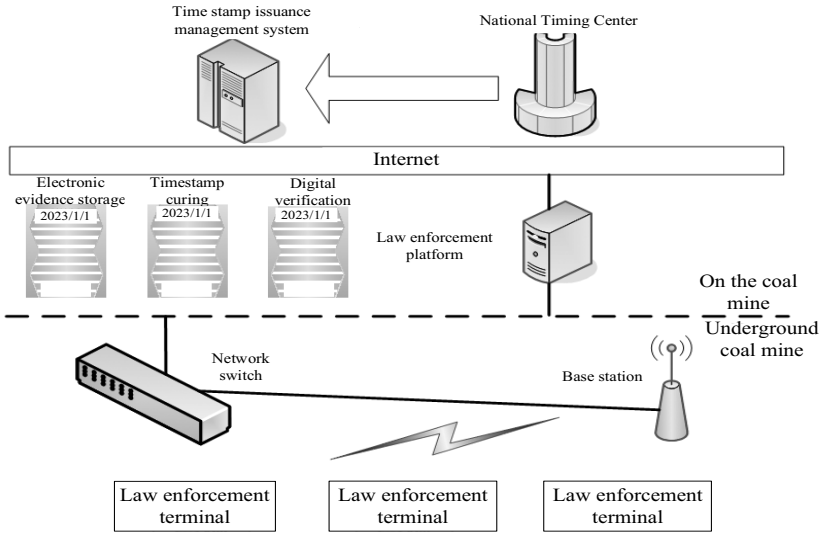
Fig. 2. Data synchronization trusted solidification flow chart.

4   Law enforcement terminal design

The law enforcement terminal is mainly composed of lighting module, positioning module, camera module, environmental parameter detection module, display module and wireless transmission module (As shown in Figure 3). ARM core board through a voltage signal control lighting module for underground lighting; Through a serial signal control positioning module for personnel positioning; Take photos and record via USB interface; Receive methane, oxygen and carbon monoxide data sent by the environmental parameter detection module through one serial port signal; Through MIPI interface control LCD display; Through a serial signal control wireless transmission module for data upload, support 4G and WIFI transmission; Voice input is controlled through a serial port signal.
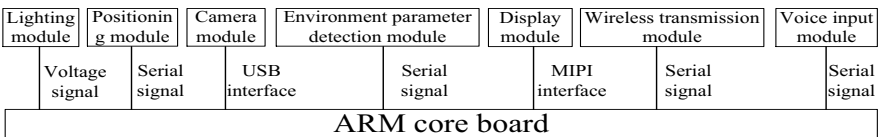

Fig. 3. Law enforcement terminal hardware block diagram.

5   Law enforcement platform design

The functional block diagram of the law enforcement platform is shown in Figure 4. In the design, the use of heterogeneous source data interaction technology and B/S software architecture can achieve law enforcement task management, law enforce-

ment data analysis, law enforcement report generation, law enforcement data query and other functions. The law enforcement task management function can realize law enforcement task editing and law enforcement task issuing; The law enforcement data analysis function analyzes and saves the trusted law enforcement data uploaded by law enforcement terminals based on asymmetric encryption algorithm. Law enforcement report generation function can automatically generate law enforcement reports based on law enforcement data; The law enforcement data query function can query law enforcement data through personnel search and time search.
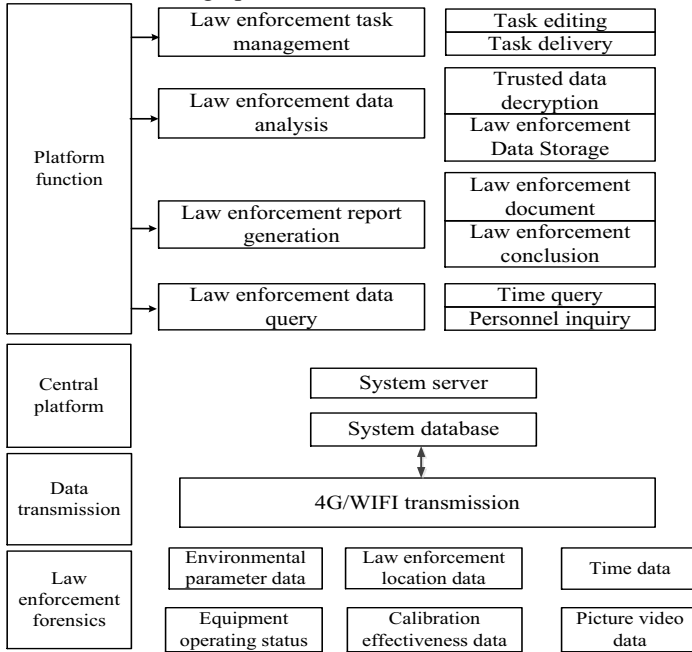

Fig. 4. Law enforcement platform functional block diagram.

6   Test

Law enforcement inspection of monitoring and monitoring equipment is carried out in underground working face, substation and other places, and law enforcement data is uploaded to the law enforcement platform on the well through the law enforcement terminal. The system performance test is shown in Table 1. Through the standard traceability, environmental parameter detection, wireless upload, law enforcement task management, law enforcement data analysis, law enforcement report generation and other functional tests, we can see that the law enforcement system has high reliability.

Table 1. Performance test sheet.

Test items	Test items	Test method	Test result
Anbiao trace-ability	According to the recognition rate	Use the law enforcement terminal camera module to identify the equipment nameplate information for online safety standard information query	During the test, the validity period of the equipment safety standard and the manufacturer can be found.
Environmental parameter detection	error	The law enforcement terminal environment parameter detection module compares the value with the portable instrument	The error meets the industry standard and is more accurate
Wireless upload	transmission delay	Test law enforcement data transmission time in downhole WIFI network coverage sites	Less than 5s
Law enforcement task management	The success rate of law enforcement tasks	Issue the law enforcement tasks to the law enforcement terminal through the platform; view the law enforcement tasks through the law enforcement terminal	During the test period, the success rate of law enforcement tasks issued by the platform was 100%
Law enforcement data analysis	Check whether the law enforcement data from the platform end is consistent with the forensics data of the law enforcement terminal	After the law enforcement terminal uploads the law enforcement data, it compares the law enforcement data on the platform end to check whether there is any inconsistency	The law enforcement platform can realize 100% analysis of data, without missing data or data tampering
Generation of law enforcement reports	Whether it has the function of automatic generation of law enforcement reports	After the law enforcement data is uploaded, view the law enforcement report from the platform	Can automatically generate enforcement reports, including enforcement documents and enforcement conclusions

7   Conclusion

In order to improve the efficiency, objectivity and science of supervision and law enforcement, and realize accurate law enforcement in the underground, a law enforcement terminal and a law enforcement platform are developed, and a credible law enforcement system is constructed. The law enforcement terminal can carry out law enforcement evidence on the underground scene, and transmit law enforcement data online to the law enforcement platform through the underground wireless network. The law enforcement platform has functions such as law enforcement task management, law enforcement data analysis, law enforcement report generation and law enforcement data query. This design law enforcement system has the following advantages:

(1) The law enforcement terminal can collect multiple law enforcement data in real time, which greatly reduces the work intensity of law enforcement personnel;

(2) Using standard traceability technology to realize online standard information inspection of downhole equipment, effectively improve the efficiency of law enforcement;

(3) Through data synchronization and reliable solidification technology, the justice and credibility of law enforcement data are realized and the objectivity of law enforcement is ensured.

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