Research on Technology Scheme of Railway Video Cloud Platform

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Abstract: With the rapid construction and development of China's railways, railway operation safety is facing many pressures. The existing video surveillance system based on IP-SAN structure has big bottlenecks in system management, system expansion, disaster recovery backup and resource sharing. It is urgent to build a more perfect and efficient video surveillance system. Based on the video surveillance system reform plan of Xi'an Railway Administration, this paper uses the video cloud platform technology, through theoretical analysis, scheme demonstration and engineering design method, plans and constructs the independent video surveillance system of high-speed railway and ordinary-speed railway, makes full use of existing facilities, and studies the implementation scheme of interface interconnection and distribution transformation with V9 platform and high-speed railway integrated video surveillance platform, which has certain reference value for the video surveillance system transformation of other railway bureaus.

1. Introduction

With the rapid construction and development of China's railways, a railway network covering the whole country has gradually formed. While the speed, capacity and density of railway transportation are greatly improved, higher requirements are put forward for railway transportation safety. Video surveillance system can intuitively discover all kinds of problems, assist public security and production departments to verify all kinds of cases, solve a series of problems such as shortage of manpower and special operating environment monitoring. In this paper, the technology of railway video cloud platform is studied based on the transformation scheme of video surveillance system of Xi'an Railway Administration.

2. Video Surveillance System

There are two main types of video surveillance systems in Xi'an Railway Administration: general-speed railway video surveillance system and high-speed railway integrated video surveillance system. The situation of other railway bureaus is similar to that of Xi'an bureau.

2.1 General-speed Railway Video Surveillance System

The general-speed railway video surveillance system is a self-built system for the departments of train service, passenger transportation, engineering and freight transportation, which is relatively independent and is set up according to two-level structure. The Railway Administration has set up a centralized monitoring and management platform of "V9". Each station (305 stations) has set up video front-end cameras, access, management, storage and other equipment to store video images locally. Station video information is connected to the centralized monitoring and management platform of "V9" of Railway Bureau by means of communication transmission system channel E1. Local video images of stations are stored by hard disk recorders without RAID protection mechanism, and the storage time is 30 days.

2.2 High-speed Railway Integrated Video Surveillance System

The construction of high-speed railway integrated video surveillance system is more standardized. It is set up according to the two-level structure of regional nodes and access nodes [1].

Xi'an North Railway Station has a regional node of railway integrated video surveillance system. The passenger-dedicated video surveillance system in Zhengxi, Daxi, Xibao and Xicheng makes use of data network to access the regional node of video surveillance system. The integrated video surveillance system owns a IP-SAN storage architecture and RAID5 array technology in the station to provide remote monitoring and adjustment functions for transportation, telecommunications, power supply, public security and other departments.

2.3 Status Analysis of Video Surveillance System

The high-speed video surveillance system is built independently by various departments, lacking unified planning and management. Video information can be shared in Railway Bureau through "V9", but it is not interconnected with the railway integrated video surveillance system built by high-speed railway. There was no uniform technical standard during the construction period, and the quality of the system can not be guaranteed. Early construction of freight video surveillance system is basically unavailable. The existing video acquisition points cover blind areas, and some equipment has been malfunctioning, which does not meet the requirements of the Railway Corporation.

The high-speed railway video surveillance system is built according to unified standard of the whole roads, which meets the needs of current use, but can not realize the interconnection with the high-speed video surveillance system. The video image storage structure is single, resources can not be flexibly scheduled, the utilization rate is low, and the video protection mechanism and repair ability are insufficient.

3. Technical Comparison of Video Surveillance System

3.1 Video Surveillance System Based on IP-SAN Technology

The "V9" platform and the integrated video surveillance platform of Xi'an Bureau can be understood as using IP-SAN technology to access real-time video streams to video storage servers. When the number of access paths of a server to the camera reaches the capacity limit, the information of the new camera will be written to the next server. At the same time, according to the storage time requirement, fixed space is allocated in the disk array to meet the real-time video stream writing.

IP-SAN technology adopts RAID 5 protection mechanism. SAN storage technology is mature and stable, and has been widely used in railway and subway. The disadvantage is that the expansion is not flexible. In addition to reconfiguring the camera information, SAN storage also needs to format the existing disk array and redesign the data distribution and protection of RAID group [6]. Moreover, the concurrent input and output bandwidth of the disk array controller is about 1000M. At present, the main function of video service is writing. In the future, when passenger transport and public security require real-time readout of video stream, SAN storage will encounter bottlenecks. The principle of video surveillance platform based on IP-SAN technology is shown in Figure 1.
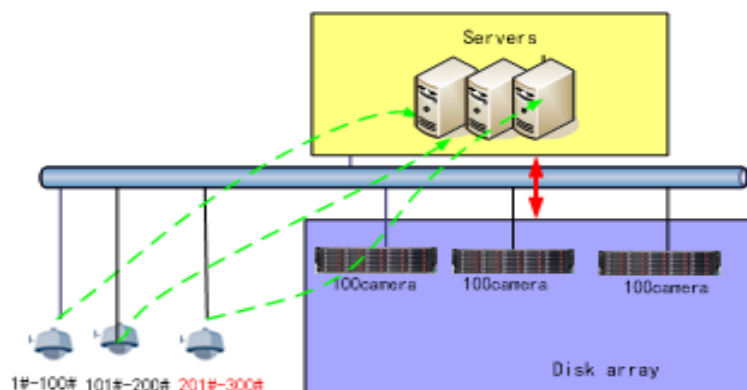

Figure 1 Principle Diagram of Video Surveillance Platform Based on IP-SAN Technology

3.2 Video Surveillance System Based on Cloud Platform Technology

Cloud platform technology is the development direction of video surveillance system, through which, real-time video streams can be accessed to cloud storage servers. Cloud storage servers distribute video storage architectures [9] and storage space according to load balance. When the storage capacity needs to be expanded, the existing business won't be affected. Cloud storage mainly adopts erasure code or copy protection mechanism [10]. When two or more hard disks fail in RAID 5, other hard disk data in RAID group are still readable, which effectively reduces the risk of data catastrophic loss. When the cloud storage node equipment fails or the front-end camera increases, the information can be stored on other local hard disks or on other cloud node devices through transmission channels, so as to achieve the comprehensive utilization of global equipment. The cloud storage principle is shown in Figure 2.
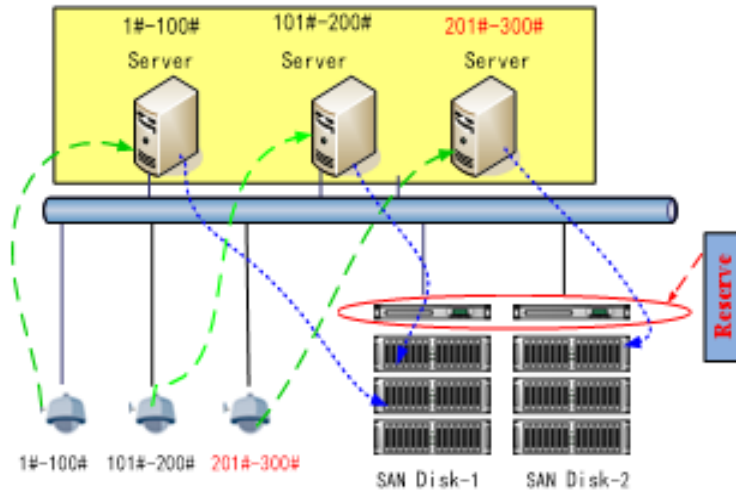

Figure 2 Cloud Storage Schematic

3.3 Technology Comparison between IP-SAN Platform and Cloud Platform

IP-SAN storage technology belongs to device-level storage. Each device completes its own video service. The performance of the system is mainly embodied by the performance of a single device, which has performance bottlenecks. With the increase of terminal equipment, management becomes more complex and the overall performance decreases. Video cloud storage belongs to system-level distributed storage. All devices in the cluster complete video service together, and there is no performance bottleneck. With the increase of equipment, the performance increases linearly. Detailed comparison of specific indicators can be found in Table 1.

Table 1 Technology Comparison between IP-SAN Storage Technology and Cloud Storage Technology

Comparison Items	IP-SAN Storage Technology	Cloud Storage Technology
Hardware Configuration	Special equipment: disk array, SAN controller.	Universal device, X86 server.
	Require RAID card.	No need for RAID card.
System Performance	Controller with single point bottleneck.	No single point bottleneck. All servers are balanced.
	Separation of computing and storage requires separate deployment of analysis and application servers, and analysis after data extraction.	Computing close to data. MapReduce framework has been installed in distributed system, which can customize the development and analysis application.
	Longitudinal expansion. With spatial expansion, the performance of computing and data IO decreases.	Horizontal expansion. With spatial expansion, computing and data IO performance increases linearly.

Device Management	Single equipment one-to-one management, numerous equipment, complex system configuration and management.	System-level unified management. Only one domain name and one IP address can realize cluster system management.
Capacity Management	The space required by the application server needs to be pre-computed. The capacity cannot be balanced dynamically, which may lead to high pressure of some equipment and low usage of others.	Upper services do not need to pre-compute the set space. Open the total capacity of virtual resource pool to the outside world, and each service can be accessed on demand.
System Reliability	Node drops, and the storage service of corresponding service is interrupted. RAID can only tolerate hard disk failures, not node failures.	Node drops, and corresponding service storage business is uninterrupted Make use of erasure codes. Hard disk faults and point faults can be tolerated.
System Expansibility	There are capacity limit, increased equipment, complex management, and decreased overall performance. Special equipment, complex deployment and expansion.	There are no capacitance limit,increased equipment, unified cluster management, enhanced performance. Universal equipment, second-order system expansion.
Load Balancing	Each unit needs to be configured separately. When business increases, it is necessary to adjust the load on the equipment to ensure the normal operation of the system. In case of equipment failure, business on the equipment will be interrupted.	System-level pressure load. When business increases, the system is adjusted uniformly to ensure load balancing. In case of equipment failure, the system will adjust the service on the fault equipment to the normal equipment evenly, so as to ensure the uninterrupted service.
Data Reading and Writing Ability	Data is stored on a single device, and the reading rate is determined by the performance of the device that stores the data.	Data is distributed on all storage devices in the cluster. When reading data, multiple devices respond simultaneously and read concurrently.
Application Extension	Need to deploy backup servers, backup arrays, and backup software separately. Can only be used as storage devices. No cloud feature. There is a risk of artificially deleting data.	Integrated backup software without separate deployment. Can be used as a hyper-convergence solution to deploy application services in distributed systems. Adopt standard interface to connect with other cloud devices. Can realize ring backup scheme and disaster recovery in different places, and prevent artificial deletion of data.

4. Reconstruction Scheme of Video Surveillance System of Xi'an Bureau

Through the analysis of the current situation of video surveillance system of Xi'an Bureau as well as the comparison of video cloud platform and IP-SAN technology, making use of cloud platform technology is greatly conducive to the system transformation, which is in line with the direction of technical development.

4.1 Overall Architecture of Video Cloud Platform

According to the overall plan of railway integrated video surveillance system, the system consists of video area node, class I video access node, class II video access node, video convergence point, video capture point, bearing network and video terminal (including video management terminal and monitoring terminal).

4.2 Video Node Selection Scheme

The system transformation should make full use of the existing facilities under the existing basic conditions. Firstly, the framework of cloud platform is built. With the renovation of existing facilities, the global video cloud platform is realized step by step.

4.2.1 Video area node

The regional node equipment of the existing integrated video surveillance system in northern Xi'an is used. Besides, its software and hardware are expanded to realize the access and

management of the new node. According to the national standard GB/T 2881-2016, the access conditions for urban Skynet and other public networks are reserved. Video image diagnosis system is added to realize intra-bureau video image diagnosis. The cloud platform technology is upgraded and the existing assets are protected after the equipment has reached its service life.

4.2.2 Class I video cloud node

Cloud platform technology needs a lot of information interaction between cloud nodes. Channel bandwidth requirements are also very high. Traditional SDH transmission system fails to meet the requirements, especially the deployment of class I nodes. Several important factors must be fully considered. First, OTN transmission channels can be provided between class I nodes and between regional nodes, or the direct connection of optical fibers can be realized. Second, node location and function positioning can be used as video information convergence center in the region. Third, it can provide necessary operating environment such as computer room and power supply. Fourth, it is convenient for transportation and maintenance.

Considering the current situation of each site of Xi'an Bureau, combined with the follow-up development, a total of 13 sites including Xi'an, Baoji and Yan'an were initially set up with Class I video cloud nodes, which configure management servers and three-tier switches respectively to realize video access, storage, sub-forwarding and management.

4.2.3 Class II video cloud node

The selection of class II video cloud nodes should be based on the site location of class I nodes, and be set at sites where the number of video cameras is relatively concentrated and the communication channel between Class II nodes is better. Xi'an Bureau has set up Class II video cloud nodes in 29 sites including Xianyang, Weinan, Baoji East and Yulin. The information transmission among cloud nodes is established by means of direct connection of optical fiber, data network and 10G transmission network.

4.2.4 Video convergence points

In addition to the stations where class I and II video access nodes are located, other stations in Xi'an are regarded as video convergence points, totaling 238 stations. A layer 2 switch is set up for each station to collect video images.

4.3 Utilization and Improvement of the Existing Video System

The existing video surveillance system of Xi'an Bureau realizes interconnection and interoperability according to the standard networking specifications under the conditions of meeting the existing Technical Requirements of Railway Integrated Video Surveillance System and Technical Requirements of Public Safety Video Surveillance Networking System for Information Transmission, Exchange and Control. The two platforms share resources among domains, including video browsing, cloud control, video query and alarm upload, and make effective use of existing resources. The interconnection of video cloud platform and the existing video surveillance system is detailed in Figure 3.
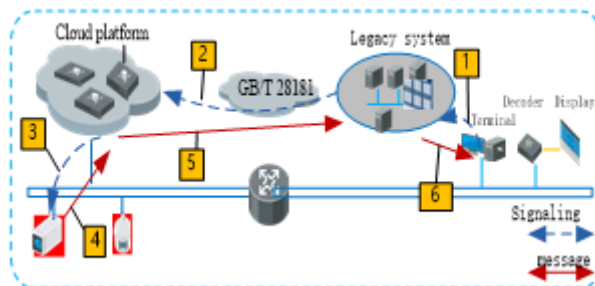

Figure 3 Video System Interconnection Schematic

Note 1: Users log on to the original surveillance platform through the client and initiate live/PTZ requests.

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Note 2: The original surveillance platform initiates scheduling requests to the video cloud platform system through the corresponding docking interface of T28181.

Note 3: Media negotiation between video cloud platform and front-end devices.

Note 4: On-line front-end devices send video streams to the video cloud platform..

Note 5: Video cloud platform forwards media streaming to the existing surveillance platform.

Note 6: The original surveillance platform forwards media stream to client or decoder.

4.3.1 Dock with the existing "V9" system

The video cloud platform of Xi'an Bureau meets the national standard GB/T 2881-2016 of Technical Requirements for Transmission and Exchange Control of Security Video Surveillance Networking System. It can realize interconnection and interoperability according to the national standard protocol. The two platforms act as different domains to realize inter-domain resource sharing, including video browsing, cloud control, video query, alarm upload and other functions. The inversion scheme with the existing "V9" system is detailed in Figure 4.
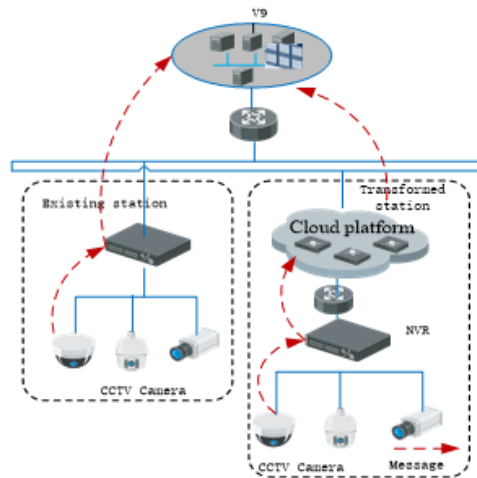

Figure 4 Interconnection Principle Diagram of Cloud Platform and V9

The gateway transforms the network transmission protocol, control protocol and device address between the existing V9 platform and the new cloud storage platform. The specific functions of the gateway include:

(1) Agent new cloud storage to register on the existing V9 platform.

(2) The two-way protocol conversion between the network transmission protocol of the existing V9 platform and the protocol specified in GB/T 2881 is carried out. The two-way protocol conversion between the existing equipment control protocol and the session initiation protocol, session description protocol, control description protocol and media playback control protocol specified in GB/T 2881-2016 is carried out.
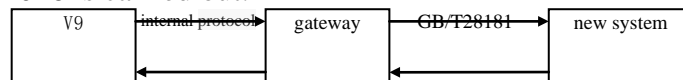
(3) Bidirectional address translation between the existing V9 platform and the device address specified in GB/T 2881-2016.

(4) Convert the streaming media transmission protocol and data encapsulation format of the existing V9 platform of general-speed railway to the corresponding protocol stipulated in GB/T 2881-206 [8].

(5) Media transmission protocol and data encapsulation format can share bidirectional resource list and re-encapsulate media stream through gateway.

Each access node of the reconstructed video cloud platform accesses the existing "V9" platform to ensure the normal use of the station's video resources by existing users. The station to be renovated will continue to maintain the existing network, and DVR will be connected to "V9". According to the construction project, after gradual reversal, the existing video system equipment will eventually be eliminated.

4.3.2 Dock with passenger-dedicated video system

In order to save investment and reduce the amount of work, in the initial stage, the connection with the existing passenger-dedicated video system is realized only by docking with the regional nodes of the existing passenger-dedicated video system, and the existing passenger-dedicated video nodes remain unchanged.

New video cloud nodes and regional nodes need to meet the interface requirements of GB/T 28181-2016. The existing regional nodes can be interconnected and interoperable according to the national standard protocol. The two platforms act as different domains to realize inter-domain resource sharing, including video browsing, cloud control, video query and alarm upload.

By using the existing video area node equipment in northern Xi'an and expanding its hardware and software, the access of new video access node and the network management of equipment are realized. The existing system has reserved interfaces for urban Skynet and other public networks according to GB/T 28181-2016. Subsequently, the existing passenger-dedicated video system will be transformed step by step according to the major modification of the equipment, and finally a global video cloud platform will be established.

5. Conclusion

According to the requirements of railway security surveillance, this paper discusses the construction scheme of video surveillance cloud platform of Xi'an Bureau. The independent video surveillance systems of high-speed railway and general-speed railway are planned and constructed as a whole. Meanwhile, the distributed implementation scheme is adopted to solve the interface problem between old and new systems and make full use of the existing resources. With the technology of video cloud platform, when the storage capacity of a few sites is insufficient or storage equipment fails, video information is automatically stored on cloud storage devices of other sites, which achieves the effect of global equipment resource sharing and comprehensive utilization.

In the process of planning and construction of railway video cloud platform, it is essential to focus on communication channels, computer room environment and power supply, in order to ensure the smooth construction and implementation of the system. The video cloud platform scheme of Xi'an Bureau is typical in the whole roads, which has high reference and application value.

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