Design and Practice of The Fire IoT Big Data Application Platform

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Abstract: The Fire IoT Big Data Application Platform is built in accordance with relevant national regulations and standards. Its main functions combine the characteristics of fire control supervision and maintenance, and are designed with Internet of Things technology, big data, mobile Internet and other multimedia technologies according to the current technical status of the fire alarm platform. It is mainly used to solve problems such as the integration of firefighting e-government, normalization of firefighting facility maintenance, and automation of fire fault alarm.

Keywords: Fire, IoT, Big Data, Decision Analysis, Data Visualization

1. Problems and Current Situation

There are many historical issues. Due to historical reasons, some high-rise buildings have inherent deficiencies in fire protection design, which have not met the current fire protection technical standards. There are problems such as low fire resistance rating, insufficient number of evacuation stairs, lack of smoke prevention and exhaust facilities, substandard fire resistance performance of building materials, narrow fire truck passages, and no rescue site.

There are many fire safety hazards. Some high-rise buildings were built early and put into use for a long time. Due to inadequate maintenance and upkeep of fire protection facilities and equipment, the fire protection facilities aged too quickly and were severely damaged, resulting in the inability of fire protection facilities and equipment to operate normally

Residents have weak awareness of fire safety. With the large-scale construction of high-rise buildings, the number of residents living in high-rise buildings is increasing day by day. At the same time, it is common for some old and old high-rise buildings to be leased to migrant workers, with high personnel mobility and a lack of basic fire safety knowledge. The use of fire, electricity, and gas does not meet fire safety requirements, leading to an increased risk of fire.

2. Construction Objectives and Content

2.1 Construction Objectives

Building front-end hardware for fire IoT, creating an IoT big data platform, establishing an intelligent fire prevention and control system with "perception evaluation warning disposal", enhancing fire prevention and control capabilities, alleviating fire prevention and control pressure, creating a bidirectional and complementary fire prevention and control ecosystem with "supervision and service", and truly achieving the goal of comprehensive perception, dynamic monitoring, intelligent warning, rapid disposal, and precise supervision of intelligent fire protection.

2.2 Construction Content

According to the requirements of IoT monitoring technology, carry out access to high-rise building fire alarm hosts, IoT monitoring of fire water systems, and video monitoring of key areas. Using front-end parsing mode, intelligent video analysis of personnel leaving the fire control room and occupation of fire truck passages is achieved, and real-time alarm results are pushed to the application platform of the headquarters. At the same time, based on hardware integration, we will initially build an IoT big data platform, build a prevention and control decision analysis system and a big data visualization system, and share data and emergency linkage with other systems to provide support for big data analysis.

3. Platform Architecture

3.1 System Architecture

The overall architecture of the big data platform is shown in Figure1.

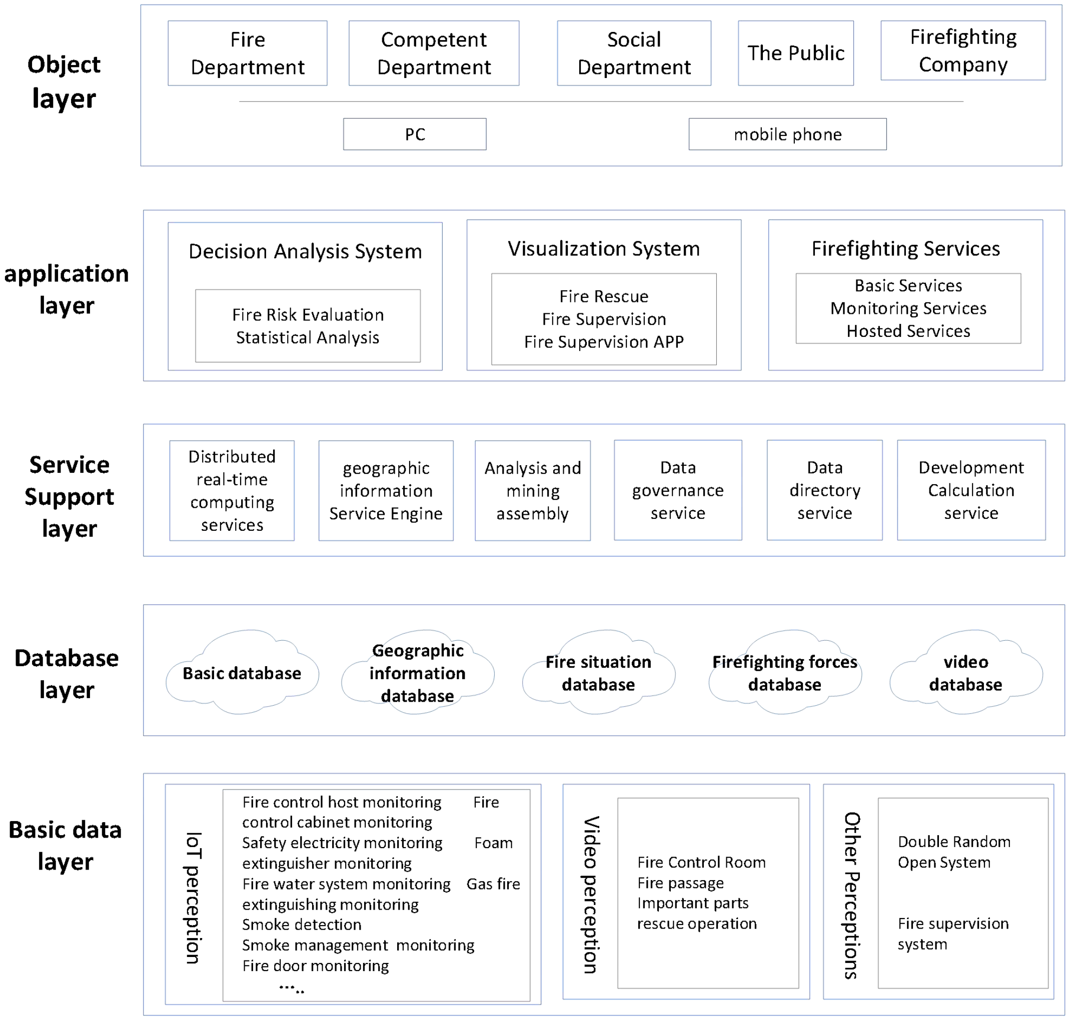

Figure 1. The overall Architecture of the Big Data Platform

3.1.1 Basic Data Layer

The basic data layer is the basic data source of the fire big data platform, including existing fire protection system data, fire protection material IoT data, video perception data, government data, industry department data, etc.

3.1.2 Database Layer

The main stored data includes structured, semi-structured, and unstructured data. By extracting shared resource data from various fire protection business databases or obtaining it from external units, and processing it through transformation, cleaning, filtering, etc., a data warehouse with the "database" as the core has been established to provide basic data support for system application services.

3.1.3 Service Support Layer

The service support layer provides various services for system data, including distributed real-time computing services, geographic information service engines, analysis and mining components, etc.

3.1.4 Application layer

Through this project construction, we aim to meet the needs of business scenarios such as prevention and control decision analysis, big data visualization, and socialized firefighting services, fully tapping into the value of firefighting big data.

3.1.5 Service recipients

Provide specific applications based on fire big data to fire departments, government regulatory agencies, fire industry units, social units, and the public through computers and mobile terminal devices.

3.2 Network Architecture

The network communication system of the big data application platform of the Internet of Things mainly involves the government extranet, the government cloud Internet, the Internet and the Internet of Things. Its network architecture is shown in the figure 2.

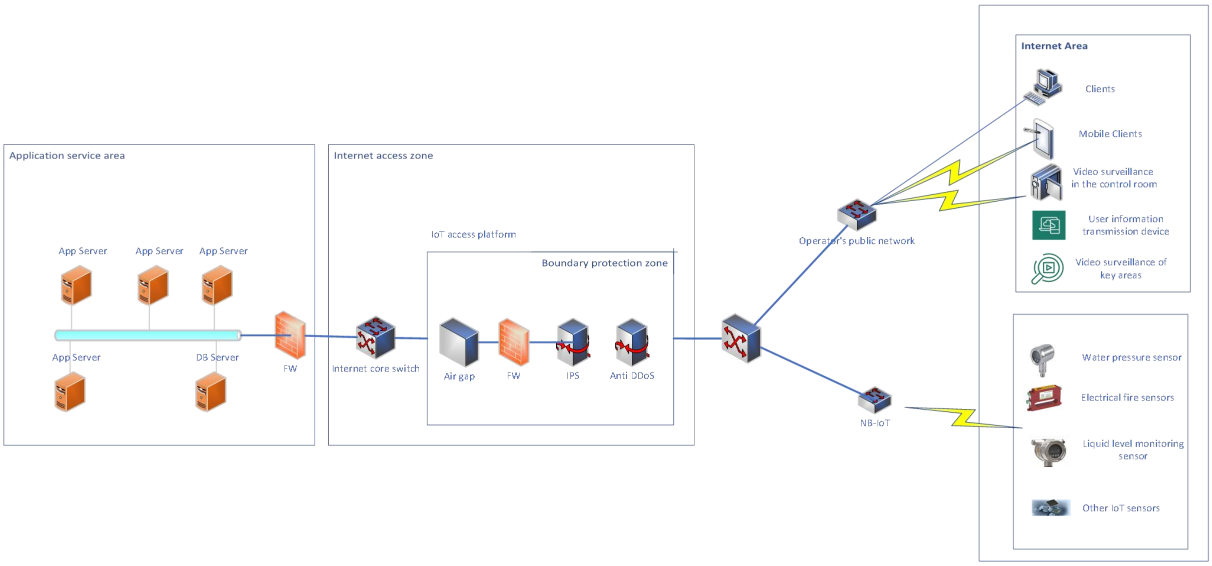

Figure 2. Network Architecture

4. Internet of Things Construction

4.1 Monitoring of Automatic Fire Alarm System

The fire alarm signal and the action and feedback signals of the fire separation facilities, indoor fire hydrant system, automatic sprinkler system, gas fire extinguishing system, foam fire extinguishing system, dry powder fire extinguishing system, smoke control system, fire power supply, broadcast system, fire elevator and other fire fighting facilities linked through the linkage controller.

Install intelligent protocol conversion equipment next to the fire automatic alarm host to transmit data to the user information transmission device. Install relays inside the fire alarm host to transmit data to the user information transmission device.

4.2 Video Terminal Monitoring of Key Areas

4.2.1 Data collection content

Video information on fire control rooms, micro fire stations, key fire areas (fire pump rooms, generator rooms, transformer rooms, boiler rooms, smoke control rooms, battery rooms, refuge floors/rooms), evacuation routes, safety exits, fire elevator rooms, fire exits, rescue sites and entrances, water pump couplings, helicopter aprons, and densely populated areas.

Among them, video terminals with obstacle recognition function should be used for important evacuation routes, safety exits, and firefighting sites to collect information on whether they are occupied or blocked; Using video terminals with obstacle recognition and license plate recognition functions for fire truck passages to capture and alert vehicles occupying fire exits; It is advisable to use video terminals with off duty detection function in the fire control room to collect information on whether personnel are on duty.

4.2.2 Terminal deployment requirements

The video capture terminal can be connected to the existing video monitoring system of networked units; The camera monitoring range should cover at least 80% of the area of the monitored object; Fully cover the designated areas of fire exits and firefighting areas; It is advisable to adopt the video cloud service platform model for construction. The platform's technical parameters must meet the requirements for the access of encoding equipment, storage equipment, and decoding equipment, provide basic video, transmission, storage, and control services, and reserve data interfaces for future application development.

4.3 Automatic Sprinkler Fire Extinguishing System Monitoring

4.3.1 Data collection content

The outlet pressure of each wet alarm valve in the wet system and the pressure at the most unfavorable point of the pipeline network corresponding to each wet alarm valve; Dry system, pre action system, rain shower system, water curtain system alarm valve group valve front pressure; Water flow indicator, signal valve, flow switch, pressure switch status signal, etc.

4.3.2 Terminal deployment requirements

Install one hydraulic sensor at the outlet of each wet alarm valve; Install one hydraulic sensor at the most unfavorable point corresponding to each wet alarm valve; Install one hydraulic sensor at the front end of the dry alarm valve group, pre action alarm valve group, and rain alarm valve group valves respectively; Install relays inside the fire sprinkler pump control cabinet.

4.4 Monitoring of Indoor Fire Hydrant System

4.4.1 Data collection content

Indoor fire hydrant pump outlet pressure; The pressure at the most unfavorable point of the pipeline network; Power status, start/stop, fault, and manual/automatic status signals of indoor fire hydrant pumps.

4.4.2 Terminal deployment requirements

Install one hydraulic sensor at the outlet of the indoor fire hydrant pump (transfer pump) outlet pipe, behind the check valve (along the direction of water flow); Install one hydraulic sensor at the most unfavorable point of the pipeline network. For systems with partitions, install one hydraulic sensor at the most unfavorable point of each partition; For high-rise buildings, install one hydraulic sensor at the end of the top and bottom floors in the high area; Install relays inside the indoor fire hydrant water pump control cabinet.

4.5 Monitoring of Outdoor Fire Hydrant System

4.5.1 Data collection content

Outdoor fire water supply network pressure; Outdoor fire hydrant pump outlet pressure; Outdoor fire hydrant pump power status, start/stop, fault, manual/automatic status signals.

4.5.2 Terminal deployment requirements

Install one hydraulic sensor at each inlet of the ring network; Install one hydraulic sensor behind the check valve (along the direction of water flow) at the outlet end of the outdoor fire hydrant pump; Install relays inside the outdoor fire hydrant water pump control cabinet.

5. Application System Construction

5.1 Prevention and Control Decision Analysis System

5.1.1 Fire dynamic risk assessment

Based on the influencing factors of building fire risk assessment, a building fire risk assessment index system is established, and the initial nodes of the Bayesian network model for building fire risk assessment are determined. The prior probability distribution of the model's root nodes is determined using expert knowledge, statistical data, and other methods. The conditional probability distribution of non root nodes is determined through statistical data, expert knowledge, weighted average, logical relationships, and other methods. A building fire risk assessment Bayesian network model is established. Through Bayesian network inference, the probabilities of the five nodes of the building fire risk assessment model, namely ignition, development, spread, extinction, and evacuation of personnel inside the building, are obtained.

Selecting the four important nodes of fire initiation, development, spread, and extinguishing during the development process of building fires as important criteria for evaluating building fire safety, and selecting evacuation nodes as the basis for evaluating personnel casualties inside the building. Therefore, these five nodes are used as standards for evaluating the magnitude of building fire risk and the severity of consequences and losses.

The fire dynamic risk assessment system can be divided into individual building fire risk assessment and regional fire risk assessment, and its main business process is carried out according to the method of "data collection evaluation model evaluation results".

5.1.2 Fire risk analysis

Generally speaking, building types can be classified according to "high and low maximization" (high-rise buildings, underground buildings, large complexes, petrochemical enterprises), "elderly and young ancient landmarks" (elderly care service institutions, early childhood education venues, cultural relics and ancient buildings, iconic buildings), etc. Different types of buildings have different functions and characteristics, and there are significant differences in height, area, materials, structure, and other aspects of the building. Even for the same type of building, due to different times or requirements of the building, there may be significant differences in certain aspects, such as the completeness of fire protection facilities inside the building and the level of fire safety management. Therefore, before conducting a building fire risk assessment, the first step is to determine the type of building and analyze the risk characteristics of each type of building.

5.1.3 Calculation process of fire probability

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5.1.4 Construction of Fire Dynamic Risk Assessment Model

The dynamic risk assessment of fires is based on various machine learning algorithms and negotiation docking to obtain information system data from departments such as public security, safety supervision, and meteorology. Through big data analysis, the probability of urban fires is predicted, and the model based on big data is continuously optimized and iterated.

5.1.5 Fire dynamic risk assessment function

Using artificial intelligence technology, taking into account factors such as building structural characteristics, fire management level, and hazard distribution, and combining with dynamic information such as remote monitoring data of fire IoT, inspection and inspection data, and hidden danger reporting data, fire risk assessment is conducted on buildings. Risk assessment model algorithms are used to provide fire risk indices and corresponding rectification suggestions for different venue buildings. And combine this system with the security task management subsystem to achieve a spiral upward risk control of risk identification, real-time evaluation, rectification and improvement, re evaluation, and re improvement, achieving identifiable and controllable building safety risks, and safeguarding building safety.

Based on the correlation between regional personal risk, social risk, and fire response time with casualties and property damage, comprehensively consider historical fire data, building type sampling, demographic data, and economic development strength of the target area; Distribution of major hazardous sources of regional hazardous chemicals; Water consumption for building fire protection; Fire station layout and response time; The type and quantity of vehicles equipped at the fire station; Other rescue force data, such as medical and transportation factors, are automatically matched, grouped, and fused according to the preset comprehensive risk assessment index system to establish a regional fire risk assessment model, providing supporting information for urban safety assessment.

5.2 Big Data Visualization System

5.2.1 Overview of Big Data Visualization System

By building a visualization platform for fire big data analysis, we aim to bridge the data sharing barriers between the fire rescue command and dispatch system, fire hazard rectification system, and fire comprehensive management system, and gather various types, types, and formats of fire safety data such as fire rescue, hazard reporting and rectification, fire Internet of Things, fire inspection, and fire maintenance, ultimately forming a fire safety data pool. Through big data visualization technology, scientific statistical analysis of data is carried out, and through big data visualization technology, it is displayed to help users grasp the macro level of urban disaster prevention and relief situation, accurately identify weak links in disaster prevention and relief.

5.2.2 Fire rescue visualization system

On the one hand, fire rescue helps urban managers grasp real-time disaster dynamics and the status of urban disaster relief forces through four modules: today's police situation, service dynamics, combat readiness strength, and combat readiness distribution. On the other hand, through the police trend and analysis module, it helps urban managers clarify the laws of urban disaster occurrence and development through historical data. When a major disaster event occurs in the city, city managers can also directly click on the alarm to gain a detailed understanding of the disaster location, current deployment force, fire area, available resources in the surrounding area, and the current state of fire spread in the affected buildings, providing support for cross departmental resource allocation and coordination among city managers.

Docking with the actual combat command platform, obtaining relevant police situation, service security, and combat readiness resource data, divided into seven modules: today's police situation, police situation trend, police situation analysis, GIS map, service dynamics, combat readiness strength, and combat readiness distribution.

5.2.3 Fire supervision visualization system

Docking with social service platforms, obtaining equipment status, fire control room duty information, social unit inspection and inspection data, unit safety index, alarm disposal, hidden danger rectification and other data, including seven modules: real-time monitoring, monitoring trends, fire control maintenance, GIS map, safety index, alarm disposal, and hidden danger rectification.

With the support of a safety index analysis model that combines dynamic and static data related to fire safety in social units, on the one hand, it helps urban managers to macroscopically grasp the risk index of each pilot unit, the overall duty compliance rate, inspection compliance rate and completion rate of fire safety key areas such as fire control rooms, the review compliance rate of hidden dangers and alarm signals, the progress of hidden danger rectification, and the service quality of fire maintenance institutions. On the other hand, urban managers can also choose units of interest to carefully examine the risk prevention and disposal situation of corresponding units from multiple dimensions such as overview, hidden dangers, anomalies, and inspections. To provide support for urban managers to focus on small areas and optimize the allocation of limited police forces, and achieve precise targeted governance.

6. Conclusion

Through the construction of the Internet of Things big data platform, we can achieve refined closed-loop management of fire safety operation and social management, improve the quality and efficiency of comprehensive business management of the fire information platform, optimize fire safety work procedures, save labor costs, help ensure the safety of life and property, and create a new model of fire safety management.

References

[1]ZHAO Xinxing. Information Construction of the Internet of Things Under the Big Data Platform[J].Information&Computer,2023,35 (16):200-202.

[2]Shu Juelin.Research and design of big data platform for IoT application[J].Computer Era,2023(07):127-132

[3]ZHENG Deping.Research on Fire Safety Risk of Chemical Enterprises under Big Data Platform[J]. Biological Chemical Engineering,2022,8(03):100-102.

[4]Ji Yongqiang.Big data-based intelligent fire supervision platform scheme design[J].Fire Protection Today,2022,7(10):29-31.

