Intelligent Emergency Broadcasting System Technology in Broadcasting Networks: A Post-print

Authors: Li Hao

Date: 2023-10-08T00:00:00+00:00

Abstract

Emergency broadcasting refers to the capability, in a social context characterized by frequent natural disasters and emergencies, to promptly deliver information about potential hazards to the public. It serves as a rapid and efficient information transmission channel, constitutes an important component of the government' s emergency management system, and represents a crucial means for command and dispatch, organizational mobilization, and information dissemination within the national emergency framework. This paper primarily investigates the technology of intelligent emergency broadcasting systems in broadcasting networks.

Full Text

Research on Intelligent Emergency Broadcasting System Technology in Radio and Television Networks

Abstract: Against the backdrop of frequent natural disasters and emergency incidents, emergency broadcasting serves as a rapid information transmission channel that can deliver hazard warnings to the public in the first instance. It constitutes a vital component of government emergency management systems and represents a critical means of command coordination, organizational mobilization, and information dissemination within national emergency frameworks. This paper investigates intelligent emergency broadcasting system technologies within radio and television networks.

Keywords: radio and television network; intelligent emergency broadcasting system technology; visual emergency broadcasting

Classification Code: TN934.4
Document Code: A

Article ID: 1671-0134(2019)03-121-03
DOI: 10.19483/j.cnki.11-4653/n.2019.03.034

Author: Li Hao
Affiliation: Henan Radio and Television Station

Since the beginning of the 21st century, the Party Central Committee and the State Council have attached great importance to the construction of a national emergency broadcasting system. Establishing an emergency broadcasting network has become increasingly critical for effectively responding to public emergencies such as natural disasters, accidents, and social security incidents. The emergency broadcasting network must cover all public areas nationwide, including urban districts, rural regions, and parks. Intelligent emergency broadcasting system technology maximizes the prevention of emergencies by delivering authoritative early warning information to society in a timely, accurate, and objective manner, thereby reducing disaster impacts and standardizing emergency information release protocols. In daily operations, intelligent emergency broadcasting systems also enhance the public service capabilities of government departments at all levels, playing crucial roles in public opinion guidance, policy communication, and information dissemination while serving as a bridge between the Party, government, and the people. In 2011, China incorporated emergency broadcasting system construction into key cultural undertakings and issued the *Twelfth Five-Year Plan for National Economic and Social Development of the People' s Republic of China*, setting new requirements for the design and development of intelligent emergency broadcasting systems. Such systems enable citizens to immediately understand what has occurred and how to respond or take shelter, thereby maximizing the protection of public resources and people' s lives and property.

1. Construction Objectives of Intelligent Emergency Broadcasting Systems in Radio and Television Networks

The construction of intelligent emergency broadcasting systems should adhere to specific design principles: government leadership, hierarchical responsibility, unified implementation, and planning. Leveraging existing radio and television network resources, these systems should be built to be practical and comprehensive in coverage, featuring flexible scheduling, convenient command, resource sharing, and reliable security. This approach continuously enhances government emergency management capabilities for handling incidents, enabling timely, rapid, and precise dissemination of emergency broadcast information across all times, locations, and periods.

(1) The system must meet the needs of local emergency incident management. Throughout the entire process of emergency incidents—before, during, and after—the intelligent emergency broadcasting system in radio and television networks should satisfy the rapid information transmission requirements of governments at all levels. It should achieve functions such as

collecting local emergency broadcast release demands and integrating release resources, while assuming responsibility for producing, broadcasting, scheduling, and controlling emergency information across entire regions, thereby improving scheduling decision-making capabilities and better controlling workflows.

(2) The system must meet advanced technical requirements. The intelligent emergency broadcasting system in radio and television networks should feature rapid production and release capabilities, real-time terminal response, and primarily adapt to standardized, IP-based, converged media, and emergency broadcasting standardization development directions. It should leverage advantages such as timely emergency information aggregation and precise signal coverage, employing new media technologies like the internet and mobile internet to innovate emergency broadcasting forms and methods.

(3) The system must horizontally interface with local emergency information release departments. The intelligent emergency broadcasting system in radio and television networks converts information into audio or subtitle signals for broadcast. It possesses functions for accessing, verifying, parsing, and converting emergency information released by meteorological departments, establishing linkage and information transmission channels with various departments such as emergency information release agencies and meteorological bureaus based on local release requirements and transmission network conditions.

(4) The system must enable vertical linkage between superior and subordinate systems and platform interconnectivity. To achieve seamless interconnectivity and unified linkage, the intelligent emergency broadcasting platform in radio and television networks should connect upward to provincial-level and downward to county (district)-level emergency broadcasting platforms. It can employ "point-to-point" modes, set priority modes such as emergency priority and superior-level priority, or use "point-to-multipoint" approaches to control grassroots village (community)-level terminals.

(5) The system must achieve graded and classified information release for different populations. Intelligent emergency broadcasting coverage should implement directional release by grade, category, and population group, achieving regional coverage, point-specific coverage, or multi-point coverage.

(6) The system must support rapid and efficient emergency response. To enhance emergency response efficiency, the intelligent emergency broadcasting system in radio and television networks should fully utilize various technical means to ensure rapid and efficient information transmission across all stages, including early warning reception, transmission coverage, and terminal reception, such as real-time release, efficient transmission, and directional reception.

(7) The system must satisfy security requirements and enable manageable, controllable information release. The system should incorporate security measures against unauthorized insertion, erroneous broadcasting, and theft of broadcast slots, along with disaster resistance and destruction prevention capabilities to meet the needs for rapid and precise emergency information release. It must prevent unauthorized units or individuals from releasing illegal information through the system to disrupt social order, enabling irregular release across all times, locations, and periods. Simultaneously, to ensure information and network security of the emergency broadcasting platform, user roles and permission management should be strengthened to guarantee manageable and controllable emergency information release, distribution, and transmission. This ensures operational security of the emergency broadcasting platform and transmission coverage security, effectively monitoring the entire information dissemination process and guaranteeing the availability, uniqueness, and non-repudiation of emergency broadcast information.

(8) The system must fully utilize existing radio and television coverage network resources. The emergency broadcast signal transmission coverage network in radio and television networks should employ multiple transmission coverage technologies, fully leveraging existing wired and wireless radio and television network resources to build an integrated urban-rural emergency broadcast signal coverage network for municipal jurisdictions. Under unified scheduling by the municipal emergency broadcasting platform and utilizing radio and television infrastructure at municipal, county, and township levels, the system should ensure mutual backup and complementary coverage among multiple transmission methods to reduce construction costs, such as through cable digital television networks and cable IP data private networks.

(9) The planning, construction, and operation management of intelligent emergency broadcasting systems should follow comprehensive utilization requirements for peacetime service and wartime emergency, combining normal and emergency operations. The system should conduct emergency knowledge popularization and policy promotion, fully utilizing the system to achieve broadcast program relay coverage and enhance public awareness of disaster prevention and resistance capabilities. Meanwhile, regular system operation drills and reliability testing of all components should be conducted to ensure the entire system remains effective and available during emergencies.

(10) Intelligent emergency broadcasting systems must be standardized and scalable. At the management, transmission network, and receiving terminal levels, the system should support seamless interfacing with meteorological bureau information release platforms and achieve five-level networking (province, city, county, township, village) and four-level controllability, strictly complying with national and industry standards and specifications.

It should reserve space for technical upgrades, business expansion, and capacity increases, supporting unified network management and monitoring control from front-end to terminal, while enabling integration and interoperability among systems and equipment from multiple manufacturers.

2. Overall Technical Scheme of Intelligent Emergency Broadcasting Systems in Radio and Television Networks

The intelligent emergency broadcasting system consists of three components: (1) The management and broadcast control system should implement strict hierarchical permission management; (2) The bidirectional transmission network employs a combination of wired and wireless transmission to further enhance system reliability, using cable television networks as the primary method and Digital Television Multimedia Broadcasting (DTMB-T) as a supplementary approach to solve signal reception issues in areas not covered by cable networks, achieving complete regional coverage and improving overall system security and reliability; (3) Emergency broadcasting terminals are divided into two categories that utilize existing broadcast facilities to expand coverage and can independently perform remote activation and emergency broadcasting functions, such as village-level loudspeaker facilities, building and school public address systems, and urban public space large screens. The first category includes intelligent emergency broadcasting terminals, outdoor large screen access terminals, and public address system interface terminals. The second category includes emergency broadcasting column terminals (broadcast receiver/amplifier + speaker) and emergency broadcasting receiver/amplifier + loudspeaker terminals.

2.1 Main Technical Methods

Bidirectional IP Signals: In emergency broadcasting signals, to enhance anti-interference capabilities, unicast, multicast, and broadcast methods are employed to improve signal quality and enable parallel transmission, connecting multiple broadcast signals with emergency broadcasting-related command IP data packets.

DVB-C Transmission Method: This technology can satisfy platform concurrency capabilities without requiring repeated cabling or point deployment. However, to achieve simultaneous transmission of daily programs and emergency information, it requires separate planning of emergency broadcast frequency points, occupying existing radio and television channels. Therefore, this technology is suitable for areas where cable digital television networks have already been deployed.

2.2 Intelligent Emergency Broadcasting Platform Architecture

(1) The municipal-level broadcasting platform primarily consists of production and transmission platforms and transmission networks. At the central

city machine room, the municipal broadcasting platform includes broadcast system servers and broadcast server software, with core equipment comprising the production and transmission platform. The broadcast system server performs functions such as routing planning for information resource trees, cross-network transmission, and forwarding. It is used for constructing system broadcast information resource trees, backend management, permission allocation, and is responsible for information collection, transmission, exchange, display, storage, control, node information distribution, and addressing. The broadcast server software serves as supporting equipment for the broadcast system server, possessing capabilities in priority and permission control, logging and monitoring, streaming media encryption and distribution, and business loading and execution. The municipal broadcast station front-end features broadcasting and management functions, with main components including telephone access machines, sub-control computers, SMS access gateways, system broadcast control software, and multiplexers. Utilizing cable radio and television transmission fiber optic trunk lines, the municipal platform connects to county-level platforms through an MSTP transmission network, enabling broadcast signal transmission to broadcasting platforms in various counties and districts while greatly ensuring signal security and stability.

(2) The county-level broadcasting platform comprises numerous components, including sub-control computers, sub-control microphones, audio sources, and encoders. It enables partitioned management and control through IP networks and supports remote access under permission allocation. The SMS access gateway supports SMS-to-voice emergency broadcasting. After system authorization, all SMS numbers can send information to the platform through collection terminals, enabling direct text-to-voice broadcasting to terminals under its jurisdiction through caller number verification, organization code verification, and password verification.

(3) The township-level broadcasting platform. To enable network return and insertion of audio sources, township-level broadcast control centers are established. Selecting bidirectional cable radio and television networks from township to county front-end machine rooms enables functions such as partitioned or point-to-point broadcast control from townships to administrative villages and receiving terminals, integrating existing network resources across townships. When higher-level broadcasting is inactive and in coordination with municipal and county-level platforms, the system can perform control functions such as area-specific, designated-area, or point-specific power on/off and volume control according to commands, enabling local real-time broadcasting and scheduled broadcasting. Additionally, the township-level broadcast center front-end represents one of the key links in broadcasting functional requirements, capable of directly broadcasting emergency or early warning information from relevant units. Using IP signals, network insertion or telephone insertion transmits signals through cable digital television to the village level, enabling signal

return from township to municipal level and providing unified broadcast signal sources to village broadcast rooms across the city.

(4) The village-level broadcasting platform. On one hand, configuring TS sound columns, broadcast loudspeakers, and dual-mode sound columns in various communities and villages enables each broadcast receiving point to employ dual-mode audio reception via wired and wireless methods. TS stream sound columns can receive and decode cable digital television signals for playback, featuring both wired TS stream and IP stream decoding capabilities. With built-in network management return modules, they enable effective municipal-level platform supervision of broadcast equipment, utilizing bidirectional radio and television transmission networks to return equipment status information to municipal machine room system servers. On the other hand, administrative villages receive higher-level broadcast signals through wired and wireless digital television signals. Broadcast rooms utilize bidirectional radio and television networks to upload signals to municipal machine room system servers, employing sub-control microphones or telephones for insertion and audio source intervention, then distributing signals to various broadcast receiving points through cable digital television signals.

3. Security System Design for Intelligent Emergency Broadcasting Systems in Radio and Television Networks

[Figure 1: see original paper] Emergency Broadcast Information Security Assurance System

The information security assurance system for emergency broadcasting systems at all levels comprises three main components: information security management systems, information security technology systems, and information security operation systems. The information security assurance system employs technical measures such as digital signatures, message verification, and command verification to ensure information security at the application level. To prevent broadcast systems from hacker attacks and virus infections and to guarantee data transmission integrity and storage, information at all levels of emergency broadcasting platforms should be protected by firewalls to enhance data confidentiality and traceability (as shown in Figure 1).

All aspects of the emergency broadcast system security assurance system comply with national information security protection level requirements. According to secure broadcasting requirements, all aspects meet general security assurance requirements, including physical security, network security, and data security. To ensure the security of emergency broadcast information release, this scheme further enhances system security from the following aspects.

3.1 Network Security

Network security is reinforced across all aspects, including network equipment log auditing, network security zone partitioning, operation and maintenance security auditing, network boundary malware filtering, network access control, and network equipment protection.

3.2 Host Security

To ensure host security, the host operating systems and databases undergo security hardening to guarantee the provision of safe and reliable application services.

3.3 Audit Security

This aims to enhance capabilities for preventing security risks and threats, ensuring long-term, reliable operation of business systems through centralized log management and security risk monitoring.

3.4 Application Security

To guarantee system application-level security, this system implements security hardening across various aspects, including emergency broadcast content usage and storage, identity authentication, communication integrity and confidentiality, software fault tolerance, and resource control.

3.5 Data Security

During data transmission, regular backups and dual-machine hot standby are implemented for important server data to ensure data integrity and storage confidentiality, such as for application servers and database servers.

3.6 Transmission Aspects

Information security technology is isolated from other services. Under different network conditions, to achieve channel security and transmission assurance, the broadcast system transmission can utilize VPN technology for VLAN partitioning. Employing separate communication dedicated network lines enhances information transmission security, thereby avoiding threats from the internet. To ensure the confidentiality, legitimacy, and integrity of broadcast data transmission, the emergency broadcasting system adopts encryption algorithms and authentication algorithms. Through comprehensive security mechanisms, it meets the security requirements of intelligent emergency broadcasting, ensuring authentication of data sources and key security while guaranteeing data legitimacy verification. Furthermore, in this system, only legally authorized terminals can operate normally. Terminal devices support username and password verification, as well as online registration authentication. Only when all five reception conditions are met can the system completely prevent unauthorized broadcasting,

insertion, and interference by malicious actors: "FM carrier + RDS subcarrier + decryption control code + correct station identification code + working status command." Additionally, to enhance emergency broadcasting system security, each generated command data set is unique, with identical control commands becoming invalid after a single transmission. This prevents security threats to the emergency broadcasting system, ensuring that even if there are co-frequency or adjacent-frequency interference signals in the space, terminals receiving identical command data will not respond, and receiving terminals will not power on.

4. Main Functions of Intelligent Emergency Broadcasting Systems in Radio and Television Networks

First, the four-level management system and broadcast terminals from municipal to village levels possess various broadcasting capabilities, including GPRS information remote broadcast control and telephone remote control broadcasting. Higher-level platforms can control all broadcast parameters for any front-end and receiving facilities and terminal equipment within their jurisdiction, including power on/off and volume control. For instance, volume can be remotely and intelligently adjusted through audio broadcast controllers installed at front-ends. Second, the four-level emergency management platforms from municipal to village levels feature telephone and SMS insertion capabilities. SMS insertion can convert text information into voice announcements, offering advantages such as speed, security, and simple operation. Telephone and SMS insertion permissions are limited to emergency broadcasting only. Additionally, municipal, county, township, and village-level platforms possess independent broadcasting capabilities even without higher-level signal support. Moreover, under emergency conditions and following the principle of emergency broadcast priority, emergency signal lights can be directly activated to enable emergency insertion at all levels. When emergency broadcasting concludes, receiving terminals automatically return to preset values with volume automatically adjusted. To achieve grouped control of public terminals, the system can implement timed broadcasting, automatic broadcasting, and regional broadcasting across municipal, county, township, and village levels according to different administrative levels and regions, or control terminals through point-to-point methods.

Upon completion of the emergency broadcasting system project, it can enhance the information release and dissemination capabilities of people's governments at all levels. As an important component of the public service broadcasting system, it can promptly respond to and handle natural disasters, accident disasters, and social security incidents. Through the construction of intelligent emergency broadcasting systems, a broad-coverage, large-audience publicity channel can be provided for policy communication and early warning information release. Serving as an information release channel for disaster prevention and resistance and other emergencies, it holds significant importance for maintaining social stability and promoting agricultural development, featuring characteristics of

speed, convenience, and precision.

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Note: Figure translations are in progress. See original paper for figures.